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United States Department of Energy

Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Lakeview, Oregon

Appendix B of the Cooperative Agreement No. DE-FC04-84AL20534

February 1989

Uranium Mill Tailings Remedial Action Project UMTRAP

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REMEDIAL ACTION PLAN
AND
SITE DESIGN FOR STABILIZATION
OF THE
INACTIVE URANIUM MILL TAILINGS SITE
AT
LAKEVIEW, OREGON

APPENDIX B TO THE COOPERATIVE AGREEMENT
No. DE-FC04-84AL20534

URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT OFFICE
ALBUQUERQUE OPERATIONS OFFICE
DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO 87108

89-0535

EXECUTIVE SUMMARY
REMEDIAL ACTION PLAN
LAKEVIEW, OREGON SITE

Background

The Lakeview inactive uranium processing site is in Lake County, Oregon, approximately one mile northwest of the town of Lakeview, sixteen miles north of the California-Oregon border, and 96 miles east of Klamath Falls. The total designated site covers an area of 258 acres consisting of a tailings pile (30 acres), seven evaporation ponds (69 acres), the mill buildings, and related structures. The mill buildings and other structures have been decontaminated and are currently being used by Goose Lake Lumber Company.

Remedial action

The tailings pile at the processing site was stabilized by Atlantic Richfield (ARCO) with an earthen cover 18-24 inches thick. The average depth of the tailings, including the cover, varies from six to eight feet. The volume of tailings and contaminated materials was estimated to be 662,000 cubic yards of tailings, windblown contaminated materials, and vicinity property materials. During remedial action under the Uranium Mill Tailings Remedial Action (UMTRA) Project, approximately 264,000 cubic yards of additional contaminated materials were identified from excavation required to remove thorium and arsenic contaminated soils.

The remedial action plan for Lakeview consists of the cleanup, relocation, consolidation, and stabilization of all residual radioactive materials in a partially below-grade disposal cell located approximately seven miles northwest of the tailings pile identified as the Collins Ranch site. A cover including a radon/infiltration barrier and rock layer for protection from erosion will be placed on top of the tailings. A rock-soil matrix will cover the topslope and provide a growth medium for vegetation. After completion of the remedial action, the U.S. Department of Energy (DOE) will retain the license and surveillance and maintenance responsibilities for the final restricted site of 13 acres.

To date, all contaminated materials from the Lakeview processing site have been relocated and stabilized at the Collins Ranch site, the radon barrier has been placed and compacted, and portions of the highly conductive sand filter are in place. The entire sideslope of the disposal site has been winterized by covering with a 20 mil plastic cover.

EPA standards compliance summary

Pursuant to the requirements of the Uranium Mill Tailings Radiation Control Act (UMTRCA), this remedial action plan will satisfy the U.S. Environmental Protection Agency (EPA) standards (40 CFR 192) for cleanup, stabilization, and control of the residual radioactive materials (hereafter referred to as tailings) at the Lakeview site. The requirement for control of the tailings

(Subpart A) will be satisfied by the construction of an engineered disposal cell. The bottom of the cell will be approximately 40 feet below the original grade at its lowest point. The cell will be covered with a 1.5 foot thick, fine-grained layer of silt and clay to form a low-permeability layer that will reduce radon releases to well below the standard of 20 picocuries per square meter per second. The radon/infiltration barrier will also limit infiltration through the tailings. The average saturated hydraulic conductivity is 7×10^{-8} centimeters per second (cm/s). A coarse-grained, six inch thick, highly conductive sand filter/drainage layer will be placed above the radon/infiltration layer on the topslope to encourage runoff of precipitation. This layer will have a hydraulic conductivity of 1.0 cm/s or greater. A one foot thick rock riprap cover will be placed over the entire cell. The topslope will have additional rock-soil matrix to encourage plant growth. These design features will operate together to provide a stabilized cover system that will withstand erosion and biointrusion, and at the same time will shed water downslope off the pile.

Compliance with the proposed EPA groundwater standards requirements of 40 CFR 192, Subpart A, will be through meeting maximum concentration limits (MCLs) for three constituents (arsenic, cadmium, and uranium) at the downgradient edge of the waste management unit, which is the proposed point of compliance (POC).

With the exception of the relic groundwater plume, the standards for cleanup of the Lakeview processing site under Subpart B of 40 CFR 192 will be satisfied with the proposed remedial action plan. Cleanup of the tailings pile, mill buildings, contaminated wood chips, windblown tailings, and vicinity properties has been accomplished by consolidating the material into the disposal cell. The DOE has verified that cleanup to standards has been accomplished. Cleanup of the relic groundwater plume will be addressed in a separate process after the proposed EPA groundwater standards have been finalized.

Groundwater monitoring

A groundwater performance monitoring program will be fully developed and discussed in the surveillance and maintenance plan for the Lakeview site. The monitoring program will include a network of monitor wells downgradient from the disposal cell at the POC to determine the performance of the disposal cell. A system of shallow wells along the northern edge of the disposal cell will be installed to monitor the two seeps identified during remedial action. Further explanation of the monitoring program is found in Appendix F, Groundwater Performance Monitoring Program.

Design changes

Changes in the remedial action plan have become necessary for two major reasons: constructability issues relating to concerns identified during remedial action, and design modifications incorporated into the cell design as a result of the proposed EPA groundwater standards (40 CFR 192). Major design changes from the April 1986 Remedial Action Plan (RAP) that are included in this RAP are:

1. An increase in the tailings volume by approximately 264,000 cubic yards due to the need to remove arsenic and thorium contamination at the disposal cell. This addition will increase the overall height of the disposal cell by 3.6 feet.

2. The installation of a French drain system along the northern edge of the disposal cell to handle potential drainage of two seeps that were breached during excavation of the disposal cell.

3. Installation of a network of shallow wells to monitor seep activity.

4. Construction of two additional lined holding ponds, increasing the wastewater storage capacity on the disposal site by approximately 15 acre feet. The addition of this feature became necessary due to the wastewater generated by the high-pressure decontamination facility and the increased estimate of the runoff potential at the disposal cell and the area above the cell.

5. Installation of a wastewater treatment plant to treat the impounded water prior to release of the water off the site. The wastewater treatment plant originally constructed for the Canonsburg UMTRA Project site was retrofitted and transported to Lakeview for local water treatment.

6. The utilization of rock material not meeting the original specifications proposed in the design drawing and RAP of April 1986. Further testing of rock sources in the area indicates the inability to produce rock meeting the original specifications.

7. Modification of the filter layer gradation on top of the pile to ensure that it serves as a highly conductive sand filter/drainage layer providing a hydraulic conductivity of 1.0 cm/s or greater. This design feature was added as part of the compliance strategy for meeting the proposed EPA groundwater standards.

8. Modification of the final elevation of the Lakeview processing site, reducing the final grade six to 12 inches below original design. This alteration, agreed to by the landowner, was implemented due to the excavation of approximately 264,000 cubic yards of additional materials.

Due to the extended time in completion of this final RAP, the DOE is able to include the actual "as built" data on the radon barrier. This information is included as part of Appendix E, Final Plans and Specifications. Revised specifications and drawings are included as the last part of Appendix E, Final Plans and Specifications.

Text changes

Many changes have been made since the previous version of the Lakeview RAP was issued in April 1986. Additions to the text in this version are indicated in bold print. The one exception to this is the printing in the entirely new Appendix F, Compliance Strategy for the Proposed EPA Groundwater Standards, which is not printed in bold type. Deletions from the text are indicated by brackets ([]). These notations have been made so that technical reviewers can identify at a glance where changes have been incorporated.

Finally, considerable time and effort was expended by the DOE, the Oregon Department of Energy, and the NRC in resolving the problems related to rock quality and durability for the Lakeview site. This issue will be discussed in Section 5.0, and Appendix E, Final Plans and Specifications.

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1.0 INTRODUCTION

1.1 PURPOSE

This Remedial Action Plan (RAP) has been developed to serve a twofold purpose. It presents the series of activities which are proposed by the U.S. Department of Energy (DOE) to accomplish long-term stabilization and control of radioactive materials at the inactive uranium processing site located in Lakeview, Oregon. It also serves to document the concurrence of both the State of Oregon and the U.S. Nuclear Regulatory Commission (NRC) in the remedial action. This agreement, upon execution by DOE and the State and concurrence by NRC, becomes Appendix B of the Cooperative Agreement.

1.2 RESPONSIBILITIES

In 1978, Congress passed Public Law 95-604, the Uranium Mill Tailings Radiation Control Act (UMTRCA) [ ], expressly finding that uranium mill tailings located at inactive (and active) processing sites may pose a health hazard to the public. Title I to the UMTRCA identified 24 sites to be designated for remedial action. On November 9, 1979, Lakeview was designated as one of the [ ] sites.

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

The DOE shall select and execute remedial action plans that will satisfy the EPA standards and other applicable Federal and state laws. Under the UMTRCA, the DOE and the State of Oregon entered into a cooperative agreement effective in June, 1984, for remedial action at the Lakeview site. The DOE will fund 90 percent and the State of Oregon will fund 10 percent of allowable costs.

All remedial actions must be selected and performed with the concurrence of the NRC. In conformance with the UMTRCA, the required NRC concurrence with the selection and performance of proposed remedial actions and the licensing of long-term maintenance and surveillance of disposal sites will be for the purpose of ensuring compliance with the standards established by the EPA. Therefore, the RAP constitutes the initial document in the licensing process. A detailed listing of the responsibilities of the project participants is included in Section 8.0 of this report.

1.3 SCOPE AND CONTENT

This document has been structured to provide a comprehensive understanding of the remedial action at the Lakeview site. It includes the detailed design of the remedial action. An extensive amount of data and supporting information have been generated for this remedial action plan and cannot all be incorporated into this single document. Pertinent information and data are included with reference given to the supporting documents.

Section 2.0 presents the EPA standards, including a discussion of their objectives. Section 3.0 traces the history of operations at the Lakeview site with a description of the present site characteristics. Section 4.0 provides a definition of site-specific problems. Section 5.0 is the Site Design for the proposed action. Section 6.0 describes the water resources protection strategy. Section 7.0 summarizes the plan for ensuring health and safety protection for the surrounding community and the on-site workers. Section 8.0 presents a detailed listing of the responsibilities of the project participants. Section 9.0 describes the features of the long-term surveillance and maintenance plan. Section 10.0 presents the Quality Assurance procedures required to ensure that all work conforms to project standards. Section 11.0 documents the ongoing activities to keep the public informed and participating in the project.

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

Appendix A, Regulatory Compliance, describes in detail the permits necessary for the remedial action activities.

Appendix B, Calculation Summaries, presents a summary of the rationale and calculations that support the design.

Appendix C, Radiological Support Plan, describes the procedures used to characterize the present radiological condition of the site and the procedures to be used to control and verify the results of remedial action activities.

Appendix D, Environmental, Health, and Safety Plan, which describes the procedures to be used to protect and health and safety of workers and the general public during remedial action activities.

Appendix E, Final Plans and Specifications, is the design that will be constructed at the Lakeview site.

Appendix F is the Compliance Strategy for the Proposed EPA Groundwater Standards.

1.4 COLLATERAL DOCUMENTS

The Processing Site Characterization Report (PSCR) (DOE, 1985a), the Environmental Assessment (EA) (DOE, 1985b), and the Disposal Site

Characterization Report (DSCR), (DOE, 1985c) describe the existing conditions at the **Lakeview** site and the results of the remedial action. These documents include details that are not reported in the RAP.

The PSCR contains all of the geotechnical, hydrological, radiological, meteorological, and physical data necessary to describe the existing conditions at the Lakeview site.

The DSCR contains all of the geotechnical, hydrological, and physical data necessary to describe the existing conditions at the Collins Ranch disposal site.

The EA describes the proposed remedial action, alternatives, and the environmental impacts of the proposed actions.

An additional supporting document is the Site Design Criteria (DOE, 1984a), which addresses general guidance on the operating procedures, formats for drawings, specifications, calculations, schedules and cost estimates, and minimum design constraints incorporated in the final design documents.

This general guidance was used in conjunction with the RAP as the basis [ ] for preparation of the final design [ ]. It is further intended to provide sufficient criteria for the reader to understand the constraints, procedures, codes, and standards used during the design and to be used during the performance of the remedial actions at the **Lakeview** site.

Copies of all these documents, as well as supporting data and calculations, are on file in the **Uranium Mill Tailings Remedial Action (UMTRA)** Project Office in Albuquerque, New Mexico.

2.0 EPA STANDARDS

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

2.1 GENERAL

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

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

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

2.2 LONG-TERM STABILITY

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

The EPA standard-setting process distinguished "passive controls" such as thick earthen covers, below-ground disposal, rock covers, and massive earth and rock dikes, from "active controls" such as semi-permanent covers, fences, warning signs, and restrictions on land use.

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.

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

Active control covers could be expected to need frequent replacement or other major repairs requiring the appropriation and expenditure of public funds. In setting the standards, the EPA called for designs which rely primarily on passive controls.

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

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

2.3 RADON EMISSIONS CONTROL

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

In establishing the emission limitation for tailings piles, the EPA sought to reduce both the maximum risk to individuals living very near to the sites and the risk to the population as a whole. With regard to individuals very near to disposal sites, the EPA estimates that exposure to radon emissions will be reduced by more than 96 percent. The radon standard will limit the increase in radon concentration attributable to a pile to a small increase above the background radon level near the disposal site. Both radon standards are design standards, with compliance to be determined on the basis of predicted rather than measured emission rates and concentrations. The EPA states that "post-remediation monitoring will not be required to show compliance, but may serve a useful role in determining whether the anticipated performance of the control system is achieved."

In establishing the radon standard, the EPA determined that the emission limitation could be achieved by well-designed thick earthen covers and that such control techniques would be compatible with the requirements of the EPA longevity standard.

2.4 WATER QUALITY PROTECTION

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

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

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

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

On September 3, 1985, the U.S. Tenth Circuit Court of Appeals set aside the EPA standards applicable to the protection of waterways and groundwater, 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 issued draft revised standards but has not issued final standards. The DOE will implement the remedial action plan, with the concurrence of the NRC and after consultation with the EPA. When the EPA re-promulages final groundwater protection standards, Subpart C 40 CFR Part 192, the DOE will evaluate the groundwater contamination at the Lakeview site and take the appropriate action to comply with such standards. All measures proposed by the DOE to meet the water-quality goals of the re-promulgated EPA standards will be submitted to the NRC for review and concurrence.

?.5 CLEANUP OF LANDS AND BUILDINGS

The EPA evaluated the risk associated with the dispersion of tailings off the site and concluded that the primary concern was the risk to man from exposure to radon daughter products inside buildings. The EPA therefore stated that the objective of the cleanup of tailings from around existing structures was to achieve an indoor radon daughter concentration (RDC) of less than 0.02 working level (WL). For open lands, the purpose of removing the contamination is to remove the potential for excessive indoor radon daughter concentrations that might arise from new construction on contaminated land. The 5.0 picocuries per gram (pCi/g) and 15 pCi/g radium-226 (Ra-226) concentration limits for 15 centimeters (cm) thick surface and subsurface layers were considered adequate to limit indoor RDCs to below 0.02 WL. A secondary concern was to limit exposure to people from gamma radiation.

The standard requires that residual radioactive materials be removed from buildings with concentrations exceeding 0.03 WL. In cases where levels are between 0.02 and 0.03 WL, the Federal government will have the flexibility to use measures such as sealants, filtration devices, or ventilation devices to reduce concentrations to below 0.02 WL.

3.0 SITE CHARACTERIZATION

Site characterization describes the Lakeview site and the proposed disposal site at Collins Ranch [ ]. Emphasis is given to the three major concerns of stability, radiation, and groundwater. The data to support the characterization may be found in the [ ] PSCR (DOE, 1985a) and the [ ] DSCR (DOE, 1985c).

3.1 HISTORY

The Lakeview uranium mill was built and operated by the Lakeview Mining Company in 1958. The owners of this firm were also the owners of the Gunnison Mining Company, who operated the mill at Gunnison, Colorado. Both companies were acquired in 1961 by Kerr-McGee Oil Industries through its subsidiary, Kermac Nuclear Fuels Corporation. Between 1960 and 1968 the property had five owners.

In 1968 the Lakeview site was acquired by Atlantic Richfield Company, who initiated in 1974, and subsequently performed, a cleanup operation on the site under a plan approved by the Oregon State Health Division. By 1977 the mill buildings and their immediate surroundings had been decontaminated to meet the then-existing requirements of the Oregon Regulations for the Control of Radiation. The property was sold on March 8, 1978, to Precision Pine Lumber Company [ ] which used the site and structures as a lumber mill and stockpile for sawdust and scrap waste. **The property containing the mill buildings, office area, and acreage for timber storage was sold to Goose Lake Lumber Company in 1987. Precision Pine Lumber Company still retains title to the former tailings pile area.**

During the 1958 to 1961 period of operations, 130,000 tons of ore were treated at the mill site. The mill operated at a rated capacity of 210 tons of ore per day and used a sodium chlorate and sulfuric acid leach process. The ore came from the White King and Lucky Lass mines, located approximately 16 road miles northwest of Lakeview.

3.2 PHYSICAL DESCRIPTION

Regional geology

The Lakeview area is located in the Basin and Range physiographic province, which is characterized by north to northwest mountains and ridges (horsts) separated by oblong narrow valleys (grabens). Both the processing site and the Collins Ranch alternate disposal site are located within the Goose Lake graben.

The regional topography has been influenced by normal faulting with upthrust sides typically steeper than downthrust sides. Intermittently during the Pleistocene Epoch (10,000 to 1,000,000 years ago) lakes filled the valley to varying depths, depositing lacustrine sediments to depths in excess of 5000 feet.

The oldest rocks in the area are Miocene and Pliocene volcanic deposits. These rocks are exposed in the Fremont and Warner Mountain horstblocks and underlie the sediments of the Goose Lake Valley. The valley fluvial terrace, lacustrine, and diatomaceous sediments range from silts and clays to conglomerates.

Surface features of the Lakeview site

The Lakeview [ ] site and tailings are located in south-central Oregon, in Lake County. The closest town is Lakeview, one mile to the southeast. Klamath Falls is approximately 96 miles west of the site. The site is approximately 16 miles north of the California-Oregon border (Figure 3.1).

The total designated site covers an area of 258 acres. This included the tailings (30 acres) and the evaporation ponds (approximately 69 acres). The tailings were stabilized with an earthen cover 18 to 24 inches thick. The pile was almost square with a very flat surface, although the [ ] cover had depressions that trap moisture. The cover supported a vigorous growth of vegetation. The average depth of the tailings, including the cover, varied from six to eight feet. An earthen dike was constructed around the tailings area before the tailings were emplaced. The tailings were fenced with a hog-wire type of fence, and radiation signs are posted. There was also a barbed-wire fence around the entire site. The mill and tailings site before remedial action are shown in Figure 3.2.

The mill buildings and other structures have been decontaminated, and the machinery and other salvageable items have been removed and decontaminated by the owners. Materials from the final decontamination of the mill buildings and surroundings areas were placed on the southeastern portion of the tailings pile and stabilized in the same manner as the remainder of the tailings.

The areas to the north and west of the site are generally swampy during much of the year due to the high water table. To the east of the site, the land is swampy during the spring and early summer but dries out later in the summer and remains dry until winter.

Precision Pine Lumber Company [ ] stored bark, wood chips, and sawdust on the northwest evaporation pond. Precision Pine Lumber Company [ ] built an addition onto the northern end of the lumber mill building. Two new buildings also have been constructed on the mill site near the old mill building; one of these is located directly over the former ore storage area.

Subsurface features of the Lakeview site

Soils immediately underlying the processing site consist of a complex series of interbedded silts, sands, and clays. These deposits are lacustrine and alluvial in origin. Groundwater is encountered at depths ranging from five to 15 feet below the land surface.

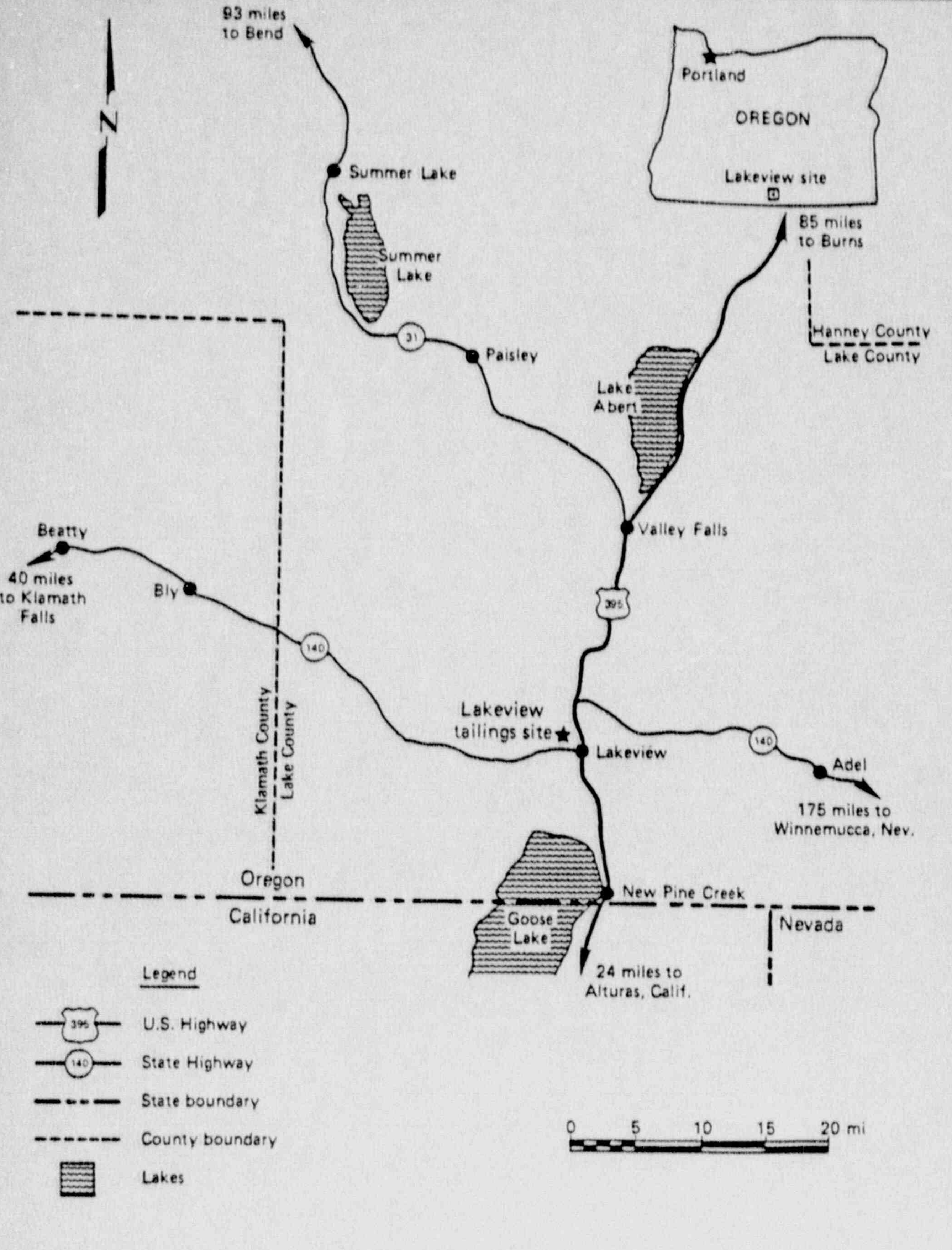


FIGURE 3.1
LAKEVIEW SITE LOCATION

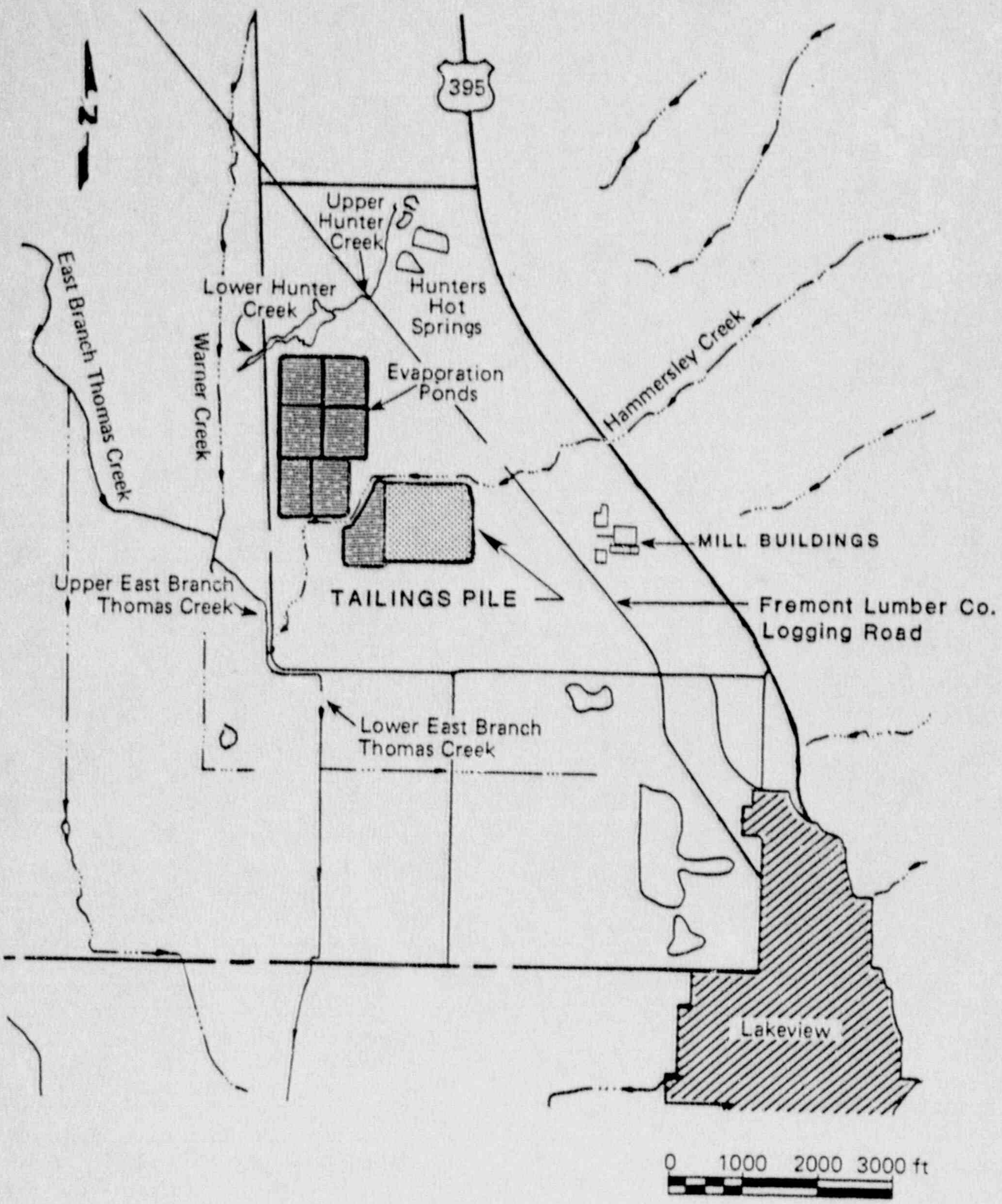


FIGURE 3.2
LAKEVIEW MILL SITE

The former processing site is located in a Known Geothermal Resource Area (KGRA). The geothermal activity is associated with the seismotectonic setting of the area. Geothermal anomalies have been observed in the form of geysers, the closest of which is Hunters Hot Springs, located 0.4 mile north of the site. Water temperatures of 60°C and 41°C encountered in two monitor wells immediately north of the evaporation ponds and a four-inch blowhole opening through snow on the southeast evaporation pond (observed on January 27, 1984) also are indications of geothermal activities in the area.

Further details of the subsurface features of the processing site may be found in the PSCR [ ] (DOE, 1985c).

Surface features of the Collins Ranch disposal site

The [ ] Collins Ranch disposal site is [ ] approximately seven road miles northwest of the Lakeview tailings site and consists of a 40-acre area in Section 12, Range 19 East, Township 38 South, Lake County, Oregon (Figure 3.3). A private logging road owned by Fremont Lumber Company connects the Lakeview tailings site with a National Forest Development Road that passes within 0.75 mile east and north of the Collins Ranch disposal site.

The site is part of a larger area of a ranch owned by John and Bridgette Collins. Prior to a range fire that occurred in August 1984, the site was leased for grazing. The area used for disposal is isolated and visible only from a distant, seldom-used National Forest Development Road. The few inhabited residences in the area are over one mile away.

Subsurface soil features of the Collins Ranch disposal site

The Collins Ranch site is located on a remnant terrace deposit east of the Fremont Mountains. This pediment has been separated from the mountain flank by erosional processes. The eastern portion of the site rests upon this pediment, which is typified by surface slopes of five to 20 percent. The western portion of the site rests upon outwash deposits of the Fremont Mountains.

Soils underlying Collins Ranch consist of interfingered and layered silty sands, sandy silts, and surficial lenses of high plasticity clays. These materials, encountered to a depth of 127 feet, form the slopes of Augur Hill, and represent a remnant pediment of outwash deposits from the nearby Fremont Mountains. Groundwater was encountered in seven of the 10 boreholes completed as monitor wells. The four remaining on-site observation well borings did not encounter groundwater within the stratigraphic interval penetrated. Four shallow wells (22 to 27 feet) in the valley, just west of the site boundary, show water-table conditions with depths to groundwater from seven to 18 feet (December 1984). One 78-foot well drilled on the disposal site near the course of a broad drainage channel on the southwest slope of Augur Hill showed groundwater at 76 feet below ground surface. A minimal depth to groundwater beneath the proposed

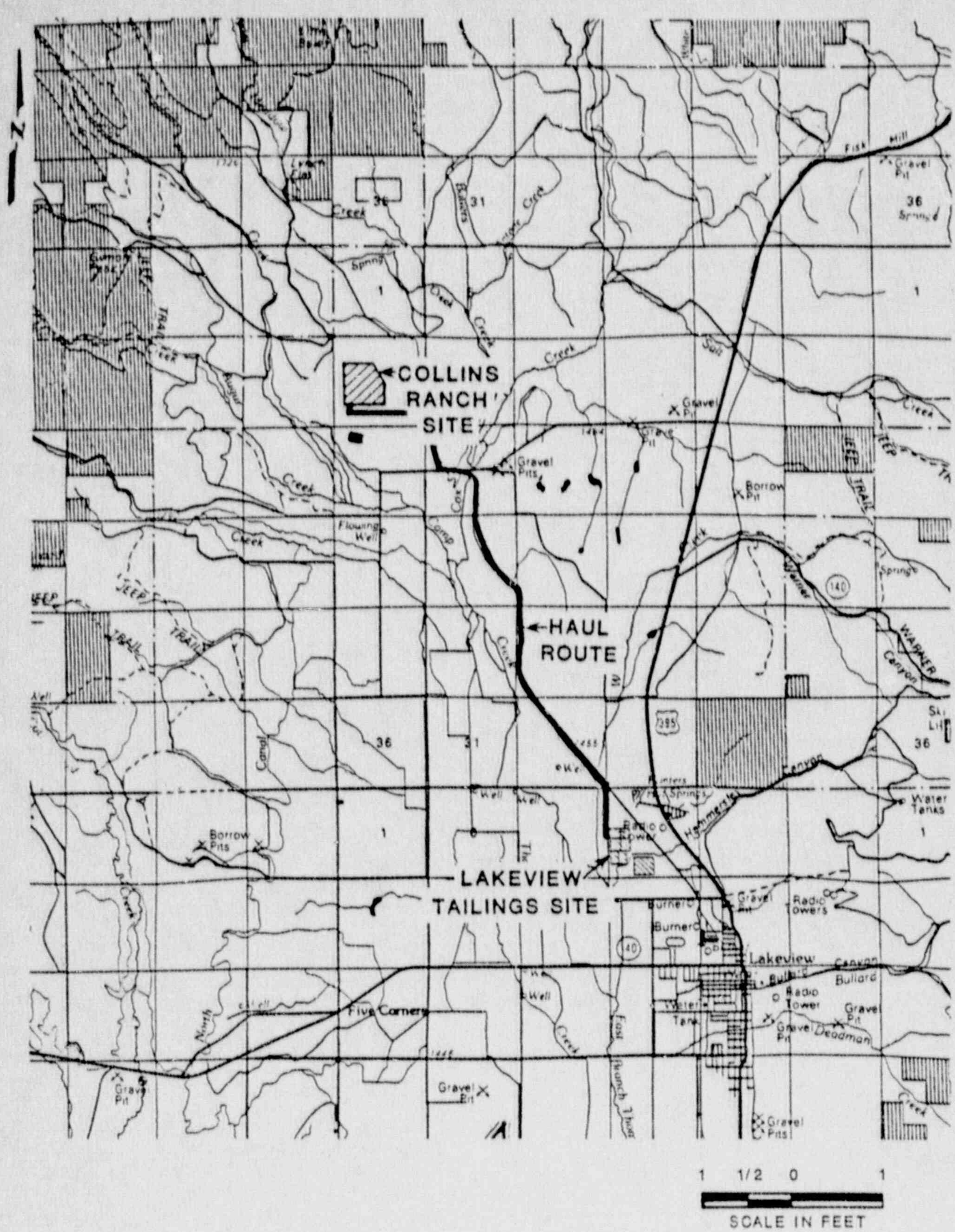


FIGURE 3.3
DISPOSAL SITE LOCATION
COLLINS RANCH SITE

boundary of the disposal site is presently about 30 feet. This depth increases moving up the slope of Augur Hill. Groundwater beneath the site moves from northwest to south-southeast under a hydraulic gradient [ ] of approximately 0.018. The groundwater flow direction is opposite the topographic slope, indicating most recharge is from the Fremont Mountains to the west, rather than from the soils at the proposed disposal site.

In the spring of 1987, two seeps were identified along the exposed surface of the north wall of the disposal cell. The maximum potential flow from seep No. 1 was estimated to be 0.7 gallons per minute (gpm). The maximum potential flow from seep No. 2 was estimated to be 0.1 gpm. Figure 3.4 shows the approximate locations of the two seeps.

Details of subsurface features of the Collins Ranch disposal site are in the [ ] DSCR (DOE, 1985c).

Groundwater conditions at the Collins Ranch disposal site are discussed in Section 3.5.

3.3 STABILITY

South-central Oregon is in an area of moderate to high seismic risk. Historical seismicity in the region is characterized by moderate-sized earthquakes associated with normal faulting within the region. Most of the faults that bound the horst and graben features of the tectonic province have been mapped. Two large major fault zones are close [ ] to the processing and disposal sites. These are the Fremont Mountain fault zone and the Summer Lake fault zone. These faults have been postulated to be capable of producing a Maximum Credible Earthquake (MCE) of 7.5 on the Richter scale. This would result in maximum horizontal bedrock acceleration of 70 and 52 percent of gravity at the processing site and the Collins Ranch site, respectively.

In addition to the ground motion experienced from a seismic event, a potential for surface rupture exists directly under the processing site due to the short distance (less than 0.5 mile) from the Fremont Mountain fault zone. This potential is not present at the Collins Ranch [ ] disposal site.

Geothermal activity at the processing site is associated with the seismotectonic setting of the area. There exists potential for solutioning of the silicious caprock or alteration by seismic events to produce venting directly beneath the tailings pile at the processing site (DOE, 1985a). This potential does not exist at the Collins Ranch site.

The geomorphic setting of both sites is relatively stable. Hammersley Creek at the processing site has a small potential to flood and meander. The slopes of the Collins Ranch site may require some protection from erosion, but are generally well protected by a natural gravel and cobble armoring.

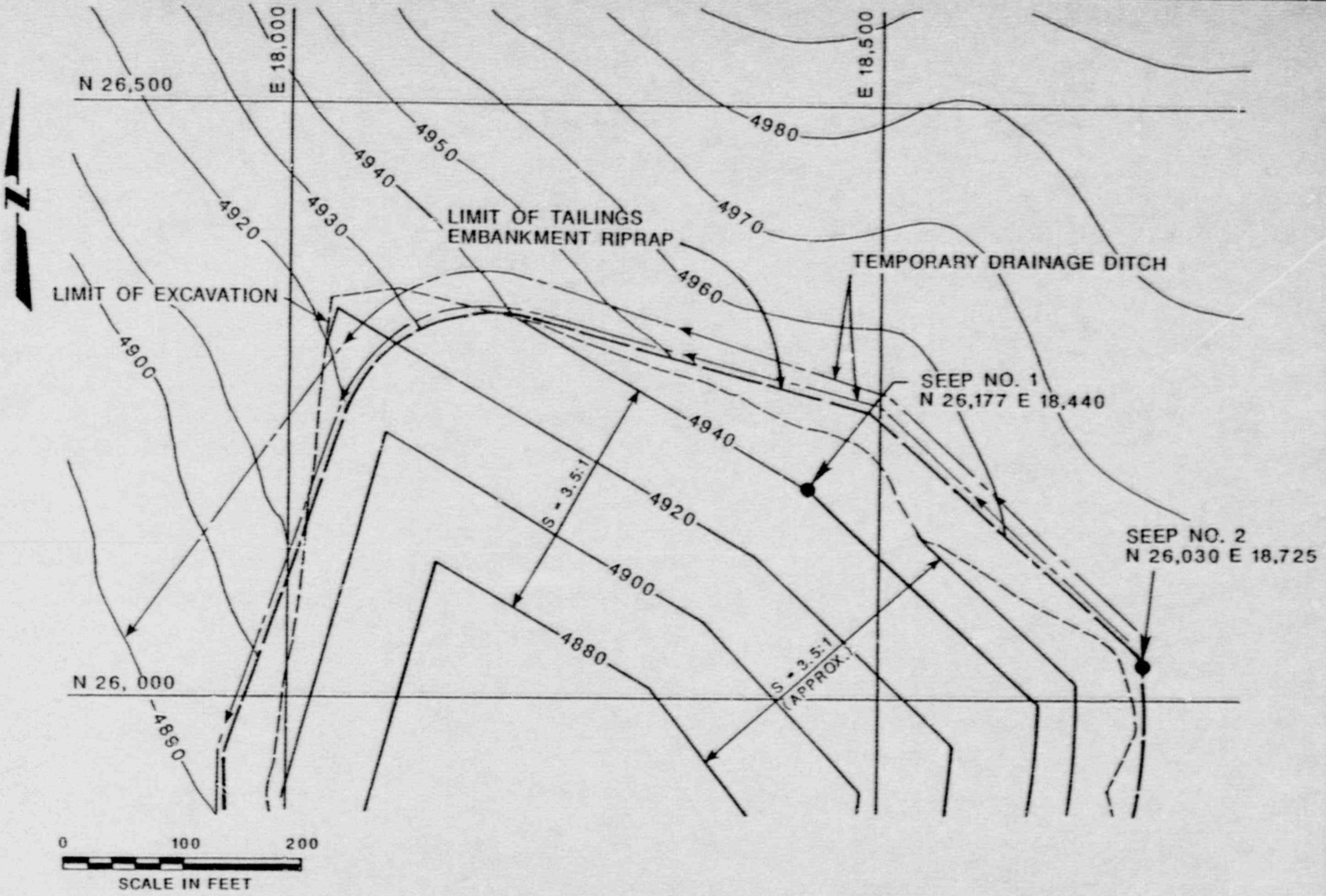


FIGURE 3.4
LOCATION OF SEEPS - COLLINS RANCH SITE

3.4 RADIATION

Background radiation levels

Radioactive elements occur naturally throughout the earth's air, water, and soil. The concentration of these elements varies greatly throughout the United States. Background soil radioactivity levels typical of the Lakeview area and not influenced by the tailings pile have been established as 0.8 pCi/g for [ ] Ra-226 (ORNL, 1980).

The average background gamma radiation exposure rate in the Lakeview region from both terrestrial and cosmic sources measured at three feet above the ground is 11 microroentgens per hour (microR/hr) with a range of eight to 19 microR/hr (ORNL, 1980). Cosmic rays (radiation from the sun and other sources external to the earth) contribute approximately 5.3 microR/hr (48 percent) to the 11 microR/hr background gamma exposure rate in the Lakeview area (EG&G, 1981).

The average outdoor background radon concentration in the Lakeview area was 0.7 picocuries per liter (pCi/l) based on measurements at eight locations. The range of radon concentrations for these 24-hour samples was 0.6 to 0.8 pCi/l (FBDU, 1981).

Lakeview tailings site

Previous remedial action activities were conducted from 1974 to 1977 at the Lakeview tailings site. These included the cleanup and stabilization of the former mill area, partial excavation of material in the evaporation ponds, and application of cover material over the tailings pile.

Samples from 21 drill holes on the former tailings pile were analyzed by gamma spectroscopy, and computer modeling was used to profile the pile contaminant distribution and the average Ra-226 concentration. The resulting average Ra-226 concentration of the tailings was 160 pCi/g; this includes the tailings, the existing two foot thick cover, and a two foot layer of contaminated material underlying the tailings (BFEC, 1984; JEG, 1984). The maximum Ra-226 concentration found was 739 pCi/g.

The soil beneath the tailings pile exceeded the EPA standard of 15 pCi/g Ra-226 to an average depth of approximately one foot. Elevated arsenic levels were also present beneath the tailings, approximately 600 parts per million (ppm) from the surface to two feet beneath the tailings pile interface. Actual site excavation showed considerably more arsenic contamination than originally expected.

Using Shiager's (1974) estimate of 2.5 (microR/hr)/(pCi/g), the base tailings gamma exposure rate would be 400 microR/hr based on the average tailings pile Ra-226 concentration of 160 pCi/g. The former cover on the tailings pile reduced the pile surface gamma exposure rate to an average of less than 25 microR/hr (EG&G, 1981).

The radon flux source term from the tailings pile was calculated using the RAECOM model (NRC, 1984), which resulted in an annual average radon flux of 59 picocuries per square meter per second (pCi/m^2s) for no-action conditions.

Results of field data from the evaporation ponds (69] cres) on the tailings site indicated elevated thorium-230 concentrations, averaging 65 pCi/g in the surface six-inch layer, 35 pCi/g in the six- to 12-inch layer, and 12 pCi/g in the 12- to 18-inch layer. Since Ra-226 activity in-growth in 1000 years would be above or borderline to EPA standards, excavation is planned to a depth of 18 inches.

Field data (ORNL, 1980; BFEC, 1984) show that minimal spread of gamma-emitting contamination has occurred by wind or water erosion into areas beyond the tailings pile or evaporation ponds. Approximately 17.4 acres immediately adjacent to the tailings pile and in isolated areas in the mill yard that were not cleaned during previous remedial action indicated elevated Ra-226 concentrations. The concentrations ranged from five to 170 pCi/g Ra-226.

Collins Ranch site

Background soil Ra-226 concentration and gamma exposure rate levels, measured [ ] in the Lakeview region, indicated average levels of 0.8 pCi/g Ra-226 and 11 microR/hr for gamma exposure rate (ONRL, 1980). [ ] Background radiation levels were measured at five locations in the Lakeview area. Results indicated an average Ra-226 concentration of less than one pCi/g, and gamma exposure rate measurements ranged from nine to 13 microR/hr (BFEC, 1984).

Background radiation measurements have also been made on the Collins Ranch site [ ] (DOE, 1985a). The mean and one standard deviation from four pressurized ionization chamber measurements were 12.1 plus or minus 0.5 microR/hr. A subsequent gamma exposure rate traverse survey indicated no readings beyond the range of 10 to 14 microR/hr. Surface soil samples were collected at the four pressurized ionization chamber measurement locations and analyzed for Ra-226, Th-230, and natural uranium. The average concentrations found were: Ra-226, 0.9 pCi/g; Th-230, 1.1 pCi/g; and natural uranium, 3.5 ppm.

A limited radon air concentration study resulted in 0.12 pCi/l during a three-month exposure period (Terradex, 1985). The ground was snow-covered during approximately half of the exposure period, which would tend to decrease the resultant radon concentration.

3.5 GROUNDWATER

Lakeview processing site

Groundwater in the valley fill deposits at the Lakeview processing site occurs under unconfined to semi-confined conditions. The below ground field characterization was concentrated upon the zone from the surface to a depth of 100 feet, the predictable limits of vertical contaminant migration. Within this zone, groundwater occurs under unconfined to semi-confined conditions within sequences of discontinuous lenses of silty to sandy clays and silty sands with minor amounts of fine gravel. More details on location and depth of site monitoring wells and on the lithology are contained in the PSCR and draft EA (DOE, 1985a,b).

The groundwater flow direction is from the northeast to southwest with an apparent hydraulic gradient of 0.01. Recharge in the site area is from local precipitation and snowmelt and groundwater flow from the Warner Mountains. There appears to be upward movement of groundwater in the geothermal area north of the site. Groundwater discharges to surface drainages, springs, and wells in the area.

Differences in water levels of two to 12 feet between monitor well pairs indicate a small downward vertical hydraulic potential that decreases from northeast to southwest across the site. A survey of domestic wells within one mile of the site showed only small differences in water level between shallow (100 feet deep) and 450 foot deep wells. Therefore, strong vertical flow gradients outside the geothermal system are unlikely, and the entire sequence of sediments behaves as a single leaky system. Two aquifer tests were performed and indicated that restricted hydraulic interconnection exists between shallow (20 to 25 feet) and deeper (70 to 75 feet) screened zones.

There are two chemically distinct types of upgradient water quality. The low temperature groundwater exhibits a calcium bicarbonate chemistry with total dissolved solids (TDS) of approximately 200 milligrams per liter (mg/l), whereas the geothermal groundwater exhibits a sodium sulfate chemistry with TDS of approximately 800 mg/l.

Two contaminant plumes are migrating from the processing site. The main plume emanates from the southeast evaporation ponds area. A lesser plume is migrating from the tailings pile area. Extent of the plumes has been determined from sulfate or TDS concentrations. Elevated concentrations of radionuclides and most heavy metals are not appearing in the groundwater, and are apparently attenuated in the subsoils beneath source areas of contamination. Differences in concentrations of elements between shallow and deep well pairs show that most of the contaminant migration has occurred in the shallow groundwater, above 30 feet, and further attenuation of soluble species occurs as seepage moves downward into the deeper 75-foot zone.

Groundwater use downgradient of the site is generally sustained by pumping from zones deeper than 75 feet. Available well records do not indicate any water usage from the shallow zone downgradient from the processing site.

Collins Ranch disposal site

Groundwater at the Collins Ranch disposal site occurs within sequences of layered silty sands, sandy silts, and surficial lenses of high plasticity clays. These layers are stratified and interfingered in a complex manner, similar to the processing site lithology, with a larger percentage of finer-grained soils (DOE, 1985a,b). Hydrochemical data from wells indicate that [ ] the shallow strata at the processing site have a high attenuative capacity. Boreholes at the Collins Ranch site indicate an even larger attenuative capacity because the strata there are finer grained and thus have larger dispersivity and larger particle surface areas for sorption processes. These materials, encountered to a depth of 127 feet, form the slopes of Augur Hill upon which the partially below-grade disposal site will be located.

Groundwater in the valley just west of the site boundary is found at depths from seven to 18 feet beneath the ground surface. The depth to groundwater beneath the site increases approaching the eastern edge of the disposal site. Six monitor wells were installed within the boundary of the disposal site at depths ranging from 47 feet to 127 feet. Three wells encountered groundwater at depths of 65 to 76 feet below the ground surface. Other wells at the site did not encounter water within the stratigraphic section penetrated.

Groundwater moves from northwest to south-southeast beneath the site, counter to the topographic slope, with an apparent hydraulic gradient of 0.018. The primary source of recharge is the Fremont Mountains to the west. Minimal recharge occurs along the small drainage divide immediately above the disposal site. Discharge occurs to a small drainage south of the site and ultimately into drainages that drain to Goose Lake, 15 miles southeast of the site. Groundwater level fluctuations due to spring snowmelt and runoff in the Fremont Mountains are being monitored and were less than two feet between the autumn of 1984 and the summer of 1985.

The chemistry of the shallow groundwater in the Collins Ranch area exhibits low TDS, high pH, and high silica (DOE, 1985b, Appendix D).

4.0 PROBLEM DESCRIPTION

4.1 GENERAL

The tailings (without the current cover) emit an estimated radon flux of 160 pCi/m^{2}s, which is in excess of the EPA standard of 20 pCi/m^{2}s.

4.2 LONG-TERM STABILITY

The tailings and contaminated rubble were not secure from physical removal off the Lakeview site. In addition, the potential for ground surface rupture and geothermal activity at the processing site precluded the long-term stabilization of the tailings at that location. By moving the tailings and contaminated material to the Collins Ranch site these [ ] risks are avoided and EPA longevity requirements can be met.

4.3 RADIATION

Radon emissions from the tailings exceeded the EPA standard of 20 pCi/m^{2}s by approximately eight times; however, the two foot thick earthen cover decreased the radon emissions by half. The radiation standards for buildings and open lands were exceeded in approximately six vicinity properties and 86.4 acres of evaporation pond or windblown contaminated areas on and around the Lakeview site. Additional vicinity properties were identified during remedial action.

4.4 WATER QUALITY

Lakeview processing site

An unconfined to semi-confined groundwater systems exists at depths greater than five to 15 feet below the ground surface. Contaminants associated with the tailings pile and evaporation ponds have moved into this aquifer and have migrated 800 feet downgradient to the southwest in the shallow groundwater zone above 30 feet. Mobile species include sulfate, manganese, and sodium. Radionuclides and most heavy metals from leachate are attenuated in the subsoils beneath the ponds and former pile area. Monitor wells screened in a deeper zone at 70 to 75 feet show sulfate and TDS concentrations increasing downgradient from the evaporation ponds. Stable isotope analyses indicate that the increasing trend in sulfate and TDS in the deeper zone is due to the influence of the geothermal system in the region (see [ ] Appendix B, Calculation Summaries).

There is no water use from the shallow zone, above 30 feet, downgradient of the site. Most domestic wells are screened at depths from 100 to 300 feet. [ ] Data show that contaminants associated with the site have not endangered any downgradient water uses. Due to the chemical nature of the contaminant plume compared to local background water quality, the limited extent of contaminants, the non-toxic nature of contamination, and the lack of uses and potential uses, aquifer restoration is not warranted.

As additional quarterly water quality data become available for the processing site, the possible long-term need for aquifer restoration will be re-examined. A separate process during a later phase of the UMTRA Project will examine the need for, and feasibility of, aquifer restoration at every UMTRA site.

Collins Ranch site

The potential for groundwater contamination at the Collins Ranch site appears to be insignificant. For every constituent of concern, the disposal site design allows proposed EPA concentration limits to be met in shallow groundwater within 50 feet of the downgradient edge of the tailings cell (see Appendix F).[]

4.5 ALTERNATIVES CONSIDERED

4.5.1 Selection of disposal site

After determination was made that a fault zone in combination with seismic and geothermal activity would preclude stabilizing the tailings at the processing site, a structured alternate disposal site selection process was followed to find a suitable disposal site.

The process consisted of a four-phase approach: Phase I designated the limits of the search region; Phase II provided for a preliminary screening of the designated search region; Phase III began the preliminary screening and evaluation of the potential disposal areas; and Phase IV identified and evaluated each of the candidate sites.

The search region designated by Phase I encompassed a 15 mile radius from the existing tailings pile. Phase II consisted of the development of regional screening guidelines, and application of those guidelines resulted in elimination of all land except 70 square miles of the search region. Under Phase III, evaluation of those 70 square miles by a technically diversified team of specialists identified six one-square-mile desirable areas. Evaluation and ranking of the six areas under Phase IV identified the two highest ranking sites for subsequent field data collection and inclusion in the EA.

The final design contained in this document was developed around the "preferred alternative," the Collins Ranch site. Other specific sites evaluated but found less desirable included the Flynn Ranch site and the Mines site. Comparison of these three sites along with stabilization in place was the subject of a discussion paper (DOE, 1985d). A detailed description of the site selection process and a comparison of alternatives [ ] is contained in the EA (DOE, 1985b).

4.5.2 Design concept

Upon selection of the preferred alternative, relocation of the tailings to the Collins Ranch site, extensive engineering studies were performed in the development of the design described in Section 5.C. Major areas of evaluation included groundwater occurrence and protection, embankment configuration, erosion protection, foundation settlement, and slope stability.

The hydrogeologic field program revealed that an unconfined to semi-confined groundwater system exists below the Collins Ranch site. Continued monitoring of groundwater levels at the site has defined seasonal water level fluctuations in this system. Details are included in Appendix B, Calculation Summaries.

Because of the abundance of silt and clay soils in the Collins Ranch area, below-grade disposal was considered a viable option. The final, partially below-grade embankment was designed to use the soils available on the site and the natural topography of the site **in the best way**, as well as to avoid the local unconfined groundwater system. The contaminated materials **would** be isolated from the shallow groundwater system by limiting infiltration through a low-permeability cover **and a highly conductive sand filter/drainage layer**, and by geochemical retardation and flow reduction through a two-foot geochemical/flow barrier liner. **A French drain system was installed along the northern edge of the disposal cell to handle water from the two seeps.**

[ ] The deepest excavation at the processing site was accomplished in late summer when groundwater levels were low, thus minimizing the dewatering effort. [ ]Details are provided in Section 5.0. **Wastewater treatment for runoff water and decontamination water was necessary at the Collins Ranch site during construction.**

The Goose Lake Basin is an area of extensive seismic activity. The disposal embankment was designed to withstand the occurrence of a Maximum Credible Earthquake (MCE). The design slopes (1 vertical to 5 horizontal) will provide the necessary factor of safety against embankment slope failure and settlement under both static and seismic loading conditions. The embankment slopes [ ] blend into the surrounding terrain and reduce the potential effects of ero- sion due to surface water flows. Final design calculations on slope stability, settlement, and erosion protection are contained in Section 5.0 and Appendix B, Calculation Summaries.

5.0 SITE DESIGN

5.1 INTRODUCTION

This section provides the maps, drawings, and other information necessary to understand the design used for relocating the tailings [ ] to the Collins Ranch disposal site. A three-dimensional isometric drawing of the original Collins Ranch site is shown in Figure 5.1. The site design is described to provide sufficient detail for the reader to evaluate the feasibility and effectiveness of the basic design concepts. The final design provides a basis for the schedule and cost estimate to be used in obtaining concurrences and funding at Federal and state levels (Appendix E, Final Plans and Specifications).

The site design demonstrates remedial action that meets the requirements of PL95-604. Although the as-built design may vary to a limited extent from the final design, the basic concepts presented in this document represent final remedial action.

5.2 SUMMARY OF PROPOSED REMEDIAL ACTION

The principal feature of the design concept is the relocation of approximately 925,810 cubic yards of tailings and contaminated materials to the Collins Ranch disposal site located about seven miles from the former mill site. The contaminated materials have been consolidated into an embankment constructed partially below grade, and enclosed with protective layers. These protective layers [ ] consist of the following:

- o A two-foot-thick compacted soil layer beneath the tailings (the "geochemical/flow barrier liner") to attenuate migration of contaminants.
- o A compacted soil layer above the contaminated materials (the "radon barrier") to reduce emission of radon gas to acceptable levels and inhibit infiltration.
- o A highly conductive sand filter/drainage layer to prevent runoff from eroding the radon barrier through the rock layer.
- o A combination of rock and a rock-soil matrix on the topslope to provide erosion protection and support vegetation.
- o A rock layer on the steeper sideslopes for erosion protection.

Construction of the embankment comprised several major elements. Material for the radon and infiltration barrier was excavated from the embankment area. Approximately 279,000 cubic yards of soil from the disposal site excavation was used for processing site backfill. A compacted geochemical/flow barrier liner two feet in thickness was constructed. The liner was constructed from select materials also excavated from the embankment area. The tailings and highly contaminated material

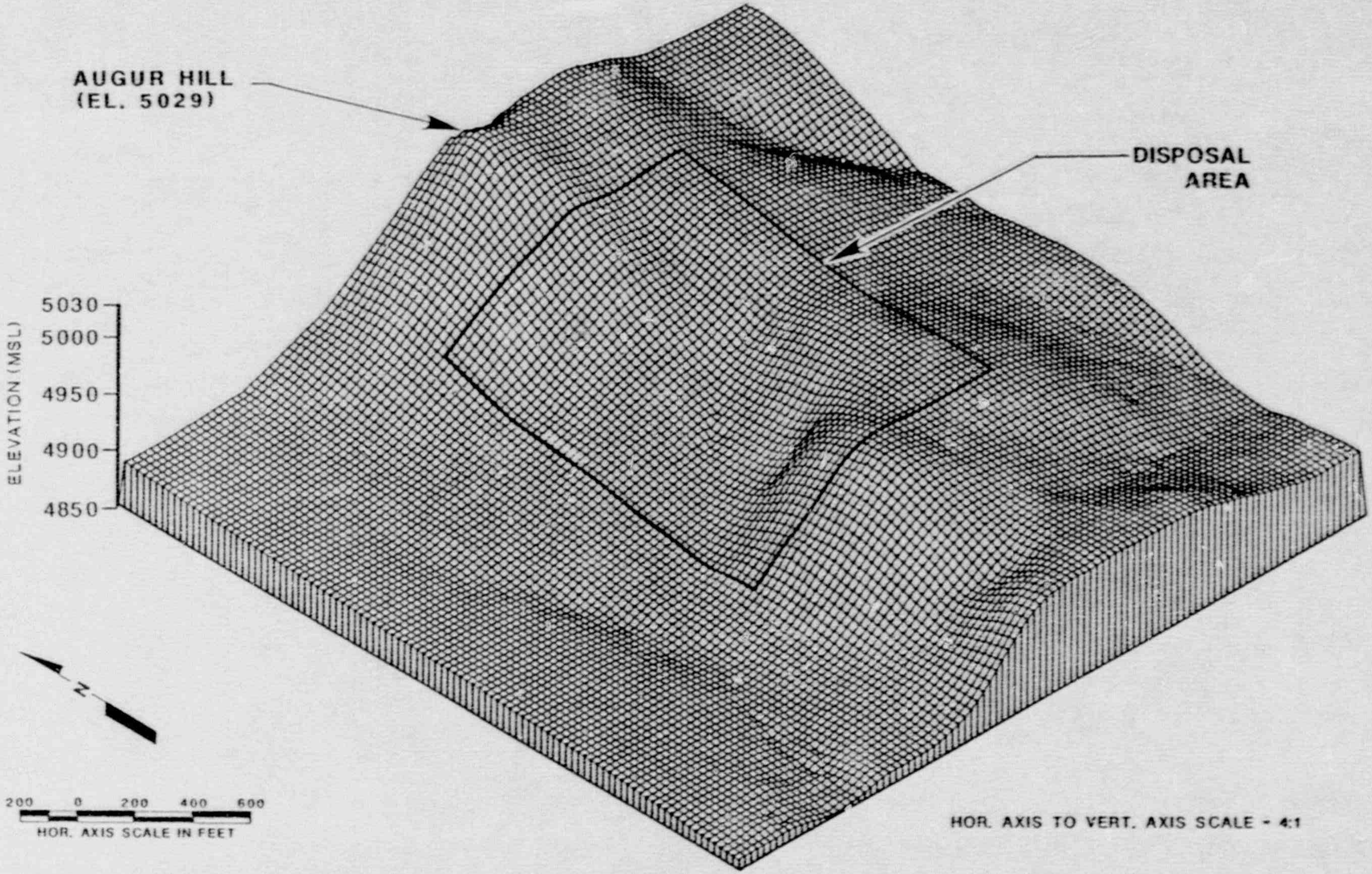


FIGURE 5.1
ORIGINAL CONDITION, COLLINS RANCH DISPOSAL SITE - ISOMETRIC

were placed and compacted first, then the less contaminated material was placed and compacted, and finally the radon barrier placed and compacted. The embankment sideslopes will be covered with rock erosion protection material designed to withstand the erosional effects of wind and water, and to impede inadvertent disturbance by man or animal. The topslopes will be capped with a rock-soil matrix that will support vegetation and at the same time protect against erosion. The rock-soil matrix will both minimize plant root intrusion [ ] and facilitate revegetation of the surface. The final embankment is shown in Figure 5.2. **The final design of the disposal cell was modified slightly in order to accommodate an additional 263,810 cubic yards of contaminated materials. This modification increased the height of the embankment by 3.6 feet.**

Relocation of the tailings from the processing site was by truck, primarily along the Fremont Lumber Company logging road. On-site access roads were constructed as needed at both sites. The trucks drove directly from the Lakeview processing site into the excavated area and spread their loads for compaction. Details are provided in Section 5.6.1. Excavated areas at the Lakeview processing site were backfilled and graded to promote drainage.

At least one source for each required construction material was identified; however, it is recognized that the construction subcontractor may select material from other sources. The fine-grained soils required for the radon barrier, the geochemical/flow barrier liner, and fine-grained fill material were obtained from the disposal site excavation. Sources of rock for erosion protection material have been identified at commercial quarries in Deadman's Canyon, near Lakeview.

5.3 DESIGN OBJECTIVES

The principal objective of this remedial action is to design control measures which meet EPA standards. These standards include specific limitations for the disposal site on the release of radon, [] limitations on the release of radiation from radium and radon daughter products, and the protection of groundwater beneath the Collins Ranch disposal site. There is also the requirement for long-term stabilization that stipulates controls will be effective for up to 1000 years, and for at least 200 years. At the processing site, radiation and radioactive contaminants must be removed until sufficiently low levels are achieved. Applicable requirements of the city of Lakeview, Lake County, the Oregon Department of Energy, and other involved state and Federal agencies were adhered to during construction. These requirements are included in Appendix A, Regulatory Compliance.

The purpose of remedial action and adherence to standards during this effort is to ensure protection of the local environment. The public must be protected both during and after remedial action from unsafe levels of radiation. The quality of surface water and groundwater must not be adversely affected by discharges from the site. The remedial action must provide assurance of long-term stabilization of the site

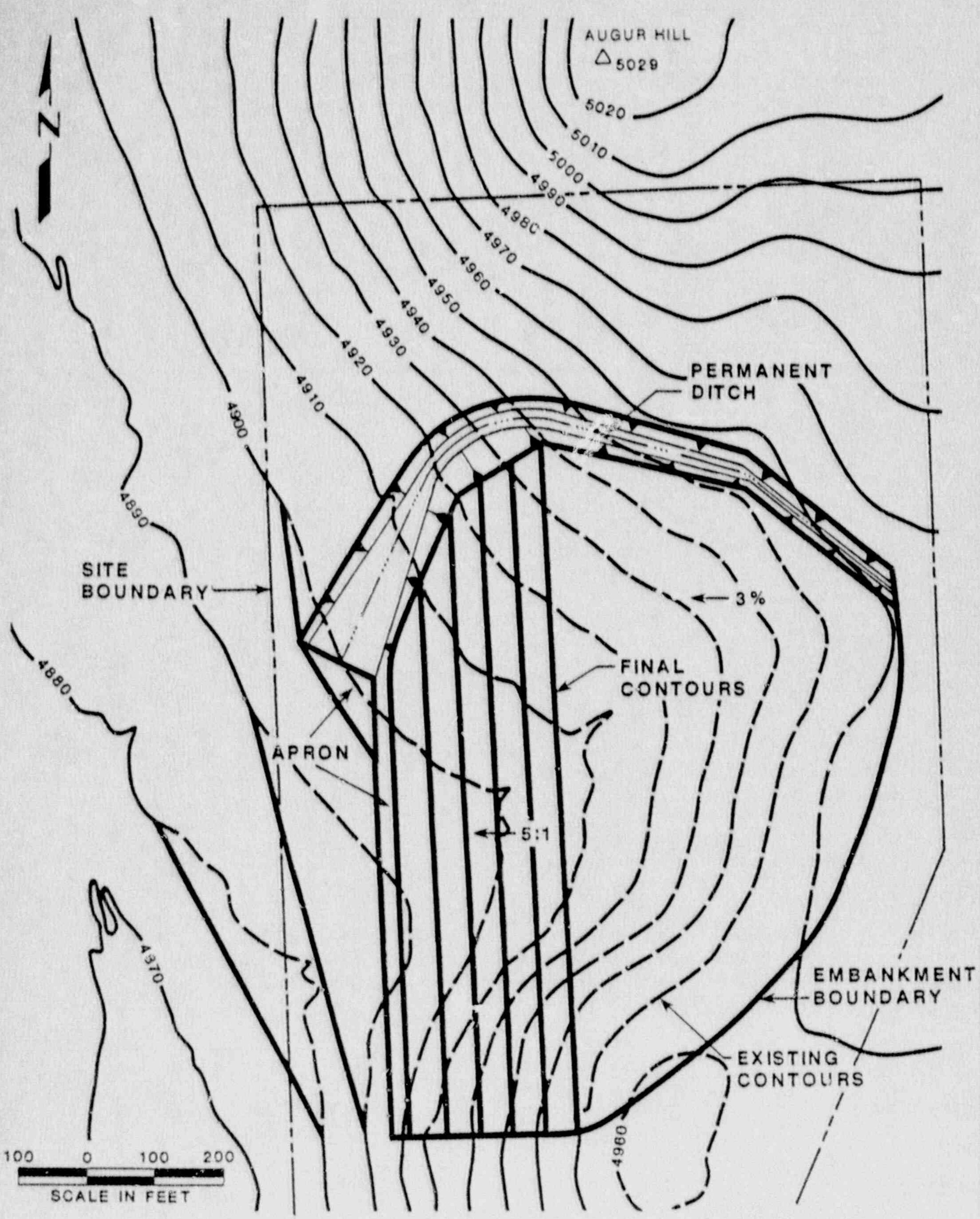


FIGURE 5.2
FINAL CONDITION - COLLINS RANCH DISPOSAL SITE

primarily by ensuring erosion control, flood protection, and earthquake stability. Inconveniences and increased hazards to the local public were minimized by considering working schedules and construction vehicle routes. The sites were fenced during construction to prevent public access and the completed Collins Ranch disposal site will have custodial surveillance and maintenance to assure continued long-term compliance with EPA standards once construction of the remedial action is completed.

The following major design objectives were established:

- o Relocate the contaminated material to the Collins Ranch site, which is in a less populated and more environmentally stable location than the processing site.
- o Reduce the average radon flux from the tailings disposal embankment to the atmosphere to levels less than 20 pCi/m^{2}s.
- o Design controls at the embankment to be effective for up to 1000 years, and at least 200 years, with minimum maintenance.
- o Minimize inadvertent human or animal intrusion into the disposal site.
- o Ensure that existing or anticipated beneficial uses of ground and surface water are not adversely affected by the stabilized tailings.
- o Reduce contaminant levels at and around the Lakeview processing site to levels which do not exceed 5.0 pCi/g of Ra-226 above background in the top 15 cm of soil and do not exceed 15 pCi/g in any 15-cm layer below that depth.
- o Minimize the land area of the final disposal area.
- o Protect against releases of contaminants from the site during construction through runoff and sediment control.
- o Minimize areas disturbed during construction and minimize exposure of workers and the general public to contaminated materials.
- o Release the entire Lakeview processing site for unrestricted use by private or public entities consistent with Lake County zoning ordinances.

5.4 DESIGN FEATURES

The remedial action [ ] stabilizes the uranium mill tailings and contaminated material at the Collins Ranch disposal site in a manner that complies with EPA standards. Detailed engineering design plans and construction specifications [ ] provided the basis for final cost estimates and for the award and execution of construction contracts. The permanent and temporary construction design features, including the rationale for the results of the design, are discussed in this section. The calculations summaries in Appendix B provide detailed support for the design rationale.

The principal feature of the design is the removal of contaminated materials from the Lakeview processing site and consolidation of the tailings and contaminated soils into a disposal embankment at the Collins Ranch site. The major construction activities for the proposed action are listed below.

- Preparation of both sites, and construction of wastewater retention basins at both sites to protect against release of contaminants. Temporary security fencing was installed at both sites.
- Construction of drainage control measures to direct generated wastewater and storm water runoff to the retention basins during construction activities.
- Installation of groundwater monitor wells at the Collins Ranch site.
- Re-routing of Hammersley Creek to flow east and then south of the existing tailings pile as necessary to keep water out of the construction area, and relocation of uncontaminated wood chips from the raffinate pond to a clean area on the site.
- Installation of measures to control erosion and sedimentation from disturbed areas during construction if required.
- Protection of surface and subsurface utilities at the Lakeview processing site during construction.
- Where required, upgrading of the haul road, [ ] the Fremont Lumber Company logging road, from northwest of the processing site to the north side of Augur Hill.
- Construction of on-site access roads to the haul road at the processing site and the disposal site.
- Excavation of materials at the Collins Ranch site and preparation of the geochemical/flow barrier liner.
- Excavation and loading of tailings and other contaminated material into trucks and transport to the disposal site.
- Construction of the tailings embankment at the Collins Ranch disposal site.
- Construction of the final cover system over the tailings to inhibit water infiltration, radon emanation, and wind and water erosion.
- Restoration of the excavated areas at the Lakeview processing site.

- Revegetation of disturbed areas at the Lakeview processing site and of the topslope of the completed tailings embankment and disturbed areas at the Collins Ranch site.

- Installation of warning signs at the Collins Ranch site to prevent inadvertent human intrusion and discourage unauthorized alteration of the site.

5.5 PERMANENT DESIGN FEATURES

5.5.1 Layout

The tailings embankment at the Collins Ranch site was sized to contain approximately **925,810** cubic yards of contaminated material and **covers** approximately 13 acres. **The height of the tailings pile design was increased by 3.6 feet to accommodate the additional cubic yards of contamination.** The embankment is built against the southwest slope of Augur Hill. A drainage ditch will direct runoff water away from the site (Figure 5.2). The site is approximately seven miles northwest of Lakeview, Oregon. The northern edge of the embankment is approximately 0.75 mile south of the Forest Service road at the north line of Section 12. **(See Figure 5.3.)**

5.5.2 Decontamination and restoration

The mill area, tailings pile, and evaporation ponds area of the Lakeview processing site were decontaminated by excavation of the contaminated soil, [ ] demolition of some small foundations, and consolidation of this material into the stabilized embankment at the Collins Ranch disposal site. All uncontaminated wood chips, which are located in the evaporation ponds area, were relocated to a clean area **on Precision Pine Lumber Company property**. The contaminated wood chips were placed in the embankment; however, the amount was limited and evenly distributed so that no more than five percent organics by volume are contained in any area of the pile.

The evaporation ponds area contained 1.0 to 1.5 feet of contaminated soil. Contamination below the tailings pile averaged two feet below the tailings-subbase interface. The contaminated materials to be consolidated in the embankment are discussed in greater detail in Appendix B, Calculation Summaries.

During processing site preparation, Hammersley Creek, which flows north of the existing tailings pile, was rerouted to a channel east and south of the tailings pile. After the remedial action has been completed, Hammersley Creek will remain in the relocation channel. The completed channel was designed to contain the flow resulting from a 10-year storm event; however, the channel will never flow at its design discharge because the

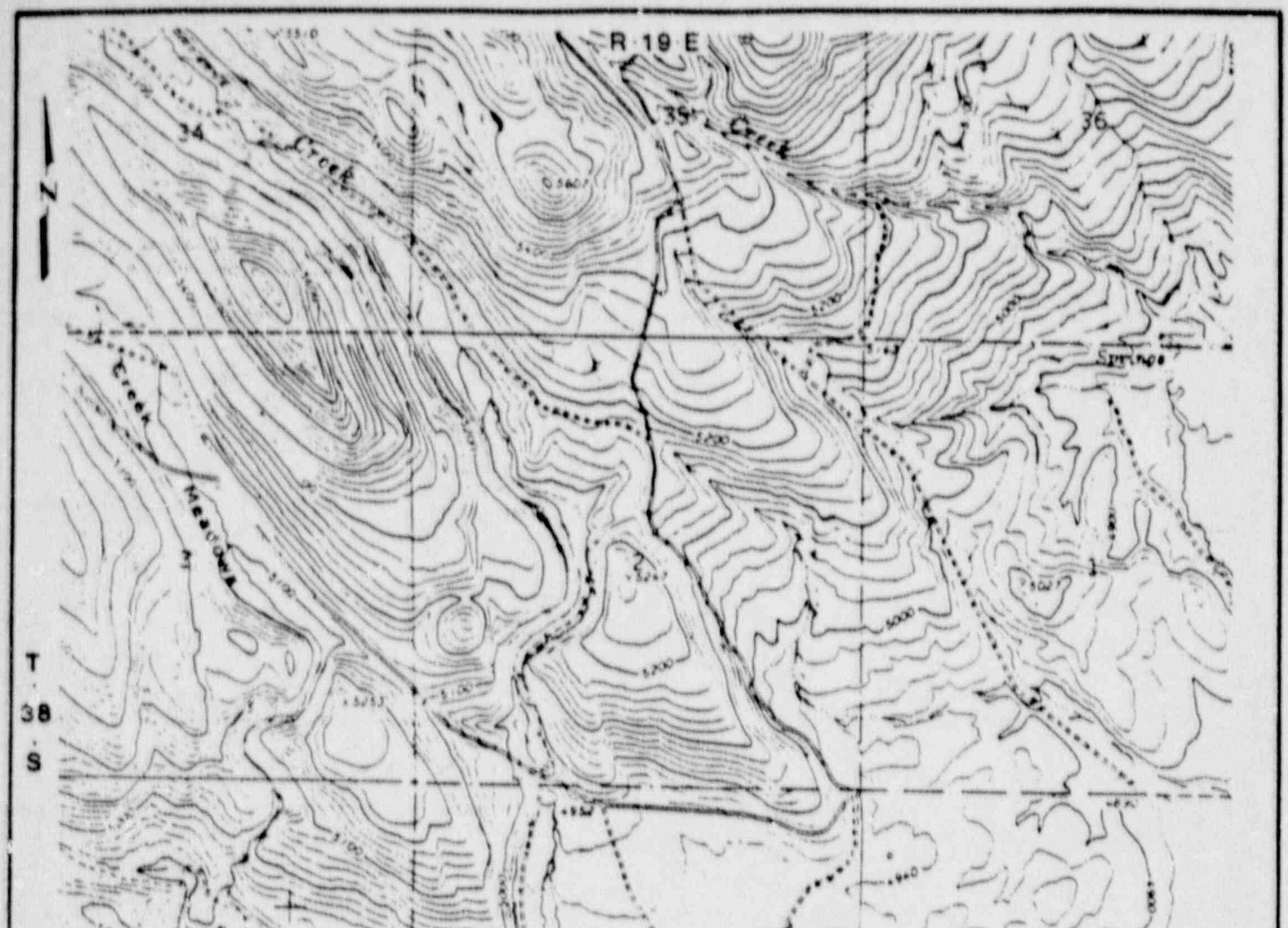


FIGURE 5.3

COLLINS RANCH DISPOSAL SITE

culvert beneath the road east of the site will constrict the flow in the channel to much less than the design flow. There is virtually no possibility for the relocated creek channel to migrate or meander since erosion protection in the channel has been designed for the 10-year event. Therefore, the relocation is considered to be permanent. The rerouting is shown in Figure 5.4.

After removal of all contaminated material, the areas of excavation on and around the Lakeview site were backfilled with uncontaminated fill and contoured as required for site drainage.

The design for the backfill at the Lakeview processing site was modified due to the additional contaminated materials encountered during remedial action and the availability of smaller quantities of clean fill than expected at the processing site. The DOE proposed to the owners of the processing site that the finished grade be reduced by six to 12 inches, thereby reducing the required backfill volume by approximately 150,000 cubic yards. The owners of the processing site agreed to this modification. However, it was still necessary to excavate and haul approximately 287,000 cubic yards of additional backfill materials from nearby borrow sources.

5.5.3 Embankment construction

The embankment was designed to contain approximately 925,810 cubic yards of contaminated materials from the Lakeview processing site and vicinity properties, to provide long-term stability, and to ensure adequate radon control. The embankment is located to most effectively use the natural topography of the area in order to reduce the potential effects of erosion.

Relocated tailings were placed in lifts and compacted on top of a geochemical/flow barrier liner constructed of select, in situ soils from the site. This layer reduces the amount and rate of possible contaminant migration towards the groundwater table. The groundwater table is approximately 30 feet below the tailings at its closest point, depending on seasonal fluctuations [ ]. Because the tailings were incidentally mixed during excavation and again during the unloading, spreading, and compacting at the Collins Ranch disposal site, extensive lenses of slimes did not exist in the compacted tailings. Consequently, differential and total settlement will not adversely affect the long-term integrity of the embankment. Detrimental settlements will not occur in the foundation, due to the overconsolidated nature of the soils there.

Once placement of the tailings was completed, contaminated soil from the evaporation ponds and windblown areas was placed in lifts and compacted on top of the relocated tailings.

Organic materials such as wood demolition debris and grubbed vegetation was evenly distributed throughout the embankment so that no more than five percent organics by volume are contained in

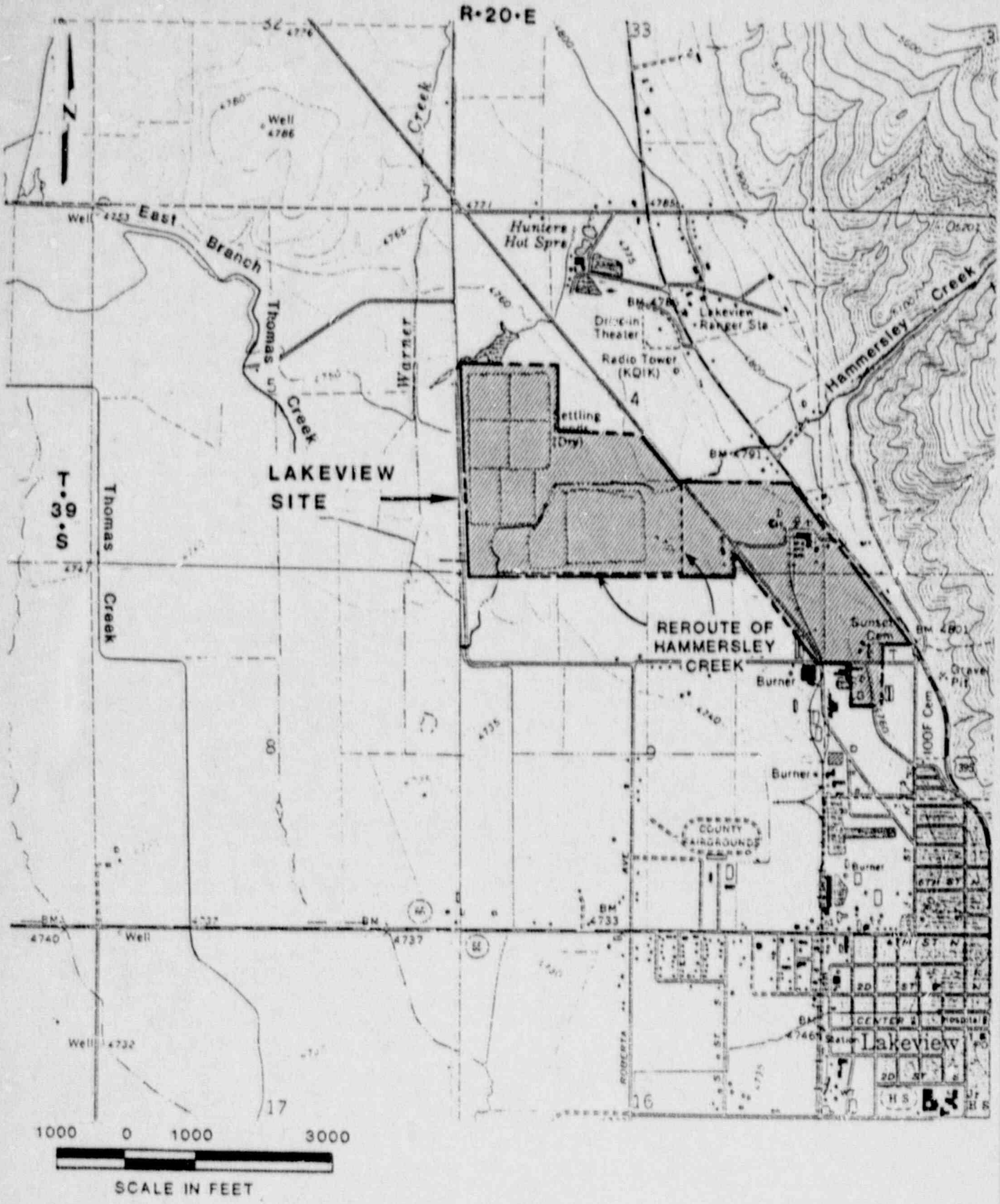


FIGURE 5.4
LAKEVIEW SITE MAP

any area of the pile. Rubble pieces were placed in the lower portions of the embankment and surrounded with compacted tailings. The procedures for this activity were specified to ensure the material was placed to avoid concentration in any area and to ensure good compaction of material around the rubble. The soil excavated from the evaporation ponds, windblown areas, and other areas of lesser contamination was the last contaminated materials placed in the embankment, in order to help reduce the overall radiation levels. Site preparation details and embankment compaction criteria are presented in the Project Site Design Criteria (DOE, 1984a) and Appendix B, Calculation Summaries.

Limiting the embankment topslopes to a two to four percent grade and the sideslopes to a 20 percent grade will provide the necessary factor of safety against embankment slope failure and will reduce the potential effects of erosion. A typical section of the embankment is presented in Figure 5.5.

5.5.4 Cover construction

The [ ] radon emanation rate will be reduced to EPA standards by the layer of less-contaminated soils over the tailings, topped by a compacted 1.5 foot thick radon barrier layer of uncontaminated silt and clay. The radon barrier thickness was based on information obtained during construction to provide the optimum design. **The actual test data on the radon barrier are available for this report and included in Appendix B, Calculation Summaries.** The materials [ ] in the upper portion of the tailings embankment are materials from the windblown areas and the evaporation ponds. These materials show average contamination of about 16 pCi/g Ra-226. The construction sequence [ ] specified [ ] that the less contaminated materials would be placed over the more contaminated tailings to reduce the radon exhalation. The compaction of the radon barrier layer [ ] produced a barrier that also retains moisture and lessens infiltration.

The radon barrier is protected by a one-foot-thick layer of rock and a six-inch **highly conductive sand filter/drainage** layer on all sides, and a rock-soil matrix on the topslope (two to four percent). The rock layer is designed to protect the radon barrier from erosion for 1000 years and thus prevent exposure of contaminated materials. The rock and rock-soil matrix cover will increase the long-term soil moisture content of the compacted radon barrier. The rock cover will also prevent erosion due to wind and water on or adjacent to the pile. **The highly conductive sand filter/drainage layer will** protect the fine-grained soils of the radon barrier from piping and erosion **and at the same time will provide a means of shedding water from the pile surface quickly.**

The rock erosion protection material is designed to withstand the occurrence of the Probable Maximum Precipitation (PMP). A PMP is defined as the maximum precipitation that could occur from the

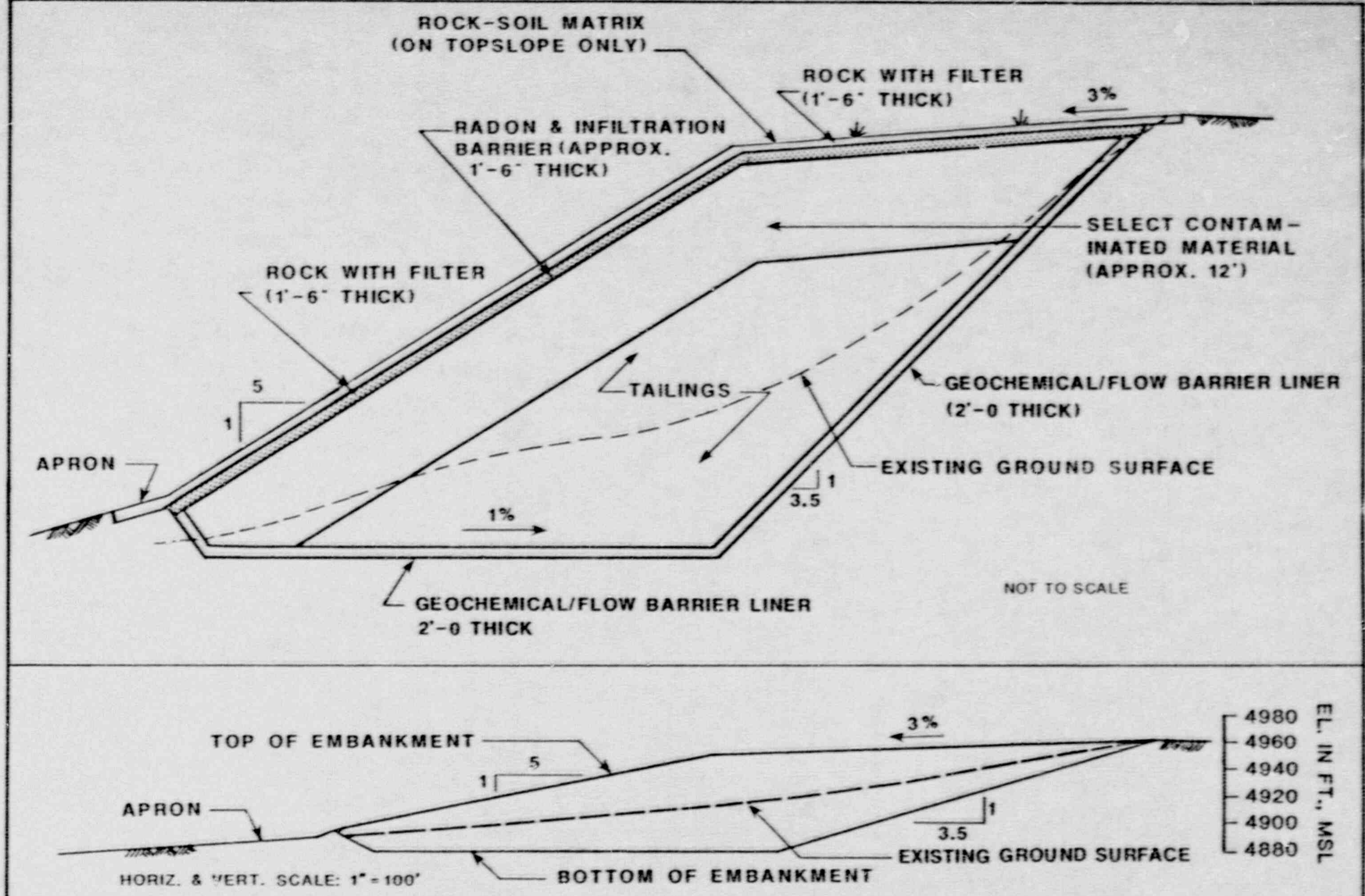


FIGURE 5.5 COLLINS RANCH DISPOSAL SITE TYPICAL CROSS SECTION

most severe combination of meteorological conditions that are reasonably possible in a region. For the Collins Ranch area, the local one-hour PMP storm is 8.4 inches. Based on this one-hour intensity, the maximum (2.5 minute) intensity was calculated. This 2.5 minute intensity was converted to an equivalent one-hour rainfall intensity of 39.6 inches per hour, which was then used for sizing [ ] the topslope erosion protection material. An intensity of 30.6 inches per hour was required to size the side-slope erosion protection material. A one-foot-thick erosion protection layer of 1.5-inches (or larger) mean diameter rock on the topslopes (two to four percent) and a one-foot-thick layer of 2.7-inch (or larger) mean diameter rock along the sideslopes (20 percent) will protect the embankment from the effects of a PMP. (See Appendix B, Calculation Summaries [ ].)

The rock layer will also protect the embankment from wind erosion and will discourage burrowing animals. The completed embankment topslopes will be covered with a rock-soil matrix and revegetated with native grass species. Slopes steeper than 10 percent are subject to high erosion stresses, which lead to rill and gully erosion (DOE, 1985e).

The rock layer has proven to be the most difficult design issue to resolve. During the pre-construction investigation in December 1985, the DOE identified the Matchett Quarry as an acceptable rock source for erosion protection materials. Specifications based on limited sampling of the area established criteria for specific gravity, absorption, sodium sulfate soundness, and L.A. abrasion limits. The contract specifications were written allowing the use of other rock sources, as long as the source met the original requirements.

In June 1986, the remedial action subcontractor elected to use the Pepperling Quarry for erosion protection materials. Based on test results from pre-production sample analysis, use of the Pepperling Quarry was approved. Production samples gathered in March 1987 on the stockpiled riprap and bedding materials showed some failing tests due to geological variation in the ore body not revealed during pre-production testing.

During this time period, an erosion protection working group was established to examine the rock issue for erosion protection for all UMTRA Project sites. Composed of representatives from the NRC, DOE, and their major subcontractors, this working group established a scoring system and procedure for oversizing and overthickening of the rock to insure the stability of the UMTRA Project tailings piles in areas with marginally suitable rock and provide an alternative to meeting the project design criteria of 1,000 years. Procedures developed by this working group were published by the NRC as part of the NUREG guidelines (Nelson et al., 1986).

As a result of the problems with the stockpiled Pepperling Quarry materials, the DOE, Oregon Department of Energy, and NRC met to evaluate the produced rock. Following a thorough sampling and testing program, and in consideration of the NUREG guidelines, all parties agreed to a one-time modification to the rock specifications for Lakeview for the stockpiled rock. This included oversizing, overthickening, and modifying the durability of certain riprap types. Specifically, Type "D" riprap was oversized and overthickened, Type "C" was overthickened, Type "B" changed in gradation, and there was no change in Type "A" sizing. Durability specifications were modified for absorption, sodium sulfate soundness, and L.A. abrasion tests.

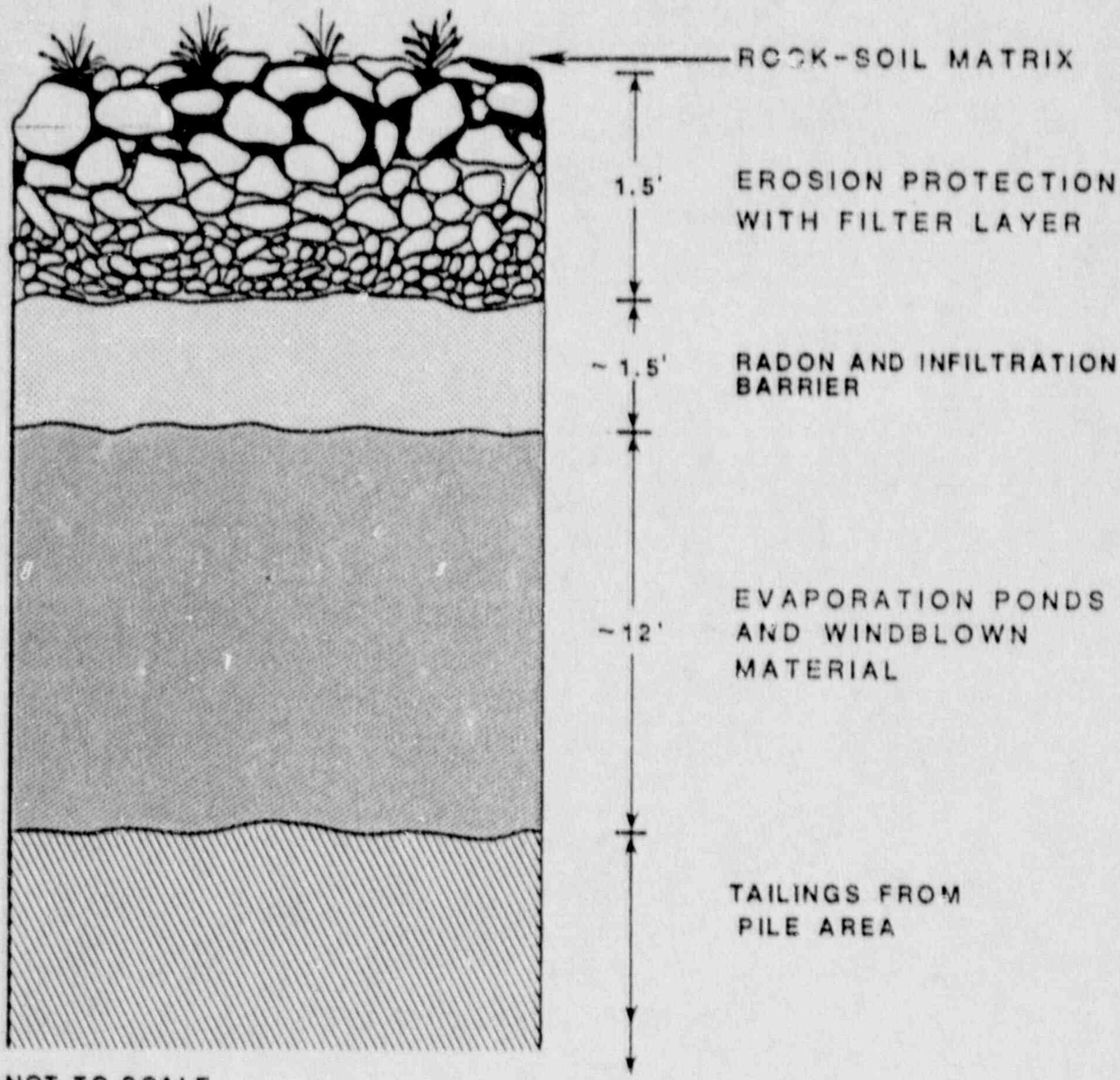
Further efforts by the subcontractor to produce good quality rock from the Pepperling Quarry in June 1988 also failed in attempts to meet the original specifications. Investigation into identifying rock sources that could meet the original specifications showed that the nearest location for such a source was the Choate Quarry, near Bend, Oregon, 145 miles northwest of Lakeview. Following extensive discussions between the DOE, Oregon Department of Energy, and the NRC, rock from the Choate Quarry was determined to be not "reasonably available."

The final agreement reached was to permit utilization of the rock scoring criteria presented in the NRC NUREG guidelines. This allows the rock to be scored qualitatively for riprap types B, C and D. The minimum score is set at 75. Additional oversizing is not necessary. Further details may be found in Appendix E, Final Plans and Specifications.

A rock-soil matrix, a combination of vegetation and surface rock, will be used to cover the completed topslopes rather than vegetated topsoil. A topsoil cover would increase the potential for gully formation and flow concentrations, thereby requiring larger mean diameter rock for erosion protection [ ] on the embankment slopes and at its base. The rock-soil matrix will be capable of supporting vegetation similar to that [ ] found in the Collins Ranch area and at the same time protect against erosion. The rock-soil matrix will not be used on the sideslopes. Figure 5.6 illustrates the embankment cover system for the embankment topslopes (see Appendix B, Calculation Summaries).

5.5.5 Site drainage

The drainage features of the embankment, along with general site grading, will ensure long-term embankment stability. The embankment sideslopes [ ] blend into the natural slopes south of Augur Hill. Runoff from the embankment will flow to the apron and then to the adjacent natural ground, modififed by grading to inhibit formation of gullies, and then to the natural drainage patterns southwest of the site. Runoff from Augur Hill will be intercepted by a drainage ditch located adjacent to the embankment and directed to the natural drainage patterns southeast of the site. The ditches [ ] have depths sufficient to carry the runoff



NOT TO SCALE

FIGURE 5.6

COLLINS RANCH COVER SYSTEM-TOPSLOPES

from the PMP storm event (see Section 5.5.7 and Appendix B, Calculation Summaries [ ]). Rock erosion protection in the ditches will prevent erosion of the adjacent embankment cover (see Appendix B for pertinent calculations). Sediment buildup in the ditches will be flushed during significant precipitation events, which will create velocities capable of moving sediment.

The exposure of two seeps along the north wall of the disposal cell during excavation resulted in the need to provide a drainage system for any potential water exiting these areas. A subsurface drain system was installed to carry any potential seep water away from the tailings and channel such water around the northern perimeter of the cell. A series of monitor wells will be installed above the drainage system to monitor any accumulation of water in the seep area. These wells will be monitored for water quantity only.

5.5.6 Groundwater protection

An unconfined to semi-confined groundwater system has been identified in the Collins Ranch disposal site area. The groundwater exists in a series of silty fine sands and clayey silts to an estimated depth of 1000 feet. Depth to water ranges from at least 20 to 30 feet below the proposed base of the tailings. The groundwater moves from northwest to south-southeast beneath the site, counter to the topographic slope, with depths to groundwater increasing towards the divide of Augur Hill. This indicates that predominant recharge to the groundwater system is from the Fremont Mountains to the west, rather than through the on-site soils. Details of existing groundwater quality and calculated hydraulic parameters are discussed in Appendix B, Calculation Summaries.

Three major design features that serve to mitigate potential groundwater contamination at the Collins Ranch site are placement of a geochemical/flow barrier liner on the sides and below the tailings; installation of a compacted radon/infiltration barrier above the tailings, and the inclusion of a high conductivity sand filter/drainage layer placed on top of the radon barrier.

The high conductivity sand filter/drainage layer is composed of clean sand and gravel with a hydraulic conductivity of 1.0 cm/s or greater. Bedding thickness will be increased to require a minimum thickness of at least six inches instead of 90 percent of six inches. This will allow for rapid shedding of water off the tailings pile.

The radon barrier will be less permeable than the liner [ ] by compacting the radon barrier to a higher density than the liner at the base of the tailings; this will avoid the possibility of a "bathtub" effect. The low permeability (hydraulic conductivity) of the soils in the radon barrier will reduce seepage of water below the tailings pile and cause a uniform seepage front. Laboratory analyses of recompacted soils taken from test pits at the site indicate that the permeability (hydraulic conductivity) of the soils in the compacted earth cover will be less than 1 x 10^{-7} cm/s. Thus, infiltration, the driving force for leachate production, and mobilization of contaminants into the groundwater system will be minimal.

The liner placed underneath the tailings and the radon barrier are composed of natural recompacted silt and clay soils (ML, MH, and CL designations in the Unified Soil Classification System). These types of soils have high neutralization, adsorpion, and ion exchange potential and thus [ ] provide a high attenuative capacity to restrict downward contaminant migration through the liner. **Together, the filter layer, radon/infiltration barrier and geochemical/flow barrier will provide adequate groundwater protection to comply with the proposed EPA groundwater standards.**

Presently, the depth to groundwater is greater than 50 feet beneath most of the existing ground surface at the disposal site; depths decrease at the toe of the excavated embankment on the edge of the valley. Water-level fluctuations from the autumn of 1984 to the summer of 1985 were less than two feet. The minumum depth to groundwater will be about 20 feet below the geochemical/flow barrier liner. Groundwater monitoring will be performed after construction to verify that unacceptable groundwater contamination does not occur.

5.5.7 Flood protection

Cross-drainage runoff at the Collins Ranch disposal site would result from the collection of runoff due to precipitation over the 29-acre drainage area above and including the site. A permanent drainage ditch will be constructed with depths capable of carrying the runoff resulting from a PMP [ ] event. The PMP runoff discharge for the ditch adjacent to the north edge of the embankment is 230 **cubic feet per second**. Erosion protection in the ditch and on the embankment is designed to remain intact during and following the unlikely occurrence of a PMP (calculations and summaries are given in Appendix B [ ]).

The protection described above will prevent any possible flooding of the tailings site. Flooding from the drainage area northwest of the site is estimated to produce flows that will not reach the toe of the embankment.

5.5.8 Site access

After remedial action is complete, access for custodial inspection purposes will be provided by an easement to the site.

5.6 CONSTRUCTION FEATURES

5.6.1 Layout

Construction activities occurred at the processing and disposal sites and along the haul road, where required.

The Remedial Action Contractor (RAC) was responsible for determining the exact location and size of all construction features such as the staging areas, decontamination facilities, temporary drainage ditches, and wastewater retention basins. The following paragraphs present the general layout to allow a better understanding of all aspects of the remedial action.

At the processing site, the staging area was northeast of the tailings pile. An equipment decontamination pad was located adjacent to the staging area. Hammersley Creek, which flows just north of the present tailings pile, was relocated to flow east of the pile and then south of the designated site boundary. Ditches or berms surrounding the site directed uncontaminated water flows to Hammersley Creek. Contaminated water was directed to a wastewater retention basin constructed on the site. A temporary fence isolated the staging area and the entire site.

At the Collins Ranch disposal site, the staging area and the decontamination pad were located in the southwest corner of the site. Drainage ditches surrounded the site and collected all runoff on the site and any water collected from excavation dewatering (if necessary). Flow in these ditches was channeled to a wastewater retention basin, located west of the embankment area. Temporary fences enclosed the entire site, the staging area, and the lease area. A stockpile area was located west of the embankment, and was used for stockpiling materials from the excavation.

5.6.2 Site access

Equipment was decontaminated as required prior to leaving the Lakeview processing site and the tailings embankment area at the Collins Ranch disposal site. The temporary fences [ ] controlled traffic entering and leaving the site and prevented unauthorized traffic from entering controlled areas.

5.6.3 Staging area facilities

During construction operations, temporary facilities were required for construction workers along with supervisory, engineering, administrative, security, and radiation monitoring personnel. The facilities consisted of office space, showers, and change facilities for personnel decontamination (if necessary), and included provisions for laundering contaminated clothing. Portable construction toilets were provided for on-site workers. On-site equipment was stored in the staging areas.

5.6.4 Utilities

All known existing utilities at the Lakeview site, as shown in Figure 5.7, were protected during construction or were relocated as necessary prior to construction.

Potable water for personnel needs at the processing site and the disposal site and a source of construction water for both sites were provided by the RAC or its construction subcontractor, as necessary.

No electricity, gas, or other utilities are available at the Collins Ranch disposal site. Electricity was supplied by running power lines and by generators. Telephone service was provided.

There is no developed water supply at the disposal site. Water for equipment decontamination, compaction, and dust control on the site was developed from an on-site well [ ]. A holding pond was developed to store water. Potable water was hauled from the nearest available source.

5.6.5 Drainage, erosion control, and wastewater retention basin

During remedial action, all drainage from both sites was effectively diverted from any waterways. Areas disturbed by construction activities were graded [ ] to direct runoff to the wastewater retention basins. [ ] In addition, the ditches were designed and maintained to carry the peak flow due to the 10-year one-hour storm event, for the area tributary to the channel. Runoff from land outside of affected areas was diverted away from the site by diversion ditches designed and maintained to prevent overflow from the peak flow due to the 10-year one-hour storm event (see Appendix B, Calculation Summaries [ ]).

The wastewater retention basins received waters resulting from:

- o Runoff from contaminated materials (potentially the greatest source of water) and disturbed areas.
- o Decontamination activities, including equipment and truck washdown.
- o Wastewater from laundering protective clothing and shower and wash basin wastewater generated from occasional personnel decontamination.
- o Processing site dewatering effluent (if contaminated).

The retention basins at both sites were designed to retain the runoff from a 10-year 24-hour storm as well as the wash water from the decontamination operations and site dewatering. The

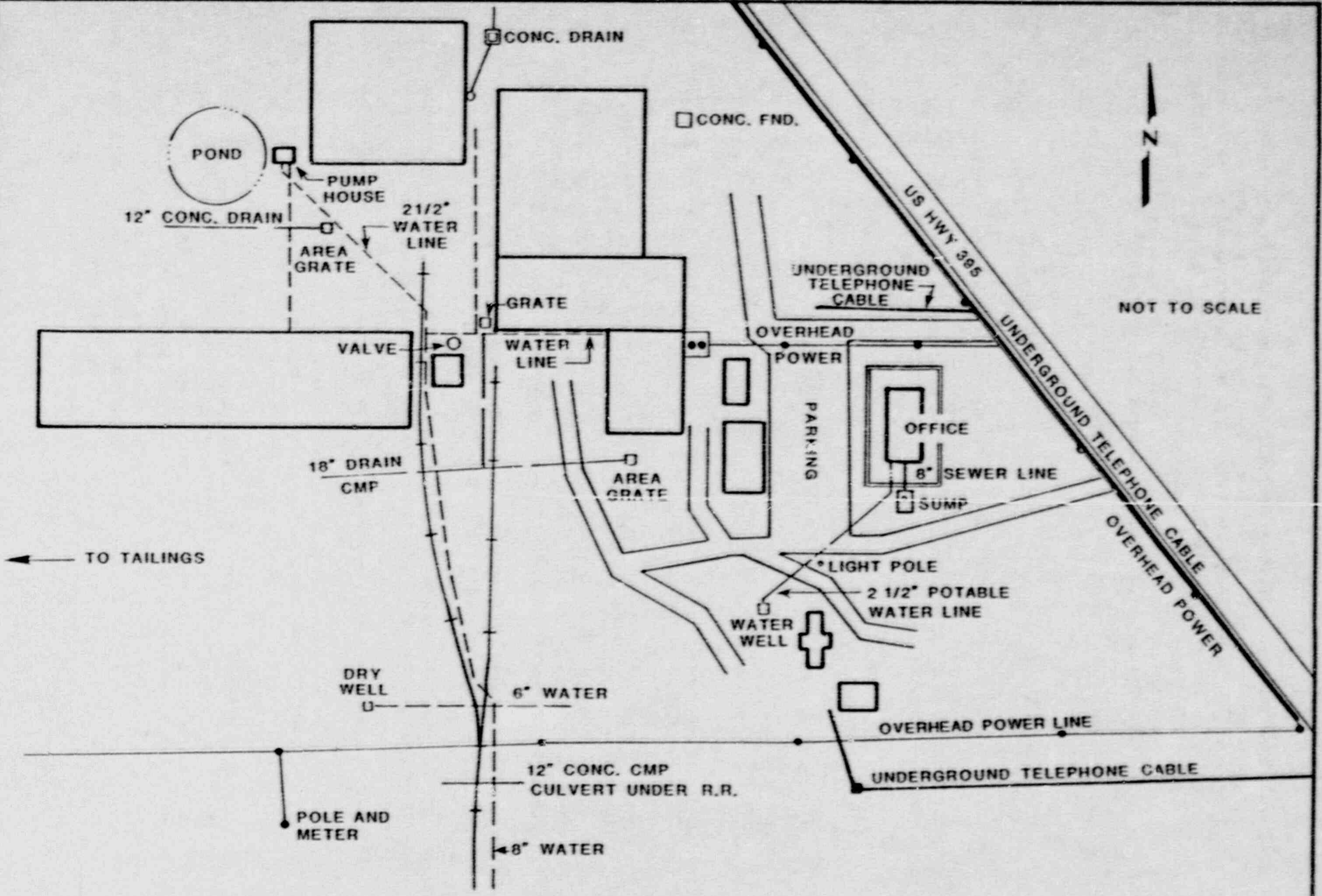


FIGURE 5.7
LOCATION OF EXISTING UTILITIES-LAKEVIEW SITE

retention basins additionally had sufficient capacity to hold all sediment inflow over the life of the project without any need for removal. The emergency outlets from the basins were designed to safely discharge the one-hour, 25-year storm peak runoff while maintaining one foot of freeboard or as required by permit. The final location of the retention basins is shown on the final design drawings. Appendix B provides design criteria for these basins.

[ ]

5.6.6 Wastewater handling

Wastewater generated from sources listed in Section 5.6.5 was collected and handled to minimize the need for any discharge from the sites. Wastewater handling comprises the following major elements:

- o Settlement of sediment in wastewater in the retention basins.
- o Evaporation from the retention basins.
- o Construction water for moisture conditioning and dust control in contaminated areas.
- o Snowmelt runoff from the partially stabilized tailings pile at Collins Ranch.

Contaminated water was effectively treated using the means listed above. The number of retention basins was increased to contain all the sediment generated during construction as necessary. At the end of construction, contaminated sediment was added to the embankment at the Collins Ranch site. []

The retention basins are shaped to maximize evaporation by having as much surface area as practical. [ ]

If unusually wet conditions made an emergency discharge necessary, wastewater was tested prior to discharge. Under such conditions, it was considered unlikely that contaminant concentrations would be above acceptable levels due to the high amount of dilution that occurred. In the event unacceptable concentrations were encountered, the RAC specified measures to ensure that any discharge meets applicable standards. (See Appendix B, Calculation Summaries, for more details.)

The original design for a wastewater retention basin at the disposal site had insufficient capacity to hold stormwater and snowmelt runoff during winter and spring seasons without release of water from the basin. This factor, along with an increased volume of water generated from the decontamination facility, required the installation of two additional wastewater retention basins, with a design capacity of five acre feet and 10 acre feet. Figure 5.8 shows the location of the two new retention basins.

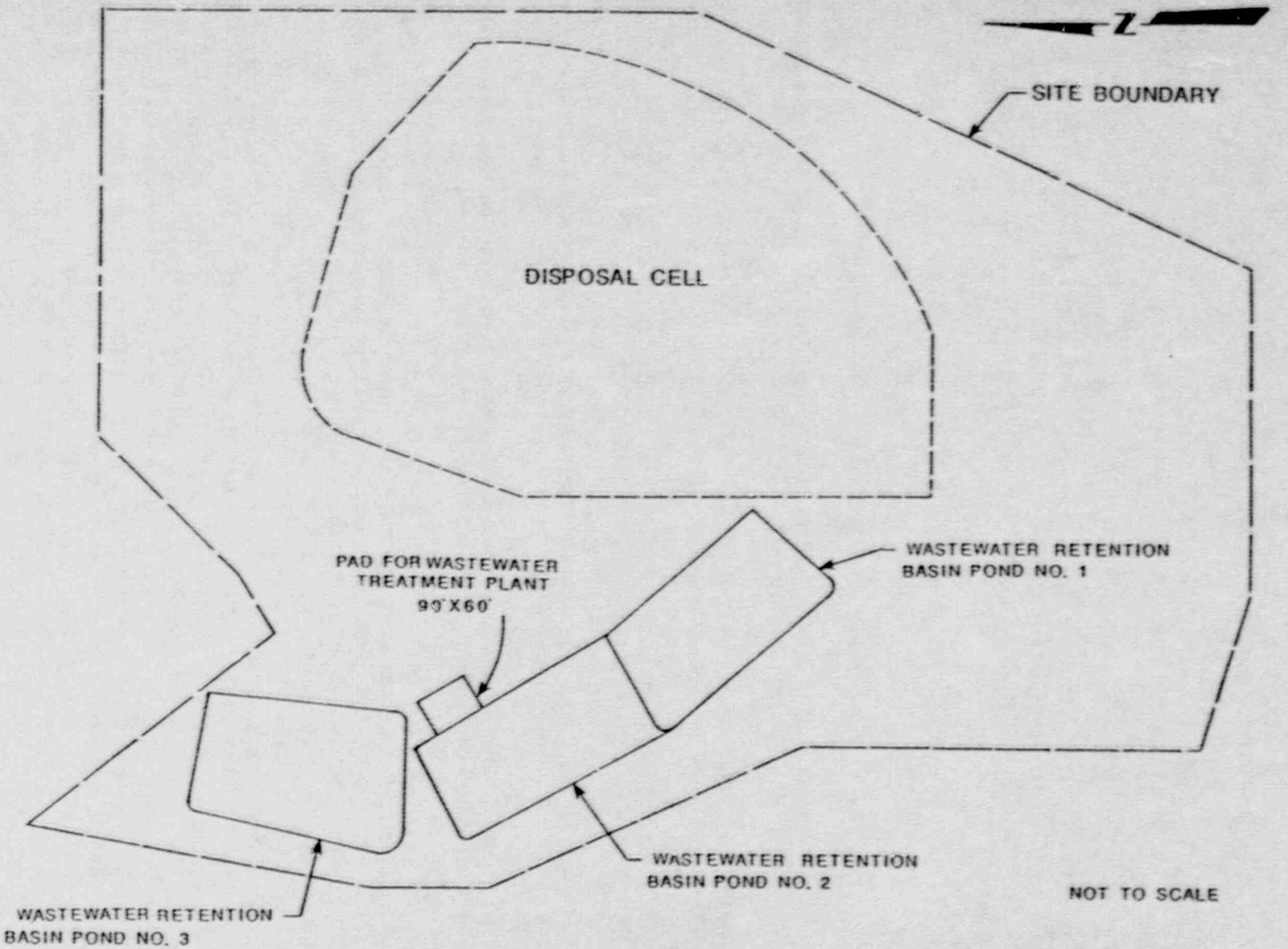


FIGURE 5.8
WASTEWATER RETENTION BASINS

Due to the additional water impounded at the Collins Ranch site, it was necessary to transport the former Canonsburg, Pennsylvania, wastewater treatment plant to Lakeview for water treatment. This chemical precipitation/membrane filtration system is capable of treating 160 gpm average with a peak capacity of 210 gpm. The location of the treatment plant is visible on Figure 5.8, adjacent to the middle evaporation pond (pond 2).

5.6.7 Dewatering

Groundwater at the Lakeview processing site is five to 15 feet below the ground surface and at times rises into the base of the tailings. The RAC encouraged the construction subcontractor to excavate deeper materials during drier portions of the year to minimize dewatering. A small volume of tailings was dried to a compactable moisture content.

[ ]

5.6.8 Equipment decontamination pad

Decontamination pads were provided to wash contaminated equipment and trucks at both the Lakeview processing site and Collins Ranch disposal sites, thereby preventing contaminated materials from being carried out of the areas. Ditches and sumps were used to direct washwater to the retention basins.

5.6.9 Dust control

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

The sources for dust suppression water in contaminated areas included recycled water from the wastewater retention basins, or water from tailings and subsoil dewatering. Uncontaminated water was used for the clean areas.

The schedules for spraying the roads and pile areas varied daily and were determined on an hour-by-hour basis. The frequency of spraying increased when combinations of low soil moisture and high wind speed are encountered.

In the event that extreme dust conditions occurred, specific controls were implemented to ensure that radioactive contamination was not dispersed into the general environment of the site.

The RAC Construction Safety and Health Management Program provides more restrictive controls as follows:

Section XIV - Environmental Control and Monitoring

A. Environmental control and monitoring are required to ensure that radioactive contamination, industrial toxics, or other hazardous materials do not disperse, by wind or water, into the general environment of the site. This may be accomplished as follows:

   1. Boundary dust collection discs and continuous air monitors will be an integral part of the RAC environmental control program. The dust collection discs will be monitored on a daily basis to track radioactive dust dispersion. Continuous air monitors will give monthly, quarterly, and annual results to monitor off-site dispersion of particulates. The RAC Environmental Assessment Manager will determine when particulates will be analyzed for gross alpha or when isotopic and elemental analyses are necessary.

   2. In the event that either of the above control monitors indicate an increase approaching unacceptable levels of radioactivity, subcontractors may be required to take the following action: reduce vehicle speeds, water dusty construction areas, and/or stop work for extreme weather conditions. The site Radiological Safety Officer (RSO) in conjunction with the site manager will determine when these measures will be necessary.

   3. Water monitoring is also required to ensure no significant degradation of potable water supplies during remedial action. Construction activities may require modification in the event that a contamination problem is indicated.

B. Noncompliance with the above requests will be resolved through the RAC DOE Albuquerque Project Office.

Additional site-specific controls will be developed and issued by the RAC prior to construction.

5.6.10 Borrow areas

Commercial quarries in Deadman's Canyon, near Lakeview, Oregon, are available that contain erosion protection and filter materials suitable for use on the embankment, ditch, and roads. Materials for radon barrier, geochemical/flow barrier liner, and site grading and restoration (at both sites) were obtained from the disposal site excavation.

5.6.11 Construction sequence

The following construction sequence represents the sequence for remedial action. The construction subcontractor was allowed the flexibility of executing his work as he chose, given certain constraints. Therefore, the actual construction sequence may have differed slightly from the following.

Initially, an access control system was established at each site and coordinated with staging and vehicle decontamination areas. A fence was installed around each site. This provided control of traffic entering and leaving each site and prevented unauthorized traffic from entering either site.

The next major item of site preparation consisted of constructing a wastewater retention basin at each site. Site preparation also included construction of drainage and erosion control measures. At the processing site, Hammersley Creek was re-routed to flow east and south of the existing pile and the uncontaminated on-site wood chips were relocated. Concurrent with these activities, construction of the access roads and any necessary upgrading of the haul road began.

Once the initial site preparation at the Collins Ranch site was completed, preparation of the disposal area began. This involved the excavation and stockpiling of surface materials to allow for the partially below-grade disposal of the tailings. Topsoil was excavated and stockpiled for use in the rock-soil matrix. After the required materials were excavated and acceptable materials were selected, the geochemical/flow barrier liner was constructed.

Concurrently, the building decontamination and demolition process (as necessary) was performed. Dewatering activities also began at this time. Tailings were excavated and moved, then contaminated materials were excavated from the windblown areas and evaporation ponds and consolidated into the disposal embankment. [ ] The movement of contaminated materials did not begin until upgrading of the haul and access roads was completed, and a sufficient area [ ] opened and prepared at the disposal area.

Uncontaminated cover materials were added to the relocated pile after the contaminated materials were in place. The uncontaminated fill was obtained from selected materials excavated from the disposal site area. Permanent drainage ditches were excavated adjacent to the stabilized tailings pile. Final closure of the embankment was not made until all contaminated materials have been placed, including those materials from demobilization activities. The embankment topslopes will be covered with a rock-soil matrix and revegetated. Signs and monuments will be placed around the site.

The final stages of restoration at the existing tailings site included providing overall site drainage, grading, and revegetation. Restoration involved the addition of uncontaminated fill to the excavated areas as required to meet EPA standards. Fill was also necessary to restore the excavated tailings area to provide drainage. The fill was obtained from the materials excavated from the Collins Ranch disposal site and other areas as necessary.

Demobilization consisted of the removal of the wastewater treatment plant, wastewater retention basins, and drainage ditches. Any contaminated water was treated and the bottom sediments and dikes were tested, and, if necessary, transported to Collins Ranch for disposal in the embankment. All decontamination areas were removed and the equipment cleaned for salvage. The staging areas were destroyed and contaminated items either cleaned or disposed of in the embankment. All contractor equipment was decontaminated and inspected prior to release from the contaminated areas. At the present time, all contaminated materials have been relocated to the Collins Ranch site.

5.7 BASIS FOR EXCAVATION

A radiological support plan (RSP) (see Appendix C) defines the monitoring surveys which were required at the processing site during excavation of contaminated materials. A final survey certified that applicable radiation standards were met following completion of construction. The DOE prepares this plan and has the responsibility for implementing the program. The following subsections describe the purpose of the RSP.

5.7.1 Radiological survey plan

Radiological surveys are performed for three purposes: site characterization, excavation control, and final radiological verification. Site characterization surveys or pre-remedial action surveys have been performed to identify volumes of material which exceed the EPA standards. The results have been used for planning and engineering design purposes. Excavation control monitoring is necessary as the work is being done to guide and control the amount of contaminated material to be removed. Finally, when the excavation control monitoring results indicate that the area meets the standards, a final radiological survey will be carefully performed to assure compliance with the cleanup criteria and the results will be documented.

5.7.2 Certification

During the remedial action operations, the DOE made [ ] data related to the cleanup **available to appropriate Federal and state agencies**. In addition, samples could be split for analysis by these agencies to allow comparison of analytical results. These data, along with any additional data reflected at the discretion of the certifying agent, will be used for the final certification report.

After remedial action, the DOE will certify that remedial action has been completed according to the plan and final design, and the site meets applicable standards.

5.8 PROPOSED FINAL CONDITION

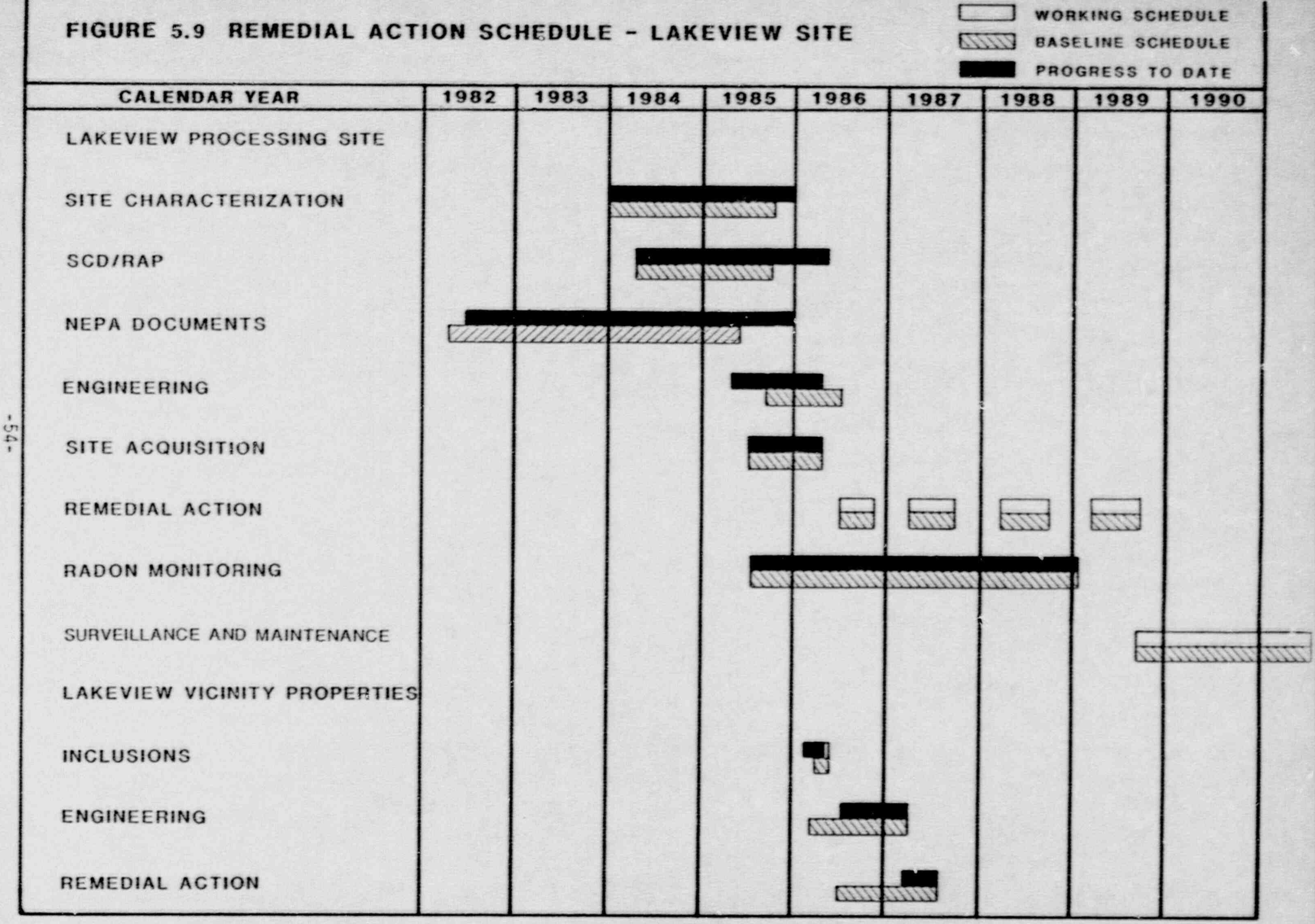
The completed tailings embankment will be partially below grade. The embankment will fit into the natural contours on the southwestern slopes of Augur Hill. The embankment will extend approximately 1060 feet at its longest section and 870 feet at its widest. From its base it will rise approximately 60 feet at a slope of 5 horizontal to 1 vertical; at this point it will be approximately 40 feet above the present ground surface. From this section it will rise at a two to four percent slope until it blends into the existing topography to the east and south. Tailings and contaminated material will be located below the present ground surface at depths varying up to 40 feet. The completed embankment will cover an area of approximately 13 acres. The embankment will be covered with one foot of rock to protect against erosion, and the topslope will be covered with a rock-soil matrix to support revegetation. Drainage channels adjacent to the embankment will divert off-site surface drainage away from the embankment. Monuments will be established at set intervals designating the embankment as Federal property.

5.9 SCHEDULE

Remedial action for the relocation option at the Lakeview processing site **began** in July 1986, and **was planned** to be completed in November 1987. **Due to an increase of contaminated materials and a problem with rock sources, completion of the Lakeview site remedial action is scheduled for August 1989.** [ ] Winter shut-down periods of 3 to 4 months have been required. Figure 5.9 is a graphical representation of the remedial action schedule. Times shown may be shorter or longer than actual due to work acceleration, funding constraints, and the like.

[]

FIGURE 5.9 REMEDIAL ACTION SCHEDULE - LAKEVIEW SITE



6.0 WATER RESOURCES PROTECTION STRATEGY

6.1 INTRODUCTION

This section summarizes the water resources protection strategy to achieve compliance with the proposed EPA groundwater protection standards at the Lakeview uranium mill tailings disposal site. A more detailed discussion is provided in Appendix F, Compliance Strategy for the Proposed EPA Groundwater Standards.

The proposed remedial action at the Lakeview uranium mill tailings site consisted of relocating the mill tailings and other contaminated materials seven road miles northwest to the Collins Ranch disposal site. There they were stabilized in a partially below-grade disposal cell which consists of a two-foot thick geochemical/flow barrier below the tailings, a low permeability radon barrier on top of the tailings, and a rock cover layer containing a highly conductive sand filter/drainage layer to allow the tailings pile to shed surface water quickly. The proposed disposal unit at the Collins Ranch site is designed to control residual radioactive materials and nonradioactive contaminants as required by the proposed EPA standards in 40 CFR Part 192(a)(3).

Testing of the background water quality data for those constituents that are part of the proposed EPA standards (52 FR 36,000) at the Collins Ranch site indicates that all constituents are below EPA standards. Tailings source concentrations have been measured from chemical analyses or pore fluids gathered from suction lysimeters placed in the Lakeview tailings pile and nearby evaporation ponds. A total of 26 samples were gathered and analyzed in this area.

Mean analytical values were obtained for all constituents of concern. Three constituents exceed the maximum concentration limits (MCLs) established by the proposed EPA groundwater standards. These are arsenic, cadmium, and uranium (U-234 and U-238). All constituents are within the MCL requirements in less than 50 feet and meet or exceed the MCL level at the point of compliance (POC), which is the downgradient edge of the tailings waste management unit. Appendix IX organics (40 CFR Part 264) were not detected in samples collected from two shallow monitor wells at the Lakeview processing site. Analytical test results are found in Appendix F.

6.2 PERFORMANCE ASSESSMENT

The performance evaluation to assess compliance of the disposal unit with the proposed EPA groundwater protection standards (by demonstrating MCLs are met) indicates that performance is primarily a function of the relative low concentrations of hazardous constituents in excess of the proposed EPA standards. Groundwater transport modeling utilized the method-of-characteristics (MOC) model developed by Konikow and Bredehoeft (1978) to represent lateral flow while the analytical procedure of Domenico and Robbins (1985) was used to estimate the distance required to effect mixing of leachate and groundwater through hydrodynamic dispersion. The results show attenuation of concentrations of all constituents to EPA MCLs within 50 feet of the edge of the tailings pile. Further details are presented in Appendix F.

6.3 PERFORMANCE MONITORING

A program to monitor groundwater quality in the uppermost aquifer downgradient from the Collins Ranch disposal site during the post-construction period will be addressed in the surveillance and maintenance plan prepared for the Collins Ranch site. At the point of compliance and downgradient from the cell, the DOE will install a ring of monitor wells (four to eight) to monitor groundwater quality and static water levels.

The exposure of two seeps along the north wall of the disposal cell during excavation resulted in the need to provide a drainage system for any potential water existing in these areas. A subsurface drainage system was installed to carry any potential seep water away from the tailings and channel such water around the northern perimeter of the cell. A series of monitor wells will be installed above the drainage system to monitor any accumulation of water in the seep area. These wells will be monitored for water quantity only. Each well location will consist of a nest of two wells to allow completion of the wells at two intervals. Estimated depths for these wells are 30 to 80 feet. Well locations are shown as Figure 6.1.

6.4 CORRECTIVE ACTION

Although failure of the disposal cell at the Collins Ranch site is not anticipated, periodic surveillance and maintenance inspections will be performed to monitor potential failure modes. Should a failure of the cell occur or if the site is found to be not in compliance with the applicable regulations following tailings stabilization corrective action plans shall be formulated and implemented within 18 months.

6.5 AQUIFER RESTORATION

The DOE has decided that aquifer restoration (groundwater cleanup) will be addressed under the next task of the UMTRA Project and be part of a separate National Environmental Policy Act (NEPA) process because the present level of site characterization is sufficient only to address whether the remedial action will comply with proposed EPA standards. Groundwater cleanup requires extensive geochemical characterization of residual wastes and a more intensive investigation of unsaturated flow and aquifer properties. A conceptual strategy must be developed, modeled, and/or tested on a benchmark scale if restoration is to take place. Realistic concentration limits and a cleanup standard could be proposed after this has been performed.

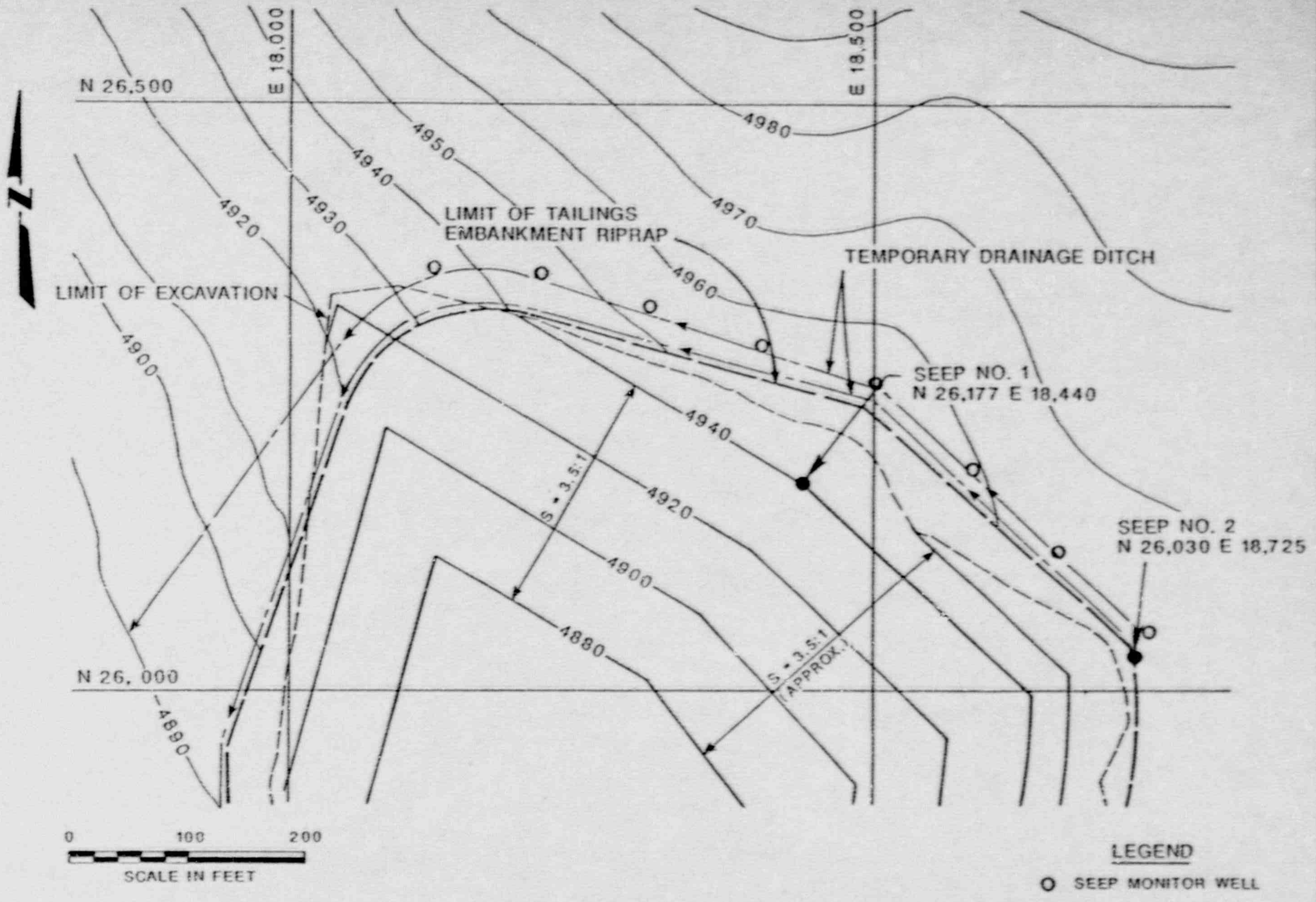


FIGURE 6.1

LOCATION OF SEEPS - COLLINS RANCH SITE

Aquifer restoration at the Lakeview processing site is not addressed in this remedial action plan because the contaminated materials were disposed of at the Collins Ranch site. For this reason, water quality impacts resulting from disposal of contaminated materials at Collins Ranch will have no impact on aquifer restoration at the Lakeview processing site. Hence, remedial action can be decoupled from aquifer restoration at the Lakeview site.

7.0 ENVIRONMENTAL, HEALTH, AND SAFETY

7.1 UMTRA PROJECT HEALTH AND SAFETY POLICY

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

7.2 ENVIRONMENTAL, HEALTH, AND SAFETY PLAN

The Environmental, Health, and Safety Plan, Appendix D, specifies the basic Federal safety and health standards and special state, local, and DOE requirements applicable to the remedial action at Lakeview. This section provides an overview of the plan and summarizes its key features. Responsibilities in carrying out this plan are delineated. Where not otherwise specified, the [] RAC will have the principal responsibility for implementing this plan. Guidance on program requirements and radiation control and monitoring is also included.

7.3 RESPONSIBILITIES

The responsibilities of the DOE, state and local governments, and the RAC for environmental, health, and safety are described below:

7.3.1 The DOE UMTRA Project Office, and appropriate divisions of the Albuquerque Operations Office

- Conduct periodic surveys, with assistance from the Technical Assistance Contractor (TAC), of contractor programs and site activities, and prepare Health and Safety Audit Reports.
- Act on employee inquiries and complaints in accordance with procedures outlined in this plan.
- Ensure compliance with the health and safety standards by reviews of UMTRA Project contractor performance, and reviews of violations of the prescribed plan and the timing and manner of correction.

7.3.2 The State of Oregon and local governments

- Participate in the remedial action planning by identifying and interpreting applicable local or state regulations.

- o Advise the DOE UMTRA Project Office of changes to regulations which apply to this project.
- o Identify and assist in obtaining necessary reviews and approvals to comply with environmental regulations.

7.3.3 The [] RAC

- o Develop implementation procedures for the requirements set forth in this plan.
- o Execute programs and policies in a manner that shall ensure compliance with the requirements set forth in this plan.
- o Assure that the required information specified in subsequent sections of this plan is recorded and reported.
- o Submit requests for variance from the design criteria of this plan to the DOE Contracting Officer or Contracting Officer's Representative.
- o Include implementation requirements and procedures of the plan in all applicable subcontracts.

7.4 KEY FEATURES OF THE HEALTH AND SAFETY PLAN

The following elements are included in the Environmental, Health, and Safety Plan (Appendix D):

7.4.1 General

The RAC will maintain on-site professional radiation health staff members whenever contaminated materials are exposed. These personnel will develop and implement procedures for all activities involving potential safety or radiological health risks.

7.4.2 Community protection

During construction, an environmental monitoring program was conducted to document the effects on the environment and exposure of the general population to environmental hazards resulting from remedial action activities. Air particulate samples, radon-222 (Rn-222) samples, groundwater samples, and surface water samples were collected and analyzed for radiological parameters. In addition, groundwater and surface water samples were analyzed for stable chemical parameters. Monitors were located in areas mutually acceptable to the state and the DOE. Monitoring locations included the upwind and downwind site boundary, and a background location.

In addition, an array of environmental radon monitors were placed around the site to provide a measurement of the average radon concentration. In order to provide immediate information, one or more real-time continuous radon monitors were also located near the site or in the community to provide an hourly read-out of radon concentrations.

Operating response plans were prepared by the RAC to formulate response to severe weather events, construction accidents, or medical emergencies. Operational alert levels were developed to control any elevated radon emissions detected by monitoring programs during construction activities. Typical responses to elevated radon levels [] include additional wetting of exposed contaminated material, reduction of the uncovered area, or suspension of operations. Administrative controls were utilized to limit increases in off-site radon levels to three pCi/l averaged during a 52-week period, and six pCi/l averaged during any calendar quarter.

7.4.3 Worker protection

Training sessions applicable to the degree of radiation hazard present at the site were conducted for all employees prior to the start of work. These sessions included a discussion of site conditions, potential radiological hazards, effects of radiation, and emergency procedures. Records were maintained to document successful completion of training by employees.

Controlled areas were designated and conspicuously marked. Access control points were established for controlled areas, and all personnel and equipment were monitored. Access control records were maintained and included a log of personnel and equipment entering and leaving the restricted area, and a log of dosimeters issued.

Protective clothing was distributed to employees at the access control point when conditions warrant. Change and cleanup facilities were provided.

Thermoluminescent dosimeters (TLDs) or film badges were supplied to permanent employees working in controlled areas. Dosimeters were changed quarterly, or more frequently if necessary. Urinalysis was used to monitor employee internal exposures, and additional dosimetry was required if positive results were noted. A system of employee health records was maintained to document individual radiation exposures and the results of personnel dosimetry and bioassays.

Air particulate samples were collected in work areas and at site boundaries. Samples were analyzed for gross alpha levels, and [] stored for later isotopic analyses if necessary. Additional samples were collected in work areas where ventilation is limited, and analyzed for radon daughter concentrations.

A respiratory protection program, with procedures for training employees and checking for adequate fit of respirators, was developed by the RAC. Respirators were used in work areas where the airborne particulates cannot be controlled by dust suppression measures. An administrative warning limit was established to restrict exposure to airborne particulate concentrations to 25 percent of the regulatory limit for radionuclides. Industrial hazards were controlled in accordance with OSHA regulations.

As referenced in the Health Physics Monitoring Plan, a formal radiological training program was initiated to include the following.

Health physics training program

A formal radiological training program, including discussion of the biological effects associated with exposure to ionizing radiation, was provided to all site workers. The program included discussion of the radiological safety procedures, emergency procedures, and instructions concerning prenatal radiation exposure. Practical demonstrations of equipment usage were incorporated, where appropriate. Literature concerning biological effects of radiation was provided to workers, as were copies of USNRC Reg. Guide 8.13, "Instructions Concerning Prenatal Radiation Exposure."

All site personnel received formal instruction in construction safety procedures, as per the program outlined in the RAC Safety and Health Management Program Plan.

Initial training sessions were approximately two hours in length. An appropriate level of training was required of workers, based on anticipated exposure levels, and upon level of management responsibility as discussed previously. Each worker passed a written examination demonstrating comprehension of the training program contents. Permanent records of instruction [ ] and examination results were maintained by the site Radiation Safety Officer and the RAC, with copies forwarded to DOE upon completion of each training session.

Topics considered during the radiological training sessions included:

- o Summary of UMTRA Project objectives.

- o Radiation types.
  - Beta.
  - Gamma.
  - Alpha.

- Units.
  - Roentgen.
  - Rad.
  - Rem.
  - Counts per minute (CPM).
  - Disinteration per minute per 100 cm^2 (DPM/100 cm^2).
  - Curie (Ci).

- Protection against radiation.
  - Time (including calculation of dose and stay time).
  - Distance.
  - Shielding.

- Protection against contamination.
  - Protective clothing (including demonstration).
  - Smoking, eating, or drinking in controlled areas.

- Biological effects.
  - Effects of acute dose.
  - Effects of chronic dose.

- Radiation zones.
  - Radiation symbol and colors.
  - Controlled area.
  - Radiation area.
  - Airborne radioactive area.
  - Posting, physical, and administrative areas.

- Personnel monitoring for radiation.
  - Film or TLD badges.
  - Self-reading dosimeters.
  - Exposure records.
  - Other types of personnel monitoring instrumentation.

- Dose limits (DOE Order 5480.1A).
  - Whole body dose.
  - Skin dose.
  - Extremity dose.
  - Airborne activity.
  - Emergency dose.
  - NRC form, NRC-4.

- Personnel monitoring for contamination.
  - Survey when leaving contaminated area.
  - Whole body counting.
  - Bioassay.

- Radiation records.
  - Exposure records.
  - Bioassay records.
  - Accuracy of information.
  - Records retention.

An appendix to the RAC Health Physics Monitoring Plan, entitled "Lakeview Health Physics Plan," was also issued prior to start of construction. That appendix addressed training and other programs tailored to site-specific conditions.

8.0 RESPONSIBILITIES OF PROJECT PARTICIPANTS

8.1 INTRODUCTION

The following defines the various responsibilities of the [] DOE UMTRA Project Office, the [] NRC, and the State of Oregon during detailed design and remedial action, and through the initiation of custodial surveillance and maintenance. Responsibilities are divided into major categories to be performed by the parties. The DOE has been assisted by its Technical Assistance Contractor (TAC), the Jacobs-Weston Team, and [] RAC, Morrison-Knudsen, Inc., (M-K). In general, the TAC assists in the preparation of concept designs and remedial action plans and provides quality assurance, audits, and recommendations for final certification. The RAC prepares detailed designs, manages field construction and environmental, health, and safety activities, provides quality assurance/control, and provides certification data. Most of the State of Oregon responsibilities were performed by the Oregon Department of Energy [].

Major areas of responsibilities for actions by the DOE, the State of Oregon, and the NRC can be summarized as follows:

1. <u>DOE (including TAC, RAC)</u>:

   Manage project activities.
   Assist State of Oregon in site acquisition.
   Obtain permits and approvals.
   Prepare detailed designs and specifications.
   Prepare Remedial Action Inspection Plan (RAIP).
   Prepare and implement Environmental, Health, and Safety Plan.
   Conduct remedial action.
   Audit remedial action.
   Negotiate in good faith with the state regarding any changes to this RAP.
   Prepare licensing plan and submit license application.
   Prepare surveillance and maintenance plan.
   Certify remedial action.
   Obtain license.
   Conduct surveillance and maintenance.

2. <u>DOE/State of Oregon</u>:

   Coordinate project activities.
   Implement public participation and information plan.
   Provide funds.

3. <u>State of Oregon</u>:

   Concur in Remedial Action Plan (RAP).
   Acquire designated processing and disposal sites.
   Assist in obtaining local permits.
   Issue applicable state permits.
   Review preliminary design documents.

Review final design documents and issue notice to DOE consenting to incurrence of construction costs.
Review and comment on the Environmental, Health, and Safety Plan.
Review and comment on the long-term surveillance and maintenance plan.
Agree with DOE on the remedial action schedule if different than that presented in Section 5.9.
Negotiate in good faith with DOE regarding any changes to this RAP.
Review and provide comments on site RAIP and licensing plan.
Support DOE in the interim and final inspections of remedial actions for the purpose of meeting compliance or noncompliance with applicable EPA Standards.
Provide notice to DOE indicating state agreement that this Remedial Action Plan has been carried out and completed.

4. <u>NRC</u>:

Concur in acquisition of disposal site.
Review and concur in RAP and RAP changes.
Review and concur in surveillance and maintenance plan.
Review and concur in final certification report.
Issue license for long-term surveillance and maintenance of the disposal site.

8.2 RESPONSIBILITIES

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

8.2.1 Regulatory compliance

Requirements for regulatory compliance, previously identified by Federal, state, and local agencies, will be incorporated into the final design specifications, as needed, by the DOE.

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

During the remedial action, the DOE audited construction activities for compliance with provisions in the permits and approvals. (Permitting agencies may independently audit relevant activities consistent with normal practice.) Summary audit reports were prepared by the DOE and were submitted to appropriate agencies as required.

8.2.2 Licensing

As part of the license application and prior to completion of the remedial action, the DOE will prepare a site custodial surveillance and maintenance plan. The plan will be submitted to the NRC and state in draft form for review and comment. The DOE shall use its best efforts to reconcile any comments resulting from this review in its preparation of a final plan.

After certification of the remedial action, a license application containing the surveillance and maintenance plan and other details will be prepared by the DOE and submitted to the NRC. The NRC will issue a license for long-term surveillance and maintenance of the disposal site.

8.2.3 Land acquisition

The State of Oregon completed title searches and appraisals, and acquired the designated [] disposal site. After completion of the remedial action, the state will transfer title of the disposal site to the DOE.

8.2.4 Detailed design

In accordance with Article II.D.6 (a) (1) of the DOE-Oregon Cooperative Agreement, the DOE provided to the state the preliminary engineering drawings for state review. The DOE also prepared final design documents. The RAC consulted with the state to prequalify bidders so as to maximize the number of qualified local area bidders.

The final design and specifications were provided to the NRC and the state. In accordance with Article II.D.6.a (2) of the Cooperative Agreement, the state provided written notice to the DOE consenting to the incurrence of construction costs.

8.2.5 Construction

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

Construction activities were audited by the DOE. The state and NRC, at their own risk, may also audit the remedial action. Required revisions to the remedial action resulting from site audits were incorporated into the final design and the remedial action plan, as necessary, by the DOE.

The state may audit such items as the following to assure that they are in conformance with the approved RAP, construction plans and specifications, RAIP, or Environmental, Health, and Safety Plan:

- o Final excavation of contaminated material.
- o Final liner and cover construction and placement.
- o Site conditions for winter construction stoppage.
- o Final site completion, and decontamination of existing mill site and adjacent properties for unrestricted use.
- o Dust control measures.
- o Health physics program.

Items of non-conformance identified by the state or NRC were corrected as soon as possible.

DOE audit reports are available to the NRC and the state upon request.

In accordance with Article II.D.7. of the DOE-State Cooperative Agreement, the state is to indicate in writing its agreement with the DOE that the Remedial Action Plan has been carried out and completed. After such agreement, the site will be certified by the DOE. The NRC will concur in the final site certification report.

8.2.6 Health and safety

The DOE prepares a site-specific Environmental, Health, and Safety (EH&S) Plan in conformance with the UMTRA Project Health and Safety Plan. The EH&S Plan is provided to the state for review and comment. As part of the implementation procedures, the DOE institutes radiation control and environmental monitoring, and develops response procedures for severe weather and medical emergencies.

Construction contractors must comply with approved procedures and file reports with the DOE that record the results of monitoring, and report accidents and illnesses. Copies of reports were provided to the state as required. Records were maintained by the DOE following remedial action construction.

Employee and public complaints were investigated by the DOE. The DOE audited construction activities. The state and the NRC may perform independent audits.

8.2.7 Public information

The DOE established a local site manager who provided input into the public information process.

Prior to and during construction, the DOE and state, with the assistance from local citizens, conducted public information meetings to inform the interested public of key aspects and current progress of the remedial action.

8.2.8 Radiological support

The DOE prepared and implemented a Radiological Support Plan, and took measures to independently assure the quality of the analyses and compliance with the procedures. The Radiological Support Plan is provided to the state for review and comment.

After remedial action, the DOE will prepare a completion report, conduct a final certification survey, and provide a recommendation for site certification. The final completion report will be provided to the state and NRC for review and comment. The NRC will concur in the final site certification.

8.2.9 Quality assurance

The DOE prepared a RAIP in conformance with guidelines established in the UMTRA Project Quality Assurance Plan (DOE, 1983). The DOE will audit the construction activities and will prepare audit reports as appropriate. The RAIP is reviewed by the state and concurred upon by NRC.

8.2.10 Surveillance and maintenance

The DOE prepares and submits the Site Surveillance and Maintenance Plan to the state and NRC for review and comment. After the NRC concurs with the plan the DOE will ensure that the plan is implemented.

8.2.11 General

The state's Program Manager reviews DOE's schedule and associated cost estimates, monthly statements of work performed, and funds expended. Any discrepancies with overall site-approved schedules, plans, and specifications will be reconciled with the DOE. The Oregon Department of Energy will maintain close communications with the UMTRA Project Office throughout project implementation.

The State of Oregon will receive quarterly billings for actual work performed.

Concerns raised by local residents will be jointly addressed by DOE and the state as required.

The Lakeview local task force is involved in reviewing site design and construction progress and in making recommendations to the State of Oregon, which in turn may submit such recommendations to the DOE. These include but are not limited to:

- The task force may address problems associated with such local impacts as dust control, traffic problems and road deterioration, contractor employee conduct, and others.
- The task force may suggest ways that the remedial action program can be of maximum benefit to the economic health of the community.

9.0 SURVEILLANCE AND MAINTENANCE

9.1 INTRODUCTION

The objectives of the custodial surveillance and maintenance program are to assure that, upon completion of remedial action, the stabilized embankment remains undisturbed, the tailings continue to be nonhazardous to the public and the local environment, and all conditions comply with the EPA standards.

The custodial surveillance and maintenance program will be defined jointly by the DOE and the NRC during the license application and approval process. Following are the basic elements that may be included in this program.

9.2 SURVEILLANCE

9.2.1 Site inspections

Site inspections constitute a visual and definitive verification that the disposal site continues to function as designed and assures continued compliance with the EPA standards. Inspections will consist of two phases: Phase I, a systematic walk-over designed to qualitatively evaluate the condition of the disposal site; and Phase II, investigations to quantitatively assess changes in the disposal site that could lead to functional failure of the design in the absence of custodial maintenance.

The Phase I inspection will be conducted on a regular schedule, such as annually, by a team of qualified professionals. The inspection team will review record drawings, engineering details, aerial photographs, and supporting documentation. A site walk-over will then be performed to evaluate any changes at the site with regard to factors such as erosion, flood effects, slope/cover stability, settlement, displacement, plant or animal intrusion, and access control. Selected groundwater wells may be monitored at intervals to ascertain water quality changes in the underlying aquifers.

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

9.2.2 Aerial photographs

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

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

9.2.3 Groundwater monitoring

To ensure compliance with post closure requirements **and EPA groundwater standards**, certain existing wells shall be preserved [] for use as monitoring wells during and after completion of the remedial action. In addition, **a ring of POC wells will be installed along the downgradient edge of the tailings waste management unit as illustrated in Figure 9.1.** [] Locations for these wells will be selected in order to monitor the performance of the tailings embankment. Details of the groundwater monitoring program will be developed during the NRC licensing process.

9.2.4 Reporting

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

9.3 CUSTODIAL MAINTENANCE

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

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

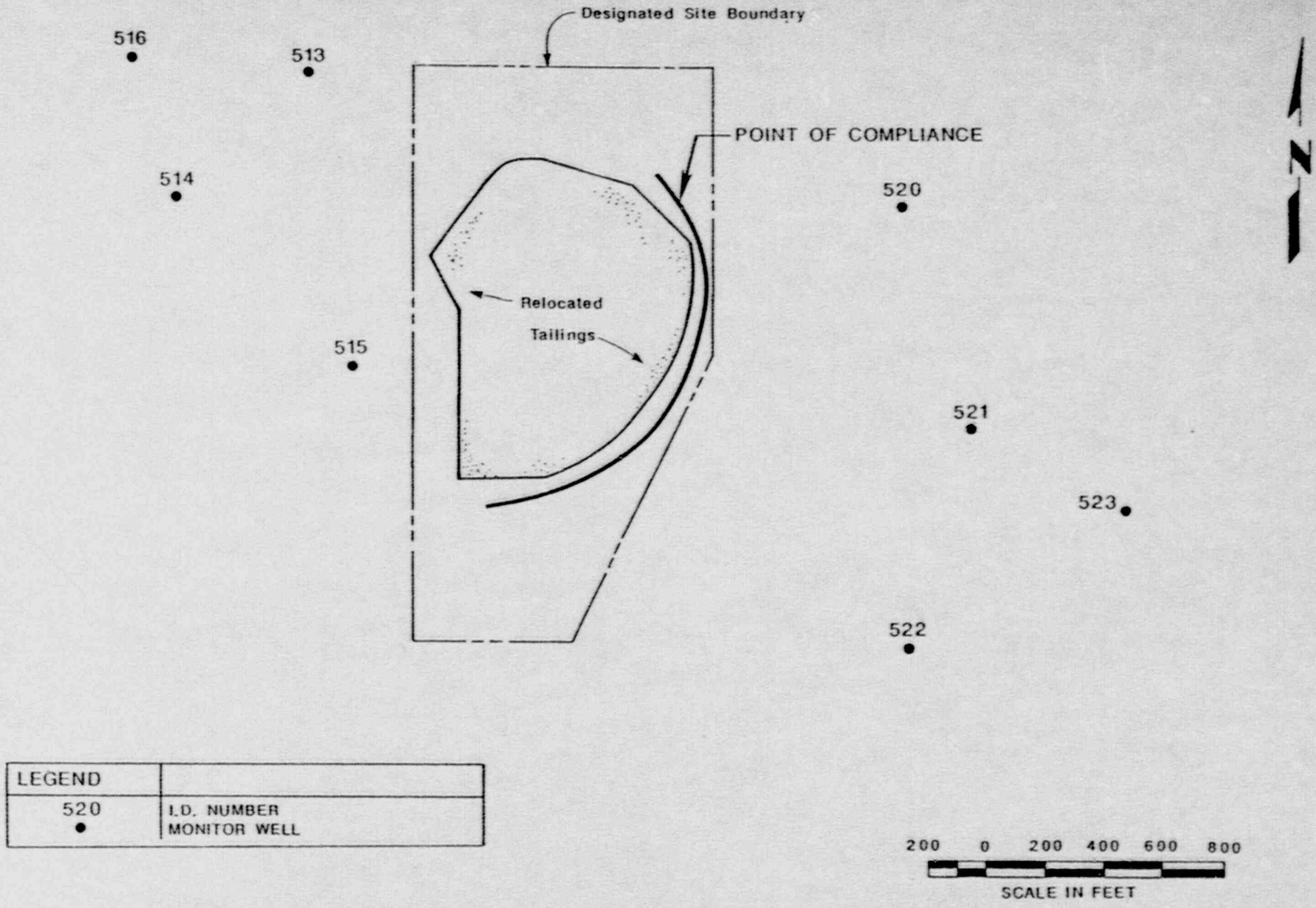


FIGURE 9.1

POINT OF COMPLIANCE AT THE COLLINS RANCH SITE

9.4 CONTINGENCY PLANS

Procedures will be developed to inspect and perform custodial maintenance of the disposal site upon the occurrence of severe meteorological events (e.g., extreme rainfall), seismic events in excess of design parameters, or unusual human intrusion as part of the Surveillance and Maintenance Plan.

10.0 QUALITY ASSURANCE

10.1 GENERAL

The [] RAC provides and maintains an effective quality assurance (QA) program and procedural system which assures that all work, materials, supplies, and services required under the contract conform to contract requirements, whether constructed or processed by the RAC or its subcontractors or procured by subcontractors or vendors. The RAC shall perform or have performed adequate inspections and tests as will ensure and substantiate that all work, materials, supplies, and services conform to contract requirements.

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

10.2 QUALITY ASSURANCE PLAN

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

10.3 DAILY INSPECTION REPORT

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

The RAC maintains current records of all inspections and shall furnish, as part of the files at the end of the project, copies of the inspection reports and all other files appropriate to each individual subcontract. The reports of inspection [ ] cover all work placement subsequent to the previous report and are verified by the RAC's designated QA representative.

10.4 MEASURING AND TEST EQUIPMENT CALIBRATION AND CONTROL

The RAC provides measuring and test equipment having the precision and accuracy needed to establish conformance with specified quality requirements. Calibrations are in accordance with nationally recognized standards. The RAC identifies procedural systems for test equipment calibration and recall.

10.5 NONCONFORMANCES

A nonconformance and change procedural system was developed by the RAC and approved by the DOE.

10.6 RECORDS CONTROL

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

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

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

10.7 CODES AND STANDARDS

The RAC had on the job site, no later than three weeks after site mobilization, the applicable quality assurance codes and standards available for ready reference by all personnel. The RAC maintains at the job site copies of all approved-for-construction drawings, specifications, and other documents which describe the remedial action.

10.8 RECORD DRAWINGS

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

10.9 MATERIAL CERTIFICATION

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

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

10.10 QUALITY ASSURANCE PROGRAM VERIFICATION

Verification of the QA program's implementation by the DOE may be accomplished by:

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

11.0 PUBLIC INFORMATION AND PUBLIC PARTICIPATION

11.1 INTRODUCTION

Section III of the UMTRCA states,

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

It is the intent of the public information and public participation program to inform the interested public fully and use the feedback in the decision-making processes and remedial action activities relative to the UMTRCA-designated site near the city of Lakeview, Lake County, Oregon. The following sections describe the actions the DOE and state have taken [] to encourage the participation of an informed public in this project.

11.2 PUBLIC PARTICIPATION

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

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

The identified issues were documented in the EA and incorporated into the decision-making process. The DOE accepted written comments for a 30-day period after publication of the EA. Interested parties were given the opportunity to comment on the EA at an official comment-taking meeting in Lakeview after the EA was published.

In addition to meetings on the EA, the DOE continued to hold public information meetings in Lakeview to describe the remedial action plan for the project and receive comments which were used in the design for remedial action.

The Lakeview Remedial Action Advisory Committee, comprised of local citizens and formed to serve as a major communication link in the decision-making process, met with the DOE and state to convey community response on project activities. The advisory committee should continue to meet periodically throughout the duration of remedial action construction.

Frequent meetings and briefings were held to provide information and project status updates and solicit public participation in the project activities. The DOE, state, local officials, and interested citizens have been and will continue to be involved in discussions regarding remedial action construction schedules, radiation monitoring reports, groundwater protection plans, and other project activities.

11.3 PUBLIC INFORMATION

In order for public participation to be effective, the public must be informed about the remedial action project in Lakeview. Several methods of information dissemination were used by the DOE. Press releases and press packets were prepared for project status updates, including report summaries, texts of presentations, and graphics.

The names and addresses of individuals, media representatives, and Federal, state, and local officials have been computerized for information dissemination purposes. Information is provided to interested persons in the Federal government, state administration, and private citizens in Lake County.

A public pre-construction meeting was conducted by the DOE. Principal topics of discussion included the remedial action design and construction schedules.

An on-site representative was designated by DOE to respond to public inquiries during remedial action construction. This representative works closely with the DOE to provide information and has met frequently with the public throughout the construction period.

A variety of printed materials have been prepared concerning the UMTRA Project and the Lakeview site. These include project fact sheets, a site fact sheet, and the [] EA []. As they are printed, these materials and other fact sheets and documents have been and will continue to be sent to interested individuals and are available in the public libraries, county offices, and the Oregon State Environmental Office. The same materials are also available at DOE designated libraries nationwide.

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GLOSSARY

absorbed dose, radiological	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad; one rad equals 100 ergs per gram.
alluvium	Unconsolidated sediments of sands, silts, clays, and gravels deposited by the aggradation processes of rivers.
alpha particle	A positively charged particle emitted from certain radionuclides. It is composed of two protons and two neutrons, and is identical to the helium nucleus.
aquifer	A saturated, permeable geologic unit that can transmit significant quantities of water under normal hydraulic gradients.
aquitard	A water-bearing zone that transmits water at a very slow rate.
atom	A unit of matter; the smallest unit of an element consisting of a dense, central, positively-charged nucleus surrounded by a system of electrons, equal in number to the number of nuclear protons and characteristically remaining undivided in chemical reactions except for a limited removal, transfer, or exchange of certain electrons.
background radiation	Levels of radiation or concentrations of radionuclides which are typical of an undisturbed area, or an area not affected by residual radioactive material.
beta particle	Charged particle emitted from the nucleus of an atom, with mass and charge equal to those of an electron.
bioassay	A method for quantitatively determining the concentration of radionuclides in a body by measuring the quantities of those radionuclides that are eliminated from the body, usually in the urine or the feces.
confined aquifer	An aquifer bound above and below by relatively impermeable strata.
contamination	In this report, [] the presence of radioactive material in undesirable concentrations and in undesirable locations. For groundwater, elevated concentrations of any chemical constituent that can be related directly to the processing site as the source.
daughter product(s)	A nuclide resulting from radioactive disintegration of a radionuclide, formed either directly or as a result of a successive transformations in a radioactive series; it may be either radioactive or stable.

decay, radioactive	Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles, photons, or both.
decontamination	The reduction of radioactive contamination from an area to a predetermined level, set by a standards-setting body such as the EPA, by removing the contaminated material.
disintegrations per minute or second	The number of radioactive decay events occurring per minute or second.
DOE	U.S. Department of Energy.
dose	A general term denoting the quantity of radiation or energy absorbed, usually by a person; for special purposes, it must be qualified. If unqualified, it refers to absorbed dose.
dose, absorbed	The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest; given in units of rads.
dose commitment	The cumulative dose equivalent that results and will result from exposure to radioactive materials over a discrete time period; given in units of rems.
dose equivalent	The quantity that expresses all kinds of radiation on a common scale for calculating the effective absorbed dose; defined as the product of the absorbed dose in rads and modifying factors, especially the qualifying factor. Given in terms of rems. Often abbreviated "dose."
dose, external	The absorbed dose that is due to a radioactive source external to the individual as opposed to radiation emitted by inhaled or ingested sources.
dose, internal	The absorbed dose or dose commitment resulting from inhaled or ingested radioactivity.
EA	Environmental Assessment.
EPA	U.S. Enviornmental Protection Agency.
exposure	A measure of the ionization produced in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The unit of exposure is the roentgen (R).
FONSI	Finding of No Significant Impact.

flux, radon	The emission of radon gas from the earth or other material, usually measured in units of picocuries per square meter per second.
gamma dose	Radiation dose caused by gamma radiation.
gamma logging (or logs)	A technique for determining gamma radiation levels at various depths in a borehole.
gamma ray	Short-wave-length electromagnetic radiation of nuclear origin with energies ranging from 10 KeV to 9 MeV.
gamma spectral analysis (gamma spectroscopy)	An analytical technique for identifying radionuclides based on their different gamma energy levels.
groundwater	Subsurface water in fully saturated soils and geologic formations.
hydraulic conductivity	Ratio of flow velocity to driving force (for viscous flow of a specified liquid in a porous medium).
hydraulic gradient	Rate of change of hydraulic head per unit of distance of flow at a given point. The driving force for advective flow in a porous medium.
half-life	The time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.
in situ	In the natural or original position.
isotopes	Nuclides having the same number of protons in their nuclei, but differing in the number of neutrons; the chemical properties of isotopes of a particular element are almost identical.
licensing	In this report, the process by which the NRC will, after the remedial actions are completed, approve the final disposition and controls over a disposal site.
maintenance, custodial	The repair of fences; repair or replacement of monitoring equipment; revegetation; minor additions to soil cover; and general disposal site upkeep such as mowing grass.
MCE	Maximum Credible Earthquake.
MCL	Maximum Concentration Limit.
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}).
MOC	Method of Characterization.

Modified Mercalli (scale)	A standard scale for the evaluation of the local intensity of earthquakes based on observed phenomena such as the resulting level of damage. Not to be confused with magnitude, such as measured by the Richter scale, which is a measure of the comparative strength of earthquakes at their sources.
monitor	To observe and make measurements resulting in data for evaluation of the performance and characteristics of the disposal site.
MSRD	Mountain States Research and Development.
NEPA	National Environmental Policy Act.
NRC	U.S. Nuclear Regulatory Commission.
OSHA	Occupational Safety and Health Act.
passive institutional controls	Those controls which require action by a governmental agency to preclude human contact with the waste or require a continuing social order. Examples include Federal ownership of a disposal site, monuments on the site, records with agencies, and physical barriers (e.g., riprap covers, vegetation, waste burial).
perched groundwater	Groundwater that is unconfined and separated from an underlying body of groundwater by an unsaturated zone.
permeability	The capacity of a rock or soil mass to transmit a fluid.
permissible dose	That dose of ionizing radiation that is considered acceptable by standards-setting bodies such as the EPA. Also, the dose of radiation that may be received by an individual within a specified period with the expectation of no substantially harmful result.
person-rem	Unit of population exposure obtained by summing individual dose-equivalent values for all people in the population. Thus, the number of person-rems attributed to one person exposed to 100 rems is equal to that attributed to 100 people each exposed to one rem.
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.
POC	Point of Compliance.
PMP	Probable Maximum Precipitation.
PMF	Probable Maximum Flood.

potentiometric (piezometric) surface	An imaginary surface that everywhere coincides with the static hydraulic head of the water in the aquifer.
[]	
proton	Elementary nuclear particle with a positive electric charge equal numerically to the charge of the electron and a mass of 1.007277 mass units. Also, the nucleus of a hydrogen atom.
PSCR	Processing Site Characterization Report.
RAC	Remedial Action Contractor.
rad	A unit of measure for absorbed dose of radiation. It is equivalent to 100 ergs per gram of material.
radioisotope	A radioactive isotope of an element with which it shares almost identical chemical properties.
radionuclide	A radioactive nuclide.
radium-226 (Ra-226)	A radioactive daughter product of uranium-238. Radium is present in all uranium-bearing ores; it has a half-life of 1620 years.
radon-222 (Rn-222)	An inert gas continuously generated by the decay of Ra-226 in rock and soil with a half-life of 3.8 days generating a series of non-gaseous radioactive decay (**daughter**) products.
radon daughter product	One of several short-lived radioactive daughter products of radon-222. All are solids.
RAIP	Remedial Action Inspection Plan.
RAP	Remedial Action Plan.
RDC	Radon daughter concentration.
recharge	The processes involved in the replenishment of water 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.
roentgen (R)	The unit of exposure. One roentgen equals 2.58 x 10^{-4} coulombs per kilogram of air. One roentgen in air is approximately equal to one rad and one rem in tissue.

soil infiltration rate	The rate at which water enters the soil surface and moves vertically downward.
soil percolation rate	The rate at which water moves through soil in all directions.
stabilization	The reduction of radioactive contamination in an area to a predetermined level by a standards-setting board such as the EPA, by encapsulating or covering the contaminated material.
standard Proctor	A test procedure to measure moisture-density relationship (ASTM D698).
surveillance	The observation of the disposal site for purposes of visual detection of need for custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.
TAC	Technical Assistance Contractor.
tailings, uranium mill	The waste material remaining after most of the uranium has been extracted from uranium ore.
TDS	Total dissolved solids.
thorium-230 (Th-230)	A radioactive daughter product of uranium 238; it has a half-life of 80,000 years and is the parent of radium-226.
TLD	Thermoluminscent Dosimeter.
transmissivity, hydraulic	A measure of the ability of an aquifer to transmit water equal to the product of the hydraulic conductivity and the saturated thickness of the aquifer.
UMTRA	Uranium Mill Tailings Remedial Action.
UMTRCA	Uranium Mill Tailings Radiation Control Act.
unconfined aquifer	An aquifer that is not confined by relatively impermeable beds. The upper water surface is called the water table.
uranium-238 (U-238)	A naturally occurring radioisotope with a half-life of 4.5 billion years; it is the parent of uranium-234, thorium-230, radium-226, radon-222, and others.
vicinity property	A property in the vicinity of the Lakeview site that is determined by the DOE, in consultation with the NRC, to be contaminated with residual radioactive material derived from the Lakeview site, and which is determined by DOE to require remedial action.
water table	The upper surface of a zone of saturation in an unconfined aquifer.

working level (WL)	A measure of radon daughter product concentrations. Technically, it is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of alpha particles with a total energy of 130,000 MeV.
working-level month (WLM)	Exposure to a worker resulting from inhalation of air with a concentration of one WL of radon daughters for 170 working hours. Continuous exposure of a member of the general public to one WL for one year results in approximately 53 WLM.

APPENDIX A

REGULATORY COMPLIANCE

TABLE OF CONTENTS

LIST OF FIGURES

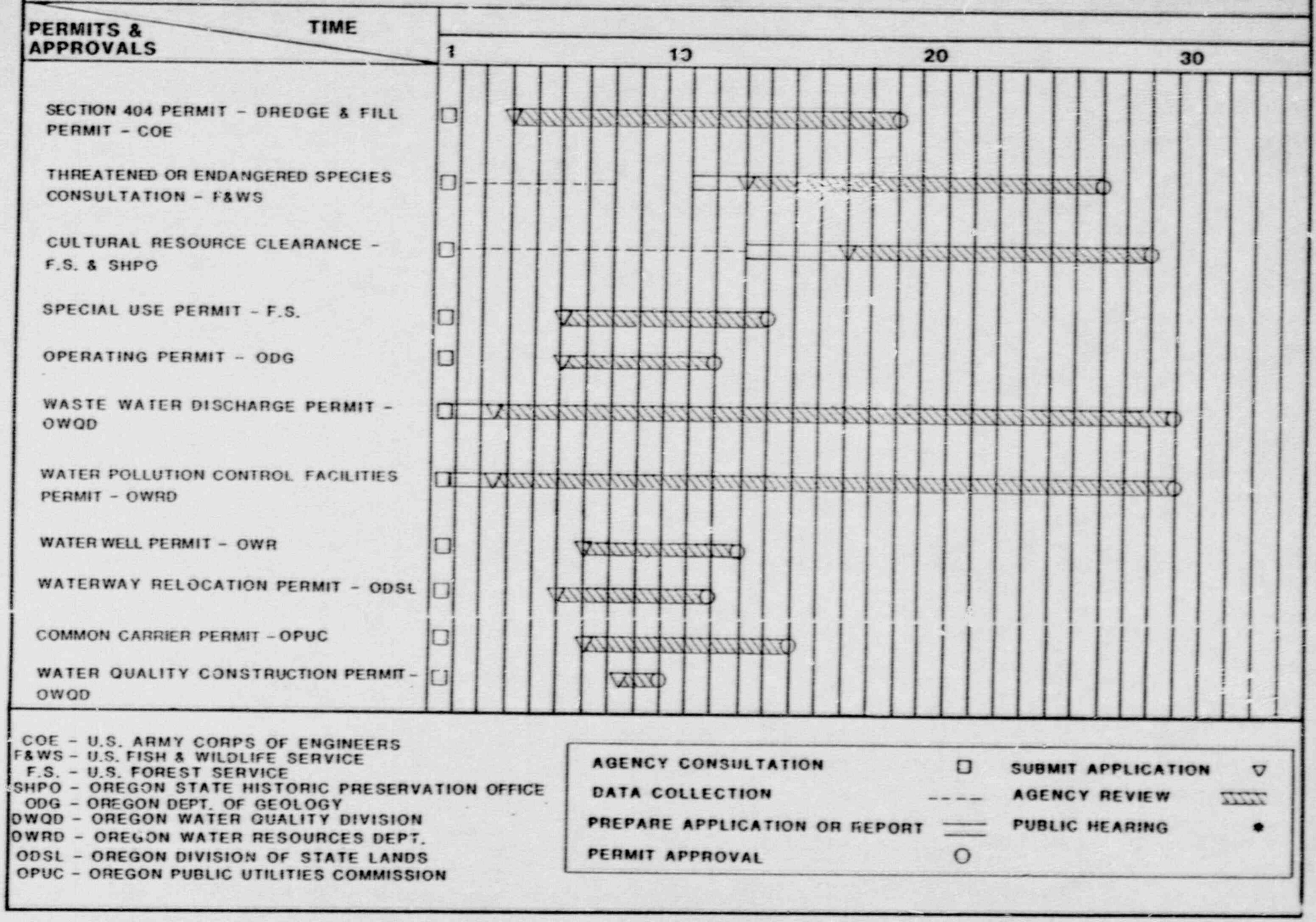
A.1 INTRODUCTION

Obtaining permits and other regulatory approvals for the proposed activities is essential for the initiation of remedial action. This [ ] appendix [ ] identifies and describes the permits, licenses, and approvals that are likely to be required for the remedial action based upon the final design (Section 5.0 of the Remedial Action Plan). Other permits and approvals may be required for activities beyond the scope of the Remedial Action Plan or due to modification to the design.

Procedures for preparing permit applications and agency review processes are outlined for each permit. The principal technical and supervisory personnel at the regulatory agencies are listed as well. The Remedial Action Contractor (RAC) should consider this [ ] appendix to be an introduction to the permitting process, while additional details must be obtained from regulatory agencies.

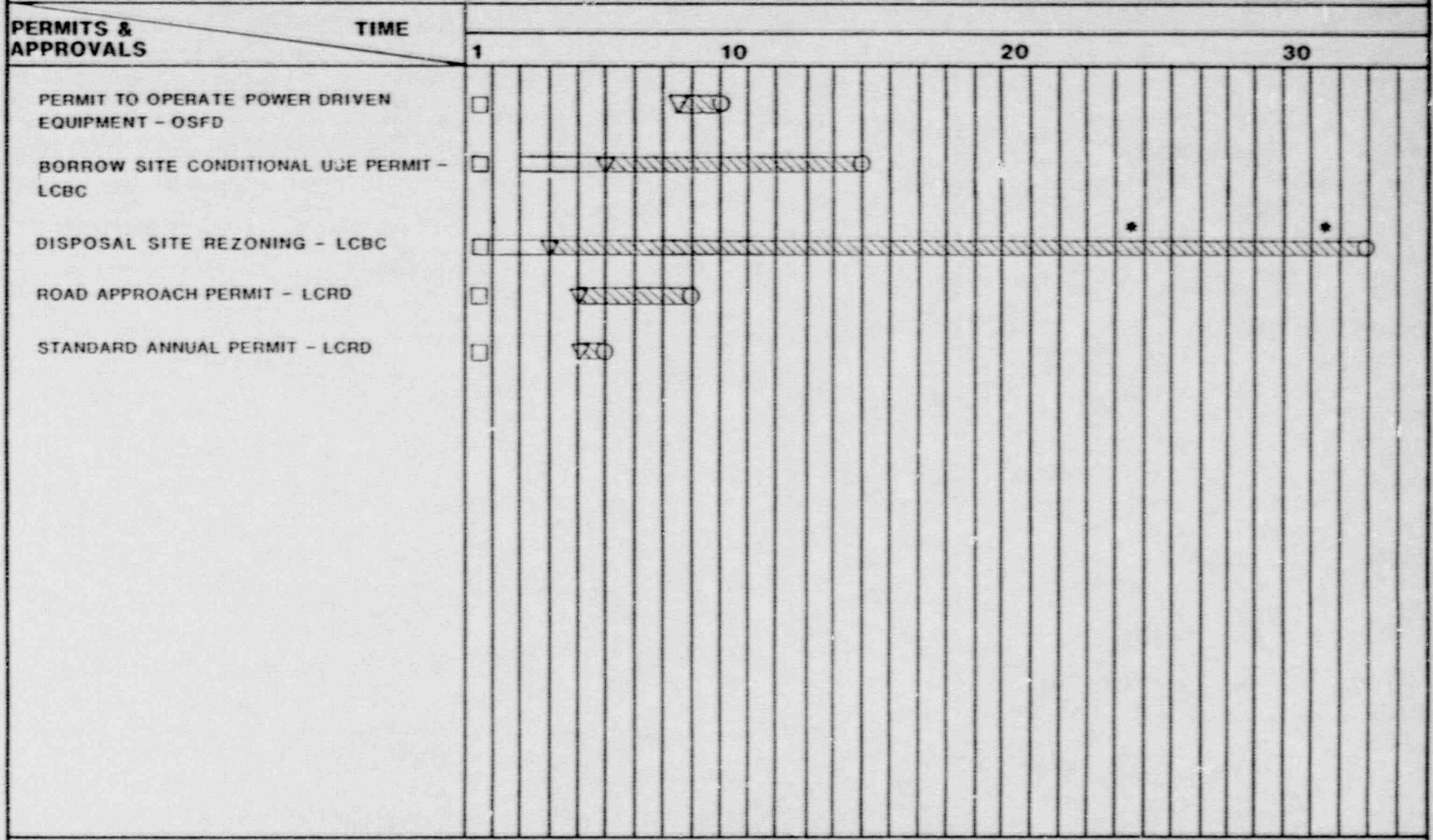
A tentative schedule for regulatory compliance activity (Figure A.1.1) was included for initial project planning purposes. Figure A.1.2 illustrates the regulatory compliance matrix. The RAC sequenced the preparation and filing of permit applications so that approvals were received in a timely manner without causing delay to construction activities. Environmental Services personnel of the Technical Assistance Contractor (TAC) provided additional assistance as needed.

FIGURE A.1.1 REGULATORY COMPLIANCE SCHEDULE LAKEVIEW, OREGON



COE - U.S. ARMY CORPS OF ENGINEERS
F&WS - U.S. FISH & WILDLIFE SERVICE
F.S. - U.S. FOREST SERVICE
SHPO - OREGON STATE HISTORIC PRESERVATION OFFICE
ODG - OREGON DEPT. OF GEOLOGY
OWQD - OREGON WATER QUALITY DIVISION
OWRD - OREGON WATER RESOURCES DEPT.
ODSL - OREGON DIVISION OF STATE LANDS
OPUC - OREGON PUBLIC UTILITIES COMMISSION

FIGURE A.1.1 (CONT.) REGULATORY COMPLIANCE SCHEDULE LAKEVIEW, OREGON



OSFD - OREGON STATE FORESTRY DEPT.
LCBC - LAKE COUNTY BOARD OF COMMISSIONERS
LCRD - LAKE COUNTY ROAD DEPARTMENT

AGENCY CONSULTATION	□	SUBMIT APPLICATION	▽
DATA COLLECTION	----	AGENCY REVIEW	▨
PREPARE APPLICATION OR REPORT	═	PUBLIC HEARING	●
PERMIT APPROVAL	○		

FIGURE A.1.2

LAKEVIEW, OREGON UMTRA PROJECT SITE REGULATORY COMPLIANCE MATRIX

PERMIT OR APPROVAL	COE	F&WS	FS	SHPO	ODG	OWQD	OWRD	ODSL	OPUC	OSFD	LCBC	LCRD
SECTION 404 PERMIT	L							C				
THREATENED OR ENDANGERED SPECIES CONSULTATION		L										
CULTURAL RESOURCE CLEARANCE			C	L								
SPECIAL USE PERMIT			L									
OPERATING PERMIT					L							
WASTE WATER DISCHARGE PERMIT						L					C	
WATER POLLUTION CONTROL						L					C	
WATER WELL PERMIT							L					
WATERWAY RELOCATION PERMIT								L				
COMMON CARRIER									L			
WATER QUALITY CONSTRUCTION PERMIT						L						
PERMIT FOR POWER DRIVEN EQUIPMENT										L		
BORROW SITE CONDITIONAL USE											L	
DISPOSAL SITE REZONING											L	
ROAD APPROACH PERMIT												L
STANDARD ANNUAL PERMIT												L

REGULATORY AGENCY

LEGEND

L - LEAD AGENCY
C - COOPERATING AGENCY
COE - CORPS OF ENGINEERS
F&WS - FISH & WILDLIFE SERVICE
FS - FOREST SERVICE
SHPO - STATE HISTORIC PRESERVATION OFFICE
ODG - OREGON DEPT. OF GEOLOGY
OWQD - OREGON WATER QUALITY DIVISION
OWRD - OREGON WATER RESOURCES DEPT.
ODSL - OREGON DIVISION STATE LANDS
OPUC - OREGON PUBLIC UTILITIES COMMISSIONER
OSFD - OREGON STATE FORESTRY DEPT.
LCBC - LAKE COUNTY BOARD OF COMMISSIONERS
LCRD - LAKE COUNTY ROAD DEPT.

ACTIVITY: SECTION 404 DREDGE AND FILL PERMIT

LEGAL CITATION: Clean Water Act of 1977, 33 USC 1344; 33 CFR 323.1 (1982), 33 CFR 230 and 40 CFR 230

AGENCY/CONTACT:
U.S. Army Corps of Engineers
Portland District
319 SW Pine
Portland, OR 97208
ATTN: Gerald Newgard, Chief of Permits
Jan Harmon, Regulatory Specialist (503) 221-6995

PROCEDURE: Placement of fill in floodplain and wetland areas will be subject to a U.S. Army Corps of Engineers (COE) permit. The COE approval of fill placement is likely to be granted by issuance of an individual Section 404 permit or covered by an existing nationwide permit.

An application for an individual permit consists of completing a "Joint Application for Permit." This permit application has been approved by the COE and the state of Oregon. The following information is required:

(1) Complete description of the proposed activity including vicinity maps, plan view drawings, and section drawings, sufficient for public notice.

(2) The location and purpose of the proposed activity.

(3) Schedule of the activity.

(4) Names and addresses of adjoining property owners.

(5) Location and dimensions of adjacent structures.

(6) A list of authorizations required by other Federal, interstate, state, or local agencies for the work, including all approvals received or denials already made.

Within 15 days of receipt of the application by the COE, the application is reviewed for completeness and the applicant is notified of the need for additional information prior to further processing. A public notice of the application is issued by the COE, also within 15 days of receipt of the application. Comments from the public and from other government agencies (e.g., the U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (FWS), and Oregon Department of Fish and Wildlife) are considered by the COE in processing the application. The COE prepares an environmental assessment (EA) of the impacts of the project and, in some cases, an environmental impact statement (EIS). A public hearing may be scheduled in some circumstances. The COE determines whether or not a permit should be issued and prepares a Statement of Findings (SOF) or, in the case of an EIS, a Record of Decision (ROD).

SPECIAL CONSIDERATIONS: Areas along Hammersley Creek may be considered to be "adjacent wetlands" by the COE. Backfilling these areas after removing [ ] contaminated soils would be deemed a "discharge of fill." Grading of unbackfilled wetland areas may also be considered a "discharge of fill" and necessitate authorization via a Section 404 Permit.

Consultation with the regional EPA Office, as required by Section 404C of the Clean Water Act, may extend the permit review period.

SCHEDULE: Section 404 permits normally require 90 days for processing, although simple applications may involve as little as 60 days.

ACTIVITY: THREATENED OR ENDANGERED SPECIES CONSULTATION PROCESS

LEGAL CITATION: Endangered Species Act of 1973, Section 7
16 USC 1531, et. seq.

AGENCY/CONTACT: U.S. Fish and Wildlife Service
Division of Endangered Species Office
2625 Parkmont Lane, Building B-2
Olympia, WA 98502
ATTN: Jim Bottorff, Project Leader (206) 524-4430

PROCEDURE: A Federal agency must ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered (T&E) species or its critical habitat. The responsible Federal agency must consult with the [ ] FWS to determine what effect, if any, the proposed action might have on T&E species.

In most cases, a letter is sent by the Federal agency to the FWS outlining the proposed action. If the FWS determines that no T&E species would be adversely affected by the action, the FWS responds stating their finding of no effect and that no further compliance measures are necessary. If the FWS identifies [] any T&E species that may be affected, the Federal agency may be required to prepare a biological assessment considering the species identified by the FWS.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: After obtaining the list of threatened or endangered species from the FWS, the Federal agency has 180 days or another mutually agreeable time period to complete a biological assessment. The Federal agency requests a Section 7 consultation and the FWS is required to issue a biological opinion within 90 days.

ACTIVITY: CULTURAL RESOURCE CLEARANCE

LEGAL CITATION: Historic Preservation Act of 1966, 16 USC 470; Executive Order 11593; and 36 CFR 800

AGENCY/CONTACT:
Historic Preservation Office
State Parks and Recreation Division
525 Trade Street SE
Salem, OR 97310
ATTN: David Talbot, State
Historic Preservation Officer
Dr. Leland Gilson
Archaeologist (503) 378-5019
Elizabeth Potter
Nomination Coordinator (503) 378-5023

PROCEDURE: All Federal agencies are required to inventory archaeological and historical resources affected by their undertakings and do whatever is possible with regard to protecting and, when necessary, recovering significant resources. Prior to **disturbing the** surface [ ], cultural resource clearance should be obtained from the State Historic Preservation Officer (SHPO) with the concurrence from the land management agency. The organization sponsoring the activity should contract with an approved archaeologist to conduct a site survey. If a survey of the area has been completed previously, a new survey may not be required. The survey report should be sent to the SHPO and the land management agency with jurisdiction (i.e., U.S. Forest Service).

If cultural resources eligible for the National Register of Historic Places would be affected by the remedial action, the U.S. Department of Energy (DOE) would make a determination of effect, and send the statement to the SHPO and Advisory Council on Historic Preservation (ACHP). Efforts to mitigate adverse effects are negotiated between the government agencies and agreed upon in a memorandum of agreement.

SPECIAL CONSIDERATIONS: Although no significant archaeological sites are present on the proposed disposal site, two [ ] sites have been identified northwest of the area in Section 3, which may be eligible for nomination to the National Register of Historic Places. A mitigation plan will be developed as required by the **Technical Assistance Contractor** (TAC) to assure that significant archaeological resources are either avoided or that scientific data from the site have been recovered prior to [ ] construction.

SCHEDULE: The state of Oregon has a committee that reviews the nominations quarterly (February, May, August, and November). The committee makes recommendations for eligibility and these recommendations are sent to Washington, D.C., where concurrence usually takes about 45 days.

The U.S. Forest Service [ ] requires two weeks to two months for review and approval.

ACTIVITY: SPECIAL USE PERMIT

LEGAL CITATION: 36 CFR 251 and 252

AGENCY/CONTACT:
U.S. Forest Service
Fremont National Forest
524 North G Street
P.O. Box 551
Lakeview, Oregon 97630
ATTN: Orville Grossarth, Forest Supervisor
Howard Querin, Lands Specialist (503) 947-2151

PROCEDURE: This permit is required for any occupancy or use of National Forest lands. A special use permit may be required if borrow sites are located on U.S. Forest Service lands. An application for a Special Use Permit (Form 2700-4) is obtained from the local U.S. Forest Service office. Information required is:

(1) Name and address of applicant.
(2) Description of lands, including map or plat.
(3) Purpose of use.
(4) Description of improvements and estimated cost.

The applicant submits the application and operating plan to the Forest Supervisor. The U.S. Forest Service staff then conducts an environmental analysis. The applicant may be required to provide a reclamation bond and a user's fee. The permit is then issued with the appropriate signatures.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: Review and approval will take four to eight weeks.

ACTIVITY: OPERATING PERMIT

LEGAL CITATION: ORS 517.750-990; OAR 632-30, et. seq.

AGENCY/CONTACT: Oregon Department of Geology & Mineral Industries
Mined Land Reclamation Division
1129 S. Santiam Road
Albany, OR 97321
ATTN: Paul Lawson, Director
Frank Schnitzer
Field Representative (503) 967-2039

PROCEDURE: Mining of non-Federal borrow sites requires [] an Operating Permit (Form SMLR-1) and Reclamation Plan Guidelines (Form SMLR-16) [] from the Oregon Department of Geology.

Information required on Form SMLR-1 is:

(1) Names and addresses of the operator and landowner.
(2) Legal location.
(3) General description of the site.
(4) Type of operation.
(5) Volume of material to be mined, number of acres affected.

Information required on Form SMLR-16 is:

(1) Name, address, and telephone number of operator or his agent and landowner.

(2) Operational plan.

(3) Proposed use of land after mining is completed.

(4) Reclamation procedures, i.e.:

- How will ground stability be ensured?
- How will topsoil be saved and stored?
- What measures will be taken to prevent erosion of topsoil during storage?
- What will be the average depth of topsoil replaced and how will the seedbed be prepared?
- What types of vegetation will be planted, what fertilizers will be used, and what will be the season of planting?

(5) Provisions to be taken to ensure proper drainage and erosion control.

(6) Visual screening to be used, if applicable.

OPERATING PERMIT (Concluded)

(7) Provisions for removing structures, equipment, and refuse from the permit area.

(8) Map of the area (scale 1" = 400' to 600').

(9) Tax lot map or number.

(10) If applicable, provisions for stream channelization, bank stabilization, and rehabilitation.

(11) Evidence, in written form, of surface owner and subsurface owner concurrence of mine operation and reclamation.

(12) List of other applicable permits with permit numbers and date of issuance.

(13) Information on any proposed water impoundments (i.e., surface area in acres, water source, public safety, public access.)

SPECIAL CONSIDERATIONS: A $390 fee is required upon submittal of the application. A performance bond or other security is required. The amount of this bond shall be determined by the department and shall not exceed $2000 per site plus $500 per acre of land forecast for mining during the next 12 months in addition to land presently mined, subject to reclamation and unreclaimed.

SCHEDULE: Maximum time for review and approval is 45 days.

ACTIVITY: WASTEWATER DISCHARGE PERMIT

LEGAL CITATION: ORS 468.740; OAR Division 340-41 & 340-45

AGENCY/CONTACT: Department of Environmental Quality (DEQ)
Water Quality Control Division
522 SW Fifth
Portland, OR 97204
ATTN: Kent Ashbaker, Section Head (503) 229-5325

PROCEDURE: This National Pollutant Discharge Elimination System (NPDES) permit applies to all operations discharging to waters of the state from a point source. Application is made by filing completed EPA Form 2, available from the Water Quality Control Division. Information required on Form 2 includes:

(1) Location, by latitude and longitude, and number designation of each effluent outfall.

(2) Name of receiving water for each outfall.

(3) A schematic flow diagram indicating sources of water, operations contributing wastewater for the effluent water balance, and treatment processes for each waste stream.

(4) A list of each operation, average flow, and treatment related to each outfall.

(5) Description of the variation and frequency of water flow.

(6) Explanation of any Federal, state, or local implementation schedule for construction or improvement of wastewater treatment or other environmental programs.

(7) Influent and effluent characteristics:
- Pollutants present.
- Source of pollutants.
- Concentration of pollutants.
- Temperature of effluent.
- Flow of effluent.
- pH of effluent.

SPECIAL CONSIDERATIONS: If a zero discharge evaporation pond is to be used during the remedial action, a Water Pollution Control Facilities (WPCF) permit is required.

A three-part fee is due upon application for the permit. This includes the following:

(1) Filing Fee, $50.00. This fee is non-refundable.

WASTEWATER DISCHARGE PERMIT (Concluded)

(2) Application Fee, $500.00. This fee is dependent on the type of classification of the facility, in this case "minor industry."

(3) Annual Compliance Fee, $100 to $225. This is dependent on the type of discharges.

A Statement of Compatibility has to be submitted to the DEQ with the permit application. This is required of any new application requiring land use clearance. The Statement of Compatibility is a certification by the local planning agencies that the proposed activity is compatible with local comprehensive land use plans. If the DEQ receives a negative local Statement of Compatibility, they cannot grant the permit.

SCHEDULE: The written application must be submitted at least 180 days before the permit is required. Once the application is received, it is reviewed for completeness. A public notice is issued, with a comment period of not less than 30 days. After the public notice, a fact sheet and proposed permit provisions are prepared. This information is forwarded to the applicant for review and comment. All comments must be submitted in writing within 14 days after mailing. The applicant can waive the 14-day period to expedite the process. After the comment period, all materials are made available to the public for inspection. If there is sufficient public interest, a public hearing may be held. The Director of the Department of Environmental Quality then either approves or denies the permit. If the applicant is dissatisfied with the decision, a hearing can be requested in writing. The request is due 20 days after the mailing date of the decision.

ACTIVITY: WATER POLLUTION CONTROL FACILITIES PERMIT

LEGAL CITATION: ORS 468.740; OAR 340-41 & 340-45

AGENCY/CONTACT:

Department of Environmental Quality []
Water Quality Control Division
522 SW Fifth
Portland, OR 97204
ATTN: Kent Ashbaker, Section Head (503) 229-5325

PROCEDURE: This permit is required for construction of wastewater treatment facilities. An application form WPCF-N is available from the DEQ. Forms are to be submitted in duplicate. Information required on the form is:

(1) Applicant name and address.

(2) Name and address of responsible official.

(3) Plant location if different from official address.

(4) General description of the proposed facility and primary method of wastewater treatment and disposal.

(5) A required exhibit that includes:
- Complete description of the proposal.
- Location of the project and adjacent facilities and waterways.
- Schedule for development.
- Schematic diagrams of industrial processes, waste streams, and treatment and disposal facilities.
- Disposal of solid waste and sludges.
- Groundwater information.
  - (a) Climatic information.
  - (b) Topography and soils profile.
  - (c) Flooding and erosion potential.
  - (d) Groundwater aquifer characteristics, including quality and gradient.
  - (e) Location of all wells and springs within a 0.5-mile radius.
- Evaluation of groundwater and surface water impacts

(6) Land use approval (Statement of Compatibility).

(7) List of other permits issued/applied for.

SPECIAL CONSIDERATION: This permit and the wastewater discharge permit (NPDES) are filed concurrently with the DEQ. The three-part fee (see discussion under Wastewater Permit) is to accompany the applications. Information required for both permits is very similar.

SCHEDULE: Approval will take approximately 180 days.

ACTIVITY: PERMIT TO APPROPRIATE GROUNDWATER

LEGAL CITATION: OAR Chapter 690

AGENCY/CONTACT: Water Resources Department
Water Rights Division
Mill Creek Office Park
555 13th Street NE
Salem, OR 97310
ATTN: William Young, Director
Wayne Overcash
Water Rights Examiner (503) 378-3066

PROCEDURE: Prior to drilling a well, a groundwater permit is required. The application is approved by the Water Rights Division.

The following information is required for the permit application:

(1) Name, address, and telephone number of applicant.
(2) Proposed use(s) of the water.
(3) Location of well and location of use.
(4) Proposed depth and estimated depth to groundwater.
(5) Quantity of water to be developed and beneficially used.
(6) Land ownership.
(7) Dates when construction will begin and end.
(8) Description of distribution system.
(9) A map must accompany the application (minimum requirements are four inches per mile). Each map must include:
  - Legal location of each well.
  - Location of canals, ditches, pipelines, or flumes.
  - Location of use.
  - Scale, section numbers, and north arrow.

SPECIAL CONSIDERATIONS: A groundwater permit is required if the use of water from a well for industrial and commercial use exceeds 5000 gallons per day.

An examination fee of $200 must be paid to file the application and establish a tentative priority date for the proposed use of water. In addition, a recording fee is also required. The minimum fee for the first cubic foot per second of water is $100, with each additional cubic foot per second $50.

After the well is drilled, Forms A, B, and C are required to be filed with the Water Rights Division. These forms are notices of beginning of construction (A), completion of construction (B), and beneficial applications of water (C). Construction of the well must begin within a year of permit approval. Completion of construction is required within 18 months, and beneficial use of the water must begin within 24 months after approval of permit.

SCHEDULE: There is a minimum 30-day waiting period. Permits are approved after the required waiting period.

ACTIVITY: WATERWAY RELOCATION PERMIT

LEGAL CITATION: ORS 541.605-541.695 and 541.990; OAR 141-85-100

AGENCY/CONTACT:
Oregon Division of State Lands
1465 State Street
Salem, OR 97310
ATTN: Earle Johnson, Section Head (503) 378-3805
Susan Payne, Permits Specialist

PROCEDURE: This permit regulates the removal of materials from beds and banks or the filling of waterways. This permit may be needed prior to removal of contamination along Hammersley Creek near the tailings pile and for the relocation of Hammersley Creek around the tailings site. Oregon Administrative Rule 141-85-100 requires a permit associated with waterway relocation if more than 50 cubic yards of material are to be removed in the relocation process. The information required for this permit is the same as required for a Section 404 permit from the COE. The application forms are the same joint application forms used for the 404 application and are available from the agency. The information required includes:

(1) Complete description of the proposed activity including vicinity maps, plan view drawings, and section drawings sufficient for public notice.
(2) Location and purpose of proposed activity.
(3) Schedule of the activity.
(4) Names and addresses of adjoining property owners.
(5) Location and dimensions of adjacent structures.

SPECIAL CONSIDERATIONS: A fee is required along with the permit application. This fee is dependent on the type of work to be performed.

The Division of State Lands recommends obtaining local government approval prior to submittal of the application. State law requires the Director to seek local government approval before a permit can be approved.

SCHEDULE: Application takes three to six weeks for approval.

ACTIVITY: COMMON CARRIER PERMIT

LEGAL CITATION: ORS Chapters 756 and 767; OAR 860 Divisions 61-68

AGENCY/CONTACT:
Public Utility Commission (PUC)
Safety Section
Labor and Industries Building
Salem, OR 97310
ATTN: Larry Koeneke, Supervisor (503) 378-4355
Carol Reynolds
Certificate Analyst (503) 378-6692

PROCEDURE: Application forms are available from the agency and contain the following:

(1) Name of applicant.
(2) Business name, address, and phone number.
(3) Type of organization (partnership, individual ownership, corporation).
(4) Social security number(s) of owner, partners, or a corporate officer.
(5) Specific commodities to be transported.
(6) Specific territory or area to be serviced.
(7) Financial statement.
(8) List of equipment.
  - Body type.
  - Make of vehicle.
  - License plate numbers.
  - Fuel type.
  - Weight.
  - Vehicle identification number.
(9) Insurance agreement - A proof of bodily, property, and cargo insurance availability to the applicant is required.
(10) Proposed rate tariff.

SPECIAL CONSIDERATIONS: A one-time fee of $150 is required upon application.

Existing carriers and applicants have the right to protest the application. Protests must be filed within 15 days after notice of the application is sent out by the PUC. If no protests are filed, it usually takes an additional two weeks for the permit to be approved.

If a protest is filed, the agency will notify the applicant. A hearing will be scheduled by the PUC. It normally takes from two to four months for a hearing to be held and a decision to be made to grant the permit.

There are numerous carriers in the state of Oregon that have existing permits.

SCHEDULE: Average processing and approval time is 60 days.

ACTIVITY: WATER QUALITY CONSTRUCTION PERMIT

LEGAL CITATION: ORS 486.74, Oregon Administrative Rule 340-14-150

AGENCY/CONTACT: Water Quality Control Division
Department of Environmental Quality
522 SW Fifth
Portland, OR 97204
ATTN: Kent Ashbaker, Section Head (503) 229-5325

PROCEDURE: A special permit for construction is required to control water quality (primarily turbidity) in the state of Oregon. This is a letter permit. There are no application forms. Information required in the request is the time period that construction is to take place and what efforts are proposed to minimize turbidity during construction.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: This letter permit is issued within one or two days after receipt of request.

ACTIVITY: PERMIT TO OPERATE POWER DRIVEN EQUIPMENT

LEGAL CITATION: ORS 477.625

AGENCY/CONTACT:

Oregon State Forestry Department
2290 North 4th Street
Lakeview, OR 97630
ATTN: Don Smith, Unit Supervisor (503) 947-3311

PROCEDURE: The Oregon State Forestry Department requires that a permit be obtained for any operation involving power-driven machinery on or near forest lands (within 0.25 mile) []. This requires the filing of a notification of intent to operate with the local forest protection office. New permits are required each year.

An application form is obtained from the local office. The following information is required:

(1) Name and telephone number of the operator.
(2) Legal location of the work site.
(3) Name of landowner.
(4) Name of timber owner.
(5) Employer I.D. number.

SPECIAL CONSIDERATIONS: This permit is only required for operations on or near forested lands.

SCHEDULE: Application is processed upon receipt. Approval takes two to three days.

ACTIVITY: BORROW SITE CONDITIONAL USE PERMIT

LEGAL CITATION: Lake County Planning Ordinance.
Lake County Comprehensive Land Use Plan

AGENCY/CONTACT: Lake County Board of Commissioners
Lake County Court House
Lakeview, OR 97630
ATTN: Janine Cannon, County Planner (503) 947-4494

PROCEDURE: The Lake County Board of Commissioners requires a Conditional Use Permit for borrow pits within Lake County. The procedure calls for filing a request for a Conditional Use Permit with the county. Information required is:

(1) Legal description of land.
(2) Description of the activity.
(3) Name of landowner.
(4) Plot plan.
(5) Schedule of activities.
(6) Reclamation plan.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: The Board meets the fourth Monday of every month. Sixteen working days prior to a Board meeting are required for staff preparation of the application.

ACTIVITY: DISPOSAL SITE REZONING
(TEXT AND PLAN/ZONE MAP AMENDMENTS)

LEGAL CITATION: ORS 197.005-197.850,
Lake County Land Use Ordinance and
Lake County Comprehensive Land Use Plan

AGENCY/CONTACT: Lake County Board of Commissioners
Lake County Court House
Lakeview, OR 97360
ATTN: Harold Gipson, Chairman
Lake County Board of Commissioners
Janine Cannon, County Planner (503) 947-4494

PROCEDURE: Lake County currently does not have a zoning classification for radioactive waste disposal. A formal written request for zoning the proposed disposal site must be filed with the Board of Commissioners along with the necessary environmental data. A formal public hearing before the Lake County Commissioners will be required prior to any necessary zoning change. Information required for rezoning is:

(1) Location and description of area to be rezoned.

(2) Rationale behind particular site selection.

(3) Description of other sites considered in the evaluation and reasons why these areas were not selected. This can include economic as well as other relevant factors.

(4) Discussion of the long-term environmental, economic, social, and energy consequences resulting from the use of the selected area along with measures designed to reduce adverse impacts.

(5) Advantages and disadvantages of using the desired area and how the new use of the site will affect the surrounding lands.

(6) Demonstration of compliance with the statewide planning goals that have been adopted in the County Comprehensive Land Use Plan.

The environmental assessment prepared for the Lakeview Uranium Mill Tailings Remedial Action (UMTRA) Project site should provide all of the necessary information.

SPECIAL CONSIDERATIONS: The Oregon Department of Energy is currently negotiating with other state agencies and the local authorities over whether rezoning will be necessary.

SCHEDULE: The rezoning process will take from four to six months. Two public hearings have to be held. The first is held by the Lake County Planning Commission, which makes its recommendation to the Lake County Board of Commissioners (LCBC). The LCBC then holds a public hearing, after which the LCBC makes its final determination.

ACTIVITY: ROAD APPROACH PERMIT

LEGAL CITATION: Lake County Ordinances

AGENCY/CONTACT:
Lake County Road Department
P.O. Box 908
Lakeview, OR 97630
ATTN: Darrel Anderson, County Engineer
Iris Robison, Office Manager (503) 947-3353

PROCEDURE: This permit is required for roads constructed off of county roads. The application is obtained from the Lake County Road Department. Information required is:

(1) Applicant's name and address.

(2) Type of permit requested (temporary or permanent).

(3) Drawings and maps showing in detail the location of the proposed activity. Drawings are to be to scale and include a vicinity map. Information on the maps and drawings should include centerline, alignment, slope and right-of-way, culvert sizes, type, and length.

SPECIAL CONSIDERATIONS: None.

SCHEDULE: Permits are approved on the first and third Wednesday of each month.

<u>ACTIVITY</u>:	STANDARD ANNUAL PERMIT
<u>LEGAL CITATION</u>:	ORS 483.528

<u>AGENCY/CONTACT</u>:

Lake County Road Department
P.O. Box 908
Lakeview, OR 97630
ATTN: Darrel Anderson, County Engineer
Iris Robison, Office Manager (503) 947-3353

<u>PROCEDURE</u>: This permit is required to haul materials on Lake County roads. Application forms are available from the road department. Information required is:

(1) Name and address of applicant.

(2) Roads to be used.

(3) Commodity to be transported.

(4) Make, serial/motor number, and license number of each vehicle to be used.

(5) Proof of insurance.

<u>SPECIAL CONSIDERATIONS</u>: Permits are issued on an annual basis. No fee is required. Transport is prohibited during hours of darkness. Each vehicle must have a permit which must be carried in the vehicle at all times.

<u>SCHEDULE</u>: Complete applications are approved upon receipt of the application.

CONCLUDING REMARKS

This section provides brief discussions of issues that at this time do not require permits.

Dust and noise control: There are no permits required for dust or noise control. However, should local residents complain, restrictions may be placed on the operations to help alleviate the problem. This can be enforced under the Lake County nuisance ordinance.

Open burning: Open burning on the processing site is prohibited by the local rural fire marshal. The disposal site falls outside the local fire marshal's jurisdiction as well as the local State Forestry jurisdiction. In these cases, the County Commissioners have the ultimate responsibility. However, they do not at this time require open burning permits.

Ballot measure No. 9: This measure, which was approved by voters in November 1984, prohibits disposal of radioactive materials in areas that have had volcanic activity within the last two million years. It also prohibits any radon gas emissions from the disposal site. Currently, the position of the state of Oregon and the [] DOE is that the Lakeview project is exempt from this ballot measure. The state and the DOE have had a cooperative agreement in place since 1984. The exempt status may be challenged in the courts in the future.

On March 25, 1987, the Oregon Court of Appeals handed down a decision against the Energy Facility Siting Council (EFSC), which if upheld, would have a major impact on the Lakeview UMTRA site. The decision is of great importance since it would require a Title I tailings site to obtain a state of Oregon site certification, similar to a Title II site, and meet the impossible locating criteria established in the state of Oregon.

The Oregon Department of Energy and the State Department of Justice went before the state legislature in May 1987 to ask for their interpretation of Ballot Measure 9. In May the state legislature clarified this bill and exempted the UMTRA Project from this measure. On January 20, 1989, the Oregon Supreme Court also reaffirmed this exemption.

APPENDIX B

CALCULATION SUMMARIES

The draft Remedial Action Plan (RAP) proposed inserting sections B.1 and B.2 of this Appendix in the final printed RAP upon completion and approval. This approach has been modified due to the voluminous materials involved. The final design for construction is bound separately in four volumes (Volumes I through IV), entitled "Calculations, Final Design for Construction." Full sets of these have previously been supplied to the U.S. Nuclear Regulatory Commission and state of Oregon. Additional copies of these calculations are available for review in the UMTRA Project Office, U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico.

The attached Appendix E, Final Plans and Specifications, contains detailed information on the Remedial Action Design.

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B.3 GEOHYDROLOGY

B.3.1 CONCEPTUAL OVERVIEW

Data were collected at the Lakeview processing site and at the Collins Ranch [] disposal site for the purpose of evaluating the present and future characteristics of the groundwater regimes. From these evaluations, the changes in water levels and the rates, characteristics, and concentrations of contaminant migration resulting from the remedial action plan have been estimated.

Due to the proximity of the Lakeview processing site to geothermal activity, an alternate disposal site selection process was undertaken. The Collins Ranch site was selected as the preferred alternative based upon an initial technical evaluation, a field drilling program, and subsequent data analysis.

The detailed Lakeview processing site hydrology is described in Section 5.0 of the draft Processing Site Characterization Report for the Lakeview site (DOE, 1984). Additional data and analyses collected by the Technical Assistance Contractor (TAC) were incorporated into Appendix D of the draft Environmental Assessment (EA) (DOE, 1985a). A summary of the processing site hydrology is presented in the following paragraphs. **Appendix F to this document presents the groundwater compliance strategy for the Collins Ranch disposal site, and includes site characterization data collected since publication of the draft EA and draft Remedial Action Plan (RAP).**

The stratigraphy beneath the **Lakeview processing** site is extremely heterogeneous. Correlations between lithologic types from borehole logs could not be made, even for holes 20 feet apart. Directly beneath the pile are four to seven feet of moist to wet silty clay, underlain by 10 to 20 feet of saturated clayey sand and gravel, followed by three to six feet of moist silty clay. Beneath this silty clay layer are sequences of silty sands and gravel separated by interlayered silty to sandy clays to a depth of at least 2000 feet below the site (Brown et al., 1980). In the upper 75 feet, borehole logs from the processing site area show that the number and thickness of less permeable silty clay lenses decreases from the northeast to the southwest corner of the site.

Beneath the Lakeview processing site, groundwater occurs in a series of interfingered silty sands and gravels separated by discontinuous lenses of clays and silty clays. Three groundwater zones have been investigated in the vicinity of the tailings pile: a shallow seasonal system about five to 15 feet deep, a shallow perennial system about 20 to 30 feet deep, and a system between depths of 60 to 75 feet. The shallowest system dries up in the summer due to a combination of natural discharge, evapotranspiration, and downward migration caused by heavy irrigation pumpage, but is restored every year by natural recharge (Glender, 1985). This system was investigated by Ford, Bacon and Davis, Inc. (FBD, 1983).

The two shallowest perennial systems were investigated by the TAC. The locations and depths of the TAC monitor wells were based on the results of electromagnetic and surface resistivity surveys of the site and surrounding areas. The surface geophysics indicated that contamination extends approximately 600 feet west of the site boundary to a depth of about 20 to 25 feet (Darr et al., 1985). Well pairs screened in the two zones showed less than seven feet difference in water levels, indicating a small potential for downward movement of water from the shallow to the deep zone. Aquifer tests conducted in both screened zones show restricted hydraulic interconnection between saturated zones and leakage occurring between semi-confining lenses.

Groundwater in the unconfined to semi-confined aquifers beneath the Lakeview site moves from northwest to south-southeast under a hydraulic gradient of approximately 0.01 (Figure B.3.1). Values of hydraulic conductivity from pump tests averaged 3.4 feet per day (ft/day) for the first perennial zone and 6.9 ft/day for the second perennial zone. Using the measured hydraulic conductivities, and a conservative estimate of effective porosity equal to 0.15, the calculated average linear velocity is between 0.23 and 0.46 ft/day (80 to 170 ft/year).

The maximum, potential source of groundwater contamination has been characterized with chemical analyses of 26 tailings and raffinate pore water samples. Table B.3.1 summarizes these analyses for key constituents. Table 4.1 in Appendix F includes tailings pore water analyses for several additional hazardous constituents, and includes U.S. Environmental Protection Agency (EPA) proposed maximum contaminant levels (MCLs) for these constituents. Considering that these concentrations were measured in pore water within the source, rather than in underlying groundwater, the concentrations can be considered low for arsenic, cadmium, molybdenum, and uranium. Sulfate, manganese, and aluminum concentrations in the tailings pore water are high; however, these constituents generally do not cause severe health effects. Although contaminant concentrations are higher in the tailings, the primary contaminant plumes originate from the raffinate ponds. The acid-forming potential of the residual aluminum and iron will be considered further in the discussion of the Collins Ranch design.

Groundwater at and around the processing site is characterized by four different geochemical facies: (1) evaporation (raffinate) pond seepage; (2) tailings pile seepage; (3) low temperature, background water; and (4) high temperature, upward-moving geothermal water. The first two facies are contaminant sources. The last two facies are ambient. Migration of evaporation pond and tailings pile seepage is generally confined to the shallow zone above 30 feet. Leachate produced by the downward movement of water through the tailings pile and the evaporation ponds or by groundwater inundation of contaminated material is generating two plumes that merge in the area west of the former tailings pile area (Figure B.3.2). The most significant source area is the southeast evaporation pond.

Table B.3.1 Lakeview pore water samples

Constituent	Number of samples	All concentrations in mg/l[a] Maximum	Minimum	Median	Arithmetic mean	Geometric mean
		Pile (primarily from slimes)				
Arsenic	6	2.19	0.012	0.078	0.535	0.122
Cadmium	6	0.249	<0.001	0.114	0.110	0.043
Molybdenum	5	0.03	<0.001	0.02	0.018	0.014
Uranium	6	0.30	0.01	0.075	0.107	0.061
Sulfate	6	12,700.0	2400.0	3400.0	6000.0	4940.0
Manganese	6	81.5	1.32	24.7	35.2	18.6
Iron	6	1.65	0.04	0.17	0.54	0.68
Aluminum	6	979.0	0.20	200.0	333.0	72.0
		Raffinate pond				
Arsenic	19	0.084	<0.01	0.01	0.029	0.016
Molybdenum	18	0.25	<0.01	0.01	0.038	0.014
Uranium	20	0.18	0.01	0.02	0.03	0.02
Sulfate	18	1600.0	840.0	1150.0	1136.0	1117.0
Manganese	20	2.64	1.09	1.78	1.68	1.63
Iron	19	4.2	<0.03	0.03	0.26	0.037
Aluminum	19	10.8	1.3	5.2	6.3	5.4

[a] mg/l = milligrams per liter

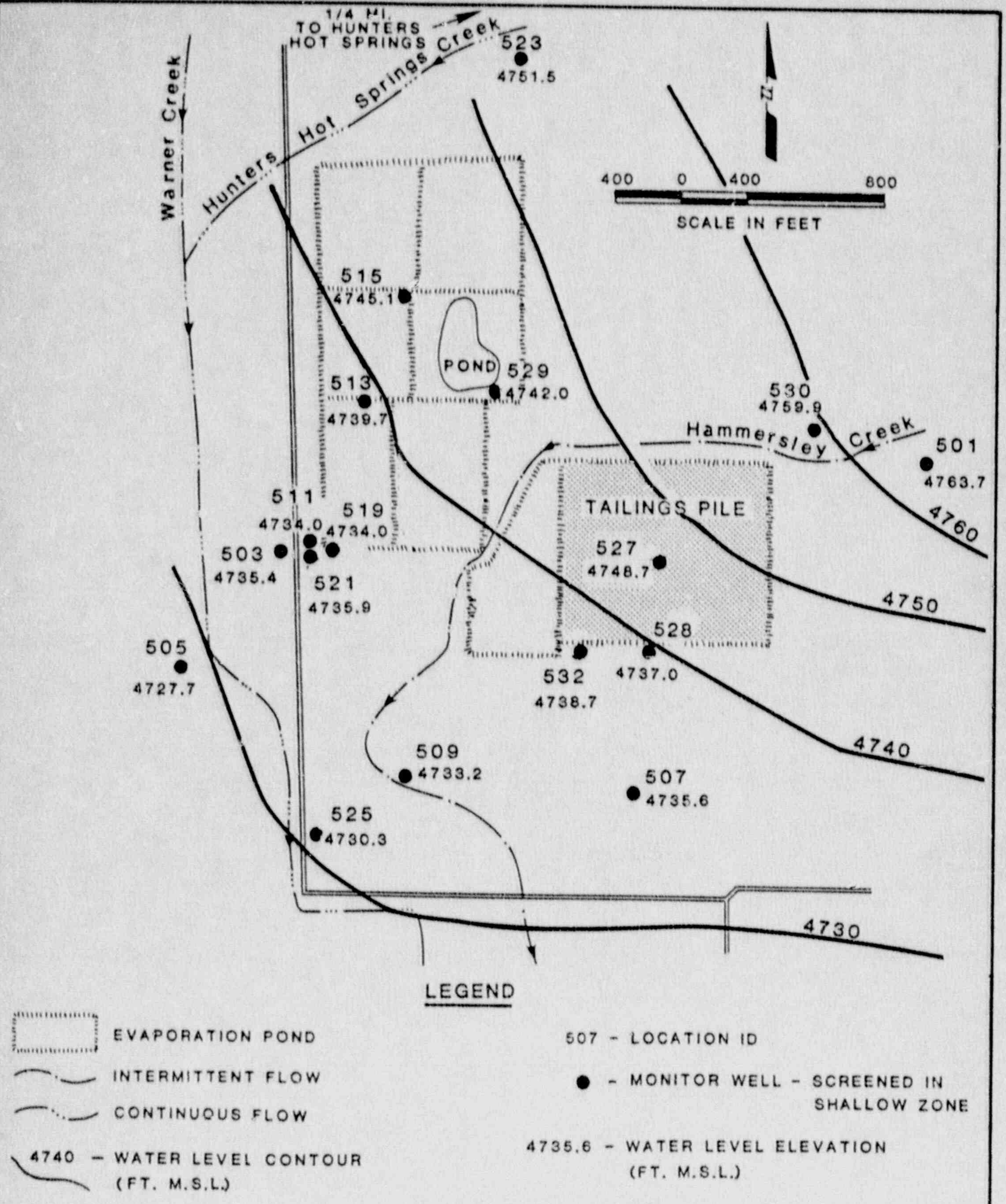


FIGURE B.3.1
POTENTIOMETRIC SURFACE OF SHALLOW AQUIFER
AT THE LAKEVIEW PROCESSING SITE

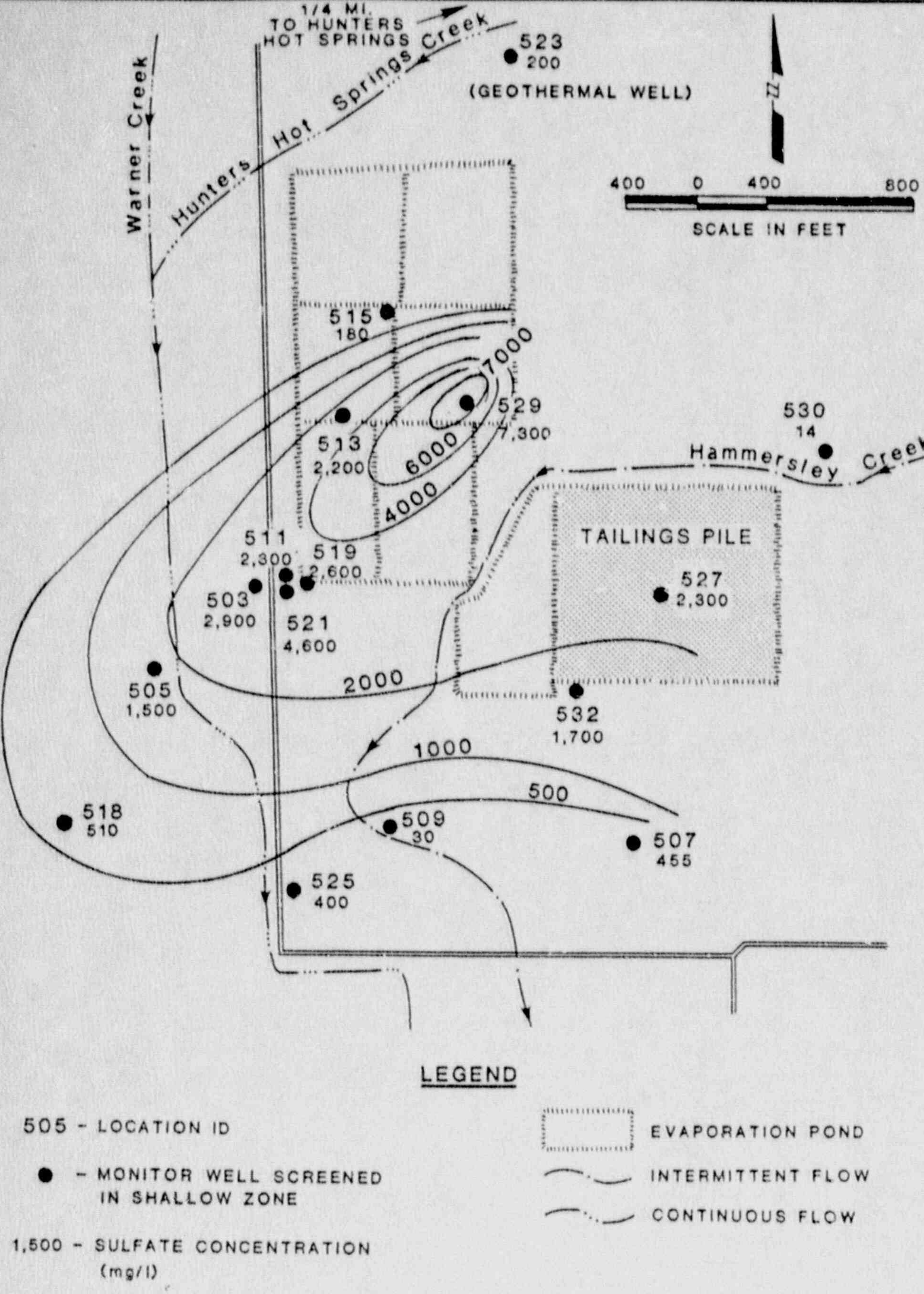


FIGURE B.3.2
SULFATE PLUME IN THE SHALLOW AQUIFER
LAKEVIEW SITE

Some samples of low temperature upgradient "background" waters exceed Oregon Department of Environmental Quality (DEQ) standards for zinc, manganese, and iron, with natural concentrations of 0.02, 2.2, and 0.28, respectively. Samples of high temperature geothermal water exceed EPA primary drinking water standards for arsenic, and secondary standards for boron and fluoride. Representative background values for each constituent are 0.11, 4.0, and 6.0 milligrams per liter (mg/l), respectively. High temperature (>20°C) geothermal water is manifest in domestic wells north of a diagonal line cutting approximately northeast to southwest through the lower evaporation ponds, in TAC wells 523 and 524 directly north of the evaporation ponds, and in Hunter and Warner Creeks. Total dissolved solids (TDS) in geothermal water ranged from 368 to 690 mg/l compared to values of about 200 mg/l in low temperature background waters.

Six constituents have elevated concentrations above state and/or Federal standards in the shallow aquifer beneath and downgradient of the evaporation ponds and tailings pile. Measured concentrations of sulfate, antimony, chromium, iron, cadmium, and manganese were as high as 7300, 0.056, 0.08, 15.5, 0.006, and 16.6 [ ] mg/l, respectively. The maximum sulfate value is greater than the [ ] EPA secondary drinking water standard as well as state water-quality standards for the Goose Lake Basin. Maximum antimony and chromium values were greater than EPA primary drinking water standards and cadmium exceeded Oregon [ ] DEQ limits for natural waters of Goose Lake Basin in one sample from beneath the tailings pile. Iron and manganese values exceeded EPA secondary drinking water standards and state of Oregon standards.

Groundwater samples from the deeper zone (60 to 75 feet) beneath the ponds and downgradient from the site did not exceed state standards for chromium, cadmium, or antimony and showed much reduced sulfate concentrations. However, Figure B.3.3 shows TDS and sulfate isopleths increasing downgradient from the evaporation ponds and tailings pile. This may indicate that shallow contaminated groundwater is migrating downward as water moves downgradient of the site. Alternatively this water may be of geothermal origin with naturally elevated sulfate and TDS concentrations.

To investigate the origin of sulfate in this deeper saturated zone, stable isotope analyses were used to discern between a geothermal source or a processing site source. Samples were collected from wells representing low temperature background water (wells 502 and 533), wells and a spring representing geothermal background water (wells 514 and 523 and Hunters Hot Spring), wells representing shallow groundwater contaminated by raffinate pond leachate (wells 511 and 513), and monitor wells furthest downgradient from the raffinate ponds, completed at depths of 20 to 25 feet and 70 to 75 feet (wells 518 and 506). Samples from wells 518 and 506 contain high sulfate and TDS. Stable isotope analyses were used to "tag" the source of the sulfate, TDS, and other constituents that are found both in the geothermal groundwater and the leachate from the raffinate ponds. Hydrogen-1, Hydrogen-2,

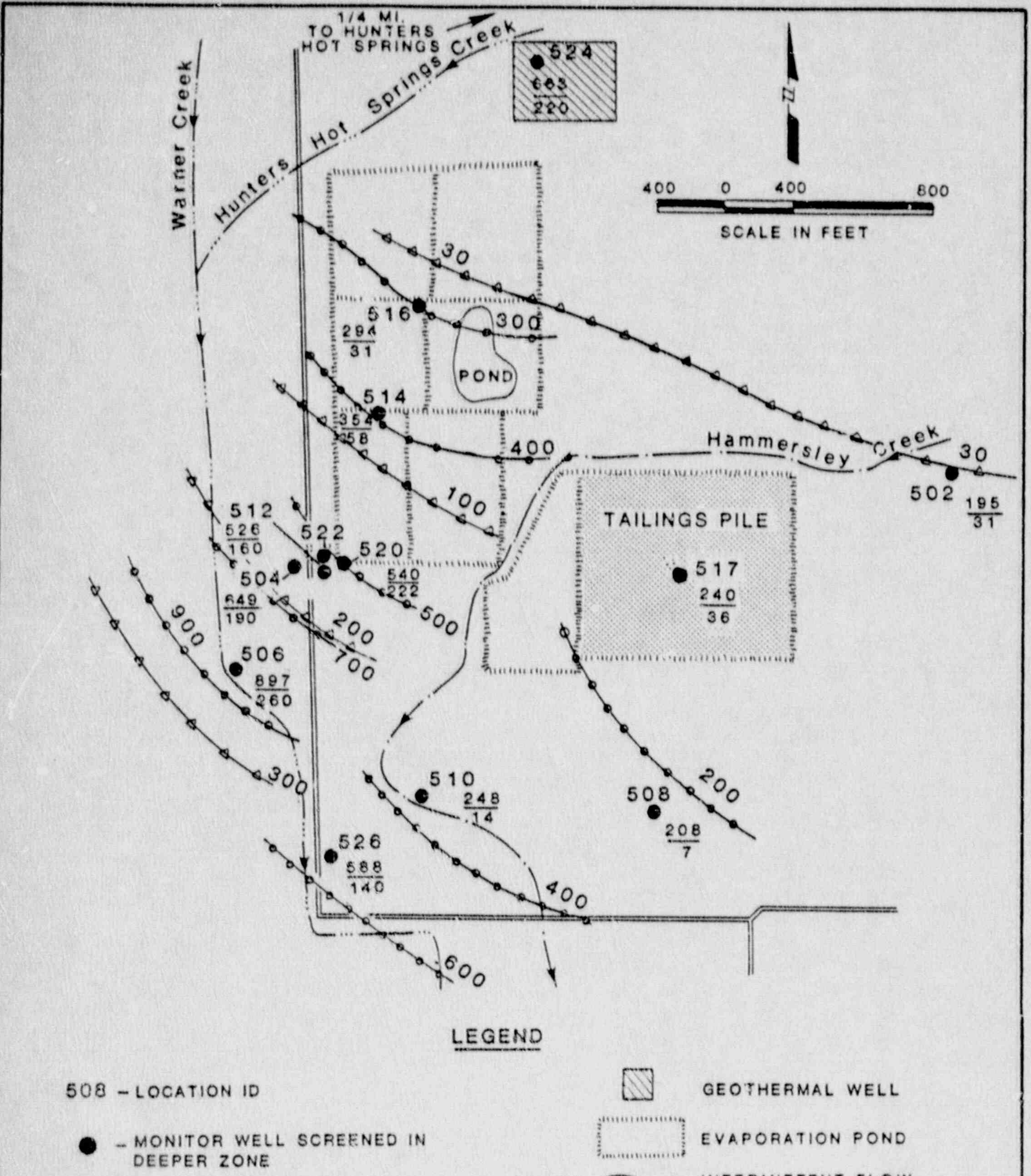


FIGURE B.3.3
TOTAL DISSOLVED SOLIDS AND SULFATE ISOPLETHS
IN THE DEEPER AQUIFER – LAKEVIEW SITE (AUGUST–SEPTEMBER 1984)

Oxygen-16, Oxygen-18, Sulfur-32, and Sulfur-34 were analyzed in each sample. A comparison of the total sulfate concentrations to the Sulfur-32/Sulfur-34 ratio gave the clearest indication of the source of contaminants to these two downgradient wells (Figure B.3.4). The samples from two downgradient wells group with the geothermal background samples, while the samples from wells 511 and 513 are separated. This analysis indicates that the primary source of sulfate, TDS, and trace constituents at distances greater than 600 feet from the site or depth greater than 25 feet is the geothermal system.

Restoration of the residual contamination in the groundwater downgradient of the Lakeview processing site will be considered in detail during a later phase of the UMTRA Project. It is probable that restoration will not be warranted because:

- o The contaminant species originating at the raffinate ponds and tailings pile are non-toxic with the exception of arsenic; however, the arsenic concentrations in the background geothermal groundwater are greater than the concentrations in the contaminant plume.

- o As indicated by water quality and stable isotope data, groundwater contamination is limited to a distance of about 800 feet downgradient of the site and a depth of approximately 25 feet.

- o There are no known groundwater uses within the contaminant plume.

- o No future source of contamination will exist at the site since [] relocation of the tailings and other contaminated materials.

Analyses of groundwater samples collected from the Collins Ranch site in October 1984 are displayed in Table B.3.2. Additional water quality data for the site are included in Appendix F. The major ions present are calcium and carbonate with a relatively large amount of dissolved silica, in a low TDS (300 mg/l) water. All samples show similar chemical speciation; however, there are notably high pH values in samples 508, 513, and 514.

B.3.2 METHODOLOGY

Because assurance of long-term [ ] stabilization at the Lakeview site was not considered possible, an alternate site selection process was initiated. A field hydrologic assessment program was conducted at the Collins Ranch alternate disposal site to physically and chemically characterize the groundwater regime. Seventeen boreholes, including ten completed as monitor wells, were drilled directly on the selected site and in the adjacent valley to the west (Figure B.3.5). Both disturbed and undisturbed samples and well-log data were obtained to

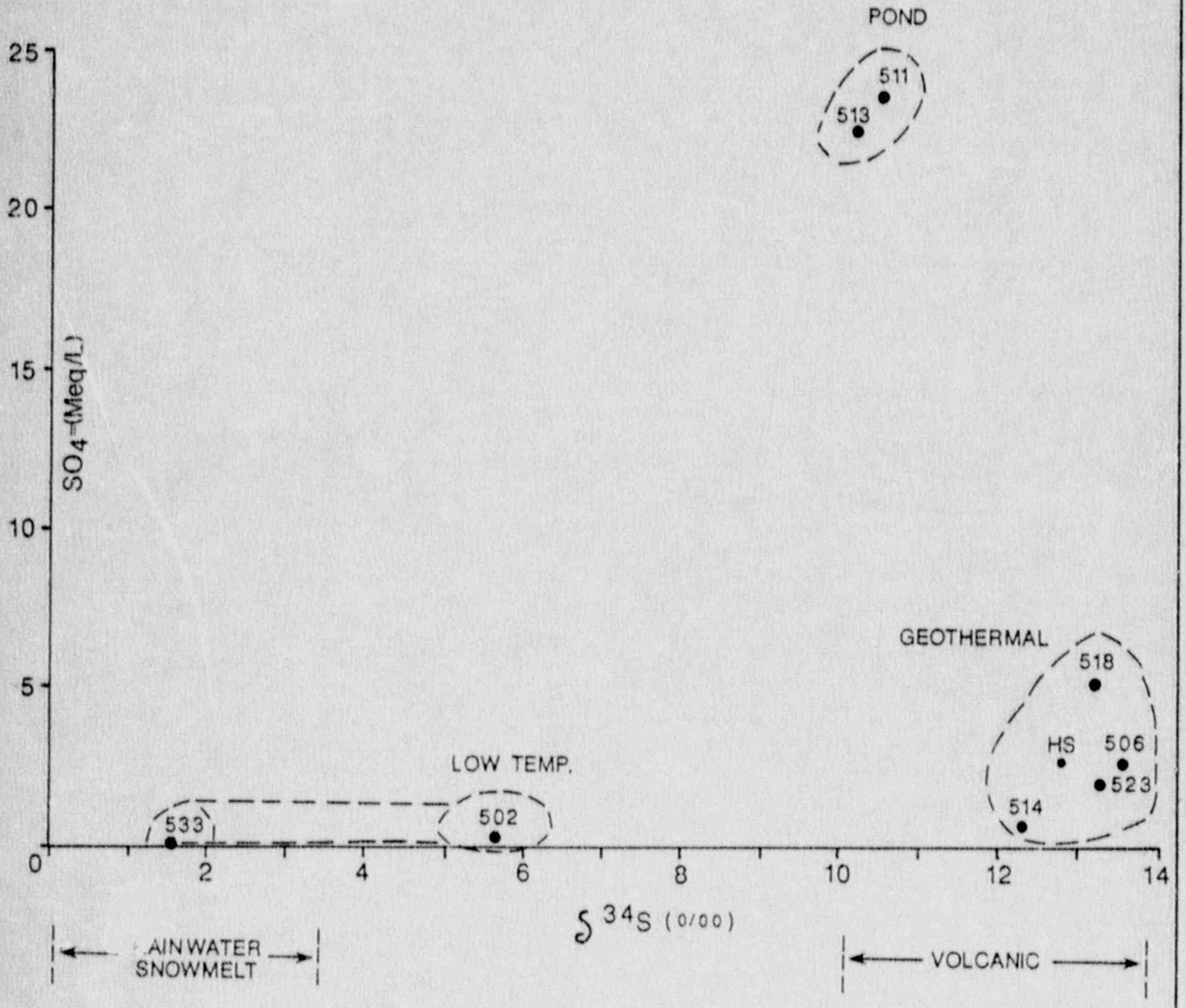


FIGURE B.3.4
DISTRIBUTION OF SULFATE CONCENTRATION vs. SULFUR-34 ISOTOPE RATIO

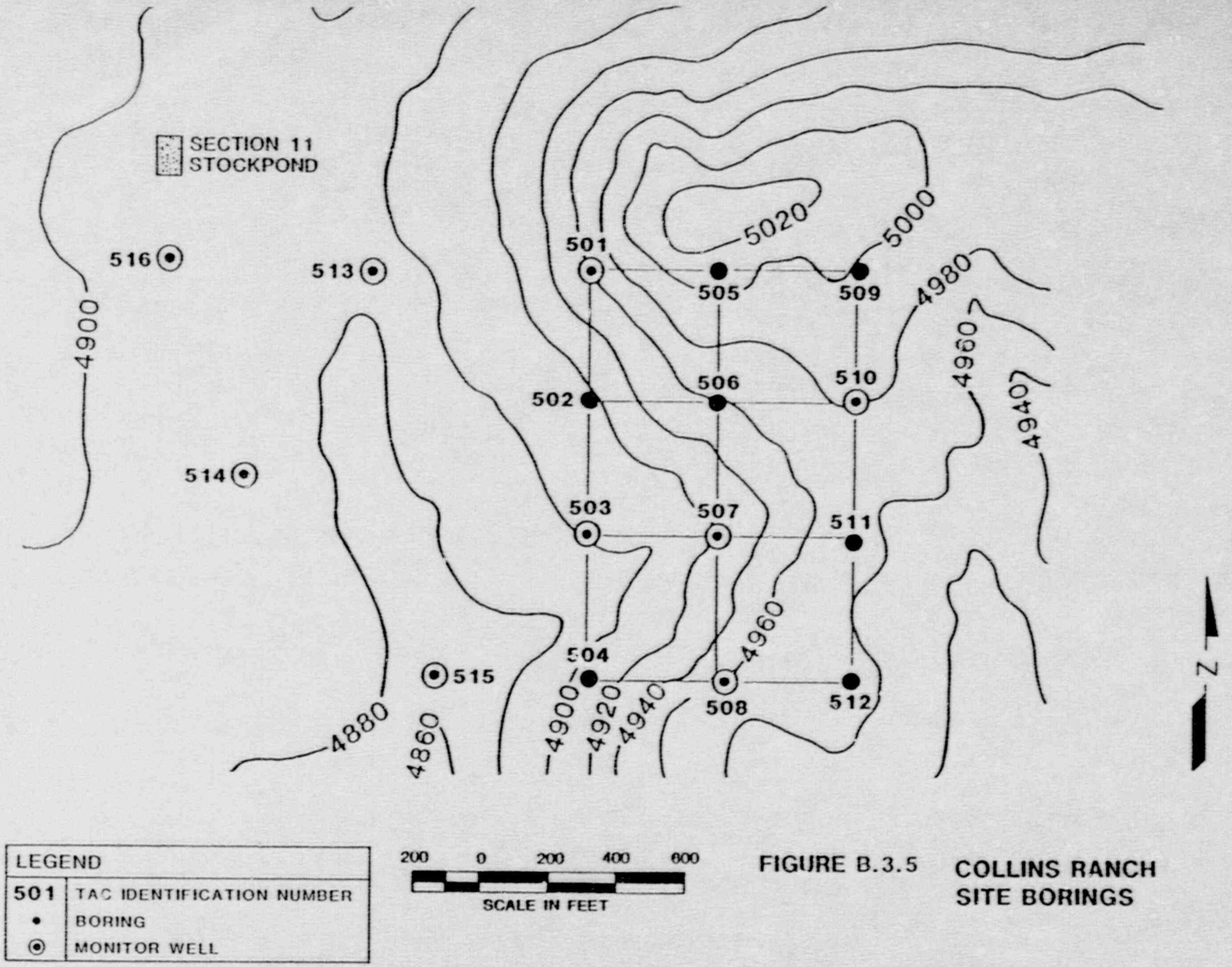


FIGURE B.3.5 COLLINS RANCH SITE BORINGS

Table B.3.2 Analyses of groundwater samples at the Collins Ranch disposal site (October 1984)

Parameter[a]	Location ID				
	LKV02-508	LKV02-513	LKV02-514	LKV02-515	LKV02-516
Na (mg/l)	20.9	27.6	21.0	13.8	24.1
K (mg/l)	8.01	11.2	10.3	7.12	11.3
Mg (mg/l)	5.45	4.48	0.77	9.53	4.41
Ca (mg/l)	29.0	21.7	51.7	36.8	15.6
Cl (mg/l)	4	6	6	3	3
SO_4 (mg/l)	13	22	23	8	7
NO_3 (mg/l)	<1	4	10	4	7
Fe (mg/l)	<0.03	<0.03	<0.03	<0.03	<0.03
Mn (mg/l)	0.02	<0.01	<0.01	<0.01	<0.01
As (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
Cr (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
Mo (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
Pb (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01
Sb (mg/l)	<0.003	<0.003	<0.003	<0.003	<0.003
Se (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005
U-234 & -238 (pCi/l)	<1/<1	<1/<1	<1/<1	<1/<1	<1/<1
Cu (mg/l)	0.05	0.02	<0.02	<0.02	<0.02
V (mg/l)	0.01	0.02	0.05	0.01	0.01
Zn (mg/l)	0.012	<0.005	0.005	0.014	0.009
NH_4 (mg/l)	0.20	0.20	0.20	0.20	0.10
B (mg/l)	0.11	0.28	0.08	0.03	0.20
F (mg/l)	0.20	0.20	0.20	0.10	0.20
Si (mg/l)	24.1	29.3	34.0	32.0	31.6
PO_4 (mg/l)	0.79	1.49	0.53	0.59	2.45
TDS (mg/l)	182	190	240	188	164
CDT (µmhos/cm)	287	322	389	310	270
pH (mg/l)	8.88	8.96	10.35	7.14	7.78
Temp.(°C)	12	12	14	14	14
Alk. (mg/l as $CaCo_3$)	144	109	142	142	120

[a] pCi/l = picocuries per liter; µmhos/cm = micromhos per centimeter.

characterize properties of the foundation materials and to describe site lithology. Seven of the **original** 10 monitor wells encountered groundwater (507, 508, 513, 514, 515, 516, and 517). Slug tests were performed to obtain a range of characteristic hydraulic conductivities at these locations. Groundwater levels were recorded to define the potentiometric surface, and continuing measurements provided indications of seasonal fluctuations. Groundwater samples were collected, with in situ parameters such as pH, temperature, and electrical conductivity recorded in the field. Analyses of chemical constituents were used to characterize the existing hydrogeochemical environment.

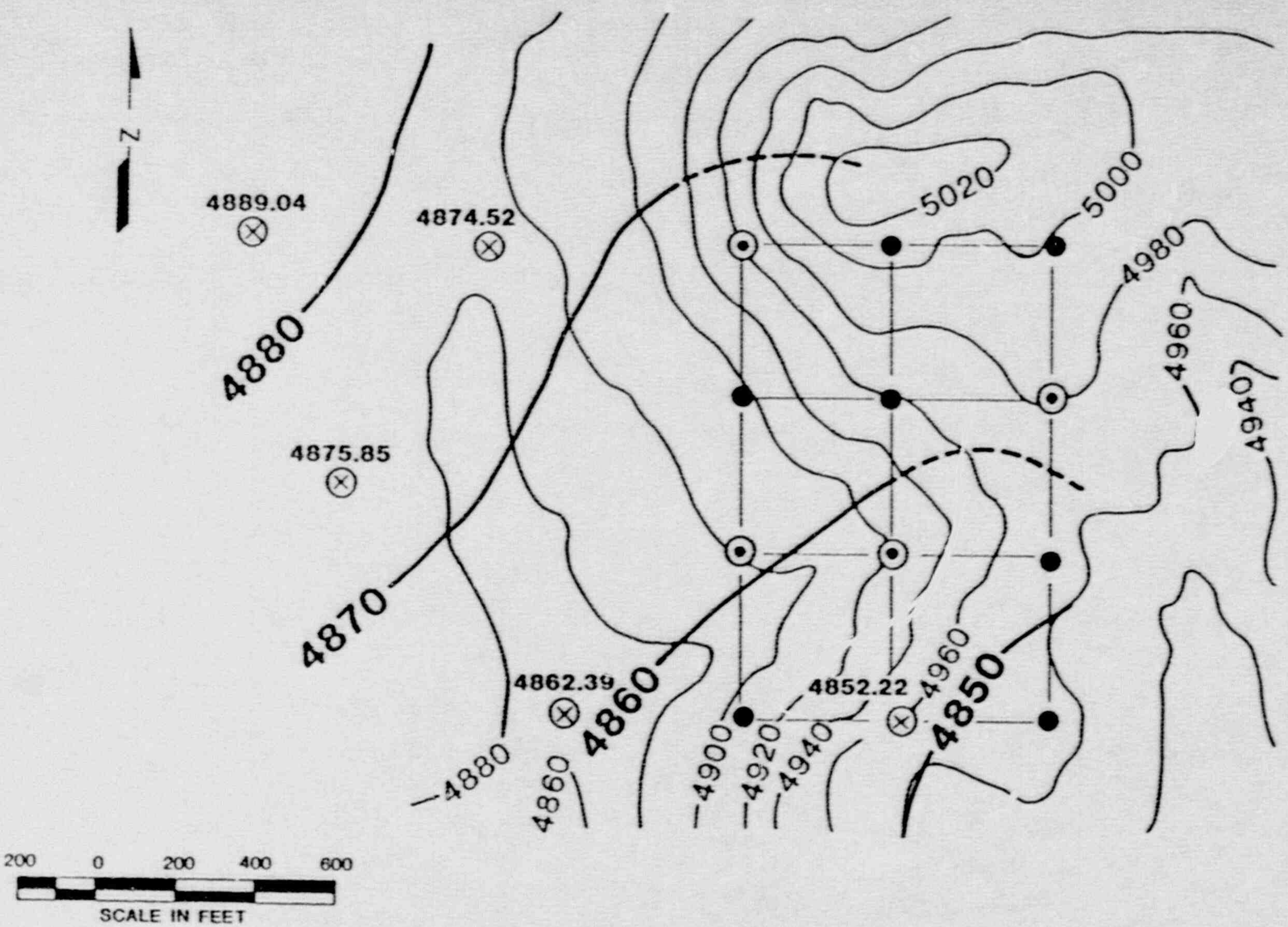
Four additional monitor wells (520-523) were installed in August 1986 at the Collins Ranch site. These wells are included in the Appendix F analyses.

B.3.3 EXISTING CONDITIONS

Figure B.3.6 is a potentiometric contour map based upon water levels encountered in five of the monitor wells in the autumn of 1984. Figure B.3.7 is a map based on seven water level measurements from the summer of 1985. Groundwater moves under an apparent hydraulic gradient of 0.018 from northwest to southeast, opposite the topographic slope of the site. Groundwater was encountered at depths from seven feet (516) to 15 feet (515) in the adjacent valley west of the disposal site. Beneath the proposed disposal site groundwater was encountered in three of the six [ ] monitor wells at depths of 76, 73, and 65 feet. The remaining three of these on-site wells did not produce groundwater throughout the maximum depth penetrated by the borehole (DOE, 1985a [ ]). The fluctuation of the [ ] water levels generally was less than two feet through the autumn of 1984 and the winter, spring, and summer of 1985.

Groundwater occurs under unconfined to semi-confined conditions within a series of fine silty sands and clayey silts that extend to an estimated depth of 1000 feet. An average hydraulic conductivity calculated from five slug tests is 0.37 ft/day for sediments above 87 feet at the site. This falls in the range of values for silty loesses and silty sand materials (Freeze and Cherry, 1979). Laboratory porosity values were calculated for a representative sand sample. The value was 0.45. Values of effective porosity listed by Todd (1980) for loess (a mixture of sediments most descriptive of the site) are about one-third the value of total porosity. A representative value of effective porosity for the Collins Ranch sediments would be 0.15.

An estimate of the average linear velocity based upon the average hydraulic conductivity of 0.37 ft/day, the hydraulic gradient equal to 0.018, and an estimated conservative value for effective porosity of fine-grained, silty, clayey soils equal to 0.15 is calculated from Darcy's Law:



LEGEND			
4852.22	WATER LEVEL ELEVATION (ft. msl)	●	BORING
4940—	TOPOGRAPHIC CONTOUR	⊙	MONITOR
4850—	POTENTIOMETRIC CONTOUR	⊗	MONITOR W/ WATER

FIGURE B.3.6 POTENTIOMETRIC SURFACE AT COLLINS RANCH SITE AUTUMN, 1984

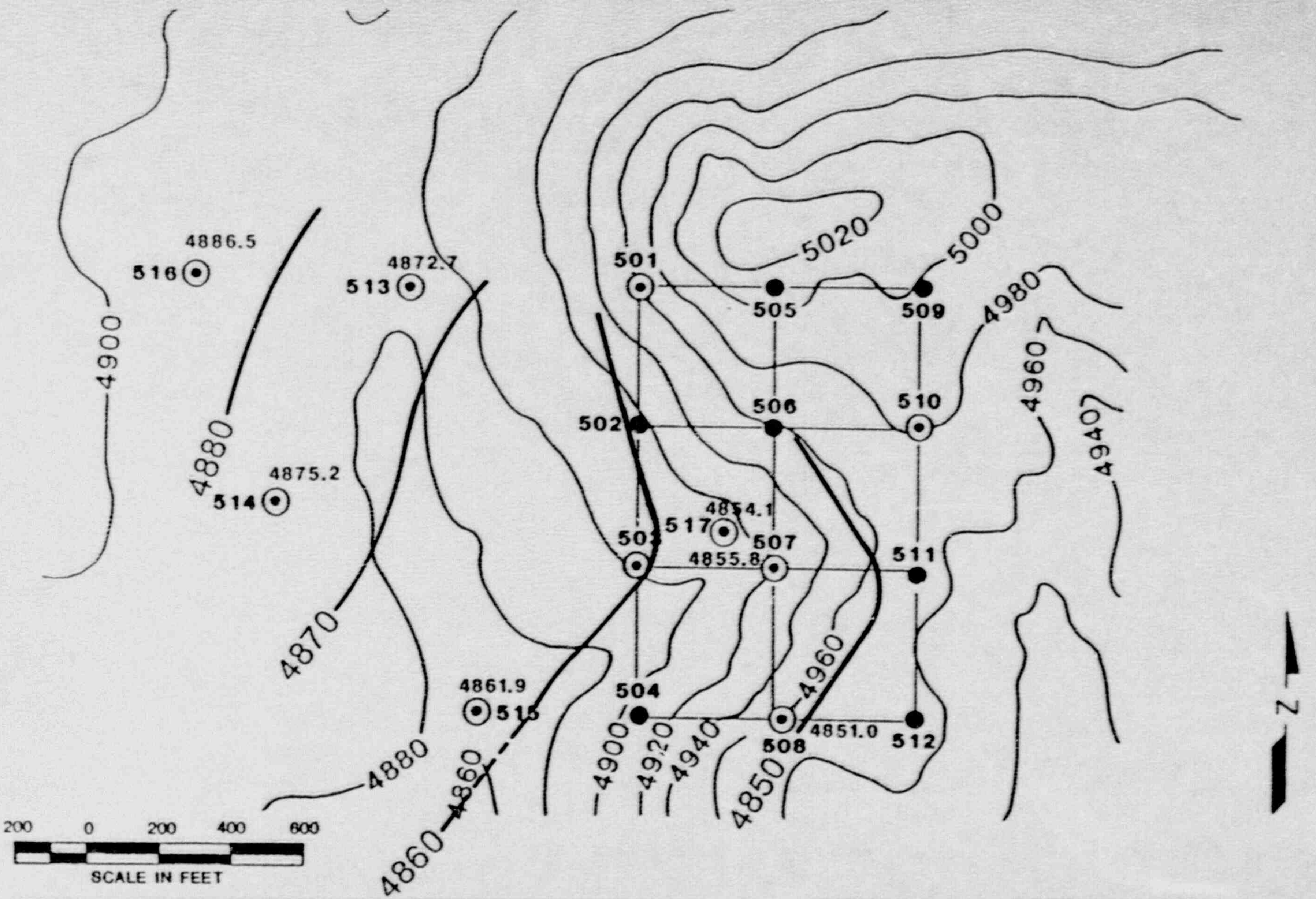


FIGURE B.3.7 POTENTIOMETRIC SURFACE AT COLLINS RANCH SITE SUMMER, 1985

LEGEND			
4852.22	WATER LEVEL ELEVATION (ft. msl)	●	BORING
4940—	TOPOGRAPHIC CONTOUR	⊙	MONITOR
4850—	POTENTIOMETRIC CONTOUR		

$$V = \frac{K\nabla h}{n_e}$$

where

V = horizontal component of average linear velocity [ ]

K = hydraulic conductivity [ ]

∇h = hydraulic gradient [ ]

n_e = effective porosity [ ] (minimum assumed value)

Thus, based upon the assumed values stated above, the calculated groundwater velocity is approximately 0.044 ft/day, toward the southeast.

The groundwater flow direction and the lack of seasonal fluctuations in static water levels show that the predominant source of recharge to the groundwater system is from the Fremont Mountains to the west, rather than infiltration through on-site soils. This is also supported by groundwater quality data showing low TDS, high silica, and high pH water typical of groundwater recharge through volcanic deposits. Soil samples, laboratory permeability tests, tensiometer measurements, and lysimeter sampling further indicate that groundwater recharge through the soils at the Collins Ranch site is minimal. These data also show that most of the recharge that does occur moves through thin, connected lenses and stringers of silty sand, rather than uniformly through the soil horizon.

- Soil samples - Undisturbed soil samples, collected while drilling well 517, contained primarily a silt matrix with horizontal and vertical connections of sand that were one to several millimeters thick. These thin sand lenses and stringers were much moister than the surrounding silt matrix.

- Permeability tests - Tests on eight samples for laboratory hydraulic conductivity produced seven values ranging from 10^{-8} to 10^{-6} centimeters per second (cm/s), while one value was approximately 10^{-4} cm/s. The seven lower values represent the predominant silt. The one higher value indicates silty sand.

- Tensiometer measurements - The solid line in Figure B.3.8 shows the suction profile recorded with a nest of seven tensiometers. The dashed line shows a typical profile expected for uniform soil during dry conditions. The profile at the Collins Ranch site indicates that water moves along tortuous paths through vertical and horizontal preferential pathways of sand rather than uniformly downward.

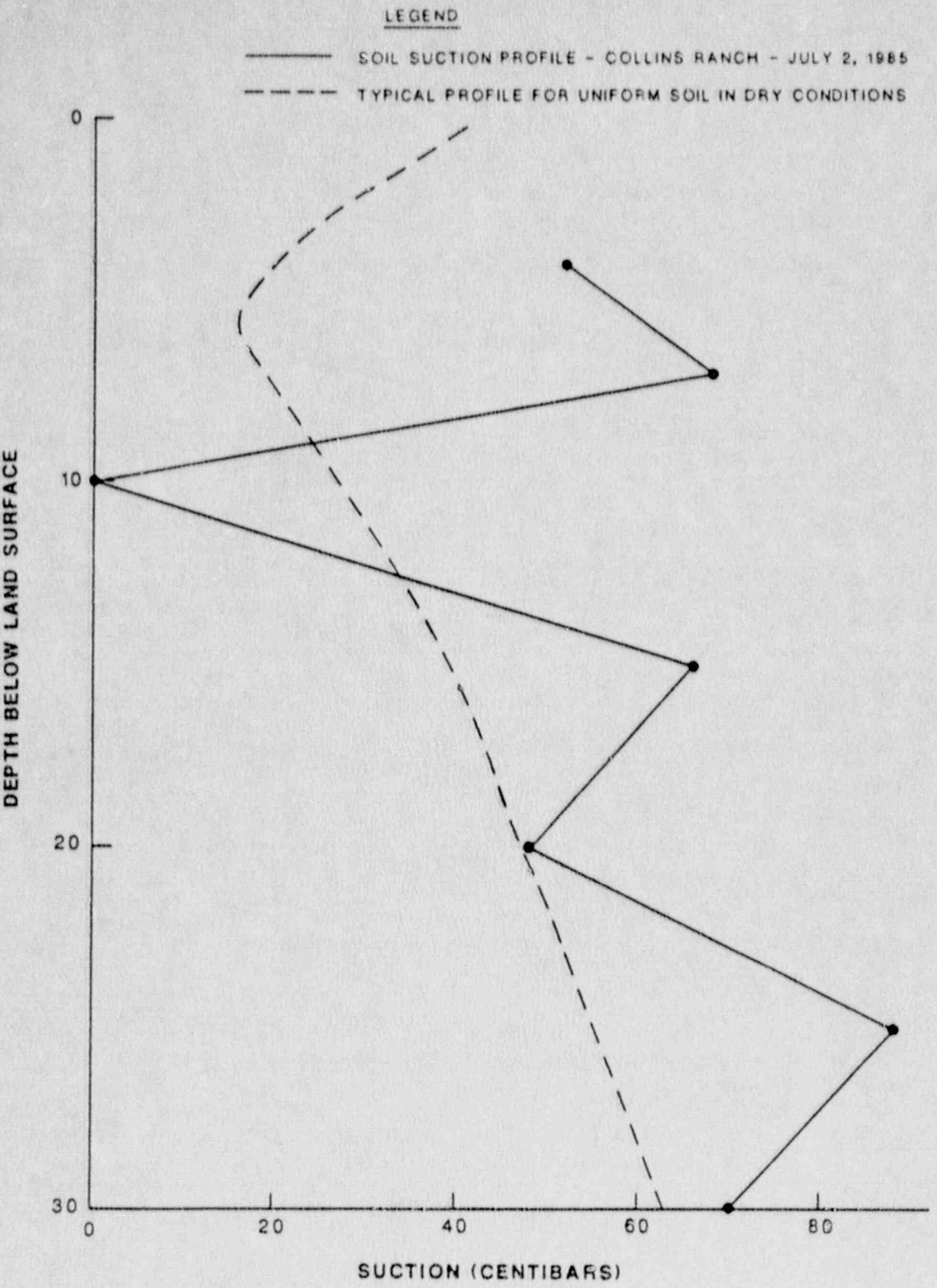


FIGURE B.3.8
SOIL SUCTION PROFILE - COLLINS RANCH SITE

- Lysimeters - Samples could be collected where a sand lens was encountered. This was at four, 10, and 30 foot depths. Samples could not be collected at seven, 15, 20, and 25 foot depths. The samples were analyzed for tritium. Tritium analyses can be used to estimate the age of modern (less than 30 years old) water. Using tritium concentrations at the three depths, relative tc the tritium concentrations of a nearby surface water sample, the estimated travel times are:
    - to a depth of four feet: at least 2.2 years.
    - to a depth of 10 feet: at least five to six years.
    - to a depth of 30 feet: at least 30 years.

Details of these calculations and supporting data are given in the Disposal Site Characterization Report (DSCR) (DOE, 1985a).

Groundwater discharges to surface drainages east of the site in the Goose Lake Valley and to heavily pumped irrigation wells.

B.3.4 REMEDIAL ACTION AND POST-REMEDIAL ACTION CONDITIONS

Appendix F presents the proposed groundwater compliance strategy for the Collins Ranch site. The following section discusses in qualitative terms the site-specific hydrogeologic, geochemical, and engineering (design) factors that will allow the site's compliance with proposed EPA groundwater standards for UMTRA disposal sites.

During relocation of the tailings to the Collins Ranch site, there were no impacts to the groundwater. The excavated and contoured disposal area on the western slope of Augur Hill did not encounter any saturated formations. Under this [] design, the base of the tailings rests at least 20 feet above the current groundwater level beneath the southwest toe of the embankment. Depth to groundwater increases in the direction of increasing tailings thickness and levels of increasing contamination from the western toe of the disposal site east to the Augur Hill divide. Two seeps on the north wall of the disposal cell were breached during remedial action. A French drain system has been installed to handle any water in this area.

During remedial action, impacts to groundwater at the Lakeview tailings site could have resulted from excavation of the contaminated materials due to the shallow position of groundwater at the site. The Remedial Action Contractor (RAC) excavated deeper materials when the water table was deeper. Excavation below the water table was avoided. Any increase in the release of contaminants was only for a short duration until all materials were removed. Dewatering of the shallowest saturated zones was not necessary to prevent the release of intercepted contaminated groundwater.

After remedial action, impacts to groundwater at the Collins Ranch disposal site will be minimal. The one-foot compacted radon and infiltration barrier cover design should further reduce the naturally low infiltration capacity of the soils at the site. This cover has a saturated hydraulic conductivity of less than 1×10^{-7} cm/s. At the lowest point of the embankment excavation coinciding with the highest groundwater elevation, the water table is presently at least 20 feet below the base of the tailings. In 1987, the water table rose less than two feet anywhere around the site following the spring snowmelt. Therefore, groundwater inundation at the base of the pile is extremely unlikely.

At the base of the excavation, a two-foot, recompacted, natural soil layer was installed under the tailings **before they were** placed [ ]. The layer is composed of excavated site materials consisting of silts and clays with an average permeability from laboratory tests of about 1×10^{-6} to 1×10^{-7} cm/s (see [ ] DOE, 1985b). This layer has three functions:

- Preferential pathways of silty sands will be eliminated. The homogeneous soil layer guarantees uniform seepage around the embankment, if and when seepage does occur.
- Laboratory tests on soils representative of this layer show that any remaining acidity produced by the relocated materials would be neutralized by the first foot of this two-foot thick layer assuming:
  - That acid will be produced by the hydrolysis of the remaining water-soluble aluminum and iron in the relocated tailings and raffinate material.
  - That the average concentrations of aluminum and iron (see Table B.3.1) in the pore water accurately represent potentially water-soluble concentrations in the total volume of relocated material.
  - That the layer contains an average of 1.3 percent carbonate, as determined by eight tests on representative soil samples.
  - That when neutralization occurs, aluminum and iron hydroxides, oxides, and oxyhydroxides, and amorphous sulfate compounds such as a gypsum will precipitate (Pyrih, 1983, Henry et al., 1982; Pyrih, 1982). Trace constituents, such as arsenic and uranium, tend to coprecipitate with the amorphous compound, thus reducing their soluble concentration. Also, the precipitates will reduce the permeability of the layer by clogging the pore space. Details of the neutralization calculations appear in the DSCR (DOE, 1985b).
- Judging from laboratory soil tests, this layer contains approximately 10 percent clay and 90 percent silt. Although the major chemical effect of this layer is to neutralize acid tailings solution, the absorptive ability of the layer also

removes trace metal contaminants from solution contacting the layer.

This soil layer provides a continuous, highly attenuative zone for contaminant adsorption and ion exchange. The properties of the soils in this layer (Section 5.0 of the RAP text) create a geochemical barrier against contaminant transport similar to, but more effective than, the interface zone between the tailings and soil present at the Lakeview processing site (DOE, 1985a[ ]).

Beneath this recompacted geochemical/flow barrier, there are presently a minimum 20 feet, and generally 50 feet or more, of unsaturated soils composed of predominantly silts, silty sands, and clayey sand-silt mixtures. By the Unified Soil Classification System, all of these soils are classified as fine-grained with more than half the particles smaller than No. 200 sieve size (or the limit visible to the naked eye). Such soils provide high dispersivity and a very large particle surface area required for sorption processes to remove solutes from solution (Bouwer, 1978). Specific sorption processes that remove contaminants from solution are ion exchange, matrix diffusion, non-specific electro-static sorption, and chemical partitioning between the aqueous and mineral phase in a system.

Travel times through this fine-grained unsaturated zone are expected to be much longer than seepage rates calculated using available saturated hydraulic conductivity values (DOE, 1985a [ ]). In laboratory tests, saturated soils representative of those beneath the site have hydraulic conductivities that range from approximately 1 x 10^{-6} to 8 x 10^{-8} cm/s (Section 5.0 of the RAP text). However, numerous investigators have shown that partially saturated, fine-grained porous media have much lower (orders of magnitude) hydraulic conductivities than if the same media are saturated (Elzeftawy and Cartwright, 1981). Furthermore, numerous studies of contaminant migration through fine-grained soils have found that radionuclides move much more slowly than the groundwater velocity (Drever, 1982; Pickens et al., 1980).

The design for tailings stabilization at the Collins Ranch site is intended to isolate the pile from groundwater and minimize infiltration and subsequent leaching of contaminants from the pile. Projected impacts to the groundwater after remedial action are based upon analytical calculations presented in Section D.2.6 of the Lakeview EA (DOE, 1985a).

Based on the analysis of the tritium data from samples at four and 10 foot depths, seepage may require from 40 to 100 years to move from the base of the embankment to the water table. This analysis neglects attenuation time for contaminant species such as uranium and arsenic, which may be on the order of 10^3 to 10^6 years (DOE, 1985a [ ]). Because the primary geochemical nature of the tailings and the substrate soils at Collins Ranch will be similar to the Lakeview processing site, it is expected that a similar geochemical equilibrium will be established and a similar chemical plume would eventually emanate from the stablized pile well into the future. In this occurrence, radionuclides and most heavy metals would be attenuated at the pile-soil interface zone, and mobile species such as sulfate, manganese, and sodium would mix with the existing low TDS groundwater beneath the site. This mixed water would move slowly (about 20 ft/year) with the groundwater toward the valley southeast of the site. There are no known shallow groundwater users within 1.5 miles downgradient from the site.

The heavy groundwater uses southeast of the site are for irrigation and municipal supply. The users are required by state statute and historically have allowed water levels to recover to pre-pumping levels (Glender, 1985). Therefore, steep hydraulic gradients toward the nearest irrigation wells should not be produced. Eventually, groundwater moving beneath the Collins Ranch site will be intercepted by these wells; however, the effects of geochemical attenuation, dispersion, and dilution should make any impact on water quality that could result from the site insignificant.

See Appendix F for a more systematic demonstration of the site's compliance with the proposed EPA groundwater standards.

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B.4 FLOOD ANALYSIS

B.4.1 CONCEPTUAL OVERVIEW

Flooding is not considered to be a hazard at the Collins Ranch site. The [ ] embankment is located along the southwest slopes of Augur Hill adjacent to a drainage divide. An area of approximately 29 acres (including the embankment area) drains toward the site. The closest perennial stream, Camp Creek, flows at an elevation 50 feet below the site at its closest point, approximately 3000 feet from the site. About one mile upstream from the site, the stream is restricted in a narrow valley, which would create high flood levels. As it approaches the site, however, the valley opens into a broad basin that lowers flood levels and reduces velocities, making it improbable that the site could be flooded by Camp Creek.

The primary purpose of this analysis is to assure that the embankment design for the Collins Ranch site satisfactorily addresses short-term and long-term protection. Short-term flood protection simply defines the extent of the 500-year flood and the impacts, if any, on the embankment or on remedial action construction activities. The primary purpose of this assessment is for compliance with Floodplains/Wetlands Environmental Review Requirements (10 CFR Part 1022).

To accomplish the objective of long-term flood protection, flow conditions resulting from a Probable Maximum Precipitation (PMP) occurring at the site were analyzed and a drainage ditches were designed to protect the embankment from the resultant runoff. Details on the ditch design are included in "Calculations, Final Design for **Construction" issued separately from this document, and available from the UMTRA Project Office, Albuquerque, New Mexico.**

B.4.2 DESIGN EVENTS

B.4.2.1 500-year flood

As stated in Section B.4.1, an estimate of the 500-year flood is used primarily for compliance with 10 CFR Part 1022.

The 500-year rainfall intensity was estimated using methods outlined in HMR-43 (ESSA, 1966) and Technical Paper No. 25 (USDC, 1955). Times of concentration were determined using overland flow and basin characteristics (AISI, 1971; 1980). Runcff hydrographs were calculated using the Linear Reservoir Routing technique (Stubchaer, 1975) and Green-Ampt infiltration parameters (Rawls and Brakensiek, 1983). Channel velocities and depths of flow were estimated using the Manning formula (COE, 1970). Cross sections of the stream channel closest to the proposed site were obtained from USGS quadrangle maps (1:2,400,000) and were assumed to have either triangular or trapezoidal shapes.

A 500-year, 24-hour rainfall of 3.4 inches was determined for the 12.5 square mile drainage area of Camp Creek above the Collins Ranch site. A discharge of 5055 cubic feet per second (cfs) was calculated for the 500-year flood. Estimated velocities ranged from six to 9.5 feet per second. Depths of flow ranged from two to seven feet. The results of this analysis show that the 500-year flood of Camp Creek would approach no closer than 2400 feet to the Collins Ranch site.

B.4.2.2 Probable Maximum Flood

The use of the Probable Maximum Flood as the design flood event to achieve long-term control of uranium tailings is not clear-cut. The EPA has proposed standards requiring that control of tailings from uranium milling must be effective for 1000 years (to the extent reasonably achievable) and, in any case, for at least 200 years. The standard design approach is to determine the magnitude and potential impacts resulting from a PMP event. If a PMP design is not practical, then alternate design events or solutions are assessed.

In the case of the Collins Ranch relocation design, it was determined that due to the single small drainage area above the site, drainage ditches could be practically designed to protect the embankment from PMP flows. If a PMP were to occur, runoff from the embankment would flow to drainage ditches located south and west of the embankment and be directed to the natural drainage patterns southwest of the site.

B.4.3 GEOMORPHIC CONSIDERATIONS

Camp Creek is deeply incised into joint or fault systems in basaltic bedrock up to about one mile northwest of the Collins Ranch site, and its position appears to be firmly fixed up to that point. South of there, the creek flows in a 0.25 to 0.50 mile wide channel 2800 to 4000 feet west of the site, and from 40 to 60 feet below the base of the proposed embankment. It has a braided channel morphology typical of a bedload stream. Streams of this type are common on alluvial fan deposits. They are generally subject to rapid shifts, bank sediments are easily eroded, and evulsion is a common occurrence. The morphology of Camp Creek indicates a channel of relatively low stability, subject to unpredictable shifts. However, since the channel is fixed in bedrock up to one mile northwest of the site, it could not threaten the stability of the site area without eroding a fairly abrupt eastward bend through the alluvial deposit that forms the terrace levels west and southwest of the Collins Ranch site.

It has also been determined that there is no potential for the formation of mudslides in the site area due to the absence of susceptible materials, such as tuffuceaous sediments, alluvial fan deposits, or unconsolidated alluvium. Even though minor rockfalls or small landslides may occur on the steep slopes that flank Camp Creek and Augur Creek upstream of the site, the volumes of material that could be involved are small and could not affect drainage directions, or result in the formation of temporary natural dams or catastrophic floods. These additional geomorphic data are contained in Appendix C of the Final DSCR for Collins Ranch (DOE, 1985).

At the present time, the creek appears to be following a pattern of continuous downcutting toward the west. The potential for a significant eastward shift through the previously mentioned terrace levels resulting in a potential erosion problem at the Collins Ranch site is very low (SHB, 1985).

Branching gully systems currently infringe on the site area from all sides. The embankment area itself is a large swale formed by a branching gully system. The main gully in this system ranges from two to four feet deep and is fed by branching gullies that drain the entire site. The system bends southward at the boundary of the site and drains to Camp Creek.

The proposed embankment design will fill the major gully infringing on the site area from the west and will eliminate the potential for headcutting of this gully system into the stabilized tailings. The placement of rock erosion protection material over the embankment and in the drainage ditches will further reduce the potential for erosion of the tailings cover system. Details are provided in "Calculations, Final Design for Construction," available from the UMTRA Project Office, Albuquerque, New Mexico. The Collins Ranch site drainage characteristics are shown in Figure B.4.1.

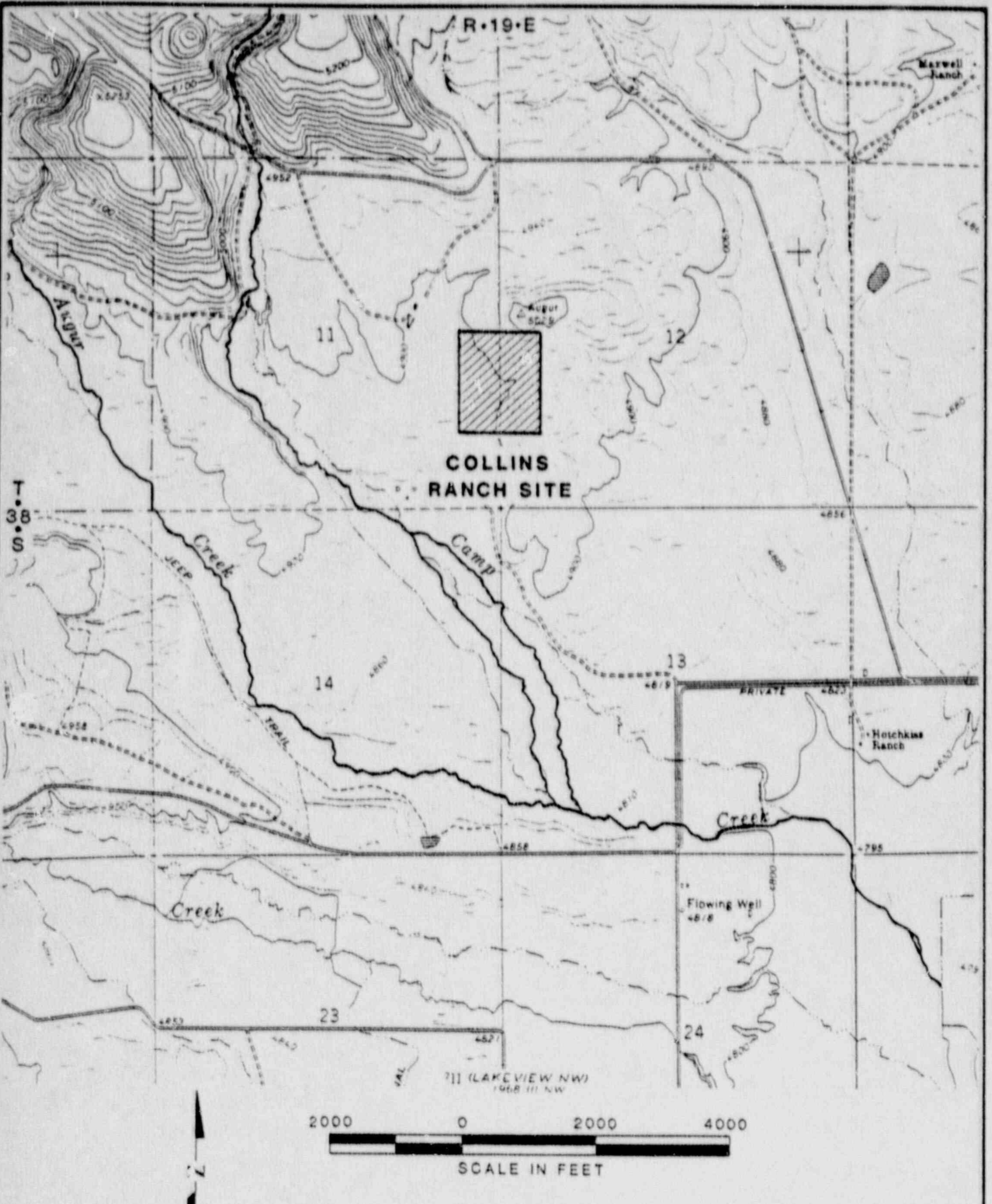

FIGURE B.4.1
COLLINS RANCH SITE - DRAINAGE CHARACTERISTICS

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APPENDIX C

RADIOLOGICAL SUPPORT PLAN

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C.1 INTRODUCTION

The Uranium Mill Tailings Radiation Control Act of 1978 (PL95-604) gave the responsibility of developing standards for remedial actions to the U.S. Environmental Protection Agency (EPA). Section 108 of PL95-604 states that the U.S. Department of Energy (DOE) shall "select and perform remedial actions at designated processing sites and disposal sites in accordance with the general standards" prescribed by the EPA. The EPA standards state:

> "Section 108 of the Act requires the Secretary of Energy to select and perform remedial actions 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 affected Indian Tribes and the Secretary of the Interior. These parties, in their respective roles under Section 108, are referred to hereafter as 'the implementing agencies.'
>
> The implementing agencies shall establish methods and procedures to provide 'reasonable assurance' that the provisions of Subparts A and B are satisfied. This should be done primarily through use of analytical models, in the case of Subpart A, and for Subpart B through measurements performed within the accuracy of currently available types of field and sampling procedures. These methods and procedures may be varied to suit conditions at specific sites."

Subpart B consists of the standards for the cleanup of land and buildings. The standards applicable to the project are:

> "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 picocuries per gram (pCi/g), averaged over the first 15 centimeters (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 working level (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 (microR/h)."

In addition to the EPA standards for buildings, removable surface alpha contamination shall not exceed 1000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2), and total non-removable alpha contamination shall not exceed 5000 dpm/100 cm^2. This limit will ensure that potential airborne radionuclide concentrations will not exceed 10 CFR 20 Appendix B standards and that physical contact with the surfaces by occupants of the structures will not result in a measurable radiation exposure.

As indicated earlier, the standards suggest that the implementing agencies determine what methods and procedures will be used to provide "reasonable assurance" that the standards are met. Reasonable assurance implies that a site-specific analysis is appropriate where the cost of demonstrating compliance with the standards is to be weighed against the health risks or other impacts associated with leaving areas which slightly exceed the standards.

The sections which follow provide the procedures used at the Lakeview site. Consideration was given to the time required to collect samples and perform the analyses.

C.2 BASIS FOR RADIOLOGICAL SURVEY STRATEGY

The Lakeview site consisted of a tailings pile, raffinate ponds, windblown areas, and small areas of contamination in the mill yard that were missed during previous remedial action activities. Excavation to remove the tailings and off-pile contaminated material from the disturbed site areas required removal of soil to a depth of several feet below grade. Most of the disturbed site areas were restored to a grade that will control the drainage. The fill material was uncontaminated and will minimize the potential health effects due to slight residual contamination.

Clean fill may not be required in some of the excavated areas, and residual contamination may remain exposed at the surface. In those areas where backfill after excavation is not required, it is highly desirable that the residual contamination will not exceed the 5.0 pCi/g limit when averaged over an area equivalent to the size of a house (one hundred square meters, or approximately 1100 square feet) [ ].

Any occupied or habitable building has been decontaminated as needed, and surveyed [ ] to [ ] ensure that the standard is met. For the Lakeview site, there were nine buildings in use on the site, with only one requiring limited decontamination. No structures were demolished.

C.3 REMEDIAL ACTION RADIOLOGICAL SURVEY PLAN

Radiological surveys are performed for three purposes: site characterization, excavation control, and final radiological verification. Site characterization surveys (or pre-remedial action surveys) are performed to identify the volume of material that exceeds the standard. The results are used for planning and engineering design. Excavation control monitoring is performed as the work is being done to guide and control the amount of contaminated material removed. Finally, when excavation control monitoring results indicate that there is a high probability that the area meets the standards, a final radiological survey is carefully performed and the results documented.

C.3.1 SITE CHARACTERIZATION SURVEYS

Radiological surveys were performed by Bendix Field Engineering Corporation (BFEC) to identify the subsurface boundary of the tailings pile to be excavated as well as the depth and area of the raffinate pond and windblown contaminated materials on adjacent land. Subsurface evaluations were performed using gamma well logging techniques and by analyzing cores from boreholes. In general, these measurements were made on a 200-foot grid. Additional measurements were performed in areas of radiological interest. The grid points were identified by a land survey tied to a state plane survey point and all recordable data were located by these coordinates.

Radiological surveys were performed by BFEC [ ] inside the buildings to determine gamma exposure rates and the levels and extent of surface contamination. [ ] The sample preparation room of the former laboratory building was identified as having a need for limited contamination.

C.3.2 EXCAVATION CONTROL MONITORING

The purpose of excavation control monitoring is to guide excavation through the use of real-time radiological measurements. It is designed to ensure that the 5.0 pCi/g (surface) and 15.0 pCi/g (subsurface) standards are met. In addition, it minimizes the possibility that material meeting the standards is also excavated. Properly performed excavation control monitoring simultaneously ensures that neither under-excavation nor over-excavation occurs.

Excavation was monitored by qualified technicians relying principally on gamma field measurements employing hand-held instruments such as gamma-scintillation detectors. This technique was used where measurements were not seriously impaired by interference from nearby tailings deposits. In areas where significant interference exists, alternate monitoring techniques were used. These techniques [ ] included use of a shielded probe gamma-scintillation instrument (operated in a gross count mode or in a delta mode) or the immediate counting of soil samples. In all cases, these techniques were routinely calibrated by comparison of the field measurements to soil samples analyzed in the laboratory and reported on a fully equilibrated dry-weight basis. Because the standards are based upon average areas of 100 m^2, the excavation control monitoring was performed on areas of this characteristic size as well.

Elevated gamma-ray radiation fields [ ] precluded exclusive use of in situ monitoring devices to estimate the surface radionuclide concentrations in soil on or immediately adjacent to the Lakeview pile. When in situ measurements could not be performed, the suggested method for analysis was to take individual or composite samples of soil, seal by canning, and immediately count the sample by gamma-ray spectrometry. Errors associated with this approach were reduced by taking several samples 30 days prior to starting work to determine calibration factors. These samples were counted, dried, pulverized, and screened with recanning for subsequent analysis. They will be counted later after the radon-222 (Rn-222) daughters reach equilibrium. Analyses of these prepared samples can then be compared to standards. Several samples were collected weekly during the remedial action and analyzed to provide a measure of the variation of the calibration factor. Site-specific procedures were issued by the RAC prior to the start of construction. [ ]

C.3.3 BUILDING DECONTAMINATION CONTROL MONITORING

In areas of known contamination, as determined by the site characterization surveys, measurements were performed after each decontamination effort to assess the effectiveness of the effort. For potentially contaminated areas, measurements were made at a minimum of either 100 percent of the area or at approximately 30 locations of surface areas of less than 500 square feet. In addition, biased measurements were made in previously contaminated areas or other areas having a high probability of being contaminated. Areas possibly requiring decontamination included the storage room (former sample preparation room) at the northwest corner of the laboratory building and the basement and crawl space of the Precision Pine Lumber Company office building. The highest total alpha measurement in the laboratory storage room was 3000 dpm/100 cm^2 on the floor, and the highest total alpha measurement in the office building crawl space was 900 dpm/100 cm^2 on the filter of the telephone center. No removable alpha measurements indicated readings above 100 dpm/100 cm^2; however, these areas warranted further investigation and possible decontamination, particularly in the office building basement because of elevated radon concentrations on the order of 8.0 picocuries per liter (pCi/l).

The previous decontamination in the mill building appears to have been successful. The weathered cement support pads used for pillars indicated the highest total alpha levels of up to 1200 dpm/100 cm^2; however, no removable alpha measurements were above 100 dpm/100 cm^2 and confirmatory removable alpha measurements should be made.

A limited amount of demolition work was required, involving the small pump house at the northwest corner of the tailings pile and some weirs in the vicinity of the evaporation ponds.

C.3.4 FINAL RADIOLOGICAL VERIFICATION SURVEY FOR LAND

The final radiological survey employed a single sampling strategy regardless of the potential for future development. The area to be surveyed was divided by 10-foot grids. Eleven contiguous 10-by-10-foot grid blocks (approximately 100 square meters total) were declared a unit parcel. Where there was a reason for suspecting a radiologically elevated area, the unit parcel was selected to include the contaminated region, thus maximizing the measured average concentration of Ra-226. A composite sample for each unit parcel was constructed by taking 15 cm deep samples of approximately equal mass at each grid point (19 to 24 samples, depending on the shape of the unit parcel). This sample was prepared and analyzed for Ra-226 content. Further excavation **sometimes was** required until analytical results of less than or equal to 5.0 (surface) or 15.0 (subsurface) pCi/g above natural background qualified the unit parcel as decontaminated property. Analytical error limits for measurements must be better than plus or minus 30 percent, at the 95 percent confidence level.

If an area to be surveyed was less than that specified above, a minimum of ten, 15 cm deep samples were used to make up the composite sample.

Samples taken in the field for analysis were prepared and analyzed. When convenient, **this was** done prior to backfilling. When the property was to be backfilled prior to receiving the final analytical results, a quick field method (that provides a high degree of assurance that the property meets standards) was developed and applied. The samples were prepared for laboratory analysis by gamma-ray spectrometry.

C.3.5 FINAL RADIOLOGICAL VERIFICATION SURVEY FOR BUILDINGS

Gamma surveys were conducted using an instrument capable of detecting 2.0 microR/h above background. Buildings were scanned while holding the instrument at three feet above the floor. Maximum, minimum, and average exposure rates were recorded for each room of the buildings. All areas where the exposure rates exceed 20 microR/h above background were noted.

Alpha detection instruments were used to monitor surface contamination. A grid system was constructed for each room of a structure which had been decontaminated. The grid size was adjusted such that a minimum of 30 grid points were defined by using grid lines not more than 30 feet nor less than three feet apart. Measurements were made at each grid point and other areas of special radiological interest such as floor drains or areas that were the most highly contaminated. Contamination was averaged over a 10 square foot area and compared with the allowable limits, as provided in Section C.1. In cases where the total contamination was greater than the limits for removal, measurements for assessing the removable contamination levels were made.

Radon daughter concentration (RDC) measurements were conducted in areas of the building where previous data indicated elevated radon daughter concentrations. An annual average radon daughter concentration was determined for all structures to assure that they met the standard.

C.4 DATA AND SAMPLE MANAGEMENT

During the cleanup operations, the Remedial Action Contractor collected data to support excavation control. Data used in declaring an area adequately decontaminated was documented in a format approved by the Uranium Mill Tailings Remedial Action (UMTRA) Project Office.

Site characterization survey data, excavation control data, and the final radiological survey data were collected using procedures and analytical methods meeting the requirements of the UMTRA Project Quality Assurance Program Plan (DOE, 1986). All data used in describing the final radiological condition of the site as well as other data as specified by the UMTRA Project Office have been provided in a convenient format for input into the UMTRA Project Data Management System. Data generated in the remedial action will be presented in a report documenting the final radiological condition of the property.

C.5 CERTIFICATION

Certification is a professional judgment by an independent party that the remedial action has been completed according to the site-specific Remedial Action Plan and meets the applicable standards.

During the remedial action operations, the Remedial Action Contractor made available to appropriate state agencies, Federal agencies, or UMTRA Project-designated contractors data related to the cleanup. In addition, samples collected during the cleanup operations may be split for analyses by these agencies to allow comparison of analytical results. These data, along with any additional data collected at the discretion of the certifying agent, will be used in the final certification report.

REFERENCE

DOE (U.S. Department of Energy), 1986. Management and Overview Quality Assurance Program Plan, UMTRA-DOE/AL-400325.0002, DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

APPENDIX D

ENVIRONMENTAL, HEALTH, AND SAFETY PLAN

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D.1 HEALTH AND SAFETY STANDARDS

D.1.1 APPLICABLE REGULATIONS

The Remedial Action Contractor (RAC) shall comply with all applicable Federal and state health and safety regulations and requirements including, but not limited to, those established pursuant to the Occupational Safety and Health Act (OSHA). Special attention should be given to the following OSHA and other Federal regulations.

- 29 CFR Part 1910, "Occupational Safety and Health Standards."
- 29 CFR Part 1926, "Safety and Health Regulations for Construction."
- 49 CFR Parts 172-174, "DOT Transportation of Hazardous Materials."
- 10 CFR Part 20, "Standards for Protection Against Radiation" (as cited in this plan).
- DOE Orders, as cited in this plan.

D.1.2 STANDARDS

The RAC shall comply with the radiation exposure standards in Tables D.1.1 and D.1.2, unless state regulations take precedence. In all cases, exposures to workers and members of the public shall be as low as reasonably achievable.

Table D.1.1 Exposure of individuals and population groups in uncontrolled areas

	Annual dose equivalent or dose commitment (rem)[a]	
Type of exposure	Based on dose to points of maximum probable exposure	Based on average dose to a suitable sample of the exposed population
Whole body, gonads, or bone marrow	0.5	0.17
Other organs	1.5	0.5

[a] In keeping with U.S. Department of Energy's policy on lowest practicable exposures, exposure to the public shall be limited to as small a fraction of the respective annual dose limits as is reasonably achievable. Dose commitment is defined as the dose equivalent (rem) received by specific organs during a period of one calendar year that was the result of the uptake of radionuclides by a person exposed (from DOE Order 5480.1).

Table D.1.2 Occupational radiation exposure standards

Type of exposure	Exposure period	Dose equivalent (dose or dose commitment[a] rem)
Whole body, head and trunk, gonads, lens of the eye[b], red bone marrow, active blood-forming organs	Year Calendar quarter	5 3
Unlimited areas of the skin (except hands and forearms), other organs, tissues, and organ systems (except bone)	Year Calendar quarter	15 5
Bone	Year Calendar quarter	30 10
Forearms	Year Calendar quarter	30 10
Hands	Year Calendar quarter	75 25

---

[a] To meet the dose commitment standards, operations must be conducted in such a manner that it would be unlikely that an individual would assimilate in a critical organ, by inhalation, ingestion, or absorption, a quantity of a radionuclide or a mixture of radionuclides that would commit the individual to an organ dose that exceeds the limits specified in the above table. Dose commitment is defined as the dose equivalent (rem) received by specific organs during a period of one calendar year that was the result of uptakes of radionuclides by a person occupationally exposed (from DOE Order 5480.1).

[b] A beta exposure below a maximum energy of 700 kilo-electron volts (KeV) will not penetrate to the lens of the eye; therefore, the applicable limit for these energies would be that for the skin (15 rem/year).

D.2 PROGRAM REQUIREMENTS

D.2.1 ORGANIZATION AND STAFFING

The RAC shall have, on the site, a qualified person responsible for the health and safety of the workers and public. This person must be provided with properly trained staff and adequate equipment to ensure that the work is done safely. The equipment, number of staff members, and staff member qualifications shall be commensurate with the scope of construction activities.

The person responsible for health and safety must have adequate access to higher management, independent of construction operations management, to ensure that health and safety concerns are considered.

D.2.2 OPERATING PROCEDURES

Operating procedures were developed and documented for all activities where there was significant health or safety risk and for activities necessary to quantitatively assess radiological or industrial hygiene hazards. Examples are dosimeter issuance and control, air sampling and analysis, and control of personnel access.

D.2.3 WORKER TRAINING

A formal training program, including a discussion of the biological effects from exposure to radiation, was provided to all site workers. The program was of sufficient duration to include discussions of industrial and radiological safety procedures, emergency procedures, and instructions concerning prenatal radiation exposure. Practical demonstrations were given, when appropriate. Each worker passed a written or oral examination with the results documented. The instructor had available for distribution literature on the biological effects of radiation. The instructor also provided each worker with the information contained in U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure." Initial training sessions required approximately two hours. Subsequent training sessions were scheduled at a frequency that ensured continuous health and safety protection for the workers.

D.2.4 RECORDS AND REPORTING REQUIREMENTS

The RAC must notify the manager of the Uranium Mill Tailings Remedial Action (UMTRA) Project and the Environment, Safety, and Health Division of any fatality or serious accident as required by DOE [ ] Order 5484.1, "Environmental Protection Safety, Health Protection Information Reporting Requirements." Fatal accidents would be investigated by the state, Federal, or local office having environmental, health, and safety responsibilities. No fatal accidents have occurred to date.

A work-related radiation exposure history has been maintained as required. New employees completed a radiation exposure history form, and results of bioassays taken at termination shall be obtained from the last employer where exposure to radiation occurred. If previous bioassay information is not available, consideration was given to providing a whole-body count or other appropriate bioassay prior to permitting the employee to do radiation-related work.

The RAC was responsible for posting the OSHA applicability and employee reporting instructions, DOE Form F-5480.1. The RAC was also responsible for recording and reporting illnesses and injuries in accordance with OSHA requirements. Copies of these reports shall be forwarded to the UMTRA Project Manager. Recordable occupational accidents and illnesses are those defined in the Occupational Safety and Health Act of 1970, and set forth by the Occupational Safety and Health Administration in 29 CFR Part 1904.12(c), (d), (e), (f), and applicable part of 1904.12(g).

The RAC has been responsible for maintaining records of employee exposures to radioactive or toxic materials or other harmful physical agents. U.S. Department of Energy Form 5484.8, "Termination Occupation Exposure Report," was forwarded to the Contracting Officer's Representative (COR) within 30 days of termination of employment, or within 30 days of the determination of exposure, in accordance with Annex A of DOE Order AL-5484.1. Forms 5484.6, "Annual Summary of Whole Body Exposures to Ionizing Radiation," and 5484.7, "Summary of Exposure Resulting in the Internal Body Depositions of Radioactive Materials for CY__," were forwarded to the COR by March 15 of each year for the preceding calendar year, in accordance with Annex A of DOE Order AL-5484.1. In addition, all radiation exposure records or a copy of all radiation exposure records have been transferred to DOE upon employee termination or completion of the contract.

The RAC has notified the UMTRA Project Manager of any unusual occurrence. An "unusual occurrence" is any unusual or unplanned event having programmatic significance such that it adversely affects or potentially affects the integrity of the site or the performance, reliability, or safety of the UMTRA Project. Examples of unusual occurrences are:

- Overflow of an evaporation pond.
- Tailings release into a stream or river.
- Tailings release beyond the site boundary.
- Tailings spill associated with a trucking accident.
- Any major fire or explosion on the site.
- Site flooding.

- o Breach of access by unauthorized personnel.

- o Acts of vandalism or major theft occurring at the site.

- o Any occurrence which could adversely affect the environment or the health and safety of the populace.

The RAC shall submit DOE Form 5484.3, "Supplementary Record of Occupational Injury/Illness," 5484.5, "Property Damage," or SF91-A, "Investigation Report of Motor Vehicle Accident," to the UMTRA Project Manager and the DOE Environment, Safety, and Health Division for each property damage incident involving more than $1000 government loss and for each motor vehicle accident involving more than $250 government loss.

A central file of all enforcement inspections and reports, along with violations and abatement actions, is maintained by the RAC for inspection by the DOE.

A central file is maintained by the COR and by contractors of formal employee health and safety complaints and their disposition. Upon request, these shall be made available for inspection by affected employees or their authorized representatives.

D.2.5 COMPLAINTS

Employees are encouraged to report to the contractor, either directly or through their authorized employee representative, any conditions or practices which they consider detrimental to their health or safety, or which they believe are in violation of applicable health and safety standards. Such complaints may be made orally or in writing.

Any employee or representative of employees who believes that a condition or practice threatens physical harm or violates health or safety standards may request an inspection by filing a complaint directly with the local agency having health and safety responsibility.

Any employee or authorized representative of employees who believes that an imminent danger exists that threatens death or serious physical harm is encouraged to bring this matter to the immediate attention of the appropriate contractor, supervisor, or designated official for resolution. In the event of inadequate corrective action, the employee and/or authorized representative may also contact the local agency having jurisdiction and/or the [ ] UMTRA Project Office in Albuquerque (by telephone) and set forth with reasonable particularity the basis for the request for an immediate inspection.

The DOE, upon receipt of a complaint of inaction concerning alleged imminent danger, or upon receipt of notice of imminent danger, will immediately ascertain whether there is a reasonable basis for the allegation. If it appears to have merit, the DOE will dispatch an inspector to the workplace involved. When an immediate inspection cannot be made, the DOE will contact the contractor immediately, gather the pertinent details concerning the situation, and if necessary, have affected employees removed from the danger area. The DOE will determine what steps, if any, the contractor intends to initiate in order to eliminate the danger. The DOE will conduct appropriate follow-up activities.

D.2.6 POSTING

Each contractor has posted DOE Form F-5480.1, "Occupational Safety and Health Protection," a poster outlining contractor responsibilities to provide safety and health protection. Each contractor [ ] also has available in the workplace DOE Form EV-628, "Occupational Safety and Health Complaint," a form to be used in reporting violations.

The forms required to be posted by this part are posted in a sufficient number of places to permit employees working in, or frequenting any portion of, the workplace to observe a copy on the way to or from their workplace.

D.2.7 INTERNAL AUDIT PROGRAM

An internal audit committee made up of the RAC's Health and Safety Manager, and others as appropriate, was established to periodically review the health and safety operations and safety-related procedures. A documented report of this review, recommendations, and follow-up actions shall be maintained by the RAC and made available for review by DOE.

D.2.8 RESTRICTIONS

No workers under age 18 shall be employed in or allowed to enter controlled areas where they could receive doses of radiation in amounts exceeding one-tenth the standards specified in Table D.1.2.

All women working in jobs involving possible radiation exposure shall be advised of the National Commission on Radiological Protection Report 39 recommendation [ ] to minimize exposure to embryos and fetuses. All [ ] women workers shall be advised of the biological risks to embryos and fetuses exposed to the various expected levels of ionizing radiation and shall be made aware that specific efforts and attention should be taken to keep radiation exposure of an embryo or fetus to the very lowest practicable level [ ].

Administrative limits shall be used to assure that workers do not exceed the quarterly or annual limits specified in Table D.1.2. Workers whose exposure levels have exceeded administrative limits or standards shall be placed on work restriction until the end of the period of concern.

D.2.9 QUALITY ASSURANCE

Field radiological measurements, sample collections, and sample analyses were performed using procedures and methods meeting the requirements of the UMTRA Project Quality Assurance Program Plan (DOE, 1986). Quality assurance procedures and record keeping methods were submitted to the [ ] UMTRA Project Office for approval prior to beginning remedial actions.

Proof of calibration must be available for all laboratory radiation detection instrumentation; and field instruments must be calibrated a minimum of once each year, or more frequently if recommended by the manufacturer. Prior to each work shift, proper response of field instruments was ensured using check sources.

Appropriate training must be completed and documented for all personnel involved in sample collection or operation of radiation detection instruments. All records of calibration, training, sample collections, field measurements, and laboratory analyses have been maintained in a clear and concise manner. Records were checked for accuracy and made available for auditor inspection at any time during the remedial action.

The [ ] UMTRA Project Office and/or the TAC has conducted periodic surveys during the remedial action to ensure compliance with the UMTRA Project Quality Assurance Program Plan.

D.3 CONTAMINATION MONITORING AND CONTROL

D.3.1 CONTROLLED AREAS

Controlled areas have been established to protect the workers and the general public from unnecessary radiation exposure, and to prevent the spread of radioactive contamination. Controlled areas include, but are not limited to, any work areas in which:

- o 10 millicuries (mCi) or more of contamination exist in the area, based on Ra-226 concentrations as determined by the initial radiological assessment.
- o The estimated external gamma dose to any individual in that work area exceeds 500 millirems (mrem/yr).
- o Airborne concentrations of radionuclides exceed quantities provided in DOE Order 5480.1A, Attachment II.
- o Transferable surface contamination exceeds 600 disintegrations per minute per 100 square centimeters (dpm/100 cm^2).

Access to these areas has been controlled for people, vehicles, and equipment by fencing the area or using other methods to prevent inadvertent exposure to contaminated material.

Smoking, drinking, and eating are prohibited in controlled areas.

Controlled areas are conspicuously marked at points of potential access with a sign or signs bearing the radiation caution symbol and the words

CAUTION
RADIOACTIVE MATERIAL

All other applicable posting and labeling requirements set forth in 10 CFR Part 20 must be followed.

D.3.2 ACCESS CONTROL

An access control point has been established and operational during all normal periods of ingress or egress. The access control point is the only point at which personnel or equipment may enter or leave the controlled areas of the site. [ ] Personnel and equipment entering or leaving the controlled areas have been controlled by the technician occupying the access control point, under the direction of the site health physicist. Restrictions to be exercised at the access control point are described in the following text.

A log of personnel and equipment entering and leaving the site was maintained at the access control point. The access control log functions as a checklist at the end of each work shift to ensure that all contractor personnel are out of the controlled area before closing the access control point.

A log of personnel dosimeters assigned to contractor personnel at the site was maintained by the technician. Dosimeters were distributed to contractor personnel at the beginning of each work shift and collected at the end of each work shift. The technician provided general instructions and precautions to personnel and notify them of any changes in work restrictions which may occur as radiological monitoring data are collected.

Reference files have been maintained at the site and contain the following information and documents:

- Records of attendance at orientation and training sessions conducted by the health physics staff.
- Records of bioassay samples submitted by the employee and analytical results from the samples.
- Records of dosimeters provided to the employee, and exposure accumulations as indicated by reports from the dosimeter service.

In addition to maintaining complete and current records as specified in Section D.3.2, the technician occupying the access control point ensured that contractor personnel are provided the appropriate protective clothing for the conditions present in the work environment. Protective clothing requirements were determined by the site health physicist based upon results of instrument surveys and sample analyses performed in the work environment. Additional guidelines for clothing requirements are provided in Section D.3.6.

Personnel were required to remove protective work clothing, such as coveralls and boot covers, before leaving the controlled area. The technician or workers then surveyed their clothing and exposed skin surfaces for contamination using instrumentation and methods described in Section D.3.3. Persons with detectable surface contamination had to undergo decontamination procedures as described in Section D.3.3 and be resurveyed before leaving the controlled area.

Equipment that was in contact with contaminated material was surveyed at the access control point before leaving the controlled area. Equipment exteriors were monitored for removable and fixed contamination, and were evaluated in accordance with procedures and limits described in Section D.3.4. Heavy equipment which was found to be contaminated was detoured to the decontamination pad, washed by contractor personnel, and re-surveyed by the access control technician.

D.3.3 PERSONNEL CONTAMINATION MONITORING

Protective clothing was removed at the access control point [ ] to minimize potential surface contamination detected during alpha frisking surveys. Any personnel contamination detected [ ] was removed to prevent dispersion of radioactive material to uncontrolled areas and to minimize exposure to subcontractor personnel. Employees leaving the controlled area were monitored before leaving at the access control point. Procedures for monitoring personnel and removing surface contamination are provided in the following text.

Instrumentation

Alpha scintillation detectors were used for personnel monitoring. The detector was connected to a ratemeter/scaler which has an audible and visual alarm with adjustable setting. An instrument with no alarm could have been used if it had a speaker over which the count rate could be heard. A portable counter was not required since monitoring was done at the entrance of the access control point, and AC power was available. A cable at least six feet long was used to connect the detector to the counter so the motions of the surveyor were not restricted.

Monitoring method

Due to the delicate nature of survey instruments and the importance of monitoring, the technician assured that personnel were properly trained prior to monitoring themselves. Standard procedures for alpha frisking were followed.

Tools and equipment carried off the site were also surveyed according to recommendations in American National Standards Institute N13.12, "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use."

Personnel monitoring procedures

In order to maintain personnel exposure to radiation at levels as low as reasonably achievable, the goal of personnel monitoring was to detect and remove all contamination. Thus, the preferred level was no detectable radioactivity above background. Any levels of activity detected during the survey which were noticeably above normally fluctuating background were considered an indication of the presence of radioactive contamination. To ensure accurate measurements, a monitor must be able to reliably detect a minimum of 500 dpm/100 cm^2 total activity.

[ ] Most cases of personnel contamination involved loose surface contamination on protective clothing or skin. If clothes were contaminated, the preferred procedure was to remove them, monitor the skin under the affected area, and supply clean clothes for the employee. The contaminated articles were then washed in the laundry area. Clothing was returned to the employee after decontamination.

In the event of surface contamination detected on skin, the contaminated area was washed and monitored again. If decontamination procedures were not effective, the site health physicist was consulted.

D.3.4 EQUIPMENT MONITORING

As vehicles and equipment were used in the controlled area, radioactive material tended to accumulate on all surfaces in contact with the contaminated material. Instrument surveys and decontamination procedures ensured that radioactive materials are not transported to uncontrolled areas. The following instructions applied to vehicles and equipment leaving the controlled area.

Instrumentation

Two instrument sets were required for equipment monitoring. A portable instrument was necessary for field monitoring, and a swipe counter was used for areas where background radiation levels are high enough to interfere with field monitor readings. The following characteristics were required for the two types of instruments:

Field monitor:

- Hand-held pancake G-M tube, proportional counter detector, or alpha scintillator.
- Large detector area.
- Thin detector window capable of detecting three milli-electron volts (MeV) or greater alpha energies.
- Detector window protected from puncture by wire screen.
- Battery-powered ratemeter/scaler.
- Speaker attached for audible indication of radiation levels detected.
- Meter display for exact indication of radiation levels in counts per minute (CPM).

Swipe counter:

- Slide tray to accept two-inch diameter samples.
- Alpha scintillation detector.
- Adjustable timer for counting circuit from about five seconds to one minute, to a maximum of one hour.

Monitoring methods

The health physics technician monitored equipment and vehicles which were in contact with the contaminated material before allowing them to leave the controlled area.

Vehicles and heavy equipment were driven to the decontamination pad for monitoring and cleaning, if necessary. All vehicles were cleaned to remove all visible soil prior to leaving a contaminated site. The following criteria were then applied.

- o For vehicles potentially in contact with material having radium-226 (Ra-226) concentrations of 200 picocuries per gram (pCi/g) or greater, the tires (and cab interior, if potentially contaminated) was monitored and decontaminated to meet the limits described below. Appropriate spot checks were made of other potentially contaminated truck surfaces.
- o For vehicles potentially in contact with material having Ra-226 concentrations less than 200 pCi/g, the tires and cab interior were periodically monitored to meet the limits described below. If contamination in excess of the limits was found, the guidelines in the preceding paragraph were used.

Background radiation could cause such high instrument readings that instrument surveys of vehicles were not feasible. When instrument surveys were inadequate, swipe surveys were performed as an alternative. Results of swipe surveys were recorded in the Removable Contamination Log, in units of dpm/100 cm^2.

Vehicle surfaces which exceeded the limits below were washed on the decontamination pad, and additional swipe samples collected and counted. [ ]

Contamination limits

Release criteria for vehicles and equipment leaving the controlled area were:

- o 3300 dpm/100 cm^2 total activity, as detected by the instrument survey.
- o 600 dpm/100 cm^2 dpm per 100 sq cm, as indicated by swipe samples.

In all cases, an extensive effort was made to reduce contamination to levels as low as reasonably achievable.

Decontamination procedures

In the event that equipment or vehicles required extensive decontamination, they were washed using high-pressure washers or other decontamination methods in the decontamination area. Vehicles were driven onto the pad for cleaning so that runoff could be contained.

Proper measures were used to protect the workers and environment during decontamination. Coveralls, boot covers, gloves, and eye protection were worn to prevent transfer of contamination to clothing, skin [ ], or eyes. Caution was exercised to prevent spray from splashing back onto workers.

The equipment was monitored again for surface contamination. If contamination was still evident on the equipment after two washings, the site health physicist was consulted for additional decontamination procedures.

The inside of a truck bed did not have to meet decontamination standards. If visible contaminated material was brushed from the truck bed, the truck could return from an alternate site to the tailings site empty or with clean fill if a tarp was covering the truck bed.

D.3.5 BUILDING DECONTAMINATION AND DEMOLITION

Loose or removable contamination in buildings was removed, affixed to the surfaces prior to demolition, or controlled to prevent dispersion to the environment during demolition. Decontamination was performed by crews supplied with adequate protective equipment (coveralls, respirators, gloves, boots, and eye protection as necessary) under the supervision of the RAC health physicist. The decontamination involved the following:

- Contaminated water from washdown activities was used as a tailings dust suppressant or monitored and disposed of in compliance with Section D.5.4.

- Decontamination, if performed by use of nuclear grade industrial vacuum cleaners, required strict maintenance of the [ ] filter and proper disposal of contents and filters.

- Dosimetry and special urinalysis samples were specified. If asbestos had been present in buildings, monitoring would have been initiated as described in Section D.4.1 of this document. No asbestos was identified during relocation of the tailings pile.

- Application of contamination fixants prior to demolition was done under the supervision of health physicists who specified protective clothing and equipment.

- Use of cutting torches, jack hammers, or other equipment for demolition of building structures would have required protective equipment for personnel. Appropriate engineering controls would have been used to prevent dispersion of contaminated dust or smoke during such activities. Demolition of buildings for cleanup of the Lakeview site was not necessary.

D.3.6 PROTECTIVE CLOTHING AND CHANGE FACILITIES

Protective clothing was available to contractor personnel to minimize surface contamination of personal clothing. Change facilities were provided and stocked to accommodate workers in compliance with the following requirements.

Protective clothing requirements

Clothing items were stocked at the access control point in a variety of sizes to fit contractor personnel and include coveralls, rubber shoe covers, knee-high rubber boots, leather gloves, and cotton gloves.

Additional items were stocked as considered necessary by the site health physicist.

Coveralls, boot covers, and gloves were worn by all personnel working in areas having significant quantities of soils or contaminated material containing 200 pCi/g or greater concentrations of Ra-226. Additional work areas having lesser amounts of contamination also required use of protective clothing, and were so designated by the site health physicist.

Use of change facilities

Change facilities were located at or near the access control point. These facilities were intended for use by contractor personnel working in controlled areas who were unable to meet surface contamination limits when leaving through access control. Change facilities included showers and sinks, lockers and benches, soap and towels, and toilets.

Change facilities were supplied with [ ] hot and cold running water to the sinks, showers, and the laundry. Wastewater from sinks, showers, and the laundry was collected in a sump and sampled prior to spraying on the tailings, or routed to an evaporation pond for treatment and discharge, where applicable.

Workers were required to shower only if widespread contamination was found on the skin. Localized contamination was washed off in the sinks. [ ] Contaminated areas were resurveyed after washing.

D.3.7 DOSIMETRY AND BIOASSAY

The dosimetry and bioassay programs provide measurements of personnel external and internal exposure to radiation. These programs were conducted in the following manner.

D.3.7.1 Personnel dosimetry

Thermoluminescent dosimeters (TLDs) or film badges were used to provide accurate measurements of personnel exposures to external sources of radiation during remedial actions. All contractor personnel who worked at least 120 hours per calendar quarter in a controlled area (as defined in Section D.3.1) were issued a dosimeter. Visitors were not given badges unless it was deemed necessary by the site health physicist.

Dosimeters were worn by contractor personnel while working in controlled areas, and returned to the technician at the access control point at the end of each work shift. The technician properly stored the TLDs to minimize non-occupational exposures due to elevated levels of background radiation.

Employees wore dosimeters on the front of the body between the neck and waist unless directed otherwise by health physics personnel. The same dosimeter was retained by an employee for the entire quarter, unless deemed otherwise by health physics personnel.

Dosimeters were exchanged quarterly and read by the dosimeter service which supplied them. The resulting data were reviewed, recorded, and initialed by the site health physicist and retained on the site until remedial actions have ceased. The site health physicist noted any increases in personnel exposures above the levels usually expected at the site, investigated potential causes of elevated exposure rates, and, when possible, eliminated the source.

Whole-body dose equivalent rates were maintained below three rems/quarter and five rems/yr. Whenever possible, engineering controls or work procedures were initiated to maintain worker exposures at levels which were as low as reasonably achievable.

D.3.7.2 Bioassay

Two methods of measuring internal deposition of radioactive materials in workers were used. Urinalysis provided information concerning potential uptake of radioactive material by contractor personnel, and whole-body counting provided an indication of an individual's body burden.

All personnel who worked at least 120 hours per calendar quarter in a controlled area submitted a urine sample prior to beginning work on the project. An exit sample was collected upon termination of the individual's work activities at the project and interim samples were collected at intervals as required by the health physics staff. Non-routine samples were required whenever a situation resulted in a potential overexposure to airborne radionuclides. Additional bioassay was required for personnel performing jobs where exposures to high airborne radionuclide concentrations are encountered.

Typically, urine samples were analyzed for thorium-230 (Th-230) concentrations. Thorium-230 was selected as the limiting isotope due to its solubility, radiotoxicity, and its presence in tailings in concentrations comparable to those of Ra-226. At the discretion of the site health physicist, additional analyses were required based on data obtained from material in specific work areas.

Analytical results had a lower limit of detection at least equal to the concentration at which resampling was indicated. Action levels (in picocuries per liter, or pCi/l) are provided below for thorium and radium.

- o Th-230:
  - 0.05 pCi/l - resample.
  - 0.1 pCi/l - investigate work conditions.
  - 0.2 pCi/l - prohibit employee from working in controlled areas.
- o Ra-226:
  - 0.5 pCi/l - resample.
  - 0.7 pCi/l - investigate work conditions.
  - 1.0 pCi/l - prohibit employee from working in controlled areas.

Analytical reports from the laboratory were retained at the project site while remedial actions were in progress; copies will be retained thereafter by the U.S. Department of Energy (DOE). Reports were reviewed by the site health physicist and results which exceeded the limit for resampling were discussed with the employee involved. The employees initialed the laboratory reports to indicate that they had been informed of the potential overexposure.

Whole-body counts were required for contractor personnel who frequently exhibited excessive radionuclide concentrations in the urine. Personnel whose work was confined to uncontrolled areas due to elevated urinalysis results were considered by the Radiological Support Contractor for whole-body counting upon termination of employment at the project site. Copies of records of whole-body counts were retained by the [ ] UMTRA Project Office.

D.3.8 AIR SAMPLING

An air sampling program was initiated during the preoperational phase and continued during the operational phase of the project. Radionuclide concentrations in the work environment was monitored and potential occupational health hazards were evaluated in determining the need for respirators and bioassay.

D.3.8.1 Air particulate sampling

Engineering controls and dust suppression techniques were used to minimize levels of airborne particulates. Methods such as vehicle speed control and water spray were commonly used. However, to ensure that the work environment was not hazardous to workers, air samples were collected and analyzed in accordance with the following requirements.

Representative work area air particulate samples were collected using lapel and work area samplers in all work areas where excavated soils average 50 pCi/g of Ra-226 or greater. Additional air particulate samples were collected during the work shift in the predominant downwind direction relative to excavation activities using high volume samplers. At the end of each shift, air particulate samples were stored in containers and marked with the following information:

- o Location of sample.
- o Date sampled.
- o Flow rate and identification number of sampler.
- o Start time and stop time of sample period.

After a delay of at least 24 hours, air filters were counted for gross alpha levels, using instrumentation described in Section D.3.4 for counting swipe samples. Gross activity levels were compared to the limit for Th-230. Air concentrations which exceeded the limit for soluble Th-230 in the work environment, as given in 10 CFR Part 20 (2×10^{-12} microcuries per milliliter), indicated the need for additional analyses and mandatory use of respirators by contractor personnel.

After counting, filters were stored in closed containers for future analyses. Samples may be stored together, according to sample location, as long as data regarding the volume of air sampled are retained. At the end of each quarter, the composited filters were analyzed for concentrations of Th-230 and Ra-226 to provide precise data on radionuclide concentrations in the work environment and potential levels of internal exposure. Results of isotopic analyses were compared to limits provided in 10 CFR Part 20 Appendix B, Table 1, and used to provide guidance on the use of respirators.

D.3.8.2 Radon daughter sampling

A sampling program for short-lived particulate radon decay products was conducted in all confined work areas where contamination may be present. The greatest potential for elevated radon daughter concentrations (RDCs) exists in enclosed areas such as buildings where ventilation is limited. Radon daughter samples were collected and evaluated for all buildings expected to contain elevated concentrations of radium, radon, or radon daughters before construction personnel entered such work areas.

If buildings were closed between work shifts, RDCs were re-evaluated before workers were permitted to enter the building to resume work. Additional samples were collected in the building during the work shift as deemed necessary by the site health physicist.

During periods of calm winds or inversions, RDCs may exceed limits in outdoor work areas which contain very high concentrations of Ra-226 in the soil. Such work areas were evaluated for RDCs on a daily basis.

The modified Kusnetz (1956) method of measuring RDCs was recommended as a quick and accurate procedure. Portable instruments can be utilized for sample collection and counting. Other comparable methods could substituted at the discretion of the site health physicist.

Radon daughter concentrations were limited to 0.33 working level (WL) in the work environment. Any work area which exceeded 0.33 WL averaged over the work period was evacuated until engineering controls could be effected or respiratory protection provided. The primary methods of alleviating excessive RDCs in the work environment was increased ventilation or decreased exhalation of radon gas into the area. Respiratory protection was used only when other methods were not feasible.

D.3.8.3 Respiratory protection

The respiratory protection program was administered in such a manner as to provide assurance that all workers were properly protected. Personnel were determined physically fit for wearing respirators through the use of medical history information and, in some cases, a medical examination. A careful evaluation and documentation of the use of respirators was accomplished by knowledgeable professional personnel.

Respirators, either cartridge types or supplied-air types, were the last resort in attempting to provide a safe work environment for contractor personnel. Engineering controls such as spraying water on dry contaminated materials were used before relying on respiratory protection. However, when airborne particulate radionuclide concentrations reach applicable regulatory limits, respirators were used and the following requirements met:

- o Employees required to use respirators were instructed in their use, and informed of the conditions under which they were required.

- Personnel required to use a respirator were beardless to ensure a good seal between the face and the respirator.

- Each worker required to wear a respirator was qualitatively fit-tested for a specific type of respirator before being issued that type of respirator.

- Respirators were only used at the request of the site health physicist. Respirators were only required after exhausting all measures for alleviating the conditions requiring respirator use.

- Cartridge-type respirators were issued for use in atmospheres containing respirable quantities of oxygen, but which are contaminated with excessive concentrations of harmful substances such as radionuclides, chemicals, or particulates.

- Self-contained breathing apparatus (SCBAs) are required in atmospheres which contain less than respirable quantities of oxygen, high concentrations of hazardous gases, or short-lived radon decay products in excess of the administrative or regulatory limit. **No occasion arose at Lakeview requiring the use of SCBA-type respirators.**

  []

- Respiratory protection factors and respiratory program details were taken from "Practices for Respiratory Protection," ANSI Z88.2-1980 (ANSI). Further guidance may be obtained from Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."

D.3.9 TRANSPORT OF CONTAMINATED MATERIAL

The DOE has complied with the applicable state or Federal regulations regarding the transportation of contaminated material. Site-specific determination of the levels of radioactivity associated with tailings and tailings-contaminated material have been made. If levels do not exceed 2000 pCi/g, the material does not meet the U.S. Department of Transportation's definition of "Radioactive Material," and trucks are not required to be placarded.

As a minimum, all trucks or train cars hauling contaminated material were tarped for transit. All visible contaminated material was removed from the exterior. The vehicles were monitored according to guidance provided in Section D.3.4.

D.4 INDUSTRIAL HAZARDS CONTROL

D.4.1 NONRADIOACTIVE AIRBORNE MATERIAL

Monitoring for respirable dust and toxic gases and fumes was required when the average eight-hour loading was expected to reach 50 percent of the Threshold Limit Value (TLV) adopted by the American Conference of Governmental Industrial Hygienists (ACGIH). Representative samples of tailings materials were taken and a weekly composite made and analyzed for lead, arsenic, selenium, quartz, and other toxic or hazardous materials. If limits were exceeded for these toxic and hazardous materials, and concentrations of radionuclides did not require respiratory protection, then exposure to levels below the TLV were maintained by wearing respirators approved by the National Institute of Occupational Safety and Health (NIOSH).

If asbestos was suspected to be present in soils or in buildings to be decontaminated, then an asbestos monitoring, protection, and record keeping program would have been initiated in accordance with 10 CFR Part 1910.1001. The eight-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed 2.0 fibers longer than five micrometers, per cubic centimeter of air. Asbestos concentrations were determined by the membrane filter method at 400 to 450x (magnification), four millimeter objective, with phase contrast illumination. **No asbestos was encountered during remedial action.**

D.4.2 NOISE

Threshold Limit Values for workers were limited to that specified by the DOE Prescribed Standard, AF161-35; 85 decibels on the A-weighted scale (dBA) for an eight-hour work day, and 80 dBA for a 16-hour work day. Noise suppression devices were used where appropriate, and the use of hearing protective devices was mandatory for levels above the TLV and encouraged for levels below the TLV. All other guidance in "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1982," ACGIH, related to noise exposure was followed.

D.4.3 PERSONAL PROTECTIVE EQUIPMENT

Plans for the use of personal protective equipment were developed based on projected need. Training was provided to employees on the use of such equipment. Such apparatus included respirators, safety eye glasses or goggles, coveralls, hard hats, gloves, shoe covers, rubber boots, and safety shoes.

D.4.4 FIRE SAFETY

Contractors maintained a fire prevention and control effort appropriate for the needs at the site. Fire extinguishers were provided and maintained and employees instructed in their use. Good housekeeping practices and proper storage of flammable and combustible liquids were also required.

D.4.5 CONSTRUCTION SAFETY

Management ensured that all provisions of 29 CFR Part 1926 were addressed prior to initiating any construction activity. Particular attention was paid to Excavations, Trenching, and Shoring (Subpart P); Signs, Signals, and Barricades (Subpart G); and Motor Vehicle, Mechanized Equipment, and Marine Operations (Subpart O). All managers were familiar with the requirements and directed the workers accordingly.

D.4.6 SANITATION

Toilet facilities were provided in accordance with 29 CFR Part 1926.51

Potable water for drinking and for washing prior to eating was provided for all employees.

D.5 ENVIRONMENTAL MONITORING

An environmental monitoring program was conducted at the project site and surrounding area. The program proceeded through three phases: preoperational, operational, and post-operational. During the preoperational phase, data was accumulated to characterize background and unimproved radiation levels in the region. Operational data provided documentation of off-site contamination generated by remedial activities at the project site. Post-operational data documented the reduced levels of contamination which occur after the contaminated materials were properly stabilized. The intent is to document the anticipated reduction in levels of contamination after pile disturbance has ceased.

The environmental monitoring program was designed to monitor non-radioactive particulate concentrations in air, radionuclide concentrations in air, and contaminants in surface water and groundwater, where applicable. Monitoring requirements are described in the following sections. Additional requirements may result from the permitting processes outlined in Section 6.0 of the Remedial Action Plan.

D.5.1 PARTICULATES IN AIR

Continuous air particulate sampling was required at points around the site boundary, commencing at least one month before remedial actions at the site. Samples were collected at eight locations: three along the site boundary in the predominant downwind directions, one at the site boundary upwind, one at the nearest residence, one at the nearest downwind residence, one at the Precision Pine Lumber Company office building, and one at a background location which was distant enough not to be influenced by site activities.

Filters were exchanged, analyzed, and evaluated in accordance with the U.S. Environmental Protection Agency (EPA) regulations (40 CFR Appendix B). Additional radiological parameters were also evaluated as required by the site health physicist. The following information is recorded when used filters are collected:

- o Sample location.
- o Sampler flow rate, or volume of air sampled.
- o Start and stop time and date of sample.
- o Sampler identification number.

After a minimum delay period of 24 hours, samples were counted for long-lived gross alpha activity using instruments required for swipe samples. Data from gross alpha measurements were compared to the appropriate limit for soluble Th-230 given in 10 CFR Part 20 Appendix B, Table II. Filters which counted above the limit were recounted five days later to allow for the decay of any remaining short-lived isotopes. Any filters that still exceeded the limit would have been sent to the radiochemistry laboratory for isotopic analysis of Th-230 and Ra-226. Total particulates would have been determined and compared to 10 CFR Part 20 Appendix B, Table II limits. **No occasion occurred requiring filters to be sent to a radiochemistry laboratory for isotopic analysis of Th-230 or Ra-226.**

D.5.2 RADON IN AIR

Environmental radon monitors (either PERM or film type detectors) were placed to provide measurement of periodic average radon concentrations in air and the data made available within two weeks. In order to provide immediate information, one real-time, continuous radon monitor was placed at the Precision Pine Lumber Company office building and at one of the downwind site boundary locations.

A guideline was set to restrict increases in off-site radon-222 (Rn-222) in air to 3.0 pCi/l, which equals one MPC (maximum permissible concentration). A weekly average of three pCi/l resulted in one MPC-week. Average annual concentrations of radon were limited to 52 MPC-weeks. During periods of remedial action, measures were employed to maintain airborne radionuclide concentrations at levels which were as low as are reasonably achievable.

D.5.3 GROUNDWATER

At least one set of preoperational groundwater samples was collected and archived from monitoring wells located in hydrologically upgradient and downgradient directions. The locations of these wells were determined by the TAC after evaluation of recently collected water data. Additional sample sets were collected quarterly throughout the construction period. [ ] Sampling collection and sample analyses procedures conformed to the UMTRA Project Quality Assurance **Program** Plan **(DOE, 1986)**. Samples were analyzed for Th-230, Ra-226, uranium, and nonradioactive elements and compounds agreed to by the UMTRA Project Office and the State of Oregon. [ ]

D.5.4 SURFACE WATER

During remedial action, evaporation ponds collected all nondomestic wastewater at both the processing site and the disposal site. The retention ponds were designed for evaporation of runoff from at least the 10-year 24-hour storm, so minimal discharge was expected during remedial action. **It was necessary to construct additional holding ponds to control the water generated by snowmelt and equipment decontamination.**

All potentially contaminated water at the processing site retention pond was sampled and analyzed at a frequency specified in the National Pollutant Discharge Elimination System permit to ensure compliance with effluent standards. Samples were analyzed for dissolved and total Th-230 and Ra-226, as a minimum. Other parameters were included as required. Radionuclides not specifically mentioned in the permit were controlled in accordance with standards given in 10 CFR Part 20 Appendix B, Table II.

Surface water in catch basins, shower water in catch tanks, and water retained after vehicle decontamination operations was sampled prior to reuse on the site. Water was treated after settling, as necessary, to meet acceptable Federal and Oregon Department of Environmental Quality standards before discharge from the site. []

D.6 EMERGENCY PROCEDURES

D.6.1 SEVERE WEATHER ACTION PLAN

A severe weather action plan was developed by the RAC to prevent extensive off-site dispersion of contamination during periods of high winds or heavy rains. The plan identified a responsible individual to be available to direct activities previously defined to mitigate the effects of the severe weather. Action levels to limit work and environmental contamination were specified.

D.6.2 MEDICAL EMERGENCIES

An emergency medical assistance plan was also developed by the RAC. Approved first-aid kits and equipment were made available to the supervisors in the field and at the access control point.

Although high levels of contamination on workers were not expected, special care was taken to decontaminate superficial cuts and abrasions.

Arrangements were made for the transport and admission of accident victims to medical facilities should the need arise. A medical emergency plan was developed, and arrangements made with local medical facilities to ensure the availability of medical assistance. Medical emergencies involving life-threatening circumstances would have been reasonable cause for waiving the contamination monitoring procedures at the access control point. If practical, a health physicist would have accompanied the injured person and performed a contamination survey using a portable monitoring instrument while in transit to the medical facility. Life-saving procedures would have taken precedence over contamination monitoring.

No life-threatening situation occurred during the transportation of the mill tailings to the Collins Ranch site.

D.6.3 OPERATIONAL PROCEDURES

The RAC established operational procedures to be used in conjunction with environmental monitoring results to ensure the health and safety of the general public. Environmental monitoring records were updated on a weekly basis and any upward trends in radon concentrations identified. Control levels were 6.0 pCi/l for a six-month average and 3.0 pCi/l for an annual average. Activities were reviewed at any time the releases exceeded 3.0 pCi/l radon above background and administrative action taken at any point where releases were more than 6.0 pCi/l above background. Increases in radon concentrations which indicated that limits were exceeded resulted in implementation of one of the following procedures, as appropriate:

I. Continue normal construction activities:

- o Wet down active working areas.
- o Wet down unprotected contaminated areas.

II. Modified work stoppage:

- o Continue wet-down procedures.
- o Employ wet-down procedure for vicinity property material coming on the site.
- o Stop work in contaminated areas.
- o Continue work in clean areas.

III. Total work stoppage

- o Stop work, including bringing vicinity property material on the site.
- o Wet down, use covers, or otherwise secure contaminated portions of the site.
- o Notify the public of the reasons for work stoppage.

Airborne particulate radionuclide concentrations were monitored and maintained below limits provided in 10 CFR Part 20 Appendix B, Table II, Column 1, using similar procedures. The DOE/UMTRA Project Office would have been notified immediately in the event that modified or total work stoppage becomes necessary. **No event requiring the stoppage of work due to an exceedance of airborne particulate radionuclide concentrations occurred at the Lakeview site.**

REFERENCES

DOE (U.S. Department of Energy), 1986. Management and Overview Quality Assurance Program Plan, UMTRA-DOE/AL-400325.0002, DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

Kusnetz, Howard L., 1956. "Radon Daughters in Mine Atmospheres--A Field Method for Determining Concentrations," in Industrial Hygiene Quarterly, March 1956, pages 85-88.

APPENDIX E

FINAL PLANS AND SPECIFICATIONS

Appendix E, Final Plans and Specifications, is divided into two sections. The first section, Specifications, includes general requirements and site work for remedial actions at the Lakeview site. The second section, Cover Design, provides the as-built data for the disposal cell cover design. This section is enhanced by Addendum 1.0, which provides additional information requested by the NRC during their review of project documents. Project Interface Documents are not included in this section since they have been provided to the state of Oregon and the NRC under separate cover.

Specifications

Division 1

General Requirements

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.1 DESCRIPTION OF THE PROJECT

A. General: The Work under the Subcontract involves two sites approximately seven miles apart: Lakeview processing site and Collins Ranch disposal site.

B. Certain facilities specified in this Subcontract are required in greater than one number as shown on the Subcontract Drawings. References made in singular shall be considered to apply to all such facilities. The sizes and shapes of these facilities may be different at each site.

C. Project Location:

1. Lakeview Processing Site: The Lakeview processing (mill) site and tailings are located in south-central Oregon, in Lake County. The closest town is Lakeview, one mile to the southeast. Klamath Falls is approximately 96 miles west of the site. The site is approximately 16 miles north of the California-Oregon border. The total designated site covers an area of 258 acres.

2. Collins Ranch Disposal Site: The Collins Ranch disposal site is located approximately seven miles northwest of the Lakeview processing site and consists of a 40-acre area in Section 12, Range 19E, Township 38S, Lake County, Oregon. A private logging road owned by Fremont Lumber Company connects the Lakeview processing site with a National Forest development road that passes within 3/4 mile north of the Collins Ranch disposal site.

D. Description of the Work:

1. The Work is generally described as site work related to the removal of contaminated residual radioactive materials from the abandoned uranium mill site at Lakeview processing site and disposal of these materials in an embankment with a protective cover at the Collins Ranch disposal site. The various construction activities include, but are not limited to the following:

a. Provision of temporary facilities including furnishing and installing of access control trailers, Subcontractor's trailer/s, Contractor's office trailer; construction of temporary roads and parking areas, if required; construction of temporary sanitary facilites; and furnishing and installing temporary utilities including power, water, heat, telephone, etc.

b. Provision of construction facilities including construction, operation and disposal of water collection and disposal system consisting of drainage ditches, pipes, sump, pumps, lined wastewater retention basins, etc. for water resulting from contaminated areas; construction of water collection system consisting of temporary drainage ditches, sumps, pumps, detention ponds if required, etc. for water resulting from uncontaminated areas; and temporary seeding.

c. Construction of permanent facilities including demolition and disposal of existing structures; removal, abandonment and disposal of existing utilities; sealing of abandoned wells; construction of monitoring wells; excavation of tailings and other contaminated materials; construction of tailings embankment; construction of vicinity properties encapsulation cell; construction of permanent drainage ditches; finish grading and restoration of sites; permanent seeding; maintenance and removal of fences installed by others; and erection of warning signs.

1.2 SCOPE OF WORK

A. General:

1. The Work required to be performed by the Subcontractor under this Subcontract consists of the construction and completion of the Work as outlined in Article 1.2.B below. Such Work is more fully detailed in the Specifications and Subcontract Drawings included herein.

2. The Work includes furnishing all plant, labor, tools, equipment, materials, transportation, and services, and performing all operations necessary for and properly incidental to the construction as shown and noted on the Subcontract Drawings and as specified in these Specifications.

B. The Work Includes:

1. Mobilization: Mobilization is specified in Section 01019.

2. Temporary Facilities: Temporary facilities are specified in Section 01500.

3. Construction Features:

   a. Staging Area Facilities: Construction of temporary facilities for construction workers along with supervisory, engineering, administrative, security, and radiation monitoring personnel including Contractor's and Subcontractor's office facilities, access control trailer to include a shower stall for emergency showers and change facilities for personnel working on the site, portable toilets for all personnel working on the site, and facilities for storing on-site equipment and construction materials.

   b. Protection of Existing Utilities: All known existing utilities shown on the Subcontract Drawings shall be protected during construction or shall be relocated as necessary for construction. The protection or relocation work shall conform to the requirements of the utility company having jurisdiction.

   c. Drainage, Erosion Control, and Waste Water Retention Basin:

      1) Construction of runoff water disposal system for water resulting from uncontaminated areas.

      2) Construction of runoff water collection system consisting of drainage ditches and a lined waste water retention basin at each site for water resulting from contaminated areas. Wastewater retention basins will receive waters resulting from:

         a) Decontamination activities including equipment and truck washdown.

         b) Storm water runoff from contaminated materials.

         c) Shower and wash basin waste water.

d) Processing site dewatering, if contaminated.

3) Temporary seeding.

d. Dewatering: Dewatering ground water from excavations at the Lakeview Processing Site by gravity drainage system or by pump system or by combination of both systems. Water from contaminated areas at Collins Ranch disposal site shall be collected in the wastewater retention basin prior to its use for dust control or compaction in the construction of the embankment. Water from uncontaminated areas shall be disposed of directly in the nearby natural drainage courses. Silty water from uncontaminated areas shall be discharged in the nearby natural courses via temporary detention pond or other similar facilities.

e. Equipment Decontamination Pad: Construction, maintenance and removal of decontamination pad, holding pond or underground tank and recirculating pump at both sites.

f. Dust Control: Dust generated by excavation, earth movement, vehicle use, temporary materials stockpiling, building decontamination, demolition, temporary stockpiling, mixing of contaminated materials and other activities shall be controlled and minimized by the use of water and water-based surfactants sprayed from hoses or trucks. The sources for dust suppression water will include recycled water from the wastewater retention basins, or water from tailings and subsoil dewatering, or Subcontractor's choice of other sources for use on contaminated areas. Water from uncontaminated areas will be used for dust control in uncontaminated areas.

g. Relocation of Hammersley Creek at Lakeview Processing Site: Hammersley Creek, which flows just north of the present tailings pile, shall be rerouted in a grass lined canal running east of the tailings pile and then south of the existing tailings just inside of the designated site boundary. Water from uncontaminated areas of the site will be discharged to Hammersley Creek. After completion of the Subcontract, the creek channel will remain east and south of the decontaminated area.

4. Permanent Features:

   a. Furnishing and installing warning signs indicating presence of radioactive materials on the disposal site, as required by the Contractor.

   b. Decontamination and Restoration:

      1) The mill area, tailings pile, evaporation ponds and windblown areas outside the mill area of the Lakeview processing site shall be decontaminated by excavation of the contaminated soil, and consolidation of this material into the stabilized embankment at the Collins Ranch disposal site. All uncontaminated wood chips, which are located in the upper portion of evaporation pond No. 1 shall be removed by others under a separate subcontract as specified in Article 1.3 below. Type 2 contaminated wood chips which exist in the bottom 12 inches of the evaporation pond shall be relocated to the disposal site embankment, evenly distributed so that the compacted embankment will contain no more than five percent by volume of wood chips.

      2) After removal of contaminated material, the areas of excavation on and around the Lakeview site and the Collins Ranch site shall be graded and seeded as shown on the Subcontract Drawings.

   c. Construction of Tailings Embankment: Construction of tailings embankment at the Collins Ranch site using tailings and other contaminated materials resulting from excavations at Lakeview processing site, using debris resulting from the demolition of structures, and using sediments from the retention basin.

   d. Construction of Vicinity Properties Encapsulation Cell: Construction of an encapsulation cell at the Collins Ranch site using contaminated materials from the vicinity properties.

   e. Cover Construction: Construction of protective cover over the tailings embankment and the vicinity properties encapsulation cell consisting of: a compacted layer of radon barrier material and layers of rock bedding and riprap.

f. Site Drainage: Construction of site and tailings embankment drainage system, an interceptor drainage ditch located above the tailings embankment to discharge the runoff to natural drainage patterns west of the site. All permanent drainage ditches shall be lined by rock riprap as shown on the Subcontract Drawings.

g. Ground Water Protection: Construction of the compacted geochemical/flow barrier liner consisting of compacted silty and clayey soils below the tailings.

h. Sealing of abandoned wells at each site.

i. Construction of monitor wells at the disposal site.

C. The above description of the Work is for general information only, and in no way limits the responsibility of the Subcontractor for constructing the Work in strict accordance with the Subcontract Drawings and Specifications listed in the Table of Contents.

D. Environmental Observations: The Work shall be performed in strict accordance with the applicable requirements of EPA, Lake County, the Oregon Department of Energy and other involved state and federal agencies (see Section SC-11 of the Special Conditions for list of permits and agencies) having jurisdiction, and in accordance with the requirements of General Provisions, General Conditions and Special Conditions.

1.3 OTHER SUBCONTRACTS

A. Other subcontracts awarded by the Contractor will be in progress during the work of this Subcontract. The Contractor or his authorized representative will be responsible for coordinating all activities between the subcontractors in accordance with the requirements of Section SC-3.A of the Special Conditions. Other subcontracts to be awarded by the Contractor are:

- o Fencing Subcontract, No. LKV-2
- o Uncontaminated Wood Chips Subcontract, No. LKV-3
- o Mill Area Windblown Tailings Subcontract, No. LKV-4

1.4 CONSTRUCTION SEQUENCE

A. Unless otherwise specified or directed, the Subcontractor shall follow the sequence of operations as set forth below. Full compensation for conforming to such requirements will be considered as included in the Bid Schedule items of Work and no additional compensation will be allowed therefor.

B. Temporary Facilities:

1. Processing Site:

   a. Install security fence and gates (by others).

   b. Abandon existing wells.

   c. Construct access control, monitoring and decontamination pad areas and staging area for temporary facilities.

   d. Remove and relocate contaminated material onto contaminated material storage area located at the north portion of Pond No. 7 from the locations of wastewater retention basin and rerouted Hammersley Creek.

   e. Reroute Hammersley Creek and construct wastewater retention basin using uncontaminated excavated material from the pond area and the creek to build the dike. Relocated creek will be a permanent feature.

   f. Relocate uncontaminated wood chips at Pond No. 1 to the designated wood chip storage area located north of the existing tailings pile (by others).

   g. Improve the existing swale surrounding the existing tailings pile for temporary drainage ditch during construction.

   h. Remove the existing hog-wire fence around the tailings pile.

2. Disposal Site:

   a. Upgrade all access and haul roads including the temporary access road between the logging road and the disposal site.

b. Abandon existing wells and construct monitor wells.

c. Install security fence and gates (by others).

d. Construct access control, monitoring and decontamination pad areas and staging area for temporary facilities.

e. Construct wastewater retention basin.

f. Construct temporary drainage ditches along the permanent drainage ditch alignment.

g. Excavate and prepare foundation of tailings embankment followed by construction of geochemical/flow barrier liner at the bottom.

C. Excavation and Relocation of Tailings Materials and Construction of Tailings Embankment:

1. Excavate tailings pile at the processing site and place tailings onto the flow barrier liner of the tailings embankment at the disposal site, hauling along the recommended transport route of Fremont Lumber Company Logging Road.

2. Restore the excavated tailings pile at the processing site to its final grade with materials excavated from the disposal site.

3. Excavate contaminated materials from the ponds and windblown areas at the processing site and place them onto the relocated compacted tailings of the tailings embankment at the disposal site.

4. Dispose of contaminated sediments from the wastewater retention basin of the processing site onto tailings embankment at the disposal site, if required; decontaminate and dispose of synthetic membrane liner of the wastewater retention basin at the processing site.

5. Restore the excavated areas including ponds, wastewater retention basin and windblown areas at the processing site with materials excavated from the disposal site.

6. Remove access control, monitoring and decontamination pad areas and staging area at the processing site, then recontour the site to the final grade, followed by permanent seeding.

7. Dispose of contaminated sediments from the temporary drainage ditches and the wastewater retention basin of the disposal site onto the tailings embankment, if required; decontaminate and dispose of synthetic membrane liner of the wastewater retention basin at the disposal site.

8. Place cover (radon barrier) on tailings embankment, construct permanent drainage ditches, then install erosion protection materials (riprap) on the tailings embankment and the ditches at the disposal site.

9. Remove access control, monitoring and decontamination pad areas, staging area, security fence and gates at the disposal site.

10. Restore wastewater retention basin area and complete final site grading and seeding of the disposal site.

11. Place warning signs along the boundary of the disposal site.

12. Construction of the vicinity properties encapsulation cell can be scheduled independently.

1.5 BORROW AREA LOCATIONS

Erosion protection riprap, bedding and base course materials will be obtained from suitable sources including commercially operated or other quarries, most of which are located adjacent to Lakeview. Limited testing of sources has been accomplished to determine acceptability of rock materials. Such test results are available for review as information to Bidders. Material for the geochemical/flow barrier liner, the radon barrier, and for processing site restoration will be obtained from the disposal site excavation.

1.6 SUBCONTRACT DRAWINGS

A. A list of Subcontract Drawings and Titles is given in the Table of Contents of these Subcontract Documents under "Subcontract Drawings".

B. Where "as shown," "as detailed," "as noted," or words of like meaning are used in the Subcontract Documents, it shall be understood that reference is being made to the Subcontract Drawings unless otherwise specified.

1.7 STATUS OF PROJECT LANDS

A. Lakeview Processing Site: Precision Pine Company owns this site. It stores bark, wood chips and sawdust on the northwest evaporation pond. It has built an addition onto the northern end of the lumber mill building. Two new buildings also have been constructed on the mill site near the old mill building; one of these is located directly over the former ore storage area. The areas to the north and west of the site are generally swampy during much of the year due to the high water table. To the east of the site, the land is swampy during the spring but surface water dries later in the summer and generally remains dry until winter. The ground water is encountered at depths ranging from 0 to 15 feet below the land surface.

B. Collins Ranch Disposal Site: This site is a part of a larger area of ranch owned by John and Bridget Collins. Prior to a range fire that occurred in August, 1984, the site was leased for grazing. The area to be used for disposal is isolated and visible only from a distant seldom-used National Forest development road. The presence of ground water revealed in five of the nine wells was at depths ranging from 7 feet in the adjacent valley to 76 feet beneath the disposal site.

C. A Finding of No Significant Impact (FONSI) has been executed by the DOE. After the State of Oregon completes its appraisals, the State will acquire the designated Project site. After completion of Subcontract (the remedial action), the State will transfer title of the designated site to the DOE.

1.8 TIME OF COMPLETION

A. The Subcontractor shall commence Work under this Subcontract according to a written Notice to Proceed issued by the Contractor not later than June 1, 1986, and shall complete the Work on or before October [illegible], 1987.

B. Termination for default, damages for delay and time extensions are specified in Article GP-6 of General Provisions.

1.9 CODES AND STANDARDS

A. Pursuant to Section GC-3 of the General Conditions, any material, method, or procedure specified by reference to the number, symbol, or title of a specific specification or standard, such as a Commercial Standard, American National Standard, Federal or State Specification, Industry or Government Code, a trade association code or standard, or other similar standard, shall comply with the requirements in the latest revision thereof and any amendments or supplements thereto in effect on the date of these Subcontract Documents, except as limited to type, class or grade, or modified in such reference.

B. The code, specification or standard referred to, except as modified in these Specifications, shall have full force and effect as though printed in these Specifications. These Specifications and standards are not furnished to bidders since manufacturers and trades involved are assumed to be familiar with their requirements. The Contractor will furnish, upon request, information as to how copies of the specifications and standards referred to may be obtained.

1.10 MANUFACTURERS' SPECIFICATIONS AND INSTRUCTIONS

A. Pursuant to Section GC-4 of the General Conditions, and unless otherwise indicated or specified, all manufactured materials, products, processes, equipment, or the like shall be installed or applied in accordance with the manufacturers' instructions, directions, or specifications. Said installation or application shall be in accordance with printed instructions furnished by the manufacturer of the material or equipment concerned for use under conditions similar to those at the jobsite. Two copies of such instructions shall be furnished to the Contractor and his acceptance thereof obtained before work is begun.

B. Any deviation from the manufacturers' printed recommendations shall be explained and acknowledged as correct for the circumstances, in writing by the particular manufacturer. Subcontractor will be held responsible for all installations contrary to the manufacturers' recommendations. If any item of material or equipment is found to be installed not in accordance with the manufacturer's recommendations, Subcontractor shall make all changes necessary to achieve such compliance.

1.11 WORK QUALITY

A. Shop and field work shall be performed by mechanics and workers skilled and experienced in the fabrication and installation of the work involved. All work on this Project shall be performed in accordance with the best practices of the various trades involved and in accordance with the Subcontract Drawings, reviewed shop drawings, and these Specifications.

B. All Work shall be erected and installed plumb, level, square and true, or true to indicated angle, and in proper alignment and relationship to the work of other trades. All finished work shall be free from defects and damage.

C. The Contractor reserves the right to reject any materials and work quality which are not considered to be up to the highest standards of the various trades involved. Such inferior material or work quality shall be repaired or replaced, as directed, at no additional cost to the Contractor.

1.12 FIELD MEASUREMENT AND TEMPLATES

Subcontractor shall secure all field measurements required for proper and accurate fabrication and installation of the work included in this Subcontract. Exact measurements are the Subcontractor's responsibility. Subcontractor shall also furnish or obtain all templates, patterns, and setting instructions required for the installation of all work. All dimensions shall be verified by the Subcontractor in the field.

1.13 ACCESS TO WORK

A. Pursuant to the requirements of Article GP-11 of the General Provisions, the authorized representatives of the following agencies will also have the right of access to inspect the Work covered by these Subcontract Documents during the performance of this Subcontract:

1. United States Department of Energy (DOE)
2. United States Nuclear Regulatory Commission (NRC)
3. State of Oregon
4. Lake County

1.14 OCCUPANCY PRIOR TO FINAL ACCEPTANCE

Provisions of Article GP-16 of the General Provisions and Section GC-5 of the General Conditions shall be complied with regarding occupancy by the Contractor prior to final acceptance.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

PART 4 - MEASUREMENT AND PAYMENT

(Not Used)

END OF SECTION 01010

SECTION 01019

MOBILIZATION

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section covers the following:

1. Organization and mobilization of Subcontractor's forces and equipment;
2. Transporting construction plant and equipment to the site and setting up of same;
3. Transporting tools, materials, and equipment to the site; and
4. Erection of temporary buildings and facilities required for initial construction operations.
5. Subsequent removal of temporary facilities, construction equipment, materials and supplies; decontamination of facilities; cleaning of equipment for salvage; cleaning of the site; and restoration and reseeding.

B. Temporary facilities and other mobilization items are specified in the General Conditions, Special Conditions and in Section 01500.

1.2 DESCRIPTION

A. Mobilization shall include:

1. Construction of temporary facilities and mobilization of all construction equipment, materials, supplies, appurtenances, and the like, manned and ready for commencing and performing the Work.
2. Assembly and delivery to the site of plant, equipment, materials, and supplies necessary for the performance of the Work but which are not intended to be incorporated in the work; the preparation of the Subcontractor's work area; the complete assembly, in working order, of equipment necessary to perform the required

work; personnel services preparatory to commencing actual work; and all other preparatory work required to permit commencement of the actual work on construction items for which payment is provided under the Subcontract.

3. Decontamination of temporary facilities, equipment, materials, supplies, appurtenances; and cleaning of equipment for salvage.
4. Subsequent removal from the site of all construction equipment, materials, supplies, appurtenances, and the like upon completion of the work.
5. Construction, maintenance and subsequent removal of temporary facilities as required by the Contractor including transport of materials to the disposal site, cleaning of the site, and restoration and reseeding.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Measurement for payment for mobilization will be by the lump sum basis.

4.2 PAYMENT

A. Payment for mobilization will be made at the lump sum price quoted therefor in the Bid Schedule, and shall include all items as specified herein. Payment will be made as follows:

1. Payment of 50 percent of the lump sum price will be made upon completion of "move-in". Move-in is defined as organization of the Subcontractor's manpower and equipment, transporting equipment to the site, and installation of Subcontractor's field office and other supporting structures.

2. Payment of the remaining 50 percent of the lump sum price will be made upon completion of work corresponding to 10 percent of the total price quoted in the Bid Schedule exclusive of the price quoted for mobilization.

B. Payment for furnishing, maintaining and subsequent decontaminating and removing of temporary facilities will be considered to be included in the Bid Schedule item for Mobilization.

END OF SECTION 01019

SECTION 01025

MEASUREMENT AND PAYMENT

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section covers descriptions of measurement and payment as they apply to this Subcontract. The provisions of this Section shall be supplemental to the requirements specified in General Provisions, General Conditions and Special Conditions.

B. Measurement methods specified in the individual Sections of these Specifications shall govern if they differ from methods specified in this Section.

C. The Subcontractor will compute all quantities. Where necessary, such computations will be based upon surveys performed by the Subcontractor.

1.2 RELATED WORK

A. General Provisions - Article GP-8: Payments to Subcontractors

B. General Conditions - Section GC-4B: Reports and Progress Payments

C. Special Conditions - Section SC-16: Variations in Quantities

D. Section 01052 - Layout of Work and Surveys

E. Section 01300 - Submittals: Schedule of Values and Progress Payment Schedule

1.3 MEASUREMENT OF QUANTITIES

A. Measurement Standards: All work to be paid for at a Contract price per unit of measurement will be measured by the Contractor in accordance with United States Standard Measures. A ton shall consist of 2,000 pounds avoirdupois.

B. Measurement by Weight:

1. Reinforcing steel, steel shapes, castings, miscellaneous metal, metal fabrications, and similar items, to be paid for by weight, shall be measured by scale or by handbook weights for the type and quantity of material actually furnished and used.

2. Material to be measured and paid for by weight shall be weighed on accurate, Contractor-approved scales, furnished by and at the expense of the Subcontractor. Use platform scales of sufficient size and capacity to permit the entire vehicle or combination of vehicles to rest on the scale platform while being weighed. Combination vehicles may be weighed as separate units provided they are disconnected while being weighed. All scales shall be inspected and certified as often as the Contractor may deem necessary to ascertain accuracy. Costs incurred, as a result of regulating, adjusting, testing, inspecting, and certifying scales, shall be borne by the Subcontractor.

3. The Contractor may be present to witness the weighing and to check and compile the daily record of such scale weights; however, in any case, the Contractor will require that the Subcontractor furnish weigh slips and daily summary weigh sheets. A duplicate weigh slip or a load slip for each vehicle weighed shall be delivered to the Contractor at the point of delivery of the material.

4. If the material is shipped by rail, the certified car weights will be accepted, provided that only actual weight of material will be paid for and not minimum car used for assessing freight tariff. Car weights will not be acceptable for material to be passed through mixing plants.

5. Trucks used to haul material being paid for by weight, shall be weighed empty daily and at such additional times as the Contractor may require. Each truck shall bear a plainly legible identification mark. The Contractor may require the weight of the material verified by weighing empty and loaded trucks on such other scales as the Contractor may designate.

C. Measurement By Volume:

1. Measurement by volume will be by the cubic dimension listed or indicated in the Bid Schedule. Method of

volume measurement will be as determined or directed by the Contractor.

2. When material is to be measured and paid for on a volume basis and it is impractical to determine the volume by the specified method of measurement, or when requested by the Subcontractor in writing and accepted by the Contractor in writing, the material will be weighed in accordance with the requirements specified for weight measurement. Such weights will be converted to volume measurement for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by the Contractor and shall be agreed to by the Subcontractor before such method of measurement of pay quantities will be accepted.

D. Measurement by Area: Measurement by area will be by the square dimension listed or indicated in the Bid Schedule. Method of square measurement will be as determined or directed by the Contractor.

E. Linear Measurement: Linear measurement will be by the linear dimension listed or indicated in the Bid Schedule. Method of linear measurement will be as determined or directed by the Contractor. Generally, items, components, or work to be measured will be measured at the centerline of the item in place.

F. Lump-Sum Measurement:

1. Lump-sum measurement will be for the entire item, unit of work, structure, or combination thereof, as listed or indicated in the Bid Schedule.

2. If the Subcontractor requests progress payments for lump-sum items or amounts in the Bid Schedule, such progress payments will be made in accordance with a Schedule of Values for that item as specified in Sections GC-4B of the General Conditions and SC-14 of the Special Conditions.

1.4 FIELD MEASUREMENT FOR PAYMENT

A. The Subcontractor will compute all quantities of Work performed, or of materials and equipment delivered to the site, for payment purposes.

B. The Subcontractor shall assist the Contractor in the taking of measurements by providing all equipment, workers, and survey crews, as required, for verification of quantities by the Contractor in accordance with the provisions of Section 01052 of these Specifications.

C. All such assistance in measurement services required of the Subcontractor, as specified, shall be performed under the direction and supervision of the Contractor.

1.5 PAYMENT

A. Payment will be full compensation for furnishing all labor, materials, tools, equipment, transportation, services, and incidentals, as specified, in Article GP-8 of the General Provisions and Section GC-4B of the General Conditions, and for performing all work necessary for completing the erection or installation of the item or work classification, including all adjusting and balancing, testing, cleaning, and all other incidental work.

B. Full compensation for all expense involved in conforming to the requirements for measuring materials or work shall be considered as included in the unit or lump-sum prices paid for the materials or work being measured, and no additional compensation will be permitted therefor.

1.6 VALUES OF UNIT PRICES

A. The number of units and quantities contained in the Bid Schedule are approximate only, and final payment will be made for the actual number of units and quantities which are incorporated in or made necessary by the Work included in this Subcontract.

B. In the event that work and/or materials or equipment are required to be furnished to a greater or lesser extent than is indicated by the Subcontract Drawings and Specifications, such work and/or materials or equipment shall be furnished in greater or lesser quantities, and the adjustment in unit price shall be made as specified in Section SC-16 of the Special Conditions.

1.7 REJECTED MATERIALS

Quantities of material wasted or disposed of in a manner not called for under the Subcontract; rejected loads of material, including material rejected after it has been placed by reasons of the failure of the Subcontractor to conform to the provisions of the Subcontract; material not unloaded from the transporting vehicle; material placed outside the limits indicated on the Subcontract Drawings or established by the Contractor; or material remaining on hand after completion of the Work, will not be paid for, and such quantities shall not be included in the final total quantities. No compensation will be permitted for loading, hauling, and disposing of rejected material.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

No separate measurement for payment for work required under this Section will be made.

4.2 PAYMENT

No separate payment will be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included in the related item of work in the Bid Schedule, or incidental to the Subcontract.

END OF SECTION 01025

SECTION 01052

LAYOUT OF WORK AND SURVEYS

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section covers the procedures and accuracy requirements for survey services for layout of work and field measurement of work quantities to be determined by surveys.

B. Before commencing any layout of work and surveys, the Subcontractor shall give the Contractor five working days written notice in advance so that the Contractor may witness such work.

C. The requirements specified herein are in addition to the requirements specified in Section GC-3 of General Conditions.

1.2 WORK NOT INCLUDED

Site markers and permanent boundary monuments will be furnished and installed by others.

1.3 DESCRIPTION

A. Reference Points: The reference points to be provided by the Contractor pursuant to Section GC-3A of General Conditions will include referenced monuments and elevation bench marks in the vicinity of the project. Initial reference points will be furnished by the Contractor. Replacement of survey stakes by the Contractor will be charged to the Subcontractor at a rate of $150 per hour. All other necessary reference points shall be established by the Subcontractor.

B. The Subcontractor shall furnish all necessary detail surveys including all lines, grades, and appropriate surveys as specified.

C. The Contractor reserves the right to perform any desired checking and/or correction of the Subcontractor's surveys but this shall not relieve the Subcontractor of responsibility for the adequate performance of the work.

D. Equipment and Personnel: The Subcontractor's instruments and other survey equipment shall be accurate, suitable for the surveys required in accordance with recognized professional standards, and in proper condition and adjustment at all times.

E. Field Notes and Records: The Subcontractor shall record surveys in duplicate page field notebooks. The original pages of such records shall be furnished to the Contractor at intervals required by the Contractor. A duplicate of each field notebook shall be furnished to the Contractor when filled or completed.

F. Use by the Contractor: The Contractor may at any time use line and grade points and markers established by the Subcontractor. The Subcontractor's surveys are a part of the Work and may be checked by the Contractor or representatives of the Contractor at any time. The Subcontractor shall be responsible for any lines, grades, or measurements which do not comply with specified or proper tolerances, or which are otherwise defective, and for any resultant defects in the Work. The Subcontractor will be required to conduct re-surveys or check surveys to correct errors indicated by review of the field notebooks or otherwise detected.

1.4 SURVEYS FOR LAYOUT AND PERFORMANCE

The Subcontractor shall perform all surveys for layout, and for performance of the Work, and shall reduce the field notes and make all necessary calculations and drawings necessary to carry out such work.

1.5 SURVEYS FOR MEASUREMENT FOR PAYMENT

When the Specifications or the Contractor require Bid Schedule items of work to be measured by surveying methods, the Subcontractor shall perform the surveys. All such surveys, including control surveys run for establishing the measurement reference lines, shall be performed in the presence of the Contractor (or a representative of the Contractor) who will witness the surveying operation by signing the field notes or keeping duplicate field notes, at the Contractor's option. The Subcontractor will reduce the field notes and calculate final quantities for payment purposes. A duplicate of the note reductions and calculations will be given to the Contractor.

1.6 SURVEYING ACCURACY AND TOLERANCES IN LAYOUT OF SURVEY STAKES

A. Tolerances in layout of Work shall not exceed the following:

Type of Line or Mark	Horizontal Position	Elevation
Permanent reference points	1 in 10,000	± .01 ft.
Structures or building construction	1 in 50,000	± .04 ft.
General Excavation and earthworks	1 in 2,000	± .10 ft.

B. Tolerances on thicknesses of layers and for elevations shown on the Subcontract Drawings shall be ± 0.10 foot.

C. These tolerances shall not supersede stricter tolerances required by the Drawings or Specifications, or by the governing authorities, and shall not otherwise relieve the Subcontractor of responsibility for measurement in compliance therewith.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

No separate measurement for payment will be made for work required under this Section.

4.2 PAYMENT

No separate payment will be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included in the related item of work in the Bid Schedule, or incidental to the Subcontract.

END OF SECTION 01052

SECTION 01300

SUBMITTALS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Specification Section describes the requirements for the following submittals:

1. Cost Profile
2. Shop Drawings
3. Samples
4. Schedules and Reports
5. Product Data
6. Manufacturer's Instructions
7. Design Calculations and Design Drawings

B. The requirements specified in this Section shall be supplemental to requirements specified in General Provisions, General Conditions, Special Conditions and any other requirements specified in individual Sections.

C. All submittals shall be in English language.

D. The Subcontractor shall submit all technical submittals including, but not limited to, shop drawings, schedules and reports, product data, manufacturer's instructions, design calculations and design drawings etc. to the Site Manager. A copy of the submittal, marked information only, shall be sent to the Contractor's Subcontract Administrator by the Subcontractor. These submittals shall be numerically serialized by the Subcontractor. The submittal serial numbers shall be consecutive and not a part of another correspondence tracking system. The Site Manager will review the submittal and clearly label as follows and return to the Subcontractor:

Submittal Review Status:

- o Approved
- o Approved as Noted
- o Revise and Resubmit
- o Rejected

1.2 COST PROFILE

A. In compliance with the U.S. Department of Energy's fiscal year funding procedures, the Subcontractor shall submit a Cost Profile reflecting the schedule of work (Project Construction Schedule) to be performed. The Cost Profile shall include the scheduled costs by month through completion of the Work scope defined in the Subcontract Documents. The cost profile shall be submitted within 30 days of receiving the Notice to Proceed.

B. At the beginning of each fiscal year (October 1), the Contractor will evaluate the Subcontractor's fiscal requirements and determine if there are conflicts.

C. Where conflicts arise between the Subcontractor's anticipated Cost Profile and the available U.S. Department of Energy fiscal year funding, the Subcontractor will submit a revised schedule of Cost Profile to the Contractor for approval.

1.3 SHOP DRAWINGS

A. The procedure for submittal of shop drawings is set forth below and is supplemental to the requirements of Section GC-4 of the General Conditions.

B. Shop drawings shall establish the actual detail of all manufactured or fabricated items, indicate proper relation of adjoining work, and incorporate minor changes of design or construction to suit actual conditions. Shop drawings shall be drawn to scale and shall be completely dimensioned.

C. Sheet sizes of shop drawings shall be in multiples of 8-1/2 by 11 inches, preferably not exceeding 22 by 34 inches, unless there is a special requirement for larger size sheets.

D. A clear space of 3 inch by 3 inch shall be provided on each drawing for the Contractor's review stamp and comments.

E. Shop drawings shall be submitted to the Contractor in the form of a reproducible transparency, along with one blackline or blueline print. Manufacturers' literature, brochures, catalog cuts, and other pertinent printed matter or data shall be submitted in triplicate.

F. After the Contractor has performed his review of shop drawings, he will return one print to the Subcontractor with one of the notations indicated in Article 1.1.D above.

G. When shop drawings and other submittals are returned marked with either "Revise and Resubmit" or "Rejected", the Subcontractor shall make such revisions and corrections and resubmit the drawings or other material in the same manner as specified above.

H. The Contractor will review and return shop drawings within thirty days of receipt.

1.4 SAMPLES

A. The procedure for submittal of samples is set forth below and is supplemental to the requirements of Section GC-4A (3) of the General Conditions.

B. The Subcontractor shall furnish the Contractor samples of the various materials, together with the finish thereon, as specified for and intended to be used on or in the Work. Samples shall be sent to the Contractor.

C. Subcontractor shall submit all samples to the Contractor at least 21 days before purchasing, fabricating, applying, or installing such materials and finishes, unless otherwise stated. The Contractor will review the samples for visual aspects such as kind, color, pattern, and texture, and will approve or ask for resubmission of samples within fourteen days of the Subcontractor's submission. All approvals of samples will be given by the Contractor in writing.

D. Unless otherwise specified in the various sections of these Specifications, the Subcontractor shall submit all samples, other than field samples, in triplicate. A cover letter shall accompany the sample and shall list all items being transmitted, designating their particular usage and location in the Project.

E. After the Contractor has performed his review and analysis of samples, he will retain two samples and will return the remaining sample to the Subcontractor, along with the Contractor's comments.

F. Samples shall be submitted and resubmitted until approved as satisfactory. Approval of a sample shall not be taken in itself to change or modify any Subcontract requirement.

All materials, color, pattern and texture in the completed building or structure shall be equal in every respect to that of the approved samples.

G. Each sample shall be identified completely as to product, color, manufacturer, trade name, lot, style, model, location of use, and Subcontract Document reference, as well as the names of the Subcontractor, Supplier, Project, and Contractor.

H. Unless otherwise specified, all samples, where applicable, shall be furnished in sizes required by the Site Manager.

I. Test samples, as designated by the Contractor, will also be selected from the materials or equipment delivered by the Subcontractor to the site for use in the work, or as requested by the Contractor. If any test sample fails to meet the specification requirements, previous approval will be withdrawn, and such materials or equipment which fail the testing, shall be subject to removal and replacement by the Subcontractor with materials or equipment meeting the Specification requirements.

J. Field samples shall be prepared at the site by the Subcontractor in the manner and number as specified in these Specifications. Affected finish work shall not be commenced until the Contractor has approved the field samples, in writing.

1.5 SCHEDULES AND REPORTS: GENERAL

A. The Subcontractor shall prepare and submit schedules and reports in accordance with the requirements of Section GC-4B of General Conditions and the requirements of this Section.

B. The Schedules and reports shall describe the Subcontractor's work plan in sufficient detail as delineated below to provide:

1. Assurance to the Contractor that the finished Work complies accurately with the Subcontract Documents, and the requirements of Section GC-4 of General Conditions are satisfied,

2. A basis for determining the progress of the work, and

3. A basis for the Contractor's internal planning activities.

C. Within ten calendar days after Notice to Proceed, the Subcontractor shall provide the schedules specified in this Section.

D. The schedules shall be in a reproducible form of the same scale or some of the schedules may be combined as required by the Contractor.

E. Unless otherwise specified, the schedules shall be presented in graphic format and shall be updated for each construction meeting, or at least monthly, and transmitted to the Contractor's Subcontract Administrator and Site Manager.

F. The Subcontractor shall obtain approval of the various schedules specified in this Section before submitting the first application for payment.

G. The Subcontractor's schedules and reports shall include the following:

1. Site Mobilization Schedule
2. Project Construction Schedule
3. Progress Payments Schedule
4. Schedule of Values
5. Schedule of Submittals
6. Weekly Status Reports
7. Monthly Progress Reports

1.6 SITE MOBILIZATION SCHEDULE

A. Format: The Subcontractor shall present, at the preconstruction conference, the schedule for site mobilization in bar chart format. The schedule shall delineate the establishment of the temporary facilities identified in Section 01500 and the Subcontractor's plan for starting the work.

B. Written Narrative: The Site Mobilization Schedule shall be accompanied by a written narrative discussion of the schedule. The narrative shall provide a man-power level by month for the first three months of the job, transportation routes proposed for delivery of major construction equipment to be used on the project, identification of special permits required and when they are needed, and a description of the temporary facilities to be provided.

C. Status and Progress: The status of mobilization schedule items will be reported in the Weekly Status Report discussed below. An updated Site Mobilization Schedule will be included in the Monthly Progress Report.

1.7 PROJECT CONSTRUCTION SCHEDULE

A. Scheduling: A preliminary issue of the Project Construction Schedule shall be prepared for review at the preconstruction conference. Fifteen days after receipt of Notice to Proceed the Subcontractor shall issue the Project Construction Schedule for approval and issue the approved Project Construction Schedule, ten days after receipt of approval and comments from the Contractor.

B. Format:

1. The preliminary issue distributed at the preconstruction conference will consist of:
    a. Critical Path Method (CPM) Schedule
    b. Subcontractor's Manpower Usage Chart
    c. Method of Construction Narrative
2. The issued for approval Project Construction Schedule will consist of the revised items listed in B.1. above.
3. The approved Project Construction Schedule will consist of the following items, each compatible with the other and developed from the same basis:
    a. Method of Construction Narrative
    b. CPM Schedule
    c. Subcontractor's Manpower Usage Chart

C. Method of Construction: Method of construction submitted at the preconstruction conference with the preliminary schedule shall be a written discussion of the Subcontractor's Methods for completing the Work. The Subcontractor shall briefly describe his approach to the Subcontract.

D. Subcontractor's Manpower Usage Chart: The Subcontractor shall submit a chart showing the monthly estimated work force at the site from Notice to Proceed through Subcontract completion. The chart shall distinguish between manual and non-manual employees.

E. The Use of Scheduled Float: In as much as Subcontractor's Schedule represents the Project Construction Schedule, the calculated scheduled float for an activity is shared by the Subcontractor and Contractor. Adjustments to the scheduled float will be equitably resolved by the Contractor.

F. Computer Generated Schedule: The Subcontractor may generate the CPM Schedule manually or by using a computer. Samples of actual project applications and computer reports produced shall be provided. The CPM Schedule shall include all definable critical items of Work.

G. Comments incorporated: The Subcontractor shall incorporate the Contractor's comments into revisions of the Project Construction Schedule, adjust the manpower loading accordingly and resubmit the schedule to the Contractor, for approval along with a summary of the changes or other means showing the changes.

H. Approved Project Construction Schedule:

1. Upon approval the Subcontractor will issue for construction use the Project Construction Schedule.

2. Updating: The schedule will be reviewed, at least monthly, by the Contractor and the Subcontractor. Updates to the schedule will be accomplished on the approved documents without changing the approved data. The updated Bar Chart will be issued monthly to the Contractor.

3. Revisions to the Schedule shall be accomplished to reflect the impact thereon of new developments and in accordance with the requirements of the Contractor. Revisions made to the schedule will be given a new revision number and submitted to the Contractor for approval.

1.8 SCHEDULE OF VALUES

A. A preliminary schedule of values for all of the Work shall be submitted together with the Project Construction Schedule. The Schedule will include quantities and prices of items aggregating the Contract Price and will subdivide the Work into component parts in sufficient detail to serve as the basis for progress payments during construction (Time vs. Subcontract Value). Such prices will include an appropriate amount of overhead and profit applicable to each item of Work which will be confirmed in writing by Subcontractor at the time of submission.

B. The finalized schedule of values will be acceptable to the Contractor as to form and substance.

1.9 SCHEDULE OF SUBMITTALS

A. Vendor Data Submittals list including data submittals, required return dates, and material deliveries shall be submitted to the Contractor's Site Manager.

B. Subcontractor Submittals List consisting of all submittals required under this Subcontract but are not included in the schedules listed in this Section shall be submitted to the Contractor's Site Manager.

C. Shop Drawings:

1. The Shop Drawings list shall be submitted by the Subcontractor as a supplement to the Project Construction Schedule.
2. The list shall depict submittal delivery dates of the shop drawings by the Subcontractor's Vendors.
3. The list shall be continually updated for progress and revised upon issuance of changes which would substantially affect the list. The updates shall be furnished upon request by the Contractor.
4. Revisions to the Shop Drawings list shall be reflected on the Project Construction Schedule.

1.10 PROGRESS PAYMENTS SCHEDULE

A. Progress Payment Schedule: The Subcontractor shall submit a proposed Progress Payment Schedule which coincides with the Project Construction Schedule. The Progress Payment Schedule shall be by month and shall total the Subcontract Price as awarded. A proposed schedule will be required at the preconstruction conference.

B. The Schedule of Payments will be subject to modification by, and approval of, the Contractor. If the Schedule is unbalanced beyond reasonable consideration, the Subcontractor will be required to revise the Schedule within reasonable limits as directed.

C. Modifications: Changes shall be made and submitted with each Schedule Revision and each executed Subcontract Price change to reflect the impact thereon of new developments.

1.11 MONTHLY PROGRESS REPORTS

A. The Subcontractor shall submit a Monthly Progress Report, listing all construction activities and their scheduled completion dates. Activities shall show the percent of completion and the days required for completion, and shall include milestone events that occured during the month.

B. A Monthly Progress Report format will be furnished to the Subcontractor, by the Contractor, at the preconstruction conference.

C. Three copies of each Monthly [illegible] Report shall be forwarded to the Contractor no [illegible] the fifth working day after the last working d[illegible] payment in the Report.

D. Monthly Progress Re[illegible] to status of the Project as of the da[illegible] event or, if [illegible]-stone event occurred [illegible] the month, [illegible] ast [illegible] date of month.

E. Other Requirements: Requests for progress payments shall be accompanied by the latest pertinent report.

1.12 WEEKLY STATUS REPORTS

The Subcontractor shall submit a Weekly Status Report to the Contractor by Friday noon. The report shall be on a form provided by the Contractor, and shall include items such as a Summary of Work completed and a Two-Week Look Ahead Bar Chart. Delinquency in submitting Weekly Status Reports may cause delays in progress payments.

1.13 PRODUCT DATA

A. Each copy shall be marked to identify applicable products, models, options, and other data; manufacturers' standard data shall be supplemented to provide information unique to the Work.

B. The Subcontractor shall submit the number of copies which the Subcontractor requires, plus two copies which will be retained by the Contractor.

1.14 MANUFACTURER'S INSTRUCTIONS

When required in individual Specification Sections, the Subcontractor shall submit manufacturer's printed instructions for delivery, storage, assembly, installation, adjusting, and finishing, in quantities specified for product data.

1.15 DESIGN CALCULATIONS AND DESIGN DRAWINGS

A. Design Calculations: When requested by the Contractor, design calculations shall be submitted to the Contractor for review with all pertinent data, assumptions, objective, criteria, applicable codes, standards and references. The calculations shall be on 8-1/2 by 11-inch or 11 by 17-inch sheets. Each design calculation set shall bear page numbers, titles, revision numbers, date and calculation number. Where multiple number of items are designed in a particular system, the calculations shall be preceded by a table of contents.

B. Design Drawings:

1. When requested by the Contractor, design drawings shall be submitted to the Contractor for review.

2. Pertinent requirements of Article 1.3 of this Section shall be applicable for submittal of design drawings.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

No separate measurement for payment for work required under this Section will be made.

4.2 PAYMENT

No separate payment will be made for work required under this Section. All costs in connection therewith shall be considered to be incidental to the applicable items of work to which they pertain.

END OF SECTION 01300

SECTION 01500

TEMPORARY FACILITIES

PART 1 - GENERAL

1.1 SCOPE

A. The Subcontractor shall furnish and install all required temporary facilities as shown or specified herein plus such facilities and equipment as are required for proper performance of the Subcontract.

B. All such temporary facilities shall be located as shown on the Subcontract Drawings, or as directed, and maintained in a clean, safe and sanitary condition at all times until completion of the Subcontract; then removed from the site and disposed of as required by the Contractor.

C. The requirements specified herein are in addition to any requirements specified elsewhere in the Subcontract Documents. Temporary facilities shall meet the requirements for all-weather service.

D. The trailers shall be equipped with skirting all around them, and the utilities shall be designed and constructed to provide uninterrupting service during winter.

E. Certain facilities specified in this Section, although referred to in singular, may be required in greater numbers. The number of facilities required shall be as shown on the Subcontract Drawings.

F. All land disturbances related to temporary facilities shall be minimized to the greatest extent possible and the land returned to its natural grade.

1.2 RELATED WORK

Section 01019 - Mobilization: Payment

1.3 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The Publications are referred to in the text by the basic designation only:

1. UMTRA Project Construction Safety and Health Management Program (MK-UMTRA-4)

2. Oregon State Highway Division: "Standard Specifications for Highway Construction", as applicable.

3. Uniform Building Code (UBC): 1985 Edition, applicable Chapters and Sections.

4. National Fire Protection Association (NFPA), as applicable.

B. All required facilities and equipment shall also be in accordance with applicable Federal, State, County, and Utility laws, rules, and regulations. Notwithstanding contrary provisions of General Provisions, General Conditions and Special Conditions, nothing in the Subcontract Drawings and Specifications shall be construed to permit work not conforming to the above.

1.3 SUBCONTRACTOR'S TEMPORARY OFFICE TRAILER

A. Subcontractor shall provide and maintain, in good condition, on each site, at least one temporary office trailer of suitable size for himself and his office staff.

B. One trailer on each site shall have a conference room of suitable size for consulting with the Contractor and DOE representatives, etc.

C. The location of the trailer/s shall be approved by the Contractor prior to setting in place.

1.4 CONTRACTOR'S TEMPORARY OFFICE TRAILER

A. The Subcontractor shall provide an office trailer for the Contractor's staff near the Subcontractor's office trailer at the processing site.

B. The trailer shall be not less than 600 square feet. The trailer shall be provided with water, power and telephone, and shall be properly lighted and temperature conditioned for summer and winter use.

1.5 ACCESS CONTROL TRAILER AND PARKING AREAS

A. The Subcontractor shall provide an access control trailer at each site to provide office space, a single shower for decontamination and change facilities for occasional use by all personnel working on the site. The office space will be for administrative, security and Health Physics personnel.

B. The trailer shall provide minimum floor space of 600 square feet with sink and shower facilities, and the requirements of 1.5.A above.

C. The Subcontractor shall provide an aggregate surfaced parking area as shown on the Subcontract Drawings, for the Contractor's staff and for the access control area.

D. Subcontractor shall provide parking facilities for construction personnel, delivery vehicles, the Contractor's representatives, and authorized visitors. Parking areas for personal cars shall be limited to the Contractor's and Subcontractor's office areas.

1.6 JANITORIAL SERVICE

The Subcontractor shall provide daily janitorial services for the access control trailer, Contractor's trailer and toilet facilities including supply of paper, soap, etc.

1.7 ROADS AND MAINTENANCE

A. General: The Subcontractor shall use existing roads as temporary access roads and haul roads to the greatest extent possible. Such existing roads may be upgraded by the Subcontractor. The private haul road currently bisects several farm properties that may require fencing, gates, or other protective features to prevent hazard to livestock and occupants and to minimize dust nuisance. Additional temporary access roads and haul roads may be constructed by the Subcontractor for his convenience, subject to the requirements set forth below. The Subcontractor shall comply with the provisions of the agreements, if any, made between the Contractor and the existing property owners.

B. Temporary Roads:

1. Construction of any temporary roads shall be coordinated with and shall be as approved by the Contractor.

2. The temporary roads shall be removed and the areas restored at the completion of the Subcontract, unless otherwise directed by the Contractor.

3. Where feasible, road cuts shall be scarified and graded to as near original grade and reseeded with seed mixture recommended by the Standard Specifications for Highway Construction of the State of Oregon, unless otherwise directed by the Contractor.

C. On all temporary roads, erosion shall be kept to minimum and suitable grades and radii of curves shall be maintained to facilitate ease of movement of vehicles and equipment.

D. Maintenance: Subcontractor shall maintain all roads during the construction period for the safe and efficient transport of equipment, supplies and personnel. Prior to Subcontract Closeout:

1. Temporary roads built by the Subcontractor for his convenience shall either be removed or left in a position as required by the Contractor.

2. Existing roads used as temporary roads shall be repaired to meet conditions equal to or better than those prevalent prior to commencement of the Work.

E. Dust Control: The Subcontractor shall be responsible for providing adequate dust and water pollution control measures during the construction of the temporary facilities and during operations on the main haul road.

1.8 STORAGE OF MATERIALS AND EQUIPMENT

A. Subcontractor shall make similar arrangements for hardstands or other necessary provisions for exterior storage areas for materials, equipment, and debris. Locations and perimeters of such facilities shall be subject to the approval of the Contractor.

B. All operations of the Subcontractor, including storage of materials, shall be confined to areas approved. Subcontractor shall be liable for any and all damage caused by him during such use by him of property of the Contractor or other parties. Subcontractor shall save the Contractor, its officers, agents, and employees free and harmless from liability of any nature or kind arising from any use, trespass, or damage occasioned by his operations on premises of a third party.

C. Subcontractor shall store construction materials and equipment within boundaries of designated areas. Storage of gasoline or similar fuels shall conform to the requirements specified in Section SC-13 of the Special Conditions.

1.9 CONSTRUCTION EQUIPMENT

A. Subcontractor shall erect, equip, and maintain all construction equipment in accordance with all applicable statutes, laws, ordinances, rules and regulations of the Contractor or other authority having jurisdiction.

B. Scaffolding, staging, runways, hoists, barricades, and similar equipment required for performance of the Subcontract shall be provided and maintained by the Subcontractor. Hoists or similar equipment shall be provided with operators and signals, as required.

C. Subcontractor shall provide, maintain, and remove upon completion of the Work, all temporary rigging, scaffolding, hoisting equipment, debris boxes, barricades around openings and excavations, fences, ladders, and all other temporary work, as required for all work hereunder, unless otherwise directed by the Site Manager.

D. Construction equipment and temporary work shall conform to all the requirements of State, County, and local authorities, OSHA, and underwriters which pertain to operation, safety, and fire hazard. Subcontractor shall furnish and install all items necessary for conformity with such requirements, whether or not called for under the separate divisions of these Specifications.

1.10 TEMPORARY SANITARY FACILITIES

A. No sanitary facilities exist at either of the existing sites. Subcontractor shall provide temporary sanitary facilities for use by all employees and persons engaged on the Work, including Subcontractor, other subcontractors, Contractor, DOE, and their employees.

B. Sanitary facilities include enclosed chemical toilets, washing sinks, and holding tanks. These facilities shall meet the requirements of applicable agency standards. Open pit or trench latrines will not be permitted.

C. Near Contractor's trailers, two enclosed chemical toilets shall be provided at each site for the exclusive use of the Contractor, DOE, and their employees.

D. Additional chemical toilets shall be provided in the Access Control Area for use by the Subcontractor, his employees and other workers and suppliers. The number of toilets to be provided shall conform to the requirements specified in Section GC-6 of the General Conditions. One wash sink shall be provided in Contractor's trailer. Access control trailer may require more than one sinks. Wash sinks shall be connected to water supply and drained to a holding tank.

E. Sanitary facilities shall be located as shown on the Subcontract Drawings and as approved by the Contractor, and shall be maintained in a sanitary condition during the entire course of the Work. Subcontractor shall keep such facilities adequately supplied with toilet paper, paper toweling, paper cups, etc., as required.

F. At completion of the work sanitary facilities shall be properly disinfected and all evidence of same, including buried tanks and concrete foundations, removed from the site to the satisfaction of the Contractor unless otherwise directed.

G. The holding tank(s) shall be kept pumped out at such intervals that the tank(s) will not overflow and contaminate the ground, flowing streams, or surface drainage.

1.11 TEMPORARY ELECTRIC POWER

A. The Subcontractor shall provide and maintain during the course and progress of the Work all electrical power and wiring requirements to facilitate the work of all trades and services associated with the Work. The Subcontractor shall make arrangements with the serving utility, where available, and shall pay all charges for providing and maintaining electrical service at each site. All temporary wiring, feeders, and connections, and any standby generators or generating capacity required in excess of the serving utility capacity shall be furnished by the Subcontractor.

B. At the Lakeview site, the electric power can be obtained by extending the existing power line. The Subcontractor shall make arrangements with the serving utility, Pacific Power and Light Company and Surprise Valley Rural Electric, for power supply. The Subcontractor shall also coordinate his requirements with the owner of the utility and the Precision Pine Company through the Contractor. At the Collins Ranch site there is no such source available and the Subcontractor shall provide portable generators of required capacities, or shall make other suitable arrangements as necessary.

C. Subcontractor shall provide power to the access control trailers and the Contractor's trailer at no extra cost to the Contractor. Subcontractor shall provide adequate temporary lighting for all Work, as required.

D. Routing of temporary conductors, including welding leads shall not create a safety hazard nor interfere with operation and maintenance of existing facilities. In connecting to existing power panels, the Subcontractor shall make prior arrangements through the Site Manager.

E. All temporary wiring installed by the Subcontractor shall be accomplished in accordance with the requirements of the National Fire Protection Association (NFPA) Codes 70 and 70E (latest edition), using acceptable code materials and equipment.

F. There may be times during the period of the subcontract when the Contractor will schedule power outages which will make temporary electrical power unavailable over any of the electrical transmission and distribution systems. Normally, these outages will be scheduled sufficiently in advance to give the Subcontractor prior notification; however, due to operational requirements, it may be necessary to "kill" the lines without prior notification. The Contractor assumes no liability for interruptions, delays, or inconveniences caused to the Subcontractor as a result of such electrical power outages or power failure, scheduled or unscheduled, except that any delay in completion of the work resulting directly from such power outages shall be deemed a delay due to unforeseeable causes beyond the control and without the fault or negligence of the Subcontractor within the meaning of the Article 6. "TERMINATION FOR DEFAULT-DAMAGES FOR DELAY TIME EXTENSIONS," of the General Provisions, and the Subcontractor shall be entitled to relief in accordance with the provisions of said Article 6, provided he gives written notice of such delay in accordance with the requirements thereof. There will be no adjustment in the Subcontract Price due to any such electrical power outage or power failure.

1.12 TEMPORARY WATER

A. Temporary water service (for potable and construction use) shall be provided at Subcontractor's expense.

B. At the Lakeview site, the Subcontractor may, through negotiations with the mill area owner, obtain water for potable use from an existing water line that supplies water to the mill from an existing well. Construction water for moisture control during compaction, and for dust control in contaminated areas of work may be obtained from the wastewater retention basin, evaporation ponds or dewatering operations or other sources of Subcontractor's choice. Construction water for moisture control during compaction and for dust control in uncontaminated areas of work may be obtained from existing local wells through negotiations with private owners or from temporary retention basin excavated to hold silted uncontaminated water from dewatering operations or other sources of Subcontractor's choice.

C. At the Collins Ranch disposal site, there is no developed source of water supply at the site. Water for equipment decontamination, compaction, and dust control on the site may be purchased from a developed well owner nearby or from an on-site well developed by the Subcontractor or from other sources of Subcontractor's choice. A holding pond or tank may be constructed for storage of developed water. Optionally, by negotiations, water may be purchased from the ranchers nearby to the site. If the Subcontractor elects to develop an on-site well, he shall be responsible for obtaining the required permits.

D. At both sites, the Subcontractor shall provide chilled drinking water in the Contractor's office. The water shall be furnished in bottles from an approved source.

E. Sanitary water service and chilled drinking water service to the access control trailers and the Contractor's trailer shall be at the Subcontractor's expense.

1.13 TEMPORARY HEAT

A. Subcontractor shall provide, at his own expense, all temporary heat as necessary for the plant, the proper installation of all work, equipment, and materials, and for the protection of all work and materials, against injury from dampness, cold, and freezing.

B. No gas service is available at either site.

C. CAL-ORE Gas Company supplies natural gas in the Lakeview area. CAL-GAS supplies bottled and bulk gas service.

1.14 TEMPORARY TELEPHONE SERVICE

A. At the Lakeview site, the Subcontractor shall make all necessary arrangements with the Telephone Utilities, Inc. for outside telephone service to the Subcontractor's and Contractor's offices.

B. There is no telephone service available at the Collins Ranch site.

C. All cost of telephone service connections shall be borne by the Subcontractor.

D. The Contractor will provide his own telephones. Monthly service charges and long distance calls chargable to the Contractor shall be billed separately to the Contractor.

1.15 BARRICADES, LIGHTS, AND FLAG PERSONS

A. Pursuant to Article GP-34 of General Provisions, Section GC-3D of General Conditions, and Sections SC-12 and SC-17 of Special Conditions, the Subcontractor shall construct and maintain fences, planking, barricades, lights, shoring, and warning signs as required by local authorities and Federal and State safety ordinances, and as required, to protect the Contractor's property from injury or loss and as necessary for the protection of the public, and provide walks around any obstructions made in a public place for carrying on the work covered in this Subcontract. Leave all protection in place and maintain until removal is authorized.

B. In addition, guard and protect all workers, pedestrians, and the public from excavations, blasting operations, construction equipment, all obstructions, and other dangerous items or areas by means of adequate railings, guard rails, temporary walks, barricades, warning signs, sirens, directional signs, overhead protection, planking, decking, danger lights, etc.

C. Flag persons, properly equipped with International Orange protective clothing and flags, shall be provided at all such times, as necessary, to direct or divert pedestrian or vehicular traffic.

1.16 SHUT-DOWN TIME OF SERVICES

The Subcontractor shall not disconnect or shut down any part of the existing utilities and services, except by express permission of the Contractor. The Subcontractor shall submit schedule of estimated shut-down time in order to obtain such permission, and shall notify all interested parties, utilities, County authorities, etc., as required.

1.17 MAINTENANCE

A. Subcontractor shall maintain the access roads, haul roads and access control area, as required by the Contractor, during the construction period for the safe and efficient transport of equipment, supplies and personnel.

B. Fencing installed by others shall be maintained by the Subcontractor. Removal of fencing is specified in Section 02050.

1.18 REMOVAL AT COMPLETION

A. Upon completion of the Work, or prior thereto when so required by the Contractor, Subcontractor shall remove all temporary facilities including all concrete foundations. Similarly, all areas utilized for temporary facilities shall be returned to substantially their original, natural state, or as otherwise indicated or directed.

B. Prior to Subcontract Closeout, the Subcontractor shall repair the existing roads and logging company haul road used as temporary roads, including regrading, recompacting and resurfacing, to at least equal or better than the original conditions existing prior to the start of the Subcontract.

C. Upon completion of the Subcontract, the Subcontractor shall leave the office trailers and access control trailers fully operational and with all services mentioned in this Section for the following durations from the date of completion of the Subcontract:

1. Office Trailers: 60 days.

2. Access Control Trailers: 30 days.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

(Not Used)

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

No separate measurement for payment for work required under this Section will be made.

4.2 PAYMENT

No separate payment will be made for work required under this Section. All costs in connection therewith shall be considered to be included in the Bid Schedule item for Mobilization.

END OF SECTION 01500

Division 2

Sitework

SECTION 02050

DEMOLITION

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for the demolition and disposal of the following facilities:

1. Existing pump house.
2. Decontamination pads constructed under this Subcontract.
3. Wastewater retention basins constructed under this Subcontract.
4. The existing hog-wire fence around the tailings pile.
5. Chain link fence and woven wire fence including gates, installed by others.

B. The locations of these facilities are shown on the Subcontract Drawings.

1.2 RELATED WORK

A. Special Conditions - Sections SC-7 and SC-8

B. Section 02090 - Sealing Abandoned Wells

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.1 DEMOLITION

A. Pollution Controls:

1. Water sprinkling, temporary enclosures, and other Contractor approved methods shall be used to limit the

amount of airborne dust and dirt to the lowest practical level. Demolition work shall comply with governing regulations pertaining to environmental protection.

2. Water shall not be used if it is likely to create hazardous or objectionable conditions such as ice, flooding, or pollution. An approved water-based biodegradable wetting agent (surfactant) such as Dupont "Duponol WAQ" or equal may be used to reduce the quantity of water required.

3. Adjacent structures and improvements shall be cleaned of dust, dirt, and debris caused by demolition operations, as required by the Contractor, or governing authorities.

4. All drainage water runoff from demolition sites shall be routed into the retention basin.

B. Demolition of Pump House: Pump house shall be demolished by methods required to complete the work in accordance with governing regulations.

C. Decontamination Pads:

1. The decontamination pads shall be demolished as required by the Contractor.

2. Grading shall be performed, as required by the Contractor, to restore existing grades unless otherwise indicated on the Subcontract Drawings.

3. Uncontaminated paving and surfacing materials shall be disposed of as required by the Contractor. Contaminated materials shall be disposed of in the tailings embankment.

D. Retention Basins:

1. After demolition, disposal and final site grading has advanced to the stage that the retention basins are no longer needed for control of contamination, as determined by the Contractor, the basins shall be demolished by removing and disposing of all contaminated materials as follows:

   a. Type 2 contaminated material shall be excavated from the retention basin area and disposed of in the tailings embankment.

b. Type 1 contaminated material within the depth of 6 inches below the finish grade surface shall be excavated and disposed of in the tailings embankment, and the excavated surface shall then be filled with uncontaminated fill and graded to final contours according to the Subcontract Drawings.

2. After the completion of the construction phase, the synthetic membrane shall be removed, decontaminated and disposed of as required by the Contractor. If the membrane cannot be decontaminated by practical means, it shall be disposed of by cutting into strips, shredding and placing in the tailings embankment in a manner that would not induce settlement, inhibit water migration, or exceed the 5 percent limit on organic material by volume.

E. Hog-Wire Fence: The existing hog-wire fence around the tailings pile shall be removed and the debris shall be disposed of as required by the Contractor.

F. Chain Link and Woven Wire Fences: Upon completion of the Subcontract, the Subcontractor shall remove chain link fence, woven wire fence, and gates, all installed by others, and dispose of as his own property.

3.2 DISPOSAL OF DEMOLITION DEBRIS

A. Demolition debris such as soils, debris, rubbish, structures and other materials resulting from demolition operations shall be disposed of as follows. All materials will be subject to testing before disposal. Testing will be performed by the Site Manager at no cost to the Subcontractor. Materials tested by the Site Manager will be classified as contaminated and uncontaminated materials as defined in Section SC-1 of the Special conditions:

1. Uncontaminated materials shall be disposed of in fills on the processing site and disposal site or stockpiled in spoil area shown on the Subcontract Drawings or as required by the Contractor.

2. Contaminated materials shall be placed in the tailings embankment at the disposal site as shown on the Subcontract Drawings.

3. Disposing of bulky materials shall be done with care to minimize the volume of voids created in the disposal mass. Pieces of wood, concrete, and steel members shall be cut or broken up to be no greater than 10 feet in length and no greater than 27 cubic feet in volume, and placed to avoid nesting.

B. Burning of materials removed from demolished structures shall not be permitted.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Measurement for payment for demolition and disposal of structures specified in this Section will be on a lump sum basis.

4.2 PAYMENT

Payment for demolition and disposal of structures specified in this Section will be by the lump sum price quoted therefor in the Bid Schedule. The price quoted shall include full compensation for furnishing all labor, materials, equipment, incidentals, and for performing all work specified in this Section including but not limited to demolishing, removing, transporting, disposal of material, and placing.

END OF SECTION 02050

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IMAGE EVALUATION
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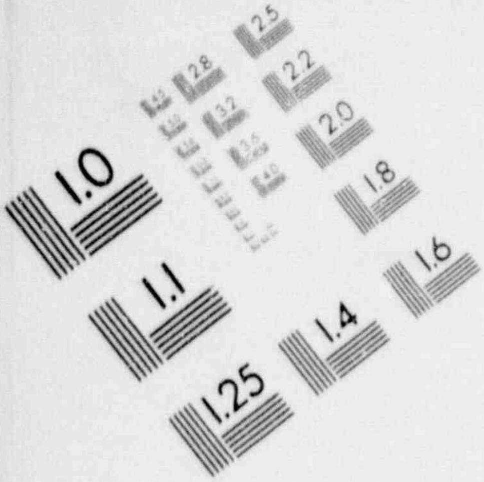

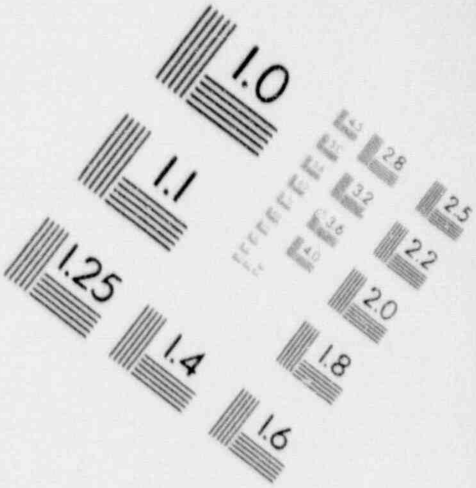

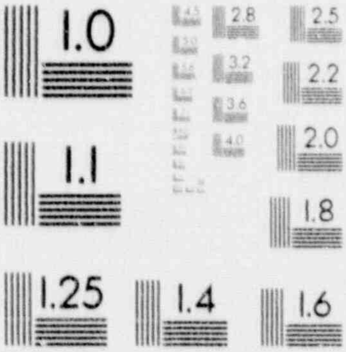

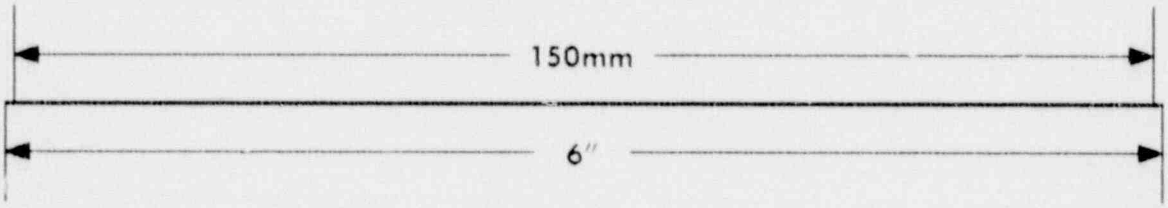

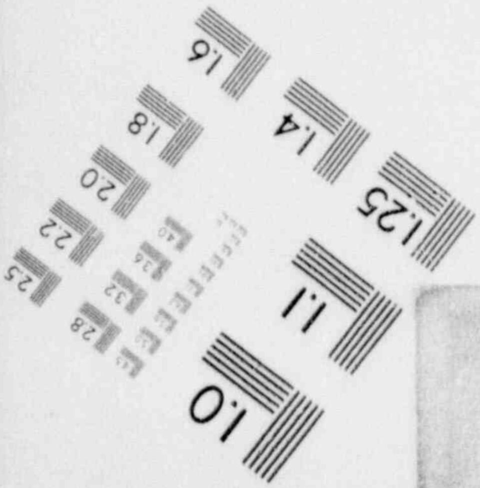

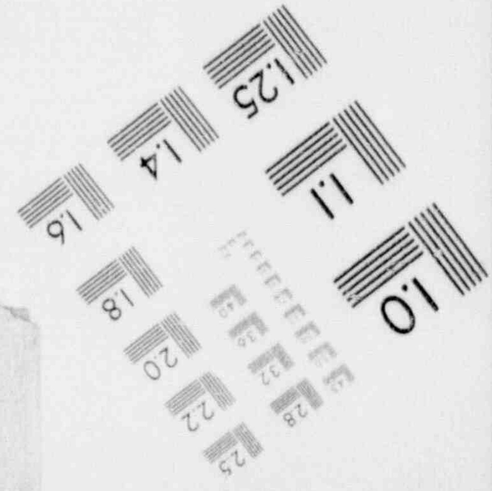

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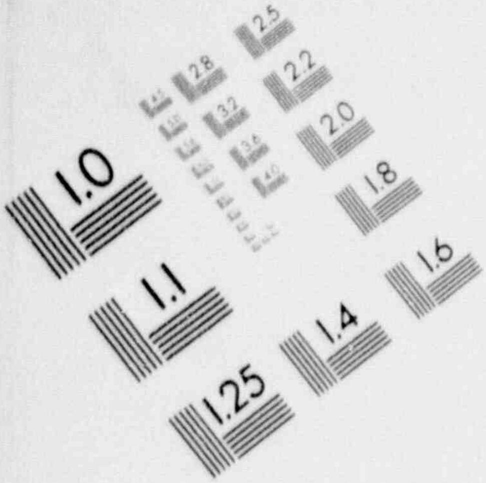

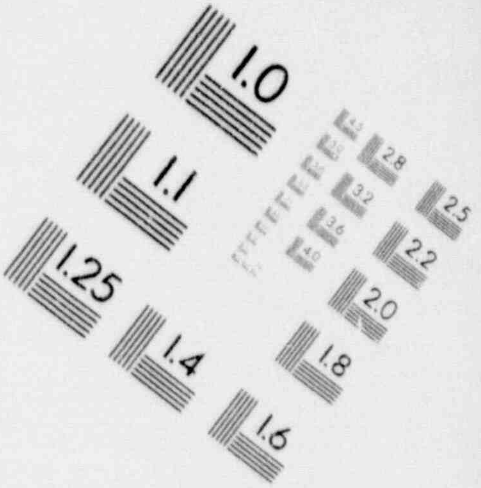

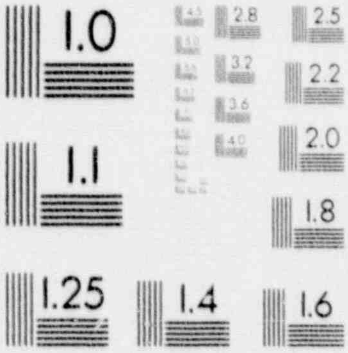

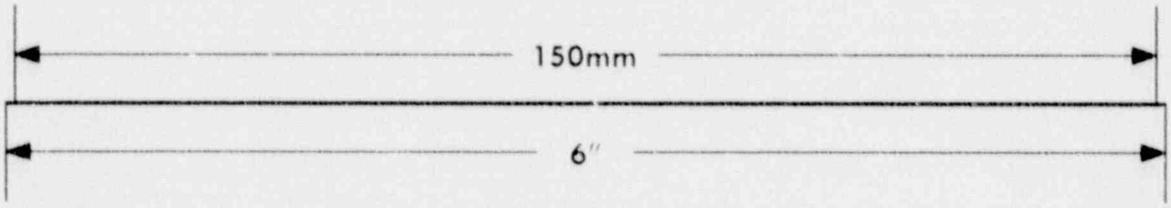

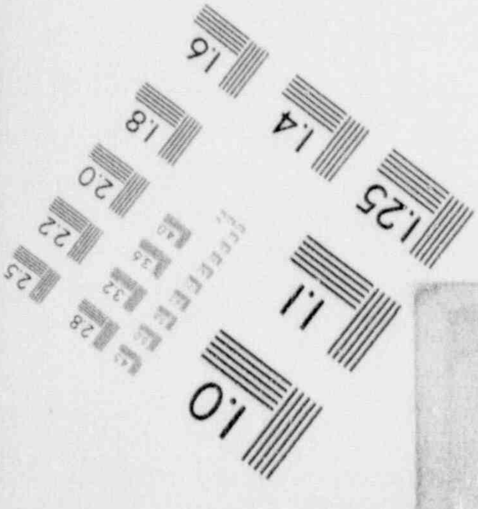

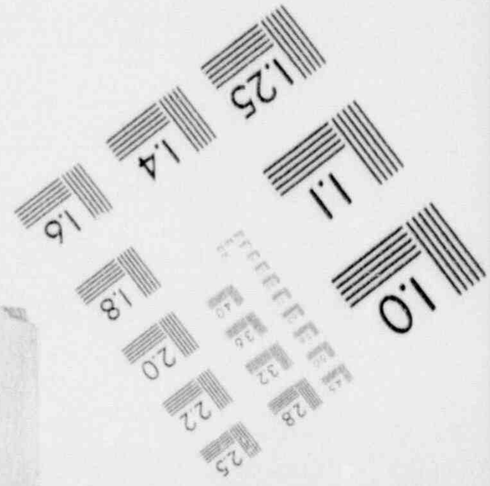

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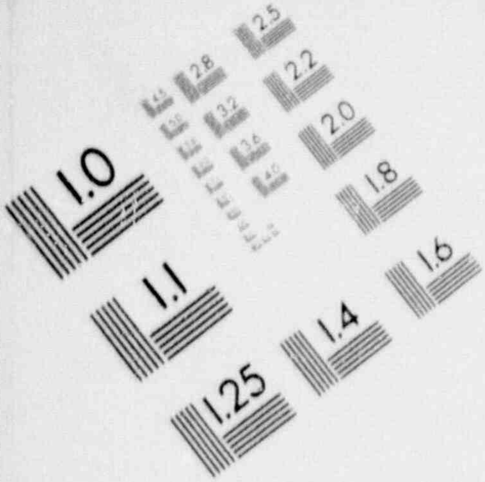

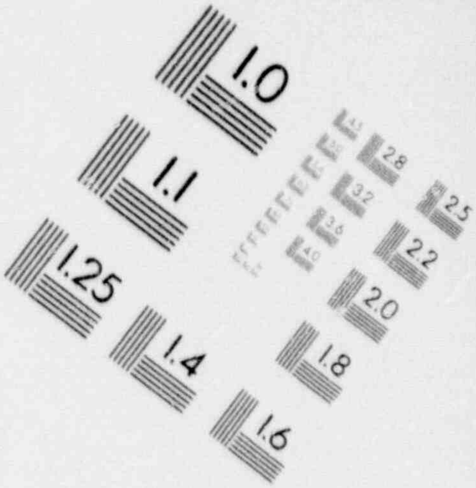

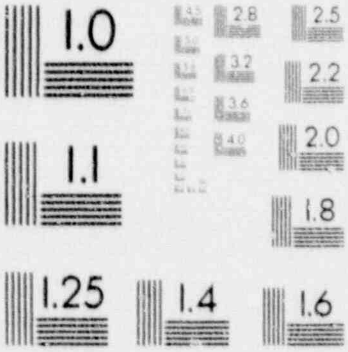

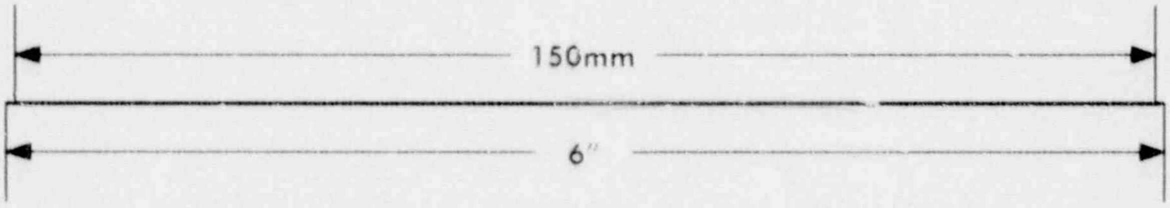

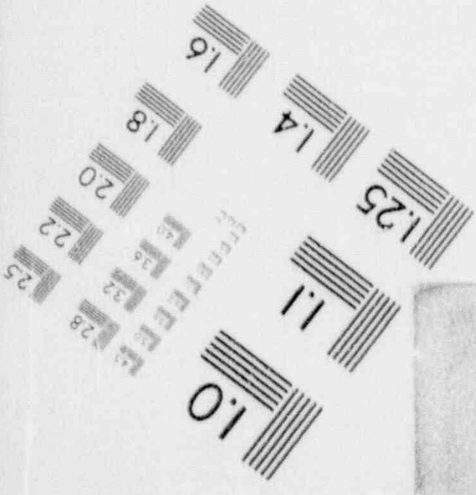

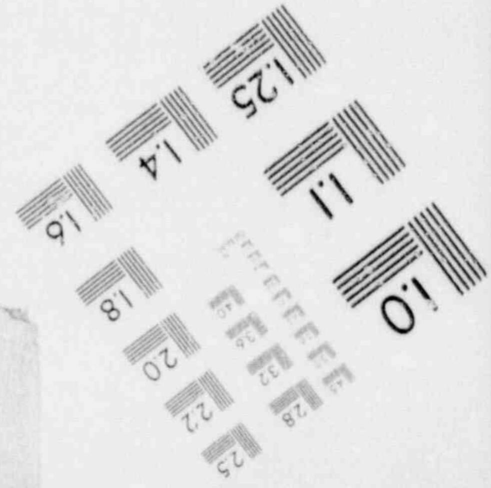

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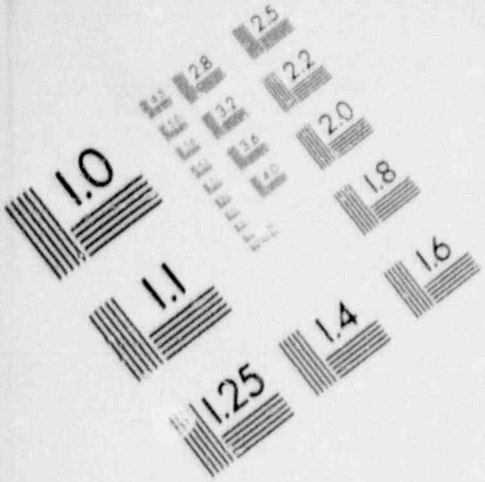
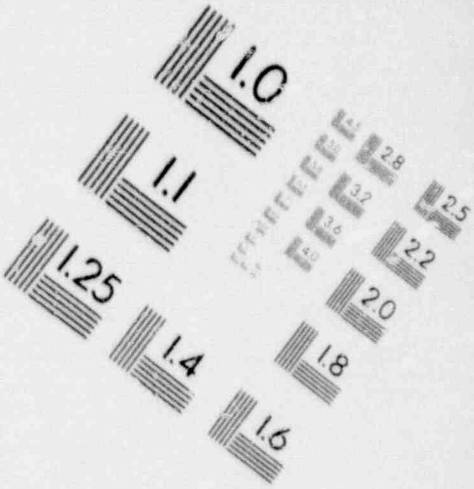
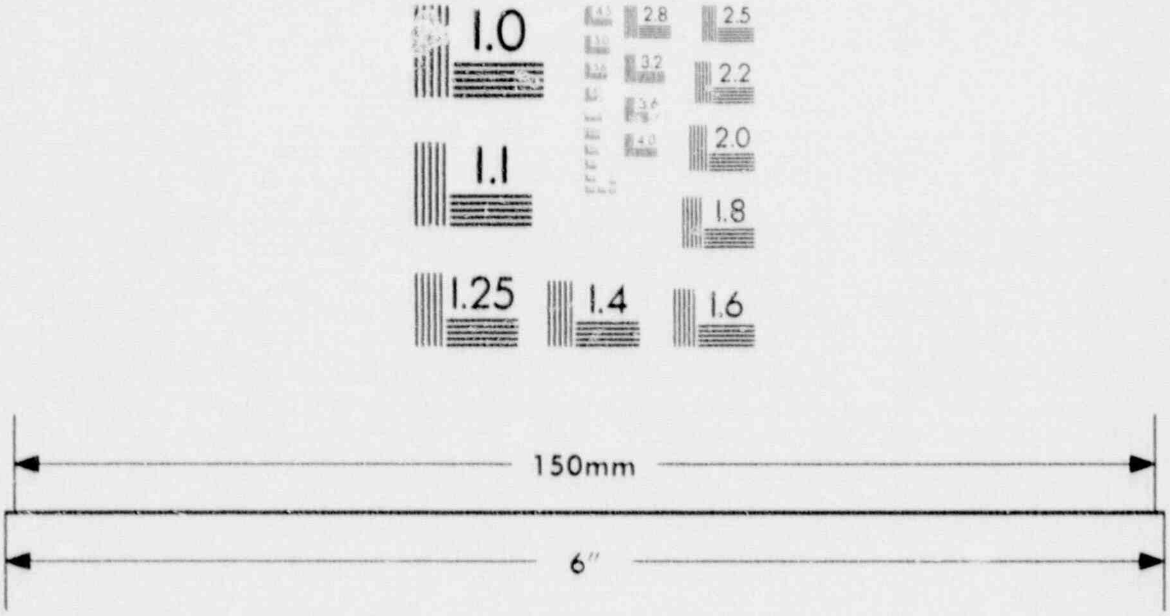
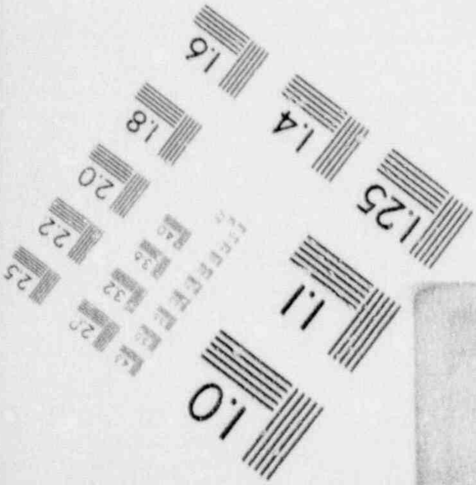
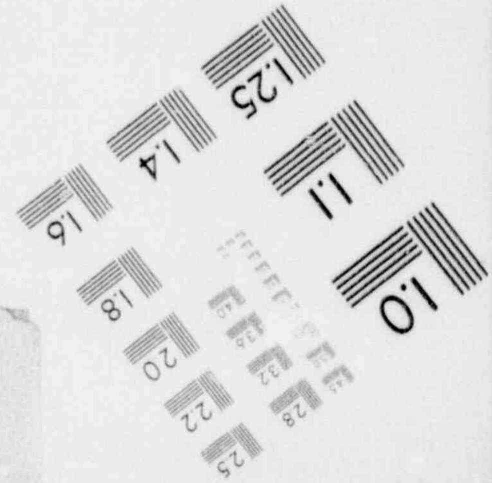










SECTION 02090

SEALING ABANDONED WELLS

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for sealing of existing test wells. The approximate locations of the known wells to be sealed are shown on the Subcontract Drawings.

B. Table 02090-1 lists all known wells that are to be sealed. Wells not listed in Table 02090-1 shall be protected, unless otherwise directed by the Contractor.

1.2 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only:

1. Manual of Water Well Construction Practices, Environmental Protection Agency, EPA-570/9-75-001.
2. American Society for Testing and Materials (ASTM): C150-84 Standard Specification for Portland Cement (Rev. A)
3. State of Oregon, Rules and Regulations Prescribing General Standards for the Construction and Maintenance of Water Wells in Oregon, Division 60, Water Resources Department, January 1, 1979.

1.3 SITE CONDITIONS

Subcontract Drawings show all known wells on and in the vicinity of the site. Wells not designated to be sealed shall be protected to prevent damage during construction. Such wells, if damaged, shall be reconstructed by the Subcontractor at no cost to the Contractor.

TABLE 02090-1

WELLS TO BE SEALED

Well No.	Depth of Well (feet)	Well Diameter (inches)	Casing Diameter and Type (inches)	Casing Depth (ft)	Perforated Interval (feet)
Processing Site:					
LVO-82-5	26.5	8.0	4" ABS	25	12
LVO-82-6	26.0	8.0	4" ABS	23	14
LVO-82-7	31.0	8.0	4" ABS	16	9
LVO-82-8	43.0	8.0	4" ABS	38	10
LVO-82-9	28.0	8.0	4" ABS	25	13
LVO-82-10	28.0	8.0	4" ABS	23	6
LKV-01-501	25.25	6.5	2" PVC	27	5
LKV-01-502	91.0	6.5	2" PVC	87	5
LKV-01-511	34.5	6.5	2" PVC	34	5
LKV-01-512	125.0	6.5	2" PVC	89	5
LKV-01-513	31.0	6.5	2" PVC	24	5
LKV-01-514	79.5	6.5	2" PVC	77	5
LKV-01-515	27.5	6.5	2" PVC	27	5
LKV-01-516	81.0	6.5	2" PVC	79	5
LKV-01-517	79.5	6.5	2" PVC	77	5
LKV-01-519	45.0	10.0	6" PVC	42	10
LKV-01-520	93.0	10.0	6" PVC	87	15
LKV-01-521	24.5	6.5	2" PVC	23	5
LKV-01-522	59.5	6.5	2" PVC	59	5
Disposal Site:					
LKV-02-501	49.5	6.5	2" PVC	49	5
LKV-02-503	54.0	6.5	2" PVC	47	5
LKV-02-507	79.5	6.5	2" PVC	78	5
LKV-02-508	92.0	6.5	2" PVC	91	5
LKV-02-510	132.5	6.5	2" PVC	127	5
LKV-02-517	250.0	6.0	2" PVC	75.8	5

PART 2 - PRODUCTS

2.1 MATERIALS

A. Approved sealing materials are as follows:

1. Cement used for sealing mixtures shall meet the requirements of ASTM C150 "Standard Specification for Portland Cement," types II (moderate sulfate resistance) or V (high sulfate resistance).

2. Cement grout shall be composed of one sack of Portland Cement (94 pounds), with 3 to 5 percent, by weight, of commercially processed sodium bentonite, to not more than 6 gallons of potable water in order to achieve a weight of not less than 15 pounds per gallon. The weight of the neat cement shall be sufficient to prevent flow of water into the well from any aquifer penetrated. Calcium chloride may be added to a Portland cement grout to accelerate the set, but it shall not exceed two (2) pounds per sack of dry cement.

PART 3 - EXECUTION

3.1 GENERAL

A. The State of Oregon Water well abandonment regulations (OAR 63-005 through 63-045) require that wells be sealed in a manner that is compatible with the well design and so as not to act as a conduit for future contamination of groundwater. Detailed well sealing criteria are outlined in the Environmental Protection Agency (EPA) Manual of Water Well Construction Practices, EPA-570/9-75-001, Article 56, pages 133-142. The basic premise of the EPA criterion is to seal abandoned wells and to restore, as much as possible, the geohydrologic regime in existance before the well was constructed. The following criteria shall apply to all wells to be sealed on and in the vicinity of the Lakeview Processing and Collins Ranch Disposal sites:

1. Well sealing operations shall be performed by a State-licensed (Oregon) drilling contractor.

2. All wells shall be sealed in such a manner that they will not act as a conduit for fluids to flow from the specific strata in which they were originally encountered.

3. All wells shall be located in the field and sealed by the Subcontractor prior to the beginning of stripping, grading or other surface-disturbing activities that will hinder the detection and sealing of wells. If any well cannot be located after a reasonable search, the Subcontractor shall, prior to the commencement of the well sealing operations, submit to the Contractor a written report documenting the well number, the areas covered and the effort spent in the search.

4. Upon discovery of any unknown wells during the earthwork operations, the Subcontractor shall give the Site Manager immediate verbal notice followed by written confirmation within 24 hours.

5. Wells shall be sealed according to the following procedures:

   a. The Subcontractor shall check each well to be sealed for obstructions that may interfere with the sealing operation and shall remove any such obstructions prior to starting filling operations.

   b. In order to seal the well properly it is preferable to remove the well casings by methods approved by the Contractor as outlined in Article 56 of the EPA Manual of Water Well Construction Practices. Upon removal, if the casings and the materials are found to be contaminated, they shall be decontaminated as required by the Contractor, or disposed of in the tailings embankment after breaking into lengths not greater than 10 feet. If casing removal is not feasible, the casing shall be perforated, ripped or otherwise disintegrated by methods outlined in Article 56, to ensure grouting of the entire annular space between the casing and the borehole.

   c. The approved methods for the placement of a grout seal shall be as follows:

      1) In wells where casing is removed, the cement grout shall be introduced at the bottom of the well or interval to be sealed (or filled) and placed progressively upward to the top of the well. The grout shall be placed by the use of grout pipe, drop pipe, tremie, cement bucket or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Dumping grout material from the top of the well shall not be permitted.

2) In wells where casing is not removed, the calculated amount of neat cement grout required to fill the well interval plus the annular space outside the lining shall be placed within the space to be cemented, running the cement through a special cementing packer manufactured for this purpose and installed immediately above the perforated or ripped zone. The cement shall be injected at a pressure calculated to be at least 50 psi greater than the normal hydrostatic pressure within the well at the point of injection.

d. For all wells located in areas where the construction grade elevation will be greater than or equal to the existing grade surface, existing casings and cement grout seals shall be removed to a minimum depth of 2 feet below the existing grade surface, and as otherwise required for construction. Grouting shall extend to 2 feet below the existing grade. The interval from the top of the grout to the existing grade surface shall be filled with a mixture of uncontaminated soil (ML or CL) and a minimum of 25 percent by weight of commercially processed sodium bentonite. The mixture of uncontaminated soil shall be hand-tamped, as required.

e. For all wells located in areas where the construction grade surface will be less than the existing grade surface (i.e. in areas of proposed cut), the existing casings and cement grout seals shall be removed to a minimum of 2 feet below the grade cut elevation and as otherwise required for construction. Grouting shall extend to 2 feet below the grade cut elevation. The interval from the top of the grout to the existing surface shall be filled with a mixture of uncontaminated soil (ML or CL) and a minimum of 25 percent by weight of commercially processed sodium bentonite. The uncontaminated soil mixture shall be hand-tamped, as required.

6. The Subcontractor shall provide the following notification of the well sealing operation:

a. The Subcontractor shall notify the Contractor and the District Watermaster in Lakeview prior to commencement of well sealing operations.

b. Within 30 days of the completion of well sealings, the Subcontractor shall submit a written water well report, fully describing all abandonment procedures, to the Oregon Water Resources Department in Salem. A copy of the report shall be submitted to the Contractor.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Measurement for payment for sealing of abandoned wells will be by the linear feet of wells sealed. The measurement will be from bottom of well to the top of seal.

4.2 PAYMENT

Payment for sealing of abandoned wells will be by the unit price per linear foot quoted therefor in the Bid Schedule. The price quoted shall include full compensation for furnishing all materials, equipment, tools, accessories, incidentals, labor, and for performing the work specified in this Section including decontamination and disposal of materials and equipment.

END OF SECTION 02090

SECTION 02110

SITE CLEARING

PART 1 - GENERAL

1.1 SCOPE

This Specification Section describes the requirements for clearing of vegetation, stripping of topsoil, and disposal of cleared and stripped materials.

1.2 DEFINITIONS

A. Clearing: Clearing is defined as removing brush and other vegetation in areas where the general ground cover is higher than two feet, consisting generally of brush and immature trees. All such vegetation shall be cleared down to the natural ground surface.

B. Stripping of Topsoil: This shall consist of the removal of topsoil, including all roots and organic materials and vegetation less than two feet high, and any other unsuitable material, by blading with a bulldozer or other equivalent means. Depth of stripping shall be 6 inches.

1.3 RELATED WORK

Section 02200 - Earthwork

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.1 PRESERVATION OF PROPERTY

Existing improvements, adjacent property, utility and other facilities, and trees and plants that are not to be removed shall be protected from injury or damage.

3.2 CLEARING

Immature trees and limbs and all other vegetation, including grasses, weeds and shrubs, in tailings areas or in areas of construction activities shall be removed, shredded, chipped, and buried by uniformly spreading them in the spoil area.

3.3 STRIPPING

A. Stripping will be required in the following areas:

1. Beneath all fills in areas where excavation is not otherwise required;

2. Beneath areas of riprap protection where excavation is not otherwise required.

3. In areas of excavation where excavated materials are to be used as fill.

B. In areas of excavation where excavated materials are not to be used as fill or backfill, and in areas of excavation where the contaminated surfaces are covered by vegetation, the removal of topsoil may be carried out together with the excavation in one operation.

C. Stripped material shall be disposed of as specified in Article 3.4.

3.4 STOCKPILING OF TOPSOIL

Stockpiling of topsoil shall be performed only when required by the Contractor upon his determination that there is sufficient organic topsoil in the area to justify the operation; otherwise the materials shall be disposed of in an approved spoil area shown on the Subcontract Drawings. The topsoil from the stockpile shall be used in finish grading of the sites.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Clearing: No separate measurement for payment will be made for clearing. All such work, will be considered incidental to applicable related items of work.

B. Stripping: Measurement for payment for stripping will be by the acres of area stripped. The quantities shall be calculated using the areas shown on the Subcontract Drawings.

4.2 PAYMENT

A. Clearing: No separate payment will be made for clearing. Full compensation for such work will be considered incidental to the applicable items of work.

B. Stripping: Payment for stripping will be by the unit price per acre quoted therefor in the Bid Schedule. The price quoted shall include full compenstaion for stripping, transportation and placement of stripped material in its final location.

END OF SECTION 02110

SECTION 02140

DEWATERING

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for dewatering of work areas and handling and disposing of the water.

B. The groundwater table at the Lakeview Processing Site fluctuates seasonaly. If the groundwater level is higher than the bottom of excavation, the Subcontractor shall dewater the excavation, as required, for performance of work in the dry. Stormwater shall be removed from the excavation to maintain dry conditions. Excavation of wet materials and removal of excess water to facilitate placement of materials shall be as specified in Articles 3.2.C and 3.4.C.4 of Section 02200.

C. A dewatering scheme for work in uncontaminated areas is not shown on the Subcontract Drawings. The Subcontractor shall, if required, design and construct systems for dewatering of uncontaminated water from work areas.

D. A gravity dewatering scheme for work in contaminated areas is limited to the temporary drainage ditches as shown on the Subcontract Drawings. The Subcontractor shall, if required, design and provide pump system for dewatering of contaminated water from work areas.

1.2 DESCRIPTION

A. The work of this Section includes, but is not limited to: dewatering the excavations by installing either well points or drainage ditches and sump pumps in the excavations, and lowering the ground-water level until it is at an elevation below the excavation limit. Water from uncontaminated areas shall be pumped, or flowed by gravity, to drainge ditches leading to the existing drainage courses that flow offsite. Water from contaminated areas shall be pumped, or allowed to flow by gravity, to drainage ditches leading to the wastewater retention basin. If the wastewater retention basin is full, the water shall be pumped to existing evaporation Pond No. 6 with the approval of the Contractor. The Contractor will be responsible for the determination of contaminated and uncontaminated areas.

B. The Subcontractor shall be responsible for designing, scheduling, utilizing, providing, and maintaining any dikes, ditches, channels, flumes, drains, sumps, pumping equipment, well points, monitoring wells, other subsurface dewatering devices, and other temporary diversion and protective work necessary to ensure that construction shall be performed in areas free from water.

1.3 RELATED WORK

A. Section 01300 - Submittals

B. Section 02200 - Earthwork

C. Section 02728 - Site Drainage

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

The Subcontractor shall furnish all materials, equipment and appurtenances required for furnishing, installing and removing dewatering facilities, and shall also supply sufficient standby pumping and auxiliary equipment to preclude any interference to pumping operations during periods of breakdown and maintenance.

PART 3 - EXECUTION

3.1 DEWATERING PROCEDURES

A. Water from uncontaminated areas shall be pumped, or allowed to flow by gravity, to natural drainage courses. To minimize off-site siltation in the receiving stream, water removed from uncontaminated areas shall be passed through silt fences, check dams, temporary detention ponds or other facilities approved by the Contractor prior to discharge from the Project Site. The silt fences shall be

Mirafi 100X Envirofence as manufactured by Mirafi Inc., P.O. Box 240967, Charlotte, NC 28224 (Phone: 1-800-438-1855), or equal.

B. Water from contaminated areas shall be pumped or allowed to flow by gravity to nearby drainage ditches leading to the wastewater retention basin or, when the capacity of this basin is exceeded, to the existing evaporation Pond No. 6 shown on the Subcontract Drawings. Water from the wastewater retention basin and evaporation Pond No. 6 may be used for dust control and moisture control in contaminated areas.

C. The water level in excavations shall be maintained below the lowest point in the excavation until the backfilling of the excavation has been completed, unless otherwise approved by the Contractor.

D. When no longer required for water control, the dewatering facilities shall be removed as the Subcontractor's property. Contaminated sediments deposited in the wastewater retention basin and evaporation Pond No. 6 shall be removed and placed in the tailings embankment as required by the Contractor. Uncontaminated sediments may be used in the grading of uncontaminated areas of work.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for dewatering will be by the lump sum.

B. The following items will be measured separately for payment purposes:

1. Excavation for retention basins shown on the Subcontract Drawings.
2. Excavation for temporary and permanent drainage ditches shown on the Subcontract Drawings.
3. Furnishing and installing of corrugated steel pipe shown on the Subcontract Drawings.

C. Measurement for payment for excavation of the retention basins shown on the Subcontract Drawings will be as specified in Section 02200.

D. Measurement for payment for temporary and permanent drainage ditches shown on the Subcontract Drawings will be as specified in Section 02728.

E. Measurement for payment for furnishing and installing corrugated steel pipe shown on the Subcontract Drawings will be as specified in Section 02728.

4.2 PAYMENT

A. Payment for dewatering will be by the lump-sum price quoted therefor in the Bid Schedule, which price shall include full compensation for furnishing all materials, equipment, labor, tools, accessories, incidentals, and for performing all work as specified in this Section including, but not limited to, the construction of additional lined and unlined temporary drainage ditches, construction of silt fences, check dams, temporary detention ponds or other facilities, the provision of pumps, sumps, additional pipes, pipe supports, excavation of pipe supports, etc., if required.

B. Payment for excavation of retention basins shown on the Subcontract Drawings will be as specified in Section 02200.

C. Payment for temporary and permanent drainage ditches shown on the Subcontract Drawings will be as specified in Section 02728.

D. Payment for furnishing and installing corrugated steel pipe shown on the Subcontract Drawings will be as specified in Section 02728.

END OF SECTION 02140

SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for the earthwork related to the construction of the following features:

1. Dust control.
2. Excavation of contaminated materials from the Lakeview Processing Site and construction of the tailings embankment at Collins Ranch Disposal Site.
3. Handling and placing of contaminated material excavated from the vicinity property and delivered at the processing site by others.
4. Construction of vicinity properties encapsulation cell.
5. Construction of temporary and permanent drainage ditches.
6. Construction of retention basins.
7. Construction of decontamination pads.
8. Relocation of Hammersley Creek.
9. Subgrade preparation for decontamination pads and permanent drainage ditches.
10. Finish grading of the sites.

1.2 WORK NOT INCLUDED

A. Earthwork related to the construction of temporary facilities including temporary access roads and haul roads specified in Section 01500 is not included in this Section.

B. Earthwork for pipe trenches is not included in this Section.

1.3 RELATED WORK

A. Section 01300 - Submittals

B. Section 02050 - Demolition

C. Section 02110 - Site Clearing

D. Section 02140 - Dewatering

E. Section 02278 - Erosion Protection

F. Section 02728 - Site Drainage

1.4 DEFINITIONS

A. Excavation: Excavation is defined as excavation required to reach the lines and grades indicated on the Subcontract Drawings or specified herein. It shall include excavation of topsoil, silt, clay, sand, gravel, talus, soft or disintegrated rock, boulders or detached pieces of solid rock; and shall also include removal and reshaping of mill tailings deposits and other contaminated material and final grading of the disposal and processing sites. During the excavation operation, tests to determine any radioactive contamination of the material to be excavated will be performed by the Contractor.

B. Contaminated Materials Excavation: Excavation of contaminated materials, Types 1 and 2, carried out to reach lines and grades indicated on the Subcontract Drawings or as specified herein.

C. Contaminated Materials, Type 1, Excavation: Excavation of contaminated materials from evaporation ponds, and windblown areas within the limits of the site. These materials contain relatively lower levels of radioactive contamination compared to the materials of the tailings pile.

D. Contaminated Materials, Type 2, Excavation: Excavation of contaminated materials from the tailings pile and other areas identified by the Contractor.

E. Uncontaminated Materials Excavation: Excavation of uncontaminated materials including top soil, silt, clay, sand, gravel, talus, soft or disintegrated rock, boulders and removal of detached pieces of solid rock carried out to reach lines and grades indicated on the Subcontract Drawings or specified herein. This excavation shall include excavations for embankment, drainage ditches, retention basins, trenches, Hammersley Creek and finish grading.

F. Overexcavation: Overexcavation is defined as excavation carried out beyond the lines and grades indicated on the Subcontract Drawings or in the Subcontract Specifications.

G. Slimes: Slimes are the fraction of the tailings consisting of silty clay, clay and clayey silt.

H. Satisfactory Materials: Satisfactory materials for use as fill or backfill shall consist of any material classified by ASTM D2487 as gravels, sands, silts and clays free from roots and other organic matter, trash, debris, frozen materials, and stones larger than 3 inches in any dimension, except as noted hereinafter. Stones with a maximum dimension up to 6 inches will be permitted for fill areas outside of building or pavement locations with 4 inches being the maximum stone dimension allowed in the upper 6 inches of the fill.

I. Unsatisfactory Materials: Unsatisfactory materials shall be materials that do not comply with the requirements for satisfactory materials and materials containing roots and other organic matter, trash, debris, frozen materials, stones that do not meet the dimensional criteria indicated in paragraph 1.4.H, and materials classified by ASTM D2487 as PT, OH, and OL, except as noted hereinbefore.

J. Percent Maximum Density: Percent maximum density is a percentage of the maximum density obtained by the test procedure presented in ASTM D698 and ASTM D1557, as applicable.

K. Topsoil: Topsoil is the existing surface soil stripped to the depth indicated and consisting of natural, friable soil representative of productive soils in the vicinity. Topsoil shall be free of any admixture of subsoil, foreign matter, objects larger than 1 inch in any dimension, toxic substances, and any material or substance that may be harmful to plant growth.

L. Tailings Embankment: Tailings embankment shall consist of a geochemical/flow barrier liner, relocated contaminated materials Types 1 and 2, and the protective cover materials placed and compacted as shown on the Subcontract Drawings and as specifed in this Section.

M. Vicinity Properties Encapsulation Cell: Vicinity properties encapsulation cell consists of embankment constructed of relocated contaminated wood chips, soils and other materials excavated from vicinity properties, and the protective cover materials as shown on the Subcontract Drawings.

N. Subgrade Preparation: Subgrade preparation includes fine grading and compaction of excavations including drainage ditches, backfills, and embankments upon which pavement, surfacing, base, subbase, bedding materials, riprap, or other structures are to be constructed.

O. Cover: Cover shall consist of the following layers of fill materials placed over the relocated contaminated materials in the tailings embankment as shown on the Subcontract Drawings:

1. Layer of radon barrier materials, and

2. Layers of bedding material and riprap material.

P. Rock-Soil Matrix: Rock-soil matrix shall consist of topsoil placed on the riprap of the top slope of the final tailings embankment filling the surface voids and resulting in a surface ready for seeding.

Q. Handling and placing of contaminated material excavated from the vicinity property and delivered at the processing site by others shall include loading of the material, transportation to the disposal site, placement, compaction and consolidation.

1.5 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The Publications are referred to in the text by the basic designation only:

1. American Society for Testing and Materials (ASTM):

ASTM C33-84	Specifications for Concrete Aggregates
ASTM D422-63	Method for Particle-Size Analysis of Soils
ASTM D698-78	Test Methods for Moisture Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb. (2.49-kg) Rammer and 12-in. (305-mm) Drop

ASTM D1140-54	Test Method for Amount of Material in Soils Finer than the No. 200 (75-um) Sieve
ASTM D1556-82	Test Method for Density of Soil in Place by the Sand-Cone Method
ASTM D1557-78	Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb. (4.54-kg) Rammer and 18-in. (457-mm) Drop
ASTM D2167-84	Test Method for Density and Unit Weight of Soil In-Place by the Rubber-Balloon Method
ASTM D2216-80	Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D2487-83	Test Method for Classification of Soils for Engineering Purposes
ASTM D2922-81	Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D4318-84	Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.6 QUALITY ASSURANCE

A. The Contractor will take soil samples and perform moisture-density, gradation and other tests to ascertain that the work is being performed in compliance with these Specifications. Samples may be taken at the place of excavation, stockpiles, or on the fill itself. The Contractor will conduct the density and other tests on the fill and related laboratory testing as frequently as the Contractor considers necessary. The Subcontractor shall remove surface material and render assistance as necessary to enable sampling and testing.

B. Methods of Sampling and Testing:

1. In-Place Density: ASTM D1556, D2167, or D2922

2. Liquid Limit, Plastic Limit and Plasticity Index: ASTM D4318

3. Particle Size Analysis: ASTM D422

4. Percentage Passing No. 200 Sieve: ASTM D1140

5. Moisture Content: ASTM D2216

6. Laboratory Moisture-Density Relations: ASTM D698, ASTM D1557

7. Soil Classification: ASTM D2487

C. Suitability of Materials: The suitability of all materials for foundations and backfill will be determined by the Contractor. Fill material will be approved material from borrow areas or required excavations.

D. The Contractor may direct that inspection trenches or test pits be cut into fills to determine that the Specifications have been met. Such trenches or pits will be of limited depth and size, and shall be backfilled with the material excavated therefrom, or other fill material meeting the requirements for the zones cut into. Backfill shall be compacted to a density at least equal to that of the contiguous fill.

E. When the Contractor directs inspection trenches or test pits to be excavated into fills and/or backfills and materials are found to meet all Specification requirements, the excavation and refilling shall be paid for as additional work pursuant to the applicable provisions of the General Conditions. Inspection trenches or test pits, and the refilling of the same, shall be at the Subcontractor's expense when it is found that the materials do not meet the Specification requirements.

F. Tolerances: See Specification Section 01052, Article 1.6.

1.7 SUBMITTALS

A. General submittal requirements are specified in Section 01300.

B. The Subcontractor shall submit to the Contractor for approval, 30 days before he intends to dispose of any material in the spoil area, a plan showing the layout of his proposed activities. The plan shall show: location of rock spoil, location of excavated material, stockpile for topsoil, layout of any sediment traps, and any other measures for pollution control.

C. In the event the quantities of radon barrier material are insufficient, the Subcontractor shall submit evidence to the Contractor that radon barrier and rock materials to be used in the cover construction meet the requirements of Article 2.1 below.

1.8 PROTECTION

A. The Subcontractor shall protect the following:

1. Trees, shrubs and other features remaining as a portion of final grading.
2. Bench marks and monuments, existing structures, fences, walks, pavings, curbs, etc. from equipment and vehicular traffic.
3. Above and below ground utilities.
4. Excavations from cave-in by shoring, bracing, sheetpiling, underpinning or by other methods.
5. Bottoms of excavations and soil adjacent to and beneath foundations from frost.
6. Perimeter of excavation top to prevent surface water runoff into excavation.
7. Monitor wells not to be abandoned.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

A. General:

1. Fill materials shall be obtained from required excavations. Additional materials, if required, shall be obtained from approved stockpiles or from other borrow areas selected by the Subcontractor. The Subcontractor shall be responsible for obtaining all required permits and approvals for borrow areas in accordance with the provisions of Section SC-11 of the Special Conditions. Designation of a borrow area does not necessarily indicate that all material within that area meets the Specification requirements specified herein.

2. The Subcontractor shall make his own determination of any processing that may be required, and shall perform testing as required to meet the Specifications for the various construction materials.

3. Application for approval of sources proposed for use by the Subcontractor shall include boring logs, borrow area maps and supporting laboratory test data. The Subcontractor also shall provide evidence of availability, right of access to private property and his plan for hauling the materials to the site. Application for approval of sources for uncontaminated fill materials shall be submitted to the Contractor at least 30 days (60 days for radon barrier materials) before use of the material at the site. In addition, the Contractor shall be granted access to each proposed source to collect samples for testing. The Contractor may perform additional tests to determine if the materials meet the requirements specified herein.

4. Approval will be based on evidence of compliance with the requirements specified herein and on verification by the Subcontractor that the volume of materials available is sufficient for construction requirements.

B. Gradations: Gradations specified shall be as determined after delivery to the site.

C. Uncontaminated Fill Materials:

1. General: Uncontaminated fill materials for general fill shall conform to the following requirements:

   a. Maximum particle size shall not be greater than 6 inches.

   b. Uncontaminated fill material, except for demolition debris as described under Article 3.2.A, Section 02050 and except for clearing and stripping debris as described in Section 02110, shall not contain more than 5 percent organic material, by volume, or other deleterious substances.

2. Radon Barrier Materials: Radon barrier materials shall conform to the following requirements:

   a. Radon barrier materials shall be uncontaminated soils obtained from the required disposal site excavation or, if insufficient, from borrow areas approved by the Contractor. The projected Ra-226 content shall not exceed 5.0 pCi/gm.

b. Radon barrier materials shall consist predominantly of soils with classification of CL, MH or ML when classified in accordance with the requirements of ASTM D2487, and graded with maximum particle size of 2 inches and minimum of 50 percent passing No. 200 Sieve. Such materials shall have a Plasticity Index (PI) of 10 or greater when tested according to ASTM D4318. Compliance with these Specifications will be determined by the Contractor.

c. Material shall be compactable to the required density, at all moisture contents within plus three or minus one percent of the optimum moisture content.

d. Radon barrier material shall not contain clearly visible organic matter or other deleterious substances.

3. Geochemical/Flow Barrier Liner Material: The geochemical/flow barrier liner materials shall be select natural uncontaminated silty and clayey materials similar to that for radon barrier obtained from the required disposal site excavation or from other onsite uncontaminated materials excavations or from offsite sources approved by the Contractor.

D. Contaminated Fill Materials: Excavated contaminated materials, approved by the Site Manager, for use as fill materials in the construction of the tailings embankment and the vicinity properties encapsulation cell shall be classified into the following categories:

1. Contaminated Fill Materials, Type 1 shall be excavated contaminated materials of type 1 defined in Section SC-1 of the Special Conditions. These materials generally result from the excavations of evaporation ponds, windblown areas and the bottom of the retention basins.

2. Contaminated Fill Materials, Type 2 shall be excavated contaminated materials of type 2 defined in Section SC-1 of the Special Conditions. These materials generally result from the excavations of the tailings pile.

PART 3 - EXECUTION

3.1 DUST CONTROL

A. Dust control shall consist of furnishing water supply, required equipment, additives, accessories and incidentals, and applying water during the completion of the Subcontract, as required by the Contractor.

B. Water shall be applied in the amounts, at the locations and for the purposes designated in this Specification, and as required by the Contractor.

C. Water shall be applied by means of pressure-type distributors or pipe lines equipped with a spray system or hoses with nozzles that will insure a uniform application of water.

D. All equipment used for the application of water shall be equipped with a positive means of shut-off.

E. Unless otherwise permitted by the Contractor or all the water is applied by means of pipe lines, at least one mobile unit with a minimum capacity of 8,000 gallons shall be available for applying water on the project at all times.

F. The Subcontractor is encouraged to use chemical additives in water. If such additives are used, furnishing and applying the additives shall be at the Subcontractor's expense.

G. The right is reserved by the Contractor to prohibit the use of a particular type of additive, to designate the locations where a particular type of additive may not be used, or to limit the amount of a particular type of additive to be used at certain locations, all if the Contractor has reasonable grounds for believing that such use will be in any way detrimental to the Work.

3.2 EXCAVATION

A. Preparation:

1. Clearing and stripping shall be as specified in Section 02110.
2. Required lines, levels, contours and datum shall be identified before the start of excavation.

3. The Subcontractor shall verify the existing aboveground and underground utilities, identify them, and notify the Contractor immediately of his finding, if any, for appropriate action.

B. General:

1. Before beginning any other excavation work or demolition work in an area, the Subcontractor shall construct the temporary site drainage facilities for such area, as specified in Section 02728.

2. At all times during excavation, the Subcontractor shall conduct his operations in such a manner as to prevent free standing water and contamination of uncontaminated materials. The Subcontractor shall, as a minimum, take the following measures to safeguard against such problems:

   a. Water leaving an excavation area or area otherwise disturbed by construction activities shall be routed into the retention basin as specified in Section 02140.

   b. Cuts in tailings materials shall not be left exposed during seasonal shutdowns to prevent erosion by wind or water. During seasonal shutdowns the exposed surfaces shall be protected by seeding or by other methods approved by the Contractor.

3. The Subcontractor shall perform required excavation to the lines and grades indicated on the Subcontract Drawings or as directed by the Contractor. He shall remove all excavated material from the excavation site and dispose of it in the designated spoil areas or use it for other purposes, as approved. In order to avoid contamination of uncontaminated material, the contaminated and uncontaminated materials shall be kept separated during excavation, stockpiling, and placement.

4. Unsuitable or low density subgrade material not readily capable of in-place compaction shall be excavated as directed by the Contractor.

5. Adequate working space for safety of personnel shall be provided within the limits of the excavation.

6. All unstable bottom material shall be removed. Large stones, debris and incompressible soils shall be re-

moved from bottoms of the excavation to a minimum depth of 12 inches. The construction of the geochemical/flow barrier liner is specified in Article 3.7 below.

7. Except as otherwise noted, care shall be exercised to preserve the material below and beyond the lines of all excavation. Where excavation is carried below grade, the Subcontractor shall backfill to the required grade or to indicated invert grade, as specified, and compacted to match the existing conditions.

8. Excavation for the convenience of the Subcontractor shall conform to the limits approved by the Contractor and shall be at no additional expense to the Contractor.

9. Excavated material shall be placed at sufficient distance, but not less than 3 feet, from edge of excavations so as not to cause cave-ins or bank slides.

10. Where practicable, suitable materials removed from excavation shall be used as fill, backfill, or aggregates. The Subcontractor shall test, screen or mix as required and stockpile as specified herein.

11. Excavations for radon barrier and geochemical/flow barrier liner materials shall be carried out in the presence of a qualified technician employed by the Contractor.

C. Contaminated Materials Excavation: Contaminated materials excavation shall include excavation of all contaminated materials from the existing tailings pile, windblown areas, vicinity properties, and the evaporation ponds. The Subcontractor shall minimize the open excavation area of contaminated materials at any time during excavation work. The Subcontractor shall operate from one or two sides at one time, progressing uniformly to opposite sides for completion, unless directed otherwise by the Site Manager. Contaminated materials shall be excavated to the depths indicated on the Subcontract Drawings, or as required by the Contractor, and placed in the proper location of the tailings embankment at the Disposal Site. The groundwater table fluctuates seasonally, therefore it is recommended that the excavation reaching the lower elevations be delayed until the ground water has receded to the lower levels. If dewatering is necessary, discharge shall be directed to the Retention Basin or Evaporation Pond No. 6 if the retention basin is full. Evaporation Pond No. 1

presently contains wood chips wasted from lumber mill operations. The uncontaminated upper portion of the waste, constituting the larger volume, shall be excavated and placed in the storage pile located on the Subcontract Drawings by others under a separate Subcontract as specified in Section 01010, Article 1.3. The contaminated bottom 12-inch thick portion shall be excavated and placed in the tailings embankment at the disposal site, however, the wood chips shall be distributed so as not to exceed 5 percent by volume in any area of the tailings embankment.

D. Contaminated Materials, Type 1, Excavation: This excavation shall include excavation of contaminated materials, type 1. The materials shall generally be excavated from the evaporation ponds, windblown areas and the bottom of the retention basins as shown on the Subcontract Drawings.

E. Contaminated Materials, Type 2, Excavation: This excavation shall include excavation of contaminated materials, type 2. The materials shall generally be excavated from the tailings pile and other areas shown on the Subcontract Drawings.

F. Uncontaminated Materials Excavation:

1. General: Uncontaminated materials excavation shall include excavations of uncontaminated materials from the various areas of the site. The excavated materials shall be used as fill in various areas of the site including the construction of berms, dikes, general fill, roadway fill, structure fill, backfill, and fill for the final grading of the site, as required. Uncontaminated excavated material may be stockpiled for later use.

2. Drainage Ditches Excavation:

   a. General: Ditches shall be cut accurately to the cross sections and grades indicated. All roots, stumps, rock, and foreign matter in the sides and bottom of ditches shall be trimmed and dressed or removed to conform to the slope, grade, and shape of section indicated. Care shall be taken not to excavate ditches below the grades indicated. Excessive ditch excavation shall be backfilled to grade with satisfactory, thoroughly compacted material. Ditches shall be maintained until final acceptance of the work.

b. Temporary Drainage Ditches:

1) Temporary drainage ditches shall be excavated at locations shown on the Subcontract Drawings to collect and transport storm runoff, wastewater and water-bound contaminated material to the retention basin during construction.

2) Temporary drainage ditches shall be excavated, fine graded, compacted, and maintained to provide drainage during construction.

3) Subgrade of temporary drainage ditches adjacent to the decontamination pads shall be protected with membrane liner from runoff, wastewater and water-bound material during construction. Membrane liner is specified in Specification Section 02771.

c. Permanent Drainage Ditches:

1) Ditches shall be excavated true to line and grade. Any erosion which occurs to ditch excavation before placing erosion protection materials shall be repaired with compacted backfill. All such repairs shall be at Subcontractor's expense and shall not be included in pay quantities, unless otherwise shown on the Subcontract Drawings.

2) The top 6 inches of the subgrade shall be compacted as specified in Article 3.5 below. After compaction has been completed, finish grading shall be done in such a manner that the sideslopes are rendered smooth surfaces. All rocks, brush, roots, large clods, and other objects shall be removed before placement of the bedding material and the riprap material.

3. Retention Basin Excavation: The retention basins shall be constructed to the lines and grades shown on the Subcontract Drawings. The retention basin at the Processing Site shall be located within the approximate limits of existing Evaporation Pond No. 7 which will require two stages of excavation. Contaminated materials shall first be excavated and stockpiled as shown on the Subcontract Drawings, then the excavation and fill for the retention basin shall be accomplished. Seasonal ponding normally occurs at the

evaporation ponds until June, after which month they remain dry until the end of the year when precipitation becomes significant. If construction operations cannot be delayed until the dry condition naturally occurs, the Subcontractor shall dewater the area as required to perform the work. Water resulting from dewatering operations shall be discharged to Evaporation Pond No. 6 for eventual evaporation. In no case shall such water be discharged to uncontaminated areas.

4. Borrow Area Excavation:

   a. Where materials are not available in sufficient quantity from the required excavations, such materials shall be obtained from borrow areas of approved sources offsite.

   b. The Subcontractor shall notify the Contractor at least 15 days in advance of opening any borrow area so that adequate time will be allowed for testing the material.

   c. Borrow areas shall meet all permit and negotiated requirements as required by the Contractor.

   d. Necessary clearing, grubbing, and disposal of debris shall be performed by the Subcontractor as incidental operations to the borrow excavation.

   e. Borrow areas shall be neatly trimmed and drained and left in such shape as will facilitate taking accurate measurements after borrow excavations are completed.

? 3 DISPOSAL OF EXCAVATED MATERIALS

A. Contaminated Materials: All contaminated materials excavated from the tailings pile, retention basins, evaporation ponds, and other areas of the site and vicinity properties shall be used in the construction of the tailings embankment and the vicinity properties encapsulation cell as specified herein.

B. Uncontaminated Materials:

   1. Uncontaminated materials excavated from the site, including excavations for trenches, drainage ditches, retention basins, decontamination pads, Hammersley Creek relocation, etc. which do not classify as 3.3.A

materials above, shall be used as uncontaminated material fill for construction of various features including site grading, or stockpiled for later use, or wasted in the spoil area, as specified in this Section and as required by the Contractor.

2. Clean, sound, unweathered rock, of suitable material, from the required excavation may be incorporated into fills, after processing as necessary, provided it meets the requirements specified in this Section.

3. Where used in fills, such material shall be transported directly from the excavation and placed in its final position in such fills whenever possible. If required by the Subcontractor's schedule, the material may be placed temporarily in stockpiles at approved locations. Material in stockpile shall be protected from contamination of any kind that would render it unsuitable for use in fills.

C. Borrow Area Materials: Materials from borrow areas shall be used for final grading of the site and for other uncontaminated material fills as specified in this Section, or as required by the Contractor.

D. Unsatisfactory or Excess Materials: Unsatisfactory and excess excavated uncontaminated material generated during the Work and not approved for use in the Work shall be disposed of in the designated stockpile/spoil areas shown on the Subcontract Drawings.

E. Garbage, refuse, debris, oil, and any waste material which is harmful to the environment or offensive to the area shall be removed from the job site and disposed of offsite in a manner approved by the authority having jurisdiction over the disposal site.

F. All operations in the stockpile/spoil areas throughout the Work shall be in strict conformity with the requirements of this Section. The Subcontractor shall ensure that silty water from the stockpile/spoil areas does not enter nearby waterways. If required, temporary berms and detention ponds shall be constructed by the Subcontractor.

3.4 FILL

A. General Requirements:

1. Clearing and stripping shall be as specified in Section 02110.

2. Fill materials shall be placed and compacted to the lines and grades shown on the Subcontract Drawings or as required by the Contractor.

3. Before commencement of backfill operations, the Subcontractor shall confirm with the Contractor that all contaminated material requiring excavation has been removed.

4. If any portion of the materials does not meet the specified requirements, the Subcontractor shall remove such material and replace it with fill materials meeting the specification at no cost to the Contractor.

5. Fill materials shall be maintained in a manner satisfactory to the Contractor until the final completion and acceptance of the work. This shall include all measures to prevent erosion or contamination during construction, including contamination by radioactive material. In particular, no surface of tailings material shall be left exposed during seasonal or other shutdowns.

B. Placing Requirements:

1. Prior to placement of materials, the in-place density of the top 6 inches of the area receiving the fill shall be at least 95 percent of maximum dry density as determined by ASTM D698. If necessary, the surface shall be plowed, harrowed, materials mixed, materials added or removed and compacted to obtain the specified densities.

2. Subgrade preparation shall be as specified in Article 3.5 below.

3. No materials shall be placed on any portion of the subgrade or against or upon any structure until consent to place such fill has been obtained from the Contractor.

4. Fill materials may require moisture conditioning (wetting or drying) prior to compaction. Some tailings slimes particularly will require spreading and extended drying time prior to compaction.

5. Fill materials shall be placed in continuous and approximately horizontal layers for their full length and width unless otherwise specified or specifically permitted by the Contractor.

6. Type 2 contaminated materials excavated from the existing tailings pile shall be placed in the lower layers of the embankment. Type 1 contaminated materials excavated from the evaporation ponds, wastewater retention basins and other windblown areas shall be placed in the upper portions of the tailings embankment.

7. Contaminated materials excavated from the vicinity properties shall be placed in the construction of the vicinity properties encapsulation cell as directed by the Contractor.

8. The method of dumping and spreading the materials shall ensure uniform distribution of the material.

9. The loose thickness of each layer of materials shall not be greater than that required to achieve the required compaction, and in no case shall exceed 10 inches.

10. The Subcontractor shall place material to a grade of 2 percent or steeper to preclude the ponding of water. No fill shall be placed on any area where ponding has been allowed to occur. Where ponding has occurred and the fill material is required to be placed, the water shall be removed and permission for placing of materials shall be obtained prior to placing of materials.

11. Materials shall not be placed on frozen subgrade or embankment material foundations, nor shall frozen material be used as fill.

C. Compaction Requirements:

1. Each layer of fill materials, except radon barrier and geochemical/flow barrier liner shall be compacted to a minimum of 90 percent of maximum dry density as determined by ASTM D698. Geochemical/flow barrier liner material shall be compacted to at least 95 percent of maximum dry density as determined by ASTM D698. Radon barrier material shall be compacted to at least 100 percent of maximum dry density as determined by ASTM D698.

2. During compaction the moisture content of fill material shall be maintained to achieve specified density. Uniform moisture distribution shall be obtained by disking, blading, or other methods approved by the Contractor prior to compaction of a layer. During

compaction of geochemical/flow barrier liner materials, moisture content shall be maintained at greater than optimum moisture as determined by ASTM D698. During compaction of geochemical/flow barrier liner materials, moisture content shall be maintained at less than optimum moisture as determined by ASTM D698.

3. If the surface of the prepared foundation or the rolled surface of any layer of fill is too dry or too smooth to bond properly with the layer of material to be placed thereon, it shall be scarified and moistened by sprinkling to the acceptable moisture content prior to placement of the next layer of fill.

4. If the rolled surface of any layer of the fill in place is too wet for proper compaction of the layer of fill material to be placed thereon, it shall be removed, allowed to dry or worked with harrow, scarifier, or other suitable equipment to reduce the water content to the required amount, and then re-compacted before the next succeeding layer of fill is placed.

5. Fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content shall be reworked to meet the density and moisture requirements or removed and replaced by acceptable fill compacted to meet these requirements.

6. Uncontaminated fill material in the spoil areas shall be placed by spreading with a bulldozer and track walking. Lift thickness before consolidation shall not exceed one foot. Consolidation shall be accomplished by routing of hauling and spreading equipment units.

7. Compaction of radon barrier shall be accomplished by the use of sheep-foot or pneumatic-tired rollers. The final layer of each zoned element shall be compacted by the use of a smooth roller.

D. Field Quality Control:

1. General: The Contractor will take samples and perform tests throughout the construction period, and the Subcontractor shall cooperate in providing access for the Contractor to areas where testing is to be performed and shall schedule his placing to avoid interference with the testing operations.

2. Tests: The Contractor will perform the following tests on a regular basis; these tests are a minimum requirement:

   a. In-place density and moisture content tests, minimum of one test per 500 cubic yards of fill placed.

   b. Classification tests, minimum of one test per 2,000 cubic yards of fill placed. This requirement shall not be applicable to the placement of contaminated materials.

   c. Gradation tests, minimum of one test per 2,000 cubic yards of fill placed. This requirement shall not be applicable to the placement of contaminated materials.

3. The placing and consolidation of the spoil area fills will be subject to the approval of the Contractor.

3.5 SUBGRADE PREPARATION

A. Decontamination Pads:

1. The entire surface of the subgrade shall be plowed, harrowed, and mixed to a depth of at least 6 inches. If subgrade stabilization material is required, it shall be incorporated into the subgrade at this time. After the material has been thoroughly mixed, the subgrade shall be accurately constructed and fine graded to indicated line, grade and contour with all high and low spots eliminated. Compaction shall be carried out for the full width to a depth of 2 1/2 ft. below finished pavement to at least 95 percent of maximum density as determined by ASTM D1557. Soft spots developed during working shall be corrected.

2. Where feasible, pneumatic-tired roller shall be used for compaction, suitable to produce the specified density and moisture content. Where compaction by roller is not feasible, mechanical tampers or vibratory compactors shall be used.

3. Subgrade shall be finished to straightedge or template within specified tolerances with the finished surface bladed to a uniform, dense, smooth texture.

B. Permanent Drainage Ditches: Top 6 inches of the subgrade of each permanent drainage ditch shall be compacted to a minimum of 95 percent of maximum density as determined by ASTM D698. After compaction has been completed, fine finishing shall be done in such a manner that the side-slopes are smooth surfaces. All rocks, brush, roots, large clods, and other objects shall be removed before placement of the bedding materials.

3.6 RELOCATION OF HAMMERSLEY CREEK (PERMANENT FACILITY)

A. Relocation of Hammersley Creek consists of the following activities:

1. Excavation and embankment of earth along the proposed alignment of the creek.
2. Disposal of excavated materials:
    - a. If the excavated materials are found to be uncontaminated materials:
        - 1) Construction of embankment along the proposed alignment of the creek where required,
        - 2) Construction of other uncontaminated material fills, or
        - 3) Wasted in the spoil area, if the excavated materials are found to be excessive.
    - b. If the excavated materials are found to be tailings materials:
        - 1) Construction of the tailings embankment at the disposal site.

B. The excavation work and the construction of fills shall conform to the applicable provisions of this Section.

3.7 CONSTRUCTION OF GEOCHEMICAL/FLOW BARRIER LINER

The Geochemical/Flow Barrier Liner shall be constructed using the materials specified in Article 2.1.C.3 above, and compacted to the minimum density specified in Article 3.4 C.1 above.

3.8 ROCK-SOIL MATRIX FOR COVER

A layer of topsoil shall be spread on the riprap of the top slope of the tailings embankment and compacted to force the topsoil to fill the surface voids of the riprap. The uncompacted topsoil layer thickness shall be selected such that after compaction the surface voids in the riprap shall be completely filled. The rock-soil matrix layer shall be maintained and protected from erosion prior to seeding of the surface. The topsoil will be obtained from the stockpile resulting from the stripping operations at the disposal site.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for the following items of excavations and fills will be by the cubic yards of materials excavated. The quantities for payment will be computed by average end area method from surveys conducted before and after excavation operations as shown on the Subcontract Drawings, or by the methods determined by the Contractor:

1. Excavation of contaminated material from tailings pile, evaporation ponds, windblown areas, and stockpile, including wood chips, and placement in tailings embankment.

2. Excavation and placement of contaminated wood chips in vicinity properties encapsulation cell.

3. Excavation and placement of radon barrier material in vicinity properties encapsulation cell.

4. Excavation of contaminated material from processing site retention basin and Hammersley Creek areas and placement in stockpile.

5. Removal and disposal of excess excavated material from stockpile at Collins Ranch disposal site.

6. Removal of uncontaminated material from the stockpile at the disposal site and placement in vicinity properties encapsulation cell.

7. Excavation of existing uncontaminated material from vicinity properties encapsulation cell area and placement in stockpile.

B. Measurement for payment for the following items of excavations will be by the cubic yards of materials excavated. The quantities for payment will be computed from the lines and dimensions shown on the Subcontract Drawings, or by average end area method from surveys conducted before and after excavation work as shown on the Subcontract Drawings, or by the methods determined by the Contractor:

1. Excavation of uncontaminated material for permanent drainage ditches.

2. Excavation of uncontaminated material for retention basins.

3. Excavation of uncontaminated material for temporary drainage ditches

4. Excavation of uncontaminated material for Hammersley Creek relocation.

5. Excavation of uncontaminated materials at Lakeview Processing site for finish grading.

6. Excavation of uncontaminated material at Collins Ranch Disposal site for finish grading.

7. Excavation of uncontaminated material from tailings embankment area and placement in stock pile, excluding stripping.

C. Measurement for payment for the following items of fills will be by the cubic yards of materials placed in the fills. The quantities for payment will be computed by the volume the fill material occupies in the final placement location. This volume will be computed from the lines and dimensions shown on the Subcontract Drawings, or by average end area method from surveys conducted before and after placing compacted fills as shown on the Subcontract Drawings, or by the methods determined by the Contractor:

1. Placement of excavated uncontaminated material in fills at Lakeview Processing Site for finish grading including material from disposal site stockpile.

2. Placement of excavated uncontaminated material from stockpile in fills at Collins Ranch Disposal Site for finish grading.

3. Placement of excavated uncontaminated material from stockpile at the disposal site for radon barrier.

4. Placement of excavated uncontaminated material from stockpile at the disposal site for geochemical/flow barrier liner.

5. Placement of uncontaminated material for fills at retention basins.

6. Placement of topsoil on top slope of tailings embankment for rock-soil matrix.

D. Separate measurement for payment will not be made for the following items, and such work will be considered incidental to the related item of work:

1. Dust control.

2. Excavation and backfill of pipe trenches.

3. Subgrade preparation.

4. Excavation and placement of uncontaminated material for decontamination pads.

E. Overexcavation: Overexcavation for the Subcontractor's convenience or due to error or lack of control by the Subcontractor will not be measured for payment and, instead, shall be backfilled with compacted contaminated or uncontaminated material fill, as required, at the Subcontractor's expense.

F. Separate measurement for payment will not be made for any other fills specified in this Section.

4.2 PAYMENT

A. Payment for the items of Article 4.1.A above will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for excavating, hauling, and placing the excavated materials in their final locations including all grading, shaping, preparing subgrade, compacting or consolidating.

B. Payment for the items of Article 4.1.B above will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for excavating and, if required, temporarily stockpiling the materials until final placement.

C. Payment for the items of Article 4.1.C above will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for hauling, and placing the excavated materials in their final locations including all grading, shaping, preparing subgrade, compacting or consolidating.

D. Separate payment will not be made for the items mentioned in Article 4.1.D above. All costs for such work will be considered to be included in the price quoted for the related item of work.

E. Separate payment will not be made for any other fills specified in this Section. All costs for furnishing and placing such fills shall be considered to be included in the related items of excavation.

END OF SECTION 02200

SECTION 02278

EROSION PROTECTION

PART 1 - GENERAL

1.1 SCOPE

This Specification Section describes the requirements for furnishing and placing riprap and bedding materials for tailings embankment and vicinity properties encapsulation cell covers, drainage ditches and energy dissipation facilities.

1.2 WORK NOT INCLUDED

Erosion protection related to the construction of temporary facilities specified in Section 01500 is not included in the scope of work of this Specification.

1.3 RELATED WORK

A. Section 01300 - Submittals

B. Section 02200 - Earthwork: Subgrade Preparation

1.4 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only:

1. American Society for Testing and Materials (ASTM):

C88-83	Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C127-84	Test Method for Specific Gravity and Absorption of Coarse Aggregate
C131-81	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
C295-85	Practice for Petrographic Examination of Aggregates for concrete.

C535-81 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

1.5 QUALITY ASSURANCE

A. Source Quality Control:

1. Monitoring of Materials at Source: The materials will be inspected at the source by the Contractor. Visual inspection will be used to ensure that the materials meet the requirements with respect to soundness and cleanliness. Material which is weathered, jointed, cracked, or seamed and material which contains unacceptable quantities of overburden, organic matter or other unsuitable material will be rejected. Materials will be tested by the Contractor to ensure that the specified requirements are satisfied.

2. Unacceptable Materials: All materials not meeting the requirements of this Section, as determined by tests and/or inspections at the source, will be rejected. All rejected materials shall be disposed of at designated disposal sites and at no additional cost to the Contractor. Materials not meeting the grading requirements shall be reprocessed or discarded. The Contractor may require modification of the processing and grading operations to ensure that the specified grading requirements are met.

1.6 SUBMITTALS

A. A site inspection report containing the information specified in Article 2.1.A.2 below shall be submitted, in triplicate, to the Contractor for review and approval of the source, in accordance with the requirements of Section 01300.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material Sources: Erosion protection materials shall be obtained from sources approved by the Contractor. Every change in source of materials shall require approval from the Contractor. One commercial quarry operating under the name, Western Roads, Inc., in Lakeview, Oregon, has been tested and evaluated as an acceptable rock source.

1. Approval of the source as a borrow area does not mean that all materials excavated will meet the requirements of this Specification. Processing or selective quarrying may be necessary to meet the quality requirements of this Section.

2. The basis for approval of the sources proposed by the Subcontractor shall be as follows:

    a. A site inspection report by an engineering geologist which will include, as a minimum, an evaluation of soundness, hardness, and durability.

    b. If available, examples of successful uses of the material including riprap that has been in place on other project sites for more than 20 years, rock that has functioned satisfactorily as foundation stone or building facing for 50 years or more, and abandoned quarry faces which have maintained their integrity after not being worked for approximately 50 years or more. Durability shall be indicated by lack of significant weathering or loss of volume and strength over decades of exposure to natural weathering elements.

    c. The materials shall meet the requirements of Article 2.1.B below of this Specification.

B. Test results shall be submitted to verify that the materials meet the following requirements:

1. The materials shall be free from radioactive or other contamination.

2. Individual pieces shall be dense, sound, resistant to abrasion, and shall be free from cracks, seams, and other defects as shown in the petrographic examination.

3. The shape of at least 75 percent of the material, by weight, shall be such that the minimum dimension is not less than one third of the maximum dimension.

4. Quality:

Tests	Designation	Requirements
Specific Gravity (Saturated Surface Dry Basis)	ASTM C127	Not less than 2.65
Absorption	ASTM C127	Not more than 0.75 percent
Soundness	ASTM C88	Na_2SO_4 Test: Not more than 5 percent loss of weight after 5 cycles
Abrasion (Los Angeles Machine)	ASTM C131 ASTM C535	Not more than 25 percent loss of weight after 500 revolutions. Ratio of weight loss after 100 revolutions to loss after 500 revolutions shall not exceed 20 percent.
Petrographic Examination	ASTM C295	The Subcontractor shall furnish a report for review by The Contractor.

5. Gradation: The materials shall meet the following gradation requirements:

a. Riprap Material:

U.S. Standard Sieve Size (Square Openings)	Percent Passing (by weight)
Type A	
4-inch	100
2-inch	23-98
1-1/2-inch	15-50
1-inch	2-25
1/2-inch	0-5

Type B	
5-inch	100
3-inch	30-60
2-inch	10-26
1-inch	0-5
Type C	
12-inch	100
8-inch	34-62
6-inch	20-36
4-inch	2-18
2-inch	0
Type D	
32-inch	100
20-inch	34-60
16-inch	20-36
12-inch	8-24
6-inch	0

b. Bedding Material:

U.S. Standard Sieve Size (Square Openings)	Percent Passing (by weight)
2-1/2-inch	100
3/4-inch	60-85
No. 4	38-58
No. 16	24-40
No. 40	12-26
No. 200	0-5

PART 3 - EXECUTION

3.1 PLACEMENT AND COMPACTION

A. Subgrade preparation (for drainage ditches, etc.) shall be as specified in Specifications Section 02200.

B. Where the required bedding material thickness is 6 inches or less, the bedding material shall be spread and compacted in one layer. Where the required thickness is more than 6 inches, the material shall be spread and compacted in two or more layers of approximately equal thickness and the maximum compacted thickness of any one layer shall not exceed 6 inches.

C. Each layer of bedding material shall be compacted by four passes of a 2- to 3-ton working weight vibratory roller operating across the slope, over the entire area of placement.

D. Riprap material shall be placed so that the larger pieces are uniformly distributed and the smaller pieces serve to fill the spaces between them to provide well-keyed, densely placed layers of riprap of the specified thicknesses.

E. Riprap material, up to a maximum nominal size of 32 inches, may be placed by end-dumping and may be spread by bulldozers or other suitable equipment. The material shall not be dropped from a height exceeding 2 feet above the in-place bedding or rip-rap material, nor in a manner to cause fracture, displacement or damage to the material being placed or already in place.

F. Construction equipment other than spreading and compaction equipment shall not be allowed to move over the placed riprap material and bedding material layers except at equipment crossovers as designated by the Contractor. Each crossover shall be cleaned of all contaminating materials and approved by the Contractor before additional materials are placed in these areas.

3.2 TOLERANCES

A. The material layers shall be placed generally to the limits and thicknesses shown on the Subcontract Drawings within the following tolerances:

1. Top of bedding material shall be within 0.1 foot of elevations shown on the Subcontract Drawings.
2. The minimum in-place thickness shall not be less than 90 percent of the thickness shown.
3. The maximum in-place thickness shall not be more than 125 percent of the thickness shown.
4. Local irregularities will be permitted provided that such irregularities do not form noticeable mounds, ridges, swales or depressions which in the opinion of the Contractor could cause concentrations of surface runoff or form ponds or gullies.

3.3 FIELD QUALITY CONTROL

A. The placement of the materials shall be monitored to ensure that the following requirements are met:

1. The correct type of material is being placed.
2. The material being placed is clean and free of unsuitable material.
3. The material is being loaded, transported and placed in a manner which minimizes segregation.
4. The material is being placed to line and grade within the tolerances and limits designated in Article 3.2 above.

B. All unsatisfactory materials shall be removed to the satisfaction of the Contractor and replaced with acceptable materials at no additional cost to the Contractor.

C. The Contractor may require that material which has become segregated or not placed according to the above requirements be regraded or adjusted, using appropriate equipment, to conform with the tolerances and limits given above, at no additional cost to the Contractor.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for furnishing and placing of the following materials will be by the cubic yards of material placed. The quantities shall be calculated from the lines and dimensions shown on the Subcontract Drawings:

1. Riprap Materials, Type A, in areas other than vicinity properties encapsulation cell
2. Riprap Materials, Type B, in areas other than vicinity properties encapsulation cell
3. Riprap Materials, Type C, in areas other than vicinity properties encapsulation cell
4. Riprap Materials, Type D, in areas other than vicinity properties encapsulation cell

5. Bedding Materials, in areas other than vicinity properties encapsulation cell
6. Riprap Materials, Type B, in vicinity properties encapsulation cell
7. Bedding Materials, in vicinity properties encapsulation cell

4.2 PAYMENT

Payment for furnishing and placing the materials of Article 4.1.A above, will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for the development of the source (where applicable) including clearing, stripping and excavating; processing the materials; testing and evaluating the materials; transporting to placement locations; placing; compacting and consolidating complete in place.

END OF SECTION 02278

SECTION 02500

PAVING AND SURFACING

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for the construction of the base and asphalt concrete pavement for the decontamination pads as shown on the Subcontract Drawings.

B. The Subcontractor shall construct the decontamination pads to the lines and grades shown on the Subcontract Drawings.

1.2 ALTERNATIVE

A. As an alternative to asphalt concrete paving the Bidder may submit with his Bid a proposal for an equivalent load bearing Portland cement concrete pavement.

B. The Bidder's proposal shall include, as a minimum, the design of the concrete pad; design calculations, drawings and specifications in accordance with the requirements of Section 01300.

C. The pavement and base course shall be designed for 24,000 pounds single axle loading with a CBR subgrade value of 3.5.

D. The Portland cement concrete shall have a minimum 28-day compressive strength of 3000 pounds per square inch.

1.3 WORK NOT INCLUDED

Roadways and other areas within the Subcontractor's construction yard and other roadways constructed by the Subcontractor for his own use or convenience are excluded.

1.4 RELATED WORK

A. Section 02050 - Demolition: Decontamination Pads

B. Section 02200 - Earthwork: Earthwork and Subgrade Preparation

1.5 REFERENCES

A. Pertinent provisions of the following listed codes and standards shall apply to the work of this Section, except as they may be modified herein, and are hereby made a part of this Specification to the extent required:

1. Standard Specifications for Highway Construction, State of Oregon, Department of Transportation, Highway Division, 1984. All references to "Engineer" shall mean "Site Manager"; all references to "Division or Highway Division" shall mean "Contractor"; and all references to "Contractor" shall mean "Subcontractor". The provisions for measurement and payment shall not be applicable. All references to "special provisions" shall not be applicable. Measurement and payment provisions shall be as specified in this Section.

2. American Society for Testing and Materials (ASTM):

D290-67	Recommended Practice for Bituminous Mixing Plant Inspection

1.6 QUALITY ASSURANCE

A. Aggregate Base:

1. Aggregate base course materials and operations may be subject to inspection, sampling and testing by a soil testing laboratory employed by the Contractor. Laboratory personnel shall have unrestricted access to the work.

2. The soil testing laboratory will analyze and test materials in the laboratory as directed by the Site Manager to determine conformance with these Specifications.

B. Pavement:

1. Bituminous paving mixture shall be the product of a bulk asphalt mixing plant regularly engaged in the production of hot-mixed, hot-laid asphalt paving mixtures.

2. Mixing plant may be inspected in accordance with ASTM D290. The inspector shall be provided with means of access to all facilities and processes involved in the production and testing of the paving materials and mixture.

3. After approval of mix design, no change shall be made in types or proportions of materials without written approval of the Site Manager.

4. An independent laboratory, employed by the Contractor, may perform tests upon paving materials and mixtures, and obtain core samples upon direction of the Site Manager. Such testing shall be for the Contractor's purposes, not as a contractual obligation for assistance in the construction of the work.

1.7 SUBMITTALS

A. The Subcontractor shall submit three copies of certification of analysis by manufacturer or supplier as required by Section 106.06 of the State of Oregon, Department of Transportation, Specifications for Highway Construction prior to the use of any materials for which the Site Manager requires that such a certificate be furnished.

B. Mix design, including source of materials, aggregate seive analysis, specific gravities of fine and coarse aggregate, and proportions of asphalt binder, by percent by weight of total mix, shall be submitted for each paving mixture to the Site Manager for approval before it is used for construction.

C. A change in aggregate source of supply shall require the submittal of a new mix design.

D. Mix design(s) shall be subject to adjustment and acceptance by the Site Manager.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Base course shall be constructed when the atmospheric temperature is above 35 degrees F. When the temperature falls below 35 degrees F., the Subcontractor shall protect all areas of completed base by approved methods against detrimental effects of freezing. Areas of completed base course damaged by freezing, rainfall, or other weather conditions shall be corrected to meet specified requirements at no additional cost to the Contractor.

B. Other environmental restrictions for placing asphaltic concrete shall be as specified in Oregon Highway Division Specifications Section 403.

PART 2 - PRODUCTS

2.1 EQUIPMENT

The Subcontractor shall provide all equipment and facilities required to perform the work of this Specification. The equipment and facilities shall be subject to approval by the Contractor.

2.2 MATERIALS

A. Base course aggregate shall meet the requirements for aggregate bases, 1-1/2"-0 gradation, Section 304 of the Oregon Highway Division Specifications.

B. Bituminous materials shall meet the requirements of Part 400 of the Oregon Highway Division Specifications.

C. Asphalt Concrete Mix Design:

1. Asphalt concrete, Class "B", mix design shall be performed in accordance with Section 403 of the Oregon Highway Division Specifications except as modified herein and as approved by the Contractor. The index of retained strength shall be at least 70%.

2. The paving asphalt shall be of viscosity grade AC-10 and shall conform to the requirements in Section 702 of the Oregon Highway Division Specifications. The asphalt content shall be 3.5-7.0 percent by weight of total mix.

3. The mineral aggregates, filler and asphalt shall be proportional and mixed as hereinafter specified to conform with the composition by weight tabulated below. Sufficient mineral filler shall be used to correct any deficiencies in the grading of the fine aggregates.

Sieve Sizes (Square Openings)	Percent Passing (By Weight)
1 inch	100
3/4 inch	95-100
3/8 inch	65-80
No. 4	45-60
No. 8	30-45
No. 30	15-25
No. 200	3-7

D. The fog coat will be an emulsified asphalt meeting Oregon Highway Division Specifications. The material shall be diluted with one part water to two parts emulsified recycling agent. Blotter material shall be applied to the treated surface at a time specified by the Contractor and before opening to traffic. Blotter material shall be a natural sand, crushed sand, volcanic cinders, or other approved material and shall be free of deleterious amounts of foreign substances.

PART 3 - EXECUTION

3.1 EARTHWORK AND SUBGRADE PREPARATION

A. Earthwork and subgrade preparation shall be as specified in Section 02200.

B. Before placing and spreading base course material the subgrade shall be cleaned of all foreign substances and shall contain no frozen material. It shall be inspected by the Contractor for adequate compaction and surface tolerances.

3.2 CONSTRUCTION OF BASE COURSE

A. The construction of the base course shall follow the requirements of Oregon Highway Division Specifications Section 304 except as modified herein and as approved by the Contractor.

B. Placement: The base course shall have water added and shall be mixed and processed so as to produce a uniform blend of material before final placement. After processing, the material shall be placed and spread on the prepared subgrade, in a uniform layer or layers not exceeding

6 inches in compacted depth, unless otherwise approved in writing by the Contractor. The spread material shall be free from segregation.

C. Compaction: Each layer of aggregate base shall be compacted to a density of not less than 95 percent of the maximum density determined in accordance with the requirements of Oregon State Highway Division (OSHD) Test Method 106.

D. Finishing:

1. The final layer of base shall be finished with equipment capable of shaping and grading the finish surface within the tolerances specified herein.

2. The finished surface of aggregate base shall not vary from the grades established by the Contractor by more than 0.05 of a foot.

3. The compacted layers of aggregate base shall be maintained in a condition satisfactory to receive the pavement material when so required.

4. Areas not within the allowable tolerance shall be corrected by scarifying, placing additional material, remixing, reshaping and recompacting to the specified density and surface tolerance.

3.3 CONSTRUCTION OF ASPHALTIC CONCRETE LAYER

A. The construction of the Class "B" asphaltic concrete layer shall be in accordance with Section 403 of the Oregon Highway Division Specifications except as modified herein and as approved by the Contractor.

B. The base course shall be primed with liquid asphalt at the approximate total rate of 0.25 gallon per square yard. The exact rate and number of applications shall be as required to ensure complete bonding of the pavement to the prepared surface, as accepted by the Site Manager. Not more than 4 hours shall elapse between the application of primer and placing of hot mix. Primer shall not be placed upon a wet surface or during precipitation.

C. Requirements of Subsection 403.13 of the Oregon Highway Division Specifications, "Job Mix Formula", shall not apply. Mixing plant requirements shall be established by the Subcontractor as required to provide asphalt concrete that meets the requirements of this Section.

D. Placement temperature specified in Subsection 403.13 of the Oregon Highway Division Specifications shall be established by the Subcontractor as required to provide asphalt concrete that meets the requirements of this Section.

E. A fog coat of bitumen approved by the Contractor shall be applied to the top surface of the asphaltic concrete. The application rate shall be 0.1 to 0.2 gallon per square yard.

3.4 CLEAN-UP AND PROTECTION

A. After completion of paving operations, surfaces shall be cleaned of excess and spilled paving materials.

B. Vehicular traffic shall be diverted from pavement until it has cooled and hardened, but in no case less than 6 hours.

3.5 MAINTENANCE

Maintenance and necessary repairs to the decontamination pads shall be provided such that the decontamination pad surfaces are kept free of holes, deep cracks or ruts, or other defects that will prevent surface drainage of all wash water and runoff to the drainage ditch, or that will impair efficient movement of traffic.

3.6 DEMOLITION AND DISPOSAL

Demolition and disposal of decontamination pads shall conform to Section 02050.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for construction of decontamination pads will be on a lump sum basis.

B. Separate measurement for payment will not be made for bituminous material including prime coat, tack coat or fog coat.

C. Measurement for payment for demolition and disposal of decontamination pads is specified in Specification Section 02050.

4.2 PAYMENT

A. Payment for construction of decontamination pads will be by the lump sum price quoted therefor in the Bid Schedule. The price quoted shall include full compensation for furnishing all equipment, materials, labor, tools, incidentals, and for performing all work for the construction including site clearing, earthwork, subgrade preparation, aggregate base, asphaltic concrete pavement or Portland cement concrete pavement, and for protection and maintenance work as shown on the Subcontract Drawings, as specified in these Specifications, and as required by the Site Manager.

B. Separate payment will not be made for bituminous material including prime coat, tack coat or fog coat. Full compensation therefor will be considered to be included in the above mentioned item of work.

C. Payment for demolition and disposal of decontamination pads is specified in Specification Section 02050.

END OF SECTION 02500

SECTION 02674

MONITOR WELLS

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section covers the requirements for all activities required to construct ground-water monitoring wells and includes the furnishing of all labor, material, transportation, tools, fuels, lubricants, plant and other equipment necessary, unless hereinafter specifically excepted, to perform all operations necessary to construct and develop the aforementioned wells.

B. The monitor wells shall be constructed and ready for use within 90 days from the date of the Notice to Proceed.

C. The Subcontractor shall be responsible for obtaining all well-drilling permits and for complying with all state and local regulations.

1.2 JOB CONDITIONS

Control of radiation contamination shall be in accordance with the requirements specified in Sections SC-7 and SC-8 of the Special Conditions.

1.3 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The Publications are referred to in the text by the basic designation only:

1. American Society for Testing and Materials (ASTM):

C150-84	Standard Specification for Portland Cement

2. American Water Works Association (AWWA):

A100-84	AWWA Standard for Water Wells

3. Environmental Protection Agency (EPA): Manual of Water Well Construction Practices, EPA-570/9-75-001.

4. Oregon Water Resources Department (OWRD): Rules and Regulations Prescribing General Standards for the Construction and Maintenance of Water Wells in Oregon, effective January 1, 1979.

1.4 SUBMITTALS

A. General Submittal Requirements: Refer to Section 01300.

B. Samples: Three samples of filter material and their sieve analysis shall be submitted to the Contractor for review and approval 30 days before placement of the materials.

C. Description of Equipment: Prior to shipment of drilling equipment to the site, the Subcontractor shall submit for Contractor's approval a description of the equipment proposed for use in the work and the names and experience record of the proposed operators.

1.5 DELIVERY, STORAGE, AND HANDLING

Filter may be delivered, bagged and stacked at the site or it may be delivered in bulk. If delivered in bulk, it shall be placed on a protective sheet preventing contact between it and the ground. It shall be protected from being damaged by providing a suitable covering.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cement shall meet the requirements of ASTM C150 Type I or V. Cement shall be compatible with existing ground water.

B. Grout shall be a mixture of one sack of Portland cement (94 pounds) to 5 gallons of water. Commercially processed bentonite clay, 3 to 5 percent by weight, shall be added to the neat cement grout.

C. Bentonite Pellets: Sodium bentonite pellets shall be 1/4 inch in diameter.

D. Casing and Well Screen: Blank casing and commercially slotted or perforated 0.030-inch opening screen shall be Schedule 80, Type I, 2-inch inside diameter, flush joint, PVC pipe as manufactured by Aardvark Corporation, Inc., 5815-A North Meridian, Puyallup, Washington 98371, or approved equal.

E. Sand/Gravel Filter: Properties, gradations, and sample approval shall be in accordance with the procedures outlined in Sections 6.3, 6.4 and 6.5 of AWWA A100.

PART 3 - EXECUTION

3.1 GENERAL

Well construction shall conform to the requirements of this Specification and details shown on the Subcontract Drawings. The Subcontractor shall collect all samples and keep an accurate log of the borehole, all as required by the Contractor and OWRD regulations. Wells shall be drilled and constructed by a driller having an Oregon State Well Drilling License.

3.2 DRILLING OF WELLS

A. General: Wells shall be drilled by a hollow stem auger or rotary drilling rig which will insure proper placement of well screen and casing. Before drilling begins, the Subcontractor shall demonstrate that all material, equipment, and experienced personnel are mobilized and the equipment is adequate for an efficient operation, and is operating in a satisfactory manner. Drilling equipment shall be adequate for drilling an 8-inch or larger diameter hole to a depth of approximately 150 feet. Each well shall extend to a depth of 15 feet below static water table.

B. Anti-Cross-Contamination Measures:

1. The Subcontractor shall at all times make diligent efforts to prevent the contamination or cross-contamination of all wells and borings. The Subcontractor shall avoid the deliberate or inadvertent introduction of foreign, toxic and contaminating substances into the well or boring. Such substances include but are not limited to oil, grease, hydraulic fluid and fuels. To reduce the potential for contamination, the drilling rigs, tools, drilling stem, and all other appurtenant equipment shall be cleaned with steam under the direct supervision of the Contractor before entering the designated project site.

2. Each time any of the above equipment enters the designated project site, it shall be steam cleaned. However, once on site, steam cleaning will not be required again unless the equipment leaves the project site or becomes contaminated with hydrocarbons or other contaminants. Additional steam cleaning required in such cases shall be performed under the supervision of and at the discretion of the Contractor.

3. Interior portions of equipment which are not accessible for cleaning with steam shall be thoroughly cleaned and flushed with fresh, potable water. Oil, grease or pipe dope shall not be used on pipe threads; non-hydrocarbon-based lubricants, such as silicon or teflon, are acceptable, however.

4. All PVC casing and screen shall be steam cleaned inside and out prior to entering the project site. The PVC pipe shall be stored in a non-contaminated area, elevated off the ground and covered. Any PVC pipe which subsequently becomes contaminated with hydrocarbons or other contaminants shall be steam cleaned again prior to use.

5. Cross-contamination shall be minimized by thoroughly cleaning all external and internal surfaces on all drilling equipment, rigs, tools, drilling stem, and all other appurtenant equipment after each hole is completed and before moving to the next drilling location. Cleaning shall be accomplished by completely removing all soil from the equipment described above and thoroughly flushing the interior and exterior of such equipment with fresh, potable water.

6. The Contractor will direct all contamination and cross-contamintion preventative actions, and all work shall be accomplished to his satisfaction. The Subcontractor shall adhere to the Contractor's directions in this matter.

3.3 CASING AND SCREEN

A. PVC casing and well screen shall be placed in the borehole as shown on the Subcontract Drawings. The bottom of the pipe shall be capped. The Subcontractor shall place the assembled PVC pipe in the well in such a manner as to avoid jarring impacts and to insure that the assembly is not damaged or misplaced. If rotary drilling methods are used centralizers shall be installed at 20 ft. intervals. Immediately after the installation of the PVC pipe, the depth of well shall be measured. The well riser shall extend above ground level, as shown on the Subcontract Drawings. The Subcontractor shall keep and submit an accurate record of the order, number, size and length of each piece of PVC pipe installed in the well.

3.4 SAND/GRAVEL FILTER

A. After the casing and the screen have been installed in their proper position for the full depth of the well, an envelope of coarse-grained silicious sand and fine gravel filter shall be placed in the annular space between the well bore and the casing/screen. The filter material shall extend a minimum of 5 feet above screen sections.

B. Materials used for the filter shall be clean and washed. Filter grain size selected by the Subcontractor shall meet the requirements of AWWA A100. The filter shall be tremied or placed in a manner to minimize segregation.

3.5 BENTONITE PELLET SEAL

A transition zone consisting of bentonite pellets shall be placed immediately above the sand/gravel filter as shown on the Subcontract Drawings.

3.6 GROUTING

To protect the well against the entry of unwanted water and contaminants from the surface, the annular space between the casing and the borehole shall be grouted from the top of the bentonite transition zone to the ground surface. Prior to grouting, the annular space shall be flushed or jetted to assure that the space is open and ready to receive grout. Grout material shall be placed by a positive displacement method such as pumping or forced injection by air pressure. Grout shall be injected in the annular space between the casing and the borehole. Grout shall be placed in one continuous operation. The grout shall consist of Portland cement and bentonite, as described in Article 2.1.B above. Other admixtures to reduce permeability, increase fluidity, and control time of set and the composition of the resultant slurry shall be approved by the Contractor.

3.7 DEVELOPMENT

After the monitoring wells are completed, they shall be thoroughly cleaned of all foreign substances. The wells shall then be developed by methods outlined in Article 52 of the EPA manual (EPA-570/9-75-001) for a period of not less than 4 hours. If air is used for development, either a non-contaminating synthetic oil lubricant shall be used for compressor lubrication, or the air stream shall be filtered to remove hydrocarbons.

3.8 CAPPING OF WELLS

A. Each well shall be equipped with a schedule 40 steel pipe casing embedded into the cement grout as shown on the Subcontract Drawings. Locking covers to prevent unwarranted access to the wells shall be installed.

B. The top of the PVC monitoring well shall be fitted with a threaded cap with a 1/8-inch diameter hole drilled in the top. The threaded cap shall be attached to the PVC casing by means of an adapter section, male threaded one end and slip jointed other end cemented to the casing with a minimal amount of PVC glue. This is the only place where solvent cement will be used in well construction. It is imperative that this coupling be above land surface, that the bare minimum amount of solvent cement be used, and that great precautions are taken so that absolutely no cement drips down into the well.

C. Any well that will be temporarily removed from service, or will be left uncompleted for a period of greater than eight hours, shall be capped by the Subcontractor with a watertight cap and equipped with some type of "vandal proof" cover satisfying the Contractor and applicable state or local regulations or recommendations.

3.9 ABANDONMENT

Should the Subcontractor elect or be required to abandon a well, he shall grout the abandoned hole as specified in Section 02090 of these Specifications.

3.10 DISPOSAL OF MATERIALS

Materials such as soils, drilling mud, debris, rubbish, and other materials resulting from drilling operations shall be stockpiled for disposal in the tailings embankment.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for constructing monitor wells will be by the linear feet of wells completed.

B. No measurement for payment will be made for wells abandoned by the Subcontractor due to lack of material, inadequate or faulty equipment or careless operating procedures.

4.2 PAYMENT

A. Payment for constructing monitor wells will be by the unit price per linear foot quoted therefor in the Bid Schedule. The price quoted shall include full compensation for furnishing all labor, materials, equipment, tools, accessories and incidentals, and for performing all work specified for complete operating wells.

B. No payment will be made for wells abandoned by the Subcontractor due to lack of material, inadequate or faulty equipment, careless operating procedures or other Subcontractor negligence. No payment will be made for sealing of wells resulting from abandonment of wells due to Subcontractor's negligence or operating error.

END OF SECTION 02674

SECTION 02728

SITE DRAINAGE

PART 1 - GENERAL

1.1 SCOPE

This Specification Section describes the requirements for the construction and maintenance of temporary and permanent drainage facilities, including temporary drainage ditches, culverts and wastewater retention basins for use during construction, as well as permanent drainage facilities, all as shown on the Subcontract Drawings.

1.2 WORK NOT INCLUDED

Drainage work related to the construction of temporary facilities specified in Section 01500 is not included in the scope of work cf this Specification.

1.3 RELATED WORK

A. Section 02050 - Demolition: Wastewater Retention Basins and Temporary Drainage Ditches

B. Section 02110 - Site Clearing

C. Section 02140 - Dewatering

D. Section 02200 - Earthwork: Excavation and Subgrade Preparation

E. Section 02278 - Erosion Protection

F. Section 02771 - Membrane Liner

G. Section 02935 - Seeding

1.4 DEFINITIONS

Disturbed Area: An area disturbed by construction operations, including but not limited to excavated areas, stockpile areas and areas from where vegetation has been removed by construction equipment.

1.5 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only:

1. American Association of State Highway and Transportation Officials (AASHTO):

M36-83	Corrugated Steel Pipe, Metallic Coated for Sewers and Drains

PART 2 - PRODUCTS

2.1 MATERIALS

A. Culverts:

1. Culvert pipe indicated as "CSP" on the Subcontract Drawings shall be corrugated steel pipe conforming to AASHTO M36, Type I (circular section), and shall be provided complete with fittings, coupling bands, and all required accessories.

2. Diameter of pipe shall be as shown on the Subcontract Drawings. Unless otherwise indicated on the Subcontract Drawings the thickness of the pipe shall be 16 gage minimum.

B. Dewatering: See Section 02140.

C. Fill materials shall be as specified in Section 02200.

D. Seed mix and mulch shall be as specified in Section 02935.

PART 3 - EXECUTION

3.1 DITCHES

A. Ditches shall be excavated true to line and grade as specified in Section 02200. Any erosion which occurs to the excavation before seeding or placing filter materials shall be repaired with carefully compacted uncontaminated fill, at no additional expense to the Contractor.

B. The subgrade of each permanent drainage ditch shall be prepared as specified in Section 02200.

3.2 SEEDING AND MULCHING

All cut and fill slopes not finished with riprap protection, including sides and inverts of ditches, shall be seeded and mulched as specified in Section 02935.

3.3 CULVERTS

A. Trenches for pipe culverts shall be excavated and pipe bedding shall be provided as shown on the Subcontract Drawings. After the pipe is satisfactorily laid, the trench shall be backfilled as shown on the Subcontract Drawings and compacted to a density at least equal to that of the adjacent soil. All culverts utilized for temporary drainage during construction shall be removed by the Subcontractor at the completion of site work.

B. The Subcontractor shall be responsible for the maintenance and repair of all culverts.

3.4 WASTEWATER RETENTION BASINS AND DRAINAGE DITCHES

A. Wastewater retention basins and drainage ditches shall be constructed as shown on the Subcontract Drawings.

B. Membrane liner shall be installed as specified in Section 02771.

3.5 EROSION PROTECTION MATERIALS

Erosion protection materials shall be placed as specified in Section 02278.

3.6 MAINTENANCE

The Subcontractor shall be responsible for the maintenance of site drainage during construction. Drainage ditches and culverts may require periodic cleaning. Culverts and ditches shall be kept free of sediment deposits, debris and other materials that may restrict or prevent drainage. The Subcontractor, when directed by the Contractor, shall remove and replace all items not functioning properly because of clogging, damage, or deterioration.

3.7 REMOVAL

At the completion of the Subcontract when the wastewater retention basins and the temporary drainage ditches are no longer required they shall be demolished as specified in Section 02050 and as required by the Contractor.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for excavation of the drainage ditches and the wastewater retention basins, and for subgrade preparation of the permanent drainage ditches is specified in Section 02200. Side ditches for roads and facilities alike shall not be included in measurement for payment. Erosion protection materials will be measured separately.

B. Measurement for payment for furnishing and installing 15-inch diameter corrugated steel pipe culvert will be by the linear feet of pipe installed.

C. Measurement for payment for furnishing and placing erosion protection materials will be as specified in Section 02278.

D. Measurement for payment for demolition of the temporary drainage ditches and the wastewater retention basins is specified in Section 02050.

4.2 PAYMENT

A. Payment for excavation of the drainage ditches and the wastewater retention basins, and for subgrade preparation of the permanent drainage ditches is specified in Section 02200.

B. Payment for furnishing and installing 15-inch diameter corrugated steel pipe culvert will be by the unit price per linear foot quoted therefor in the Bid Schedule. The price quoted shall include full compensation for furnishing all materials, tools, equipment, incidentals, labor, and for performing all work including excavation, backfilling, compacting, removal, etc. for complete installation.

C. Payment for furnishing and placing erosion protection materials will be as specified in Section 02276.

D. Payment for demolition of the temporary drainage ditches and the wastewater retention basins shall be considered to be included in the Bid Schedule item for demolition specified in Section 02050.

END OF SECTION 02728

SECTION 02771

MEMBRANE LINER

PART 1 - GENERAL

1.1 SCOPE

This Specification Section describes the requirements for furnishing and installing membrane liner systems for wastewater retention basins, emergency spillways and particular drainage ditches.

1.2 SYSTEM DESCRIPTION

A. Liner system shall consist of liner, adhesives and accessories required for sterilizing ground and installing liner, vents and other appurtenances.

B. The retention basins and ditches, where lining is required, will carry water produced from stormwater runoff, decontamination and dewatering operations, including minor amounts of sediment transportation. Major contaminants in the water will consist of the following maximum concentrations:

Chlorides	2,400 mg/l
Sulfates ($NaSO_4$)	7,000 mg/l
Total Dissolved Solids	11,000 mg/l
pH	5.6 - 9.3

1.3 RELATED WORK

A. Section 01300 - Submittals

B. Section 02050 - Demolition

C. Section 02200 - Earthwork

D. Section 02728 - Site Drainage

1.4 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The Publications are referred to in the text by the basic designation only:

1. American Society for Testing and Materials (ASTM):

D638-84	Test Method for Tensile Properties of Plastics
D792-66	Test Methods for Specific Gravity and Density of Plastics by Displacement (R1979)
D1004-66	Test Method for Initial Tear Resistance of Plastic Film and Sheeting (R1981)
D1593-81	Specification for Nonrigid Vinyl Chloride Plastic Sheeting
D2301-84	Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

2. Federal Standards (FS):

101C	Test Methods for Packaging of Materials

1.5 QUALITY ASSURANCE

A. Manufacturer: The manufacturer of the liner shall have manufactured, fabricated and supervised installation of at least 1,000,000 square feet of membrane liners.

B. Installation Worker Qualifications: The installation workers shall have installed a minimum of 500,000 square feet of membrane liners.

C. Installation Supervisor: Installation of the membrane liner shall be performed under the supervision of an Installation Supervisor qualified and approved by the manufacturer.

1.6 SUBMITTALS

A. General submittal requirements are specified in Section 01300.

B. The Subcontractor shall submit the following to the Contractor for review and approval 30 days before placement of the material:

1. Product data.
2. Samples of material and accessories.
3. Certificate signed by the manufacturer that the system proposed meets the Specification.
4. Installation details.
5. Manufacturer's installation instructions.
6. Test reports.

1.7 WARRANTY

Liner materials and factory seams shall be warranteed to be free from defects in materials and workmanship for a period of 3 years from the date of acceptance. Installation and field seams shall be warranteed free of defects for a period of 3 years from the date of acceptance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

The liner material shall be the product of a manufacturer successfully engaged in the business of manufacturing liner materials for the last ten years.

2.2 MATERIAL

A. The thermoplastic elastomer lining material shall be manufactured from a synthetic rubber compound and shall be polyethylene (PE) or chlorinated polyethylene (CPE), specifically compounded for use in hydraulic facilities.

B. The lining shall be of unreinforced construction consisting of calendered synthetic rubber sheeting.

C. Physical Properties:

Property	Test Method	Data
Density	ASTM D792	0.930 gms/cc, min.
Thickness	ASTM D1593 or D2301	CPE 30 mil, nominal PE 40 mil, nominal
Puncture Resistance	FED STD 101C, Method 2031	130 lbs. min.
Tensile Strength	ASTM D638,	
@ Yield		45 lbs/inch, min.
@ Break		105 lbs/inch, min.
Elongation @ Break	ASTM D638	650 percent, min.
Tear Resistance	ASTM D1004	15 lbs., min.

2.2 FABRICATION

The roll goods shall be factory fabricated into optimum sized panels up to 20,000 square feet, using an approved seaming method as prescribed by the manufacturer. When the seam is tested to shear, failure of the material including the seam shall not occur at the bonded surfaces.

PART 3 - EXECUTION

3.1 GENERAL

The liner systems shall be installed as shown on the Subcontract Drawings and as recommended by the manufacturer.

3.2 GROUND SURFACE PREPARATION

A. Surfaces to be lined shall be smooth and free of sharp rocks or vegetation. If the liner is not applied within 15 days of surface preparation, the surface shall be protected against growth of vegetation by the application of a suitable short-lived soil sterilant as approved by the Contractor.

B. Certification from an Installation Supervisor shall be required stating that the surface on which the liner is to be placed is acceptable. No installation of lining shall commence until this certification is furnished to the Contractor. The receiving surface shall be kept in the accepted condition until the installation of the lining is accomplished.

3.3 FIELD SEAMS

All field seams shall be performed using only the manufacturer's approved methods, adhesives and application directions. The minimum width of overlap of field seams shall be 4 inches. The contact surfaces of the panel overlap shall be cleaned to remove all dirt, dust or other foreign materials. A nominal 6-inch overlap of liner panels shall be allowed to keep dirt out of the field seams. When bonding the seams, the temperature of the sheet and adhesive shall be not less than 55°F. Artificial heat shall be applied if ambient conditions create lower temperature .

3.4 INSPECTION

A. All field seams shall be 100 percent inspected by the Installation Supervisor.

B. The site shall be available at all reasonable times for inspection of finished work or work in progress by the Contractor. Any seams or areas found to be defective shall be repaired according to the manufacturer's instructions at no cost to the Contractor. In no case shall these be less rigorous than the specifications for field seaming.

3.5 ANCHORING

During installation, necessary precautions shall be taken to insure the liner will not be damaged or moved by wind, rain or dust. The liner shall be installed in such a manner that prior to filling, the liner will be protected from damage or movement by wind, water, and dust.

3.6 TEMPORARY EROSION PROTECTION-CONSTRUCTION PHASE

A. Synthetic membrane shall be placed on the prepared wastewater retention basins subgrade including the emergency spillways, as shown on the Subcontract Drawings.

B. Membrane edges to be joined are overlapped and sealed as recommended by the manufacturer.

C. The Subcontractor shall maintain and if required, repair synthetic membrane to provide efficient protection from runoff erosion and contamination.

D. Demolition and disposal of the membrane liner shall conform to the requirements of Section 02050.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for furnishing and installing membrane liner for the wastewater retention basins, emergency spillways and decontamination pad side ditches will be by the square yards of material installed. The quantities for payment will be calculated from the lines and dimensions shown on the Subcontract Drawings. The surfaces shall be measured parallel to the liner material installed.

B. Measurement for payment for preparation of subgrade shall be as specified in Section 02200.

4.2 PAYMENT

A. Payment for furnishing and installing membrane liner for the wastewater retention basins, emergency spillways, and decontamination pad side ditches will be by the unit price per square yard quoted therefor in the Bid Schedule. The price quoted shall include full compensation for furnishing all materials, tools, equipment, Installation Supervisor, incidentals and for performing all work as specified.

B. Payment for preparation of subgrade shall be as specified in Section 02200.

END OF SECTION 02771

SECTION 02850

SIGNS

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for furnishing, fabricating and erecting warning signs to indicate the presence of radioactive materials.

B. The signs shall be installed at locations shown on the Subcontract Drawings and as specified in this Section. Signs shall be installed upon completion of all other Subcontract work at the disposal site.

1.2 DEFINITIONS

A. Legend: The word legend shall mean the entire message and border for a sign.

B. Message: A group of words, numbers and symbols shall constitute the message for a sign.

1.3 DESIGN REQUIREMENTS

A. The signs shall display the following legend:

1. The international symbol indicating the presence of radioactive materials,
2. The site is government property, and contains uranium mill tailings, and
3. Trespassing is forbidden.

B. The sign at the entrance to the site shall display the information specified in Article 1.3.A above plus the name and telephone number of the responsible agency.

1.4 SUBMITTALS

A. General submittal requirements are specified in Section 01300.

B. Unless otherwise specified, the Subcontractor shall submit, in triplicate, the following to the Contractor for review:

1. Site layout showing locations of the signs.

2. Working drawings showing the layout for the legend on each type of sign. The layout shall include all vertical and horizontal spacing dimensions, including the length of each individual word. A continuous dimension line shall be used for each line of legend and the total of the numerical dimensions given on each line shall be equal to the length of the sign. The name of the sign fabricator, the manufacturer for all fabricated legends and the origin of the letter spacing used to determine the word lengths shall be noted on all working drawings for signs. Only one sign layout shall be shown on each sheet of working drawings submitted. The working drawing sheets shall be 8-1/2 inches by 11 inches.

3. Installation details.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this Specification to the exstent referenced. The publications are referred to in the text by the basic designation only:

1. Oregon State Highway Division: Standard Specifications for Highway Construction, 1974 Edition.

2. American Association of State Highway and Transportation Officials (AASHTO): AASHTO Manual for Signing and Pavement Marking of the National System of Interstate and Defense Highways.

PART 2 - PRODUCTS

2.1 SIZE AND DESIGN

A. The perimeter sign shall conform to the requirements shown in Figure 02850-A.

B. The entrance sign shall conform to the requirements shown in Figure 02850-B.

2.2 SIGN BACKGROUND

A. The signs shall have yellow reflectorized sheeting background on sheet aluminum with non-reflectorized black screened legend.

B. The colors used for sign backgrounds shall match the highway color tolerance charts produced by Hale Color Consultants, 1220 Bolton Street, Baltimore, Maryland 21217, or approved equal. Where required, the colors shall conform to the color coordinates specified. If color coordinates are not specified, the color sample, called for herein, shall be subject to visual matching to determine the acceptability of the color.

2.3 MATERIALS

A. The materials shall be of the kinds and types as specified herein and shall meet the requirements of applicable subsections of Specification Section 761 of the Standard Specifications for Highway Construction of the Oregon State Highway Division.

B. Sign fabrications shall conform to the requirements of subsections 645.32 and 645.33.

C. Reflective sheeting application shall conform to subsection 645.32.

D. Legend installation shall meet the requirements of subsection 645.36.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Signs shall be located and erected as shown on Contractor-approved drawings, and as required by the Site Manager.

B. The distance between perimeter signs shall not exceed 500 feet.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Measurement for payment for furnishing, fabricating and erecting signs specified in this Section will be by the number of signs actually furnished and installed.

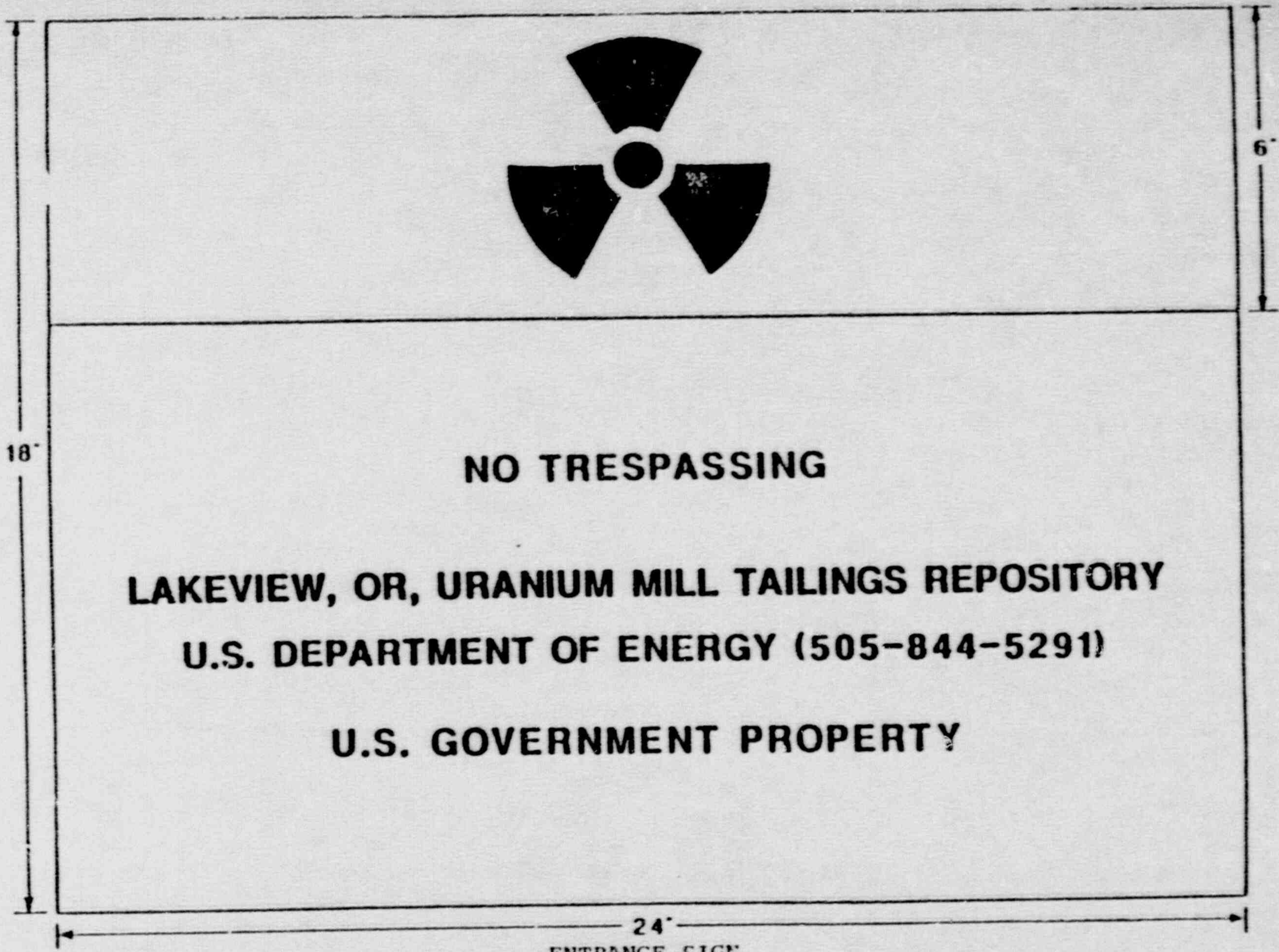
4.2 PAYMENT

Payment for furnishing, fabricating and erecting signs specified in this Section will be by the unit price per each quoted therefor in the Bid Schedule. The price quoted shall include full compensation for designing, furnishing, fabricating, providing all labor, materials and incidentals, and for installing signs complete in place including all work such as excavating, concreting and alike.

END OF SECTION 02850

PERIMETER SIGN
FIGURE 02850-A

SECTION 02850



ENTRANCE SIGN

FIGURE 02850-B

SECTION 02850

SECTION 02935

SEEDING

PART 1 - GENERAL

1.1 SCOPE

This Specification Section covers seeding. All exposed areas not covered by riprap shall be seeded as required to control erosion.

1.2 WORK NOT INCLUDED

Seeding related to the Temporary Facilities specified in Section 01500 is not included in the Scope of Work of this Section.

1.3 MATERIAL STORAGE

A. Seeds shall be stored in sealed waterproof containers in a cool, dry location and shall be kept out of direct sunlight until ready for use.

B. Fertilizer shall be delivered and stored in waterproof containers which will show the chemical analysis and name of manufacturer.

PART 2 - MATERIALS

2.1 SEED MIX

A. Temporary Cover: One of the following seed mixes shall be used for temporary seeding of exposed areas during construction:

Seed Species	Seeding Rate (Pounds Per Acre)
1. Winter or Spring Wheat or Rye (98% purity, 85% total germination)	80

2. Spring Barley (99% purity, 85% total germination)	80
3. Annual or Perennial Ryegrass (98% purity, 85% total germination)	20

B. Drainage Ditches: The seed mix for all temporary and permanent drainage ditches shall consist of one of the following:

Seed Species	Seeding Rate (Pounds Per Acre)
1. Pubescent Wheatgrass (90% purity, 85% total germination)	25
2. Streambank Wheatgrass (90% purity, 80% total germination)	25
3. Intermediate Wheatgrass (94% purity, 85% total germination)	25
4. Hard Fescue (95% purity, 85% total germination)	12
5. Crested Wheatgrass (94% purity, 85% total germination)	15

C. Permanent Cover: One of the following seed mixtures shall be used for seeding of final grades:

Seed Species	Seeding Rate (Pounds Per Acre)
1. Crested Wheatgrass (94% purity, 85% total germination)	10
Pubescent Wheatgrass (90% purity, 85% total germination)	15
Intermediate Wheatgrass (94% purity, 85% total germination)	15
Total	40
2. Cereal Rye (98% purity, 85% total germination)	30

	Pubescent Wheatgrass (90% purity, 85% total germination)	15
	Intermediate Wheatgrass (94% purity, 85% total germination)	15
	Total	60
3.	Crested Wheatgrass (94% purity, 85% total germination)	10
	Streambank Wheatgrass (90% purity, 80% total germination)	30
	Total	40
4.	Wheatgrass (90% purity, 85% total germination)	20
	Hard Fescue (95% purity, 85% total germination)	10
	Big Bluegrass (90% purity, 70% total germination)	10
	Total	40
5.	Crested Wheatgrass (94% purity, 85% total germination)	10
	Hard Fescue (95% purity, 85% total germination)	15
	Big Bluegrass (90% purity, 70% total germination)	10
	Total	35

2.2 ACCEPTANCE OF SEED

Final acceptance of seed will be made by the Contractor based on the following: Seed shall be furnished separately or in mixture in standard sealed containers with (1) seed name; (2) lot number; (3) net weight; (4) percentages of purity and of germination; and (5) percentage of maximum weed seed content clearly marked for each kind of seed. The Subcontractor shall furnish the Contractor duplicate copies of a statement by the vendor, certifying that each lot of seed has been tested by a recognized laboratory for seed testing within 6 months of date of delivery. This statement shall include: (1) name and address of laboratory, (2) date of test, (3) lot number for each kind of seed, and (4) results of tests as to name, percentages of purity and of germination, and percentage of weed content, for each kind of seed furnished, and, in case of a mixture, the proportions of each kind of seed.

2.3 LIME

Lime, if required, shall be agricultural grade limestone.

2.4 FERTILIZER

Fertilizer shall be a standard commercial grade and provide the minimum percentage of available nutrients specified. Fertilizer shall be furnished in new, clean, and sealed containers with the name, weight, and guaranteed analysis of contents clearly marked. A liquid form of fertilizer containing the minimum percentage of available nutrients may be used.

2.5 MULCH

Mulch shall consist of cereal straw. Cereal straw shall be from grain crops that are free from noxious weeds, mold, or other objectionable material. Mulch shall be in an air-dry condition and suitable for placing with mulch blower equipment. Final acceptance of mulch will be by the Contractor.

2.6 WATER

Water used in the planting or care of vegetation shall be free of oils, acids, alkalies, salts, or any substance injurious to plant life.

PART 3 - EXECUTION

3.1 PREPARATION

A. Timing:

1. During Construction: All exposed surfaces not covered by riprap shall be seeded as soon as practical after completion or shutdowns, but not later than 20 days thereafter, using one of the seed mixes specified in Article 2.1.A or 2.1.C above, mulched, or provided with other forms of surface protection approved by the Contractor. All drainage ditches shall be seeded using one of the seed mixes specified in Article 2.1.B above. Erosion protection of these exposed areas shall be completed as soon as practical after the completion of surface-disturbing activities, but no later than 20 days thereafter. If seeding cannot be done because of seasonal restrictions, the exposed surfaces shall be protected as required by the Contractor.

2. Final Grades: All disturbed areas not covered by gravel or riprap shall be seeded using one of the seed mixes specified in Article 2.1.C above. The top slope of the final tailings embankment shall be covered with a rock-soil matrix and revegetated. Final seeding shall be completed as soon as practical after completion of final grading, but no later than 20 days thereafter. Seeding materials shall not be applied during windy weather, when the ground is excessively wet or frozen, or when snow is present.

B. Before applying seed for permanent cover of a given area, the area shall be graded as shown on the Drawings, with surfaces sloping gradually towards drainage courses, with no enclosed low spots where water can accumulate. Areas to be seeded that have been damaged by erosion or other causes shall be restored prior to seeding and then cultivated to provide a reasonably firm but friable seedbed. A minimum of 6 inches of surface soil shall be in a loose condition at the time of fertilizer and seed application.

C. Enrichment:

1. During Construction: Drainage ditches shall be enriched for seeding by applying fertilizer to the surface of prepared soil prior to the application of

the seed and mulch. Fertilizer consisting of 12% nitrogen, 12% phosphate, 12% potash and 15% sulfur shall be applied at the rate of 300 pounds per acre unless Subcontractor can demonstrate to the Contractor that a different fertilizer mix or a lesser rate of application is justified on the basis of laboratory testing of the soil to be seeded.

2. Final Grades: The Subcontractor shall determine the enrichment requirements for final grades based on the results of laboratory tests of representative soil samples. Fertilizer shall be applied to the prepared soil surface prior to applying the seed and mulch. Estimated type and quantities of fertilizer to be used are stated in C.1. above.

3.2 APPLICATION

A. Seed shall be applied by hydroseeding at the rate specified. The seed shall be mixed with water to produce a slurry and applied under pressure.

B. Mulch shall then be applied as soon as practical at a rate of approximately 3 tons per acre to promote growth and provide temporary stabilization. Mulch shall be secured by track-walking with bulldozer or by other suitable equipment as approved by the Contractor. Mulching shall not be done in the presence of free surface water.

3.3 CARE DURING CONSTRUCTION

The Subcontractor shall be responsible for protecting and caring for areas seeded before final acceptance of the work. The Subcontractor shall repair any damage to seeded areas caused by construction operations without additional compensation.

3.4 PLANT ESTABLISHMENT

The Subcontractor shall be responsible for watering and caring for seeded areas as required to establish growth during the 30 days following seeding. If satisfactory growth is not established during this period, reseeding by the Subcontractor will be required during normal seasonal periods at no cost to the Contractor.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for the following items of seeding will be by the acres of surfaces actually seeded and approved:

1. Temporary seeding.

2. Permanent seeding.

B. No separate measurement for payment will be made for any incidental work and services; e.g., loosening the surface, applying lime and fertilizer, mulching, and watering related to seeding of cuts and fill areas.

4.2 PAYMENT

Payment for seeding items specified in Article 4.1.A above will be by the applicable unit prices per acre quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for furnishing all materials, tools, equipment, incidentals, labor, and for performing all work specified herein for complete work.

END OF SECTION 02935

LAKEVIEW COVER DESIGN

The enclosed radon barrier cover design consists of the final calculations for radon barrier thickness for the stabilized Lakeview tailings at Collins Ranch. Following submittal of these calculations to the NRC and their subsequent review, additional information was requested on the actual field measurements taken on the radon barrier materials. This information is included in Addendum 1.0 to this design section.

OVERVIEW OF RADON BARRIER THICKNESS CALCULATIONS FOR LAKEVIEW DISPOSAL SITE

The final calculation for radon barrier thickness required at the Lakeview Disposal Site is Calculation No. 13-739-16-00, "Radon Barrier Re-evaluation During Construction-C", attached as Appendix 1. This calculation uses the final distribution of contaminated materials, as defined in Data Source 2 (Sheets 8-14 of the calculation), with diffusion coefficients, emanating fractions and other parameters as indicated in attached Table 1. (The source of each parameter used is cited in the Table 1, and the source documents, except for Ref. 1, are included herein as Appendices.) Rather than averaging the contamination readings from a given depth or elevation, a conservative, efficient approach was adopted, in which the three borings with the highest contamination and emanation levels were analyzed to give an upper bound on thickness required. The NRC-approved computer code, RAECOM (Ref. 1), was used to perform the calculations.

The calculated barrier thickness required to meet the EPA standard for radon exhalation, using the boring with the vertical distribution of levels of contamination giving the greatest thickness requirement, is 3.5 inches.

REFERENCE

1. Rogers, V.C., K. K. Nielson, and D. R. Kalkawarf, 1984, "Radon Attenuation Handbook for Uranium Mill Tailings Cover Design", U.S Nuclear Regulatory Commission, NUREG/CR-3533.

APPENDICES

1. "Radon Barrier Re-evaluation During Construction-C", MKE Calculation No. 13-791-16-00.

2. "Radon Barrier Re-evaluation During Construction-B", MKE Calculation No. 13-791-09-00.

3. "Radon Barrier Re-evaluation During Construction-A", MKE Calculation No. 13-739-08-00.

4. "Tailings Properties for Radon Barrier Design", MKE Calculation No. 13-739-02-00.

TABLE 1

Parameters Used in Final Calculation for Radon Barrier Thickness
(Calculation "C")

Material Parameter	Material Modeled	Value Used in Calculation			Source of Value Used in Calculation
Ra-226 Concentration (pCi/g)	Select Contaminated Material (Upper 10' of Contaminated Material).	2 to 45 (Actual 2' interval values from Borings LK-DS-04, -14 and -16).*			Computed from data on Sh. 8-14 in Calc. C, accounting for in growth of thorium as per Sh. 3. Results are shown on Sh. 19, 21 and 23.
	Tailings & Lower Contaminated Material (Below top 10' of Contaminated Material).	4 to 192 (Actual 2' intervals from Borings LK-DS-04, -14 and -16).			
Diffusion Coefficient (cm^2/sec.)	Radon Barrier	0.010			Maximum value determined in Calculation B (Sh. 2 & 3) using moisture saturation values from Calc. A (Sh. 7).
	Select Contaminated Material	~~0.010~~ 0.10 JCP 3-29-83			Ref. 1, pg. 3-7 (conservative value used in absence of data for select contaminated material).
	Tailings and Lower Contaminated Material	0.917			Test data and Ref. 1, p. 3-7 and xvi, in Calculation 13-739-02-00 (Appendix 3).
Emanating Fraction	Contaminated Material and Tailings	0.18 to 0.40 (actual 2' inverval values from Borings LK-DS-04, -14 and -16.			Sh. 8-14 in Calc. C (field data), plus 0.40 in upper 10' and 0.27 below,where data not available.
Bulk Density(d), Water Content(w) and Porosity(n)		d	w	n	
	Radon Barrier	1.20	26.7	0.53	Calculation A, Sh. 6.
	Select Contaminated Material	0.65	25.0	0.71	Calculation 13-739-02-00, Sh. 1.
	Tailings and Lower Contaminated Material	1.18	21.0	0.53	

*Boring LK-DS-04 had highest readings below top 10'; LK-DS-14 and -16 had highest readings in upper 10'.

APPENDIX 1

"Radon Barrier Re-evaluation During Construction - C"

(MKE Calculation No. 13-791-16-00)

MKE DOCUMENT NO. 4005-LKV-C-01-02244-00

Calculation Cover Sheet

Contract No. 4005 **Discipline** ESCI/UMTRA **Calc. No.** 13-791-16-00
No. of Sheets 26

Project

UMTRA - LAKEVIEW (LAKEVIEW, OREGON)

Feature

RADON BARRIER

Item

RE-EVALUATION DURING CONSTRUCTION - C

Sources of Data

1. MKE CALC. NO. 13-739-09-00, "RADON BARRIER, RE-EVALUATION DURING CONSTRUCTION - B", MKE DOC. NO. 4005-LKV-C-01-01913-00
2. MK-FERGUSON COMPANY, IOC OF 12-11-87 TO T.R. WATHEN, MKE DOC. NO. 4005-LKV-I-02-~~02198~~-00 02236
3. MK-F IOC TO TR WATHEN, 12-17-87, MKE DOC NO. 4005-LKV-I-02-02215-00

Sources of Formulae & References

1. "UMTRA DESIGN PROCEDURES", REVISION 4, MKE DOC. NO. 4005-GEN-Q-01-00571-03, 9-17-87
2. "RADON ATTENUATION HANDBOOK FOR URANIUM MILL TAILINGS COVER DESIGN", NUREG/CR-3533, PREPARED FOR U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, D.C. APRIL, 1984
3. PROGRAM "RAECOM", REVISION 1.1, ENGINEERING COMPUTER SERVICES DEPT, MKE, AUGUST, 1985
4. MKE CALC. NO. 00-141-04-00 "MAXIMUM (RADIUM CONTENT) VALUE DURING DESIGN LIFE", MKE DOC. NO. 4005-GEN-C-01-03580-00

Preliminary Calc. ☐ Final Calc. ☒ Supersedes Calc. No. ______

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
—	———	JCPorter	12-30-87	upc (UPC)	12-31-87	G.R.Thien	12/31/87

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 1
Project UMTRA - LKV
Contract No. 4005
File No.
Feature RADON BARRIER
Designed JCP
Date 12-30-8
Item RE-EVALUATION DURING CONSTRUCTION - C
Checked
Date 12-31-8

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MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - LKV
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Date 12-31-8

PURPOSE

THE PURPOSE OF THIS CALCULATION IS TO RE-EVALUATE RADON BARRIER THICKNESS USING ADDITIONAL RADIUM AND THORIUM & EMANATION DATA (DATA SOURCE 2)

METHOD

1. MINIMUM ALLOWABLE RADON BARRIER THICKNESS IS DETERMINED USING THE RAECOM COMPUTER PROGRAM.

2. THE MAXIMUM RADIUM CONCENTRATION OVER THE TAILINGS EMBANKMENT DESIGN LIFE IS CALCULATED AS FOLLOWS:

$$Ra_t = \frac{\lambda_2 (Th)_0 (e^{-\lambda_1 t} - e^{-\lambda_2 t})}{\lambda_2 - \lambda_1} + (Ra)_0 e^{-\lambda_2 t} \quad \text{(REF. 1)}$$

WHERE: λ_1 = DECAY CONSTANT FOR Thorium-230 = 8.63×10^{-6}/yr
λ_2 = DECAY CONSTANT FOR Radium-226 = 4.32×10^{-4}/yr
$(Th)_0$ = INITIAL CONTENT OF Thorium-230
$(Ra)_0$ = INITIAL CONTENT OF Radium-226
t = TIME

IF $\frac{(Ra)_0}{(Th)_0} < 0.99$, Ra_{max} OCCURS AT $t > 1000$ YEARS

METHOD (Cont.)

THEREFORE, FOR THE 1000 YEAR DESIGN LIFE, $t = 1000$ AND

$$Ra_{max} = \frac{(4.32\times10^{-4})(Th)_0 \left(e^{-(8.63\times10^{-6})(1000)} - e^{-(4.32\times10^{-4})(1000)}\right)}{4.32\times10^{-4} - 8.63\times10^{-6}} + Ra_0\, e^{-(4.32\times10^{-4})(1000)}$$

$$Ra_{max} = 0.3492(Th)_0 + 0.6492(Ra)_0$$

IF $\frac{(Ra)_0}{(Th)_0} > 0.99$, Ra_{max} OCCURS AT

$$t = 2362.0 \ln\left[50 - 49\left(\frac{(Ra)_0}{(Th)_0}\right)\right] \quad \text{(REF 4)}$$

FOR $\frac{(Ra)_0}{(Th)_0} \geq$ APPROXMATELY 1.02, THE NATURAL LOG FUNCTION BECOMES INFINITELY SMALL $\therefore Ra_{max} = (Ra)_0$

3. WHEN THE RADON EMANATING FRACTION IS NOT GIVEN, $E = 0.40$ IS USED FOR SELECT CONTAMINATED MATERIAL AND $E = 0.27$ IS USED FOR TAILINGS.

4. ALL OTHER SOIL PARAMETERS WERE OBTAINED FROM RE-EVALUATION - B MKE CALC. NO. 13-739-09-00 (DATA SOURCE 1) UNLESS OTHERWISE NOTED IN THIS CALCULATION.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - LKV
Feature RADON BARRIER
Item RE-EVALUATION DURING CONSTRUCTION - C

Sheet 4
Contract No. 4005
File No.
Designed JCP
Date 12-30-87
Checked
Date 12·31·87

SUMMARY

AFTER ANALYZING THE CORE BORE SAMPLING DATA FROM CHEM-NUCLEAR SYSTEMS, INC. (DATA SOURCE 2), THREE HOLES WERE CHOSEN TO ANALYZE BECAUSE OF THEIR HIGH CONTAMINATION AND EMANATION LEVELS.

TWO OF THE HOLES (LKV-DS-14 AND LKV-DS-16) BEST REPRESENT THE MOST HIGHLY CONTAMINATED MATERIAL NEAREST THE RADON BARRIER, I.E. THE TOP 10' OF CONTAMINATED PILE MATERIAL. THIS MATERIAL IS REFERED TO AS SELECT CONTAMINATED MATERIAL AS THERE IS NO TAILINGS MATERIAL PRESENT. DUE TO THE LACK OF AVAILABLE DIFFUSION COEFFICIENT DATA, A VERY CONSERVATIVE VALUE OF 0.10 WAS USED (TO REPRESENT THE WORST CASE, (REF 2, PG 3-7)). THE RESULTING REQUIRED RADON BARRIER THICKNESS IS 3 cm (1.2") AND 0 cm (0") RESPECTIVELY. THIS IS WELL BELOW THE 46 cm (18") RADON BARRIER SPECIFIED FOR THE CELL.

THE OTHER HOLE (LK-DS-04) REPRESENTS THE MOST HIGHLY CONTAMINATED TAILINGS MATERIAL. THE RESULTING RADON BARRIER THICKNESS IS 9 cm (3.5"). THIS AGAIN IS WELL BELOW THE 46 cm (18") DESIGN THICKNESS SPECIFIED FOR THE CELL.

SUMMARY (Cont.)

TO CHECK THAT THE RADON BARRIER DESIGN IS ADEQUATE UNDER THE WORST POSSIBLE SCENARIO, A COMPOSITE "HOLE" WAS ANALYSED CONSISTING OF THE HIGHEST CONTAMINATION LEVELS (2' INTERVALS) FROM THE ADDITIONAL CORE BORE DATA SUPPLIED BY CNSI. SELECT CONTAMINATED MATERIAL WAS GIVEN A DIFFUSION COEFFICIENT OF 0.10 TO AGAIN REPRESENT THE WORST POSSIBLE CASE. THE RESULTING RADON BARRIER THICKNESS IS 27 cm (10.6") WHICH IS LESS THAN THE 46 cm (18") DESIGN THICKNESS SPECIFIED FOR THE CELL.

THIS ANALYSIS DEMONSTRATES THAT THE 1.5' RADON BARRIER SPECIFIED FOR THE LAKEVIEW DISPOSAL CELL IS ADEQUATE TO LIMIT RADON EMISSIONS TO THE ACCEPTED SURFACE FLUX LIMIT OF 20 pCi/m²/s, EVEN UNDER CONDITIONS THAT ARE WORSE THAN THOSE PRESENTLY EXISTING AT ANY POINT IN THE DISPOSAL CELL.

LOCATION	REQUIRED RADON BARRIER THICKNESS
LK-DS-04	9 cm (3.5")
LK-DS-14	3 cm (1.2")
LK-DS-16	0 cm (0")
COMPOSITE "HOLE"	27 cm (10.6")

Cell Sampling Locations
DATA SOURCE 3

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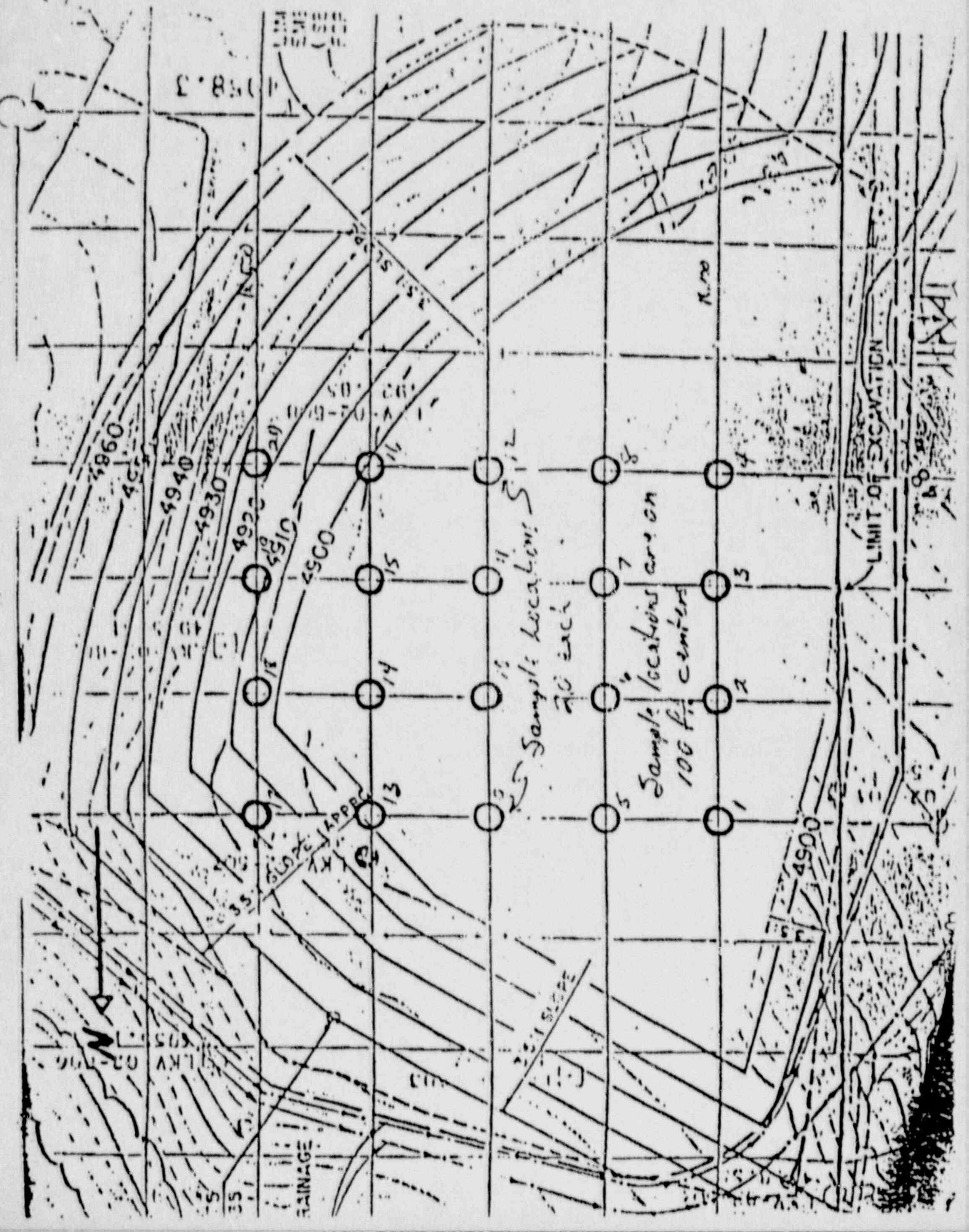
MKE DOCUMENT NO. 4005-LKV-M-02-02216-00

17 '87 13:45 MK-FERGUSON COMPANY P03



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DATA SOURCE 3

LAKEVIEW
Cell Sample COORDINATES

SAMPLE No	N	E
1	26,000	18,100
2	25,900	18,100
3	25,800	18,100
4	25,700	18,100
5	26,000	18,200
6	25,900	18,200
7	25,800	18,200
8	25,700	18,200
9	26,000	18,300
10	25,900	18,300
11	25,800	18,300
12	25,700	18,300
13	26,000	18,400
14	25,900	18,400
15	25,800	18,400
16	25,700	18,400
17	26,000	18,500
18	25,900	18,500
19	25,800	18,500
20	25,700	18,500

MKE DOCUMENT NO. 4005-LKV-I-02-02236-00

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

INTER-OFFICE CORRESPONDENCE

DATE: December 11, 1987

TO: T.R. Wathen

FROM: J.E. Williams

LOCATION: San Francisco, CA - MKE

LOCATION: Albuquerque, NM - 3050

SUBJECT: Lakeview Radon Emanation

Attached please find the revised radon emanation report prepared by CNSI for the Lakeview core bore sampling work at the disposal site.

Please prepare final calculations as required to submit to the NRC and state prior to January 7, 1988.

Should you have any questions, please contact Garth Stowe of CNSI.

kja

Attachment

cc w/ attachment: J.E. Williams
R.E. Cooney
File
cc w/o attachment: J.B. Hymas
J.G. Stowe

Attachments: 4005-LKV-I-06-02237-00
4005-LKV-R-06-02238-00

RECEIVED · MKE
DEC 1
UMTRA · S

0181K

STA001

DATA SOURCE 2 . JCP 12-30-87

Arc 12·31·87

Radon Emanation
Lakeview, OR
Core Bore Sampling at Disposal Cell

Sample ID	Elevation	Initial Count Ra 226 pCi/gm	20 Day Count Ra 226 pCi/gm	+8 hr Count Count Ra 226 pCi/gm	Th 230 pCi/gm	Radon Emanation %
LK-DS-1						
	4925	< MDA	< MDA	< MDA	10	---
	4923	< MDA	2.25	< MDA	4.0	---
	4921	< MDA	1.47	< MDA	1.5	---
	4919	< MDA	< MDA	< MDA	2.0	---
	4917	< MDA	< MDA	< MDA	11	---
	4915	76.6	90.1	70.3	78	22%
	4913	47.8	54.4	37.7	54	31%
	4911	95.0	105.6	71.8	86	32%
	4909	98.4	107.8	73.1	81	32%
	4907					
LK-DS-2 Elevation						
	4925	< MDA	< MDA	< MDA	8.9	---
	4923	< MDA	< MDA	< MDA	28	---
	4921	< MDA	< MDA	< MDA	9.3	---
	4919	< MDA	< MDA	< MDA	5.9	---
	4917	< MDA	< MDA	< MDA	8.1	---
	4915	63.1	69.9	56.5	50	19%
	4913	81.4	88.2	60.9	84	31%
	4911	48.5	53.5	39.0	59	27%
	4909	62.8	69.4	49.6	63	29%
LK-DS-3 Elevation						
	4925	< MDA	< MDA	< MDA	7	---
	4923	< MDA	< MDA	< MDA	20	---
	4921	< MDA	< MDA	< MDA	31	---
	4919	< MDA	< MDA	< MDA	8.8	---
	4917	< MDA	< MDA	< MDA	5.7	---
	4915	83.3	93.1	70.9	67	24%
	4913	82.4	90.7	72.9	95	20%
	4911	24.8	29.2	20.7	48	29%
	4909	83.2	94.4	62.5	37	34%
LK-DS-4						
	4925	< MDA	< MDA	< MDA	16	---
	4923	< MDA	< MDA	< MDA	20	---
	4921	< MDA	< MDA	< MDA	9.1	---
	4919	< MDA	< MDA	< MDA	4.7	---
	4917	1.4	2.2	1.3	8.1	41%
	4915	170.4	198.8	151.5	140	24%
	4913	84.5	93.8	64.2	96	32%
	4911	20.3	25.0	16.8	78	33%
	4909	42.9	44.6	33.6	80	25%
	4907	74.0	95.0	78.2	79	18%

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Radon Emanation Cont.
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Sample ID	Elevation	Initial Count Ra 226 pCi/gm	20 Day Count Ra 226 pCi/gm	+8 hr Count Count Ra 226 pCi/gm	Th 230 pCi/gm	Radon Emanation %
LK-DS-5						
	4927	< MDA	< MDA	< MDA	14	---
	4925	< MDA	< MDA	< MDA	15	---
	4923	< MDA	< MDA	< MDA	27	---
	4921	< MDA	< MDA	< MDA	29	---
	4919	< MDA	< MDA	< MDA	29	---
	4917	< MDA	< MDA	< MDA	36	---
	4915	< MDA	< MDA	< MDA	45	---
	4913	5.3	6.6	4.1	7.9	38%
	4911	3.8	5.6	4.4	7.6	21%
	4909	68.3	81.4	60.3	70	26%
	4907	70.95	85.5	68.3	51	20%
LK-DS-6						
	4945	< MDA	< MDA	< MDA	14	---
	4943	< MDA	< MDA	< MDA	19	---
	4941	< MDA	< MDA	< MDA	18	---
	4939	< MDA	< MDA	< MDA	16	---
	4937	1.47	< MDA	< MDA	18	---
	4935	1.5	< MDA	< MDA	12	---
	4933	< MDA	< MDA	< MDA	15	---
	4931	< MDA	4.44	2.49	3.4	44%
	4929	4.1	6.2	4.1	6.6	34%
	4927	2.9	4.0	3.1	5.2	22%
	4925	68.2	80.3	65.2	87	19%
LK-DS-7						
	4955	< MDA	< MDA	< MDA	---	---
	4953	< MDA	< MDA	< MDA	19	---
	4951	< MDA	< MDA	< MDA	26	---
	4949	< MDA	< MDA	< MDA	20	---
	4947	< MDA	< MDA	< MDA	15	---
	4945	< MDA	< MDA	< MDA	34	---
	4943	< MDA	< MDA	< MDA	22	---
	4941	2.4	2.8	3.9	15	~~1.39%~~ ~~139%~~
	4939	6.1	6.5	6.0	5.3	8%
	4937	5.6	7.8	5.0	10	36%
	4935	83.6	96.1	64.83	84	33%

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Sample ID	Elevation	Initial Count Ra 226 pCi/gm	20 Day Count Ra 226 pCi/gm	+8 hr Count Count Ra 226 pCi/gm	Th 230 pCi/gm	Radon Emanation %
LK-DS-8						
	4943	1.5	< MDA	< MDA	47	---
	4941	1.5	< MDA	< MDA	17	---
	4939	1.5	< MDA	< MDA	20	---
	4937	1.5	< MDA	< MDA	10	---
	4935	1.5	< MDA	< MDA	40	---
	4933	1.5	< MDA	< MDA	31	---
	4931	< MDA	< MDA	< MDA	20	---
	4929	3.5	4.4	2.9	2.4	34%
	4927	4.8	5.3	6.4	8.1	---
	4925	5.4	7.5	6.2	7.9	17%
LK-DS-9						
	4951	< MDA	< MDA	1.5	2.7	---
	4949	1.1	< MDA	< MDA	9.1	---
	4947	< MDA	< MDA	< MDA	10	---
	4945	< MDA	< MDA	< MDA	11	---
	4943	< MDA	< MDA	< MDA	12	---
	4941	< MDA	4.13	< MDA	26	---
	4939	< MDA	< MDA	< MDA	2.6	---
	4937	4.04	5.6	4.55	18	19%
	4935	< MDA	< MDA	< MDA	34	---
	4933	6.7	8.1	6.3	19	22%
	4931	35.1	42.8	34.6	45	19%
LK-DS-10						
	4951	< MDA	1.5	< MDA	15	---
	4949	1.1	1.9	1.3	1.9	32%
	4947	< MDA	< MDA	< MDA	8.5	---
	4945	< MDA	< MDA	< MDA	9.8	---
	4943	< MDA	< MDA	< MDA	11	---
	4941	< MDA	< MDA	< MDA	23	---
	4939	< MDA	< MDA	< MDA	25	---
	4937	3.8	4.7	4.69	12	---
	4935	< MDA	< MDA	< MDA	28	---
	4933	9.10	11.2	8.79	5.7	22%
	4931	5.49	8.23	5.00	9.2	39%

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DATA SOURCE 2 JCP 12-30-87

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Sample ID	Elevation	Initial Count Ra 226 pCi/gm	20 Day Count Ra 226 pCi/gm	+8 hr Count Count Ra 226 pCi/gm	Th 230 pCi/gm	Radon Emanation %
LK-DS-11						
	4951	---	0.9	---	26	---
	4949	< MDA	< MDA	< MDA	53	---
	4947	< MDA	1.5	< MDA	27	---
	4945	< MDA	< MDA	< MDA	6.9	---
	4943	< MDA	< MDA	< MDA	17	---
	4941	< MDA	< MDA	< MDA	22	---
	4939	< MDA	< MDA	< MDA	24	---
	4937	3.1	3.7	2.85	3.5	33%
	4935	3.2	5.4	2.85	5.9	47%
	4933	< MDA	< MDA	< MDA	9.6	---
	4931	< MDA	< MDA	< MDA	19	---
LK-DS-12						
	4951	< MDA	< MDA	< MDA	25	---
	4949	< MDA	< MDA	< MDA	35	---
	4947	< MDA	< MDA	< MDA	40	---
	4945	< MDA	< MDA	< MDA	25	---
	4943	< MDA	< MDA	< MDA	29	---
	4941	< MDA	< MDA	< MDA	16	---
	4939	< MDA	< MDA	< MDA	24	---
	4937	< MDA	< MDA	< MDA	31	---
	4935	9.57	10.7	8.45	18	21%
	4933	< MDA	< MDA	< MDA	17	---
	4931	< MDA	1.54	1.50	9.5	3%
LK-DS-13						
	4954	< MDA	< MDA	< MDA	25	---
	4952	< MDA	< MDA	< MDA	23	---
	4950	< MDA	< MDA	1.7	3.7	---
	4948	< MDA	< MDA	< MDA	12	---
	4946	< MDA	< MDA	< MDA	13	---
	4944	< MDA	< MDA	< MDA	11	---
	4942	< MDA	< MDA	< MDA	25	---
	4940	< MDA	< MDA	< MDA	42	---
	4938	2.4	3.7	2.52	62	32%
	4936	< MDA	< MDA	< MDA	21	---
	4934	4.58	5.58	3.56	8.9	36%

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DATA SOURCE 2

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Sample ID	Elevation	Initial Count Ra 226 pCi/gm	20 Day Count Ra 226 pCi/gm	+8 hr Count Count Ra 226 pCi/gm	Th 230 pCi/gm	Radon Emanation %
LK-DS-14						
	4954	1.84	2.15	1.97	150	~~6%~~ 40%
	4952	< MDA	2.0	1.3	64	35%
	4950	< MDA	< MDA	1.5	4.1	---
	4948	< MDA	< MDA	< MDA	41	---
	4946	< MDA	< MDA	< MDA	16	---
	4944	< MDA	< MDA	< MDA	15	---
	4942	< MDA	< MDA	< MDA	34	---
	4940	< MDA	< MDA	< MDA	78	---
	4938	< MDA	< MDA	< MDA	21	---
	4936	< MDA	< MDA	< MDA	32	---
	4934	4.35	5.73	4.55	5.4	21%
LK-DS-15						
	4954	1.56	< MDA	1.31	4.9	---
	4952	< MDA	1.6	< MDA	29	---
	4950	< MDA	< MDA	< MDA	14	---
	4948	< MDA	1.5	< MDA	3.0	---
	4946	< MDA	< MDA	< MDA	11	---
	4944	< MDA	< MDA	< MDA	14	---
	4942	< MDA	< MDA	< MDA	17	---
	4940	< MDA	< MDA	< MDA	30	---
	4938	< MDA	2.0	1.2	4.3	40%
	4936	< MDA	< MDA	< MDA	21	---
	4934	< MDA	< MDA	< MDA	14	---
LK-DS-16 Elevation 4938						
	4958	< MDA	2.63	1.33	47	49%
	4956	< MDA	< MDA	< MDA	92	---
	4954	< MDA	< MDA	< MDA	52	---
	4952	< MDA	< MDA	< MDA	16	---
	4950	< MDA	< MDA	< MDA	14	---
	4948	< MDA	< MDA	1.4	20	---
	4946	< MDA	< MDA	< MDA	17	---
	4944	< MDA	< MDA	< MDA	16	---
	4942	< MDA	2.35	< MDA	6.6	---
	4940	4.88	5.3	5.3	7.7	~~0%~~
	4938	< MDA	< MDA	< MDA	16	---

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Radon Emanation Cont.
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DATA SOURCE 2

JCP 12-30-87
12-31-87

Sample ID	Elevation	Initial Count Ra 226 pCi/gm	20 Day Count Ra 226 pCi/gm	+8 hr Count Count Ra 226 pCi/gm	Th 230 pCi/gm	Radon Emanation %
LK-DS-17						
	4955	< MDA	< MDA	< MDA	26	---
	4953	< MDA	< MDA	< MDA	40	---
	4951	< MDA	< MDA	< MDA	29	---
	4949	< MDA	< MDA	< MDA	7.7	---
	4947	< MDA	< MDA	< MDA	3.7	---
	4945	< MDA	< MDA	< MDA	14	---
	4943	< MDA	1.4	< MDA	10	---
	4941	< MDA	< MDA	< MDA	30	---
	4939	< MDA	< MDA	< MDA	26	---
	4937	< MDA	< MDA	< MDA	15	---
	4935	7.0	10.7	7.8	11	27%
LK-DS-18						
	4957	< MDA	1.83	< MDA	32	---
	4955	1.0	< MDA	< MDA	16	---
	4953	< MDA	2.6	< MDA	42	---
	4951	1.6	1.8	1.9	1.5	---
	4949	< MDA	< MDA	< MDA	32	---
	4947	< MDA	< MDA	< MDA	4.6	---
	4945	< MDA	< MDA	< MDA	3.1	---
	4943	< MDA	< MDA	< MDA	21	---
	4941	< MDA	< MDA	< MDA	4.4	---
	4939	< MDA	< MDA	< MDA	11	---
	4937	2.8	4.4	3.9	11	11%
LK-DS-19						
	4957	< MDA	< MDA	< MDA	44	---
	4955	< MDA	< MDA	< MDA	75	---
	4953	< MDA	< MDA	< MDA	53	---
	4951	< MDA	< MDA	< MDA	23	---
	4949	1.8	1.8	1.5	10	17%
	4947	< MDA	< MDA	< MDA	9.6	---
	4945	< MDA	< MDA	< MDA	16	---
	4943	< MDA	< MDA	< MDA	16	---
	4941	< MDA	< MDA	1.4	39	---
	4939	3.6	4.4	3.4	3.7	23%
	4937	3.11	5.6	4.5	6.0	20%

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Radon Emanation Cont.
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DATA SOURCE 2

JCP 12-30-87
[illegible] 12-31-87

Sample ID	Elevation	Initial Count Ra 226 pCi/gm	20 Day Count Ra 226 pCi/gm	+8 hr Count Count Ra 226 pCi/gm	Th 230 pCi/gm	Radon Emanation %
LK-DS-20						
	4957	1.4	< MDA	1.55	66	---
	4955	< MDA	< MDA	< MDA	28	---
	4953	< MDA	< MDA	< MDA	26	---
	4951	< MDA	< MDA	1.6	9.3	---
	4949	< MDA	< MDA	< MDA	30	---
	4947	< MDA	< MDA	< MDA	6.6	---
	4945	< MDA	< MDA	< MDA	6.0	---
	4943	< MDA	< MDA	< MDA	9.1	---
	4941	< MDA	< MDA	< MDA	12	---
	4939	< MDA	< MDA	< MDA	38	---
	4937	4.94	6.6	5.53	25	16%

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

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Project UMTRA - LKV

Contract No. 4005

File No.

Feature RADON BARRIER DESIGN

Designed JCP

Date 12-28-8?

Item MAX. RADIUM CONC. DURING DESIGN LIFE

Checked

Date 12-31-87

Sample ID	ELEVATION (ft)	[pCi/g] Ra 226 CONC	[pCi/g] Th 230 CONC	RADON EMANATION	[pCi/g] RADIUM CONC
LK-DS-1	4925-4923	1	10	---	4
	4923-4921	2.25	4	---	3
	4921-4919	1.47	1.5	---	1
	4919-4917	1	2	---	1
	4917-4915	1	11	---	4
	4915-4907	89.5	74.8	0.29	89.5
LK-DS-2	4925-4923	1	8.9	---	4
	4923-4921	1	28	---	10
	4921-4919	1	9.3	---	4
	4919-4917	1	5.9	---	3
	4917-4915	1	8.1	---	3
	4915-4907	70.3	64	0.27	70.3
LK-DS-3	4925-4923	1	7	---	3
	4923-4921	1	20	---	8
	4921-4119	1	31	---	11
	4119-4117	1	8.8	---	4
	4117-4115	1	5.7	---	3
	4115-4907	76.9	61.8	0.27	76.9
LK-DS-4	4925-4923	1	16	---	6
	4923-4921	1	20	---	8
	4921-4919	1	9.1	---	4
	4919-4917	1	4.7	---	2
	4917-4915	2.2	8.1	0.41	4
	4915-4907	91.4	94.6	0.26	92
LK-DS-5	4927-4925	1	14	---	6
	4925-4923	1	15	---	6
	4923-4921	1	27	---	10
	4921-4919	1	29	---	11
	4919-4917	1	29	---	11
	4917-4905	30.2	36.3	0.31	32
LK-DS-6	4945-4943	1	14	---	6
	4943-4941	1	19	---	7
	4941-4939	1	18	---	7
	4939-4937	1	16	---	6
	4937-4935	1	18	---	7
	4935-4923	16.1	21.5	0.33	18

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - LKV
Feature RADON BARRIER DESIGN
Item MAX RADIUM CONC. DURING DESIGN LIFE
Contract No. 4005
Designed JCP
Checked
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File No.
Date 12-28-8
Date 12·31·8

SAMPLE I.D.	ELEVATION (ft)	Ra-226 CONC [pCi/g]	Th-230 CONC [pCi/g]	RADON EMANATION	RADIUM CONC [pCi/g]
LK-DS-7	4955-4953	1	1	---	1
	4953-4951	1	19	---	7
	4951-4949	1	26	---	10
	4949-4947	1	20	---	8
	4947-4945	1	15	---	6
	4945-4932	19.2	28.4	0.49	22
LK-DS-8	4943-4941	1	47	---	17
	4941-4939	1	17	---	7
	4939-4937	1	20	---	8
	4937-4935	1	10	---	4
	4935-4933	1	40	---	15
	4933-4923	3.8	13.9	0.34	7
LK-DS-9	4951-4949	1	2.7	---	2
	4949-4947	1	9.1	---	4
	4947-4945	1	10	---	4
	4945-4943	1	11	---	4
	4943-4941	1	12	---	5
	4941-4929	10.4	24.1	0.3	15
LK-DS-10	4951-4949	1.5	15	---	6
	4949-4947	1.9	1.9	0.32	2
	4947-4945	1	8.5	---	4
	4945-4943	1	9.8	---	4
	4943-4941	1	11	---	4
	4941-4929	4.5	17.2	0.37	9
LK-DS-11	4951-4949	0.9	26	---	10
	4949-4947	1	53	---	19
	4947-4945	1.5	27	---	10
	4945-4943	1	6.9	---	3
	4943-4941	1	17	---	7
	4941-4929	2.2	14	0.4	6
LK-DS-12	4951-4949	1	25	---	9
	4949-4947	1	35	---	13
	4947-4945	1	40	---	15
	4945-4943	1	25	---	9
	4943-4941	1	29	---	11
	4941-4929	2.7	19.3	0.31	8
LK-DS-13	4954-4952	1	25	---	9
	4952-4950	1	23	---	9
	4950-5948	1	3.7	---	2
	4948-4946	1	12	---	5

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - LKV
Feature RADON BARRIER DESIGN
Item MAX RADIUM CONC. DURING DESIGN LIFE
Contract No. 4005
Designed JCP
Checked KAC
Sheet 17
File No.
Date 12-28-87
Date 12.31.87

SAMPLE I. D.	ELEVATION (ft)	Ra-226 CONC [pCi/g]	Th-230 CONC [pCi/g]	RADON EMANATION	RADIUM CONC [pCi/g]
LK-DS-13 (Cont.)	4946-4944	1	13	---	5
	4944-4932	2.2	28.3	0.38	11
LK-DS-14	4954-4952	2.15	150	0.08	54
	4952-4950	2	64	0.35	24
	4950-4948	1	4.1	---	2
	4948-4946	1	41	---	15
	4946-4944	1	16	---	6
	4944-4932	1.9	30.9	0.37	17
LK-DS-15	4954-4952	1	4.9	---	2
	4952-4950	1.6	29	---	11
	4950-4948	1	14	---	6
	4948-4946	1.5	5	---	2
	4946-4944	1	11	---	4
	4944-4032	1.2	16.8	0.4	7
LK-DS-16	4958-4956	2.63	47	0.49	18
	4956-4954	1	92	---	33
	4954-4952	1	52	---	19
	4952-4950	1	16	---	6
	4950-4948	1	14	---	6
	4948-4936	1.9	13.9	0.33	6
LK-DS-17	4955-4953	1	26	---	10
	4953-4951	1	40	---	15
	4951-4949	1	29	---	11
	4949-4947	1	7.7	---	3
	4947-4945	1	3.7	---	2
	4945-4933	2.7	17.7	0.38	8
LK-DS-18	4957-4955	1.83	32	---	12
	4955-4953	1	16	---	6
	4953-4951	2.6	42	---	16
	4951-4949	1.8	1.5	---	2
	4949-4947	1	32	---	12
	4947-4935	1.6	9.2	0.35	4
LK-DS-19	4957-4955	1	44	---	16
	4955-4953	1	75	---	27
	4953-4951	1	53	---	19
	4951-4949	1	23	---	9
	4949-4947	1.8	10	0.17	5
	4947-4935	2.3	15.1	0.34	7

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Project UMTRA - LKU

Contract No. 4005

File No.

Feature RADON BARRIER DESIGN

Designed JCP

Date 12-28-8

Item MAX. RADIUM CONC. DURING DESIGN LIFE

Checked

Date 12-31-87

SAMPLE I.D.	ELEVATION (ft)	Ra-226 CONC. [pCi/g]	Th-230 CONC. [pCi/g]	RADON EMANATION	RADIUM CONC. [pCi/g]
LK-DS-20	4957-4955	1	66	---	24
	4955-4953	1	28	---	10
	4953-4951	1	28	---	10
	4951-4949	1	9.3	---	4
	4949-4947	1	30	---	11
	4947-4935	1.9	16.1	0.36	7

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```
MKE                                                                  Page    1
RAECOM Program                        Input data                     30-DEC-87

Heading                UMTRA-LAKEVIEW RADON BARRIER REEVALUATION-C  LK-DS-04
Layers                      11
Initial flux             0.000
Ambient rn               0.700
Optimized layer             11
Surface flux limit      20.000
Precision               0.0001

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.    CM        CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
----- ---------  ---------   --------  ------ ---------  -------------  ------------ ---------
    1      61.0    0.01700      0.530    95.0      0.18           1.18     0.0000800   21.0000
    2      61.0    0.01700      0.530    57.0      0.25           1.18     0.0000666   21.0000
    3      61.0    0.01700      0.530    43.0      0.33           1.18     0.0000663   21.0000
    4      61.0    0.01700      0.530    94.0      0.32           1.18     0.0001406   21.0000
    5      61.0    0.01700      0.530   199.0      0.24           1.18     0.0002233   21.0000
    6      61.0    0.10000      0.710     4.0      0.41           0.65     0.0000032   25.0000
    7      61.0    0.10000      0.710     2.0      0.40           0.65     0.0000015   25.0000
    8      61.0    0.10000      0.710     4.0      0.40           0.63     0.0000031   25.0000
    9      61.0    0.10000      0.710     8.0      0.40           0.65     0.0000062   25.0000
   10      61.0    0.10000      0.710     6.0      0.40           0.65     0.0000046   25.0000
   11      45.7    0.01000      0.530     0.0      0.00           1.20     0.0000000   26.7000


PROGRAM RAECOM. VERSION 1.1

UMTRA-LAKEVIEW RADON BARRIER REEVALUATION-C  LK-DS-04

**********  I N P U T   P A R A M E T E R S  ****************

NUMBER OF LAYERS :                   11
RADON FLUX INTO LAYER 1 :             0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :         0.700      PCI/LITER

LAYER11 ADJUSTED TO MEET JCRIT :       20.0    +/-  0.100E-03 PCI/M2/SEC

BARE SOURCE FLUX (JO) FROM LAYER 1 :  22.50      PCI/M2/SEC


LAYER   THICKNESS        DIFF COEFF        POROSITY         SOURCE          MOISTURE
          (CM)           (CM2/SEC)                      (PCI/CM3/SEC)  (DRY WT. PERCENT)

  1        61.           1.7000E-02         0.5300        7.9951E-05        21.00
  2        61.           1.7000E-02         0.5300        6.6625E-05        21.00
  3        61.           1.7000E-02         0.5300        6.6345E-05        21.00
  4        61.           1.7000E-02         0.5300        1.4064E-04        21.00
  5        61.           1.7000E-02         0.5300        2.2330E-04        21.00
  6        61.           1.0000E-01         0.7100        3.1530E-06        25.00
  7        61.           1.0000E-01         0.7100        1.5380E-06        25.00
  8        61.           1.0000E-01         0.7100        3.0761E-06        25.00
  9        61.           1.0000E-01         0.7100        6.1521E-06        25.00
 10        61.           1.0000E-01         0.7100        4.6141E-06        25.00
```

case version #

Tailings & Non-Select Contaminated Mat'l

Select Contaminated Material

Radon Barrier

```
11        46.         1.0000E-02         0.5300         0.0000E+00         26.70
```

Boring # LK-DS-04 (Cont.)

JCP 12-30-87

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```
***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

      LAYER    THICKNESS          EXIT FLUX              EXIT CONC.           MIC
                  (CM)          (PCI/M2/SEC)            (PCI/LITER)

        1          61.           8.4587E-01              3.6641E+04          0.6279
        2          61.          -2.5500E+00              3.7196E+04          0.6279
        3          61.          -7.2614E+00              4.0396E+04          0.6279
        4          61            1.0461E+01              3.9352E+04          0.6279
        5          61.           6.2000E+01              1.5722E+04          0.6279
        6          61.           4.7458E+01              1.5258E+04          0.7960
        7          61.           3.5941E+01              1.1698E+04          0.7960
        8          61.           2.7925E+01              8.9726E+03          0.7960
        9          61.           2.3455E+01              6.7798E+03          0.7960
       10          61.           2.0155E+01              4.9185E+03          0.7960
       11           9.           1.9999E+01              3.6885E-01          0.5269
```

```
Heading               UMTRA-LAKEVIEW RADON BARRIER REEVALUATION-C  LK-DS-14
Layers                          12
Initial flux                 0.000
Ambient rn                   0.700
Optimized layer                 12
Surface flux limit          20.000
Precision                   0.0001

LAYER THICKNESS  DIFFUSION    POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC      FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
----- ---------  ---------    --------  ------ ---------  ------------   -----------  --------
    1      61.0   0.10000       0.710     6.0      0.21           0.65     0.0000024   25.0000
    2      61.0   0.10000       0.710    12.0      0.40           0.65     0.0000092   25.0000
    3      61.0   0.10000       0.710     8.0      0.40           0.65     0.0000062   25.0000
    4      61.0   0.10000       0.710    28.0      0.40           0.65     0.0000215   25.0000
    5      61.0   0.10000       0.710    13.0      0.40           0.65     0.0000100   25.0000
    6      61.0   0.10000       0.710     6.0      0.40           0.65     0.0000046   25.0000
    7      61.0   0.10000       0.710     6.0      0.40           0.65     0.0000046   25.0000
    8      61.0   0.10000       0.710    15.0      0.40           0.65     0.0000115   25.0000
    9      61.0   0.10000       0.710     2.0      0.40           0.65     0.0000015   25.0000
   10      61.0   0.10000       0.710    24.0      0.35           0.65     0.0000161   25.0000
   11      61.0   0.10000       0.710    54.0      0.40           0.65     0.0000415   25.0000
   12      45.7   0.01000       0.530     0.0      0.00           1.20     0.0000000   26.7000


PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW RADON BARRIER REEVALUATION-C  LK-DS-14

 **********  I N P U T   P A R A M E T E R S  ****************

NUMBER OF LAYERS :                      12
RADON FLUX INTO LAYER 1 :               0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :           0.700     PCI/LITER

LAYER12 ADJUSTED TO MEET JCRIT :         20.0    +/-  0.100E-03 PCI/M2/SEC

BARE SOURCE FLUX (JO) FROM LAYER 1 :   1.023     PCI/M2/SEC

LAYER   THICKNESS       DIFF COEFF        POROSITY         SOURCE         MOISTURE
          (CM)          (CM2/SEC)                      (PCI/CM3/SEC) (DRY WT. PERCENT)

  1        61.         1.0000E-01         0.7100        2.4224E-06        25.00
  2        61.         1.0000E-01         0.7100        9.2282E-06        25.00
  3        61.         1.0000E-01         0.7100        6.1521E-06        25.00
  4        61.         1.0000E-01         0.7100        2.1532E-05        25.00
  5        61.         1.0000E-01         0.7100        9.9972E-06        25.00
  6        61.         1.0000E-01         0.7100        4.6141E-06        25.00
  7        61.         1.0000E-01         0.7100        4.6141E-06        25.00
  8        61.         1.0000E-01         0.7100        1.1535E-05        25.00
  9        61.         1.0000E-01         0.7100        1.5380E-06        25.00
```

Core Boring #

JCP 12-30-87
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Assumed to be Select Contaminated Mat'l, based on low Ra-226.

Radon Barrier

Sheet [illegible]

```
   10        61.        1.0000E-01        0.7100       1.6149E-05        25.00
   11        61.        1.0000E-01        0.7100       4.1527E-05        25.00
   12        46.        1.0000E-02        0.5300       0.0000E+00        26.70
```

Boring # LK-DS-14 (Cont)

JCP 12-30-87
12.31.87

```
***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

      LAYER    THICKNESS         EXIT FLUX              EXIT CONC.          MIC
                 (CM)          (PCI/M2/SEC)            (PCI/LITER)

        1         61.           1.0000E+04              3.7538E+03         0.7960
        2         61.          -1.8057E+00              3.9293E+03         0.7960
        3         61.          -2.7978E+00              4.1258E+03         0.7960
        4         61.           2.7383E+00              4.1283E+03         0.7960
        5         61.           3.4285E+00              3.8651E+03         0.7960
        6         61.           2.0265E+00              3.6323E+03         0.7960
        7         61.           7.8393E-01              3.5123E+03         0.7960
        8         61.           2.6397E+00              3.3662E+03         0.7960
        9         61.           3.1673E-01              3.2400E+03         0.7960
       10         61.           4.4295E+00              3.0374E+03         0.7960
       11         61.           2.0025E+01              1.9937E+03         0.7960
       12          3.           2.0000E+01              3.6885E-01         0.5269
```

```
MKE
RAECOM Program                                  Input data                             Page    1
                                                                                       30-DEC-87

Heading                   UMTRA-LAKEVIEW RADON BARRIER REEVALUATION-C  LK-DS-16
Layers                          12
Initial flux                 0.000
Ambient rn                   0.700
Optimized layer                 12
Surface flux limit          20.000
Precision                   0.0001

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== ========= =========    ========  ====== =========  ============   ===========  =========
    1      61.0   0.10000       0.710     6.0      0.40          0.65     0.0000046   25.0000
    2      61.0   0.10000       0.710     6.0      0.40          0.65     0.0000046   25.0000
    3      61.0   0.10000       0.710     4.0      0.40          0.65     0.0000031   25.0000
    4      61.0   0.10000       0.710     6.0      0.40          0.65     0.0000046   25.0000
    5      61.0   0.10000       0.710     7.0      0.40          0.65     0.0000054   25.0000
    6      61.0   0.10000       0.710     8.0      0.40          0.65     0.0000062   25.0000
    7      61.0   0.10000       0.710     6.0      0.40          0.65     0.0000046   25.0000
    8      61.0   0.10000       0.710     6.0      0.40          0.65     0.0000046   25.0000
    9      61.0   0.10000       0.710    19.0      0.40          0.65     0.0000146   25.0000
   10      61.0   0.10000       0.710    33.0      0.40          0.65     0.0000254   25.0000
   11      61.0   0.10000       0.710    18.0      0.49          0.65     0.0000170   25.0000
   12      45.7   0.00000       0.530     0.0      0.00          1.20     0.0000000   26.7000


PROGRAM RAECOM. VERSION 1.1

UMTRA-LAKEVIEW RADON BARRIER REEVALUATION-C  LK-DS-16

**********  I N P U T   P A R A M E T E R S  ***************

NUMBER OF LAYERS :                    12
RADON FLUX INTO LAYER 1 :              0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :          0.700     PCI/LITER

LAYER12 ADJUSTED TO MEET JCRIT :        20.0     +/-  0.100E-03 PCI/M2/SEC

BARE SOURCE FLUX (JO) FROM LAYER 1 :   1.948     PCI/M2/SEC


LAYER  THICKNESS         DIFF COEFF        POROSITY        SOURCE          MOISTURE
         (CM)            (CM2/SEC)                     (PCI/CM3/SEC) (DRY WT. PERCENT)

  1       61.            1.0000E-01        0.7100        4.6141E-06         25.00
  2       61.            1.0000E-01        0.7100        4.6141E-06         25.00
  3       61.            1.0000E-01        0.7100        3.0761E-06         25.00
  4       61.            1.0000E-01        0.7100        4.6141E-06         25.00
  5       61.            1.0000E-01        0.7100        5.3831E-06         25.00
  6       61.            1.0000E-01        0.7100        6.1521E-06         25.00
  7       61.            1.0000E-01        0.7100        4.6141E-06         25.00
  8       61.            1.0000E-01        0.7100        4.6141E-06         25.00
  9       61.            1.0000E-01        0.7100        1.4611E-05         25.00
```

Core Boring #

JCP 12-30-87

12-31-87

Assumed to be select Contaminated Mat'l based on Low Ra-226

Radon Barrier

Sheet [illegible]

```
  10        61.       1.0000E-01      0.7100      2.5377E-05      25.00
  11        61.       1.0000E-01      0.7100      1.6957E-05      25.00
  12        46.       7.2611E-03      0.5300      0.0000E+00      26.70
```

Boring # LK-DS-16 (Cont)

JCP 12-30-87
12-31-87

```
***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

      LAYER    THICKNESS        EXIT FLUX            EXIT CONC.          MIC
                 (CM)         (PCI/M2/SEC)         (PCI/LITER)

        1         61.         7.6422E-03           2.1886E+03         0.7960
        2         61.         1.5886E-02           2.1876E+03         0.7960
        3         61.        -6.4945E-01           2.2146E+03         0.7960
        4         61.        -6.9104E-01           2.2718E+03         0.7960
        5         61.        -4.4956E-01           2.3205E+03         0.7960
        6         61.         9.3970E-02           2.3357E+03         0.7960
        7         61.        -2.9936E-02           2.3329E+03         0.7960
        8         61.        -1.5620E-01           2.3409E+03         0.7960
        9         61.         4.0916E+00           2.1729E+03         0.7960
       10         61.         1.3385E+01           1.4270E+03         0.7960
       11         61.         2.0037E+01           5.5719E-01         0.7960
       12          0.         2.0037E+01           3.6885E-01         0.5269
```

Sheet 25

JCP 12-30-87
wc 12-31-87

COMPOSITE "HOLE"

```
MKE
RAECOM Program                          Input data                          Page    1
                                                                           29-DEC-87

Heading                 UMTRA-LAKEVIEW RADON BARRIER REEVALUATION-C
Layers                          9
Initial flux                0.000
Ambient rn                  0.700
Optimized layer                 9
Surface flux limit         20.000
Precision                  0.0001

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY  SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3         PCI/CM3-SEC  % DRY WT
----- ---------  ---------   --------  ------ ---------  ------------  -----------  ---------
  1     243.8    0.01700       0.530   108.0      0.27           1.18    0.0001363    21.0000
  2      61.0    0.01700       0.530    94.0      0.27           1.18    0.0001187    21.0000
  3      61.0    0.01700       0.530   199.0      0.27           1.18    0.0002512    21.0000
  4      61.0    0.10000       0.710    15.0      0.40           0.65    0.0000115    25.0000
  5      61.0    0.10000       0.710    15.0      0.40           0.65    0.0000115    25.0000
  6      61.0    0.10000       0.710    19.0      0.40           0.65    0.0000146    25.0000
  7      61.0    0.10000       0.710    33.0      0.40           0.65    0.0000254    25.0000
  8      61.0    0.10000       0.710    54.0      0.49           0.65    0.0000509    25.0000
  9      45.7    0.01000       0.530     0.0      0.00           1.20    0.0000000    26.7000


PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW RADON BARRIER REEVALUATION-C

 **********  I N P U T   P A R A M E T E R S  ****************

NUMBER OF LAYERS :                      9
RADON FLUX INTO LAYER 1 :               0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :           0.700     PCI/LITER

LAYER 9 ADJUSTED TO MEET JCRIT :         20.0    +/-  0.100E-03 PCI/M2/SEC

BARE SOURCE FLUX (JO) FROM LAYER 1 :    64.44     PCI/M2/SEC


LAYER  THICKNESS         DIFF COEFF        POROSITY          SOURCE          MOISTURE
          (CM)           (CM2/SEC)                       (PCI/CM3/SEC) (DRY WT. PERCENT)

  1        244.          1.7000E-02         0.5300        1.3634E-04         21.00
  2         61.          1.7000E-02         0.5300        1.1866E-04         21.00
  3         61.          1.7000E-02         0.5300        2.5121E-04         21.00
  4         61.          1.0000E-01         0.7100        1.1535E-05         25.00
  5         61.          1.0000E-01         0.7100        1.1535E-05         25.00
  6         61.          1.0000E-01         0.7100        1.4611E-05         25.00
  7         61.          1.0000E-01         0.7100        2.5377E-05         25.00
  8         61.          1.0000E-01         0.7100        5.0870E-05         25.00
  9         46.          1.0000E-02         0.5300        0.0000E+00         26.70
```

COMPOSITE HOLE (Cont.)

```
***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

   LAYER   THICKNESS      EXIT FLUX           EXIT CONC.          MIC
             (CM)       (PCI/M2/SEC)        (PCI/LITER)

     1       244.        9. 1782E+00         5. 5675E+04        0. 6279
     2        61.        1. 1978E+01         4. 8776E+04        0. 6279
     3        61.        6. 6710E+01         2. 3114E+04        0. 6279
     4        61.        4. 7397E+01         2. 4431E+04        0. 7960
     5        61.        3. 1812E+01         2. 1050E+04        0. 7960
     6        61.        2. 0078E+01         1. 8836E+04        0. 7960
     7        61.        1. 4647E+01         1. 7353E+04        0. 7960
     8        61.        2. 1553E+01         1. 5808E+04        0. 7960
     9        27.        1. 9999E+01         3. 6885E-01        0. 5269
```

JCP 12-30-87

WC 12·31·87

APPENDIX 2

"Radon Barrier Re-evaluation During Construction - B"

(MKE Calculation No. 13-739-09-00)

Calculation Cover Sheet

Calc. No. 13-739-09-00

Contract No. 4005

Discipline ESC/UMTRA

No. of Sheets 4

Project
UMTRA-LKV (Lakeview, Oregon)

Feature
Radon Barrier

Item
Re-evaluation During Construction - B

Sources of Data

Sources of Formulae & References

1. MKE Calculation No. 13-739-08-00, "Radon Barrier, Re-evaluation During Construction - A", MKE Doc. No. 4005-LKV-C-01-01676-00, Feb. 19, 1987.
2. Rogers & Associates Engineering Corporation, Letter of April 10, 1987, to Mr. Daniel D. Dzaak, MKE Doc. No. 4005-LKV-L-09-03759-00.

Preliminary Calc. ☐ Final Calc. ☐ Supersedes Calc. No. ______

		GRT/SAB	5/27/87	ARJ	5/27/87	A R Thin	5/27/87
Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date

Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA-LKV
Feature Radon Barrier
Item Re-evaluation During Construction-B
Contract No. 4005
Designed GRT
Checked sls
Sheet 1
File No.
Date 5/26/87
Date 5/27/87

1.0 Purpose: To re-evaluate radon barrier thickness requirement using additional diffusion coefficient data (Ref. 2).

Radon barrier ?

2. Diffusion Coefficient: Data from Ref. 1 & Ref. 2 are plotted on Sh. 2. The values corresponding to the best fit (by eye) curve are:

10^{-2} cm²/sec. @ m = 0.60
5.5×10^{-3} cm²/sec @ m = 0.75
2.9×10^{-3} cm²/sec @ m = 0.81

m values for three analyses done in Ref. 1.

3. Calculations: Using all other data identical to that used in Ref. 1 the resulting radon barrier thickness requirements are:

ASSUMING THE WORST CASE OCCURS WITH A HIGH DIFFUSION COEFFICIENT IN AREAS C/G THE THICKNESS REQUIRED IS 8 Cm.

same thickness would be required in Areas D-F [See Ref. 1, Sh. 9]

GRT 5/27
SLS 5/29/8

UMTRA-LKV

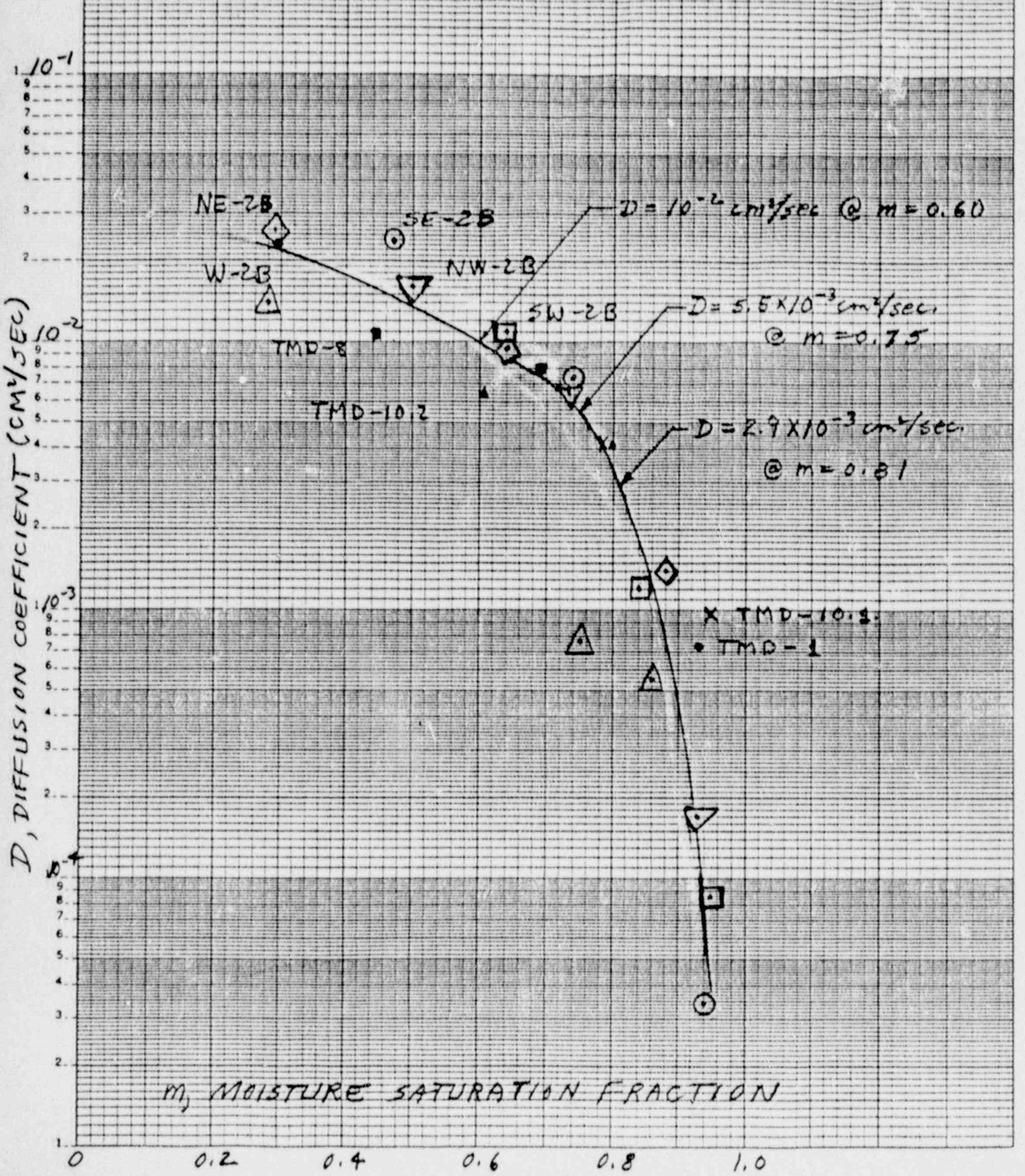
Sheet 2

RADON BARRIER

RE-EVALUATION DURING CONSTRUCTION-B

GRT 5/26/87
[illegible] 5/27/87

DIFFUSION COEFFICIENT



```
                  Heading                        UMTRA-LAKEVIEW 4005.RADON BARRIER REEVALUATION-A, AREAS C/G
                  Layers                      5
                  Initial flux            0.000
                  Ambient rn              0.700
                  Optimized layer             5
                  Surface flux limit     20.000
                  Precision               0.0010

                  LAYER THICKNESS  DIFFUSION     POROSITY  RA-226 EMANATING  BULK DENSITY    SOURCE TERM  MOISTURE
TAILINGS          NO.   CM         CM2-SEC       FRACTION  PCI/G  FRACTION   G/CM3           PCI/CM3-SEC  % DRY WT
                  ===== ========= =========     ========  ====== ========== =============   ===========  =========
          21.98'  1       670.0    0.01700         0.530   166.2      0.27            1.18    0.0002098    21.0000
SELECT     9.38'  2       286.0    0.04400         0.710    15.0      0.40            0.65    0.0000115    25.0000
CONTAM.    1.41'  3        43.0    0.04400         0.600    23.0      0.40            1.10    0.0000354    15.0000
MAT'L.     2.30'  4        70.0    0.04400         0.710    36.0      0.40            0.63    0.0000277    25.0000
R.B        0.98'  5        30.0    0.01000         0.530     0.0      0.00            1.20    0.0000000    26.7000


                 PROGRAM RAECOM, VERSION 1.1

                 UMTRA-LAKEVIEW 4005.RADON BARRIER REEVALUATION-A, AREAS C/G

                   ********** I N P U T   P A R A M E T E R S ***************

                 NUMBER OF LAYERS :                      5
                 RADON FLUX INTO LAYER 1 :               0.000E+00 PCI/M2/SEC
                 SURFACE RADON CONCENTRATION :           0.700     PCI/LITER

                 LAYER 5 ADJUSTED TO MEET JCRIT :         20.0     +/-  0.100E-02 PCI/M2/SEC

                 BARE SOURCE FLUX (JO) FROM LAYER 1 :    100.0     PCI/M2/SEC

                 LAYER  THICKNESS          DIFF COEFF         POROSITY          SOURCE             MOISTURE
                          (CM)             (CM2/SEC)                       (PCI/CM3/SEC) (DRY WT. PERCENT)

                    1      670.            1.7000E-02         0.5300          2.0981E-04           21.00
                    2      286.            4.4000E-02         0.7100          1.1535E-05           25.00
                    3       43.            4.4000E-02         0.6000          3.5420E-05           15.00
                    4       70.            4.4000E-02         0.7100          2.7685E-05           25.00
                    5       30.            1.0000E-02         0.5300          0.0000E+00           26.70

                 ***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

                         LAYER     THICKNESS        EXIT FLUX           EXIT CONC.          MIC
                                     (CM)          (PCI/M2/SEC)        (PCI/LITER)

                           1         670.          7.0021E+01          2.9971E+04        0.6279
                           2         286.          9.2834E+00          1.0196E+04        0.7960
                           3          43.          1.3334E+01          8.4213E+03        0.8002
```

BVP 5/27/87
GRT 5/27/87

```
4        70.        2.0138E+01        4.6982E+03        0.7960
5     .   8.        1.9996E+01        3.6883E-01        0.5269
```

SHT 4
SAS 5/27/87
GRT 5/27/87

MKE DOCUMENT NO. 4005-GEN-L-09-03759-00

R
A
E

Rogers & Associates Engineering Corporation

Post Office Box 330
Salt Lake City, Utah 84110-0330
(801) 263-1600

April 10, 1987

Mr. Daniel D. Dzaack
Manager, Contracts
Jacobs Engineering Group, Inc.
5301 Central Avenue NE, Suite 1700
Albuquerque, NM 87108

C8468-98

Dear Mr. Dzaack:

Enclosed are three copies of the results of the radon diffusion coefficient tests on the cover soil samples received on February 23, 1987. These samples were from the Lakeview, Oregon site. The parameters for NW-2B and W-2B were interchanged following telephoned instructions from Steve Green on April 3, 1987. These results constitute the complete deliverables for Task 98 of our contract ASD-34-6703-85-001.

The laboratory test procedure for these tests was described in our QA procedures dated April 1986.

Please call me if you have any questions regarding these tests or the results.

Sincerely yours,

Kirk K. Nielson

Kirk K. Nielson

KKN/dd
Enclosures: (LEFT TO DOCUMENT)
cc/Vern Rogers

RECEIVED - MKE
MAY 21 '87
UMTRA-S.F.

515 East 4500 South • Suite G-200 • Salt Lake City, Utah 84107

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 10-APRIL-87

CONTRACT C8468-98

BY KYB /KYB

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION[a] (Mp/P)	COMMENTS POROSITY
SE-2B	22.9	1.15	(100) 2.4E-02	0.47	0.57
SE-2B	36.9	1.15	" 7.3E-03	0.74	0.57
SE-2B	47.1	1.14	(100) 3.4E-05	0.94	0.57

[a] BASED ON A SPECIFIC GRAVITY OF 2.670 g/cm^3.

MAX. DRY DENSITY = 1.136 G/CC
OPTIMUM MOISTURE = 45.1 % OF DRY WT
TEST DENS = 1.136 G/CC
TEST POROSITY = 0.574

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 10-APRIL-87

CONTRACT C8468-98

BY RYB JKW

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm³)	RADON DIFFUSION COEFF. (cm²/s)	SATURATION[a] (Mp/P)	COMMENTS POROSITY
SW-2B	32.5	1.13	(100%) 1.1E-02	0.64	0.58
SW-2B	43.0	1.13	" 1.3E-03	0.84	0.58
SW-2B	48.3	1.13	" 8.6E-05	0.95	0.58

[a] BASED ON A SPECIFIC GRAVITY OF 2.670 g/cm³.

MAX. DRY DENSITY = 1.128 G/CC
OPTIMUM MOISTURE = 43.6 % OF DRY WT
TEST DENS = 1.128 G/CC
TEST POROSITY = 0.577

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REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 10-APRIL-87

CONTRACT C8468-98

BY RYB

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm³)	RADON DIFFUSION COEFF. (cm²/s)	SATURATION* (Mρ/P)	COMMENTS POROSITY
W-2B	9.1	1.43	(101%) 1.4E-02	0.28	0.46
W-2B	24.3	1.43	(100%) 7.6E-03	0.75	0.46
W-2B	27.6	1.43	(101%) 5.5E-04	0.86	0.46

*BASED ON A SPECIFIC GRAVITY OF 2.630 g/cm³.

MAX. DRY DENSITY = 1.418 G/CC
OPTIMUM MOISTURE = 27.9 % OF DRY WT
TEST DENS = 1.418 G/CC
TEST POROSITY = 0.461

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RAE-FORM 48D

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 10-APRIL-87

CONTRACT C8468-08

BY RYB /KKW

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION* (Mp/P)	COMMENTS POROSITY
NE-2B	13.0	1.22	(100%) 2.6E-02	0.29	0.54
NE-2B	28.7	1.22	" 9.5E-03	0.64	0.54
NE-2B	37.0	1.22	" 1.4E-03	0.83	0.54

*BASED ON A SPECIFIC GRAVITY OF 2.660 g/cm^3.

MAX. DRY DENSITY = 1.215 G/CC
OPTIMUM MOISTURE = 38.5 % OF DRY WT
TEST DENS = 1.215 G/CC
TEST POROSITY = 0.543

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REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 10-APKIL-87

CONTRACT C8468-98

BY RYK /KKW

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm³)	RADON DIFFUSION COEFF. (cm²/s)	SATURATION[a] (Mρ/P)	COMMENTS POROSITY
NW-2B	26.8	1.10	(98%) 1.6E-02	0.50	0.60
NW-2B	40.2	1.09	(97%) 6.7E-03	0.73	0.60
NW-2B	51.3	1.09	" 1.7E-04	0.93	0.60

[a] BASED ON A SPECIFIC GRAVITY OF 2.720 g/cm³.

MAX. DRY DENSITY = 1.123 G/CC
OPTIMUM MOISTURE = 46.4 % OF DRY WT
TEST DENS = 1.123 G/CC
TEST POROSITY = 0.587

APPENDIX 3

"Radon Barrier Re-evaluation During Construction - A"

(MKE Calculation No. 13-739-08-00)

6RT

Calculation Cover Sheet

MKE DOCUMENT NO. 4005-LKV-C-01-01676-00

Calc. No. 13-739-08-00

Contract No. 4005 Discipline ESCI/UMT No. of Sheets 29

Project

UMTRA-LKV (LAKEVIEW, OREGON)

Feature

RADON BARRIER

Item

REEVALUATION DURING CONSTRUCTION - A

Sources of Data & References

1. MKE Calculation No. 13-739-05-00, "Radon Barrier - Thickness and Site Radon Flux," 10-14-85, MKE Doc. No. 4005-LKV-C-01-00387-00.
2. MKE Telephone Conversation Record, 12-17-85, Frank Guros (MKE) and John Smith (TAC), Subject: LKV-Radon Barrier Design, MKE Doc. No. 4005-LKV-T-01-00512-00.
3. Rogers & Associates, Engineering Corp., Letter June 24, 1986, C 8468-67, MKE Doc. No. 4005-LKV-L-09-00960-00 (Diffusion Coefficient Test Results)

~~Sources of Formulae & References~~

4. MKE Memorandum Report, "Borrow Material Evaluation - Lakeview, Oregon, May 1986", MKE Doc. No. 4005-LKV-R-01-00813-00.
5. Chen and Associates, October 24, 1986, Job No. 1-816-86 (Soil Test Results) MKE Doc. No. 4005-LKV-L-09-01247-00.
6. Chen and Associates, November 12, 1986, Job. No. 1-816-86 (Capillary Moisture Test Results) MKE Doc. No. 4005-LKV-L-09-01283-00.
7. MKE UMTRA Design Procedures, MKE Doc. No. 4005-GEN-Q-01-00571-02
8. Rogers, V.C., Nielson, K.K., and Kalkwarf, D.R., April 1984 Radon Attenuation Handbook for Uranium Mill Tailings Cover Design, NUREG/CR-3533 U.S. Nuclear Regulatory Commission, Washington D.C.
9. Chen and Associates, April 11, 1986, Job No. 1 172 86, Part 1 (Capillary Moisture Test Results) MKE Doc. No. 4005-LKV-L-09-02639-00.

<REFERENCES CONTINUED ON NEXT SHEET (sheet "a")>

Preliminary Calc. ☒ Final Calc. ☐ Supersedes Calc. No. ———

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
0	———	F.B. Guros K. R. [illegible]	2-14-87 [illegible]	G. R. Thiers F.B. Guros	2-11-87 2-19-87	E. F. [illegible]	2.19.87

Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA-LKV
Contract No. 4005
Feature RADON BARRIER
Item REEVALUATION DURING CONSTRUCTION - A
Sheet a
File No.
Designed FCK
Date 2-18-87
Checked GPT
Date 2-19-87

REFERENCES (CONT.)

10. U.S. Soil Conservation Service, May 8, 1986, Letter from Otto W. Baume to Ms. Maureen Betz (Morrison-Knudsen Co., Inc.), Subject: "Results of Soil Sample Analyses (Projects RT86-PA093, RT86-OR094, RT86-NM095, RT86-CO108)", Midwest National Technical Center, Lincoln, Nebraska. (MKE Doc. No. 4005-GEN-L-09-02787-00)

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN C   NY

Project UMTRA-LKV
Contr. No. 4005
Sheet 1
File No.
Feature RADON BARRIER
Designed FRG
Date 2-6-87
Item REEVALUATION DURING CONSTRUCTION-A
Checked GRT
Date 2-19-87

SUMMARY AND CONCLUSIONS

1. AVERAGE SITE RADON FLUX (1-FOOT THICK BARRIER):

CALC.	REVISED VALUE							THIS CALC. RUN No.	AVERAGE SITE RADON FLUX (pCi/m²·s) (sheet 9)
	MAIN PILE TAILINGS		RADON BARRIER						
	Ra-226	E	D (cm²/sec)	w (%)	m	n	ρ (g/cm³)		
PRELIM. (Ref. 1)	189	0.4	0.037	13	0.22	0.61	0.98	—	25.6
THIS CALC.	166.2	0.27	0.0045	36.7	0.81	0.53	1.17	1	3.7
	↓	↓	0.006	36.7	0.75	0.56	1.14	2	4.8
	↓	↓	0.009	26.7	0.60	0.53	1.20	3	8.9

2. Results for average site radon flux and changes in calculation values indicate substantially greater radon attenuation capability for radon barrier soils than was estimated in preliminary design calculation.

3. Uncertainty in soil properties and test results for the radon barrier can make a difference of a factor of 2.4 ($= \frac{8.9}{3.7}$) in estimated average site radon flux.
Uncertainty in soil properties and test results is based on comparison of results from 2 independent laboratories for sample splits.

4. Additional evaluations of in-place material properties (as outlined in Ref. 1) are required before adequate radon barrier thickness can be verified. Both contaminated and uncontaminated material data are required.

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA-LKV
Contr. No. 4005
Sheet 2
File No.
Feature RADON BARRIER
Designed FRG
Date 2-5-87
Item REEVALUATION DURING CONSTRUCTION-A
Checked GRT
Date 2-10-87

1.0 PURPOSE

This calculation reevaluates required radon barrier thickness to meet radon flux standards, using the following data and information:

A. Preliminary design calculation No. 13-739-05-00, "Radon Barrier - Thickness and Site Radon Flux" (Note: A revised final calculation subsequent to preliminary calculation was not prepared). (Ref. 1)

B. Revised emanation fraction = 0.27 for main pile tailings (see MKE Telephone Conversation Record, Frank Guros (MKE) and John Smith (TAC), 12-17-85, MKE Doc. No. 4005-LKV-T-01-00512-00) (Ref. 2)

C. Diffusion coefficient test results for samples obtained from test pits in area of disposal site foundation excavation. [Rogers & Associates Engineering Corp. Letter, June 24, 1986, CE468-67, MKE Doc. No. 4005-LKV-L-09-00960-00] (Ref. 3) Also, soil classification test* results for splits of these samples from MKE Memorandum Report - Borrow Material Evaluation, Lakeview, Oregon, May 1986, MKE Doc. No. 4005-LKV-R-01-00813-00. (* including compaction test results) (Ref. 4). Also, capillary moisture test result for 1 of these samples (Ref. 9, TMD-10.1 ($\gamma_d = 100\% \pm \gamma_{d max}$)).

See sheets 26-29.

D. Data for samples from material stockpiled for liner and radon barrier:
  1. Soil test results from Chen and Associates, Oct. 24, 1986, Job No. 1 816 86, (MKE Doc. No. 4005-LKV-L-09-01247-00). (Ref. 5)
  2. Capillary moisture test results from Chen and Associates, November 12, 1986, Job. No. 1 816 86, (MKE Doc. No. 4005-LKV-L-09-01283-00) (Ref. 6) (See sheet 25).

This reevaluation is an intermediate step that primarily evaluates the effect of recent data for radon barrier materials (from stockpile) on design thickness required to meet radon flux criteria. It is not a final calculation for construction.

E. Adjusted main pile tailings average radium content = 166.2 pCi/g (MKE Calc. No. 13-726-02-00)

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA-LKV
Contr. No. 4005
Feature RADON BARRIER
Designed ERG
Item REEVALUATION DURING CONSTRUCTION - A
Checked GRT
Sheet 3
File No.
Date 2-5-87
Date 2-19-87

2.0 METHOD

2.1 Radon Flux: RAECOM Program (Referred to by Ref. 7) and used previously (Ref. 1)

2.2. Material Properties: Same as Ref. 1, except for following as determined in this calculation:

A. Main pile tailings emanation fraction - Use E = 0.27 (Ref. 2)

B. Radon barrier dry unit weight, moisture content, porosity and diffusion coefficient.

2.3 Embankment Layering: Use layering from Ref. 1 for Option 1 (Select contaminated material placed evenly over main pile tailings). Perform calculations for both A) Average Ra-226 content for entire select contaminated material layer and B) Average and above-average Ra-226 content sublayers within select contaminated material layer. (See Ref. 1 for layering)

Project UMTRA-LKV　Contract No. 4005　Sheet 4
Feature RADON BARRIER　Designed FNG　Date 2-5-87
Item RE-EVALUATION DURING CONSTRUCTION-A　Checked GRT　Date 2-19-87

3.0 RADON BARRIER PROPERTIES

3.1 Dry Unit Weight, Porosity, Moisture Content, Moisture Saturation Fraction

A. Samples Tested At Specified Compaction③:

SAMPLE No. ①	USCS Class.	G_s	ASTM D698		CAPILLARY MOISTURE TEST RESULTS		DATA SOURCE (REF. No.)
			γ_d (pcf)	w_{opt} %	γ_d (pcf)	15-BAR w (%)	
TMD-1	ML	2.36	84.5	30.7	—	—	4
TMD-8	MH	2.39	74.1	43.9	—	—	4
TMD-9.2	MH	2.37	72.0	37.5	—	—	4
TMD-10.1	ML	2.28	72.7	37.0	73.4②	29.18②	4, 9
TMD-10.2	MH	2.48	70.3	48.0	—	—	4
SE-2A	MH	2.67	70.9	45.1	70.7	38.54	5, 6
SW-2A	MH	2.67	70.4	43.6	70.3	39.18	5, 6
NW-2A	MH	2.72	70.1	46.4	69.7	39.77	5, 6
AVERAGES-ALL SAMPLES		2.49	73.1	—	71.0	36.7	
AVERAGES-CAPILLARY MOISTURE TEST SAMPLES ONLY		2.58	71.0	—	71.0	36.7	

NOTES

① Only samples with ≥ 50% minus No. 200 sieve, from area of foundation excavation or from liner/radon barrier stockpile.
② Only 1 test result from Ref. 9 for sample at ~100% γ_{dMAX}
③ Minimum density = 100% γ_{dMAX} by ASTM D698 is specified for radon barrier.

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA-LKV Contract No. 4005 Sheet 5 File No.

Feature RADON BARRIER Designed FKS Date 2-6-87

Item REEVALUATION DURING CONSTRUCTION - A Checked GRT Date 2-13-87

B. Notes - Uncertainty in Soil Properties (Based on Test Results from Independent Laboratories)

Capillary tests for sample Nos. SE-2A, SW-2A, and NW-2A were performed on samples obtained from material stockpile used for liner and intended for use in radon barrier. The stockpiled material was selected from materials from foundation excavation for embankment. Sample No. TMD-10.1 was obtained prior to foundation excavation from a test pit in the area of foundation excavation. Test results for all of the samples on sheet 4 were obtained from tests performed by Chen and Associates, Denver, Colorado.

Prior to construction, samples were obtained from test pits in the area of foundation excavation for embankment. These samples were split and capillary moisture tests were performed on these splits by a) Chen and Associates, Denver, Colorado,* and b) National Soil Science Laboratory (NSSL) of the U.S. Soil Conservation Service, Lincoln, Nebraska.** Comparison of results from both Chen and NSSL indicated that Chen results for 15-bar moisture content were consistently greater than NSSL results for the same suction pressure.

A comparison of test results on sample splits tested by a) Chen and b) NSSL is given on sheet 6. NSSL indicated that a significant portion of the silt-size fraction of their samples appeared to be volcanic ash, "...which would make predictions of chemical and physical properties based on soil texture improbable...". Therefore, Lakeview borrow soils are apparently unusual with respect to most soils, which may explain a part of the difficulty in obtaining comparable test results for capillary moisture and calculated moisture saturation fraction (sheet 6).

Based on comparison on sheet 6, significant uncertainty exists in moisture saturation fraction for design, based on difficulty in obtaining repeatable Gs and 15-bar w for Lakeview soils.

[continued on sheet 7)

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* Chen & Associates, Ref. 9

** U.S. Soil Conservation Service, May 8, 1986, Subject: Results of Soil Sample Analyses (Projects RT86-PA093, RT86-OR094, RT86-NM095, and RT86-CO108) [MKE Doc. No. 4005-GEN-L-09-02737-00]

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA-LKV
Feature RADON BARRIER
Item REEVALUATION DURING CONSTRUCTION - A

Contra No. 4KCS
Designed FRG
Checked GRT

Sheet 6
File No. –
Date 2-6-87
Date 2-19-87

COMPARISON OF SOIL TEST RESULTS: CHEN & ASSOC. VS. NSSL*

SAMPLE No.	USCS CLASS. (Ref. 9)	G_s		ASTM D698 $(\gamma_d)_{max}$ (pcf) {CHEN ONLY} (Ref. 9) ①	CAPILLARY MOISTURE TEST RESULTS						MOISTURE SATURATION AT 15-BAR w AND 100% γ_{dmax} ②, m	
		CHEN (Ref. 9)	NSSL (Ref. 10)		CHEN (Ref. 9)			NSSL (Ref. 10)			CHEN m	NSSL m
					γ_d (pcf)	γ_d/γ_{dmax} (%)	15-BAR w %	γ_d (pcf)	γ_d/γ_{dmax} (%)①	15-BAR w %		
TMD-1	ML	2.36	2.59	84.5	76.22	90	27.82	①	90	20.3	0.88	0.58
TMD-8	MH	2.39	2.58	74.1	69.75	94③	39.05	①	95③	31.5	0.92	0.69
TMD-9.2	MH	2.37	2.60	72.0	68.36	95	36.00	①	95	27.6	0.81	0.57
TMD-10.2	MH	2.48	2.57	70.3	66.56	95	41.50	①	95	27.3	0.86	0.55
AVERAGES		2.40	2.58	75.2	—	—	36.1	—	—	26.7	0.87	0.60

*See also pp. 5 & 7

NOTES

① Only Chen & Assoc. performed compaction tests. Chen & Assoc. reportedly directed NSSL to run tests at same γ_d as γ_d used by Chen & Assoc. to perform capillary moisture tests.

② Calculation results shown are used to evaluate impact of different G_s and 15-Bar w values* on saturation. Assume small changes in relative compaction do not affect 15-Bar w (NGB at MKE has additional information indicating this assumption is valid.)
(* by different labs on sample splits)

③ Sample was directed to be tested at 95% of γ_{dmax} – Assume NSSL achieved 95%, although Chen & Assoc. only achieved 94%.

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA-LKV
Feature RADON BARRIER
Item REEVALUATION DURING CONSTRUCTION-A
Contract No. 4005
Designed FBG
Checked GOT
Sheet 7
File No.
Date 2-5-87
Date 2-19-87

Designer recommends that additional evaluation of predicted site radon flux be made. Additional evaluation may include the following:

1. Calculate site average flux with diffusion coefficient, porosity, and moisture content based on adjusted NSSL results (for 100% compaction). This calculation is included below as Calc. Run No. 3.

2. Verify 15-bar moisture content and Gs by Chen & Associates by using an independent laboratory. (However, exact consensus between independent labs may not be achievable or necessary provided standards are met with more conservative values)

The unusual nature of Lakeview borrow soils is sufficient to justify relatively conservative approach to design for radon flux attenuation. A conservative approach for choosing minimum allowable thickness (if greater than required for radon attenuation) may also be warranted on the same basis.

C. Values for Calculation:

CALC. RUN No.	G_s	γ_d (pcf)	ρ (g/cm³)	n ①	w_{15} (15-Bar) %	m ②	Diffusion Coeff. D cm²/sec (Sheet 8)	Notes
1	2.49	73.1	1.17	0.53	36.7	0.81	$4.5 \cdot 10^{-3}$	Average of all data for G_s, γ_d, and w_{15} (sheet 4)
2	2.58	71.0	1.14	0.56	36.7	0.75	$6 \cdot 10^{-3}$	Average of data for samples tested for 15-bar capillary moisture (w_{15}) only.
3	2.59	75.2	1.20	0.53	26.7	0.60	$9 \cdot 10^{-3}$	Estimated average of NSSL results (sheet 6) adjusted from 95% to 100% × $\gamma_{d\,max}$

NOTES:

① $n = 1 - (\gamma_d / G_s \gamma_w)$

② $m = (w/100) / (1/\rho - 1/G_s)$

UMTRA·LK · 4005 SHEET E

RADON BARRIER

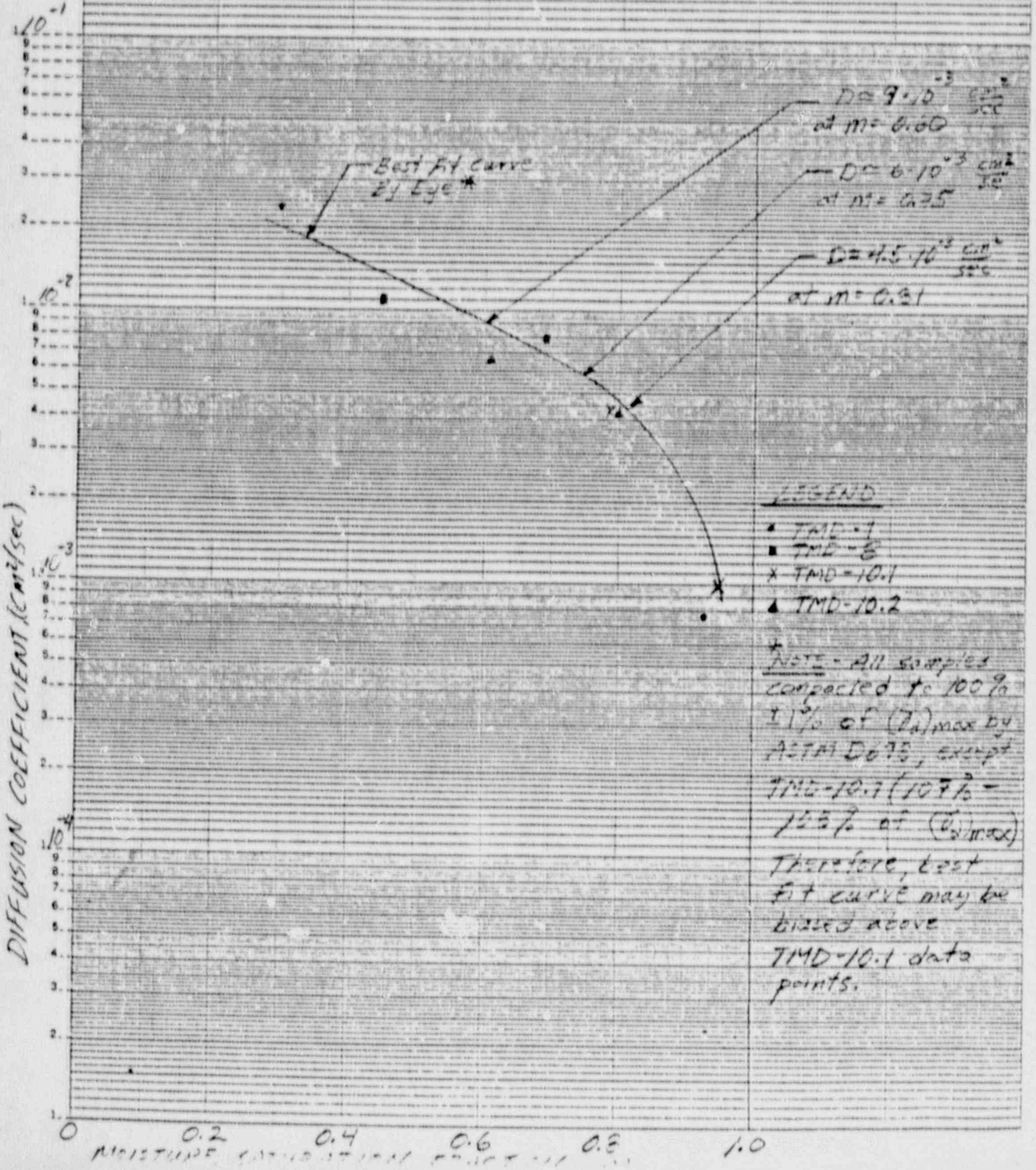
REEVALUATION DURING CONSTRUCTION—A

3.2 Diffusion Coefficient FEG 2-5-87

AR — 2-19-87

Data From Ref. 3

(Sheets 26-29)



*NOTE - All samples compacted to 100% ± 1% of $(\gamma_d)_{max}$ by ASTM D698, except TMD-10.1 (107% - 153% of $(\gamma_d)_{max}$) Therefore, best fit curve may be biased above TMD-10.1 data points.

Project UINTA-LEJ
Feature RADON BARRIER
Item REEVALUATION DURING CONSTRUCTION - A
Contract No. 4CCT
Designed FRC
Checked GPT
Sheet 9
File No.
Date 2-6-87
Date 2-19-87

5.0 AVERAGE SITE RADON FLUX

5.1 Average site radon flux is calculated by area-weighted method. Areas A, B, C, D, E, F, and G are defined on sheet 57, Ref. 1. These are subareas of preliminary design embankment. (Preliminary design embankment is considered adequate for purposes of this calculation, considering that as-constructed contamination data and embankment shape/size are not available at this time.)

5.2 Average site radon flux for 1' thick radon barrier only is calculated below and compared with results from Ref. 1, since 1-foot thick barrier, under ideal conditions, should be adequate to reduce radon flux to acceptable levels (see results below).

AREA No. (Ref. 1)	AREA (FT²) (Ref. 1) (I)	RADON FLUX THIS CALC. PAGE NO.	RADON FLUX $\left(\frac{pCi}{m^2 \cdot s}\right)$	AREA × RADON FLUX (II)	AREA-WEIGHTED SITE AVERAGE FLUX = Σ(II)/Σ(I)
A	84,930	10	2.79	236,955	3.7 (Calc. Run No. 1)
B	27,000	10	2.79	75,330	
C	214,450	11	3.93	842,906	
D	54,770	12	3.93	215,246	
E	62,040	13	3.93	243,817	
F	65,830	14	3.93	258,712	
G	40,280	11	3.93	158,300	
A	(Same as above)	15	3.61	306,597	4.8 (Calc. Run No. 2)
B		15	3.61	97,470	
C		16	5.09	1,091,703	
D		17	5.09	278,779	
E		18	5.09	315,784	
F		19	5.09	335,075	
G		16	5.09	205,025	
A	(Same as above)	20	6.72	570,730	8.9 (Calc. Run No. 3)
B		20	6.72	181,440	
C		21	9.47	2,031,126	
D		22	9.47	518,672	
E		23	9.47	587,519	
F		24	9.47	623,410	
G		21	9.47	381,452	

5.3 RAECOM RADON FLUX CALCULATIONS (5 pp.)

```
MKE
RAECOM Program                         Input data                        ~~Page 1~~
                                                                         5-FEB-87
```

5-5.3 10

```
Heading              UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA A/B
Layers                    4
Initial flux          0.000
Ambient rn            0.700
Optimized layer           0
Surface flux limit    0.000
Precision            0.0010
```

FRG 2-5-87
GRT 2-13-87

```
LAYER THICKNESS DIFFUSION   POROSITY RA-226 EMANATING BULK DENSITY  SOURCE TERM  MOISTURE
NO.   CM        CM2-SEC     FRACTION PCI/G  FRACTION  G/CM3        PCI/CM3-SEC  % DRY WT
===== ========= =========   ======== ====== ========= ============ ============ ========
9.5'  1   286.0   0.04400      0.710   15.0      0.40         0.65    0.0000115  25.0000
1.41' 2    43.0   0.04400      0.600   23.0      0.40         1.10    0.0000354  15.0000
2.3'  3    70.0   0.04400      0.710   36.0      0.40         0.65    0.0000277  25.0000
0.98' 4    30.0   0.00450      0.530    0.0      0.00         1.17    0.0000000  36.7000
```

OUTPUT RESULT

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA A/B

********** I N P U T   P A R A M E T E R S **************

NUMBER OF LAYERS :                        4
RADON FLUX INTO LAYER 1 :                 0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :             0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :      11.41     PCI/M2/SEC

LAYER  THICKNESS       DIFF COEFF        POROSITY        SOURCE        MOISTURE
         (CM)          (CM2/SEC)                     (PCI/CM3/SEC) (DRY WT. PERCENT)

  1      286.          4.4000E-02         0.7100      1.1535E-05       25.00
  2       43.          4.4000E-02         0.6000      3.5420E-05       15.00
  3       70.          4.4000E-02         0.7100      2.7685E-05       25.00
  4       30.          4.5000E-03         0.5300      0.0000E+00       36.70

***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

      LAYER   THICKNESS       EXIT FLUX          EXIT CONC.        MIC
                 (CM)        (PCI/M2/SEC)       (PCI/LITER)

        1        286.        -5.6936E+00         8.2345E+03      0.7960
        2         43.        -1.2247E+00         8.8375E+03      0.8002
        3         70.         3.3943E+00         8.5524E+03      0.7960
        4         30.         2.7879E+00         2.4482E-01      0.3497
```

MKE VAX FILE LKYAB. DAT

MKE
RAECOM Program   Input data   ~~Page 1~~ SHEET 11
5-FEB-87

```
Heading               UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREAS C/G
Layers                     5
Initial flux           0.000
Ambient rn             0.700
Optimized layer            0
Surface Flux limit     0.000
Precision             0.0010
```

FBG 2-5-87
GRT 2-19-87

```
LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== ========= ==========  ========  ====== =========  ============   ===========  ========
    1     670.0   0.01700       0.530  166.2      0.27           1.18   0.0002098    21.0000
    2     286.0   0.04400       0.710   15.0      0.40           0.65   0.0000115    25.0000
    3      43.0   0.04400       0.600   23.0      0.40           1.10   0.0000354    15.0000
    4      70.0   0.04400       0.710   36.0      0.40           0.65   0.0000277    25.0000
    5      30.0   0.00450       0.530    0.0      0.00           1.17   0.0000000    36.7000
```

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREAS C/G

  ********** I N P U T   P A R A M E T E R S **************

NUMBER OF LAYERS :                      5
RADON FLUX INTO LAYER 1 :               0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :           0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :   100.0      PCI/M2/SEC

LAYER  THICKNESS       DIFF COEFF      POROSITY       SOURCE          MOISTURE
         (CM)          (CM2/SEC)                   (PCI/CM3/SEC) (DRY WT. PERCENT)

  1      670.          1.7000E-02       0.5300       2.0981E-04         21.00
  2      286.          4.4000E-02       0.7100       1.1535E-05         25.00
  3       43.          4.4000E-02       0.6000       3.5420E-05         15.00
  4       70.          4.4000E-02       0.7100       2.7685E-05         25.00
  5       30.          4.5000E-03       0.5300       0.0000E+00         36.70


***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

        LAYER   THICKNESS        EXIT FLUX          EXIT CONC.         MIC
                  (CM)         (PCI/M2/SEC)        (PCI/LITER)

          1       670.          6.9492E+01         3.0500E+04        0.6279
          2       286.          2.2175E+00         1.3529E+04        0.7960
          3        43.          4.1119E+00         1.3089E+04        0.8002
          4        70.          4.7795E+00         1.2042E+04        0.7960
          5        30.          3.9257E+00         2.4482E-01        0.3497
```

MKE VAX FILE LKVCG.DAT

MKE
RAECOM Program

Input data

~~Page 1~~ SHEET 12
5-FEB-87

```
Heading              UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA D
Layers                      5
Initial flux            0.000
Ambient rn              0.700
Optimized layer             0
Surface flux limit      0.000
Precision              0.0010
```

FLG 2-5-87
GRT 2-19-87

```
LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  ========    ========  ====== =========  ============   ===========  =========
    1   1707.0    0.01700       0.530   166.2      0.27          1.18     0.0002098    21.0000
    2    286.0    0.04400       0.710    15.0      0.40          0.65     0.0000115    25.0000
    3     43.0    0.04400       0.600    23.0      0.40          1.10     0.0000354    15.0000
    4     70.0    0.04400       0.710    36.0      0.40          0.65     0.0000277    25.0000
    5     30.0    0.00450       0.530     0.0      0.00          1.17     0.0000000    36.7000
```

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA D

********** I N P U T   P A R A M E T E R S **************

NUMBER OF LAYERS :                          5
RADON FLUX INTO LAYER 1 :                   0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :               0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :        100.0     PCI/M2/SEC

LAYER  THICKNESS       DIFF COEFF       POROSITY        SOURCE         MOISTURE
         (CM)          (CM2/SEC)                   (PCI/CM3/SEC) (DRY WT. PERCENT)

  1      1707.         1.7000E-02        0.5300       2.0981E-04        21.00
  2       286.         4.4000E-02        0.7100       1.1535E-05        25.00
  3        43.         4.4000E-02        0.6000       3.5420E-05        15.00
  4        70.         4.4000E-02        0.7100       2.7685E-05        25.00
  5        30.         4.5000E-03        0.5300       0.0000E+00        36.70

***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

      LAYER   THICKNESS       EXIT FLUX           EXIT CONC.          MIC
                (CM)        (PCI/M2/SEC)         (PCI/LITER)

        1      1707.         6.9492E+01          3.0500E+04        0.6279
        2       286.         2.2175E+00          1.3529E+04        0.7960
        3        43.         4.1119E+00          1.3089E+04        0.8002
        4        70.         4.7795E+00          1.2042E+04        0.7960
        5        30.         3.9257E+00          2.4482E-01        0.3497
```

MKE VAX FILE LKVD.DAT

~~Page 1~~ SHEET 13

```
MKE
RAECOM Program                                Input data                          5-FEB-87

Heading                 UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION, AREA E
Layers                          5
Initial Flux                0.000
Ambient rn                  0.700
Optimized layer                 0
Surface flux limit          0.000
Precision                  0.0010
```

FEG 2-5-87
GRT 2-19-87

```
LAYER THICKNESS  DIFFUSION   POROSITY RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== ========= =========   ======== ====== =========  ============   ===========  ========
    1    1340.0   0.01700      0.530  166.2      0.27          1.18    0.0002098    21.0000
    2     286.0   0.04400      0.710   15.0      0.40          0.65    0.0000115    25.0000
    3      43.0   0.04400      0.600   23.0      0.40          1.10    0.0000354    15.0000
    4      70.0   0.04400      0.710   36.0      0.40          0.65    0.0000277    25.0000
    5      30.0   0.00450      0.530    0.0      0.00          1.17    0.0000000    36.7000



PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION, AREA E

 ********* I N P U T   P A R A M E T E R S **************

NUMBER OF LAYERS :                       5
RADON FLUX INTO LAYER 1 :                0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :            0.700     PCI/LITER
BARE SOURCE FLUX (J0) FROM LAYER 1 :     100.0     PCI/M2/SEC

LAYER  THICKNESS      DIFF COEFF      POROSITY      SOURCE        MOISTURE
          (CM)        (CM2/SEC)                  (PCI/CM3/SEC) (DRY WT. PERCENT)

  1      1340.        1.7000E-02      0.5300      2.0981E-04        21.00
  2       286.        4.4000E-02      0.7100      1.1535E-05        25.00
  3        43.        4.4000E-02      0.6000      3.5420E-05        15.00
  4        70.        4.4000E-02      0.7100      2.7685E-05        25.00
  5        30.        4.5000E-03      0.5300      0.0000E+00        36.70


***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

        LAYER   THICKNESS      EXIT FLUX        EXIT CONC.       MIC
                   (CM)       (PCI/M2/SEC)      (PCI/LITER)

          1       1340.       6.9492E+01       3.0500E+04      0.6279
          2        286.       2.2175E+00       1.3529E+04      0.7960
          3         43.       4.1119E+00       1.3089E+04      0.8002
          4         70.       4.7795E+00       1.2042E+04      0.7960
          5         30.       3.9257E+00       2.4482E-01      0.3497
```

MKE VAX FILE LKVE.DAT

~~Page 1~~ SHEET 14

```
MKE
RAECOM Program                              Input data                                  5-FEB-87
```

MKE VAX FILE LKV

FRG 2-5-87
GRT 2-13-87

```
Heading                UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA F
Layers                        5
Initial Flux              0.000
Ambient rn                0.700
Optimized layer               0
Surface flux limit        0.000
Precision                0.0010


LAYER THICKNESS  DIFFUSION    POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC      FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  =========    ========  ====== =========  ============   ===========  =========
    1     366.0    0.01700       0.530  166.2       0.27          1.18     0.0002098    21.0000
    2     286.0    0.04400       0.710   15.0       0.40          0.65     0.0000115    25.0000
    3      43.0    0.04400       0.600   23.0       0.40          1.10     0.0000354    15.0000
    4      70.0    0.04400       0.710   36.0       0.40          0.65     0.0000277    25.0000
    5      30.0    0.00450       0.530    0.0       0.00          1.17     0.0000000    36.7000



PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA F

 ********** I N P U T   P A R A M E T E R S **************

NUMBER OF LAYERS :                           5
RADON FLUX INTO LAYER 1 :                    0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :                0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :         99.99     PCI/M2/SEC


LAYER  THICKNESS        DIFF COEFF       POROSITY        SOURCE         MOISTURE
         (CM)           (CM2/SEC)                   (PCI/CM3/SEC) (DRY WT. PERCENT)

  1      366.          1.7000E-02        0.5300       2.0981E-04        21.00
  2      286.          4.4000E-02        0.7100       1.1535E-05        25.00
  3       43.          4.4000E-02        0.6000       3.5420E-05        15.00
  4       70.          4.4000E-02        0.7100       2.7685E-05        25.00
  5       30.          4.5000E-03        0.5300       0.0000E+00        36.70


***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

         LAYER   THICKNESS        EXIT FLUX          EXIT CONC.          MIC
                   (CM)         (PCI/M2/SEC)        (PCI/LITER)

           1       366.          6.9472E+01         3.0493E+04         0.6279
           2       286.          2.2153E+00         1.3527E+04         0.7960
           3        43.          4.1104E+00         1.3087E+04         0.8002
           4        70.          4.7791E+00         1.2041E+04         0.7960
           5        30.          3.9254E+00         2.4482E-01         0.3497
```

MKE VAX FILE LKVF.DAT

Sheet 15

```
MKE
RAECOM Program                         Input data                            Page   1
                                                                             12-FEB-87
Heading              UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA A/B
Layers                      4
Initial flux            0.000
Ambient rn              0.700
Optimized layer             0
Surface flux limit      0.000
Precision              0.0010

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY  SOURCE TERM   MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3         PCI/CM3-SEC   % DRY WT
===== =========  =========   ========  ====== =========  ============  ===========   =========
  1      286.0    0.04400     0.710    15.0      0.40            0.65   0.0000115     25.0000
  2       43.0    0.04400     0.600    23.0      0.40            1.10   0.0000354     15.0000
  3       70.0    0.04400     0.710    36.0      0.40            0.65   0.0000277     25.0000
  4       30.0    0.00600     0.530     0.0      0.00            1.17   0.0000000     36.7000

PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA A/B

********** I N P U T   P A R A M E T E R S ***************

NUMBER OF LAYERS :                           4
RADON FLUX INTO LAYER 1 :                    0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :                0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :         11.41     PCI/M2/SEC

LAYER  THICKNESS        DIFF COEFF        POROSITY        SOURCE         MOISTURE
          (CM)          (CM2/SEC)                    (PCI/CM3/SEC) (DRY WT. PERCENT)

  1       286.          4.4000E-02         0.7100       1.1535E-05       25.00
  2        43.          4.4000E-02         0.6000       3.5420E-05       15.00
  3        70.          4.4000E-02         0.7100       2.7685E-05       25.00
  4        30.          6.0000E-03         0.5300       0.0000E+00       36.70

***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

      LAYER    THICKNESS        EXIT FLUX          EXIT CONC.         MIC
                  (CM)        (PCI/M2/SEC)        (PCI/LITER)

        1         286.        -5.3280E+00         8.0584E+03        0.7960
        2          43.        -7.4355E-01         8.5922E+03        0.8002
        3          70.         4.1952E+00         8.1673E+03        0.7960
        4          30.         3.6113E+00         2.4482E-01        0.3477
```

SLB 2/12/87

✓ FEG 2-18-87

m

0.15

Checker's Comment: Calculation should have been made with porosity = 0.56 and bulk density = 1.14. However, difference is negligible for purposes of this calculation.

FEG 2-18-87

SLB 2-18-87

Sheet 16

Shb 2/12/87
FEG 2-18-87

```
RAECOM Program                                    Input data                                    Page    1
                                                                                                12-FEB-87

Heading                     UMTRA-LAKVIEW 4005, RADON BARRIER REEVALUATION-A, AREAS C/G
Layers                               5
Initial flux                     0.000
Ambient rn                       0.700
Optimized layer                      0
Surface flux limit               0.000
Precision                       0.0010

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  =========   ========  ====== =========  ============   ===========  =========
    1     670.0    0.01700      0.530  166.2       0.27          1.18     0.0002078    21.0000
    2     286.0    0.04400      0.710   15.0       0.40          0.65     0.0000115    25.0000
    3      43.0    0.04400      0.600   23.0       0.40          1.10     0.0000354    15.0000
    4      70.0    0.04400      0.710   36.0       0.40          0.65     0.0000277    25.0000
    5      30.0    0.00600      0.530    0.0       0.00          1.17     0.0000000    36.7000
```

1.2

See comment, Sheet 15
FEG 2-18-87
Shb 2/18/87

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKVIEW 4005, RADON BARRIER REEVALUATION-A, AREAS C/G

 **********  I N P U T   P A R A M E T E R S  ****************

NUMBER OF LAYERS :                            5
RADON FLUX INTO LAYER 1 :                     0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :                 0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :          100.0     PCI/M2/SEC

LAYER  THICKNESS         DIFF COEFF         POROSITY         SOURCE         MOISTURE
          (CM)           (CM2/SEC)                      (PCI/CM3/SEC) (DRY WT. PERCENT)

  1        670.          1.7000E-02          0.5300        2.0981E-04         21.00
  2        286.          4.4000E-02          0.7100        1.1535E-05         25.00
  3         43.          4.4000E-02          0.6000        3.5420E-05         15.00
  4         70.          4.4000E-02          0.7100        2.7685E-05         25.00
  5         30.          6.0000E-03          0.5300        0.0000E+00         36.70

***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

       LAYER     THICKNESS        EXIT FLUX            EXIT CONC.          MIC
                    (CM)        (PCI/M2/SEC)          (PCI/LITER)

         1          670.         6.9531E+01           3.0461E+04         0.6277
         2          286.         2.7368E+00           1.3294E+04         0.7960
         3           43.         4.7897E+00           1.2748E+04         0.8002
         4           70.         5.9082E+00           1.1503E+04         0.7960
         5           30.         5.0859E+00           2.4482E-01         0.3497
```

Sheet 17

SHS 2/12/87

✓ FGG 2-16-87

```
MKE
RAECOM Program                               Input data                                  Page    1
                                                                                          12-FEB-87

Heading                  UMTRA-LAKVIEW 4005, RADON BARRIER REEVALUATION-A, AREA D
Layers                         5
Initial flux               0.000
Ambient rn                 0.700
Optimized layer                0
Surface flux limit         0.000
Precision                 0.0010

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== ========= =========   ========  ====== =========  ============   ===========  =========
    1    1707.0   0.01700      0.530  166.2       0.27           1.18     0.0002098    21.0000
    2     286.0   0.04400      0.710   15.0       0.40           0.65     0.0000115    25.0000
    3      43.0   0.04400      0.600   23.0       0.40           1.10     0.0000354    15.0000
    4      70.0   0.04400      0.710   36.0       0.40           0.65     0.0000277    25.0000
    5      30.0   0.00600      0.530    0.0       0.00           1.17     0.0000000    36.7000
```

→ see comment, sheet 15
FGG 2-16-87
SHS 2/13/87

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKVIEW 4005, RADON BARRIER REEVALUATION-A, AREA D

 **********  I N P U T   P A R A M E T E R S  ****************

NUMBER OF LAYERS :                      5
RADON FLUX INTO LAYER 1 :               0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :           0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :    100.0     PCI/M2/SEC

LAYER  THICKNESS      DIFF COEFF      POROSITY        SOURCE          MOISTURE
         (CM)         (CM2/SEC)                   (PCI/CM3/SEC) (DRY WT. PERCENT)

  1      1707.        1.7000E-02       0.5300      2.0981E-04         21.00
  2       286.        4.4000E-02       0.7100      1.1535E-05         25.00
  3        43.        4.4000E-02       0.6000      3.5420E-05         15.00
  4        70.        4.4000E-02       0.7100      2.7685E-05         25.00
  5        30.        6.0000E-03       0.5300      0.0000E+00         36.70

*****  R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

       LAYER    THICKNESS      EXIT FLUX         EXIT CONC.        MIC
                  (CM)       (PCI/M2/SEC)       (PCI/LITER)

         1       1707.       6.9531E+01        3.0461E+04       0.6279
         2        286.       2.7368E+00        1.3284E+04       0.7960
         3         43.       4.7697E+00        1.2746E+04       0.8002
         4         70.       5.9082E+00        1.1503E+04       0.7960
         5         30.       5.0837E+00        2.4482E-01       0.3497
```

Sheet 18

```
MKE
RAECOM Program                      Input data                        Page    1
                                                                      12-FEB-87

Heading            UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION, AREA E
Layers                         5
Initial flux               0.000
Ambient rn                 0.700
Optimized layer               -0
Surface flux limit         0.000
Precision                 0.0010

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY  SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3         PCI/CM3-SEC  % DRY WT
===== =========  =========   ========  ====== =========  ============  ===========  =========
    1    1340.0   0.01700      0.530   166.2      0.27           1.18    0.0002098    21.0000
    2     286.0   0.04400      0.710    15.0      0.40           0.65    0.0000115    25.0000
    3      43.0   0.04400      0.600    23.0      0.40           1.10    0.0000354    15.0000
    4      70.0   0.04400      0.710    36.0      0.40           0.65    0.0000277    25.0000
    5      30.0   0.00600      0.530     0.0      0.00           1.17    0.0000000    36.7000
```

SHS 2/12/87

JFGS 2-6-87

See comment, sheet 15

FGS 2-16-87
SHS 2/18/87

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION, AREA E

**********  I N P U T   P A R A M E T E R S  ****************

NUMBER OF LAYERS :                       5
RADON FLUX INTO LAYER 1 :                0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :            0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :     100.0     PCI/M2/SEC

LAYER  THICKNESS      DIFF COEFF      POROSITY       SOURCE       MOISTURE
         (CM)         (CM2/SEC)                 (PCI/CM3/SEC) (DRY WT. PERCENT)

  1      1340.        1.7000E-02      0.5300      2.0981E-04       21.00
  2       286.        4.4000E-02      0.7100      1.1535E-05       25.00
  3        43.        4.4000E-02      0.6000      3.5420E-05       15.00
  4        70.        4.4000E-02      0.7100      2.7685E-05       25.00
  5        30.        6.0000E-03      0.5300      0.0000E+00       36.70

*****  R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

     LAYER   THICKNESS       EXIT FLUX           EXIT CONC.         MIC
               (CM)        (PCI/M2/SEC)         (PCI/LITER)

       1       1340.        6.9531E+01          3.0461E+04        0.6279
       2        286.        2.7368E+00          1.3284E+04        0.7960
       3         43.        4.7897E+00          1.2746E+04        0.8002
       4         70.        5.9082E+00          1.1503E+04        0.7960
       5         30.        5.0839E+00          2.4432E-01        0.3497
```

Sheet 19

```
MKE
RAECOM Program
                                    Input data                        Page    1
                                                                      12-FEB-87
```

GHS 2|12|87

```
Heading               UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA F
Layers                       5
Initial flux             0.000
Ambient rn               0.700
Optimized layer              0
Surface flux limit       0.000
Precision               0.0010
```

✓ FEG 2-18-87

```
LAYER THICKNESS  DIFFUSION   POROSITY RA-226 EMANATING BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION PCI/G  FRACTION  G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  =========   ======== ====== ========= ============   ===========  =========
    1     366.0    0.01700      0.530  166.2      0.27          1.18    0.0002098    21.0000
    2     286.0    0.04400      0.710   15.0      0.40          0.65    0.0000115    25.0000
    3      43.0    0.04400      0.600   23.0      0.40          1.10    0.0000354    15.0000
    4      70.0    0.04400      0.710   36.0      0.40          0.65    0.0000277    25.0000
    5      30.0    0.00600      0.530    0.0      0.00          1.17    0.0000000    36.7000
```

↳ See comment, sheet 15

FEG 2-18-87

GHS 2|18|87

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA F

********** I N P U T   P A R A M E T E R S ****************

NUMBER OF LAYERS :                       5
RADON FLUX INTO LAYER 1 :                0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :            0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :    99.99      PCI/M2/SEC

LAYER  THICKNESS        DIFF COEFF       POROSITY        SOURCE          MOISTURE
         (CM)           (CM2/SEC)                    (PCI/CM3/SEC) (DRY WT. PERCENT)

  1      366.           1.7000E-02        0.5300       2.0981E-04         21.00
  2      286.           4.4000E-02        0.7100       1.1535E-05         25.00
  3       43.           4.4000E-02        0.6000       3.5420E-05         15.00
  4       70.           4.4000E-02        0.7100       2.7685E-05         25.00
  5       30.           6.0000E-03        0.5300       0.0000E+00         36.70

***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

      LAYER    THICKNESS        EXIT FLUX          EXIT CONC.        MIC
                 (CM)         (PCI/M2/SEC)        (PCI/LITER)

        1        366.          6.9511E+01         3.0454E+04       0.6279
        2        286.          2.7346E+00         1.3282E+04       0.7960
        3         43.          4.7881E+00         1.2744E+04       0.8002
        4         70.          5.9073E+00         1.1502E+04       0.7960
        5         30.          5.0353E+00         2.4482E-01       0.3497
```

SHEET 20

```
MKE                                                                    Page   1
RAECOM Program                         Input data                      18-FEB-87

Heading                         UMTRA-LAKEVIEW 4005,RADONBARRIER REEVALUATION-A, AREAS A/B
Layers                       4
Initial flux             0.000
Ambient rn               0.700
Optimized layer              0
Surface flux limit       0.000
Precision               0.0010

LAYER THICKNESS  DIFFUSION  POROSITY RA-226 EMANATING BULK DENSITY  SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC    FRACTION PCI/G  FRACTION  G/CM3         PCI/CM3-SEC  % DRY WT
===== ========== ========== ======== ====== ========= ============  ===========  ========
    1     286.0    0.04400     0.710  15.0      0.40          0.65    0.0000115   25.0000
    2      43.0    0.04400     0.600  23.0      0.40          1.10    0.0000354   15.0000
    3      70.0    0.04400     0.710  36.0      0.40          0.65    0.0000277   25.0000
    4      30.0    0.00900     0.530   0.0      0.00          1.20    0.0000000   26.7000
```

FRG 2-18-87
GRT 2-19-87

0.01

```
PROGRAM RAECOM, VERSION 1.1

            UMTRA-LAKEVIEW 4005,RADONBARRIER REEVALUATION-A, AREAS A/B

 ********** I N P U T   P A R A M E T E R S **************

NUMBER OF LAYERS :                    4
RADON FLUX INTO LAYER 1 :             0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :         0.700     PCI/LITER
BARE SOURCE FLUX (J0) FROM LAYER 1 :  11.41     PCI/M2/SEC

LAYER  THICKNESS       DIFF COEFF       POROSITY         SOURCE          MOISTURE
          (CM)         (CM2/SEC)                     (PCI/CM3/SEC) (DRY WT. PERCENT)

  1        286.        4.4000E-02        0.7100        1.1535E-05         25.00
  2         43.        4.4000E-02        0.6000        3.5420E-05         15.00
  3         70.        4.4000E-02        0.7100        2.7685E-05         25.00
  4         30.        9.0000E-03        0.5300        0.0000E+00         26.70

***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

        LAYER   THICKNESS       EXIT FLUX          EXIT CONC.         MIC
                  (CM)        (PCI/M2/SEC)        (PCI/LITER)

          1        286.       -3.8479E+00         7.3450E+03        0.7960
          2         43.        1.1942E+00         7.5993E+03        0.8002
          3         70.        7.4377E+00         6.6105E+03        0.7960
          4         30.        6.7196E+00         3.6885E-01        0.5269
```

Sheet 21

```
MKE                                                                   Page   1
RAECOM Program                        Input data                      18-FEB-87

Heading               UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREAS C/G
Layers                      5
Initial flux            0.000
Ambient rn              0.700
Optimized layer             0
Surface flux limit      0.000
Precision              0.0010
```

FCG 2-18-87
GRT 2-19-87

```
LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  =========   ========  ====== =========  ============   ===========  ========
    1    670.0    0.01700       0.530   166.2      0.27          1.18    0.0002098    21.0000
    2    286.0    0.04400       0.710    15.0      0.40          0.65    0.0000115    25.0000
    3     43.0    0.04400       0.600    23.0      0.40          1.10    0.0000354    15.0000
    4     70.0    0.04400       0.710    36.0      0.40          0.65    0.0000277    25.0000
    5     30.0    0.00900       0.530     0.0      0.00          1.20    0.0000000    26.7000
```

1   0.56

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREAS C/G

 ********** I N P U T   P A R A M E T E R S ***************

NUMBER OF LAYERS :                    5
RADON FLUX INTO LAYER 1 :             0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :         0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :  100.0     PCI/M2/SEC

LAYER  THICKNESS      DIFF COEFF       POROSITY         SOURCE         MOISTURE
          (CM)        (CM2/SEC)                    (PCI/CM3/SEC) (DRY WT. PERCENT)

   1        670.      1.7000E-02        0.5300       2.0981E-04         21.00
   2        286.      4.4000E-02        0.7100       1.1535E-05         25.00
   3         43.      4.4000E-02        0.6000       3.5420E-05         15.00
   4         70.      4.4000E-02        0.7100       2.7685E-05         25.00
   5         30.      9.0000E-03        0.5300       0.0000E+00         26.70


***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

         LAYER   THICKNESS      EXIT FLUX          EXIT CONC.          MIC
                    (CM)      (PCI/M2/SEC)        (PCI/LITER)

           1        670.      6.9688E+01          3.0304E+04         0.6279
           2        286.      4.8409E+00          1.2291E+04         0.7960
           3         43.      7.5309E+00          1.1356E+04         0.8002
           4         70.      1.0482E+01          9.3157E+03         0.7960
           5         30.      9.4697E+00          3.6803E-01         0.5249
```

Sheet 22

FRG 2-18-87
GRT 2-19-87

```
MKE                                                                      Page   1
RAECOM Program                          Input data                       18-FEB-87

Heading                UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA D
Layers                       5
Initial flux             0.000
Ambient rn               0.700
Optimized layer              0
Surface flux limit       0.000
Precision               0.0010

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  =========   ========  ====== =========  ============   ===========  ========
    1    1707.0    0.01700      0.530  166.2       0.27          1.18     0.0002098   21.0000
    2     286.0    0.04400      0.710   15.0       0.40          0.65     0.0000115   25.0000
    3      43.0    0.04400      0.600   23.0       0.40          1.10     0.0000354   15.0000
    4      70.0    0.04400      0.710   36.0       0.40          0.65     0.0000277   25.0000
    5      30.0    0.00900      0.530    0.0       0.00          1.20     0.0000000   26.7000


PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA D

 ********** I N P U T   P A R A M E T E R S ***************

NUMBER OF LAYERS :                      5
RADON FLUX INTO LAYER 1 :               0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :           0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :    100.0     PCI/M2/SEC

LAYER  THICKNESS       DIFF COEFF      POROSITY        SOURCE        MOISTURE
          (CM)         (CM2/SEC)                   (PCI/CM3/SEC) (DRY WT. PERCENT)

  1       1707.        1.7000E-02       0.5300       2.0981E-04       21.00
  2        286.        4.4000E-02       0.7100       1.1535E-05       25.00
  3         43.        4.4000E-02       0.6000       3.5420E-05       15.00
  4         70.        4.4000E-02       0.7100       2.7685E-05       25.00
  5         30.        9.0000E-03       0.5300       0.0000E+00       26.70


***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

        LAYER   THICKNESS       EXIT FLUX          EXIT CONC.        MIC
                   (CM)      (PCI/M2/SEC)        (PCI/LITER)

          1        1707.       6.9688E+01         3.0304E+04       0.6279
          2         286.       4.8409E+00         1.2291E+04       0.7960
          3          43.       7.5359E+00         1.1356E+04       0.8002
          4          70.       1.0482E+01         9.3157E+03       0.7960
          5          30.       9.4697E+00         3.6085E-01       0.5269
```

Sheet 23

```
MKE                                                                  Page   1
RAECOM Program                          Input data                   18-FEB-87

Heading               UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA E
Layers                      5
Initial flux            0.000
Ambient rn              0.700
Optimized layer             0
Surface flux limit      0.000
Precision               0.0010
```

FRG 2-18-87
GRT 2-19-87

```
LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  =========   ========  ====== =========  ============   ===========  =========
    1    1340.0    0.01700      0.530   166.2      0.27          1.18    0.0002098    21.0000
    2     286.0    0.04400      0.710    15.0      0.40          0.65    0.0000115    25.0000
    3      43.0    0.04400      0.600    23.0      0.40          1.10    0.0000354    15.0000
    4      70.0    0.04400      0.710    36.0      0.40          0.65    0.0000277    25.0000
    5      30.0    0.00900      0.530     0.0      0.00          1.20    0.0000000    26.7000



PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA E

 ********** I N P U T   P A R A M E T E R S ***************

NUMBER OF LAYERS :                       5
RADON FLUX INTO LAYER 1 :                0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :            0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :     100.0     PCI/M2/SEC


LAYER  THICKNESS      DIFF COEFF       POROSITY        SOURCE          MOISTURE
          (CM)         (CM2/SEC)                   (PCI/CM3/SEC) (DRY WT. PERCENT)

  1       1340.        1.7000E-02        0.5300        2.0981E-04          21.00
  2        286.        4.4000E-02        0.7100        1.1535E-05          25.00
  3         43.        4.4000E-02        0.6000        3.5420E-05          15.00
  4         70.        4.4000E-02        0.7100        2.7685E-05          25.00
  5         30.        9.0000E-03        0.5300        0.0000E+00          26.70


 ***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

        LAYER   THICKNESS       EXIT FLUX         EXIT CONC.          MIC
                   (CM)        (PCI/M2/SEC)       (PCI/LITER)

          1        1340.        6.9688E+01         3.0304E+04        0.6279
          2         286.        4.9409E+00         1.2291E+04        0.7960
          3          43.        7.5359E+00         1.1356E+04        0.0002
          4          70.        1.0432E+01         9.3157E+03        0.7960
          5          30.        9.4677E+00         3.6005E-01        0.5269
```

Sheet 24

```
MKE                                                                   Page   1
RAECOM Program                          Input data                    10-FEB-87

Heading                 UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA F
Layers                       5
Initial flux             0.000
Ambient rn               0.700
Optimized layer              0
Surface flux limit       0.000
Precision               0.0010

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  =========   ========  ====== =========  ============   ===========  =========
    1     366.0    0.01700      0.530  166.2       0.27          1.18     0.0002098    21.0000
    2     286.0    0.04400      0.710   15.0       0.40          0.65     0.0000115    25.0000
    3      43.0    0.04400      0.600   23.0       0.40          1.10     0.0000354    15.0000
    4      70.0    0.04400      0.710   36.0       0.40          0.65     0.0000277    25.0000
    5      30.0    0.00900      0.530    0.0       0.00          1.20     0.0000000    26.7000


PROGRAM RAECOM, VERSION 1.1

UMTRA-LAKEVIEW 4005, RADON BARRIER REEVALUATION-A, AREA F

********** I N P U T   P A R A M E T E R S **************

NUMBER OF LAYERS :                      5
RADON FLUX INTO LAYER 1 :               0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :           0.700     PCI/LITER
BARE SOURCE FLUX (JO) FROM LAYER 1 :    99.99     PCI/M2/SEC

LAYER  THICKNESS      DIFF COEFF      POROSITY       SOURCE         MOISTURE
         (CM)         (CM2/SEC)                   (PCI/CM3/SEC) (DRY WT. PERCENT)

  1       366.        1.7000E-02       0.5300      2.0981E-04        21.00
  2       286.        4.4000E-02       0.7100      1.1535E-05        25.00
  3        43.        4.4000E-02       0.6000      3.5420E-05        15.00
  4        70.        4.4000E-02       0.7100      2.7685E-05        25.00
  5        30.        9.0000E-03       0.5300      0.0000E+00        26.70


***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

       LAYER   THICKNESS      EXIT FLUX          EXIT CONC.        MIC
                 (CM)       (PCI/M2/SEC)        (PCI/LITER)

         1       366.        6.9669E+01         3.0297E+04       0.6279
         2       286.        4.8385E+00         1.2290E+04       0.7960
         3        43.        7.5341E+00         1.1355E+04       0.8002
         4        70.        1.0451E+01         9.3150E+03       0.7960
         5        30.        9.4690E+00         3.6805E-01       0.5269
```

FLG 2-18-87

GRT 2-19-87

UMTRA-LKV 4005
RADON BARRIER
REEVALUATION DURING CONSTRUCTION-A

SHEET 25
FBG 2-5-87
GRT 2-19-87

P.O. No. 3050-511-9376
Job No. 1 816 86

Ref. 6

TABLE III
CAPILLARY-MOISTURE RELATIONSHIP
Lakeview, Oregon

Test No.	1	2	3	4	5
Sample Designation	SE-2A	SW-2A	W-2A	NW-2A	NE-2A
Remolded Moisture Content %	47.7	46.4	30.7	49.2	40.4
Remolded Dry Density, PCF	70.7	70.3	88.7	69.7	76.1
Capillary Pressure, Bar	Moisture Content %				
0.5	47.93	48.25	30.18	49.68	40.46
0.7	47.48	47.60	29.75	49.53	40.00
1.0	48.37	47.26	30.41	50.44	40.88
2.0	45.88	45.93	27.60	47.28	38.05
4.0	44.56	44.57	25.76	45.74	36.30
7.0	42.99	43.09	24.33	43.96	34.60
10.0	40.98	41.36	22.53	41.82	32.36
15.0	38.54	39.18	20.75	39.77	30.10

Note: Above Moisture Contents are Percent by Dry Weight.

ADDED TO SHEET FOR THIS CALCULATION

Percent of Maximum Dry Density by ASTM D698	100	100	100	99	100
USCS	MH	MH	SM	MH	SM
PI	20	20	4	20	16

UMTRA-LKV 4005 RADON BARRIER REEVALUATION DURING CONSTRUCTION-A SHEET 26

Rogers & Associates Engineering Corporation

FRG 2-17-87
GRT 2-19-87

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE JUNE 24, 1986

CONTRACT C8468-67

BY RYB RW

From Ref. 3

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED ________

ADDED TO TABLE FOR THIS CALCULATION

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION[a] (Mρ/P)	COMMENTS POROSITY	% of $(\gamma_d)_{max}$
TMD-1	9.5	1.35	2.4E-02	0.30	0.43	100
TMD-1	29.0	1.36	7.7E-04	0.93	0.42	100

[a] BASED ON A SPECIFIC GRAVITY OF 2.360 g/cm^3.

MAX. DRY DENSITY = 1.354 G/CC
OPTIMUM MOISTURE = 30.7 % OF DRY WT
TEST DENS = 1.354 G/CC
TEST POROSITY = 0.426

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RAE

UMTRA-LKV 4005 RADON BARRIER REEVALUATION DURING CON SECTION-A SHEET 27

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

FRG 2-17-87
GRT 2-13-87

From REF. 3

REPORT DATE JUNE 24, 1986

CONTRACT C8468-67

BY RYB RW

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

ADDED TO TABLE FOR THIS CALCULATION ⇐

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm³)	RADON DIFFUSION COEFF. (cm²/s)	SATURATION* (Mp/P)	COMMENTS POROSITY	% of (γ_d)max
TMD-8	18.9	1.20	1.1E-02	0.45	0.50	101
TMD-8	29.3	1.18	7.9E-03	0.69	0.51	99

*BASED ON A SPECIFIC GRAVITY OF 2.390 g/cm³.

MAX. DRY DENSITY = 1.188 G/CC
OPTIMUM MOISTURE = 43.9 % OF DRY WT
TEST DENS = 1.188 G/CC
TEST POROSITY = 0.503

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UMTRA-LKV 4005 RADON BARRIER RECALCULATION DURING CONSTRUC. N-A SHEET 28

Rogers & Associates Engineering Corporation

FCG 2-18-87
GRT 2-13-87

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

From REF. 3

REPORT DATE JUNE 24, 1986

CONTRACT C8468-67

BY RYB YKW

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

ADDED TO TABLE FOR THIS CALCULATION ⇓

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION* (Mp/P)	COMMENTS POROSITY	[illegible]
IMD-10.1	28.0	1.26	4.4E-03	0.79	0.45	.05
IMD-10.1	34.3	1.25	1.0E-03	0.95	0.45	.07

*BASED ON A SPECIFIC GRAVITY OF 2.280 g/cm^3.

MAX. DRY DENSITY = 1.245 G/CC
OPTIMUM MOISTURE = 37.0 % OF DRY WT
TEST DENS = 1.245 G/CC
TEST POROSITY = 0.454

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UMTRA-LKV 4005 RADON BARRIER REVALUATION DURING CONSTRUC N-A SHEET 28

Rogers & Associates Engineering Corporation

FEC 2-18-87
GRT 2-13-87

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

From Ref. 3

REPORT DATE JUNE 24, 1986

CONTRACT C8468-67

BY RYB Ylw

ADDED TO TABLE FOR THIS CALCULATION

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm³)	RADON DIFFUSION COEFF. (cm²/s)	SATURATION* (Mp/P)	COMMENTS POROSITY	[illegible]
IMD-10.1	28.0	1.26	4.4E-03	0.79	0.45	.06
IMD-10.1	34.3	1.25	1.0E-03	0.95	0.45	.07

*BASED ON A SPECIFIC GRAVITY OF 2.280 g/cm³.

MAX. DRY DENSITY = 1.245 G/CC
OPTIMUM MOISTURE = 37.0 % OF DRY WT
TEST DENS = 1.245 G/CC
TEST POROSITY = 0.454

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UMTRA-LKV 4005 RADON BARRIER REEVALUATION DURING CONSTRUCTION-A SHEET 29

Rogers & Associates Engineering Corporation

FBG 2-18-87
GRT 2-19-87

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

FROM REF. 3

REPORT DATE JUNE 24, 1986

CONTRACT C8468-67

BY KYB KW

SAMPLE IDENTIFICATION COVER SOILS - LAKEVIEW, OREGON

SUBMITTED BY JACOBS-WESTON TEAM DATE RECEIVED

ADDED TO TABLE FOR THIS CALCULATION

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION* (Mp/P)	COMMENTS POROSITY	% of (W)max
TMD-10.2	29.1	1.13	6.6E-03	0.81	0.54	100%
TMD-10.2	38.0	1.14	4.3E-03	0.80	0.54	101%

*BASED ON A SPECIFIC GRAVITY OF 2.480 g/cm³.

MAX. DRY DENSITY = 1.127 G/CC
OPTIMUM MOISTURE = 48.1 % OF DRY WT
TEST DENS = 1.127 G/CC
TEST POROSITY = 0.546

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APPENDIX 4

"Tailings Properties for Radon Barrier Design"

(MKE Calculation No. 13-739-02-00)

MKE DOCUMENT NO: 4005-LKV-C-01-00331-00 grr

Calculation Cover Sheet

Contract No. 4005 Discipline ESCI/UMTRA

Calc. No. 13-739-02-00

No. of Sheets 42 bv

Project

UMTRA/LAKEVIEW. OREGON

Feature

Embankment Design

Item

Tailings Properties for Radon Barrier Design

Sources of Data & References

1. Jacob-Weston Team "Radiological Data Analysis and Interpretation, Lakeview Processing site. File Report" MKE Doc No. 4005-LKV-I-02-00110-00
2. V.C. Rogers, K.K. Nielson/RAE, D.R. Kalkwarf/PNL "Radon Attenuation Handbook for Uranium Mill Tailings Cover Design" April, 1984 NUREG/CR-3533, MKE DOC NO. 3093-GEN-R-09-01382-00

~~Sources of Formulae & References~~

3. "Disposal site characterization Report for the Alternate Uranium Mill Tailings Disposal site at Collins Ranch Near Lakeview, Oregon" Draft, March 1985 UMTRA-DOE/AL-050123-0001
4. "Processing site characterization Report for the Uranium Mill Tailings Site at Lakeview. Oregon" Draft. Appendices. March 1985 UMTRA-DOE/AL050106-0000
5. U.S. Department of Energy, "Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Lakeview, Oregon", Draft, March 1985
6. U.S. Department of Energy, "Technical Summary of the UMTRA Technology Development Program (1980-1984)", Final, UMTRA-DOE/AL-200125.0000, January 1985.
7. Gee, G.W, Nielson, K.K. & Rogers, V.C, "Predicting Long-Term Moisture in Earthen Covers", Proc. 6th Symp. on Mgmt. of Uranium Mill Tailings, .., Fort Collins, CO. 1984

Preliminary Calc. ☒ Final Calc. ☒ Supersedes Calc. No. ______

A	—	F.B. Guros	6-28-85	WY Lin	6/28/85	EFY	7-30-85
Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date

IECO Form 42-110

INTERNATIONAL ENGINEERING COMPANY, INC.

Project LISBON-LKY
Feature EMBANKMENT DESIGN
Item

Contract No. 4005
Designed FBG
Checked WYL

Sheet 1
File No.
Date 6-21-85
Date 6/~~x~~/85

[redacted]

SUMMARY : TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

MATERIAL & LAYER	SPECIFIC GRAVITY	% FINER THAN #200 SIEVE, f_{cm}	COMPACTION (ASTM D698)		IN-PLACE PROPERTIES										
			MAX. DRY UNIT WEIGHT pcf	OPTIMUM MOISTURE CONTENT %	DRY UNIT WEIGHT ③		LONG-TERM MOISTURE ④		POROSITY	EMANATION COEFFICIENT ⑤	DIFFUSION COEFFICIENT ⑥ cm²/sec	LAYER THICKNESS ⑦		Ra-226 CONTENT ⑦ pCi/g	
					pcf	g/cm³	WEIGHT %	SATURATION FRACTION, m_r				ft.	cm.		
UPPER LAYER (ML) (EVAPORATION POND MATERIAL, "ASH")①	2.23	87	45.1	64.2	40.6	0.65	25	0.23	0.71	0.4	0.044	20	610	14 —	
LOWER LAYER (CH, ML, SM) (MAIN TAILINGS PILE)②	2.49 (2.43-2.59)	66 (37-86)	81.8 (76.7-85.3)	28.8 (26.3-30.0)	73.6	1.18	21	0.47	0.53	0.4	0.017	40	1220	160	

NOTES:

1. Single sample results, unless otherwise indicated
2. Average and range, "( )", of 3 samples, unless otherwise indicated.
3. 90% of maximum dry unit weight by ASTM D698.
4. See sheets 31 & 34
5. See sheet 5
6. See sheet 34
7. Values used in conceptual design (Ref. 5). These values should be evaluated further in final design.

ADDITIONAL DATA NEEDED:

1. Emanation coefficient of evaporation pond material is probably not adequately justified with existing data (see sheets 3-7). Additional data on emanation coefficient of low radium content material is needed. Site specific data can be used, or possibly additional literature study can be used to extrapolate existing data.
2. Diffusion coefficient of evaporation pond material is not justified in magnitude adequately by site specific results. However, diffusion coefficient shown above is greater than single sample results for site, and is based on a general correlation for all soils.

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PURPOSE :

The purpose of this calculation is to determine all of the tailings properties needed for radon barrier design, except radium content and geometry (e.g thickness) of the tailings in the embankment. (Radium content and geometry of the tailings will be evaluated in another calculation).

INDEX :

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EMANATION COEFFICIENT

1. Sampling Locations:
   Main Pile - northeast quadrant
   center
   southwest quadrant
   (see sample locations on data sheets, i.e. borehole no. and depth, sheets 8-11)

2. Material Types: (sheets 8-11)
   Sands
   Slimes
   Mixtures of sands & slimes

3. Radium Contents: 144 - 702 pCi/g
   (sheets 8-11)

4. Moisture Contents: 4.4 - 17 % (Dry weight Basis)
   (sheets 8-11)

5. Depths of Samples: 1' - 8'

6. Discussion of Choice of E For Design

   a. E varies with moisture, and increases with increasing moisture content to an upper limit at values of m (moisture saturation) ranging from $0.2 \le m \le 0.4$ nearly all of a variety of tailings sources. The upper limit depends on the tailings and ranges from $0.1 \le E \le 0.4$ (Ref. 2, p. 5-2)

   b. Radon flux from bare tailings, and also from a single cover above bare tailings, is directly proportional to E of the tailings. (Eqns. 3 & 4, Ref. 2)

c. Samples for emanation coefficient tests were taken from locations in the tailings pile that should provide samples representative of the entire pile, both in area and depth. The tailings pile is estimated to contain 424,300 cy., (Ref. 4, p. 26) including 1.5-2.0' of existing cover (Ref. 4, p. 4) and about 2.0' of subpile contaminated material (Ref. 4, p. 26). Average tailings depth, including cover, is 7'.

d. The tailings pile represents over 2/3 of the estimated total volume of contaminated material (Ref. 5, p. B-6). The average Ra 226 content of the pile volume is 160 pCi/g; while the remainder of the material averages 14 pCi/g. projected radium content.

e. The tailings pile (including subpile) contaminated materials will be placed in the disposal embankment prior to placement of lesser-contaminated, off-pile materials (Ref. 5, p. B-32)

f. E test results for Lakeview tailings vary with radium content of the test samples (sheets 6-7), where $0.12 \leq E \leq 0.43$

E is relatively insensitive to radium content above about 260 pCi/g Ra 226 content. The average value of E above this content $= 0.24 \pm 0.06\ (1\sigma)$ (32 test results)

g. However, the average radium concentration of the tailings $\simeq$ 160 pCi/g. ~~At this content.~~ For Ra 226 contents of 140-210 pCi/g the average value of $E = 0.39 \pm 0.04\ (1\sigma)$ (8 test results). Apparently, the samples

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tested for radon emanation coefficient were not representative of the main pile or of all the tailings, because samples with lower Ra-226 contents were not tested.

7. Summary - Emanation Coefficient selection

The radon emanation coefficient E will be selected based on the following:

a. E varies from 0.1 to 0.4 for a wide variety of tailing sources.

b. E at the Lakeview site averages about 0.39 for test samples with radium contents near the average content for the tailings pile and subpile materials.

c. E increases with decreasing radium content, and lower contaminated materials are to be placed over the tailings pile and subpile materials.

8. Conclusion : <u>Use E=0.4 for preliminary design</u>*

*However, the radium contents for the tailings yielding the range in E (7.a above) should be checked, or the range of E should be checked by other means to be sure that E will not average higher than 0.4 for radium contents as low as 14 pCi/g (average of lower contaminated materials, Ref. 5, p. B-34)

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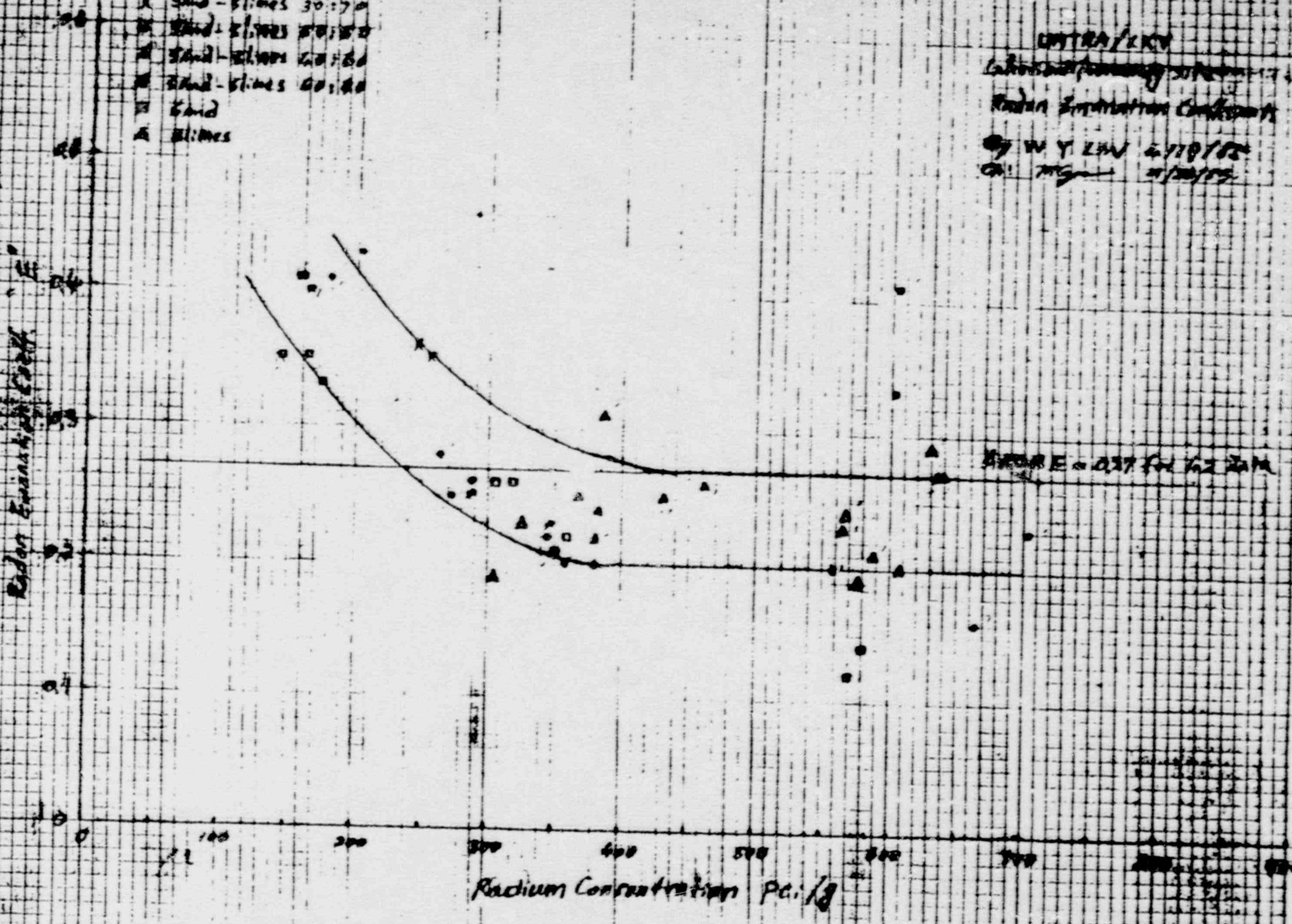
EMBANKMENT DESIGN

TAILINGS PROPERTIES FOR RADON BARRIER DESIGN



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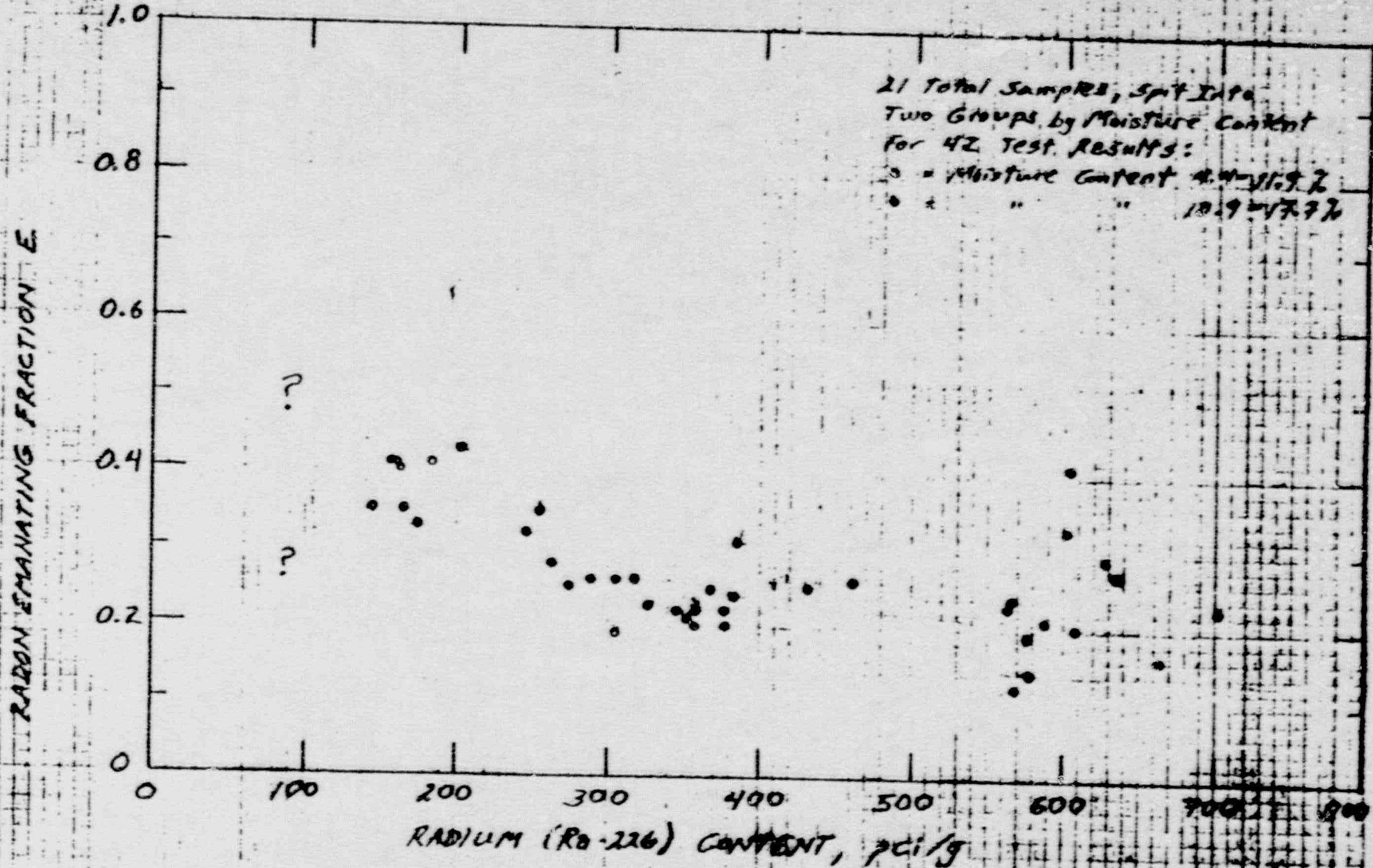
TAILINGS PROPERTIES FOR RADON BARRIER DESIGN Ckd WYL [illegible]



EMANATION COEFFICIENT DATA DIFFERENTIATED BY MOISTURE CONTENT OF TEST SAMPLES FROM SAMPLE SPLITS

TAILINGS PROPERTIES FOR
RADON BARRIER DESIGN

Sheet 8

chkd. FBG 6-14-85

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REPORT OF RADIUM AND EMANATION COEFFICIENT MEASUREMENTS
(LAB PROCEDURE RAE-SQAP-3.1)

Note:* Borehole Nos. and Depths for each sample No. (sheets 4-7) obtained from 22 March, 1984 letter from S.M. Rush (Bendix) to V. Rogers (Rogers and Assoc.) in Ref. 1.

REPORT DATE 18 July 1984

CONTRACT C-46-3d

BY BJB/KKN

SAMPLE IDENTIFICATION Lakeview Tailings Samples

SUBMITTED BY Jacobs Engineering Group

DATE RECEIVED Samples 16 March 84
Parameters 30 May 84

SAMPLE NUMBER	MOISTURE (DRY WT. %)	RADON EMANATION COEFFICIENT °	RADIUM° (pCi/gram)	COMMENTS** sand:slimes ✓
561 DH-4 3.5'-6.0' ✓	5.8	0.20 ± .01	358 ± 3	mix 50:50 ✓ 1½'-6' (½' sand - 1½ slime - 1½ [illegible] ✓
561 "	12.5	.20 ± .01	379 ± 3	mix 50:50 ✓ ✓
562 DH-4 6.0'-8.0' ✓	7.3	.25 ± .01	368 ± 3	mix 40:60 ✓ ✓
562 "	15.1	.31 ± .01	385 ± 4	mix 40:60 ✓ ✓
567 DH-143 1.0'-3.0' ✓	7.8	.40 ± .01	163 ± 2	Sand ✓ ✓
567 "	11.6	.35 ± .01	164 ± 2	Sand ✓ ✓
568 DH-143 3.0'-5.0' ✓	6.6	.35 ± .01	144 ± 2	Sand ✓ ✓
568 "	11.4	.33 ± .01	174 ± 2	Sand ✓ ✓
569 DH-143 5.0'-7.0' ✓	10.4	.33 ± .01	601 ± 4	mix 60:40 ✓ ✓
569 "	16.6	.41 ± .01	604 ± 4	mix 60:40 ✓
575 DH-147 1.5'-4.0' ✓	7.4	.41 ± .01	160 ± 2	Sand ✓
575 "	14.5	.41 ± .01	159 ± 2	Sand ✓ ✓
		Σ 3.95		

°UNCERTAINTIES BASED ON GAMMA-RAY COUNTING STATISTICS ONLY.

*Note: Borehole Designations at processing site changed, i.e. "DH-" changed to "LKV-01-" (e.g. DH-4 changed to "LKV-01-4")

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** See Letter, 18 July 1984 K.K. Nielson to D.D. Dzaak in Ref. 1

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UMTRA-LKV 400S
TAILINGS PROPERTIES FOR RADON
BARRIER DESIGN

SHEET 9

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REPORT OF RADIUM AND EMANATION COEFFICIENT MEASUREMENTS
(LAB PROCEDURE RAE-SQAP-3.1)

See sheet 8 for Notes

REPORT DATE 18 July 1984

CONTRACT C-46-3d

BY BJB/KKN

SAMPLE IDENTIFICATION Lakeview Tailings Samples

SUBMITTED BY Jacobs Engineering Group DATE RECEIVED 30 May 1984

SAMPLE NUMBER	MOISTURE (DRY WT. %)	RADON EMANATION COEFFICIENT[a]	RADIUM[a] (pCi/gram)	COMMENTS
576 DH-147 4.0'-6.0' ✓	6.4	0.25 ± .01	273 ± 3	Mix 50:50 ✓
576 "	14.2	.28 ± .01	263 ± 3	Mix 50:50 ✓
577 DH-147 6.0'-8.0' ✓	5.7	.12 ± .01	569 ± 4	Sand ✓
577 "	12.7	.14 ± .01	578 ± 4	Sand ✓
578 DH-147 8.0'-10.0' ✓	7.4	.16 ± .01	662 ± 5	Mix 50:50 ✓
578 "	12.7	.23 ± .01	702 ± 5	Mix 50:50 ✓
612 DH-29 2.0'-4.0' ✓	4.9	.26 ± .01	307 ± 3	Sand ✓
612 "	12.5	.26 ± .01	318 ± 3	Sand ✓
613 DH-29 4.0'-6.0' ✓	5.1	.21 ± .01	351 ± 3	Sand ✓
613 "	12.9	.22 ± .01	358 ± 3	Sand
622 DH-7 1.0'-3.0' ✓	9.2	.36 ± .01	245 ± 3	Mix 30:70 ✓
622 "	15.1	.35 ± .01	255 ± 3	Mix 30:70 ✓
		Σ 2.84		

[a] UNCERTAINTIES BASED ON GAMMA-RAY COUNTING STATISTICS ONLY.

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REPORT OF RADIUM AND EMANATION COEFFICIENT MEASUREMENTS

(LAB PROCEDURE RAE-SQAP-3.1)

See sheet 8
for Notes

REPORT DATE 18 July 1984

CONTRACT C-46-3d

BY BJB/KKN

SAMPLE IDENTIFICATION Lakeview Tailings Samples

SUBMITTED BY Jacobs Engineering Group DATE RECEIVED 30 May 1984

SAMPLE NUMBER	MOISTURE (DRY WT. %)	RADON EMANATION COEFFICIENT[a]	RADIUM[a] (pCi/gram)	COMMENTS
623 DH-7 3.0-5.0' ✓	4.4	0.19 ± .01	305 ± 3	slimes ✓
623 "	10.9	.23 ± .01	327 ± 3	slimes ✓
624 DH-7 5.0'-7.0' ✓	8.9	.24 ± .01	567 ± 4	slimes ✓
624 "	12.7	.23 ±.01	564 ± 4	slimes ✓
631 DH-1 1.5'-4.0' ✓	6.6	.41 ± .01	182 ± 2	Mix 50:50
631 "	12.1	.43 ± .01	202 ± 3	Mix 50:50 ✓
632 DH-1 4.0'-6.0' ✓	7.0	.26 ± .01	289 ± 3	Mix 50:50 ✓
632 "	13.4	.22 ± .01	345 ± 3	Mix 50:50 ✓
633 DH-1 6.0'-8.0' ✓	6.9	.29 ± .01	628 ± 4	slimes ✓
633 "	12.8	.27 ± .01	634 ± 5	slimes ✓
641 DH-3 3.5'-5.0' ✓	8.3	.22 ± .01	377 ± 3	Mix 60:60 ✓
641 "	17.7	.26 ± .01	461 ± 4	Mix 60:60 ✓
		Σ 325		

[a] UNCERTAINTIES BASED ON GAMMA-RAY COUNTING STATISTICS ONLY.

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REPORT OF RADIUM AND EMANATION COEFFICIENT MEASUREMENTS
(LAB PROCEDURE RAE-SQAP-3.1)

See sheet 8
for Notes

REPORT DATE 18 July 1984

CONTRACT C-46-3d

BY BJR/KKN

SAMPLE IDENTIFICATION Lakeview Tailings Samples

SUBMITTED BY Jacobs Engineering Group   DATE RECEIVED 30 May 1984

SAMPLE NUMBER	MOISTURE (DRY WT. %)	RADON EMANATION COEFFICIENT*	RADIUM* (pCi/gram)	COMMENTS
642 DH-3 5.0'-7.0' ✓	6.0	0.20 ± .01	609 ± 4	slimes ✓ ✓
642 "	12.8	.27 ± .01	638 ± 4	slimes ✓ ✓
650 DH-10 5.0'-7.0' ✓	6.2	.24 ± .01	383 ± 3	mix 40:60 ✓ ✓
650 "	10.6	.25 ± .01	431 ± 4	mix 40:60 ✓ ✓
651 DH-10 7.0'-8.5' ✓	11.9	.21 ± .01	588 ± 4	slimes ✓
651 "	16.9	.19 ± .01	576 ± 4	slimes ✓
		Σ 1.36		
	$E_{ave} = \frac{3.95 + 2.84 + 3.25 + 1.36}{42} = 0.27$			FOR ALL DATA
			✓	

*UNCERTAINTIES BASED ON GAMMA-RAY COUNTING STATISTICS ONLY.

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SUMMARY: LONG-TERM MOISTURE CONTENT OF TAILINGS

TAILINGS TYPE	IN-PLACE PROPERTIES			OPTIMUM MOISTURE CONTENT %	% FINER THAN #200 SIEVE	IN SITU PROPERTIES		LONG-TERM MOISTURE CONTENTS AND MOISTURE SATURATION VALUES					
								REF 2, P. 4-6		15 BAR MOISTURE		REF 5, p. B-35	
	DRY UNIT WEIGHT PCF	SPECIFIC GRAVITY	POROSITY			w, %	DRY UNIT WEIGHT	w %	mr	w %	mr	w %	mr
Evaporation Pond (ML) ①	40.6	2.23	0.71	84.2	87	83.8 43.1 ② 82.1 ③	40.1	60	0.55	25	0.23	21	0.19 ④
Slimes (CH) ①	75.1	2.59	0.54	30.0	66	(NA) 26.8 ③	74.5	24	0.54	17	0.37	21	0.47 ④
Mixed Sands and Slimes (ML) ①	76.8	2.46	0.50	26.3	72	26.4 28.4 ③	76.1	21	0.52	15	0.37	21	0.52 ④
Sands (SM) ①	69.0	2.43	0.54	30.0	39	31.3 27.5 ③	65.6	23	0.47	13	0.27	21	0.43 ④
All Main Pile Tailings	73.6 ⑤	—	0.53 ⑤	—	—	23.9 ⑤	—	—	—	—	—	21	0.47

① Single sample test results.
② Study conducted and samples taken during very wet site conditions, with ponded rain and snowmelt present throughout the site.
③ From Ref. 5, Table B.1.6. Average of 2 samples.
④ Using w = 21% from Ref. 5 and other data as shown above.
⑤ Ref. 5, Table B.1.8

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LONG-TERM MOISTURE CONTENT

The long-term moisture content of the tailings is needed to determine the appropriate diffusion coefficient for design.

Lesser-contaminated materials are to be placed over the relatively higher-contaminated materials from the main tailings pile. The long-term moisture content of the upper materials will have a greater influence on diffusion of radon into the cover. Therefore, greater emphasis will be placed on estimating the long-term moisture content of materials other than materials from the main tailings pile. Long-term moisture of the main pile tailings will also be estimated for comparison and possible use in design.

1. Lesser Contaminated Materials (off-pile)

   a. Material Types & Quantities (Ref. 5, p. B-6)

Evaporation Pond and Berms	180,500 cy
Windblown, Mill Yard and Tailings Pile Berms	23,300 cy
Vicinity Properties	300 cy
Total off-pile	204,100 c.y.

Since the evaporation pond and berm materials make up 88% ± of the lesser contaminated materials, the long-term moisture content of those pond and berm materials will be representative of the upper tailings in the embankment.

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6. Evaporation Pond Soil Data (one sample)

1) Grain size : 87 % finer than #200 sieve
21 % " " 2 micron "

Sample location N 9200 / E 4400 , 0-15"
(Ref. 1)
(Nearby borings = LKV-01-186 & LKV-01-187)

2) List of Borings in Evaporation Pond & Berm Area

513 (Ref. 4, p. 189)	✓	LKV-01-172	} MKC Doc. No. 4005-	*
514 "	✓	-173	} LKV-B-04-00175-00	✓
515 "	✓	-179	Ref. 4, App. C	✓
516 "	✓	-180	"	✓
(529) ——	**	-181	"	✓
		-182	"	✓
		-185	"	✓
		-186	"	✓
			"	✓

✓ = ML in topmost soil layer (covered by wood chips in some cases)
* = CL, ML, & CH in topmost soil layer
** = No Log available from TAC
++ = No logs in Ref. 4 or source report noted in ref. 4.

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3) Material Type & Properties - Evaporation Ponds ('ash') -

"The raffinate pond contaminated material consists of silt (ML)." (Ref. 4, p. 183)

Available logs verify this conclusion, based on visual identification (see '2)' above).

One sample was classified by laboratory means as ML (Pond #3, 0-1.5' (15" ?), see '1)' above also) This sample was non-plastic, as LL and PL values could not be obtained (Ref. 1, January 28, 1985 correspondence "from JSmith to RRager (both Jacobs Weston Team), Subject "Lakeview Tailings Soil Mechanical Properties")

Compaction test results by ASTM D698 indicated a maximum dry density of 45.1 pcf and an optimum moisture of 64.2 % (saturation = 90%). Specific gravity was measured as 2.228 (data from same Ref. as immediately above).

Void ratio of these tailings at 90% of maximum dry density:

$$\gamma_{d_{max}}(0.9) = 40.6 \text{ pcf.} = \gamma_d \text{ in-place}$$

$\gamma_d = \frac{G\gamma_w}{1+e}$ $\quad n = \frac{e}{1+e}$ = porosity

e = void ratio

$$e = \frac{G\gamma_w}{\gamma_d} - 1 = 2.4 \qquad n = 0.71 ;$$

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4) Long-Term Moisture Content of Evaporation Pond (ML) Material

First Method: (Ref. 2, p. 4-6)

$$m_r = 0.124 P^{1/2} - 0.0012 E - 0.04 + 0.156 f_{cm}$$

$P = 16.56$ in (Ref. 4, p. 212)
$E = 45$ in (Ref. 4, p. 213)
$f_{cm} = 87\%$ (one sample) or 50% (minimum for ML)

$m_r = 0.55$ ($f_{cm} = 87\%$) (moisture saturation)
$= 0.50$ (" $= 50\%$) (" ")

$$m = \frac{\rho M}{P} 10^{-2}$$ (ρ = unit weight, g/cm^3) (P = porosity)

M = moisture content, dry weight %

$$= \frac{\rho m}{P}(100) = \frac{0.71 m}{0.65} (100)$$

$M = 60\%$ ($f_{cm} = 87\%$) (moisture content)
$M = 55\%$ ($f_{cm} = 50\%$) (" ")

These are very high moisture contents relative to most soils, but less than optimum moisture content (84%) for this sample.

Due to the unusual characteristics of this soil (low G, low γ_{dmax}, high W_{opt}, high porosity) and the non-plastic consistency of a sample with 87% fines, this soil may not be adequately similiar to the majority of soil types used to determine the relationship in Ref. 4. Therefore, another estimate or estimates of the long-term moisture content should be made.

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. 4) (continued)

Second Method - In Situ Moisture Content

Boring Nos. 172 & 173 (Ref. 4, App. C, Table I-1)

No. 172: No moisture data
No. 173: 53.4 % (102-108") ML*
53.0 % (108-140") ML*
22.9 % (140-147") CH*

* From boring logs, MKE Doc. No. 4005-LKV-B-04-00175-00

The samples were taken during very wet site conditions, when ponded rain and snow melt were present throughout the site (Ref. 4, App. C, pp. 4-5) Therefore, it appears that the silt can only sustain a maximum water content of about 53 % during wet weather (based on on sample) The long term moisture ~~moisture~~ content will be less than this, perhaps considerably less. This method indicates that the first method may not be appropriate to estimate long-term moisture saturation of this soil

Third Method - Capillary Moisture Tests

Capillary moisture tests were performed on 3 samples from the main tailings pile and on 1 sample from the evaporation pond (Ref. 4, Table 7.6). (No test method was indicated in Ref. 4 or in data reported in Ref. 1, January 28, 1985 correspondence from RRager to JSmith (both Jacobs Weston Team). The method is assumed to be ASTM D3152, as performed on potential radon barrier materials.

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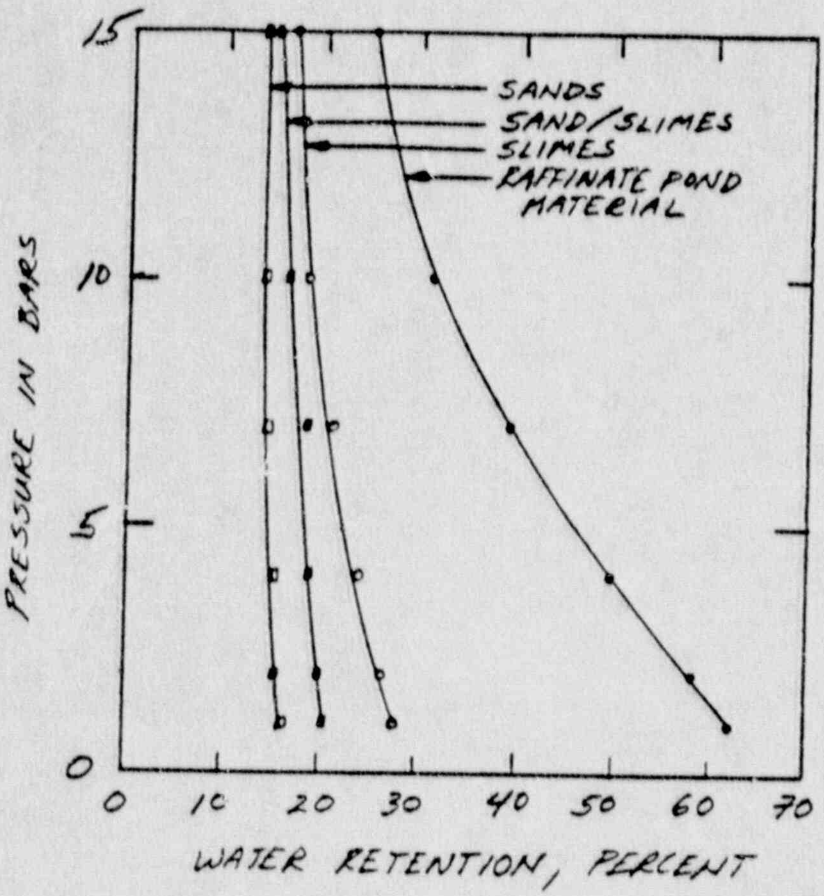
4) (Continued)

Method 3 (continued)



Recent research indicates that the 15 bar moisture content (i.e. ~ wilting point) may be the long-term moisture content of many compacted soils (Ref. 7, p. 274). This may be a conservative value since the wilting point is the moisture content at which plants can no longer extract moisture from the soil. However, due to the limited data and unusual properties of the evaporation pond ML soil, the moisture saturation at the 15 bar moisture content will be used for an estimate.

4) (continued)

15-bar moisture content = 25%

$$m = \frac{25(0.65)}{0.71} 10^{-2}$$ (see sheet 15 for equation)

$m = 0.23$ (approximately half of results using Method 1, above)

CONCLUSION: use $m_r = 0.23$ to determine diffusion coefficient of evaporation pond soils.

5) Long-Term Moisture of Tailings from Main Pile

First Method (Ref. 2, p. 4-6) (Data from Ref. 4, Tables 7.1 to 7.3)

Tailings Type	In-Place Density* pcf	Specific Gravity	fcm, Percent Finer Than #200 Sieve	m_r **	M, % Dry weight Moisture ***
Slimes	75.1	2.59	86	0.54	24.0
Sands and Slimes	76.8	2.46	72	0.52	21.1
Sands	69.0	2.43	39	0.47	23.2

* 90% of maximum dry density by ASTM D698

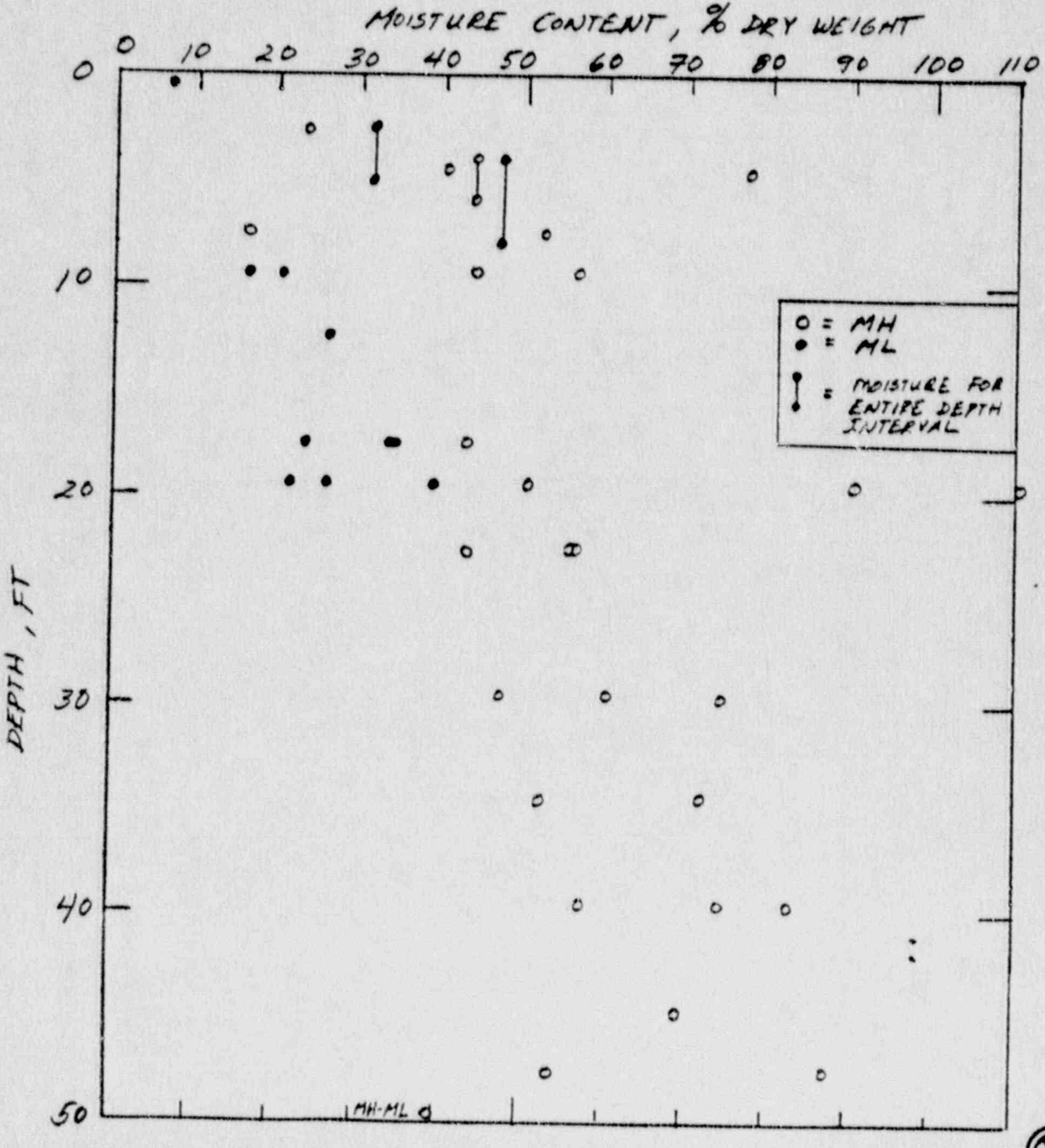
** $m_r = 0.124(16.56)^{1/2} - 0.0012(45) - 0.04 + 0.156(fcm)$ [see sheet 15]

*** $M = \frac{p\,m}{\rho} 100$, $p = \frac{e}{1+e}$ $e = \frac{G\gamma_w}{\gamma_d} - 1$ (see sheet 14 for equation)

5) (continued)

<u>Second Method</u> - In situ Moisture of Soils at Disposal site

see sheets 20 through 24 for plot and data for in situ moisture content of soils at disposal site. Results for silts only are plotted below (upper 50' only)



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Project UMTRA/LKV
Feature Embankment Design
Item TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

Contract No. 6006
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Sheet 203
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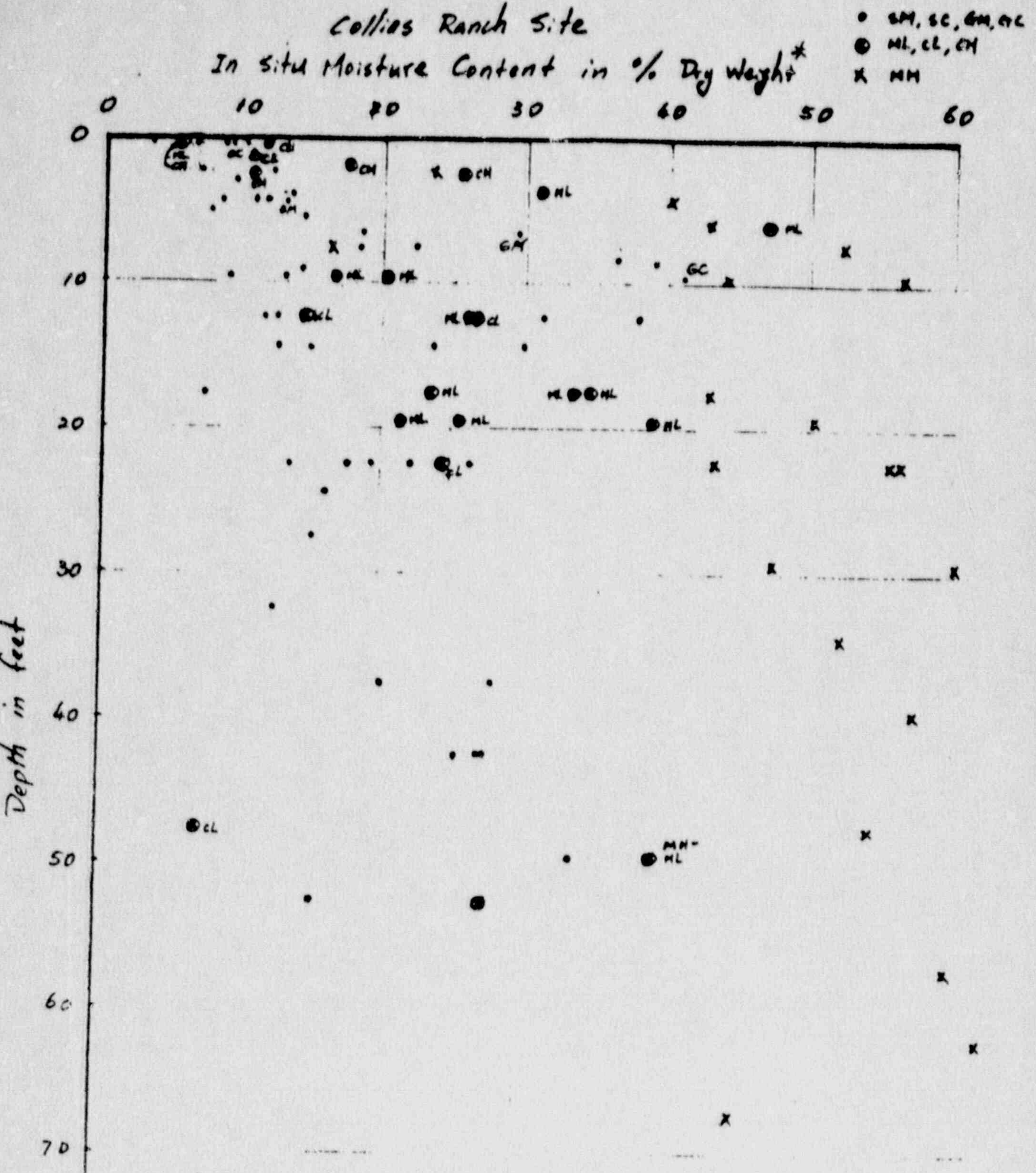
Date 6-26-85

Collins Ranch Site
In situ Moisture Content in % Dry Weight*



* DATA FOR DEPTHS BELOW 80' AND MOISTURE CONTENTS >64% NOT SHOWN.

Table 7.1 Foundat[illegible]hanical properties

(Source: Ref. 3)

Location I.D.	Sample depth (ft)	USCS classification	In-situ moisture content (%)	In-situ dry density (pcf)	Specific gravity	Atterberg limits (percent)		
						Liquid limit	Plastic limit	Plasticity index
501	0.5	SC	6.8	--	--	--	--	--
	2.5	CH	25.9	--	--	--	--	--
	7.5	MH	52.3	--	--	--	--	--
	22.5	SM	17.7	--	--	--	--	--
	25.5	SM	--	--	--	NP	NP	NP
	29.5	MH	60.2	--	--	103	49	54
	37.5	SM	28.0	--	--	--	--	--
	42.5	SM	27.6	--	--	--	--	--
	49.5	SM	33.5	--	--	NP	NP	NP
502	2.5	MH	23.5	--	--	--	--	--
	12.5	SM	11.7	--	--	--	--	--
	22.5	MH	55.7	--	--	88	53	35
503	4.5	SC	11.5	--	--	--	--	--
	12.5	CL	14.5	--	--	39	21	18
	22.5	CL	24.1	--	--	--	--	--
	29.5	MH	47.5	--	--	62	40	22
	32.5	SM	12.5	--	--	--	--	--
	37.5	SM	20.4	--	--	--	--	--
	42.5	SM	25.4	--	--	--	--	--
	47.5	MH	87.5	--	--	117	67	50
504	7.5	SC	18.3	--	--	--	--	--
	12.5	CL	26.9	--	--	43	24	19
	17.5	ML	23.5	--	--	43	27	16
	22.5	MH	56.6	--	--	83	52	31
505	2.5	CH	10.6	--	--	--	--	--
	9.5	SM	13.1	--	--	--	--	--
	17.5	SM	7.5	--	--	NP	NP	NP
	22.5	SM	13.5	--	--	NP	NP	Np
506	0.5	SM	8.9	--	--	--	--	--
	9.5	ML	20.5	--	--	43	36	7
	19.5	MH	50.5	--	--	89	43	45

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TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

Sheet 21

of properties (Continued)

Source : Ref. 3

Location I.D.	Sample depth (ft)	USCS classification	In-situ moisture content (%)	In-situ dry density (pcf)	Specific gravity	Atterberg limits (percent)		
						Liquid limit	Plastic limit	Plasticity index
507	0.5	ML	5.9	--	--	--	--	--
	4.5	MH	40.1	--	--	--	--	--
	9.5	SM-SP	9.0	--	--	--	--	--
	14.5	SM	12.9	--	--	--	--	--
	19.5 ✓	MH	90.1	42.6	2.62	83	37	46
	19.5 ✓	MH	110.7	--	--	139	50	89
	24.5	SM-SP	16.0	--	--	NP	NP	NP
	29.5	MH	74.5	--	--	--	--	--
	32.5	MH	--	--	--	69	39	30
	34.5	MH	52.5	--	--	--	--	--
	39.5	MH	57.7	--	--	--	--	--
	47.5	CL	7.1	--	--	40	27	13
	52.5	ML	27.8	--	--	--	--	--
	57.5	MH	60.0	--	--	96	58	38
	62.5	MH	62.4	--	--	--	--	--
	67.5	MH	45.0	--	--	58	50	8
	72.5	SM	13.6	--	--	--	--	--
508	9.5 ✓	MH	56.2	63.3	2.60	67	36	31
	19.5	ML	25.9	--	--	--	--	--
	22.5	MH	43.6	--	--	--	--	--
	27.5	SM	15.3	--	--	NP	NP	NP
	34.5	MH	71.8	--	--	--	--	--
	42.5	SM	27.5	--	--	NP	NP	NP
	47.5	MH	54.3	--	--	--	--	--
	49.5	MH-ML	39.3	--	--	--	--	--
	74.5	MH	48.5	--	--	82	44	38
509	0.5	SM-GM	3.6	--	--	--	--	--
	7.5	SM	22.6	--	--	NP	NP	NP
	22.5	SM	22.2	--	--	NP	NP	NP
510	2.5	SC	12.0	--	--	--	--	--
	7.5	SC	70.0	--	--	--	--	--
	12.5	ML	26.0	--	--	--	--	--
	14.5	SM	23.9	--	--	NP	NP	NP

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TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

Sheet 22

Table 7.1 Foundation material properties (Concluded)

Source: 3

Location I.D.	Sample depth (ft)	USCS classification	In-situ moisture content (%)	In-situ dry density (pcf)	Specific gravity	Atterberg limits (percent) Liquid limit	Plastic limit	Plasticity index
510	22.5	MH	--	--	2.59	57	42	15
	39.5	MH	82.9	--	--	81	42	30
	39.5	MH	74.9	--	--	70	38	32
	44.5	MH	67.9	--	--	90	46	44
	52.5	SM	15.7	--	--	NP	NP	NP
	82.5	MH	68.0	--	--	97	53	44
	104.5	MH	58.1	--	--	93	43	50
	119.5	ML	22.0	--	--	--	--	--
✓ 511	0.5	SM	--	--	--	NP	NP	NP
	7.5	MH	16.1	--	--	100	61	39
	9.5	ML	16.6	--	--	22	18	4
	14.5	SM	15.0	--	--	37	31	6
	19.5	ML	21.7	--	--	NP	NP	NP
✓ 512	0.5	CH	5.8	--	--	--	--	--
	4.5	SC	8.6	--	--	--	--	--
	12.5	SM	12.4	--	--	--	--	--
	22.5	SC	19.5	--	--	--	--	--
513	0.5	CL	11.8	--	--	--	--	--
	12.5	SM	31.7	--	--	--	--	--
	17.5	ML	33.8	--	--	--	--	--
	22.5	SM	26.1 - Below W.T.	--	--	--	--	--
514	9.5	GC	41.1	--	--	--	--	--
	17.5	ML	34.8	--	--	--	--	--
515	0.5	GC	9.0	--	--	--	--	--
	4.5	MH	77.0	--	--	--	--	--
	12.5	SM	38.0	--	--	--	--	--
	17.5	MH	43.0	--	--	--	--	--
516	4.5	GM	13.0	--	--	--	--	--
	9.5	MH	44.0	--	--	--	--	--
	14.5	SM	30.0 - saturated	--	--	--	--	--
	19.5	ML	39.0 Below saturated SM layer	--	--	--	--	--

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TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

Sheet 23

Table 9.1 Soil characteristics, on-site radon barrier materials

(Source: Ref. 3)

Test pit number	Sample depth (ft)	Atterberg limits LL	PL	PI	USCS classification	In-situ dry unit weight (pcf)	In-situ moisture content (%)	Specific gravity
LKV02-801	2.5				GP		5.8	
	5.0				GP		7.4	
	8.0				GP		13.0	
LKV02-802	2.5				GP		7.8	
	5.0-8.0				GM	90.0	29.8 Below W.T.	2.58
	8.5	N/P	N/P	N/P	SM		36.6	
LKV02-803	0-1.5	30	18	12	CL		10.4	
	1.5-2.5	55	19	36	CH		17.3	
	2.5-3.0				SP-SM		7.2	
	3.0-8.0				SC		14.2	
	8.0-10.0				--		14.2	
LKV02-804	2.5-6.0				SM		11.4	2.55
LKV02-805	4.0-8.0	49	37	12	ML		47.3	2.50
LKV02-806	4.0-6.0	64	36	28	MH		43.7	2.53
LKV02-807	2.0-3.5	31	20	11	SC		9.9	
	3.5-6.0	N/P	N/P	N/P	SP-SM	91.0	13.4	2.53
	6.0-7.0				SM		18.4	
	7.0-10.0	N/P	N/P	N/P			39.0	
LKV02-808	2.5-5.0	N/P	N/P	N/P	ML		31.7	
LKV02-809	3.5-9.0				GW		10.5	2.99

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TAILINGS PROPERTIES FOR RADON BARRIER DESIGN
Sheet 24

Project UMTRA - LKV
Feature EMBANKMENT DESIGN
Item TAILINGS PROPERTIES FOR RADON BARRIER DESIGN
Contract No. 4005
Designed FBG
Checked WYL
Sheet 25
File No.
Date 6-20-85
Date 6/24/85

5) (continued)

SECOND METHOD (continued)

In situ moisture contents varied widely. ML results tended to be significantly less than MH results (sheet 19). ML results for the disposal area foundation were significantly less than two ML results for two depth intervals in nearby possible radon barrier material sources (sheets 21 through 24 and sheet 19). Sand and gravel results were very widely scattered (sheet 20).

Weather and site conditions during sampling at the disposal site, before and during sampling, would need to be representative of long-term conditions before in situ moisture contents could be used. Demonstrating this to a reliable degree would be impractical. In addition, in situ densities of ML soils were not measured at the disposal site, nor should it be assumed that the minerology of those soils is similiar to the evaporation pond ML soils. (as it would affect moisture retention).

Relative to other disposal site soils, the ML soils tended to a) retain much less moisture than MH soils, b) retain moisture near and below the average of widely scattered results (by inspection) for all SM, SC, GM, and GC soils, and all CL and CH soils.

INTERNATIONAL ENGINEERING COMPANY, INC.

Project UMTRA-LKV | Contract No. 4005 | Sheet 26
Feature EMBANKMENT DESIGN | Designed FBG | File No.
Item TAILINGS PROPERTIES FOR RADON BARRIER DESIGN | Checked WYL | Date 6-20-85
Date 6/[illegible]/85

5) (continued)

Third Method - Capillary Moisture Tests

See sheet 17 for plot of tailings data

TAILINGS TYPE	IN-PLACE UNIT WEIGHT pcf *	SPECIFIC GRAVITY	M, 15-BAR MOISTURE CONTENT %	m (FRACTION OF SATURATION) **
Slimes	75.1	2.59	16.6	0.37
Sands & Slimes	76.8	2.46	15.0	0.37
Sands	69.0	2.43	13.3	0.27

*At 90% maximum dry density according to ASTM D

** $m = \frac{\rho M}{p} 10^{-2}$

ρ = unit weight, g/cm³

p = porosity = $\frac{e}{1+e}$

where $e = \frac{G\gamma_w}{\gamma_d} - 1$ (see sheet 14 for equation)

6) In Situ Moisture of Tailings

See sheets 27 through 30 for data and summary on sheet 31.

UMTRA-LKV 4005
TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

Sheet 27

FBG 6-14-85
WYL 6/[illegible]/[illegible]

"... this study was conducted when surface conditions were very wet..." (Ref. 4, App. B, p.37)

Appendix I

BOREHOLE ANALYTICAL DATA

Tailings pile
Lakeview processing site

Table I-1 presents gamma-ray-spectroscopic analytical data, Table I-2 trace-metal data, and Table I-3 radioelement data for samples collected from the boreholes. The analytical uncertainties in Table I-1 are reported at the two-standard-deviation (2σ) level. The MBH numbers in the tables are sample numbers; thorium and potassium values represent equivalent concentrations.

SYMBOL	LOCATION
TP	Tailings Pile
WB	Windblown
EP	Evap. Pond
M	Mill Area

Table I-1

Borehole-Sample Gamma-Ray-Spectroscopy Data

Hole No.	Grid Coordinates North	Grid Coordinates East	Depth (in.)	MBH No.	Moisture (%)	Concentration Ra-226 (pCi/g)	Concentration Thorium (ppm)	Concentration Potassium (%)
1	7626	5601	0-22	629	-	1 ± 1	3 ± 1	1.1 ± 0.1
			18-48	631	32.9	243 ± 22	<28 ± 1	<1.6 ± 0.4
			48-72	632	-	319 ± 22	<13 ± 1	<2.2 ± 0.4
TP			72-96	633	37.7	696 ± 51	<7 ± 1	<2.3 ± 0.4
			96-120	634	25.1	18 ± 2	<2 ± 1	1.4 ± 0.4
			120-144	635	22.8	4 ± 1	<2 ± 1	1.3 ± 0.4
			144-168	636	21.4	2 ± 1	3 ± 2	1.7 ± 0.4
			168-192	637	25.3	1 ± 1	5 ± 2	1.4 ± 0.4
			192-216	638	14.7	1 ± 1	7 ± 2	2.3 ± 0.6
3	7614	6040	0-6	249	30.6	1 ± 1	5 ± 2	1.5 ± 0.4
			42-60	641	-	235 ± 16	<12 ± 1	<2.0 ± 0.4
			60-84	642	-	663 ± 47	113 ± 24	<1.5 ± 0.4
TP			84-108	643	22.1	11 ± 1	<2 ± 1	1.6 ± 0.4
			108-132	644	20.1	3 ± 1	<1 ± 1	1.6 ± 0.4
			132-156	645	19.7	4 ± 1	<1 ± 1	1.3 ± 0.4
			156-168	646	21.7	1 ± 1	5 ± 2	1.9 ± 0.4
4	7611	6200	42-72	561	-	356 ± 26	<14 ± 1	<1.9 ± 0.4
			72-96	562	-	488 ± 31	<14 ± 1	<2.2 ± 0.4
TP			96-120	563	24.1	5 ± 1	<2 ± 1	<1.4 ± 0.4
			120-144	564	25.7	7 ± 1	<2 ± 1	<1.2 ± 0.4
			144-168	565	22.4	6 ± 1	<5 ± 2	<1.6 ± 0.2
5	7605	6399	0-22	549	-	8 ± 1	<2 ± 0	<1.2 ± 0.3
			22-48	550	23.4	52 ± 2	<3 ± 1	<1.5 ± 0.4
TP			48-72	551	32.1	192 ± 10	<5 ± 1	3.0 ± 0.8
			72-96	552	34.4	415 ± 18	288 ± 27	<1.2 ± 0.4
			96-120	553	38.7	586 ± 27	94 ± 26	<1.3 ± 0.1
			120-132	554	37.7	633 ± 33	<8 ± 1	<0.7 ± 0.1
			132-144	555	20.2	8 ± 1	6 ± 2	1.3 ± 0.4
			144-168	556	18.6	9 ± 1	8 ± 4	1.5 ± 0.4
			168-192	557	13.9	2 ± 1	9 ± 2	2.4 ± 0.6
			192-216	558	14.4	1 ± 1	10 ± 2	2.2 ± 0:6

LKV, PSCR, Draft, March 1985   Σ599.7 for 24 data ✓

UMTRA-LKV
4005
TAILINGS PROPERTIES
FOR RADON
BARRIER DESIGN

Tailings pile
Lakeview Processing site

Sheet 28

Table I-1 (continued)

FEG 6-19-85
WYL 6/24/85

Hole No.	Grid Coordinates		Depth (in.)	MEH No.	Moisture (%)	Concentration		
	North	East				Ra-226 (pCi/g)	Thorium (ppm)	Potassium (%)
6	7599	6600	0-24	541	26.1	1 ± 1	5 ± 2	<2 ± 0.2
			24-48	542	17.5	88 ± 8	<24 ± 1	<1.6 ± 0.4
			48-72	543	-	204 ± 12	<12 ± 1	<2.2 ± 0.4
	TP		72-90	544	-	335 ± 29	62 ± 18	<2.1 ± 0.4
			90-108	545	-	345 ± 31	<32 ± 1	<0.8 ± 0.2
			108-120	546	32.6	465 ± 41	<35 ± 12	0.8 ± 0.2
			120-132	547	10.4	10 ± 2	<8 ± 4	<2.4 ± 0.4
			144-174	548	15.4	2 ± 1	5 ± 2	1.9 ± 0.4
7	7828	5568	0-6	248	24.3	1 ± 1	6 ± 2	1.6 ± 0.4
			12-36	622	-	266 ± 16	<12 ± 1	<2.1 ± 0.4
			36-60	623	-	325 ± 24	<13 ± 1	<1.7 ± 0.4
	TP		60-84	624	-	564 ± 39	<15 ± 1	<1.0 ± 0.2
			84-108	625	26.6	9 ± 1	<2 ± 1	1.4 ± 0.4
			108-132	626	24.9	1 ± 1	<1 ± 1	1.5 ± 0.4
			132-156	627	26.0	1 ± 1	8 ± 2	1.8 ± 0.4
			156-168	628	12.5	1 ± 1	9 ± 2	2.2 ± 0.6
10	7899	62103	0-6	250	24.3	1 ± 1	<1 ± 1	1.5 ± 0.4
			60-84	650	-	409 ± 26	136 ± 20	<1.9 ± 0.4
	TP	?	84-102	651	37.6	597 ± 39	54 ± 12	<2.6 ± 0.4
			120-144	653	21.3	4 ± 1	<2 ± 1	1.5 ± 0.4
			144-168	654	23.6	1 ± 1	5 ± 2	1.6 ± 0.4
18	8007	6598	36-60	583	-	319 ± 14	<11 ± 1	<2.1 ± 0.2
			60-64	584	-	35 ± 4	<9 ± 4	<0.6 ± 0.2
	TP		64-96	585	18.8	1 ± 1	5 ± 2	1.5 ± 0.4
			96-120	586	14.0	2 ± 1	12 ± 2	2.4 ± 0.6
24	8208	6598	48-60	589	-	503 ± 26	<13 ± 1	<1.4 ± 0.2
			60-72	590	25.5	10 ± 1	49 ± 6	<1.4 ± 0.4
	TP		72-96	591	22.5	2 ± 1	<2 ± 1	<1.3 ± 0.4
			96-120	592	22.2	1 ± 1	4 ± 2	1.4 ± 0.4
27	8473	6001	12-54	602	27.8	407 ± 22	<6 ± 1	3.2 ± 1.0
			54-72	603	32.2	6 ± 1	<2 ± 1	1.5 ± 0.4
	TP		72-96	604	26.4	3 ± 1	6 ± 2	1.4 ± 0.4
			96-120	605	24.0	1 ± 1	6 ± 2	1.5 ± 0.4
28	8415	6201	24-48	607	-	349 ± 20	<8 ± 1	2.8 ± 0.8
			48-72	608	25.5	5 ± 1	<6 ± 2	<1.6 ± 0.2
	TP		72-96	609	20.3	<1 ± 1	<4 ± 2	<1.6 ± 0.2
			96-120	610	14.1	<1 ± 1	<9 ± 2	<2.2 ± 0.4
29	8444	6402	0-6	246	29.4	1 ± 1	<3 ± 2	<1.3 ± 0.4
			24-48	612	-	332 ± 20	<8 ± 1	<1.0 ± 0.1
			48-72	613	-	376 ± 24	29 ± 12	<1.0 + 0.1
	TP		72-96	614	20.7	<1 ± 1	<3 ± 2	<1.4 ± 0.2
			96-120	615	23.3	<1 ± 1	<3 ± 2	<1.4 ± 0.2
30	8407	6598	0-12	593	-	<1 ± 1	<5 ± 1	<1.4 ± 0.3
			12-24	594	-	34 ± 2	<4 ± 1	<1.4 ± 0.4
	TP		24-48	595	-	26 ± 2	<3 ± 1	<1.2 ± 0.4
			48-72	596	25.7	371 ± 18	<5 ± 1	<3.3 ± 0.4
			72-96	597	18.6	3 ± 1	<7 ± 2	<1.6 ± 0.2

LKV, PSCR, Draft, March 1985

Σ 714.1 for 31 data

Average Moist. Cont M = (599.7 + 714.1 + 216.6) ÷ (24 + 31 + 9) = 0.239 ✓

(see Note on Sheet 27 re wet conditions during sampling.)

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Sheet 29

TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

FBG 6-19-85
WYL 6/25/85

Table I-1 (continued)

Hole No.	Grid Coordinates North	Grid Coordinates East	Depth (in.)	MEH No.	Moisture (%)	Concentration Ra-226 (pCi/g)	Concentration Thorium (ppm)	Concentration Potassium (%)
			96-120	598	18.1	<1 ± 1	<3 ± 2	<1.7 ± 0.2
			120-144	599	12.5	<1 ± 1	<10 ± 2	<2.7 ± 0.4
			144-168	600	11.8	<1 ± 1	<9 ± 2	<2.3 ± 0.4
143	7454	6001	12-36	567	-	168 ± 10	<6 ± 1	<1.7 ± 0.4
			36-60	568	-	192 ± 12	<7 ± 1	<1.8 ± 0.6
	TP		60-84	569	-	596 ± 45	<16 ± 1	<1.7 ± 0.4
			84-96	570	27.5	15 ± 2	<2 ± 1	1.5 ± 0.4
			96-120	571	25.6	1 ± 1	<1 ± 1	1.6 ± 0.4
			120-144	572	22.9	8 ± 1	<2 ± 1	1.5 ± 0.4
			144-168	573	21.2	1 ± 1	5 ± 2	1.6 ± 0.4
146	7688	7113 WE	0-6	92	24.2	1 ± 1	4 ± 2	1.6 ± 0.4
147	7460	5699	0-6	245	24.6	1 ± 1	<2 ± 1	<1.2 ± 0.2
	TP		18-48	575	-	157 ± 8	<11 ± 1	<2.4 ± 0.4
			48-72	576	-	241 ± 14	<7 ± 1	2.9 ± 0.8
			72-96	577	-	593 ± 26	<9 ± 1	<1.0 ± 0.1
			96-120	578	-	739 ± 37	<11 ± 1	<1.1 ± 0.1
			120-132	579	27.8	2 ± 1	4 ± 2	1.1 ± 0.4
			168-192	580	23.0	1 ± 1	<2 ± 1	1.5 ± 0.4
			192-216	581	20.7	1 ± 1	<1 ± 1	1.5 ± 0.4
148	8121	5512 TP	0-6	247	23.3	2 ± 1	<2 ± 1	1.4 ± 0.4
149	8535	6735 WE	0-6	243	34.5	17 ± 2	<2 ± 1	1.6 ± 0.4
			12-24	539	26.9	1 ± 1	6 ± 2	1.6 ± 0.4
152	8610	6591 WE	0-6	242	23.7	3 ± 1	6 ± 2	1.6 ± 0.4
			12-24	538	23.4	2 ± 1	<4 ± 2	<1.6 ± 0.2
153	8621	6400 WE	0-6	244	33.1	3 ± 1	<2 ± 1	1.9 ± 0.4
			84-96	540	19.7	1 ± 1	7 ± 2	2.0 ± 0.4
155	7653	8857 M	0-6	237	12.1	1 ± 1	5 ± 2	1.7 ± 0.4
			24-36	524	12.1	1 ± 1	5 ± 2	1.3 ± 0.4
156	7569	9213 M	0-6	241	17.7	1 ± 1	4 ± 2	1.3 ± 0.4
			12-18	537	15.3	1 ± 1	6 ± 2	1.3 ± 0.4
157	7627	8479 M	0-6	227	42.8	1 ± 1	<2 ± 1	1.8 ± 0.4
158	7500	9051 M	0-6	240	18.7	1 ± 1	13 ± 2	3.3 ± 0.8
			24-36	536	15.3	1 ± 1	13 ± 2	2.8 ± 0.6
159	7713	8366 M	0-6	226	31.1	2 ± 1	7 ± 4	2.4 ± 0.6
160	7834	8856 M	0-6	232	20.9	1 ± 1	9 ± 2	2.6 ± 0.6
			36-48	520	18.0	2 ± 1	<6 ± 2	<1.6 ± 0.2
161	7757	9134 M	0-6	239	22.1	11 ± 1	7 ± 4	1.6 ± 0.4
162	7953	8817 M	0-6	233	6.2	1 ± 1	12 ± 2	2.6 ± 0.6
			48-60	521	15.8	22 ± 2	<2 ± 1	2.0 ± 0.6
163	7927	8462 M	24-30	504	31.2	<2 ± 1	<22 ± 1	<1.8 ± 0.4
			30-66	505	28.4	1 ± 1	5 ± 2	1.5 ± 0.4
			66-99	506	18.4	1 ± 1	5 ± 2	1.6 ± 0.4
			99-120	507	23.3	1 ± 1	5 ± 2	1.6 ± 0.4
164	8098	9079 M	2-8	238	44.5	1 ± 1	6 ± 2	1.9 ± 0,4
			24-36	525	15.6	1 ± 1	13 ± 4	3.5 ± 0.8
165	8161	9003 M	0-6	234	68.0	1 ± 1	7 ± 4	2.5 ± 0.6
			48-60	522	16.1	1 ± 1	7 ± 2	1.4 ± 0.4

UMTRA- LKV 4005
TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

Sheet 30

FEB 6·19·85
WYL 6/25/85

Table I-1 (continued)

Hole No.	Grid Coordinates North	Grid Coordinates East	Depth (in.)	MEE No.	Moisture (%)	Concentration Ra-226 (pCi/g)	Concentration Thorium (ppm)	Concentration Potassium (%)
166	8187	8563 M	0–6	231	6.8	1 ± 1	10 ± 2	2.5 ± 0.6
			48–60	519	18.6	<1 ± 1	<5 ± 2	<1.4 ± 0.2
167	8416	8802 M	0–6	229	18.2	2 ± 1	5 ± 2	1.5 ± 0.4
			24-28	508	24.4	<1 ± 1	<21 ± 1	<1.3 ± 0.2
			28-48	509	27.5	<1 ± 1	4 ± 2	1.3 ± 0.4
			48-54	510	26.3	<1 ± 1	<20 ± 1	<7.6 ± 0.3
			54-94	511	21.5	1 ± 1	6 ± 2	1.1 ± 0.4
			94-100	512	19.1	<2 ± 1	<19 ± 1	<0.8 ± 0.2
			100-104	513	25.1	<3 ± 1	<21 ± 1	<1.0 ± 0.2
			104-120	514	23.4	<1 ± 1	<1 ± 1	1.2 ± 0.4
			120-136	515	24.8	1 ± 1	5 ± 2	1.1 ± 0.2
			136-139	516	25.5	<4 ± 1	<3 ± 2	<1.3 ± 0.2
			139-162	517	22.2	1 ± 1	5 ± 2	1.3 ± 0.4
			162-174	518	2.8	5 ± 1	<17 ± 1	<1.3 ± 0.2
168	8246	9004 M	0–6	236	14.3	1 ± 1	9 ± 2	2.7 ± 0.6
169	8052	8870 M	0–6	235	31.2	1 ± 1	13 ± 2	3.0 ± 0.6
			36–48	523	14.8	1 ± 1	<1 ± 1	1.1 ± 0.2
170	8373	8916 M	0–6	230	8.6	1 ± 1	10 ± 2	1.9 ± 0.4
171	8491	8672 M	0–6	228	15.5	1 ± 1	6 ± 2	1.7 ± 0.4
172	10065	4302 EP	96-100	093	-	1 ± 1	<5 ± 4	<0.3 ± 0.2
			100-110	094	-	<1 ± 1	<4 ± 1	<0.6 ± 0.1
			110-128	095	-	<1 ± 1	<3 ± 1	<0.3 ± 0.2
			128-138	096	-	<1 ± 1	<3 ± 1	<0.6 ± 0.2
			138-144	097	-	<1 ± 1	<3 ± 1	<0.4 ± 0.1
173	9818	4505 EP	102-108	500	53.4	<1 ± 1	<8 ± 4	<2.6 ± 0.1
			108-140	501	53.0	<1 ± 1	<1 ± 1	<0.3 ± 0.1
			140-147	502	22.9	1 ± 1	6 ± 2	2.1 ± 0.6

DIFFUSION COEFFICIENT

1. Sampling Locations:
   Main Pile - Southern half (3 samples)
   Evaporation Pond (Pond. No. 3)

2. Material Types
   Slimes
   Mixed Sands & Slimes
   Sand
   Ash (evaporation pond raffinate)

3. Depths of Samples
   4.5 - 5.5' (slimes)
   5' - 6' (mixed)
   5.5 - 6.5 (sands)
   0 - 15" (ash)

4. Moisture Contents

14-32% (slimes)	(saturation 0.32-0.70)
15-28% (mixed)	(" 0.36-0.78)
14%-20% (sands)	(" 0.28-0.41)
30-64% (ash)	(" 0.28-0.57)

5. Discussion of Choice of D for Design

   a. Sampling was not extensive, either in depth or areal distribution of sample locations. Considering 1) the average depth of the tailings (including cover) is 7 feet (Ref. 4, p.4) and 2) the large body of data for diffusion coefficients (Ref. 2), the sampling could be considered representative of the southern half of the tailings pile. The southern half of the pile could be assumed to be representative of the entire pile, unless information to the contrary is forthcoming. The tailings pile (including cover) represents about 2/3 of the total volume of material to be placed in the embankment (see sheet 4, "d.")

b. Due to the limited sampling and test results, diffusion coefficients chosen from the test data should be conservative relative to the average value or the value from a "best-fit" curve.

c. The tailings pile is to be placed before other, lesser contaminated materials (including evaporation pond materials. Therefore, for the upper layer(s) of contaminated material, the higher diffusion coefficient of the ash or the tailings should be used (assuming the diffusion coefficient of the tailings is representative of non-ash, lesser contaminated materials) (see d below, also)

d. Properties of the evaporation pond material will be adequate to describe the upper tailings layer in the embankment, since the evaporation pond material (including the pond berms) constitute ±85% of the quantity of lesser-contaminated material to be placed in the top of the embankment (see sheet 12)

e. Diffusion coefficients will be chosen based on the moisture saturation due to the estimated placement density and long-term moisture content (see sheets 12 through 31).

INTERNATIONAL ENGINEERING COMPANY, INC.

Project UMTRA-LKV Contract No. 4805 File No.
Feature EMBANKMENT DESIGN Designed FBG Date 6-27-85
Item TAILINGS PROPERTIES FOR RADON BARRIER DESIGN Checked WYL Date 6/28/85

Sheet 33

6. Diffusion Coefficients of Tailings (Use Two Layers)

a. Upper Layer:

1) Long-Term Moisture - Use 15 bar moisture content for long-term conditions, which results in $m_r = 0.23$ (Sheet 31 This value is justified by a) limited sampling, where only one sample was characterized and b) Ref. 2 estimate of long-term moisture content gave a moisture content greater than that found in samples taken under very wet site conditions.

2) Diffusion Coefficient - Based on limited sampling, use curve from Ref. 2 formula and $p = 0.71$ to find D (instead of using data for single sample)(see sheet 35). The site-specific test results for the one sample are used to indicate that the diffusion coefficient should not be greater than the curve value (using Ref. 2 and in-place $p = 0.71$).

$\therefore D = 0.044 \ cm^2/sec$ (Sheet 35)

b. Lower Layer:

1) Long-Term Moisture: Estimates of m_r by a) Ref. 2 (NUREG/CR-3533) and b) in the RAP (Ref. 5) (see sheet 37) appear reasonable relative to m_r for samples taken under very wet site conditions. The lower tailings also will not have the unusually low density and high porosity in-place that the evaporation pond materials will have. Use $m_r = 0.47$ for design.

2) Diffusion Coefficient: The diffusion coefficient of the lower tailings will have less effect on the site radon flux than the coefficient of the upper layer. $\therefore$ Test data for site samples and Ref. 2 relationship for D are nearly equal at $m_r = 0.47$ (sheet 37.)

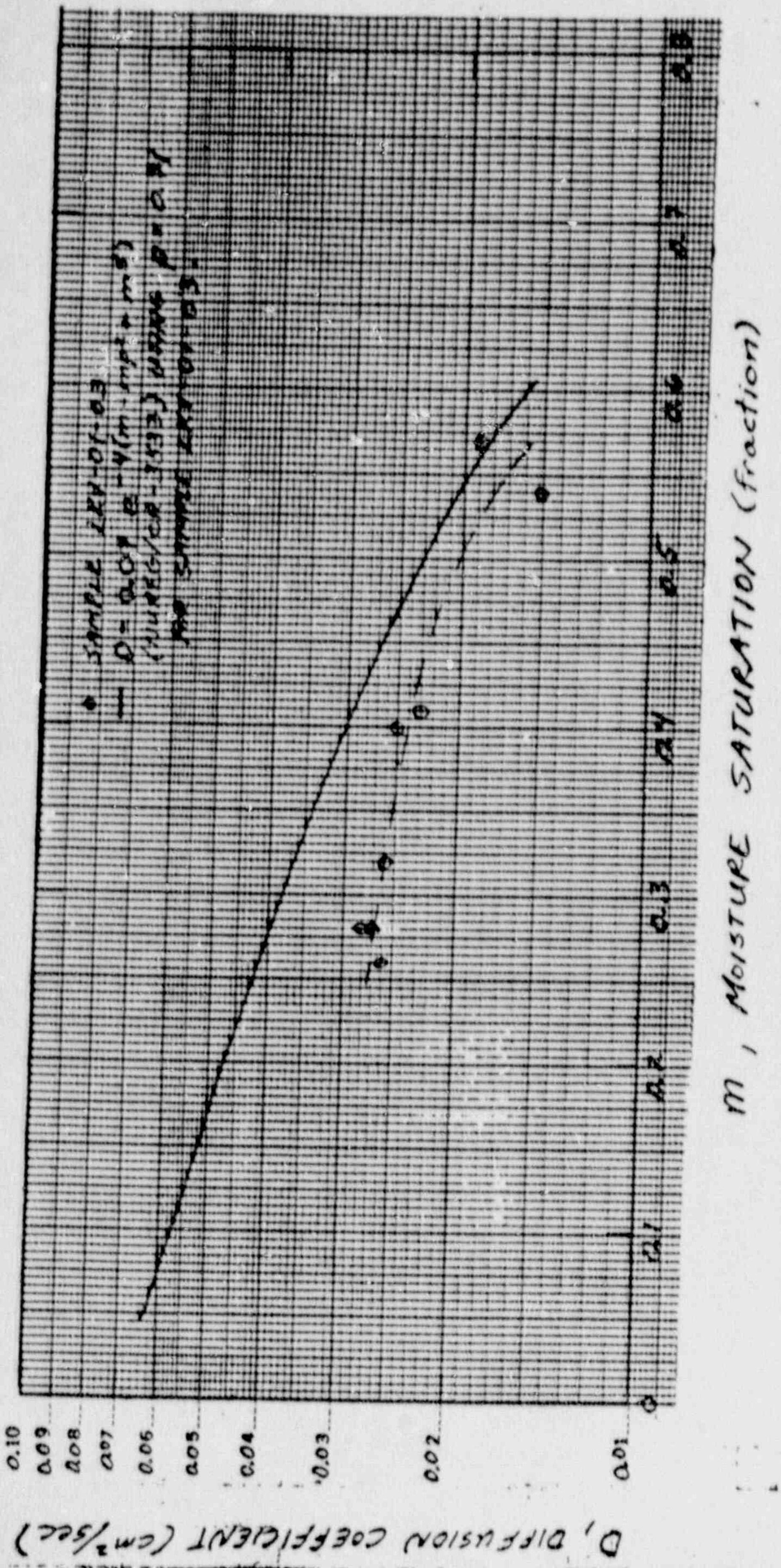
$\therefore D = 0.017 \ cm^2/sec$ (sheet 37)

INTERNATIONAL ENGINEERING COMPANY, INC. Sheet 35

Project UMTRA-LEY Contract No. 4005 File No.

Feature EMBANKMENT DESIGN Designed FCG Date 6-19-85

Item TAILINGS PROPERTIES FOR RADON BARRIER DESIGN Checked WYL Date 6/20/85



DIFFUSION COEFFICIENT FOR EVAPORATION POND MATERIALS

UMTRA-LKV 4005
TAILINGS PROPERTIES FOR RADON
BARRIER DESIGN

Sheet 36

Chk. FBG 6-17-85

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 5 OCT 1984

CONTRACT C46-2e

BY BJB/KKN

• BORING LOCATION N-9200/E-4400, RAFFINATE, EVAP. POND 3 (@ 0-1.5 (NOT BORING LKV-01-03!)

0-15"

SAMPLE IDENTIFICATION Lakeview Tailings - LKV-01-03 0.15' (ash) •

SUBMITTED BY Jacobs Engineering Group

DATE RECEIVED 10 SEP 1984

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION* (Mp/P)	COMMENTS Porosity
LKV-01-3	30.1	0.660	2.8×10^{-2}	0.28	0.70
"	30.5	.618	2.6×10^{-2}	.26	.72
"	32.0	.636	2.7×10^{-2}	.28	.71
"	36.4	.626	2.6×10^{-2}	.32	.72
"	45.2	.630	2.5×10^{-2}	.40	.72
"	45.3	.647	2.3×10^{-2}	.41	.71
"	60.7	.639	1.5×10^{-2}	.54	.71
"	63.7	.635	1.9×10^{-2}	.57	.72

*BASED ON A SPECIFIC GRAVITY OF 2.23 g/cm^3.

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RAE

* See Ref. 1, January 1985 correspondence RRager to JSmith (both Jacobs Weston Team) for original specific gravity and compaction test results for this sample that correspond with Table 4.13, Ref. 4.

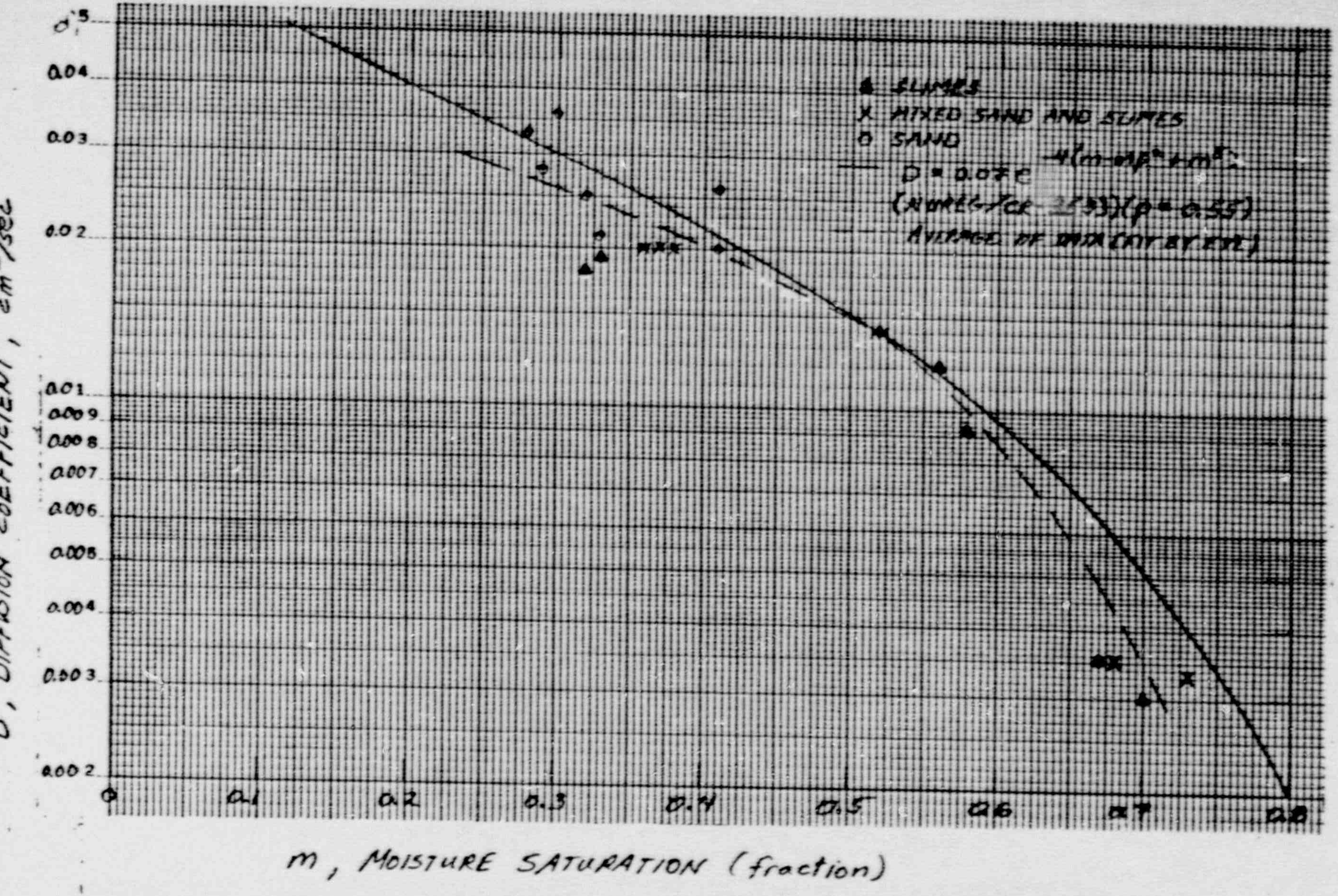
Radiological Data (Ref. 1)

INTERNATIONAL ENGINEERING COMPANY, INC.

Project UMTRA - LKY
Feature EMBANKMENT DESIGN
Item TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

Contract No. 4005
Designed FBG
Checked WYL

Sheet 13
File No.
Date 6-21-85
Date 6/20/85



DIFFUSION COEFFICIENT FOR TAILINGS FROM MAIN PILE

UMTRA-LKV 4005
TAILINGS PROPERTIES FOR
RADON BARRIER DESIGN

Sheet 3B1.

Ckd. FBG 6-14-85

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 5 OCT 84

CONTRACT C46-2e

BY BJB/KKN

SAMPLE IDENTIFICATION Lakeview Tailings LKV01-7 4.5-5.5' (slime) a

SUBMITTED BY Jacobs Engineering Group DATE RECEIVED 10 SEP 84

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm^3)	RADON DIFFUSION COEFF. (cm^2/s)	SATURATION[a] (Mp/P)	COMMENTS porosity
LKV-01-7	14.2	1.21	1.8×10^{-2}	0.32	0.53
"	14.4	1.21	1.9×10^{-2}	.33	.53
"	24.9	1.20	1.2×10^{-2}	.56	.54
"	25.9	1.20	9.6×10^{-3}	.58	.54
"	29.4	1.21	3.5×10^{-3}	.67	.53
"	32.0	1.19	3.0×10^{-3}	.70	.54

[a] BASED ON A SPECIFIC GRAVITY OF 2.59 g/cm^3.

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RAE

Radiological Data (Ref. 1)

UMTRA - LKV 4005
TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

Sheet 39

Ckd. FBG 6-14-85

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 5 OCT 84

CONTRACT C46-2e

BY BJB/KKN

SAMPLE IDENTIFICATION Lakeview Tailings LKV01-10 5.6' (mixed) x

SUBMITTED BY Jacobs Engineering Group DATE RECEIVED 10 SEP 84

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm³)	RADON DIFFUSION COEFF. (cm²/s)	SATURATION* (Mp/P)	COMMENTS porosity
LKV01-10	14.7	1.23	2.0×10^{-2}	0.36	0.50
"	15.2	1.23	2.0×10^{-2}	.37	.50
"	15.8	1.22	2.0×10^{-2}	.38	.50
"	21.4	1.22	1.4×10^{-2}	.52	.50
"	22.0	1.21	1.4×10^{-2}	.52	.51
"	29.7	1.23	3.3×10^{-3}	.73	.50
"	27.8	1.23	3.5×10^{-3}	.68	.50

*BASED ON A SPECIFIC GRAVITY OF 2.46 g/cm³.

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RAE

Radiological Data (Ref. 1)

RAE-FORM 46b

UMTRA-LKV 4005
TAILINGS PROPERTIES FOR
RADON BARRIER DESIGN

Sheet 40

Ckd. FBG 6-14-85

Rogers & Associates Engineering Corporation

REPORT OF RADON DIFFUSION COEFFICIENT MEASUREMENTS (TIME-DEPENDENT DIFFUSION TEST METHOD RAE-SQAP-3.6)

REPORT DATE 5 OCT 84

CONTRACT C46-2e

BY BJB/KKN

SAMPLE IDENTIFICATION Lakeview Uranium Mill Tailings LKV01-5 5.5-6.5' (sand) •

SUBMITTED BY Jacobs Engineering Group DATE RECEIVED 10 SEP 84

SAMPLE NUMBER	MOISTURE (DRY WT.%)	DENSITY (g/cm³)	RADON DIFFUSION COEFF. (cm²/s)	SATURATION* (Mp/P)	COMMENTS porosity
LKV-01-5	13.7	1.10	3.3×10^{-2}	0.28	0.55
•	14.3	1.11	2.8×10^{-2}	.29	.54
•	14.8	1.11	3.6×10^{-2}	.30	.54
•	15.9	1.10	2.5×10^{-2}	.32	.55
•	16.8	1.09	2.1×10^{-2}	.33	.55
•	20.0	1.11	2.0×10^{-2}	.41	.54
•	20.2	1.11	2.6×10^{-2}	.41	.54

*BASED ON A SPECIFIC GRAVITY OF 2.43 g/cm³.

RAE

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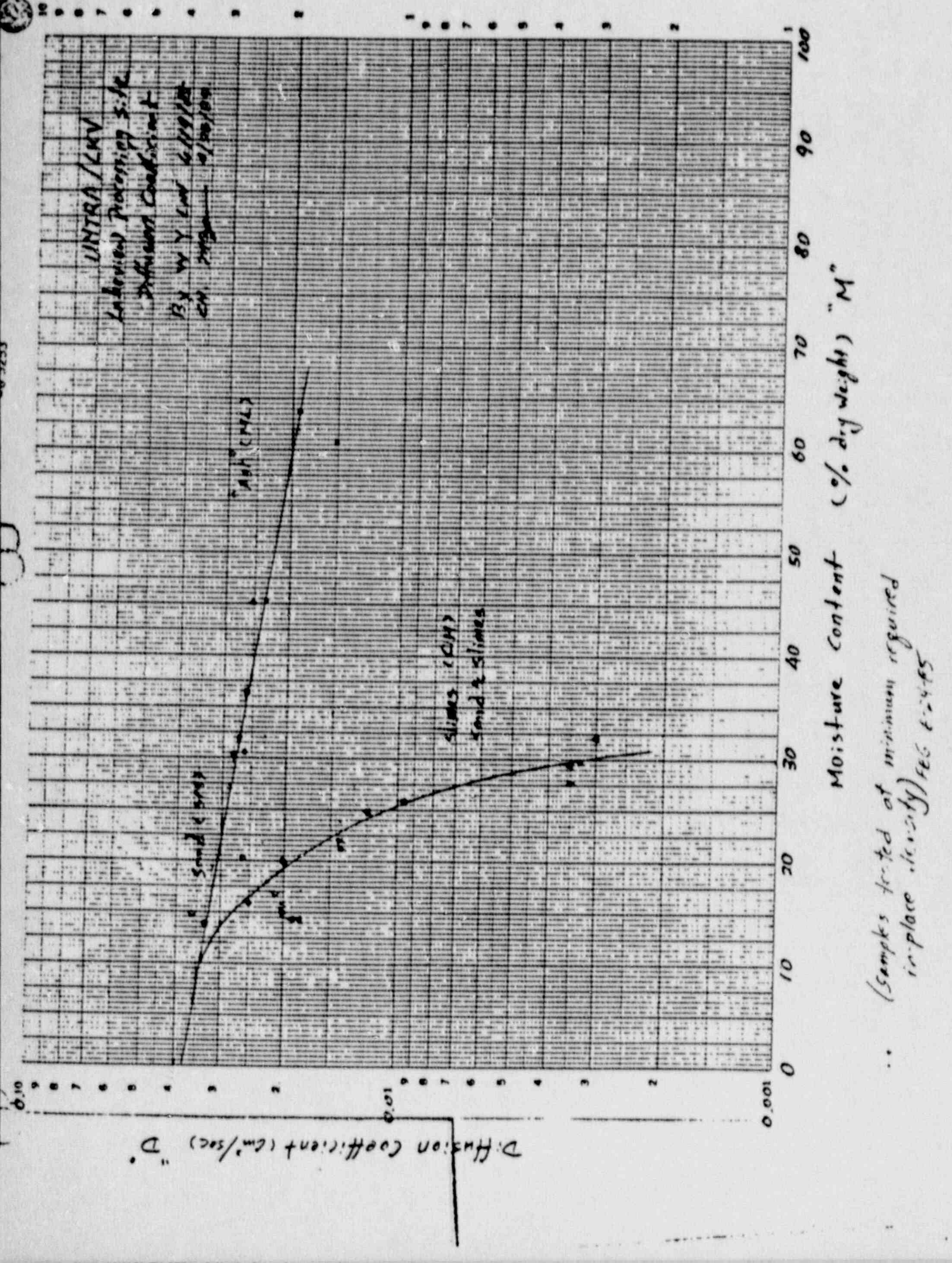
Radiological Data (Ref. 1)

RAE-FORM 46b

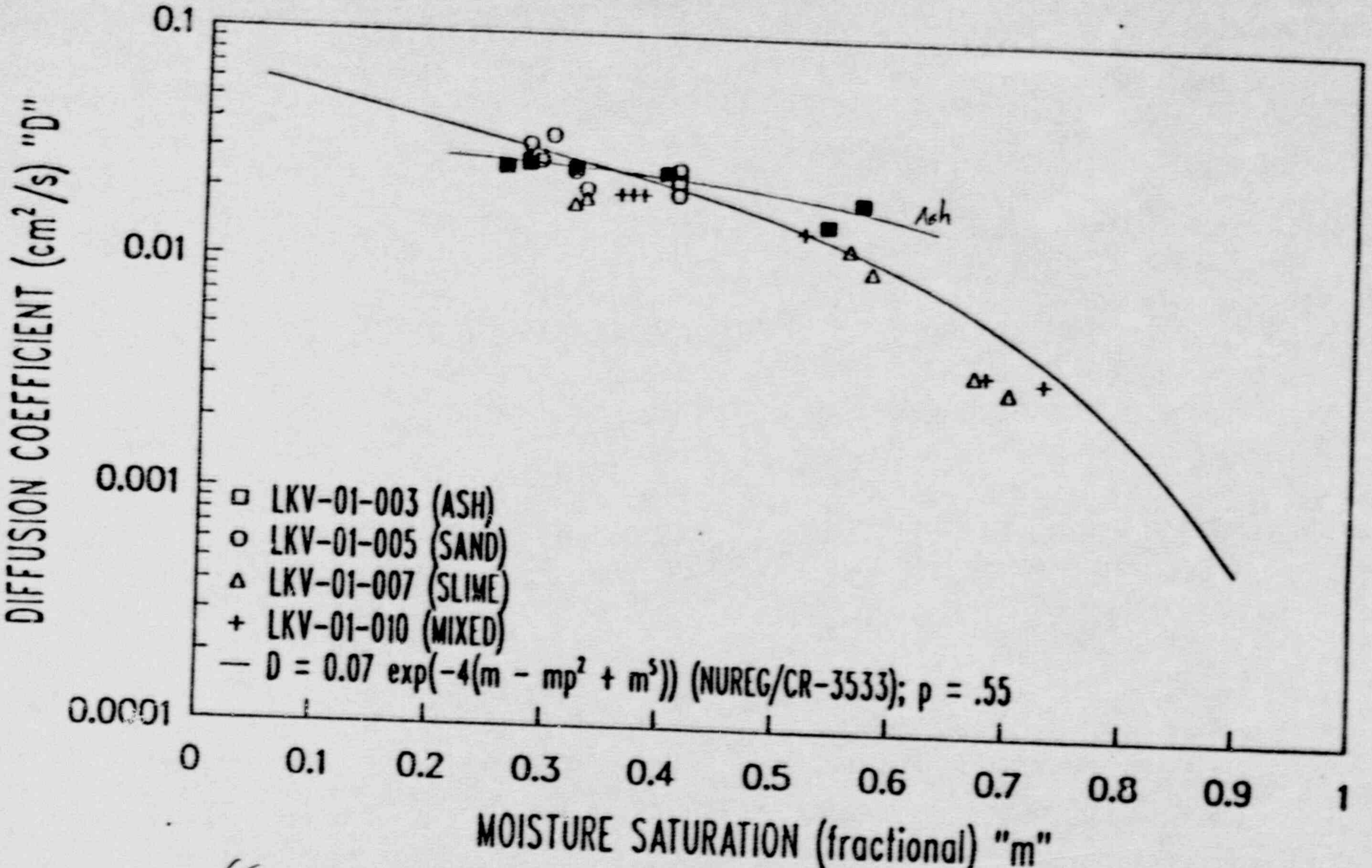
UMTRA-LKV 4005
TAILINGS PROPERTIES FOR
RADON BARRIER DESIGN

Sheet 42



UMTRA - LKV 4005
TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

LAKEVIEW TAILINGS



(Same plot as Ref. 4, Figure 4.18)

Figure 1

FBG 6-24-85

Sheet 41

ADDENDUM 1.0

Calculation Cover Sheet

Contract No. 4005-12 **Discipline** ESCUP

Calc. No. 13-791-26-~~00~~ 01
No. of Sheets (Calc): 27

Project UMTRA - LKV

No. of Attachment Sheets: 12

Feature Radon Barrier

Item Reevaluation Using Field Measured Parameters.

Sources of Data

(1) UMTRA-LKV: 'Overview of Radon Barrier Thickness Calculations for the Lakeview Disposal Site (3/18/88)
MKE Doc. No. 4005-LKV-R-01-02344-00 (with four appendices)*

(2) UMTRA-LKV: 'Compaction Test Logs for Thorium Contaminated and Tailings.' (10/21/88)
MKE Doc. No. 4005-LKV-R-02-02937 & 02938.

Sources of Formulae & References

(3) Rogers, Nielson & Kalkwarf (1984): 'Radon Attenuation Handbook for Uranium Mill Tailings Cover Design', US Nuclear Regulatory Comm, NUREG/CR-3533.

(4) UMTRA Design Procedures, MKE DOC. NO. 4005-GEN-G-01-00571-06 July 1983, Revised January 1988.

Rev. 1
(5) UMTRA-LKV: 'Processing Site Characterization Report', Draft, DOE March 1985. MKE Doc. No 4005-LKV-R-03-00150-00
(6) UMTRA-LKV: 'Information to Bidders', March 1986
MKE Doc. No. 4005-LKV-R-01-00732-00

* Sheets 15 through 18 & Appendix 1 in Ref. (1) are attached to this calculation.

Preliminary Calc. ☐ Final Calc. ☑ Supersedes Calc. No. ———

Rev No	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
1	Minor revisions Sh. 1, 2, 4, 5, 7, 11 & 25; small notes on A1 - A12	AEHian	11/30/88	[illegible]	[illegible]	[illegible]	11/30/88
C	——— ———	AEHian RH Prudi[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 1/25
Project UMTRA -LKV
Contract No. 4005-17
File No. 791
Feature Radon Barrier Re-evaluation
Designed ABH
Date 11-9-88
Item
Checked MSP
Date 11-9-88

Rev. 1 [ABH 11-29-88.
msp 11-30-88

Contents

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - LKV
Feature Radon Barrier Re-Evaluation
Item

Contract No. 4605-17
Designed ABH
Checked MSP

Sheet 2/25
File No. 791
Date 11-9-88
Date 11-9-88

Rev. 1 { ABH 11/28/88
MSP 11/30/88

Purpose

To evaluate the adequacy of the as-built radon barrier soil, field measured density, moisture and Ra-concentrations.

Method

1. RAECOM 'model' computer code is used for this evaluation (Ref. 3)
2. Diffusion coefficients, and emanating fractions ~~and source terms~~ HTay MSP for the different materials are kept the same as in the final calculation (See attached Table 1 from Ref. 1 - Sheet 24 of 25 this calculation) and Sh. 4a of 25) Rev 1 MSP
3. Radon Concentrations are obtained from MK-F/CNSI's core sampling on the disposal cell at LKV site. Measured Ra- and Th- concentrations have been used to arrive at the expected maximum Ra-concentrations over the design life ~~[illegible]~~ HTay MSP. For the upper 10 feet of Thorium Contaminated / Select materials and the underlying ~~[illegible]~~ HTay MSP tailings and non-select contaminated materials the density and moisture parameters and the Radium concentrations are averaged by 2-ft layers. Porosities are computed from the bulk density and the measured specific gravity of solids (See Sheet 25 of 25)

Project UMTRA - LKV
Feature Radon Barrier Re-evaluation
Item
Contract No. 4005-17
Designed ABH
Checked Mrp
Sheet 3/25
File No. 791
Date 11/9/68
Date 11-9-88

Conclusion

The results of the evaluation show that using field measured densities, moistures and Radium contents of the tailings materials and conservative estimates of emanating fractions and diffusion coefficients, the calculated surface radon flux at the disposal site of 7.5 $pCi/m^2/s$ meets the EPA standard ($< 20 pCi/m^2/s$).

Project UMTRA – LKV
Feature Radon Barrier Re.evaluation
Item
Contract No. 4505-17
Designed ABH
Checked MSP
Sheet 4/25
File No. 791
Date 11-8-88
Date 11-8-88
Rev.1 { ABH 11/28/88
Rev.1 { MSI 11-30-88

Summary of Parameters

Radon Barrier:

Thickness (as designed) = 18 inches (45.7 cm)

Bulk density = 1.20 g/cc [≈ 74.9 pcf]

Diffusion Coefficient = 0.01 cm^2/s

Select Contaminated (top 10 feet)

Thickness (as placed) = 10 feet.

Bulk density = 52.6 to 58.9 pcf [averaged in each 2-ft layer]

Inplace moisture = 54.2 to 59.9 % ["]

Diffusion Coefficient = 0.10 cm^2/s [conservatively assumed](1)

Emanating fraction = 0.40 to 0.49 [-- " based on measured values](2

Ra-concentration = 5.3 to 11.5 pCi/g [averaged in ea. 2-ft lyr]

Tailings & Non-Select Contaminated (lower 12 feet)

Thickness (varies) : 12 feet used in RAECOM

Bulk density = 56.8 to 76.8 pcf [averaged in each 2-ft layer]

Inplace moisture = 40.9 to 58.0 % ["](3

Diffusion Coefficient = 0.017 cm^2/s [conservatively assumed]

Emanating fraction = 0.27 [cons. estimated based on measured valu

Ra-concentration = 17.3 to 28.3 pCi/g [averaged in each 2-ft lyr]

REV 1

(1) Ref.3, Page 3-7 shows that the largest diffusion coefficient values measured are less than the values assumed.

(2) Ref.1, App.1, Sheet 17, Boring LK-DS-16 shows THAT the largest emanating fraction WAS assume FOR THE THORIUM CONTAMINATED MAT'L.

(3) Calculation at lower water content (Sheets 6B and 6C) indicates that for a fixed diffusion coefficient, flux decreases as water content decreases (due to reduction in radon concentration gradient caused by increase in void space) so that end-of-construction water content is conservative. (if water increases with time, diffusion coefficient will decrease (Ref. 3, pages 3-7)

11/28 MSP 11.30

MTRA - LKV

Radon Barrier Re-evolution

5/25

ABH/11-9-86

MSP - 11-9-88

Rev. 1 { ABH 11/28/88.
MSP 11-30-88

```
MKE                                                                     Page    1
RAECOM Program                          Input data                      9-NOV-88

Heading                 UMTRA-LKV  RADON BARRIER RE_EVAL(13-791-16-RE) "LYR AVE'D X2FT" 11/09B
Layers                         12
Initial flux                0.000
Ambient rn                  0.700
Optimized layer                 0
Surface flux limit         20.000
Precision                  0.0010


LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY   SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3          PCI/CM3-SEC  % DRY WT
===== =========  ==========  ========  ====== =========  ============   ===========  ========
   1       61.0     0.01700     0.550    25.9      0.27          1.15     0.0000307   43.9000
   2       61.0     0.01700     0.590    17.3      0.27          1.01     0.0000168   55.0000
   3       61.0     0.01700     0.520    23.3      0.27          1.19     0.0000302   41.5000
   4       61.0     0.01700     0.510    19.3      0.27          1.23     0.0000264   40.9000
   5       61.0     0.01700     0.580    22.3      0.27          1.05     0.0000229   51.0000
   6       61.0     0.01700     0.630    28.3      0.27          0.91     0.0000232   58.0000
   7       61.0     0.10000     0.580     6.6      0.40          0.94     0.0000090   54.5000
   8       61.0     0.10000     0.620     5.3      0.40          0.84     0.0000060   59.9000
   9       61.0     0.10000     0.600     8.7      0.40          0.88     0.0000107   58.6000
  10       61.0     0.10000     0.610    11.5      0.40          0.86     0.0000136   59.1000
  11       61.0     0.10000     0.590    11.0      0.49          0.92     0.0000176   54.2000
  12       45.7     0.01000     0.530     0.0      0.00          1.20     0.0000000   26.7000
```

└ 18" thick cover

```
PROGRAM RAECOM, VERSION 1.1

UMTRA-LKV  RADON BARRIER RE_EVAL(13-791-16-RE) "LYR AVE'D X2FT" 11/09B

********** I N P U T   P A R A M E T E R S **************

NUMBER OF LAYERS :                       12
RADON FLUX INTO LAYER 1 :                 0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :             0.700     PCI/LITER

LAYER 2 EXCEEDS SATURATION.  MOISTURE CHANGED FROM  0.550 TO  0.528


LAYER 3 EXCEEDS SATURATION.  MOISTURE CHANGED FROM  0.415 TO  0.397


LAYER 4 EXCEEDS SATURATION   MOISTURE CHANGED FROM  0.409 TO  0.382


LAYER 5 EXCEEDS SATURATION   MOISTURE CHANGED FROM  0.510 TO  0.506


LAYER 7 EXCEEDS SATURATION   MOISTURE CHANGED FROM  0.545 TO  0.506
```

[Note: The RAECOM program assumes a specific gravity of 2.70, causing 0.1 to ~~2.0~~ 3.9% reduction in moisture content used. As shown in attached supplemental runs — sheets 6B & 6C this causes a slight ~~increase~~ decrease in radon flux of about 0.33 pCi/m²/s (compare sheets 6A & 6.

REV 1 → [The effect is small, but indicates the end-of-construction flux would be ~ 0.33 pCi/m²/s greater than that calculated on sheet 6A. This adjustment is therefore shown on Sh. 6 A] ABH 11/28 MSP 11-30

UMTRA - LKV
Radon Barrier Re-evaluation.

6/25

ABH / 11-9-88

MSP / 11-9-88

Rev. 1 { ABH 11/28/88

```
LAYER 8 EXCEEDS SATURATION.  MOISTURE CHANGED FROM  0.599 TO  0.598


LAYER 9 EXCEEDS SATURATION.  MOISTURE CHANGED FROM  0.586 TO  0.550


LAYER10 EXCEEDS SATURATION.  MOISTURE CHANGED FROM  0.591 TO  0.574


LAYER11 EXCEEDS SATURATION.  MOISTURE CHANGED FROM  0.542 TO  0.528


BARE SOURCE FLUX (J0) FROM LAYER 1 :  8.968     PCI/M2/SEC

LAYER  THICKNESS        DIFF COEFF      POROSITY        SOURCE        MOISTURE
          (CM)          (CM2/SEC)                   (PCI/CM3/SEC) (DRY WT. PERCENT)

  1        61.          1.7000E-02       0.5500       3.0706E-05        43.90
  2        61.          1.7000E-02       0.5900       1.6792E-05        52.76   (-2.2)
  3        61.          1.7000E-02       0.5200       3.0233E-05        39.72   (- 1.8)
  4        61.          1.7000E-02       0.5100       2.6392E-05        38.16   (- 2.7)
  5        61.          1.7000E-02       0.5600       2.2890E-05        50.63   (- 0.4)
  6        61.          1.7000E-02       0.6300       2.3178E-05        58.00
  7        61.          1.0000E-01       0.5800       8.9851E-06        50.63   (- 3.9)
  8        61.          1.0000E-01       0.6200       6.0317E-06        59.82   (- 0.1)
  9        61.          1.0000E-01       0.6000       1.0718E-05        55.00   (- 3.6)
 10        61.          1.0000E-01       0.6100       1.3619E-05        57.35   (- 1.7)
 11        61.          1.0000E-01       0.5900       1.7650E-05        52.76   (- 1.4)
 12        46.          1.0000E-02       0.5300       0.0000E+00        26.70
```

corrections for over-saturation.

```
***** R E S U L T S   O F   R A D O N   D I F F U S I O N   C A L C U L A T I O N *****

        LAYER   THICKNESS      EXIT FLUX          EXIT CONC.        MIC
                  (CM)       (PCI/M2/SEC)        (PCI/LITER)

          1        61.        1.5558E+00          1.2085E+04       0.2824
          2        61.       -8.6377E-01          1.1248E+04       0.2674
          3        61.        1.1669E+00          1.1154E+04       0.2674
          4        61.        2.4414E+00          9.9312E+03       0.2674
          5        61.        3.8007E+00          8.0711E+03       0.2674
          6        61.        5.9231E+00          6.9732E+03       0.3194
          7        61.        4.9823E+00          5.2679E+03       0.2674
          8        61.        3.2509E+00          4.8655E+03       0.2674
          9        61.        3.5644E+00          4.5213E+03       0.2674
         10        61.        5.2592E+00          4.0830E+03       0.2674
         11        61.        8.7751E+00          3.3622E+03       0.2674
         12        46.        7.1490E+00          3.6085E-01       0.5269
                              0.33               (SEE SH 5)
                              7.48 pCi/m²/s      ← surface exit flux.
```

62/25

ABH 11/10/88
MSI 11-10-88
Rev. 1 { ABH 11/28/88

RUN MADE TO SHOW EFFECT OF USING A LOWER MOISTURE CONTENT
. SEE SH5

```
RNC                                                                  Page   1
RAECOM Program                       Input data                      10-NOV-88

Heading              UMTRA-LKV  RADON BARRIER RE_EVAL(13-791-16-RE) "LYR AVE'D X2FT" 11/10D
Layers                       12
Initial flux              0.000
Ambient ra                0.700
Optimized layer               0
Surface flux limit       20.000
Precision                0.0010

LAYER THICKNESS  DIFFUSION   POROSITY  RA-226 EMANATING  BULK DENSITY  SOURCE TERM  MOISTURE
NO.   CM         CM2-SEC     FRACTION  PCI/G  FRACTION   G/CM3         PCI/CM3-SEC  % DRY WT
===== ========== =========== ========= ====== ========== ============= ============ =========
   1      61.0    0.01700      0.550    25.9     0.27            1.15   0.0000307    43.9000
   2      61.0    0.01700      0.590    17.3     0.27            1.01   0.0000168    50.6000
   3      61.0    0.01700      0.520    23.3     0.27            1.19   0.0000302    37.9000
   4      61.0    0.01700      0.510    19.3     0.27            1.23   0.0000264    35.5000
   5      61.0    0.01700      0.560    22.3     0.27            1.05   0.0000229    50.2000
   6      61.0    0.01700      0.680    20.3     0.27            0.91   0.0000232    58.0000
   7      61.0    0.10000      0.580     6.6     0.40            0.94   0.0000090    46.7000
   8      61.0    0.10000      0.620     5.3     0.40            0.84   0.0000060    59.7000
   9      61.0    0.10000      0.600     8.7     0.40            0.88   0.0000107    51.4000
  10      61.0    0.10000      0.610    11.5     0.40            0.86   0.0000136    55.7000
  11      61.0    0.10000      0.590    11.0     0.40            0.92   0.0000176    51.4000
  12      45.7    0.01000      0.530     0.0     0.00            1.20   0.0000000    26.7000


PROGRAM RAECOM, VERSION 1.1

UMTRA-LKV  RADON BARRIER RE_EVAL(13-791-16-RE) "LYR AVE'D X2FT" 11/10D

********** I N P U T   P A R A M E T E R S ***************

NUMBER OF LAYERS :                        12
RADON FLUX INTO LAYER 1 :                 0.000E+00 PCI/M2/SEC
SURFACE RADON CONCENTRATION :             0.700     PCI/LITER
BARE SOURCE FLUX (JJ) FROM LAYER 1 :      6.968     PCI/M2/SEC


LAYER  THICKNESS       DIFF COEFF      POROSITY       SOURCE        MOISTURE
         (CM)          (CM2/SEC)                  (PCI/CM3/SEC) (DRY WT. PERCENT)

  1       61          1.7000E-02       0.5500      3.0706E-05       43.90
  2       61          1.7000E-02       0.5900      1.6792E-05       50.60   — 2 (2.2)
  3       61          1.7000E-02       0.5200      3.0230E-05       37.90   — 2 (1.8)
  4       61          1.7000E-02       0.5100      2.6392E-05       35.50   — 2 (2.7)
  5       61          1.7000E-02       0.5600      2.2890E-05       50.20   — 2 (0.4)
  6       61          1.7000E-02       0.6800      2.3178E-05       58.00
  7       61.         1.0000E-01       0.5800      8.9931E-06       46.70   — 2 (3.9)
  8       61          1.0000E-01       0.6200      6.0317E-06       59.70   — 2 (0.1)
  9       61          1.0000E-01       0.6000      1.0719E-05       51.40   — 2 (3.6)
 10       61          1.0000E-01       0.6100      1.3619E-05       55.70   — 2 (1.9)
 11       61          1.0000E-01       0.5900      1.7600E-05       51.40   — 2 (1.2)
 12       46.         1.0000E-02       0.5300      0.0000E+00       26.70
```

over corrected

ABH 11/10/88
MSI 11-10-88

```
***** RESULTS OF RADON DIFFUSION CALCULATION *****

 LAYER   THICKNESS        EXIT FLUX            EXIT CONC.          MIC
            (CM)        (PCI/M2/SEC)          (PCI/LITER)

   1        61.          2.0098E+00            1.1271E+04        0.2824
   2        61.          6.1402E-01            1.1401E+04        0.2974
   3        61.          1.2569E+00            1.1374E+04        0.3010
   4        61.          1.9315E+00            1.0956E+04        0.3185
   5        61.          3.5985E+00            7.7702E+03        0.2737
   6        61.          6.1526E+00            6.3971E+03        0.3194
   7        61.          4.7238E+00            5.9279E+03        0.3243
   8        61.          3.2659E+00            4.5240E+03        0.2489
   9        61.          3.2403E+00            4.9763E+03        0.3154
  10        61.          4.8980E+00            4.1400E+03        0.2885
  11        61.          8.3734E+00            3.4356E+03        0.2863
  12        44.          6.8218E+00            3.6680E-01        0.5249
```

7.1490

0.33

compared with sheet 6A.

MORRISON KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA-LKV
Feature Radon Barrier Re-evaluation
Item
Contract No. 4005-17
Designed ABH
Checked MSP
Sheet 7/25
File No. 791
Date 11-9-88
Date 11-9-88

Layer Averaging for Max. Radium Content

[Summary of Results Developed on Sheets 8 & 9]

① Upper 10 feet (Thorium Contaminated / Select)

Layer #	No. of samples	Average Ra Content (pCi/g)	Emanating Fraction	Diffusion Coeff (cm^2/s)
1 (2 ft)	20	11.0	0.49^{a}	0.10
2 (2 ft)	20	11.5	0.40^{b}	
3 (2 ft)	20	8.7		
4 (2 ft)	20	5.3		
5 (2 ft)	20	6.6		

② Lower 12 feet (Tailings and Non-Select Contaminateds)

6 (2 ft)	20	28.3	0.27^{c}	0.017
7 (2 ft)	20	22.3		
8 (2 ft)	20	19.3		
9 (2 ft)	20	23.3		
10 (2 ft)	17	17.3		
11 (2 ft)	15	25.9		

Source of Emanating Fraction:

a. from Ref. 1, App. 1, sheets 23 & 25.

b., c. } from Ref. 1, Table 1 (attached)

Sheet 8/25

Project UMTRA - LKV

Contract No. 4005-17

File No. 701

Feature Radon Barrier Re-evaluation.

Designed ABH

Date 10-26-88

Item Average Ra-concentrations

Checked PS

Date 10-28-88

Ra- Concentrations

Source of Data:

UMTRA - LKV
Radon Barrier Re-evaluation During Construction - C [Ref 1]
MKE Calc. 13-791-16-00/ MKE Doc. No 4005-LKV-C-01-0224-08
Sheets 15-18 (ATTACHED)

Upper 10 feet (Th Contaminated)

Top 2-feet. R_a Conc[pCi/g] $= (2\times4 + 3 + 3\times6 + 1 + 17 + 2 + 6 + 10$
$+ 2\times9 + 54 + 2 + 18 + 10 + 12 + 16 + 24)/20$
$= 10.95$

2nd 2-feet R_a Conc[pCi/g] $= (3 + 10 + 2\times8 + 6 + 3\times7 + 4 + 2 + 19 + 13$
$+ 9 + 24 + 11 + 33 + 15 + 6 + 27 + 10)/20$
$= 11.45$

3rd 2-feet R_a Conc[pCi/g] $= (1 + 4 + 11 + 4 + 10 + 7 + 10 + 8 + 2\times4$
$+ 10 + 15 + 2\times2 + 6 + 19 + 11 + 16 + 19 + 10)/20$
$= 8.65$

4th 2-feet R_a Conc[pCi/g] $= (1 + 3 + 4 + 2 + 11 + 6 + 3 + 3\times4 + 3 + 9$
$+ 5 + 15 + 2 + 6 + 3 + 2 + 9 + 4)/20$
$= 5.25$

5th 2-feet R_a Conc[pCi/g] $= (4 + 2\times3 + 4 + 11 + 7 + 6 + 15 + 5 + 4 + 7$
$+ 11 + 5 + 6 + 4 + 3 + 2 + 12 + 5 + 11)/20$
$= 6.55$

MORRISON- UDSEN ENGINEERS, INC.
A MORRISON KNUDSE PANY

Project UMTRA - LKV.
Feature Radon Barrier Re-evaluation
Item

Sheet 9/25
Contract No. 4015-17 File No. 701
Designed ABH Date 11-8-88
Checked [illegible] Date 11-8-88

lower 12 feet.

6th 2-ft

$$\begin{aligned}\text{Ra Cont [pCi/g]} &= (90.1+69.9+93.1+198.8+13.2+4.8+12.5\\&+11.5+11.8+8.7+8.3+6.2+4.5+5.9\\&+5.5+7.6+5.5+2.3+4.0+3.0)/20\\&= 28.3\end{aligned}$$

7th 2-ft

$$\begin{aligned}\text{Ra Cont [pCi/g]} &= (54.4+88.2+92.1+94.4+16.4+5.9+8.3\\&+7.6+1.6+9.4+9.0+9.0+9.4+2.5\\&+6.6+6.6+4.4+1.8+6.2+2.4)/20\\&= 22.3\end{aligned}$$

8th 2-ft

$$\begin{aligned}\text{Ra Cont. [pCi/g]} &= (105.6+55.3+35.7+43.5+7.0+4.4\\&+7.1+4.4+9.9+7.2+3.7+11.5+15.3\\&+27.9+11.1+6.2+11.1+8.0+6.2+3.8)/20\\&= 19.3\end{aligned}$$

9th 2-ft.

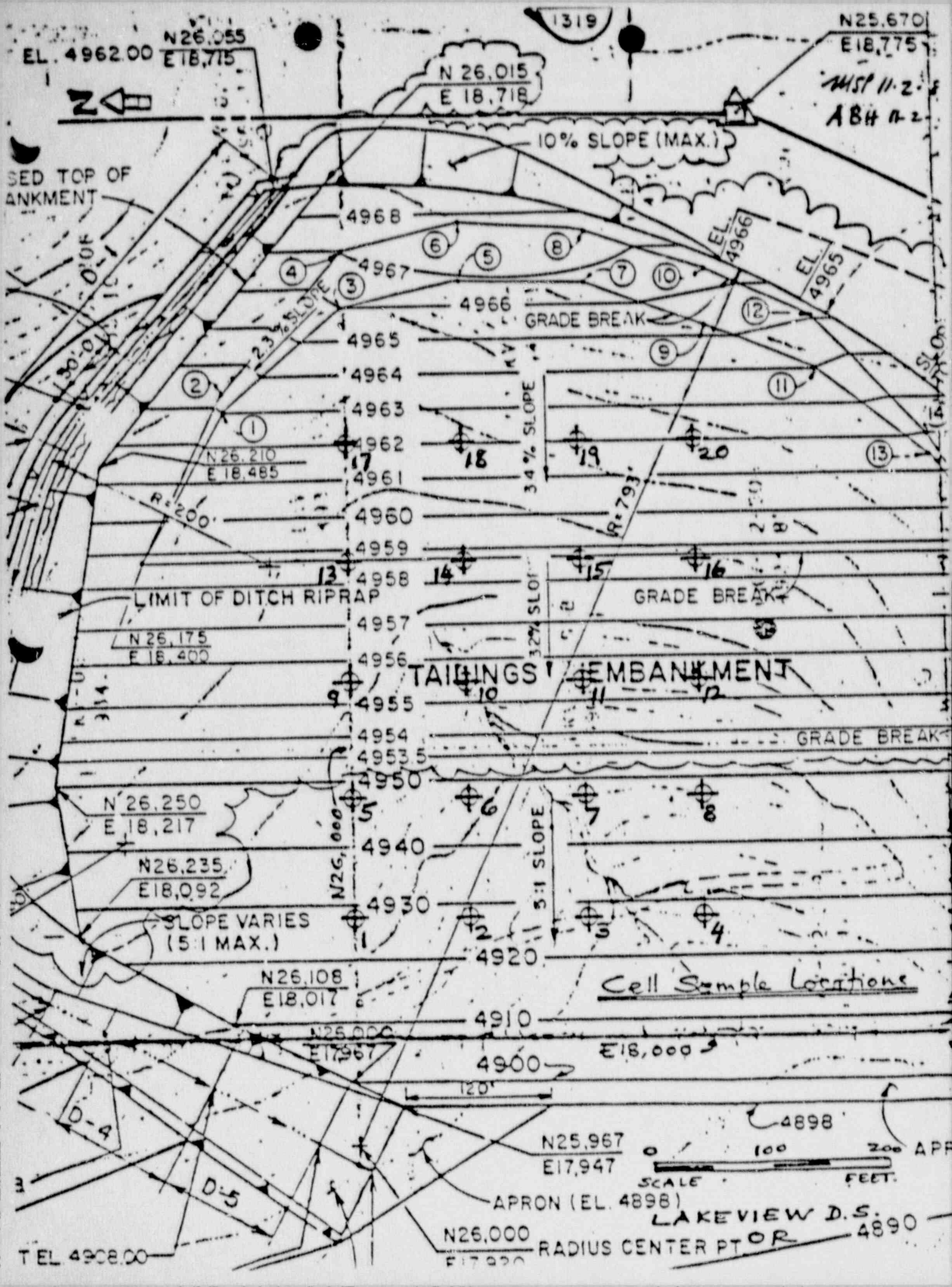
$$\begin{aligned}\text{Ra Cont. [pCi/g]} &= (107.8+69.4+94.4+56.9+6.3+6.3+6.5\\&+6.3+12.5+10.4+5.6+13.2+24.1+8.0\\&+2.8+3.8+9.7+2.2+14.3+4.8)/20\\&= 23.3\end{aligned}$$

10th 2-ft

$$\begin{aligned}\text{Ra Cont [pCi/g]} &= (95.0+81.4+4.4+8.6+7.6+11.9+11.2\\&+4.0+6.6+8.0+11.8+8.0+6.1+5.9\\&+4.5+4.4+13.9)/17\\&= 17.3\end{aligned}$$

11th 2-ft.

$$\begin{aligned}\text{Ra Cont [pCi/g]} &= (85.5+82.4+96.1+42.5+8.6+7.3+4.3\\&+6.7+5.7+5.5+6.2+10.8+6.7\\&+5.7+13.0)/15\\&= 25.9\end{aligned}$$



Cell Sample Locations

LAKEVIEW D.S.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 11/25
Project UMTRA -LKV
Contract No. 4005
File No.
Feature RADON BARRIER DESIGN
Designed RM Rogov
Date 10-31-88
Item MAX. RADIUM CONTENT DURING DES. LIFE
Checked ABHtay
Date 11-1-88

Rev. 1 { ABH 11/28/88
MSP 11-30-88

From Ref. 1/Appendix 1

SAMPLE ID	ELEVATION (ft)	col (3) Ra 226 cont. [pCi/g]	Th-230 cont. [pCi/g]	Max. Ra Cont. [pCi/g] (see Note 1.) (Sh. 15)	
				t = 1000 yrs	actual max
LK-DS-1	4915-4913	90.1	78	85.73	90.1
	4913-4911	54.4	54	54.17	54.4
	4911-4909	105.6	86	98.59	105.6
	4909-4907	107.8	81	98.27	107.8
LK-DS-2	4915-4913	69.9	50	62.84	69.9
	4913-4911	88.2	84	86.59	88.2
	4911-4909	53.5	59	55.33	55.3
	4909-4907	69.4	63	67.05	69.4
LK-DS-3	4115-4913	93.1	67	83.84	93.1
	4913-4911	90.7	95	92.05	92.1
	4911-4909	29.2	48	35.72	35.7
	4909-4907	94.4	37	74.20	94.4
LK-DS-4	4915-4913	198.8	140	177.95	198.8
	4913-4911	93.8	96	94.42	94.4
	4911-4909	25.0	78	43.47	43.5
	4909-4907	44.6	80	56.89	56.9
	4907-4905	95.0	79	89.26	95.0
LK-DS-5	4917-4915	1	36	13.22	13.2
	4915-4913	1	45	16.36	16.4
	4913-4911	6.6	7.9	7.04	7.0
	4911-4909	5.6	7.6	6.29	6.3
	4909-4907	81.4	70	77.29	81.4
	4907-4905	85.5	51	73.32	85.5
LK-DS-6	4935-4933	1	12	4.84	4.8
	4933-4931	1	15	5.89	5.9
	4931-4929	4.44	3.4	4.07	4.4
	4929-4927	6.2	6.6	6.33	6.3
	4927-4925	4.0	5.2	4.41	4.4
	4925-4923	80.2	87	82.4	82.4

{* Actual max = greater of Ra-226 at present [Col (3)] and at t = 1000 years.} REV.

MORRISON KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 12/23
Project UMTRA-LKV
Contract No. 4005
File No.
Feature RADON BARRIER DESIGN
Designed RM Brody
Date 10-31-88
Item MAX. RADIUM CONTENT DURING DES. LIFE
Checked ABH
Date 11-1-88

SAMPLE ID	ELEVATION (ft)	Ra-226 cont. [pCi/g]	Th-230 cont. [pCi/g]	Max Ra. Cont [pCi/g]	
				t=1000 yrs	actual max
LK-DS-7	4945-4943	1	34	12.52	12.5
	4943-4941	1	22	8.33	8.3
	4941-4939	2.8	15	7.06	7.1
	4939-4937	6.5	5.3	6.07	6.5
	4937-4935	7.8	10	8.56	8.6
	4935-4933	96.1	84	91.72	96.1
LK-DS-8	4933-4931	1	31	11.47	115
	4931-4929	1	20	7.63	7.6
	4929-4927	4.4	2.4	3.69	4.4
	4927-4925	5.3	8.1	6.27	6.3
	4925-4923	7.5	7.9	7.63	7.6
LK-DS-9	4941-4939	4.13	26	11.76	11.8
	4939-4937	1	2.6	1.56	1.6
	4937-4935	5.6	18	9.92	9.9
	4935-4933	1	34	12.52	12.5
	4933-4931	8.1	19	11.89	11.9
	4931-4929	42.8	45	43.50	43.5
LK-DS-10	4941-4939	1	23	8.68	8.7
	4939-4937	1	25	9.38	9.4
	4937-4935	4.7	12	7.24	7.2
	4935-4933	1	28	10.43	10.4
	4933-4931	11.2	5.7	9.26	11.2
	4931-4929	8.23	9.2	8.56	8.6

MORRISON KNUDSEN ENGINEERS, INC.
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Project UMTRA-LKV
Feature RADON BARRIER DESIGN
Item MAX. RADIUM CONTENT DURING DES. LIFE

Contract No. 4005
Designed R M Brody
Checked ABH

Sheet 13/25
File No.
Date 10-31-88
Date 11-1-88

SAMPLE ID	ELEVATION (ft)	Ra-226 cont. [pCi/g]	Th-230 cont. [pCi/g]	Max Ra Cont. [pCi/g]	
				t = 1000 yrs	actual max
LK-DS-11	4941-4939	1	22	8.33	8.3
	4939-4937	1	24	9.03	9.0
	4937-4935	3.7	3.5	3.62	3.7
	4935-4933	5.4	5.9	5.57	5.6
	4933-4931	1	9.6	4.00	4.0
	4931-4929	1	19	7.28	7.3
LK-DS-12	4941-4939	1	16	6.24	6.2
	4939-4937	1	24	9.03	9.0
	4937-4935	1	31	11.47	11.5
	4935-4933	10.7	18	13.23	13.2
	4933-4931	1	17	6.59	6.6
	4931-4929	1.54	9.5	4.32	4.3
LK-DS-13	4944-4942	1	11	4.49	4.5
	4942-4940	1	25	9.38	9.4
	4940-4938	1	42	15.31	15.3
	4938-4936	3.7	62	24.05	24.1
	4936-4934	1	21	7.98	8.0
	4934-4932	5.58	8.9	6.73	6.7
LK-DS-14	4944-4942	1	15	5.89	5.9
	4942-4940	1	34	12.52	12.5
	4940-4938	1	78	27.88	27.9
	4938-4936	1	21	7.98	8.0
	4936-4934	1	32	11.82	11.8
	4934-4932	5.73	5.4	5.61	5.7

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - LKV
Feature RADON BARRIER DESIGN
Item MAX. RADIUM CONT. DURING DESIGN LIFE

Contract No. 4005
Designed RMB
Checked ABH

Sheet 14/25
File No.
Date 10-31-88
Date 11-1-88

SAMPLE ID	ELEVATION (ft)	Ra-226 cont. [pCi/g]	Th-230 cont. [pCi/g]	Max. Ra Cont. [pCi/g]	
				t = 1000 yrs	actual max.
LK-DS-15	4944-4942	1	14	5.54	5.5
	4942-4940	1	17	6.59	6.6
	4940-4938	1	30	11.12	11.1
	4938-4936	2.0	4.3	2.80	2.8
	4936-4934	1	21	7.98	8.0
	4934-4932	1	14	5.54	5.5
LK-DS-16	4948-4946	1	20	7.63	7.6
	4946-4944	1	17	6.59	6.6
	4944-4942	1	16	6.24	6.2
	4942-4940	2.35	6.6	3.83	3.8
	4940-4938	5.3	7.7	6.13	6.1
	4938-4936	1	16	6.24	6.2
LK-DS-17	4945-4943	1	14	5.54	5.5
	4943-4941	1.4	10	4.40	4.4
	4941-4939	1	30	11.12	11.1
	4939-4937	1	26	9.73	9.7
	4937-4935	1	15	5.89	5.9
	4935-4933	10.7	11	10.79	10.8
LK-DS-18	4947-4945	1	4.6	2.26	2.3
	4945-4943	1	3.1	1.73	1.7
	4943-4941	1	21	7.98	6.0
	4941-4939	1	4.4	2.19	2.2
	4939-4937	1	11	4.49	4.5
	4937-4935	4.4	11	6.70	6.7

MORRISON NUDSEN ENGINEERS, INC.
A MORRISON KNUDS OMPANY

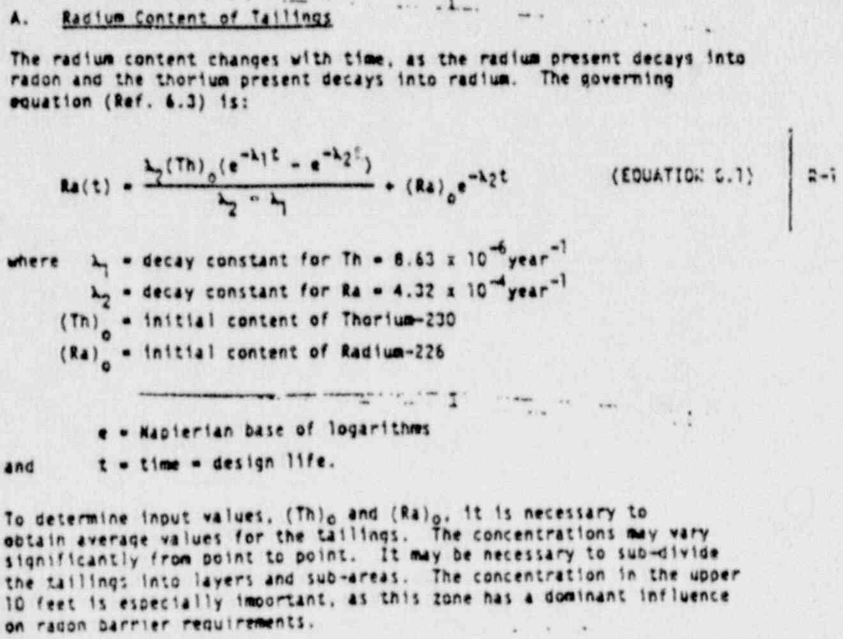
Project UMTRA-LKV
Feature RADON BARRIER DESIGN
Item MAX. RADIUM CONTENT DURING DES. LIFE

Contract No. 4005
Designed R M BRODY
Checked ABH

Sheet 15/2
File No.
Date 10-31-88
Date 11-1-88

SAMPLE ID	ELEVATION (ft)	Ra-226 conc. [pCi/g]	Th-230 conc. [pCi/g]	Max. Ra Cont. [pCi/g]	
				t = 1000 yrs	actual max
LK-DS-19	4947-4945	1	9.6	4.00	4.0
	4945-4943	1	16	6.24	6.2
	4943-4941	1	16	6.24	6.2
	4941-4939	1	39	14.27	14.3
	4939-4937	4.4	3.7	4.15	4.4
	4937-4935	5.6	6.0	5.73	5.7
LK-DS-20	4947-4945	1	6.6	2.95	3.0
	4945-4943	1	6.0	2.74	2.7
	4943-4941	1	9.1	3.83	3.8
	4941-4939	1	12	4.84	4.8
	4939-4937	1	38	13.92	13.9
	4937-4935	6.6	25	13.01	13.0

NOTE 1. The 1,000 year Radium Content was calculated by the following formula from the UMTRA Design Procedure Manual method (Ref. 4) pg 6-1.



A. <u>Radium Content of Tailings</u>

The radium content changes with time, as the radium present decays into radon and the thorium present decays into radium. The governing equation (Ref. 6.3) is:

$$Ra(t) = \frac{\lambda_1 (Th)_o (e^{-\lambda_1 t} - e^{-\lambda_2 t})}{\lambda_2 - \lambda_1} + (Ra)_o e^{-\lambda_2 t} \quad \text{(EQUATION 6.1)}$$

R-1

where λ_1 = decay constant for Th = 8.63×10^{-6} $year^{-1}$
λ_2 = decay constant for Ra = 4.32×10^{-4} $year^{-1}$
$(Th)_o$ = initial content of Thorium-230
$(Ra)_o$ = initial content of Radium-226

e = Napierian base of logarithms
and t = time = design life.

To determine input values, $(Th)_o$ and $(Ra)_o$, it is necessary to obtain average values for the tailings. The concentrations may vary significantly from point to point. It may be necessary to sub-divide the tailings into layers and sub-areas. The concentration in the upper 10 feet is especially important, as this zone has a dominant influence on radon barrier requirements.

Sheet 16/25

Project UMTRA - LKV. Contract No. 4005-17 File No. 791
Feature RADON BARRIER Designed ABH Date 11-9-88.
Item RE-EVALUATION Checked MSP Date 11-9-88

Layer Averaging for Densities and Moisture.
[Summary of Results from Sheets 17 thru 23]

① Upper 10 feet (Thorium Contaminated / Select).

Layer #	Thickness (ft)	No. of Samples	Average Density (γ_d) (pcf)	(g/cc)	Porosity* (frac)	Average Moisture (%)
1	2 ft.	20	57.1	0.92	0.59	54.2
2	"	20	53.8	0.86	0.61	59.1
3	"	20	55.0	0.88	0.60	58.6
4	"	20	52.6	0.84	0.62	59.9
5	"	20	58.9	0.94	0.58	54.5

② Lower 12 feet (Tailings and Non-Select Contaminateds)

6	2 ft.	20	56.8	0.91	0.63	58.0
7	"	20	65.6	1.05	0.58	51.0
8	"	20	76.8	1.23	0.51	40.9
9	"	20	74.3	1.19	0.52	41.5
10	"	18	63.3	1.01	0.59	55.0
11.	"	16	71.8	1.15	0.54	43.9

* Porosity is calculated as follows:

$$\gamma_d = \frac{G_s \gamma_w}{1+e}$$

$G_s = 2.23$ for upper layer (evap. pond material - 'ash')

$= 2.49$ for tailings.

whence $e = \frac{G_s \gamma_w}{\gamma_d} - 1$

and $p = \frac{e}{1+e}$

for values of G_s see table on sheet 25 of 25.

[illegible] 11.4.88
AEH/11-8-8

MK-FERGUSON COMPANY
A MORRISON KNUDSEN COMPANY

INTER-OFFICE CORRESPONDENCE

DATE: November 3, 1988

TO: Jerry Thiers/Alan Htay

FROM: Wm. J. Tate, Jr.

LOCATION: San Francisco, CA

LOCATION: Lakeview, OR

SUBJECT: Thorium Test Data for the Upper 10'-0" and Tailings Data on the Lower 10'-0"

AVERAGED OVER ALL SAMPLES W/ THE SAME DEPTH

Sample ID	Elev.	Location	% Comp.	DRY DENSITY	Moist.	Test No.		DRY DENSITY	MOIST.
LK-DS-1		N26,000-E18,100							
	4925	N25,922-E18,151	90	47.7	49.2	Th/CM-036		57.1	54.2
	4923	N25,563-E18,113	90	48.0	70.8	Th/CM-038		53.8	59.1
	4921	N25,993-E18,154	95	50.8	65.3	Th/CM-032		55.0	58.5
	4919	N26,000-E18,111	98	46.6	59.1	Th/CM-029		52.6	59.9
	4917	N26,075-E18,025	100+	58.0	40.2	Th/CM-026		58.9	54.5
	4915	N25,850-E18,097	91	46.9	69.5	Th/CM-017		56.2	58.0
	4913	N25,874-E18,118	100+	40.3	29.2	T/CM-415	*	65.6	51.0
	4911	N25,700-E18,225	90	89.1	24.1	T/CM-338	*	76.8	40.9
	4909	N25,980-E18,090	100	96.3	26.7	T/CM-375	*	74.3	41.5
	4907	N26,050-E18,150	100	95.3	29.3	T/CM-204	*	63.3	55.0
LK-DS-2		N25,900-E18,100							
	4925	N25,922-E18,151	90	47.7	49.2	Th/CM-036			
	4923	N25,562-E18,113	90	48.0	70.8	Th/CM-038			
	4921	N25,993-E18,154	95	50.8	65.3	Th/CM-032			
	4919	N25,998-E18,111	98	46.6	59.1	Th/CM-029			
	4917	N26,075-E18,100	100+	58.0	52.0	Th/CM-026			
	4915	N25,850-E18,097	91	46.9	69.5	Th/CM-017			
	4913	N25,874-E18,118	100+	90.4	29.2	T/CM-415	*		
	4911	N25,700-E18,225	90	89.1	24.1	T/CM-338	*		
	4909	N25,980-E18,090	100	96.3	26.7	T/CM-375	*		
LK-DS-3		N25,800-E18,100							
	4925	N25,837-E18,227	90	47.8	67.4	Th/CM-037			
	4923	N25,500-E18,106	90	47.9	47.9	Th/CM-035			
	4921	N25,993-E18,154	95	50.8	65.3	Th/CM-032			
	4919	N25,999-E18,094	96	49.9	71.6	Th/CM-016			
	4917	N25,665-E18,085	100+	48.4	71.5	Th/CM-031			
	4915	N25,850-E18,097	91	46.9	69.5	Th/CM-017			
	4913	N25,798-E18,090	97	85.3	28.1	T/CM-379	*		
	4911	N25,700-E18,225	90	89.1	24.1	T/CM-338	*		
	4909	N25,980-E18,090	100	96.3	26.7	T/CM-375	*		

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ABH/11-8-88

Sample ID	Elev.	Location	% Comp.	DRY DENSITY	Moist.	Test No.	
LK-DS-5		N26,000-E18,200					
	4927	N25,775-E18,135	91	42.5	83.7	Th/CM-040	
	4925	N25,922-E18,151	90	47.7	49.2	Th/CM-036	
	4923	N25,562-E18,113	90	48.0	70.8	Th/CM-038	
	4921	N25,993-E18,154	95	50.8	65.3	Th/CM-032	
	4919	N25,964-E18,215	90	46.7	69.4	Th/CM-019	
	4917	N26,075-E18,025	100+	58.0	52.0	Th/CM-026	
	4915	N25,835-E18,162	100	92.4	27.2	T/CM-429	☆
	4913	N26,030-E18,300	92	87.7	33.2	T/CM-216	☆
	4911	N25,700-E18,225	90	89.1	24.1	T/CM-338	☆
	4909	N25,790-E18,120	90	83.5	33.9	T/CM-321	☆
	4907	N26,050-E18,150	100+	95.3	29.3	T/CM-204	☆
LK-DS-6		N25,900-E18,200					
	4945	N25,842-E18,252	90	55.6	49.7	Th/CM-177	
	4942	N25,773-E18,179	97	50.0	64.7	Th/CM-145	
	4941	N25,863-E18,342	95	50.3	72.9	Th/CM-130	
	4939	N25,911-E18,336	94	45.9	73.0	Th/CM-110	
	4937	N25,800-E18,225	100+	71.2	39.1	Th/CM-098	
	4935	N25,878-E18,249	100+	55.9	50.3	Th/CM-068	
	4933	N25,784-E18,204	100+	49.6	60.3	Th/CM-082	☆
	4931	N25,878-E18,156	100+	100.2	22.0	T/CM-559	☆
	4929	N26,035-E18,262	9	87.6	27.5	T/CM-455	☆
	4927	N25,766-E18,198	100+	101.6	21.9	T/CM-543	☆
	4925	N25,866-E18,286	100+	100.4	15.0	T/CM-469	☆
LK-DS-7		N25,800-E18,200					
	4955	N25,582-E18,342	100+	56.6	63.2	Th/CM-265	
	4953	N25,611-E18,364	100+	71.2	44.4	Th/CM-321	
	4951	N25,735-E18,281	90	49.5	64.7	Th/CM-255	
	4949	N25,716-E18,255	90	45.4	68.2	Th/CM-245	
	4947	N25,777-E18,241	100+	63.6	53.7	Th/CM-230	
	4945	N25,042-E18,252	90	55.6	49.7	Th/CM-177	
	4943	N25,828-E18,432	96	44.7	29.8	T/CM-567	☆
	4941	N25,863-E18,342	95	50.3	72.9	Th/CM-130	
	4939	N25,898-E18,171	100+	55.1	55.1	Th/CM-138	
	4937	N25,800-E18,225	100+	71.2	39.1	Th/CM-098	
	4935	N25,749-E18,205	91	46.6	69.2	Th/CM-105	
LK-DS-8		N25,700-E18,200					
	4943	N25,734-E18,246	98	60.1	52.5	Th/CM-176	
	4941	N25,863-E18,342	95	50.3	72.9	Th/CM-130	
	4939	N25,898-E18,171	100+	55.1	55.1	Th/CM-138	
	4937	N25,671-E18,300	100+	62.3	50.7	Th/CM-132	
	4935	N25,749-E18,205	91	46.6	69.2	Th/CM-105	
	4933	N25,784-E18,205	100+	49.6	60.3	Th/CM-082	
	4931	N25,634-E18,291	100+	101.1	22.5	T/CM-563	★
	4929	N25,684-E18,276	100+	99.9	21.9	T/CM-555	★
	4927	N25,767-E18,189	96	91.0	21.6	T/CM-556	★
	4925	N25,681-E18,153	100+	106.3	25.2	T/CM-539	★

[illegible]
ABH/11-8-88

Sample ID	Elev.	Location	% Comp.	DRY DENSITY	Moist.	Test No.	
LK-DS-9		N26,000-E18,300					
	4951	N25,774-E18,300	100+	67.4	45.2	Th/CM-257	
	4949	N25,716-E18,255	90	45.4	68.2	Th/CM-245	
	4947	N25,917-E18,372	92	56.5	49.3	Th/CM-175	
	4945	N25,881-E18,318	92	61.2	50.3	Th/CM-166	
	4943	N26,052-E18,207	91	60.3	52.4	Th/CM-165	
	4941	N25,863-E18,342	95	50.3	72.9	Th/CM-130	
	4939	N25,911-E18,336	94	45.9	73.0	Th/CM-110	
	4937	N25,800-E18,225	100+	71.2	39.1	Th/CM-098	
	4935	N25,890-E18,280	100+	46.8	81.2	Th/CM-095	
	4933	N25,954-E18,385	100+	52.4	65.7	Th/CM-112	
	4931	N25,878-E18,156	100+	100.2	22.0	T/CM-559	*
LK-DS-10		N25,900-E18,300					
	4951	N25,942-E18,272	99	42.0	62.8	Th/CM-247	
	4949	N26,046-E18,350	100+	70.6	50.1	Th/CM-160	
	4947	N25,917-E18,372	92	56.5	49.3	Th/CM-175	
	4945	N25,881-E18,318	92	61.2	50.3	Th/CM-166	
	4943	N25,772-E18,417	100+	76.1	39.8	Th/CM-156	
	4941	N25,863-E18,342	95	50.2	72.9	Th/CM-130	
	4939	N25,911-E18,336	94	45.9	73.0	Th/CM-110	
	4937	N25,800-E18,225	100+	71.2	39.1	Th/CM-098	
	4935	N25,827-E18,318	100+	56.5	50.1	Th/CM-069	
	4933	N25,954-E18,385	100+	52.4	65.7	Th/CM-112	
	4931	N25,884-E18,381	100+	95.4	21.4	T/CM-516	*
LK-DS-11		N25,800-E18,300					
	4951	N25,774-E18,300	100+	67.4	45.2	Th/CM-257	
	4949	N25,650-E18,274	100+	53.0	62.4	Th/CM-248	
	4947	N25,816-E18,367	100+	62.1	50.3	Th/CM-181	
	4945	N25,881-E18,318	92	61.2	50.3	Th/CM-166	
	4943	N25,734-E18,246	98	60.1	52.5	Th/CM-176	
	4941	N25,863-E18,336	95	50.3	72.9	Th/CM-130	
	4939	N25,911-E18,336	94	45.9	73.0	Th/CM-110	
	4937	N25,745-E18,354	91	46.9	72.8	Th/CM-104	
	4935	N25,827-E18,318	100+	56.5	50.1	Th/CM-069	
	4933	N25,792-E18,306	95	44.1	70.8	Th/CM-087	
	4931	N25,818-E18,357	90	85.7	23.5	T/CM-540	*
LK-DS-12		N25,700-E18,300					
	4951	N25,774-E18,300	100+	67.4	45.2	Th/CM-257	
	4949	N25,650-E18,274	100+	53.0	62.4	Th/CM-248	
	4947	N25,677-E18,412	98	51.6	65.2	Th/CM-222	
	4945	N25,650-E18,251	97	50.8	64.8	Th/CM-226	
	4943	N25,772-E18,417	100+	76.1	39.8	Th/CM-156	
	4941	N25,863-E18,342	95	50.3	72.9	Th/CM-130	
	4939	N25,911-E18,336	94	45.4	73.0	Th/CM-110	
	4937	N25,671-E18,300	100+	62.2	50.7	Th/CM-132	
	4935	N25,718-E18,300	100+	56.5	75.4	Th/CM-069	
	4933	N25,640-E18,105	94	44.2	75.9	Th/CM-049	
	4931	N25,761-E18,276	99	89.4	26.9	T/CM-504	*

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AB+1/11-8-88

Sample ID	Elev.	Location	% Comp.	DRY DENSITY	Moist.	Test No.
LK-DS-13		N26,000-E18,400				
	4954	N25,870-E18,347	100+	63.9	43.0	Th/CM-286
	4952	N25,926-E18,406	100+	49.7	66.8	Th/CM-232
	4950	N25,972-E18,416	98	60.1	52.0	Th/CM-183
	4948	N25,931-E18,242	92	56.4	46.2	Th/CM-219
	4946	N26,007-E18,414	90	64.0	44.5	Th/CM-157
	4944	N26,054-E18,431	100+	57.0	34.5	Th/CM-207
	4942	N26,132-E18,402	90	50.9	59.0	Th/CM-195
	4940	N25,686-E18,570	100+	46.5	56.8	Th/CM-129
	4938	N25,818-E18,400	94	92.1	25.2	T/CM-564 *
	4936	N25,718-E18,300	100+	51.6	75.4	Th/CM-088
	4934	N25,757-E18,410	100+	51.1	75.3	Th/CM-108
LK-DS-15		N25,800-E18,400				
	4954	N25,784-E18,504	100+	66.0	46.6	Th/CM-274
	4952	N25,749-E18,495	100+	55.3	64.8	Th/CM-267
	4950	N25,737-E18,468	99	50.3	56.6	Th/CM-241
	4948	N25,692-E18,369	90	45.4	66.2	Th/CM-246
	4946	N25,617-E18,567	94	52.4	54.7	Th/CM-204
	4944	N25,822-E18,456	100+	62.2	54.0	Th/CM-172
	4942	N25,755-E18,350	98	53.4	61.7	Th/CM-146
	4940	N25,826-E18,295	98	50.2	63.0	Th/CM-142
	4938	N25,818-E18,400	94	92.1	25.2	T/CM-564 *
	4936	N25,835-E18,299	93	47.6	73.7	Th/CM-102
	4934	N25,757-E18,410	100+	51.1	75.3	Th/CM-108
LK-DS-17		N26,000-E18,500				
	4955	N25,976-E18,598	99	56.1	61.2	Th/CM-194
	4953	N26,032-E18,549	90	55.0	58.1	Th/CM-214
	4951	N25,850-E18,432	100+	57.7	58.4	Th/CM-180
	4949	N26,065-E18,552	100+	51.9	73.5	Th/CM-294
	4947	N26,016-E18,481	99	65.6	48.4	Th/CM-168
	4945	N26,066-E18,563	94	57.0	66.7	Th/CM-186
	4943	N26,020-E18,510	100+	46.2	71.6	Th/CM-099
	4941	N25,863-E18,342	95	50.3	72.9	Th/CM-130
	4939	N25,951-E18,375	96	46.9	67.6	Th/CM-118
	4937	N26,188-E18,293	100+	64.0	52.2	Th/CM-182
	4935	N26,052-E18,385	100+	99.2	20.3	T/CM-542 *
LK-DS-18		N25,900-E18,500				
	4957	N25,892-E18,597	100+	54.8	53.2	Th/CM-277
	4955	N25,816-E18,644	100+	52.0	54.0	Th/CM-270
	4953	N25,867-E18,512	100+	55.0	64.5	Th/CM-262
	4951	N25,822-E18,473	90	55.5	54.0	Th/CM-213
	4949	N25,976-E18,598	99	56.1	61.2	Th/CM-194
	4947	N25,956-E18,492	94	67.1	52.2	Th/CM-164
	4945	N25,749-E18,594	90	55.2	56.5	Th/CM-170
	4943	N25,828-E18,432	96	94.7	29.8	T/CM-567 *
	4941	N25,638-E18,507	100+	65.0	43.8	Th/CM-134
	4939	N25,951-E18,375	96	42.1	67.6	Th/CM-118
	4937	N25,692-E18,700	100	[illegible]	45.1	Th/CM-074

21/-

[illegible]
ABH/ 11-8-5

				DRY DENSITY			
LK-DS-19		N25.800-E18.500					
	4957	N25,520-E18,512	100	56.6	71.2	Th/CM-285	
	4955	N25,547-E18,480	91	52.5	47.0	Th/CM-281	
	4953	N25,584-E18,516	100	67.6	33.8	Th/CM-327	
	4951	N25,498-E18,465	96	51.9	61.9	Th/CM-272	
	4949	N25,686-E18,538	98	51.3	67.2	Th/CM-220	
	4947	N25,612-E18,501	100	57.7	51.0	Th/CM-250	
	4945	N25,749-E18,594	90	55.5	56.5	Th/CM-170	
	4943	N25,828-E18,432	96	94.7	29.8	T/CM-567	*
	4941	N25,638-E18,507	100+	65.0	43.8	Th/CM-134	
	4939	N25,599-E18,498	100+	51.1	57.6	Th/CM-126	
	4937	N25,692-E18,700	100	49.8	45.1	Th/CM-074	
LK-DS-20		N25.700-E18.500					
	4957	N25,688-E18,513	100+	62.1	38.4	Th/CM-319	
	4955	N25,816-E18,644	100+	58.0	54.0	Th/CM-270	
	4953	N25,739-E18,538	98	51.7	64.9	Th/CM-268	
	4951	N25,822-E18,473	90	55.5	54.0	Th/CM-218	
	4949	N25,686-E18,538	98	51.3	67.2	Th/CM-220	
	4947	N25.743-E18.543	98	55.6	65.0	Th/CM-197	
	4945	N25,749-E18,594	90	55.5	56.5	Th/CM-170	
	4943	N25,828-E18,432	96	94.7	29.8	T/CM-567	*
	4941	N25,638-E18,507	100+	65.0	43.8	Th/CM-134	
	4939	N25,599-E18,498	100+	51.1	57.6	Th/CM-126	
	4937	N25,658-E18,485	96	49.4	57.4	Th/CM-108	

[illegible]
ABH/11-8-

Top 10' under Thorium

#4	N25,700	E18,100	Elev. 4911
#14	N25,900	E18,400	Elev. 4944
#16	N25,700	E18,400	Elev. 4958

Test Hole #4

Elev.	Test No.	Location	% Comp.	γ_d pcf	Moist.	Porosity
4911	T/CM-411	25,650-18,163	100+	✓ 97.5	31.9	
4909	T/CM-384	25,740-18,140	90 ~~100+~~	✓ 82.4	23.0 ~~25.1~~	
4907	T/CM-294	25,700-18,330	99	✓ 89.4	30.2	
4905	T/CM-370	25,640-18,080	96	✓ 84.2	31.3	
4903	T/CM-369	25,785-18,060	100+	✓ 90.2	27.8	
4901	T/CM-344	25,610-18,130	100+	✓ 94.1	22.9	

Test Hole #14

Elev.	Test No.	Location	% Comp.	γ_d pcf	Moist.	Porosity
*4944	T/CM-568	25,674-18,526	100+	✓ 103.4	19.7	
*4942	T/CM-567	25,828-18,432	96	✓ 94.7	29.8	
*4940	Th/CM-110	25,911-18,336	94	✓ 45.9	73.0	
*4938	Th/CM-094	25,830-18,423	100+	49.2	71.0	
4936	Th/CM-088	25,718-18,300	100+	51.6	75.4	
4934	Th/CM-108	25,757-18,410	100+	51.1	74.4	

Test Hole #16

Elev.	Test No.	Location	% Comp.		Moist.
4948	Th/CM-174R1	25,885-18,545	94	58.1	53.9
4946	Th/CM-175	25,917-18,372	92	56.5	49.3
*4944	Same as above			103.4	19.7
*4942	"	"		94.7	29.8
*4940	"	"		45.9	73.0
*4938	"	"			

23/-

ABH/10-25-8

#4	N25,700	[illegible].100	Elevation 4925
#14	N25,900	E18,400	Elevation 4954
#16	N25,700	E18,400	Elevation 4958

Composite
#16
the rest of time permits

[illegible]

Test Hole #4 Corrected by Bill Tate over telephone 10/25 4:00p.

Th 10

Elev.	Test No.	Location	γ_d pcf	% Comp.	Moist %	Porosity
4925	Th/CM-039R5 ~~T/CM-336~~	N25670-E18120 ~~[illegible]~~	✓53.3	100	75.0 ~~21.8~~	0.62
~~4925~~	~~T/CM-339~~	~~N25,681-E18,153~~		~~100~~	~~20.3~~	
4923	Th/CM-034 ~~T/CM-310~~	N25715-E18116 ~~[illegible]~~	✓47.9	90 ~~98~~	67.6 ~~56.7~~	0.65
4921	Th/CM-031 ~~[illegible]~~	N25643-E18133 ~~[illegible]~~	✓48.4	91 ~~100~~	67.5 ~~[illegible]~~	0.65
4919	Th/CM-019 ~~T/CM-450~~	N25964-E18215 ~~[illegible]~~	✓44.7	90 ~~92~~	67.4 ~~[illegible]~~	0.67
4917	Th/CM-030	N25,665-E18,085	✓48.2	100	71.5 ~~[illegible]~~	0.66
4915	Th/CM-025 ~~T/CM-429~~	N25863-E18100 ~~[illegible]~~	✓52.4	100	71.3 ~~[illegible]~~	0.58
4913	Th/CM-018	N25,700-E18,061	✓48.8	94	66.3	0.65
4911	Th/CM-013	N25,750-E18,075	43.5	96	71.2	0.69
~~4909~~	~~T/CM-324~~	~~N25,790-E18,120~~		~~90~~	~~33.9~~	
~~4907~~	~~Th/CM-009~~	~~N25,630-E18,058~~		~~97~~	~~69.7~~	

Test Hole #14

Elev.	Test No.	Location	γ_d pcf	% Comp.	Moist %	Porosity
4954	Th ~~T~~/CM-286	N25,870-E18,347	✓63.9	100	43.0 ~~56.2~~	0.54
4952	Th ~~T~~/CM-271	N25,898-E18,420	✓50.5	93	65.2	0.64
4950	Th ~~T~~/CM-183	N25,97~~2~~2-E18,416	✓60.1	98	52.0	0.57
4948	Th ~~T~~/CM-219	N25,931-E18,242	✓56.4	92	46.2	0.66
4946	Th ~~T~~/CM-157	N26,007-E18,414	✓64.0	90	44.5	0.54
4944	Th ~~T~~/CM-151	N25,909-E18,434	✓63.7	90	43.4	0.54

Test Hole #16

Elev.	Test No.	Location	γ_d pcf	% Comp.	Moist %	Porosity
4958	Th/CM-380 ~~[illegible]~~	N25767-E18642 ~~N25,800-E18,479~~	✓61.4	93	39.6 ~~19.5~~	0.56
4956	Th ~~T~~/CM-278	N25,730-E18,549	✓57.5	100	45.8	0.59
4954	Th ~~T~~/CM-274	N25,784-E18,504	✓66.0	100	46.6	0.53
4952	Th ~~T~~/CM-259	N25,744-E18,511	✓49.5	90	64.2	0.65
4950	Th ~~T~~/CM-183	N25,972-E18,416	✓60.1	98	52.0	0.57
4948	Th ~~T~~/CM-219	N25,931-E18,242	✓56.4	92	46.2	0.60

1

Parameters Used in Final Calculation for Radon Barrier Thickness (Calculation "C")

Material Parameter	Material Modeled	Value Used in Calculation				Source of Value Used in Calculation
Ra-226 Concentration (pCi/g)	Select Contaminated Material (Upper 10' of Contaminated Material).	2 to 45 (Actual 2' interval values from Borings LK-DS-04, -14 and -16).*				Computed from data on Sh. 8-14 in Calc. C, accounting for in growth of thorium as per Sh. 3. Results are shown on Sh. 19, 21 and 23.
	Tailings & Lower Contaminated Material (Below top 10' of Contaminated Material).	4 to 199 (Actual 2' intervals from Borings LK-DS-04, -14 and -16).				
Diffusion Coefficient (cm²/sec.)	Radon Barrier	0.010				Maximum value determined in Calculation B (Sh. 2 & 3) using moisture saturation values from Calc. A (Sh. 7).
	Select Contaminated Material	~~0.010~~ 0.10 JCP 3-29-83				Ref. 1, pg. 3-7 (conservative value used in absence of data for select contaminated material).
	Tailings and Lower Contaminated Material	0.017				Test data and Ref. 1, p. 3-7 and xvi, in Calculation 13-739-02-00 (Appendix 3).
Emanating Fraction	Contaminated Material and Tailings	0.18 to 0.40 (actual 2' inverval values from Borings LK-DS-04, -14 and -16.				Sh. 8-14 in Calc. C (field data), plus 0.40 in upper 10' and 0.27 below, where data not available.
Bulk Density(d), Water Content(w) and Porosity(n)		d	w	n		
	Radon Barrier	1.20	26.7	0.53		Calculation A, Sh. 6.
	Select Contaminated Material	0.65	25.0	0.71		Calculation 13-739-02-00, Sh. 1.
	Tailings and Lower Contaminated Material	1.18	21.0	0.53		

*Boring LK-DS-04 had highest readings below top 10'; LK-DS-14 and -16 had highest readings in upper 10'.

[Table 1 from Ref. 1]

MKE Doc. No. 4085-LKV-R-01-02345-00

A2H/11-10-

JLS/11-10-

REV 1

Notes: (contd. from below) –

9. It is possible that additional excavation in the evaporation ponds area will encounter sands and gravels (8), in which case the sp. gravity will be higher. The higher sp. gravity will lead to higher porosity with accompanying reduction in flux due to decrease in radon concentration in the void spaces, as shown on Sh. 5 & 16A, B, C

11-30-88

INTERNATIONAL ENGINEERING COMPANY, INC.

Project [illegible]
Feature [illegible]
Item
Contract No. 4005
Designed LLG
Checked WJL
Sheet 1
File No.
Date 6-21-85
Date 6/21/85

SUMMARY: TAILINGS PROPERTIES FOR RADON BARRIER DESIGN

MATERIAL & LAYER	SPECIFIC GRAVITY	% FINER THAN #200 SIEVE, f_{cm}	COMPACTION (ASTM D698)		IN-PLACE PROPERTIES									
			MAX. DRY UNIT WEIGHT	OPTIMUM MOISTURE CONTENT	DRY UNIT WEIGHT ③		LONG-TERM MOISTURE ④		POROSITY	EMANATION COEFFICIENT ⑤	DIFFUSION COEFFICIENT ⑥	LAYER THICKNESS ⑦		Ra-226 CONTENT ⑦
			pcf	%	pcf	g/cm³	WEIGHT %	SATURATION FRACTION, m_r			cm²/sec	ft.	cm.	pCi/g
UPPER LAYER (ML) (EVAPORATION POND MATERIAL, "ASH")	⑨ ① 2.23	87	45.1	84.2	40.6	0.65	25	0.23	0.71	0.4	0.044	20	610	14
LOWER LAYER (CH, ML, SM) (MAIN TAILINGS FILL)⁽²⁾	2.49 (2.43-2.57)	66 (39-56)	81.8 (76.7-85.3)	29.8 (26.3-30.0)	73.6	1.18	21	0.47	0.53	0.4	0.017	40	1220	160

NOTES:

1. Single sample results, unless otherwise indicated
2. Average and range, "( )", of 3 samples, unless otherwise indicated.
3. 90% of maximum dry unit weight by ASTM D698.
4. See sheets 31 & 34
5. See sheet 5
6. See sheet 34
7. Values used in conceptual design (Ref. 5). These values should be evaluated further in final design.

v1 [8. For lithology of evaporation ponds area see additional sheets A5 to A12]

HHa / 11-29-88

1: 9 see upper right

ADDITIONAL DATA NEEDED:

1. Emanation coefficient of evaporation pond material is probably not adequately justified with existing data (see sheets 3-7). Additional data on emanation coefficient of low radium content material is needed. Site specific data can be used, or possibly additional literature study can be used to extrapolate existing data.
2. Diffusion coefficient of evaporation pond material is not justified in magnitude adequately by site specific results. However, diffusion coefficient shown above is greater than single sample results for site, and is based on a general correlation for all soils.

(See Ref. 1, Appendix 4)

Rev. 1
ABH 11-30-88
MRO 11-30-88

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet [illegible]
Project UMTRA - LKY
Contract No. 405
File No.
Feature RADON BARRIER DESIGN
Designed JCP
Date 12-28-8
Item MAX. RADIUM CONC DURING DESIGN LIFE
Checked [illegible]
Date 12·31·87

A&H 11/28/89
MC 11·30·89

Sample ID	ELEVATION (ft)	[pCi/g] Ra 226 CONC	[pCi/g] Th 230 CONC	RADON EMANATION	[pCi/g] RADIUM CONC
LK-DS-1	4925-4923	1	10	---	0
	4923-4921	2.25	4	---	3
	4921-4919	1.47	1.5	---	1
	4919-4917	1	2	---	1
	4917-4915	1	11	---	4
	4915-4907	89.5	74.8	0.29	89.5
LK-DS-2	4925-4923	1	8.9	---	0
	4923-4921	1	28	---	10
	4921-4919	1	9.3	---	4
	4919-4917	1	5.9	---	3
	4917-4915	1	8.1	---	3
	4915-4907	70.3	64	0.27	70.3
LK-DS-3	4925-4923	1	7	---	3
	4923-4921	1	20	---	8
	4921-4119	1	31	---	11
	4119-4117	1	8.8	---	4
	4117-4115	1	5.7	---	3
	4115-4907	76.9	61.8	0.27	76.9
LK-DS-4	4925-4923	1	16	---	6
	4923-4921	1	20	---	8
	4921-4919	1	9.1	---	0
	4919-4917	1	4.7	---	2
	4917-4915	2.2	8.1	0.41	4
	4915-4907	91.4	94.6	0.26	92
LK-DS-5	4927-4925	1	14	---	6
	4925-4923	1	15	---	6
	4923-4921	1	27	---	10
	4921-4919	1	29	---	11
	4919-4917	1	29	---	11
	4917-4905	30.2	36.3	0.31	32
LK-DS-6	4945-4943	1	14	---	6
	4943-4941	1	19	---	7
	4941-4939	1	18	---	7
	4939-4937	1	16	---	6
	4937-4935	1	18	---	7
	4935-4923	16.1	21.5	0.33	18

[See Appendix 1, Sheets 15 to 18, of Ref. 1]

Sheet

Project UMTRA - LKV

Feature RADON BARRIER DESIGN

Item MAX RADIUM CONC DURING DESIGN LIFE

Contract No. 6005

Designed JCP

Checked

File No.

Date 12-28-8

Date 12-31-87

ABH 11/26/88
MCl 11/30/88

SAMPLE I.D.	ELEVATION (ft)	Ra-226 CONC [pCi/g]	Th-230 CONC [pCi/g]	RADON EMANATION	RADIUM CONC [pCi/g]
LK-DS-7	4955-4953	1	1	---	1
	4953-4951	1	19	---	7
	4951-4949	1	26	---	10
	4949-4947	1	20	---	8
	4947-49[illegible]	1	15	---	6
	4945-4932	19.2	28.4	0.49	22
LK-DS-8	4943-4941	1	47	---	17
	4941-4939	1	17	---	7
	4939-4937	1	20	---	8
	4937-4935	1	10	---	4
	4935-4933	1	40	---	15
	4933-4923	3.8	13.9	0.36	7
LK-DS-9	4951-4949	1	2.7	---	2
	4949-4947	1	9.1	---	4
	4947-4945	1	10	---	4
	4945-4943	1	11	---	4
	4943-4941	1	12	---	5
	4941-4929	10.4	24.1	0.3	15
LK-DS-10	4951-4949	1.5	15	---	6
	4949-4947	1.9	1.9	0.32	2
	4947-4945	1	8.5	---	4
	4945-4943	1	9.8	---	4
	4943-4941	1	11	---	4
	4941-4929	4.5	17.2	0.37	9
LK-DS-11	4951-4949	0.9	26	---	10
	4949-4947	1	53	---	19
	4947-4945	1.5	27	---	10
	4945-4943	1	6.9	---	3
	4943-4941	1	17	---	7
	4941-4929	2.2	14	0.4	6
LK-DS-12	4951-4949	1	25	---	9
	4949-4947	1	35	---	13
	4947-4945	1	40	---	15
	4945-4943	1	25	---	9
	4943-4941	1	29	---	11
	4941-4929	2.7	19.3	0.31	8
LK-DS-13	4954-4952	1	25	---	9
	4952-4950	1	23	---	9
	4950-5948	1	3.7	---	2
	4948-4946	1	12	---	5

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - LKV
Feature RADON BARRIER DESIGN
Item MAX RADIUM CONC. DURING DESIGN LIFE

Contract No. 4205
Designed JCD
Checked VAC

Sheet 4 17
File No.
Date 12-28-8
Date 12-31-8
ABH 11/28/88
MKP 11-30-88

SAMPLE I. D.	ELEVATION (ft)	Ra-226 CONC [pCi/g]	Th-230 CONC [pCi/g]	RADON EMANATION	RADIUM CONC [pCi/g]
LK-DS-13 (Cont.)	4946-4944	1	13	---	5
	4944-4932	2.2	28.3	0.38	11
LK-DS-14	4954-4952	2.15	150	0.08	54
	4952-4950	2	64	0.35	24
	4950-4948	1	4.1	---	2
	4948-4946	1	41	---	15
	4946-4944	1	16	---	6
	4944-4932	1.8	30.9	0.37	12
LK-DS-15	4954-4952	1	4.9	---	2
	4952-4950	1.6	29	---	11
	4950-4948	1	14	---	6
	4948-4946	1.5	3	---	2
	4946-4944		11	---	4
	4944-4032	1.[illegible]	16.8	0.4	7
LK-DS-16	4958-4956	2.63	47	0.49	18
	4956-4954	1	92	---	33
	4954-4952	1	52	---	19
	4952-4950	1	16	---	6
	4950-4948	1	14	---	6
	4948-4936	1.9	13.9	0.33	6
LK-DS-17	4955-4953	1	26	---	10
	4953-4951	1	40	---	15
	4951-4949	1	29	---	11
	4949-4947	1	7.7	---	3
	4947-4945	1	3.7	---	2
	4945-4933	2.7	17.7	0.38	8
LK-DS-18	4957-4955	1.83	32	---	12
	4955-4953	1	16	---	6
	4953-4951	2.6	42	---	16
	4951-4949	1.8	1.5	---	2
	4949-4947	1	32	---	12
	4947-4935	1.6	9.2	0.35	4
LK-DS-19	4957-4955	1	44	---	16
	4955-4953	1	75	---	27
	4953-4951	1	53	---	19
	4951-4949	1	23	---	9
	4949-4947	1.9	10	0.17	5
	4947-4935	2.3	15.1	0.34	7

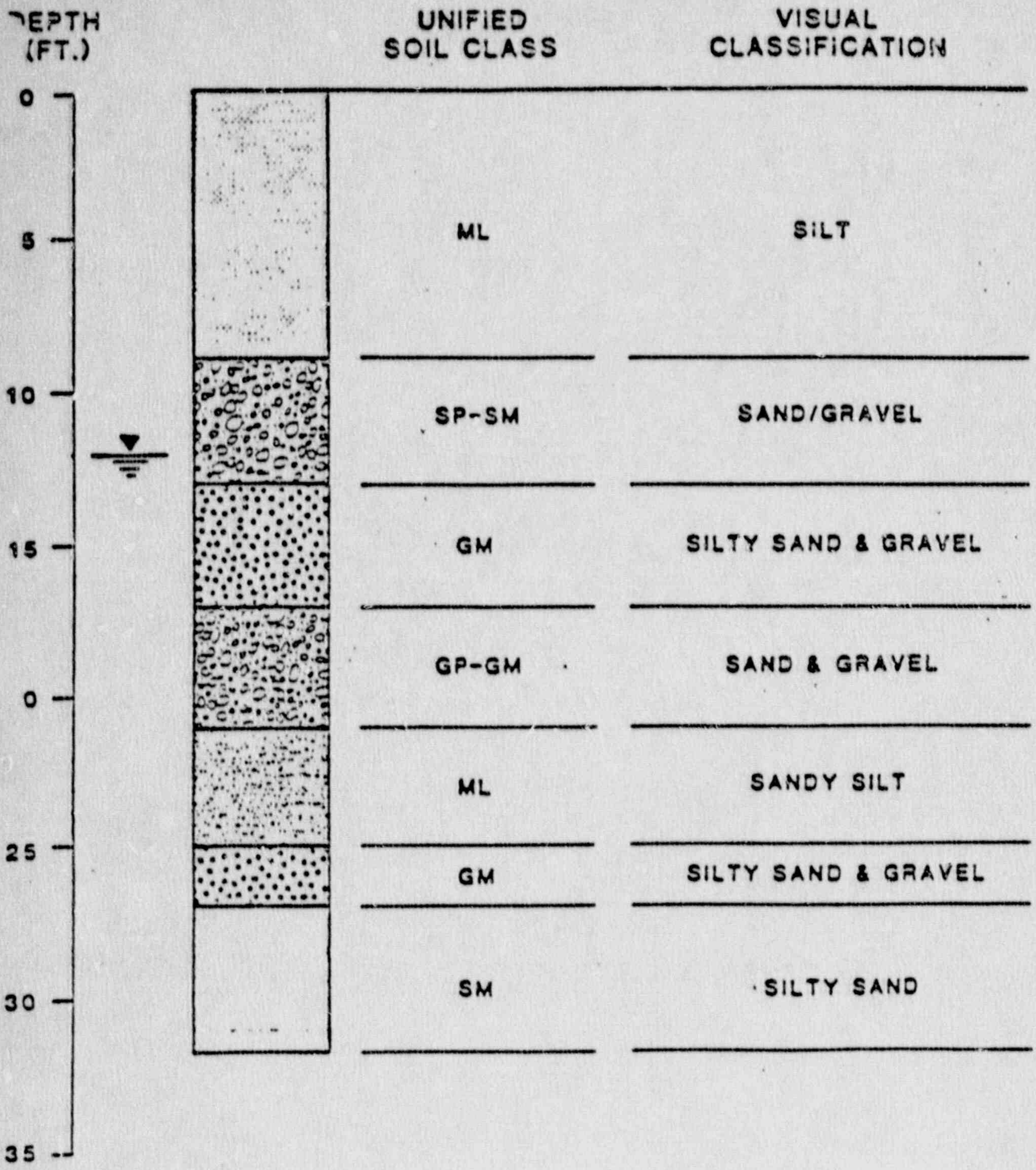
MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet ~~10~~ [illegible]
Contract No. 4005
File No.
Project UMTRA - LKV
Feature RADON BARRIER DESIGN
Designed JCP
Date 12-29-8
Item MAX. RADIUM CONC. DURING DESIGN LIFE
Checked
Date 12-31-87
ABH 11/28/88
MSP 11-30-88

SAMPLE ID.	ELEVATION (ft)	Ra-226 CONC. [pCi/g]	Th-230 CONC. [pCi/g]	RADON EMANATION	RADIUM CONC. [pCi/g]
LK-DS-20	4957-4955	1	66	---	24
	4955-4953	1	28	---	10
	4953-4951	1	28	---	10
	4951-4949	1	9.3	---	4
	4949-4947	1	30	---	11
	4947-4935	1.9	16.1	0.36	7

AB #/ 11-29-88

AMP 11-30-88



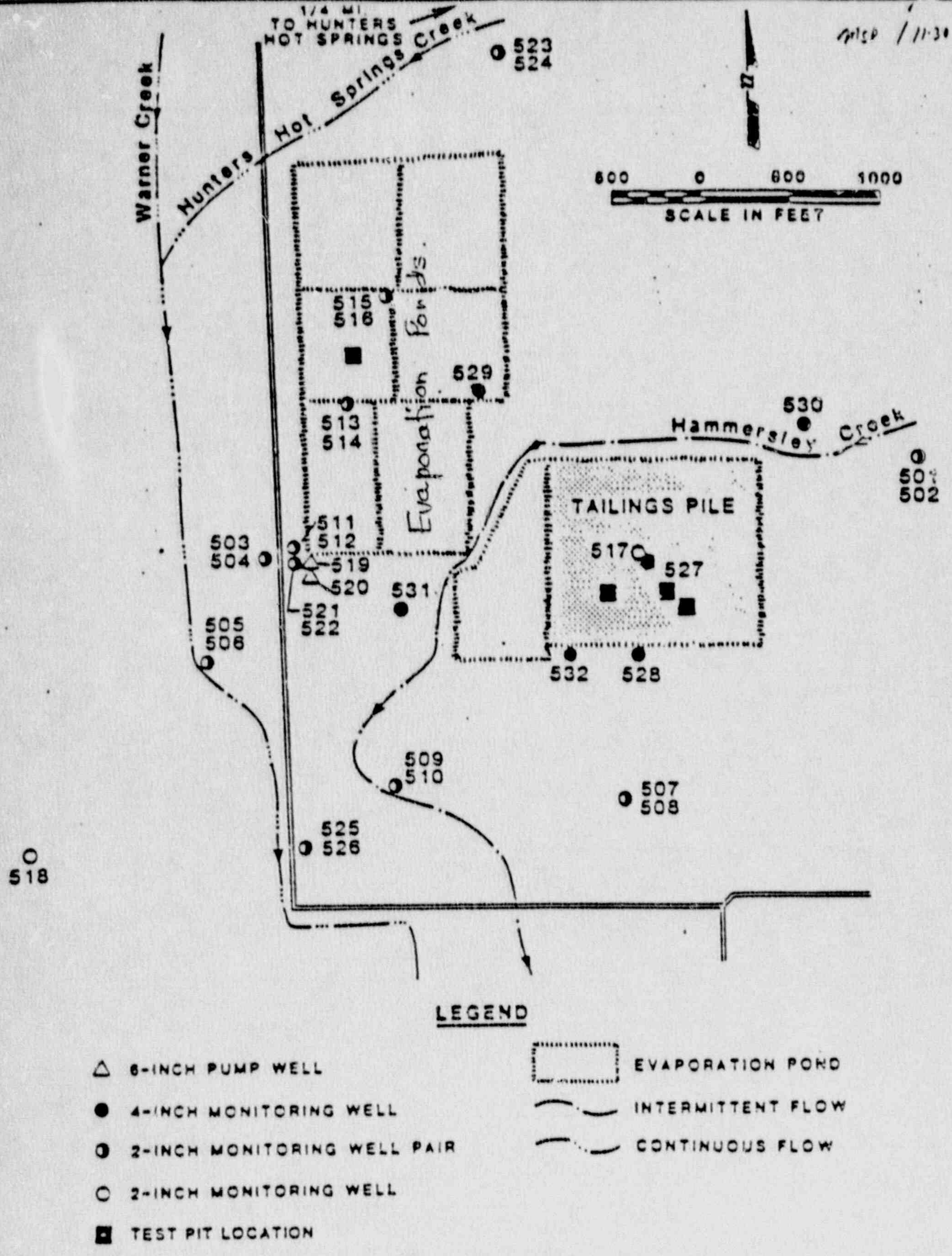
[see Fig. 5.1 of Ref. 5]

~~FIGURE 5.1~~

SAMPLE BOREHOLE LOG FOR LAKEVIEW PROCESSING SITE

AB# / 11-07-84

MSP / 11-30-84



~~FIGURE 7.4~~

LAKEVIEW PROCESSING SITE BOREHOLE
WELL AND TEST PIT LOCATIONS

[See Figs. 5.6 and 7.4 of Ref. 5]

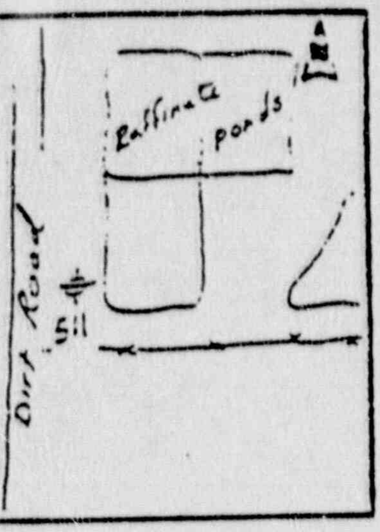
JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

A3½ / 11-23-
MSP / 11-30-88

BOREHOLE LOG

~~Page 1 of 1~~

TION MAP:



SITE ID: LKV 01 LOCATION ID: 511
APPROX. SITE COORDINATES (ft.):
N ~~[illegible]~~ 7006.32 E ~~[illegible]~~ 4023.96
GROUND ELEVATION (ft. MSL): ~~[illegible]~~ 4744.63
DRILLING METHOD: Hollow Stem Auger
DRILLER: Jim Carter
DATE STARTED: 7-11-84
DATE COMPLETED: 7-16-84
FIELD REP.: MP Wood

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
7-16-84	9:45	14
7-12-84	9:55	25

OCATION DESCRIPTION
TE CONDITION

EPTH (ft.)	SAMPLE			UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
	INT.	TYPE	ID		
0		S 3-6 8	001	ML	Silt, some fine sand, NP, very dark gray (10YR, 3/1M) damp Note: 1" seam of saturated sandy silt @ 3½-4'
5		S 9-10 11	002	SP-SM	Sand, pred fine-med, some gravel, some silt, NP, dark yellowish brown (10YR, 3/4M) very moist
10		S 18-16 25	003		
				GM	Silty sand & gravel, poorly graded to 0.04', subangular, NP, black, (10YR 2/1M) Sat
15		S 11-7 13	004	GP-GM	Sand & gravel, poorly graded to 0.04, some silt, subangular NP dark olive gray (5Y, 3/2M).. Sat
20		S 3-12 10	005	ML	Sandy silt, NP dark olive gray (5Y, 3/2M damp
				GM	Silty sand & gravel, poorly graded to 0.04' subangular NP, dark olive gray (5Y, 3/2M) very moist
25		14-47 50	006	SM	Silty sand, fine, NP dark olive gray (5Y, 3/2M) Sat Note: occasional seam of sandy silt.
		S 32-52 Ry.175	007		Groundwater @ 34.5' Total depth [illegible] 31.975'

COMMENTS: Steel casing elev - 4748.38
PVC casing elev 4 [illegible]

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

[See App. C of Ref. 5 and also Sect. A of Ref. 6]

A-8

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

ABH / 11-29-88
MSP / 11-30-88

BOREHOLE LOG

Page 1 of 2

ATION MAP:

SITE ID: LKV 01 LOCATION ID: 512
APPROX. SITE COORDINATES (ft.):
N ~~[illegible]~~ 8002.76 E ~~[illegible]~~ 4023.27
GROUND ELEVATION (ft. MSL): ~~[illegible]~~ 4744.35
DRILLING METHOD: Hollow Stem Auger
DRILLER: Jim Carter
DATE STARTED: 7-13-88
DATE COMPLETED: 7-13-88
FIELD REP.: W L Wood

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
7-13-88	7:15	14

OCATION DESCRIPTION South west corner of west-central collection pond
ITE CONDITION Flat, grass covered

DEPTH (ft.)	SAMPLE INT.	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
0				ML	clayey silt, low pl, very dark brown (10YR, 2/2 M) moist Note: 6" seam of saturated silty sand @ 4'
5		S 6-14 10	001	ML	Silt, some fine sand, N.P. dark gray (10YR, 4/1 M) damp
10		S 20-22 26	002	GP	Sand & gravel, poorly graded to .04', some silt, N.P. ~~[illegible]~~ olive gray (5Y, 4/2 M) moist
15		S 19-18 22	003	SP	Sand, poorly graded fine to med, some fine gravel, N.P. dark olive gray (5Y, 3/2 M) sat
20		S 16-8 9	004	CL	Sandy clay, small amount of fine gravel, med. Pl., black (5Y, 2.5/2 M) moist
					Sand, poorly graded fine, some silt, trace of fine gravel, N.P. dark olive gray (5Y, 3/2 M)
25		S [illegible]-23 38	005	SP-SM	silty clay, med.-H. Pl., dark olive gray (5Y, 3/2 M)
				CH	

OMMENTS: Steel casing elev - [illegible] 33
PVC casing elev - [illegible]

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

II-7

ABH / 11-29-8
MSP / 11-30-88

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG

Page ~~[illegible]~~

TION MAP:

Same as #514

SITE ID: LKV 01 LOCATION ID: 515
APPROX. SITE COORDINATES (ft.):
N ~~[illegible]~~ 6612.49 E ~~[illegible]~~ 4577.08
GROUND ELEVATION (ft. MSL): [illegible] 4748.09
DRILLING METHOD: Hollow Stem Auger
DRILLER: Jim Carter
DATE STARTED: 7-21-84
DATE COMPLETED: 7-21-84
FIELD REP.: [illegible]

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
7-21-84	730	11

OCATION DESCRIPTION
TE CONDITION

EPTH (ft.)	SAMPLE INT.	TYPE	ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
0		4-4-9	001	ML	Silt, some fine sand, [illegible] low PL to NP, dark brown to light gray (10 YR 3/3 to 10 YR, [illegible]) moist
5		2-5-12	002	SM-GM	Silty sand and gravel, poorly graded to 0.07', subrounded, trace of clay, very low PL, olive brown (2.5Y, 4/4) very moist to sat
10		23-27-31	003		
15		30-31-50/.44	004	SP-GM	Sand and gravel poorly graded to 0.04', some silt, subrounded, NP, dark olive gray (5Y, 3/2 M) sat
20		5-17-29	005	SC	Clayey sand, fine, low PL dark gray (5Y, 4/1 M) very damp
					Silty sand, fine, NP dark olive gray (5Y, 3/2 M) moist
25		19-30-50/.375	006	SM	Sandy clay, med. PL olive gray (5Y, 4/2 M) moist
30		21-[illegible]	007	CH	[illegible]

COMMENTS: Steel casing elev - 4751.47
PVC casing elev - 4751.47

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
[illegible] - 3" O.D. thin-walled Shelby tube

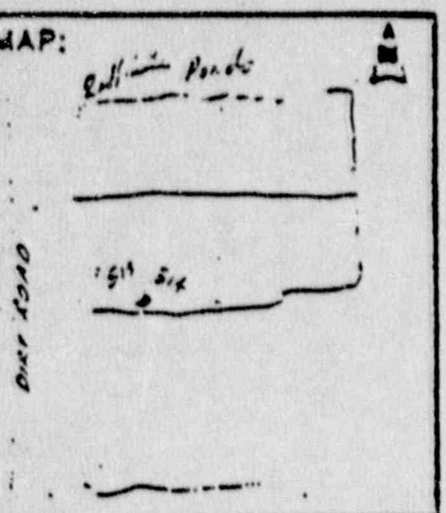
JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

AEH / 11-29-8
MCP / 11-30-8

BOREHOLE LOG

~~Page of~~ 2

.TION MAP:



SITE ID: LKV 01 LOCATION ID: 512
APPROX. SITE COORDINATES (ft.):
N ~~[illegible]~~ 8812.30 E ~~[illegible]~~ 4380.97
GROUND ELEVATION (ft. MSL): ~~[illegible]~~ 4748.55
DRILLING METHOD: Hollow Stem Auger
DRILLER: Jim Scott
DATE STARTED: 7-20-84
DATE COMPLETED: 7-20-84
FIELD REP.: M R Wood

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
7-20-84	1:22	9.5

OCATION DESCRIPTION

ITE CONDITION

DEPTH (ft.)	SAMPLE INT.	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
0				ML	Sandy silt, NP, dark brown to light gray (7.5YR 3/2M to 5YR, 7/1M) moist to saturated.
		5-7 10	001		
				GM	Silty sand and gravel, poorly graded ± 0.04, subrounded NP, dark brown (10YR, 3/3M) ~~moist to~~ sat.
10		15-19 25	002		
				SM-SP	Sand considerable fine gravel, some silt, NP, black (5Y, 2.5/2M) sat.
15		17-13 19	003		
				SC	Clayey sand, fine, low pl, olive gray (5Y, 4/2M) moist to sat.
20		11-13 15	004		
				SM	Silty sand, fine, NP black (5Y, 2.5/2M) saturated
25		28- 50/.42	005		

COMMENTS: Steel casing elev - 4751.63
PVC casing elev - 4751.52

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 2" O.D. thin-walled Shelby tube

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

AE#/ 11-27-86
[illegible] / 11-[illegible]-86

BOREHOLE LOG

~~[illegible]~~

TION MAP:

Same as #516

SITE ID: LKV 01 LOCATION ID: 515
APPROX. SITE COORDINATES (ft.):
N [illegible] 945.50 E [illegible] 4401.34
GROUND ELEVATION (ft. MSL): [illegible] 4250.97
DRILLING METHOD: Hollow stem auger
DRILLER: [illegible]
DATE STARTED:
DATE COMPLETED:
FIELD REP.: [illegible]

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
11-19-86	3:45	[illegible]
11-19-86	6:04	11.[illegible]

OCATION DESCRIPTION
TE CONDITION

EPTH (ft.)	SAMPLE INT.	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
0		S 4-3 5	001	ML	Silt, some fine sand, N.P. dark brown (10YR, 3/3 m) to light gray (10YR, 7/1 M)
		S 3-7 8	002		
10		S 20-19 15	003	GP-GM	Sand and gravel, poorly graded [illegible] subrounded, some silt, N.P. dark (brown, 10YR, 3/3M) Sat
				SM	Silty sand, poorly graded fine to med., N.P. dark gray (10YR, 4/1 M) Sat
15		S 3-7 7	004	CL	Silty clay, H.P., dark gray (10YR, 4/1 M) moist
				SM-GP	Sand & gravel, poorly graded to [illegible] some silt, N.P. black (5Y, 2.5/2 M) Sat
20		S 35-40 29	005		
					Silty clay, H.P. dark gray 5Y 4/1 M) moist
25		S 35-15 9	006	CH	
					St. auger @ 24.5' St. sampler @ 26'

OMMENTS: Steel casing elev - 4753.02
PVC casing elev - 4753.02

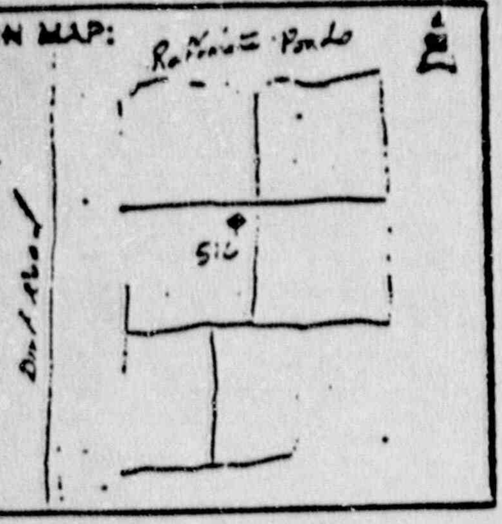
SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

ABH/11-27-88
MCP/11-30-88

BOREHOLE LOG

Page 2 of 2

ON MAP:



SITE ID: LKV 01 LOCATION ID: 516
APPROX. SITE COORDINATES (ft.):
N [illegible].14 E ~~[illegible]~~ 4597.44
GROUND ELEVATION (ft. MSL): ~~[illegible]~~ 4750.95
DRILLING METHOD:
DRILLER: Jim Grier
DATE STARTED: 7-19-84
DATE COMPLETED: 7-1 -84
FIELD REP.: W.D. Wood

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)
7-19-84	725	3½

:ATION DESCRIPTION

E CONDITION

PTH t.)	SAMPLE INT.	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
0				ML	Sandy silt, some clay, low Pl, very dark grayish brown (10YR, 3/2 m) moist note: 6" seam of saturated silty sand @ 3½'
5		T 750#	001	ML	Silt, some [illegible] [illegible] N.P. gray (10YR, 6/1m) moist.
10		S 2.5 6	002	GP-GM	Sand and gravel, poorly graded to 0.04' some silt, N.P. dark brown (10YR 4/3m) moist
15		S 11-15 12	003	GM	silty sand and gravel, [illegible] N.P. black (5Y, 2.5/2m) sat. w/ occasional seams of silt.
20		S 35-[illegible] 27	004		
					Sandy Clay, low-medium pl, dark olive gray (5Y, 3/2m) moist
25		S 12-16 16	005	CL	note: occasional seam of sand.

COMMENTS: Steel casing elev. - 4752.45
w/ [illegible] elev. - 4752.04

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. drive sample
T - 3" O.D. Thin-walled Shelby tube

APPENDIX F

COMPLIANCE STRATEGY FOR THE PROPOSED EPA GROUNDWATER STANDARDS

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LIST OF TABLES

F.1 INTRODUCTION

F.1.1 PURPOSE AND SCOPE

This report documents a compliance strategy for the proposed U.S. Environmental Protection Agency (EPA) groundwater standards for Uranium Mill Tailings Remedial Action (UMTRA) (40 CFR Part 192) at the Collins Ranch disposal site. The scope of this report includes a summary of existing hydrogeologic conditions at Collins Ranch; a detailed discussion of disposal cell design considerations; an analysis and discussion of impacts to groundwater from tailings seepage from the disposal cell at Collins Ranch; and a discussion of how the disposal cell at Collins Ranch will meet the proposed EPA groundwater protection standards.

F.1.2 PREVIOUS INVESTIGATIONS

The hydrogeology of the Collins Ranch area has been reported in detail by the U.S. Department of Energy (DOE) in a final Environmental Assessment (EA) (DOE, 1985a) and in a Remedial Action Plan (RAP) (DOE, 1985b). Previous regional and site-specific investigations were used in preparation of the EA and RAP. Please refer to the DOE documents for a complete list of references.

F.1.3 LOCATION

Collins Ranch is approximately four miles northwest of the Lakeview processing site (Figure F.1.1).

F.1.4 GROUNDWATER PROTECTION STANDARDS

On January 5, 1983, the EPA promulgated final standards for the disposal site and for cleanup of inactive uranium processing sites under the Uranium Mill Tailings Radiation Control Act (UMTRCA) (48 FR 590). However, on September 3, 1985, the groundwater provisions of the regulations (40 CFR Part 192.20 (a)(2)-(3)) were remanded to the EPA by the U.S. Tenth Circuit Court of Appeals. Revised standards were issued by the EPA on September 24, 1987 and are presented in Table F.1.1.

Under the UMTRCA, the DOE must comply with the proposed standards until final standards are promulgated. As a result, remedial action taken with regard to the Lakeview site would not preclude subsequent design enhancements if needed to achieve compliance and would not limit the selection of reasonable groundwater restoration methods that may be necessary when the final standards are promulgated. The DOE has characterized conditions at the Lakeview uranium mill tailings site and assessed whether the proposed remedial action would comply with the proposed EPA groundwater standards. The conceptual design has been modified to achieve compliance with the requirements of Subpart A of the proposed standards. When the final standards are promulgated, the

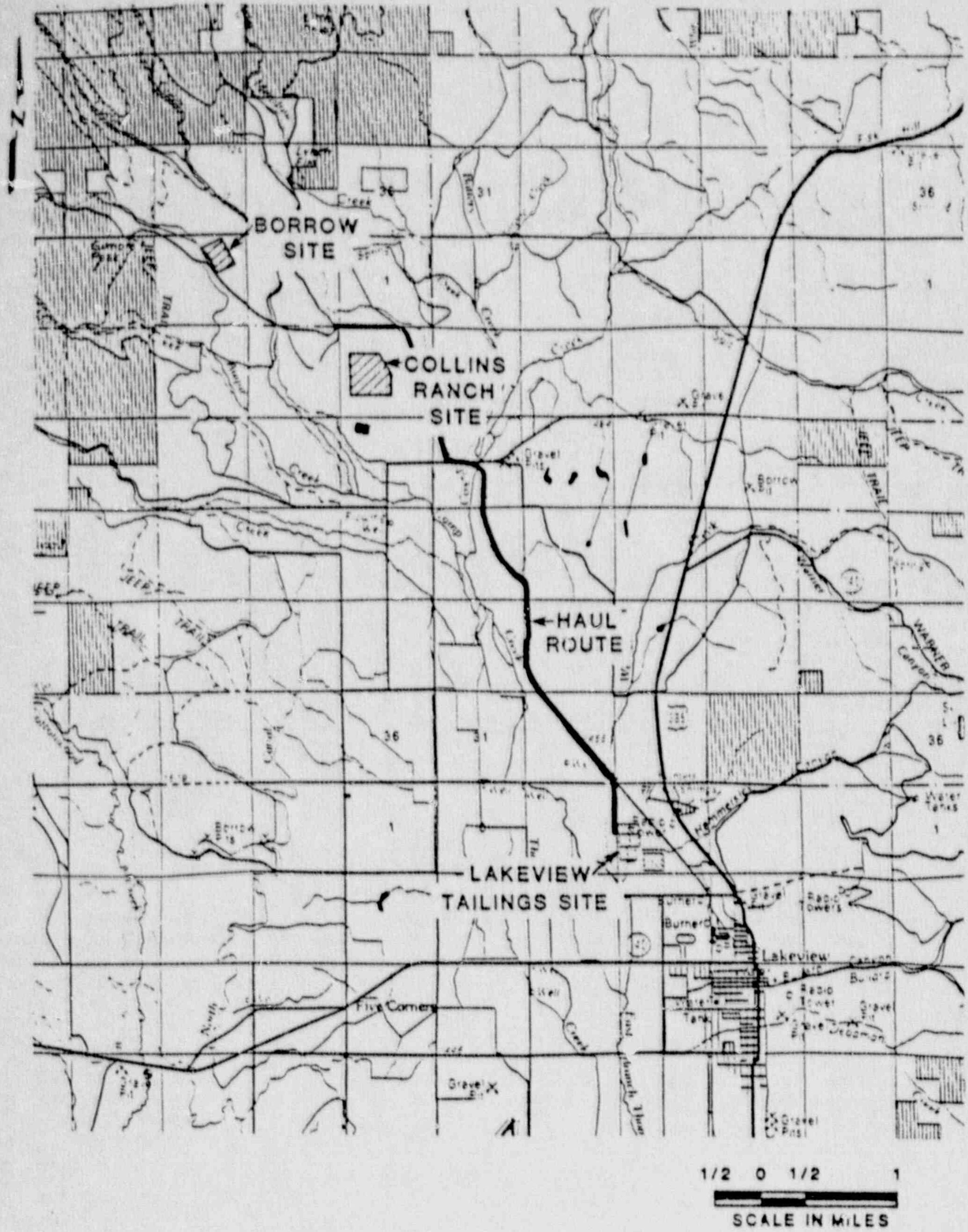

FIGURE F.1.1
DISPOSAL SITE LOCATION
COLLINS RANCH SITE

Table F.1.1 Water quality standards (Maximum Concentration Limits) applicable to UMTRA Project sites[a]

Constituent	Proposed EPA MCL
Inorganic chemical (mg/l)	
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Molybdenum	0.1
Nitrate (as N)	10.0
Selenium	0.01
Silver	0.05
Inorganic chemical (pCi/l)	
Radium-226 & -228	5.0
Uranium-234 & -238	30 (0.044 mg/l)
Gross alpha	15

[a] Proposed EPA groundwater standards, 40 CFR Part 192; mg/l = milligrams per liter; pCi/l = picocuries per liter. The proposed standards also include a list of hazardous organic constituents (plus beryllium, antimony, cyanide, and thallium) which are not normally associated with uranium mill tailings or are present only in very small quantities; see 40 CFR Part 261, Appendix VIII, as amended by 40 CFR Part 264, Appendix IX, (EPA, 1987).

DOE will evaluate groundwater protection requirements and undertake such action as is necessary to ensure that the final standards are met. The need for the extent of aquifer restoration will be evaluated in a separate process in accordance with the National Environmental Policy Act (NEPA).

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

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

The proposed EPA groundwater standards for UMTRA are discussed below.

Subpart A (40 CFR Part 192.01-192-02) consists of the requirements for control of potential contaminant release to the groundwater at disposal sites. It incorporates the following:

- RCRA list of hazardous constituents (40 CFR Part 264.93).
- RCRA Maximum Concentration Limits (MCLs) (40 CFR Part 264.94), background limits, or Alternate Concentration Limits (ACLs). The establishment of ACLs must be concurred in by the Nuclear Regulatory Commission (NRC), be as low as reasonably achievable (ALARA), and satisfy the water quality protection considerations stipulated in 40 CFR 264.94 (b).
- RCRA Point of Compliance (POC) (40 CFR Part 264.95).
- Four hazardous constituents and associated MCLs (molybdenum, radium, uranium, and nitrate) are added to those taken from the drinking water standards. (Note: an MCL for an additional constituent, gross alpha activity, is included separately and without discussion in Subpart A.)
- A liner or equivalent beneath the disposal site if tailings contain excess water (40 CFR Part 192.20).
- Monitoring during a post-remedial action period to verify design performance.
- Corrective action to be initiated within 18 months after monitoring indicates or projects an exceedance of the applicable concentration limits.

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

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

Subpart C (40 CFR Part 192.22) addresses supplemental standards applicable to Subparts A and B. The supplemental standards provide for alternative actions which come as close to the standards as reasonable under the circumstances. The NRC must concur in the application of supplemental standards. The supplemental standards may be applied if protection of human health and the environment is assured (40 CFR Part 192.22(d)) and any of the following apply:

- o The proposed action would cause more environmental harm than it would prevent (40 CFR Part 192.21(b)).
- o Restoration is technically impracticable from an engineering perspective (40 CFR Part 192.21(f)).
- o The groundwater is Class III (40 CFR Part 192.21(g)).

F.2 SUMMARY OF EXISTING HYDROGEOLOGICAL CONDITIONS

F.2.1 STRATIGRAPHY

Site characterization efforts at the Collins Ranch site were initiated as part of the alternate site selection process. To assess groundwater conditions, 20 boreholes were drilled, of which nine were completed as monitor wells. Figure F.2.1 shows the locations of these wells. The boreholes were lithologically logged and disturbed soil samples were taken to characterize the subsurface at Collins Ranch. Lithologic borehole logs are on file in the UMTRA Project Office, Albuquerque, New Mexico.

The unconsolidated alluvial sediments at the Collins Ranch disposal site are finer-grained than those at the Lakeview processing site. Subsurface conditions at the disposal site consist of interfingered and layered silty sands, sandy silts, and surficial lenses of high plasticity clays of Quaternary age. These materials, encountered to depths of 250 feet, form the slopes of Augur Hill, and represent a remnant of outwash deposits from the nearby Fremont Mountains. The depth to bedrock is undetermined, but is estimated to be 1000 feet, based upon depth of sediments encountered along the eastern edge of the Goose Lake Basin (DOE, 1985a).

The occurrence and quality of groundwater in the alluvium at Collins Ranch is summarized in the following sections.

F.2.2 GROUNDWATER

F.2.2.1 Occurrence

Groundwater was encountered in nine of the 20 boreholes completed as monitor wells within the unconsolidated alluvial aquifer at Collins Ranch. Four shallow wells (24 to 30 feet), just west of the site boundary, show water-table conditions with depths to groundwater from seven to 18 feet; five deeper wells (78 to 152 feet), east of the site boundary, show water-table conditions with depths to groundwater from 76 to 90 feet. Based upon the five water level elevations measured in the fall of 1984, a potentiometric surface map was constructed (Figure F.2.2). Figure F.2.3 is a potentiometric surface map developed from the water level elevations measured in June 1988. Figure F.2.4 is a schematic hydrogeologic cross-section of the Collins Ranch site; the depth to groundwater below the base of the Collins Ranch disposal cell is approximately 30 feet.

Groundwater in the alluvium flows from northwest to south-southeast, opposite the topographic slope, indicating that most recharge is from the Fremont Mountains to the west, rather than the small areal drainage immediately above the disposal site.

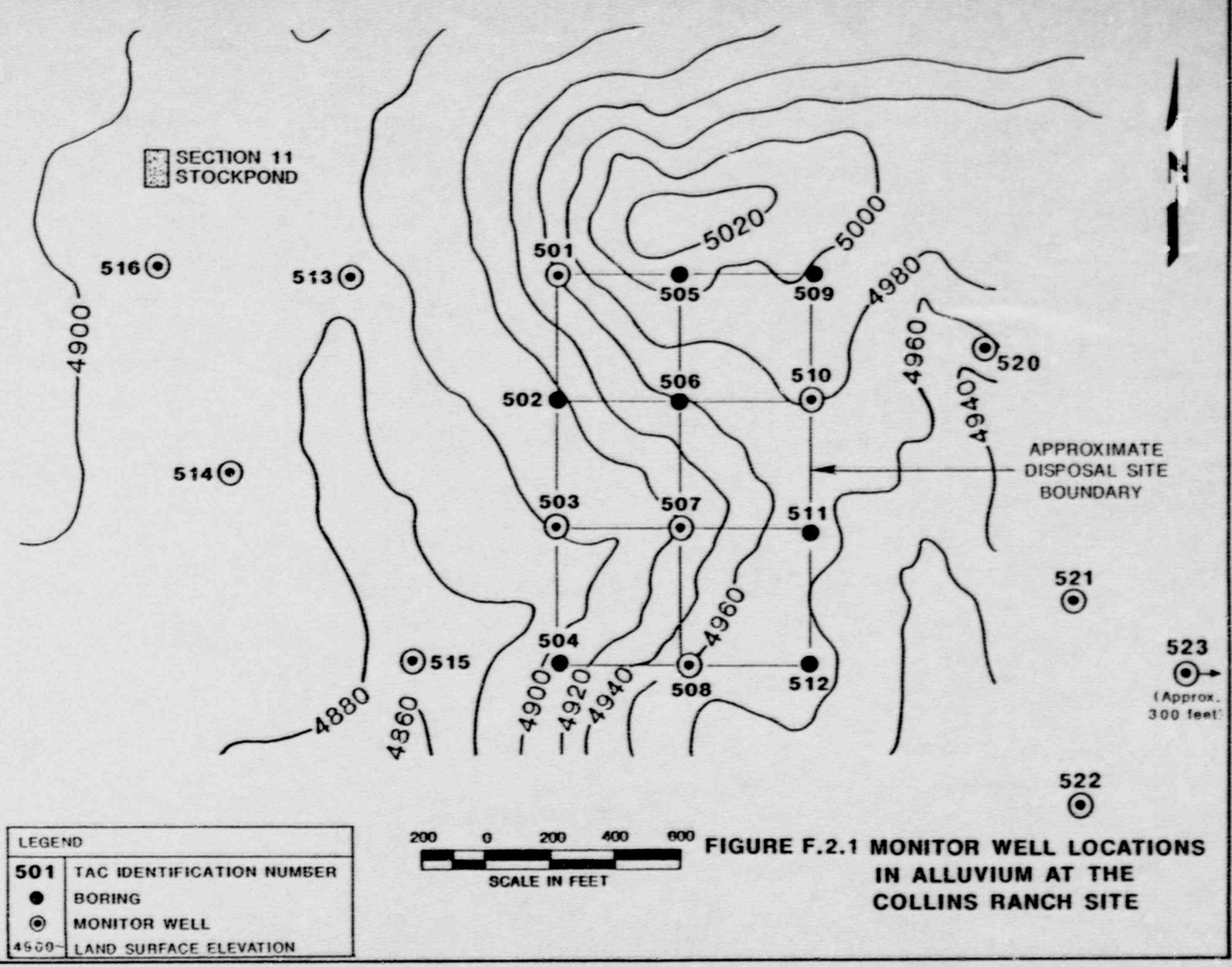

FIGURE F.2.1 MONITOR WELL LOCATIONS IN ALLUVIUM AT THE COLLINS RANCH SITE

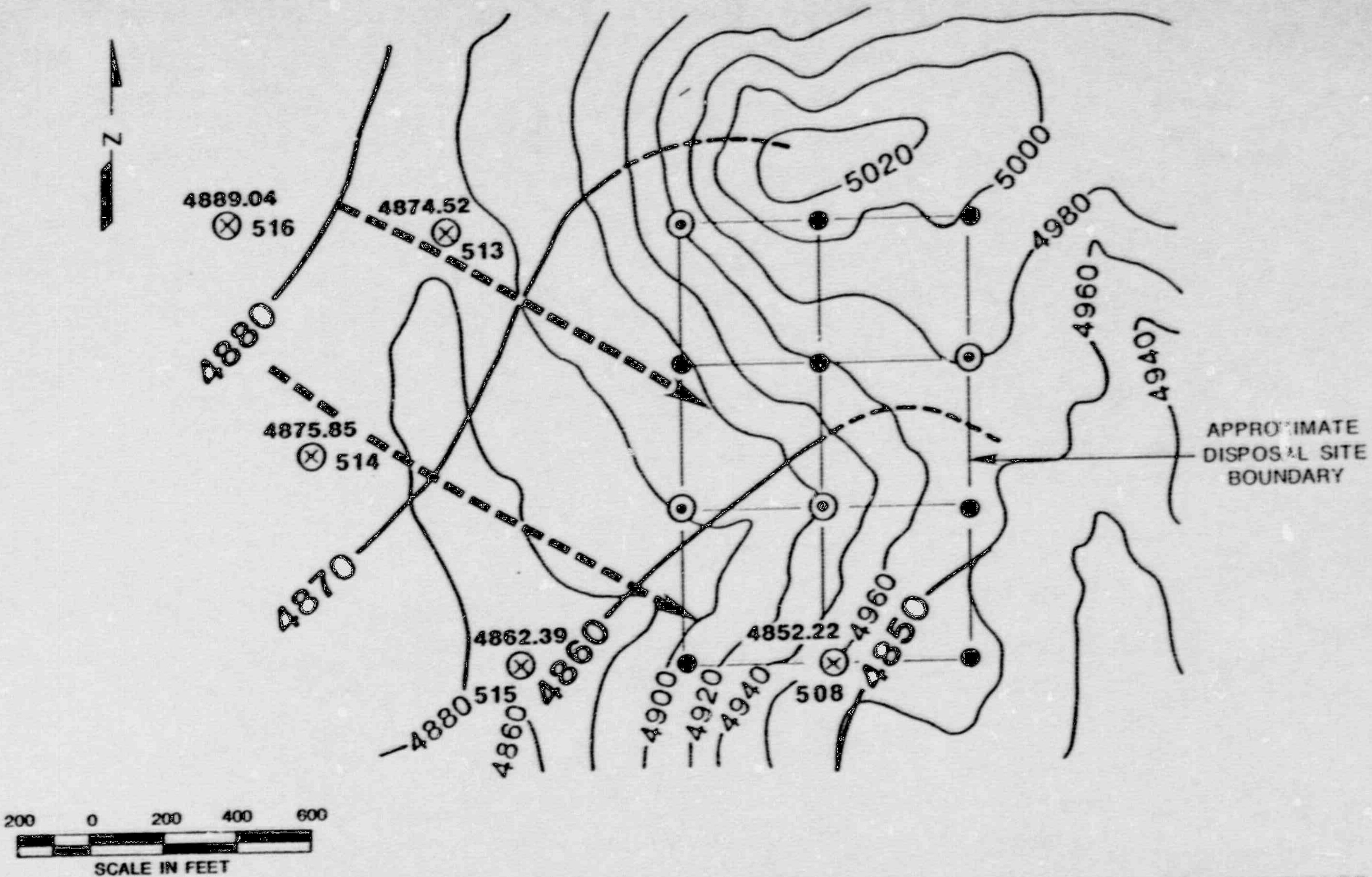

FIGURE F.2.2 POTENTIOMETRIC SURFACE IN ALLUVIUM AT THE COLLINS RANCH SITE AUTUMN 1984

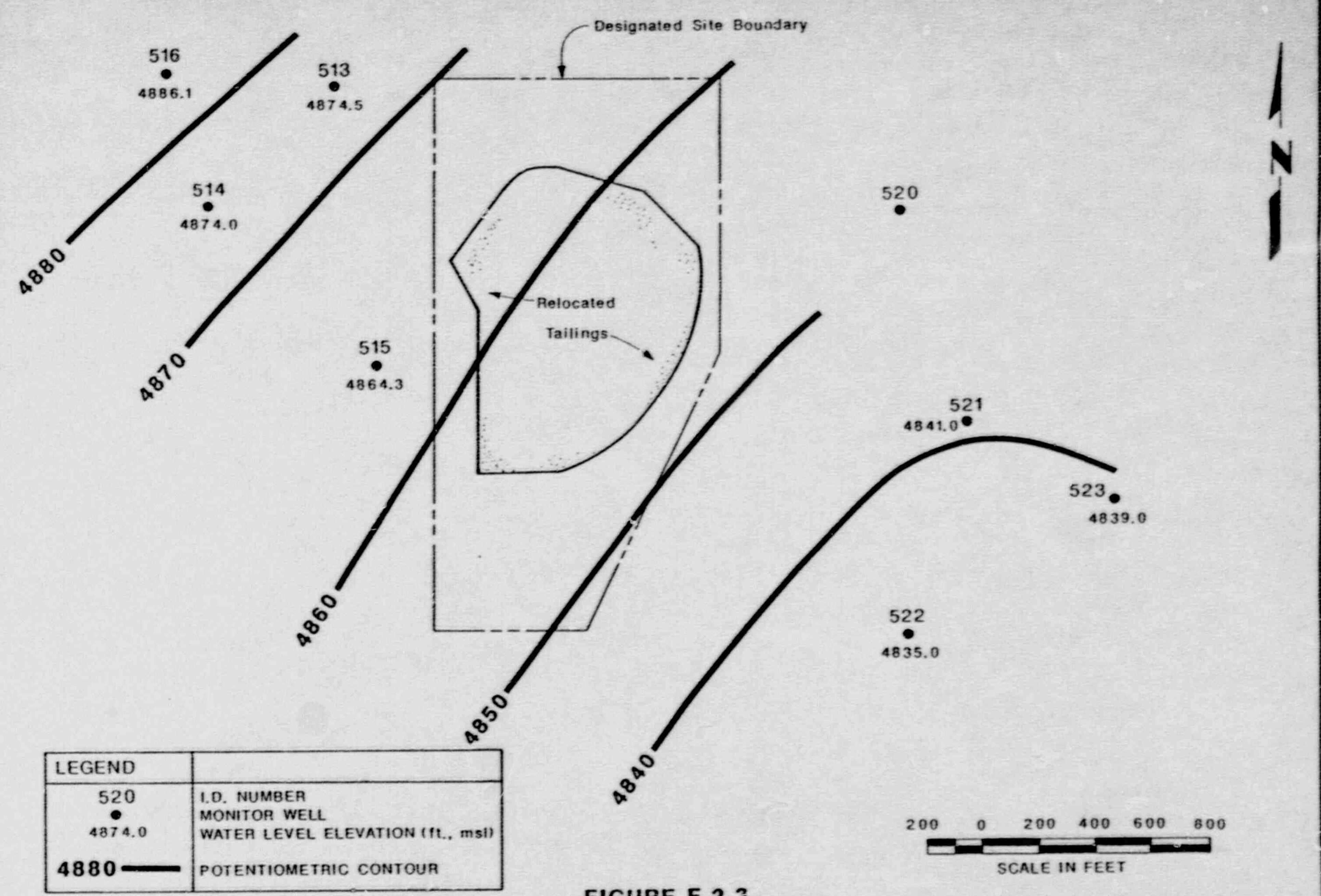

FIGURE F.2.3

POTENTIOMETRIC SURFACE IN ALLUVIUM AT THE COLLINS RANCH SITE
JUNE 1988

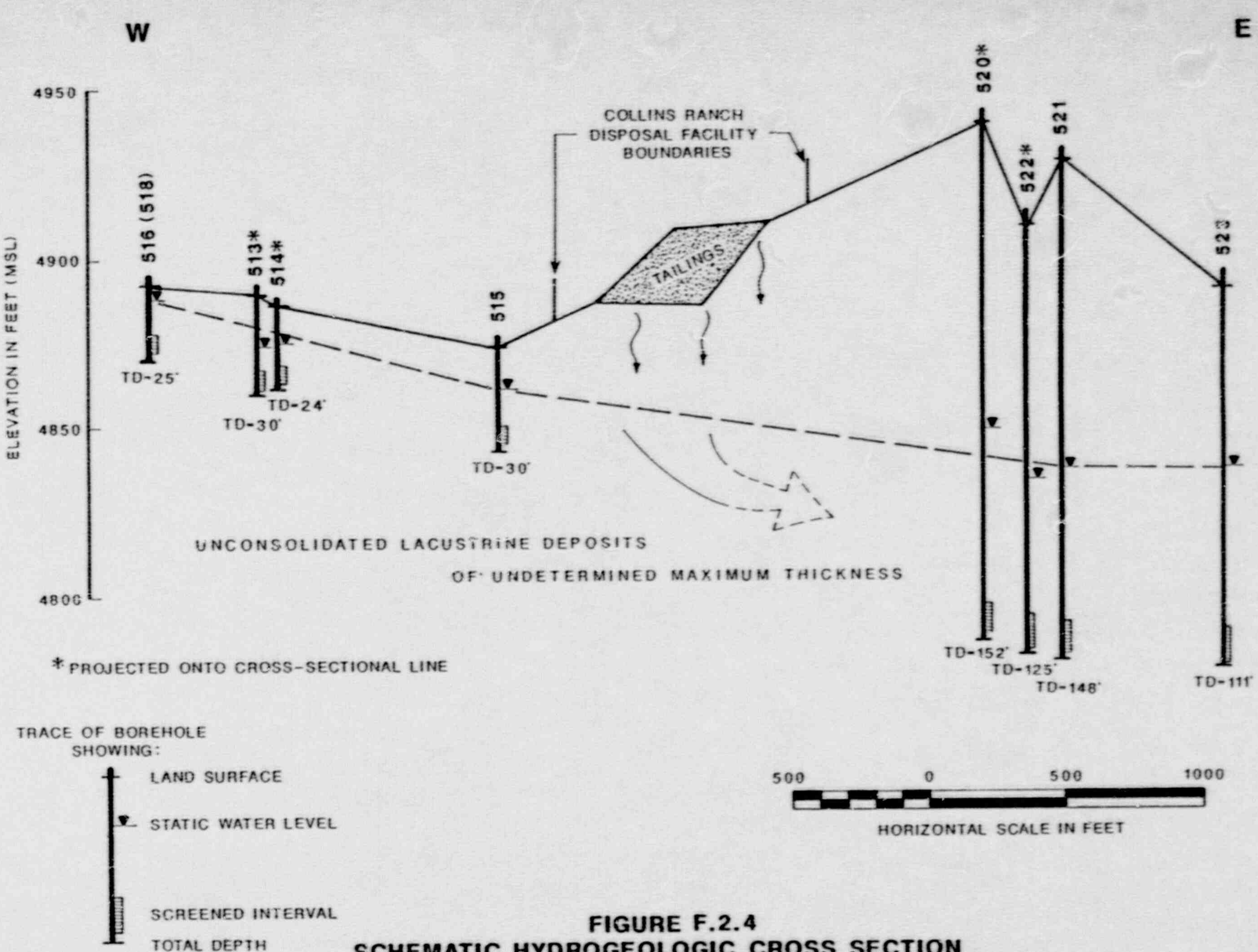

FIGURE F.2.4
SCHEMATIC HYDROGEOLOGIC CROSS SECTION
COLLINS RANCH DISPOSAL SITE

An hydraulic gradient of 0.018, an average hydraulic conductivity of 0.64 feet/day, and an effective porosity of 0.15 were reported for the unconsolidated aquifer at Collins Ranch (DOE, 1985a). The minimum saturated thickness for this aquifer is 60 feet (Figure F.2.4). Further discussion of these parameters is provided in Section 4.2.2.

In order to evaluate seasonal groundwater fluctuations, water levels have been measured quarterly through September 1988. Groundwater elevations were found to fluctuate less than about six feet, leading to the conclusion that groundwater will not impinge upon the base of the Collins Ranch disposal cell.

F.2.2.2 Background water quality

Water quality data for the Collins Ranch unconsolidated aquifer are presented in Appendix A. Monitor wells 508, 513, 514, 515, 516, 520, 521, 522, and 523 were sampled between October 1984 and March 1988; the locations of these wells are shown on Figure F.2.1. Because these samples were collected before remedial actions began, they are representative of background water quality.

Total dissolved solids (TDS) from 28 water samples average 194 milligrams per liter (mg/l); the range is from 134 to 380 mg/l. The groundwater contains relatively low concentrations of calcium (22 mg/l); magnesium (5 mg/l); sodium (16 mg/l); sulfate (8 mg/l); and organic carbon (2 mg/l) (DOE, 1985a). These values are the means of the available sample analyses.

Table F.2.1 shows the background concentrations of those constituents at Collins Ranch that are part of the proposed EPA standards (52 FR 36000). The maximum concentrations measured for all but one constituent were below the proposed MCLs; cadmium exceeded the MCL in one sample. Nine samples from the same well, taken before and after the sample showing exceedance of the cadmium MCL, showed cadmium concentrations between the analytical detection limit and 0.003 mg/l. The maximum observed cadmium concentration in all other wells at Collins Ranch is 0.004 mg/l. The single exceedance of the proposed EPA MCL for cadmium is assumed to be erroneous, and is therefore not considered to be representative of background water quality in the alluvial aquifer at the Collins Ranch disposal site.

F.2.2.3 Use and alternative supplies

Existing use

The Lake County Watermaster has no well records for a three-mile area surrounding the Collins Ranch disposal site.

Table F.2.1 Concentrations of proposed EPA constituents in background groundwater of the alluvial aquifer at the Collins Ranch disposal site[a]

Constituent[b]	Proposed EPA MCL	Minimum observed	Average observed	Maximum observed	No. of samples
Arsenic	0.05	0.001	0.0048	0.006	28
Barium	1.0	0.005	0.006	0.01	4
Cadmium	0.01	0.0005	0.0011	0.017	24
Chromium	0.05	0.005	0.0077	0.02	20
Lead	0.05	0.005	0.0050	0.005	8
Mercury	0.002	0.0001	0.0001	0.0002	4
Molybdenum	0.10	0.005	0.0050	0.005	4
Nitrate	44	2.0	5.00	13.0	28
Selenium	0.01	0.0025	0.0025	0.0025	8
Silver	0.05	0.005	0.0050	0.005	4
Radium-226 & -228	5.0 pCi/l	0.05	1.00	1.4	16
Uranium-234 & -238	0.044	0.0001	0.0011	0.0015	16
Gross alpha	15 pCi/l	0.0000	0.9866	2.3	10

[a] Water sample analyses between 10/84 and 3/88 from monitor wells 508, 513, 514, 515, 516, 520, 521, 522, and 523 at Collins Ranch disposal site. See Figure F.2.1 for locations of wells.

[b] All values in mg/l unless noted otherwise; pCi/l = picocuries per liter. The EPA proposed groundwater constituents for UMTRA sites include a list of hazardous organic constituents (40 CFR Part 261, Appendix VIII; 40 CFR Part 264, Appendix IX). These hazardous organics do not occur naturally in groundwater and would not be expected to occur within background alluvial groundwater at the Collins Ranch site.

The degree of future groundwater development would be governed by the availability of water rights, by land use restrictions on the Federal land, and by economic factors on nearby private land.

In the immediate vicinity of the Collins Ranch site, groundwater is not currently used. However, a water use survey in February 1985 identified two private wells located 1.25-1.5 miles from the site (DOE, 1985c).

The value of water in the area will probably parallel the value of agricultural products that can be produced by the water supply. Alternatively, population growth in the area could increase demand for a domestic water supply. On a qualitative or relative basis, it can be concluded that the value of groundwater resources in the area is moderate to high.

Alternative supplies

In the unlikely event that the disposal site contaminates groundwater beyond the Point of Compliance at the disposal facility, several alternative water supplies are available. Surface water could be obtained from perennial streams, if water rights are available. Deep, bedrock groundwater may also be available but probably at significant expense.

F.3 DISPOSAL CELL DESIGN FEATURES TO PROTECT WATER RESOURCES

The disposal cell cover system being constructed for the Collins Ranch disposal site follows a standard UMTRA Project design. Details are presented in Section 3.2. The following section discusses items which are important in the design of the disposal cell cover for the site.

F.3.1 DESIGN CONSIDERATIONS

The Collins Ranch disposal site is in the northern Basin and Range physiographic province of south-central Oregon. The site is located within the Goose Lake graben, a structural feature filled with in excess of 5,000 feet of unconsolidated to partially consolidated lacustrine sediments (DOE, 1985a). The average elevation of the disposal area is about 4950 feet. Tailings have been placed at the site in a partially below-grade disposal cell; the base of the excavation is at an elevation of about 4890 feet. The disposal cell foundation consists of a two-foot thick, compacted soil layer acting as a geochemical attenuation layer (DOE, 1985a), underlain by at least 30 feet of unsaturated, relatively fine-grained Quaternary sediments (Figure F.3.1). Below this is approximately 1000 feet of saturated alluvial Quaternary sediments (DOE, 1985a).

In terms of groundwater protection and long-term performance of the disposal cell at the Collins Ranch site, the following items are of importance for disposal cell design:

- Climate.
- Infiltration of precipitation and tailings seepage.
- Subsurface drainage.

The following is a discussion of these design considerations.

F.3.1.1 <u>Climate</u>

Climatological data for the Lakeview area are summarized in Appendix C of the EA for the Lakeview tailings site (DOE, 1985a). Climatological data specifically for the Collins Ranch disposal site are not available because there is no weather station near this location. Precipitation at Lakeview averages 16 inches annually (DOE, 1985a). For purposes of disposal cell cover design and impact assessments, the climatological conditions were assumed to result in continuous saturation of the clay cover. This assumption is sufficiently conservative to allow impacts to be evaluated on a worst-case basis.

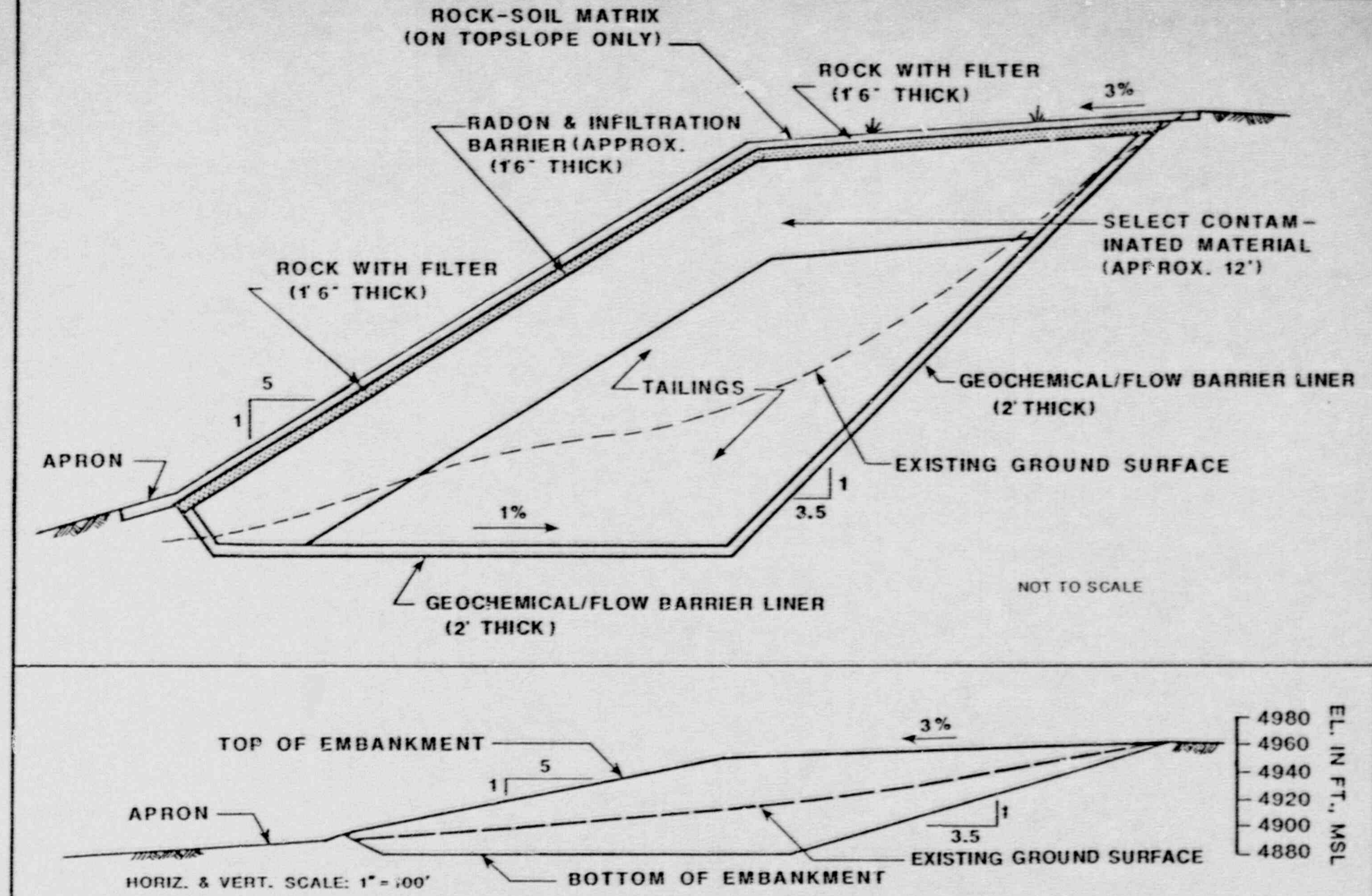

FIGURE F.3.1
COLLINS RANCH DISPOSAL SITE
TYPICAL CROSS SECTION

F.3.1.2 Tailings seepage

Tailings seepage is the water that percolates through the disposal cell and out the bottom. Details of the tailings seepage rate are discussed in more detail in Section 4.2.3. "Mounding" of tailings leachate beneath the Collins Ranch disposal cell is not predicted to occur due to the low predicted infiltration rate, the hydraulic conductivity of the natural foundation materials, and the depth to groundwater.

F.3.1.3 Subsurface drainage

Drainage of tailings seepage into the foundation alluvium may occur as a result of percolation through the disposal cell. Drainage may also occur at the fringes of the cell where excess water will run off the cover of the disposal cell. The foundation alluvium must have a hydraulic conductivity that can transmit the tailings seepage in order to prevent leachate from perching at the base of the excavation.

Previous tests performed on the natural foundation materials indicate a saturated hydraulic conductivity for these materials between 1×10^{-6} and 1×10^{-7} centimeters per second (cm/s) (DOE, 1985b). As the saturated hydraulic conductivity of the low-permeability cover is 7×10^{-8} cm/s (see Section 4.2.2), subsurface drainage will not create a perched condition.

Water added to the tailings during construction may initially drain at a rate higher than the steady state infiltration rate through the cover. No evidence of such seepage has been observed to date. Because the tailings have a high percentage of fine-grained slimes, this condition is not expected to occur.

F.3.2 COVER DESIGN

The current cover design includes a low conductivity clay layer, a high conductivity sand filter/drainage layer, and riprap erosion protection (Figure F.3.1). The Collins Ranch disposal cell cover will consist of a series of layers on top of the compacted, reconfigured tailings placed within the excavation. The design is intended to (1) prevent radon emanations into the atmosphere; (2) limit the amount of infiltration into the tailings from direct precipitation over the pile; (3) limit or prevent erosion from surface flow; and (4) promote runoff from the pile and prevent surface ponding. Figure F.3.1 shows a generalized cross section through the pile, and the details of the cover on the top and sideslopes of the pile. Table F.3.1 lists the function of each in meeting the above objectives. The following sections provide design details, and a qualitative description of performance, for each component, and a discussion of the longevity of each component.

Table F.3.1 Assessment and purposes of cover components

Cover component	Purpose
Erosion and biointrusion barrier	Required to impede roots and burrowing animals. Required to control erosion for topslope.
Drain	Required to drain water laterally off pile.
Infiltration barrier clay	Impedes infiltration.

F.3.2.1 Radon/infiltration barrier

The compacted soil radon/infiltration barrier has been placed immediately above the compacted tailings and contaminated soils. This barrier will suppress the diffusion of radon gas generated within the tailings, and limit the amount of precipitation reaching the tailings.

Design Criteria: The radon/infiltration barrier is a standard feature on UMTRA Project piles, and has been designed and placed in accordance with accepted UMTRA Project procedures. The soil was selected, placed, and compacted so that the average saturated hydraulic conductivity is 7×10^{-8} cm/s (Chen and Associates, 1986).

Performance: In conjunction with the overlying drain/bedding layer, infiltration of precipitation into the cell will be limited by the saturated hydraulic conductivity of the radon/infiltration barrier.

F.3.2.2 Drain/bedding layer

The sand layer shown in Figure F.3.1 serves the following functions:

- A filter to prevent erosion of the radon barrier by interstitial flow.
- A bedding layer erosion barrier.
- A drain which sheds water laterally; i.e., downslope off the pile.
- A protection layer over the radon barrier; the sand prevents damage of the radon barrier by equipment during remedial action construction.

Design Criteria: Clean sand and gravel with an hydraulic conductivity of 1.0 cm/s or greater. The gradation should be chosen to preclude damage of the underlying radon/infiltration barrier. The gradation should, to the extent practical, prevent erosion of the radon barrier. Layer thickness will be at least one foot.

Performance: The drain will quickly shed water off the pile, downslope, and above the radon/infiltration barrier.

F.3.2.3 Erosion barrier

Plant roots and burrowing animals must not be allowed to reach the tailings and bring contaminants to the surface. A layer of cobbles between the rock-soil matrix and radon barrier will achieve this while concurrently protecting against erosion. Hakonson (1986) has shown that such a layer deterred all penetration by burrowing animals and most roots. The root penetration that did occur was attributed to the piping of fines into interstitial voids. This can be prevented by the application of overlying layers of sorted gravels.

The following is a summary of design specifications, performance, and longevity for this layer.

Design Criteria: The matrix will be designed in accordance with standard UMTRA Project procedures to resist erosion by flow in gullies that might develop in the soil. Durable rock meeting NRC requirements will be used. The upper three inches will be chocked with smaller durable rock so that the resulting gradation prevents piping of the overlying soil into the voids of the rock erosion barrier.

Performance: The size of the rock will prevent erosion by flow in gullies. This layer will also function as a biointrusion barrier. The large size of the rock will prevent burrowing animals from penetrating through to the radon/infiltration barrier. The chocked rock will prevent seeping water from caving soil particles into the voids of the rock.

Longevity: Durable natural materials will be used in constructing all components of the cover. The cover may therefore be assumed to function as designed for the design life of the cell (1000 years).

F.4 DISPOSAL AND CONTROL OF RADIOACTIVE MATERIALS AND NONRADIOACTIVE TOXICS

F.4.1 GROUNDWATER PROTECTION STANDARDS FOR DISPOSAL

For the Collins Ranch disposal site, 40 CFR Part 192.02 requires three basic factors for setting the groundwater protection standard. These are (1) determination of hazardous constituents; (2) proposal of a concentration limit for each hazardous constituent found to exist in the tailings or leachate; (3) specification of the POC.

F.4.1.1 Hazardous constituents

The tailings source-concentrations have been estimated from chemical analyses of the tailings pore fluid from suction lysimeter samples. Water quality analyses from shallow monitor well samples taken from beneath the tailings pile at the processing site also reflect source concentrations, but may have been influenced by mixing with groundwater. Concentrations of proposed EPA constituents in lysimeter samples and groundwater are summarized in Table F.4.1.

Appendix IX (EPA, 1987) hazardous organic constituents were analyzed in groundwater samples from two monitor wells at the Lakeview processing site in November 1988. These wells included an upgradient background well (LKV01-501) and a shallow well (LKV01-503) immediately downgradient of the tailings pile and evaporation ponds (see Figure D.2.7, DOE, 1985a). None of the Appendix IX hazardous organic constituents were detected in the samples from the wells; these organics are not reasonably expected to be derived from the milling process used at the site.

Table F.4.1 includes water quality analyses from two lysimeter nests which were installed in the Lakeview tailings pile and evaporation ponds. The data are representative of pore fluid concentrations within the tailings. Maximum observed concentrations within the shallow alluvial groundwater beneath the previously existing tailings pile are also presented in Table F.4.1. Representative concentrations for the proposed EPA constituents within the tailings pore fluid are discussed below.

Arsenic

A representative source value for arsenic is 0.147 mg/l, based upon mean concentrations of arsenic from the lysimeter sample (0.147 mg/l) and from the shallow monitor wells (0.08 mg/l).

Table F.4.1 Observed concentrations of proposed EPA constituents in tailings pore fluid and in shallow groundwater beneath the Lakeview processing site

Constituent[a]	Proposed EPA MCL	Average of lysimeter samples[b]	Maximum observed in shallow groundwater[c]
Arsenic	0.05	0.147	0.08
Barium	1.0	<0.10	0.10
Cadmium	0.01	0.03	<0.01
Chromium	0.05	0.01	0.01
Lead	0.05	<0.01	0.01
Mercury	0.002	NM	0.0003
Molybdenum	0.10	0.04	0.07
Nitrate	44	17	2
Selenium	0.01	<0.005	0.03
Silver	0.05	<0.01	<0.01
Uranium-234 & -238	0.044	0.048	0.004
Radium-226 & -228	5.0 pCi/l	NM	<2 pCi/l
Gross alpha	15 pCi/l	NM	NM

[a] Constituent values are in mg/l unless noted otherwise; pCi/l = picocuries per liter; NM = not measured. Appendix IX organics (40 CFR Part 264) were not detected in samples collected from two shallow monitor wells at the Lakeview processing site (see text, Section F.4.1.1).

[b] Average of 26 analyses of lysimeter samples at the Lakeview tailings site.

[c] Maximum concentration observed in Lakeview shallow alluvial wells (LKV01-513, 515, 527, 529) beneath the Lakeview processing site.

Barium

Barium has been detected in groundwater beneath the previous tailings pile in a concentration equal to the analytical detection limit (0.10 mg/l) and is not present within the tailings in detectable concentrations.

The disposal of tailings at the Collins ranch site will therefore not cause the groundwater beneath or downgradient of the disposal cell to become contaminated with barium.

Cadmium

The maximum concentration of cadmium presented in Table F.4.1 suggests a conservative estimate of the source concentration for cadmium is the average of the lysimeter samples (0.03 mg/l).

Chromium

Chromium has been detected in concentrations equal to the analytical detection limit (0.01 mg/l) in groundwater beneath the processing site, and was below the detection limit in tailings pore fluid.

Lead

Detectable amounts of lead were not measured in the lysimeter samples; however, lead was measured as equal to the analytical detection limit in shallow groundwater at the processing site. While it is highly unlikely that any significant quantity of lead will be leached through the disposal cell at the Collins Ranch site, a conservative value for the source concentration of lead is 0.01 mg/l.

Mercury

Mercury has been detected in very low concentrations (0.0003 mg/l) in the shallow groundwater beneath the previous tailings pile, and has not been measured within the tailings.

Molybdenum

An estimate of the source concentration of molybdenum is the average of the lysimeter samples (0.04 mg/l), which is below the proposed EPA MCL for molybdenum.

Nitrate

An estimate of the source concentration of nitrate is the average of the lysimeter samples (17 mg/l), which is below the EPA proposed MCL for nitrate.

Selenium

An estimate of the source concentration of selenium is the average of the lysimeter samples (<0.005 mg/l), which is below the EPA proposed MCL for selenium.

Silver

Silver is below analytical detection limits in groundwater beneath the processing site, as well as within the tailings.

Uranium-234 and -238

A conservative estimate of the source concentration for uranium (U) (U-234 and U-238) is equal to the average concentration measured in the lysimeter samples (0.048 mg/l).

Radium-226 and -228

Because of the large sample volume required to analyze radium-226 and -228, activities are not available for this radionuclide. The maximum observed activity in the shallow groundwater beneath the processing site (<2.0 pCi/l) is considered to be representative of the source activity for Ra-226 and 228 and is below the EPA proposed MCL of 5.0 pCi/l for Ra-226 and Ra-228.

Gross alpha

Gross alpha activity was not measured in either the lysimeter samples or the shallow groundwater beneath the tailings pile.

Summary

In summary, representative source concentrations/activities for hazardous constituents that exceed the proposed EPA MCLs in tailings pore fluids or shallow groundwater at the processing site are as follows:

- o Arsenic - 0.147 mg/l
- o Cadmium - 0.03 mg/l
- o U-234 and -238 - 0.048 mg/l

F.4.1.2 Proposed concentration limits

Pursuant to 40 CFR Parts 192.02(a)(3) (ii and v) and 264.94, concentration limits at the POC must be proposed for the hazardous constituents identified within the tailings at the Collins Ranch site (see Section 4.1.1). The POC will be discussed in Section 4.1.3.

Background concentrations for all of the proposed EPA constituents in the groundwater underlying the Collins Ranch site were presented in Table 2.1 of Section 2.2.2. Table F.2.1 shows that none of the average concentrations exceed the proposed EPA MCLs for the constituents that are listed. Since no mean background concentrations exceed the proposed MCLs, background values will not be substituted for MCLs for any concentration limits for hazardous constituents.

In Section 4.1.1 it was stated that concentrations of barium, chromium, lead, mercury, molybdenum, nitrate, selenium, silver, and Ra-226 and -228 were found to be either not present within the tailings at levels above the analytical detection limit, or to be present at levels that are below the proposed EPA MCLs for those constituents. Therefore, there are no proposed concentration limits for these constituents. Concentration limits for the remaining hazardous constituents identified in Section 4.1.1 (arsenic, cadmium, and U-234 and -238), which are above the proposed EPA MCLs within the tailings, are the proposed EPA MCLs. The performance assessment (Section 4.2) indicates that arsenic, cadmium, and uranium 234 and 238 will not exceed EPA MCLs at the POC.

F.4.1.3 Point of Compliance (POC)

The proposed POC is the downgradient edge of the tailings waste management unit, shown on Figures F.4.1 and 4.2.

F.4.2 PERFORMANCE ASSESSMENT

Pursuant to 40 CFR Part 192, this section addresses the potential impacts to groundwater from the ongoing remedial actions at Collins Ranch. This section includes an analysis of the performance of the cell, and of the impacts of tailings seepage on groundwater. The analytical procedures and the application of these procedures to the Collins Ranch site are described in the following text.

Two models were used to simulate post-closure operation of the containment cell. The method-of-characteristics (MOC) model, developed by Konikow and Bredehoeft (1978), was configured to represent lateral flow in the uppermost aquifer beneath and adjacent to the cell. The model allows the hydrodynamic effects of leachate percolation to be estimated, and the influence of lateral dispersion to be evaluated. Because the model is two-dimensional, injected leachate and groundwater underflow must be assumed to be completely mixed beneath the cell. The model shows that, given a conservative estimate of aquifer thickness, such a mixture will not exceed the proposed MCLs for any constituent.

The approximate analytical procedure of Domenico and Robbins (1985) was used to estimate the distance required to effect mixing of leachate with groundwater through hydrodynamic dispersion. The results show attenuation of concentrations of all constituents to EPA MCLs within 50 feet of the edge of the tailings.

The edge of the disposal cell, shown on Figure F.4.1, extends 100 feet downgradient of the underlying tailings. Because the POC is 100 feet from the edge of the tailings, the proposed MCLs are predicted to be met at the POC.

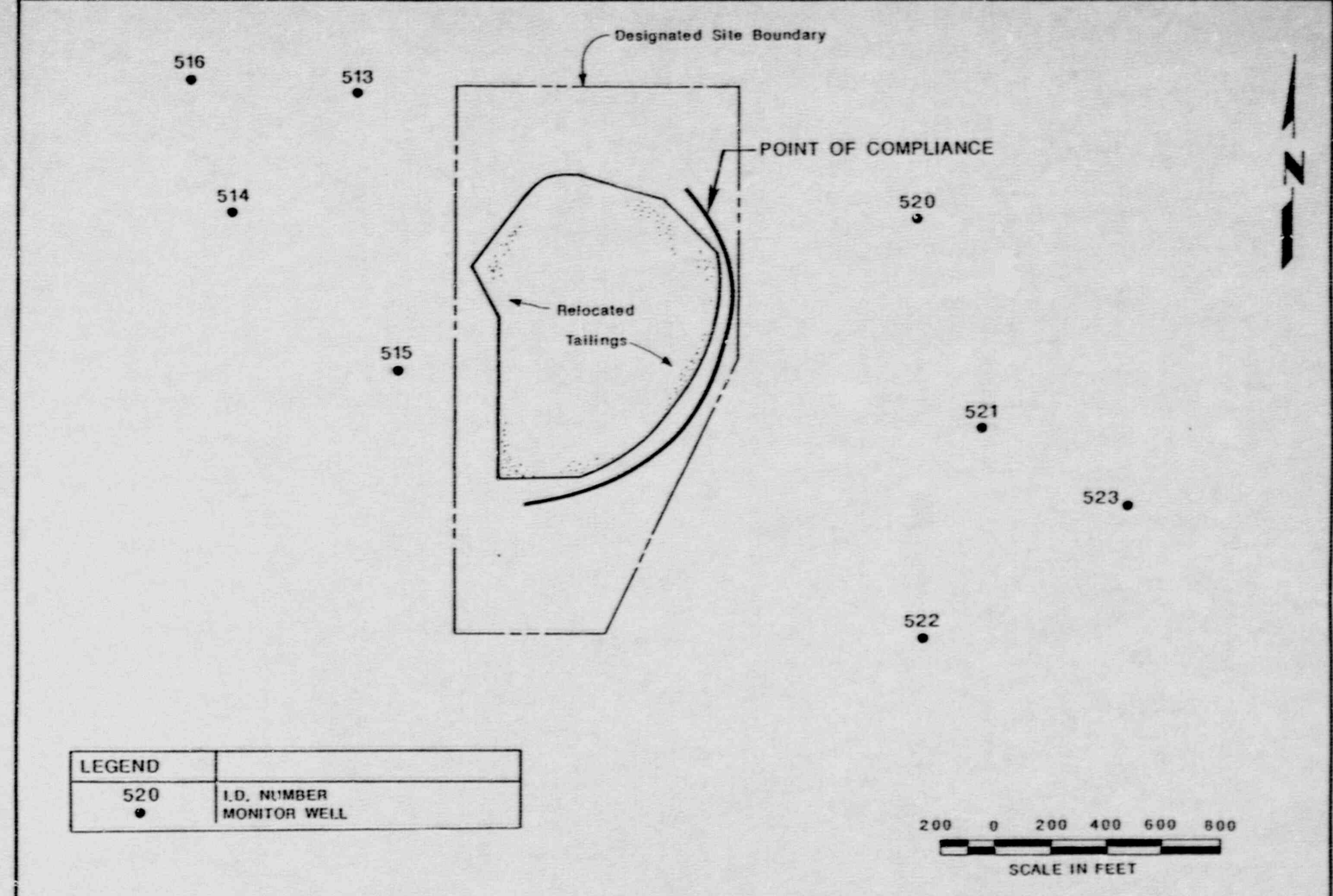

FIGURE F.4.1

POINT OF COMPLIANCE AT THE COLLINS RANCH SITE

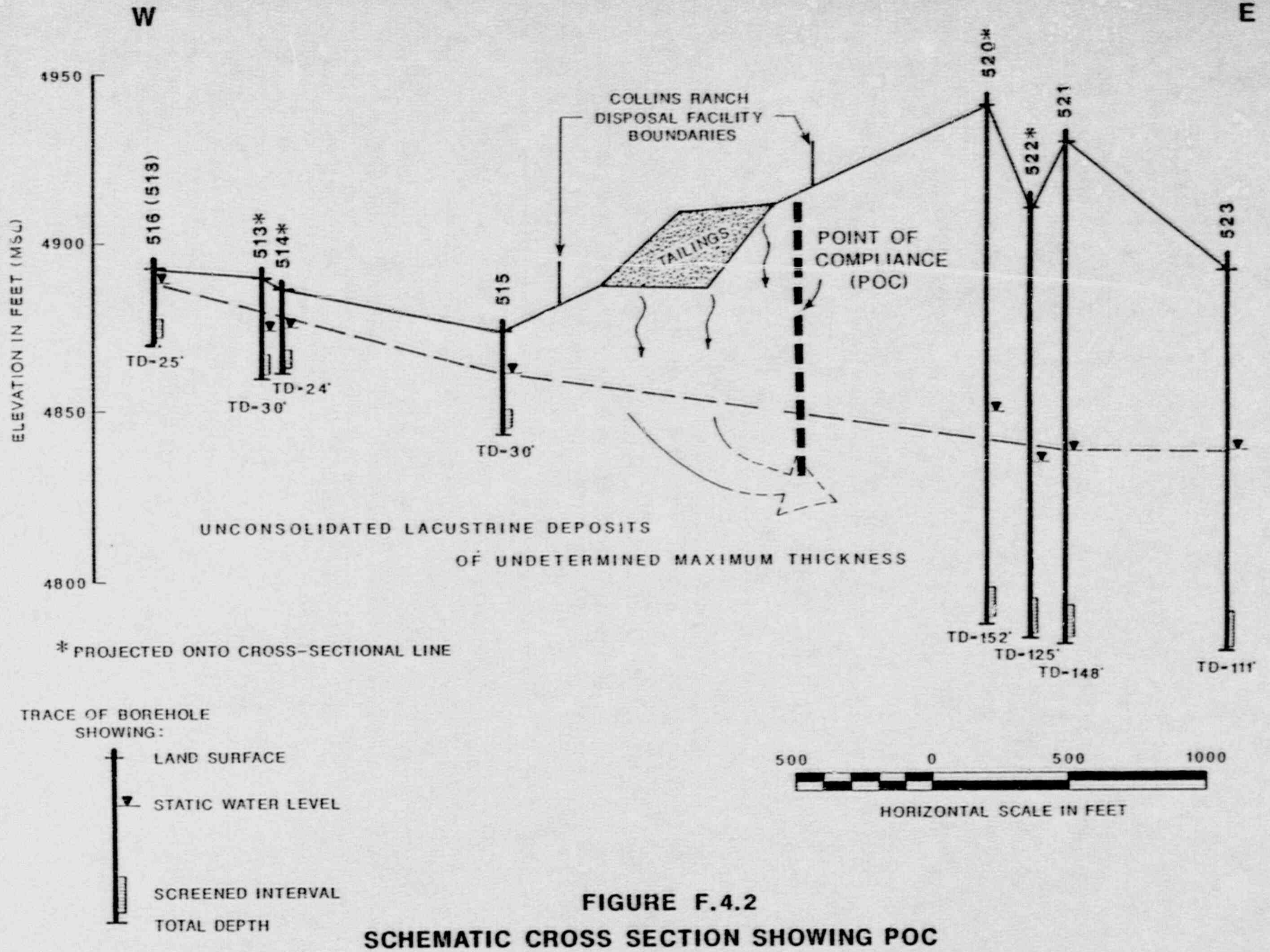

FIGURE F.4.2
SCHEMATIC CROSS SECTION SHOWING POC
AT COLLINS RANCH SITE

F.4.2.1 Model descriptions

The MOC model (Konikow and Bredehoeft, 1978) combines a finite difference solution of the groundwater flow equation in two dimensions with a method of characteristics approximation of advection and dispersion. The model allows regional variation in aquifer permeability, thickness, and recharge over a uniform rectangular grid. Specified heads and fluxes can be used to describe aquifer boundaries. Steady state leakage to or from an adjacent aquifer having unvarying head may also be included. The model requires a uniform (but not necessarily equal) grid spacing in both dimensions. This constraint forces a trade-off between grid spacings sufficiently large to cover the region of interest and spacings sufficiently small to resolve concentration changes near the pile.

Domenico and Robbins (1985) present an approximate analytical solution to the advection-dispersion equation in three dimensions. The solution assumes a uniform steady state flow field, and a uniform, constant, rectangular source of contaminants perpendicular to the direction of flow (Figure F.4.3).

These two approaches jointly allow comprehensive assessment of contaminant transport through sub-pile groundwater. The MOC model allows the hydrodynamic effects of leachate on the groundwater flow system to be evaluated, and provides an estimate of average sub-pile contaminant concentrations, but has limitations in resolving contaminant distributions very near the cell. The Domenico and Robbins approach allows concentrations immediately downgradient of the cell to be estimated given a conservative idealization of the contaminant source.

F.4.2.2 Aquifer, disposal cell, and source term parameters

Tailings from the Lakeview processing site have been placed in a hillside excavation at the Collins Ranch site. Groundwater beneath the site first occurs within the unconsolidated sediments approximately 30 feet below the base of the tailings. Water-level data from monitor wells completed in these sediments indicate flow to the south-southeast under a gradient of approximately 0.018 (Figure F.2.2). Although the total thickness of the unconsolidated deposits beneath the cell is not known, monitor well data indicate a minimum saturated thickness of 60 feet (Figure F.2.4). The average hydraulic conductivity, as measured with falling-head slug tests, is 0.64 feet per day (ft/day) and the porosity has been estimated to be 0.15 (DOE, 1985a). Because tracer studies have not been conducted, longitudinal and transverse dispersivities were taken from conservative values found in the literature (Davis et al., 1985). Aquifer parameters are summarized in Table F.4.2.

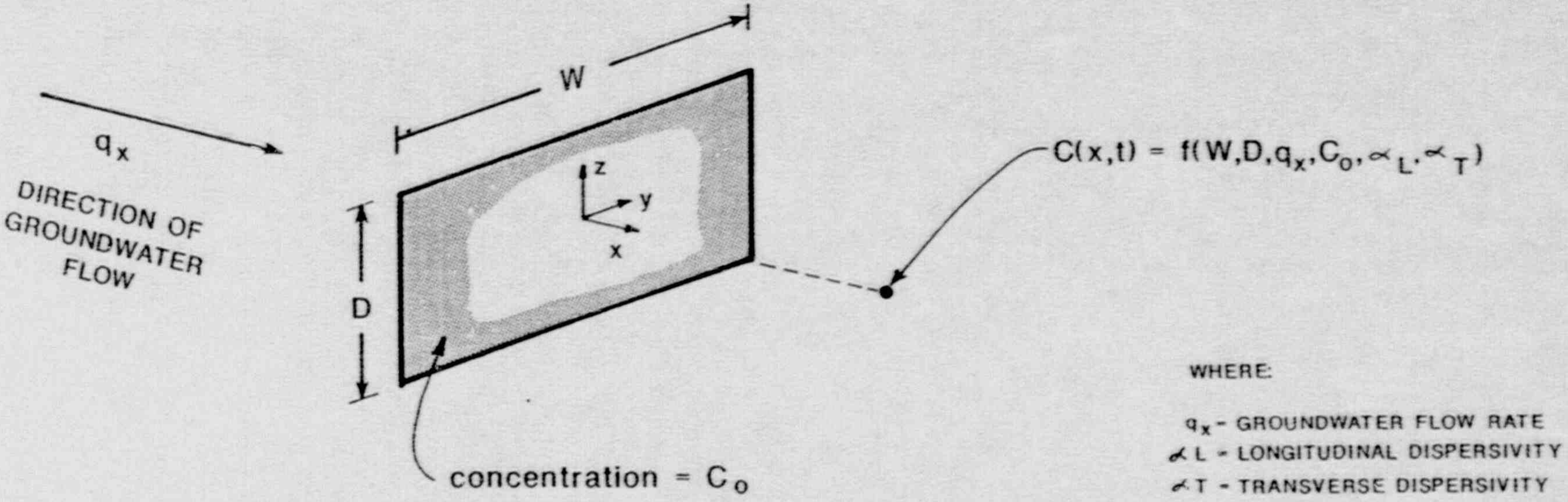

FIGURE F.4.3
SOURCE CONFIGURATION FOR THE DOMENICO-ROBBINS MODEL

Table F.4.2 Hydrologic parameters of the aquifer underlying the Collins Ranch disposal site

Hydraulic conductivity:	0.64 ft/day[a]
Effective porosity:	0.15[a]
Saturated thickness:	60 ft[b]
Hydraulic gradient:	0.018[a]
Longitudinal dispersivity:	50 ft[c]
Transverse dispersivity:	10 ft[c]

[a] Ref. DOE, 1985a.

[b] From Figure F.2.4.

[c] Ref. Davis et al., 1985.

Figure F.3.1 shows a typical cross section through the disposal cell. Infiltration of precipitation and diffusion of radon generated by the tailings are retarded by a low-conductivity clay cap covering the cell. Table F.4.3 presents the results of hydraulic conductivity tests performed by Chen and Associates (1986) on the clay cover material. As a conservative estimate, infiltration through the cover, and therefore percolation of leachate from the tailings into the underlying aquifer, was assumed to occur continually at a rate equal to the saturated hydraulic conductivity of the clay cap. The assumption of continual saturation of the infiltration/radon barrier constitutes a worst-case condition in terms of groundwater impacts, and is highly conservative. Runoff of precipitation, lateral drainage through the sand filter layer, interception of precipitation by the cobble armor, and evaporation of water stored in the sand filter will all reduce the amount of water available for infiltration. It may be expected that these processes will limit the availability of water to the extent that the infiltration/radon barrier will seldom be in a saturated state. The effective bulk conductivity of the clay barrier was estimated (as the arithmetic mean of the available samples) to be 7×10^{-8} cm/s. This estimate represents a worst-case spatial distribution of the variability in conductivity shown in the data. Hydraulic conductivity is expected to show slight variations both vertically and horizontally. The lower-conductivity zones will therefore have a greater influence on the bulk conductivity of the barrier than is accounted for by the uniformly weighted arithmetic mean.

Table F.4.4 presents the source term descriptions for the three constituents having mean tailings pore-water concentrations in excess of the EPA's MCLs. Concentrations of these constituents, which were considered to be conservative in groundwater, were evaluated in terms of the critical concentration ratio. The critical concentration ratio for a particular constituent is defined as the volumetric fraction of pore water, in a mixture of pore water and native groundwater, that will result in a concentration of that constituent equal

Table F.4.3 Saturated hydraulic conductivities for the cover materials at 100% compaction, moisture contents 1-3% above optimum[a]

Sample		Conductivity (cm/s)
SE-2A		4.9×10^{-8}
SW-2A		1.6×10^{-7}
W-2A		2.0×10^{-8}
NW-2A		3.4×10^{-8}
NE-2A		8.6×10^{-8}
	Average	7×10^{-8}

[a] Ref. Chen and Associates, 1986

Table F.4.4 Summary of source term parameters used in the solute-transport model

Constituent	Source concentration[a]	Average background concentration	Critical concentration ratio[b]
Arsenic	0.147 mg/l	0.005 mg/l	0.32
Cadmium	0.03 mg/l	.001 mg/l	0.31
U-234 & -238	0.048 mg/l	0.001 mg/l	0.91

[a] See Section 4.1.1.

[b] Critical concentration ratio $= \dfrac{\text{(EPA MCL - average background)}}{\text{(Source concentration - average background)}}$

to the concentration limit. The critical concentration ratio allows a single model, using a generic source term, to evaluate the performance of a design with regard to all constituents which are not geochemically retarded. In the following analyses, no geochemical attenuation of leachate concentrations has been considered, allowing a single simulation to be used for all constituents.

F.4.2.3 Performance simulation

The MOC model was configured to represent the aquifer below and surrounding the tailings. Fixed-head boundary conditions were used to establish a uniform gradient of 0.018 in the aquifer. Leachate injection rate was calculated as the product of the average saturated hydraulic conductivity of the cover material and the area of the cell. Aquifer thickness was assumed to be 60 feet. The results show a sub-pile concentration ratio of 0.21. All constituents have critical ratios exceeding 0.21, implying that a volumetric fraction of tailings pore water greater than 0.21 is required to produce concentrations exceeding the proposed limits. Dilution of tailings seepage with groundwater flowing in a 60-foot zone beneath the cell is therefore predicted to result in compliance with the proposed limits.

Because the MOC model is two-dimensional, injected leachate is assumed to fully mix with groundwater beneath the cell. The Domenico-Robbins analytical solution of the convection-dispersion equation was used to estimate the distance required to achieve an acceptable degree of mixing through hydrodynamic dispersion downgradient of the edge of the tailings. The model requires the source to be described as a uniform rectangular plane normal to the direction of flow. The source length was specified as the maximum width of the cell perpendicular to the prevailing flow direction (900 feet). The vertical extent of the source was calculated from the rate of leachate production, the rate of groundwater underflow, and the maximum path length beneath the cell. In this approach, the leachate is considered to create a contaminant 'wedge' on top of native groundwater (Figure F.4.4). Dispersion beneath the cell is thereby neglected. The model was used to estimate the distance required to disperse the constituent most elevated above the MCL (arsenic) to acceptable concentrations, relying only on dispersion beyond the downgradient edge of the cell. The approach is essentially the same as that used in the EPA's Vertical and Horizontal Spreading (VHS) model (Federal Register, November 27, 1985) to evaluate delisting applications for hazardous waste sites.

Assuming continual saturation of the clay barrier and the aquifer properties described above, leachate is estimated to occupy the upper 11.2 feet of the aquifer at the downgradient toe of the cell. Arsenic concentrations (and consequently the

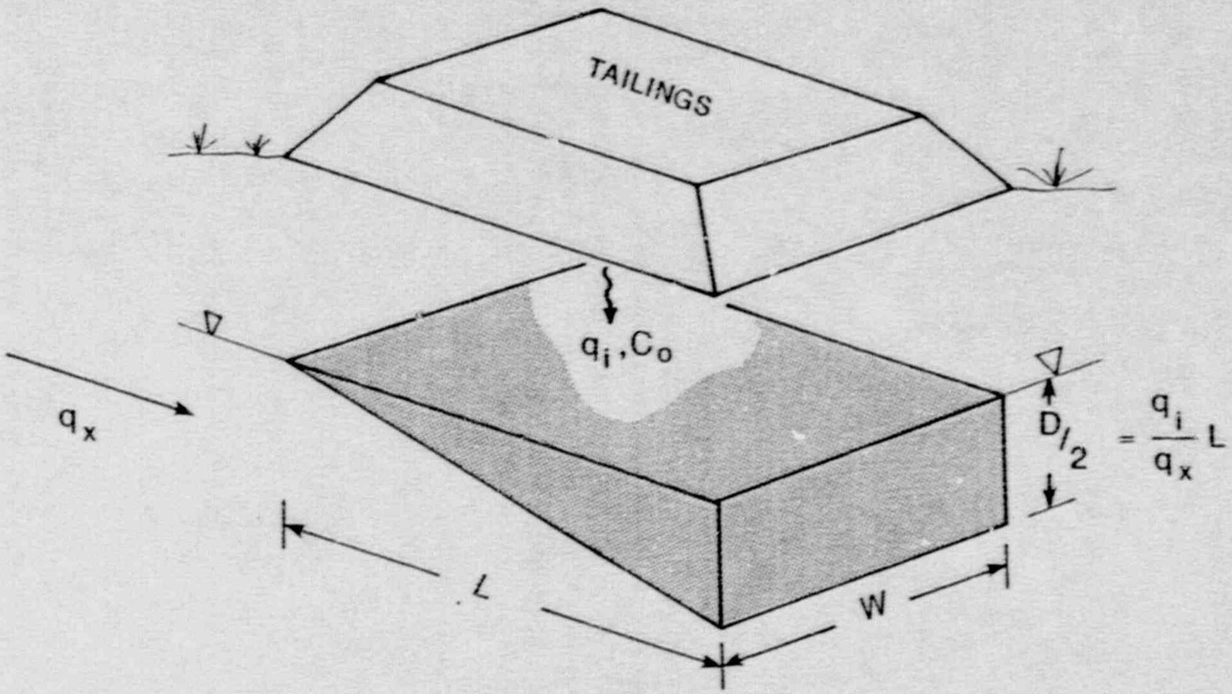

FIGURE F.4.4
RELATIONSHIP BETWEEN PILE GEOMETRY AND THE SOURCE TERM
FOR THE DOMENICO-ROBBINS MODEL

concentrations of cadmium and uranium) are calculated to fall below their respective MCLs within 50 feet of the edge of the tailings, and therefore to be below MCLs at the point of compliance, 100 feet from the downgradient edge of the tailings.

- o Reduction of constituent concentrations in leachate by the geochemical liner has not been considered.
- o Dispersion beneath the cell has not been included.
- o Reduction in contaminant 'wedge' thickness away from the center of the cell has not been considered.

Because the cell performance relies on intrinsic properties of construction materials rather than on the dynamics of the interaction of the cell with the environment, performance is expected to be robust with respect to possible environmental changes over the design life, such as invasion of shallow-rooted vegetation or changes in climate.

F.4.2.4 Impacts summary

Table F.4.5 summarizes the distance from the edge of the tailings at which each constituent is expected to be found at or below respective MCLs. The proposed POC for the disposal site is actually 100 feet downgradient from the edge of the emplaced tailings. The maximum distance predicted for natural dispersive processes to reduce leachate concentration to acceptable levels is 50 feet from the edge of the tailings. Estimated concentrations for those constituents exceeding MCLs in pore water are considered conservative for the following reasons.

- o Parameter values (dispersivity, cover conductivity) were chosen conservatively.
- o The cover system may not operate in a continually saturated state, reducing the amount of leachate generated below the amount assumed in this analysis.
- o Reduction of constituent concentrations in leachate by the geochemical liner has not been considered.
- o Dispersion beneath the cell has not been included.
- o Reduction in contaminant 'wedge' thickness away from the center of the cell has not been considered.

Because the cell performance relies on intrinsic properties of construction materials rather than on the dynamics of the interaction of the cell with the environment, performance is expected to be robust with respect to possible environmental

Table F.4.5 Summary of impacts, Collins Ranch disposal site[a]

Constituent[b]	Proposed EPA MCL	Background level	Distance to meet EPA MCL (ft)	Meets MCL at POC	Remarks
Arsenic	0.05	0.01	<50	Yes	Dilution beneath and immediately downgradient of the cell to concentration below MCL
Barium	1.0	<0.1	0	Yes	Pore water concentration below MCL
Cadmium	0.01	0.002	<50	Yes	Dilution beneath and immediately downgradient of the cell to concentration below MCL
Chromium	0.05	<0.01	0	Yes	Pore water concentration below MCL
Lead	0.05	<0.005	0	Yes	Pore water concentration below MCL
Mercury	0.002	0.0001	0	Yes	Pore water concentration below MCL
Molybdenum	0.1	<0.005	0	Yes	Pore water concentration below MCL
Nitrate	44	7	0	Yes	Pore water concentration below MCL
Selenium	0.01	0.003	0	Yes	Pore water concentration below MCL
Silver	0.05	<0.005	0	Yes	Pore water concentration below MCL
Uranium-234 & -238	0.044	0.0011	<50	Yes	Dilution beneath and immediately downgradient of the cell to concentration below MCL
Radium-226 & -228	5.0 pCi/l	1.1 pCi/l	0	Yes	Pore water concentration below MCL

[a] Concentrations are in mg/l unless noted otherwise.

[b] Appendix IX organic constituents (40 CFR Part 264) were not detected in groundwater samples from two wells at the Lakeview processing site.

changes over the design life, such as invasion of shallow-rooted vegetation or changes in climate.

F.4.3 CLOSURE PERFORMANCE ASSESSMENT

Pursuant to 40 CFR Parts 264.111(a and b), this section discusses the adequacy of the proposed disposal cell design to minimize the need for active maintenance and to minimize or eliminate releases of hazardous constituents to groundwater.

The need to minimize active maintenance is achieved by:

- Using natural, durable materials.
- Shaping the pile to accommodate natural forces (e.g., erosion).

Sections F.3.1 and F.3.2 of this document have described the design requirements, the performance, and the expected longevity of the various components of the proposed covers. As discussed in those sections, all materials chosen meet NRC requirements applicable to the UMTRA Project, are as durable as is reasonably achievable, and are placed to promote their long-term performance in the absence of maintenance. Specifically:

- The radon barrier of compacted soil is placed below the zone where it can be subject to the influence of natural forces such as wind and direct precipitation. It is protected from erosion by the design of overlying layers.
- The sand filter, drain, and bedding layer is clean, durable, and will not deteriorate. It is sized to avoid plugging by piping of soil particles and is protected from erosion by the overlying rock layer.
- The erosion barrier is composed of durable rock that meets NRC longevity criteria. It will be sized to resist gully erosion by the runoff from the probable maximum precipitation.

The pile morphology has been designed to provide slope, settlement, and deformation integrity. Therefore, the need for maintenance is minimized.

The DOE is required to document a performance assessment monitoring and surveillance plan. The DOE has compiled an UMTRA Project Surveillance and Maintenance (S&M) plan. That document will constitute the basis of the surveillance and performance monitoring program to be undertaken at the Collins Ranch site. As is standard on other UMTRA Project sites, a site-specific S&M plan will be compiled and included in preparation of the final site design.

Attention will be particularly directed in the site-specific S&M plan to the following:

- Vegetation growth.
- Soil erosion and gully development.
- Rock erosion.
- Intrusion of herbivores.
- Soil moisture changes.

F.4.4 GROUNDWATER PERFORMANCE MONITORING PROGRAM

Pursuant to 40 CFR Part 192.020(a)(4)(b), this section addresses a monitoring plan to be carried out during the post-construction period.

Details of a performance monitoring plan will be supplied in a separate document. The DOE recognizes the need to monitor the disposal cell at Collins Ranch, and Table F.4.6 summarizes monitoring needs on a preliminary basis.

Presently there are an inadequate number of monitor wells in the vicinity of the proposed disposal cell. The DOE will install a number of wells (four to eight) downgradient and peripheral to the cell to monitor groundwater quality and static water levels at the point of compliance and downgradient from the cell. Also summarized in Table F.4.6 are rationale for monitoring the disposal cell cover.

F.4.5 CORRECTIVE ACTION PLAN

Pursuant to 40 CFR 192.02(a)(4)(c), this section addresses a corrective action plan to bring the disposal site into compliance if the groundwater standards are found or projected to be exceeded. Proposing a specific, detailed action plan to cleanup or control the movement of groundwater at this time is not possible; however, Table F.4.7 summarizes potential failure modes for the Collins Ranch disposal site and potential remedial action for those modes. Should a failure of the cell occur or if the site is found to be in noncompliance following tailings stabilization, within 18 months corrective action plans shall be formulated and implemented.

F.4.6 AQUIFER RESTORATION

Cleanup of contaminated groundwater is required under the conditions of Subpart B of EPA's proposed UMTRA Project standards. As part of a separate NEPA process, the need for and extent of aquifer restoration at the Lakeview processing site will be determined based on the extent of existing contamination, the potential for current or future use of the aquifer for drinking water supplies, and the technical practicability of restoring the aquifer from an engineering perspective. Studies are currently underway to develop plans, guidance materials, and procedures for aquifer restoration activities. Implementation is currently planned to start in 1989 after the EPA standards are finalized.

Table F.4.6 Summary of performance monitoring needs for the Collins Ranch disposal site

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- Monitor at point of compliance and downgradient
  - Groundwater quality
  - Groundwater elevations

- Monitor at site
  - Vegetation growth
  - Biointrusion
  - Soil erosion
  - Possible instrumentation of the cover for moisture flux

- Interpret data to evaluate
  - Moisture flux
  - Radon barrier moisture content

Aquifer restoration at the Lakeview processing site is not addressed in the remedial action plan because the contaminated materials will be disposed of at the Collins Ranch site. For this reason, water quality impacts resulting from disposal of contaminated materials at Collins Ranch will have no impact on aquifer restoration at the Lakeview processing site. Hence, remedial action can be decoupled from aquifer restoration at the Lakeview site.

Active restoration methods fall into two general categories: (1) above-ground treatment methods wherein the contaminated water is removed from the aquifer, treated, and either disposed of, used, or reinjected into the aquifer; and (2) in situ methods, such as the addition of chemical (lixiviants) or biological agents to fix contamination in place. An aquifer restoration program at the Lakeview site may involve one or more of the restoration methods discussed below.

F.4.6.1 Extraction methods

Contaminated groundwater can be extracted from wells or trenches. The use of trenches is limited to relatively shallow contamination and is particularly useful in materials with low hydraulic conductivities. Wells may be used for groundwater extraction when the hydraulic conductivity of the water-bearing materials is sufficiently high, or when the contamination is relatively deep.

F.4.6.2 Treatment methods

The need for treatment prior to discharge or reinjection into an aquifer depends upon the concentrations of contaminants in the extracted groundwater and the applicability of regulations on the discharge of effluent to surface water and

Table F.4.7 Corrective action plan summary for the Collins Ranch disposal site

Failure scenario	Remedial action
Contaminated seepage emerges in artificially induced springs below the pile.	Modify cover to eliminate excess infiltration.
Groundwater quality deterioration occurs off-site due to tailings seepage.	Modify cover and apply institutional controls (groundwater restoration impractical).
Radon barrier cracks due to dessication.	Replace high permeability filter layer with lower permeability layer.
Siltation of erosion protection layer	No action needed unless it increases infiltration or induces vegetation.
Vegetation threatens integrity of radon barrier.	Apply biointrusion barrier
Biointrusion by animals.	Modify rock cover.
Frost heave.	Not a realistic failure scenario due to unsaturated conditions.
Erosion of cover.	Not a realistic failure scenario (pile is designed to resist probable maximum precipitation and probable maximum flood events).

groundwater. The preferred treatment methods depend on the concentrations and types of contaminants, the background water quality, the volumetric requirements of the treatment stream, and the area available for treatment facilities. Chemical treatment methods include chemical precipitation, coagulation, ion exchange, flocculation, neutralization, sorption, and reverse osmosis. Contaminated groundwater can also be evaporated in ponds. Biological treatment can be used to transform nitrate to nitrogen gas and oxygen gas.

In addition to above-ground treatment, two in situ treatment methods are possible. These are lixiviant injection and the use of permeable treatment beds or walls. In situ treatment would mobilize contaminants by causing oxidation conditions so that contaminants could be removed quickly from the subsurface.

A lixiviant is a solution of complexing species (ions or molecules) that enhances the solubility of species (metals) to be removed from the aquifer during restoration. For example, injection of lixiviants containing hydrogen peroxide or oxygen to oxidize the system, then sodium bicarbonate to increase the pH, may be useful for removing contaminants that may leach from the solid phase. Lixiviant technology must be tested under site-specific conditions.

Lixiviants would be introduced by injection or infiltration upgradient of the contamination. The lixiviants would move through the contaminated zone, interact with the liquid and solid phases, become impregnated with the contaminants, and be extracted at the leading edge of the contaminant plume.

Permeable treatment beds are subsurface structures installed below the water table, which provide an artificial reducing zone for contaminants in the groundwater. Following reduction and precipitation of the contaminants onto the treatment beds, the treatment bed materials are removed from the groundwater.

In situ chemical reduction, without the use of permeable treatment beds, could temporarily reduce solute concentrations to less than the EPA MCLs, but dissolution or desorption could occur as the geochemical environment equilibrates. Therefore, in situ chemical reduction does not provide long-term assurances that the adequate water quality could be maintained.

F.4.6.3 Discharge of treated water

Following the extraction and treatment of contaminated water, it will be discharged. Options for discharge include:

- Discharge to surface water.
- Infiltration into groundwater through ponds or infiltration galleries.
- Injection into shallow wells.
- Injection into deep wells.

F.4.6.4 Natural flushing

Natural flushing is a passive restoration method whereby dissolved or precipitated contaminants in groundwater are dispersed or removed by the natural flow of groundwater. Under Subpart B of the proposed EPA standards, passive restoration may be permitted if it can be demonstrated that natural flushing can occur within a period of 100 years or less and where groundwater is not now, and is not projected to be, used for a community water supply (or other substantial use) within this period.

Natural flushing may be employed at the processing sites as the sole method for aquifer restoration, or it may be used in conjunction with any of the active restoration methods described above.

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ATTACHMENT A
TO
APPENDIX F

WATER QUALITY DATA

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                              GROUND WATER QUALITY STATISTICS BY PARAMETER
                                          SITE: COLLINS RANCH
                                        REPORT DATE: 09/23/88
                                         10/02/84 TO 03/17/88


FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND


                UNITS OF  SAMPLE                                                            STANDARD   COEFFICIENT   -STATISTICAL RANGE--
 PARAMETER      MEASURE    SIZE     MINIMUM      MAXIMUM        MEAN         MEDIAN    VARIANCE  DEVIATION OF VARIATION   MINIMUM     MAXIMUM
-------------  ----------- ---   -----------  -----------  -----------  -----------  --------- --------- -------------  ---------   ---------
ALKALINITY     MG/L CACO3   28       41.0000     158.0000      97.2143      99.5000 .1020E+04 .3194E+02   .3286E+02     .3332E+02   .1611E+03
ALUMINUM       MG/L          8         .0500        .0500        .0500        .0500 .2230E-17 .1493E-08   .2987E-05     .5000E-01   .5000E-01
AMMONIUM       MG/L         23         .0500        .2000        .0826        .0500 .3320E-02 .5762E-01   .6975E+02     .0000       .1979E+00
ANTIMONY       MG/L         20         .0045        .0050        .0047        .0045 .6125E-06 .7826E-03   .4672E+02     .1098E-03   .3240E-02
ARSENIC        MG/L         28         .0010        .0060        .0048        .0050 .7447E-06 .8630E-03   .1790E+02     .3095E-02   .6547E-02
AS (TOTAL)     MG/L         12         .0010        .0430        .0077        .0050 .1246E-03 .1116E-01   .1440E+03     .0000       .3007E-01
BARIUM         MG/L          4         .0050        .0100        .0062        .0050 .6250E-05 .2500E-02   .4000E+02     .1250E-02   .1125E-01
BORON          MG/L         18         .0050        .2800        .0647        .0500 .4881E-02 .6986E-01   .1079E+03     .0000       .2044E+00
CA (TOTAL)     MG/L         12       11.6000      32.0000      19.1417      16.2500 .5110E+02 .7148E+01   .3734E+02     .4845E+01   .3344E+02
CADMIUM        MG/L         24         .0005        .0170        .0017        .0005 .1173E-04 .3424E-02   .2024E+03     .0000       .8540E-02
CALCIUM        MG/L         28        9.0600      51.7000      22.1629      20.8000 .9537E+02 .9766E+01   .4406E+02     .2632E+01   .4169E+02
CD (TOTAL)     MG/L         12         .0005        .0030        .0011        .0008 .8561E-06 .9252E-03   .8541E+02     .0000       .2934E-02
CHLORIDE       MG/L         28        1.9000       6.0000       3.3357       3.0000 .1389E+01 .1179E+01   .3533E+02     .9786E+00   .5693E+01
CHROMIUM       MG/L         20         .0050        .0200        .0067        .0050 .2178E-04 .4667E-02   .6913E+02     .0000       .1608E-01
COBALT         MG/L          8         .0250        .0250        .0250        .0250 .5576E-18 .7467E-09   .2987E-05     .2500E-01   .2500E-01
CONDUCTANCE    UMHO/CM      28       85.0000    1000.0000     227.2143     152.5000 .4639E+05 .2154E+03   .9693E+02     .0000       .6530E+03
COPPER         MG/L          8         .0100        .0200        .0112        .0100 .1250E-04 .3536E-02   .3143E+02     .4179E-02   .1837E-01
CR (TOTAL)     MG/L         12         .0050        .0300        .0112        .0050 .7784E-04 .8823E-02   .7842E+02     .0000       .2890E-01
FE (TOTAL)     MG/L         12         .0150      16.9000       4.5329       3.0050 .2382E+02 .4881E+01   .1077E+03     .0000       .1429E+02
FLUORIDE       MG/L         26         .0100        .3000        .1312        .1000 .5714E-02 .7560E-01   .5764E+02     .0000       .2823E+00
GROSS ALPHA    PCI/L        10         .0000       2.3000        .2300        .0000 .5290E+00 .7273E+00   .3162E+03     .0000       .1685E+01
GROSS BETA     PCI/L        10        1.5000       4.8000       3.9500       4.3000 .9384E+00 .9687E+00   .2452E+02     .2043E+01   .5887E+01
IRON           MG/L         28         .0150       3.3100        .1466        .0150 .3849E+00 .6204E+00   .4232E+03     .0000       .1387E+01
K (TOTAL)      MG/L         12        3.2100       5.1100       4.1467       4.2100 .4649E+00 .6818E+00   .1644E+02     .2783E+01   .5510E+01
LEAD           MG/L          8         .0050        .0050        .0050        .0050 .3872E-20 .6223E-10   .1245E-05     .5000E-02   .5000E-02
MAGNESIUM      MG/L         28         .7720       9.5300       4.8822       4.6100 .3778E+01 .1944E+01   .3981E+02     .9950E+00   .8769E+01
MANGANESE      MG/L         28         .0050        .0300        .0112        .0050 .7556E-04 .8692E-02   .7776E+02     .0000       .2856E-01
MERCURY        MG/L          4         .0001        .0002        .0001        .0001 .2500E-08 .5000E-04   .4000E+02     .2500E-04   .2250E-03
MG (TOTAL)     MG/L         12        3.5400       8.7400       5.3625       5.0000 .2408E+01 .1552E+01   .2894E+02     .2259E+01   .8466E+01
MN (TOTAL)     MG/L         12         .0050        .4800        .1792        .1850 .2275E-01 .1508E+00   .8418E+02     .0000       .4808E+00
MOLYBDENUM     MG/L          4         .0050        .0050        .0050        .0050 .0000     .0000       .0000         .5000E-02   .5000E-02
NA (TOTAL)     MG/L         12        2.9000      37.4000      10.8917       8.9000 .8453E+02 .9194E+01   .8441E+02     .0000       .2928E+02
NICKEL         MG/L          4         .0200        .0200        .0200        .0200 .0000     .0000       .0000         .2000E-01   .2000E-01
NITRATE        MG/L         28        2.0000      13.0000       7.0571       6.6000 .8740E+01 .2956E+01   .4189E+02     .1144E+01   .1297E+02
NO2 & NO3      MG/L          4        1.5000       3.0000       2.0550       1.8600 .5121E+00 .7156E+00   .3482E+02     .6238E+00   .3486E+01
ORG. CARBON    MG/L          4        1.0000       2.9000       2.0500       2.1500 .7509E+00 .8665E+00   .4225E+02     .3179E+00   .3782E+01
PB-210         PCI/L         4         .5000        .5500        .5250        .5250 .8333E-03 .2887E-01   .5499E+01     .4673E+00   .5827E+00
PH             SU           28        6.2400      10.3500       6.9751       7.3450 .1370E+02 .6852E+01   .1329E+03     .0000       .6412E+01
PHOSPHATE      MG/L         12         .0500       2.4500       1.0183        .9500 .4862E+00 .6973E+00   .6848E+02     .0000       .2413E+01
PO-210         PCI/L         4         .5000        .5000        .5000        .5000 .0000     .0000       .0000         .5000E+00   .5000E+00
POTASSIUM      MG/L         28        3.1900      11.3000       5.9146       5.3500 .5628E+01 .2372E+01   .4011E+02     .1170E+01   .1066E+02
RA-226         PCI/G         4         .5000        .5000        .5000        .5000 .0000     .0000       .0000         .5000E+00   .5000E+00
RA-226         PCI/L        12         .0000        .9000        .2500        .1500 .1100E+00 .3317E+00   .1327E+03     .0000       .9133E+00
RA-228         PCI/L        16        -.2000       6.3000        .7937        .4000 .2526E+01 .1589E+01   .2002E+03     .0000       .3972E+01
SB (TOTAL)     MG/L         12         .0015        .0050        .0018        .0015 .1021E-05 .1010E-02   .5639E+02     .0000       .3512E-02
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                              GROUND WATER QUALITY STATISTICS BY PARAMETER
                                          SITE: COLLINS RANCH
                                          REPORT DATE: 05/23/88
                                          10/02/84 TO 03/17/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

               UNITS OF SAMPLE                                                        STANDARD  COEFFICIENT  -STATISTICAL RANGE-
  PARAMETER    MEASURE   SIZE    MINIMUM     MAXIMUM     MEAN        MEDIAN    VARIANCE  DEVIATION OF VARIATION MINIMUM    MAXIMUM
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SELENIUM     MG/L         8        .0025       .0025       .0025       .0025 .9680E-21 .3111E-10  .1245E-05   .2500E-02 .2500E-02
SILCON       MG/L         8      26.5000     38.3000     31.8125     31.8000 .1179E+02 .3434E+01  .1079E+02   .2494E+02 .3868E+02
SILICA       MG/L         8      44.8000     89.0000     65.7250     68.5000 .1705E+03 .1306E+02  .1987E+02   .3961E+02 .9184E+02
SILVER       MG/L         4        .0050       .0050       .0050       .0050 .0000     .0000      .0000       .5000E-02 .5000E-02
SODIUM       MG/L        28       5.8000     37.1000     15.5775     12.7500 .7628E+02 .8734E+01  .5607E+02   .0000     .3304E+02
STRONTIUM    MG/L        12        .0500       .2000       .1292       .1000 .2935E-02 .5418E-01  .4195E+02   .2080E-01 .2375E+00
SULFATE      MG/L        28        .2000     23.0000      7.5464      6.1500 .3325E+02 .5766E+01  .7641E+02   .0000     .1908E+02
TEMPERATURE  C - DEGREE  28       3.0000     16.0000     10.5964     10.7500 .7275E+01 .2697E+01  .2545E+02   .5202E+01 .1599E+02
TH-230       PCI/G        4        .5000       .5000       .5000       .5000 .0000     .0000      .0000       .5000E+00 .5000E+00
TH-230       PCI/L       12        .0000       .9000       .1500       .1000 .6091E-01 .2469E+00  .1645E+03   .0000     .6436E+00
TIN          MG/L         4        .0025       .0025       .0025       .0025 .0000     .0000      .0000       .2500E-02 .2500E-02
TOTAL SOLIDS MG/L        28     134.0000    380.0000    194.2500    186.5000 .1935E+04 .4399E+02  .2264E+02   .1063E+03 .2822E+03
TOX          MG/L         2        .0500       .0500       .0500       .0500 .0000     .0000      .0000       .5000E-01 .5000E-01
U (TOTAL)    MG/L        12        .0001       .0090       .0028       .0018 .6814E-05 .2610E-02  .9393E+02   .0000     .8000E-02
U-234        PCI/L        4        .5000       .5000       .5000       .5000 .0000     .0000      .0000       .5000E+00 .5000E+00
U 238        PCI/L        4        .5000       .5000       .5000       .5000 .0000     .0000      .0000       .5000E+00 .5000E+00
URANIUM      MG/L        16        .0001       .0015       .0011       .0015 .3747E-06 .6122E-03  .5778E+02   .0000     .2284E-02
VANADIUM     MG/L         4        .0100       .0500       .0225       .0150 .3583E-03 .1893E-01  .8413E+02   .0000     .6036E-01
ZINC         MG/L        24        .0025      1.9000       .1113       .0090 .1547E+00 .3933E+00  .3534E+03   .0000     .8979E+00
ZN (TOTAL)   MG/L        12        .0025       .7150       .1552       .0635 .5092E-01 .2256E+00  .1454E+03   .0000     .6065E+00

MAPPER DATA FILE: LKV02*UGPGWQ101613
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GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 12/17/85
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		508-01 10/02/84	508-01 03/10/85	508-01 07/08/85	508-01 12/17/85	517-01 07/09/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	144.00	99.00	98.00	109.	110.00
ALUMINUM	MG/L	< 0.10	< 0.10	-	-	-
AMMONIUM	MG/L	0.20	< 0.10	0.40	-	< 0.10
ANTIMONY	MG/L	< 0.003	< 0.003	-	-	-
ARSENIC	MG/L	< 0.01	0.01	0.02	< 0.01	< 0.01
BARIUM	MG/L	< 0.01	-	-	-	-
BORON	MG/L	0.11	< 0.01	-	-	-
CADMIUM	MG/L	< 0.001	< 0.002	0.002	-	< 0.001
CALCIUM	MG/L	29.00	25.70	22.00	20.1	24.00
CHLORIDE	MG/L	4.00	4.70	2.00	2.	< 1.00
CHROMIUM	MG/L	< 0.01	< 0.01	-	-	-
COBALT	MG/L	< 0.05	< 0.05	-	-	-
CONDUCTANCE	UMHO/CM	287.00	120.00	220.00	150.	150.00
COPPER	MG/L	0.05	< 0.02	-	-	-
FLUORIDE	MG/L	0.20	0.20	0.20	0.5	0.20
IRON	MG/L	< 0.03	< 0.03	< 0.03	0.05	< 0.03
LEAD	MG/L	< 0.01	< 0.01	-	-	-
MAGNESIUM	MG/L	5.45	4.03	2.30	4.22	4.70
MANGANESE	MG/L	0.02	< 0.01	< 0.01	0.02	< 0.01
MERCURY	MG/L	< 0.0002	-	-	-	-
MOLYBDENUM	MG/L	< 0.01	-	-	-	-
NICKEL	MG/L	< 0.04	-	-	-	-
NITRATE	MG/L	< 1.00	< 1.00	8.00	< 1.	2.00
NO2 & NO3	MG/L	-	-	1.90	-	0.40
ORG. CARBON	MG/L	2.40	-	-	-	-
PB-210	PCI/L	< 1.10	-	-	-	-
PH	SU	8.88	8.37	9.48	8.63	8.20
PHOSPHATE	MG/L	0.79	1.08	1.30	-	0.10
PO-210	PCI/L	< 1.00	-	-	-	-
POTASSIUM	MG/L	8.01	8.00	8.60	6.2	4.20
RA-226	PCI/G	< 1.00	-	-	-	-
RA-228	PCI/L	< 1.00	-	-	-	-
SELENIUM	MG/L	< 0.005	< 0.005	-	-	-
SILCON	MG/L	24.10	20.50	-	-	-
SILICA	MG/L	-	-	27.00	55.	55.00
SILVER	MG/L	< 0.01	-	-	-	-
SODIUM	MG/L	20.90	18.00	21.00	14.5	15.00
STRONTIUM	MG/L	0.10	0.10	0.20	-	0.10
SULFATE	MG/L	13.00	24.00	8.00	4.	< 5.00
TEMPERATURE	C - DEGREE	12.00	9.00	18.00	8.5	12.00
TH-230	PCI/G	< 1.00	-	-	-	-
TIN	MG/L	< 0.005	-	-	-	-
TOTAL SOLIDS	MG/L	182.00	284.00	180.00	108.	180.00
TOX	MG/L	-	< 0.10	-	-	-
U-234	PCI/L	< 1.00	-	-	-	-
U-238	PCI/L	< 1.00	-	-	-	-

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                                        GROUND WATER QUALITY DATA BY LOCATION
                                         SITE: COLLINS RANCH
                                                   10/02/84 TO 12/17/85
                                                  REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

                           ------------------------------- LOCATION ID - SAMPLE ID AND LOG DATE -------------------------------
                             508-01  10/02/84      508-01  03/19/85      508-01  07/08/85      508-01  12/17/85      517-01  07/09/85
                           ----------------------------------------------------------------------------------------------------
               UNIT OF          PARAMETER             PARAMETER             PARAMETER             PARAMETER             PARAMETER
PARAMETER      MEASURE     VALUE+/-UNCERTAINTY   VALUE+/-UNCERTAINTY   VALUE+/-UNCERTAINTY   VALUE+/-UNCERTAINTY   VALUE+/-UNCERTAINTY
-------------  ----------  -------------------   -------------------   -------------------   -------------------   -------------------
URANIUM        MG/L                -             <      0.003                  -                     -                     -
VANADIUM       MG/L              0.01                   -                      -                     -                     -
ZINC           MG/L              0.012                0.048                  0.048                   -                   0.006
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GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 12/17/85
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		517-01 12/17/85	517-02 12/17/85	517-03 12/17/85	517-04 12/17/85	517-05 12/17/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	112.	112.	112.	112.	112.
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	-	-	-	-	-
BORON	MG/L	-	-	-	-	-
CADMIUM	MG/L	-	-	-	-	-
CALCIUM	MG/L	12.6	12.5	12.5	12.5	12.5
CHLORIDE	MG/L	2.	2.	2.	2.	2.
CHROMIUM	MG/L	-	-	-	-	-
COBALT	MG/L	-	-	-	-	-
CONDUCTANCE	UMHO/CM	140.	140.	140.	140.	140.
COPPER	MG/L	-	-	-	-	-
FLUORIDE	MG/L	0.1	< 0.1	< 0.1	< 0.1	< 0.1
IRON	MG/L	0.09	0.1	0.09	0.09	0.1
LEAD	MG/L	-	-	-	-	-
MAGNESIUM	MG/L	5.97	5.95	5.95	5.95	5.95
MANGANESE	MG/L	0.02	0.02	0.02	0.02	0.02
MERCURY	MG/L	-	-	-	-	-
MOLYBDENUM	MG/L	-	-	-	-	-
NICKEL	MG/L	-	-	-	-	-
NITRATE	MG/L	10.	10.	10.	10.	10.
NO2 & NO3	MG/L	-	-	-	-	-
ORG. CARBON	MG/L	-	-	-	-	-
PB-210	PCI/L	-	-	-	-	-
PH	SU	7.56	7.56	7.56	7.56	7.56
PHOSPHATE	MG/L	-	-	-	-	-
PO-210	PCI/L	-	-	-	-	-
POTASSIUM	MG/L	4.33	4.43	4.43	4.43	4.43
RA-226	PCI/G	-	-	-	-	-
RA-228	PCI/L	-	-	-	-	-
SELENIUM	MG/L	-	-	-	-	-
SILCON	MG/L	-	-	-	-	-
SILICA	MG/L	68.	68.	68.	65.	65.
SILVER	MG/L	-	-	-	-	-
SODIUM	MG/L	26.3	31.8	31.8	31.8	31.8
STRONTIUM	MG/L	-	-	-	-	-
SULFATE	MG/L	3.	8.	8.	8.	8.
TEMPERATURE	C - DEGREE	10.5	10.5	10.5	10.5	10.5
TH-230	PCI/G	-	-	-	-	-
TIN	MG/L	-	-	-	-	-
TOTAL SOLIDS	MG/L	98.	150.	150.	150.	150.
TOX	MG/L	-	-	-	-	-
U-234	PCI/L	-	-	-	-	-
U-238	PCI/L	-	-	-	-	-

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                                        GROUND WATER QUALITY DATA BY LOCATION
                                         SITE: [illegible]
                                               10/02/84 TO 12/17/85
                                              REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

                     ---------------------------------- LOCATION ID - SAMPLE ID AND LOG DATE -----------------------------------
                       517-01  12/17/85        517-02  12/17/85        517-03  12/17/85        517-04  12/17/85        517-05  12/17/85
                     ----------------------------------------------------------------------------------------------------------
             UNIT OF        PARAMETER               PARAMETER               PARAMETER               PARAMETER               PARAMETER
PARAMETER    MEASURE   VALUE+/-UNCERTAINTY     VALUE+/-UNCERTAINTY     VALUE+/-UNCERTAINTY     VALUE+/-UNCERTAINTY     VALUE+/-UNCERTAINTY
-----------  --------- -------------------     -------------------     -------------------     -------------------     -------------------
URANIUM      MG/L               -                       -                       -                       -                       -
VANADIUM     MG/L               -                       -                       -                       -                       -
ZINC         MG/L               -                       -                       -                       -                       -

 MAPPER DATA FILE NAME: LKV02*UDPGW4101612
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GROUND WATER QUALITY DATA BY LOCATION
SITE: [illegible] RANCH
10/02/78, TO 03/17/88
REPORT DATE: 05/23/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

LOCATION ID - SAMPLE ID AND LOG DATE

PARAMETER	UNIT OF MEASURE	513-01 10/03/84 PARAMETER VALUE+/-UNCERTAINTY	513-01 03/10/85 PARAMETER VALUE+/-UNCERTAINTY	513-01 07/09/85 PARAMETER VALUE+/-UNCERTAINTY	513-01 12/16/85 PARAMETER VALUE+/-UNCERTAINTY	514-01 10/03/84 PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	109.00	117.00	99.00	109.	0142.00
ALUMINUM	MG/L	< 0.19	< 0.10	-	-	< 0.10
AMMONIUM	MG/L	0.20	< 0.10	< 0.10	-	0.20
ANTIMONY	MG/L	< 0.003	< 0.003	-	-	< 0.003
ARSENIC	MG/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AS (TOTAL)	MG/L	-	-	-	-	-
BARIUM	MG/L	< 0.01	-	-	-	< 0.01
BORON	MG/L	0.28	0.01	-	-	0.08
CA (TOTAL)	MG/L	-	-	-	-	-
CADMIUM	MG/L	< 0.001	0.003	< 0.001	-	< 0.001
CALCIUM	MG/L	21.70	22.80	21.00	13.4	51.70
CD (TOTAL)	MG/L	-	-	-	-	-
CHLORIDE	MG/L	6.00	4.10	4.00	5.	6.00
CHROMIUM	MG/L	< 0.01	< 0.01	-	-	< 0.01
COBALT	MG/L	< 0.05	< 0.05	-	-	< 0.05
CONDUCTANCE	UMHO/CM	322.00	165.00	160.00	155.	389.00
COPPER	MG/L	0.02	< 0.02	-	-	< 0.02
CR (TOTAL)	MG/L	-	-	-	-	-
FE (TOTAL)	MG/L	-	-	-	-	-
FLUORIDE	MG/L	0.20	0.10	0.10	0.3	0.20
GROSS ALPHA	PCI/L	-	-	-	-	-
GROSS BETA	PCI/L	-	-	-	-	-
IRON	MG/L	< 0.03	< 0.03	< 0.03	0.07	< 0.03
K (TOTAL)	MG/L	-	-	-	-	-
LEAD	MG/L	< 0.01	< 0.01	-	-	< 0.01
MAGNESIUM	MG/L	4.48	5.53	5.50	5.75	0.772
MANGANESE	MG/L	< 0.01	< 0.01	< 0.01	0.02	< 0.01
MERCURY	MG/L	< 0.0002	-	-	-	< 0.0002
MG (TOTAL)	MG/L	-	-	-	-	-
MN (TOTAL)	MG/L	-	-	-	-	-
MOLYBDENUM	MG/L	< 0.01	-	-	-	< 0.01
NA (TOTAL)	MG/L	-	-	-	-	-
NICKEL	MG/L	< 0.04	-	-	-	< 0.04
NITRATE	MG/L	4.00	4.00	7.00	4.	10.00
NO2 & NO3	MG/L	-	-	1.50	-	-
ORG. CARBON	MG/L	2.90	-	-	-	2.60
PB-210	PCI/L	< 1.00	-	-	-	< 1.00
PH	SU	8.96	8.62	7.35	7.79	10.35
PHOSPHATE	MG/L	1.49	1.66	1.60	-	0.53
PO-210	PCI/L	< 1.00	-	-	-	< 1.00
POTASSIUM	MG/L	11.20	9.73	7.80	6.6	10.30
RA-226	PCI/G	< 1.00	-	-	-	< 1.00
RA-226	PCI/L	-	-	-	-	-
RA-228	PCI/L	< 1.00	-	-	-	< 1.00
SR (TOTAL)	MG/L	-	-	-	-	-
SELENIUM	MG/L	< 0.005	< 0.005	-	-	< 0.005

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/23/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE				
		513-01 10/03/84	513-01 03/10/85	513-01 07/09/85	513-01 12/16/85	514-01 10/03/84
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
SILCON	MG/L	29.30	26.50	-	-	34.00
SILICA	MG/L	-	-	57.00	70.	-
SILVER	MG/L	< 0.01	-	-	-	< 0.01
SODIUM	MG/L	27.60	16.60	13.00	29.6	21.00
STRONTIUM	MG/L	0.10	0.10	0.10	-	0.20
SULFATE	MG/L	22.00	7.00	< 5.00	4.	23.00
TEMPERATURE	C - DEGREE	12.00	12.00	11.00	9.2	14.00
TH-230	PCI/G	< 1.00	-	-	-	< 1.00
TH-230	PCI/L	-	-	-	-	-
TIN	MG/L	< 0.005	-	-	-	< 0.005
TOTAL SOLIDS	MG/L	190.00	248.00	190.00	166.	240.00
TOX	MG/L	-	< 0.10	-	-	-
U (TOTAL)	MG/L	-	-	-	-	-
U-234	PCI/L	< 1.00	-	-	-	< 1.00
U-238	PCI/L	< 1.00	-	-	-	< 1.00
URANIUM	MG/L	-	< 0.003	-	-	-
VANADIUM	MG/L	0.07	-	-	-	0.05
ZINC	MG/L	< 0.005	0.007	0.02	-	0.005
ZN (TOTAL)	MG/L	-	-	-	-	-

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/09/85 TO 01/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE									
		514-01 03/09/85		514-01 07/09/85		514-01 12/18/85		514-01 09/30/86		514-01 01/31/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	109.00		96.00		103.		92.		158.	
ALUMINUM	MG/L	< 0.10		-		-		-		-	
AMMONIUM	MG/L	< 0.10		< 0.10		-		-		< 0.1	
ANTIMONY	MG/L	< 0.003		-		-		< 0.003		< 0.003	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		0.005	
AS (TOTAL)	MG/L	-		-		-		< 0.01		0.043	
BARIUM	MG/L	-		-		-		-		-	
BORON	MG/L	< 0.01		-		-		< 0.1		< 0.1	
CA (TOTAL)	MG/L	-		-		-		16.9		25.1	
CADMIUM	MG/L	< 0.001		0.004		-		< 0.001		< 0.001	
CALCIUM	MG/L	35.20		30.00		19.1		16.8		27.8	
CD (TOTAL)	MG/L	-		-		-		< 0.001		0.001	
CHLORIDE	MG/L	2.60		2.00		3.		4.		2.2	
CHROMIUM	MG/L	< 0.01		-		-		0.02		0.01	
COBALT	MG/L	< 0.05		-		-		-		-	
CONDUCTANCE	UMHO/CM	135.00		150.00		145.		133.		139.	
COPPER	MG/L	< 0.02		-		-		-		-	
CR (TOTAL)	MG/L	-		-		-		0.03		0.02	
FE (TOTAL)	MG/L	-		-		-		16.9		4.26	
FLUORIDE	MG/L	0.20		0.10		0.3		0.2		0.2	
GROSS ALPHA	PCI/L	-		-		-		-		0.0	1.8
GROSS BETA	PCI/L	-		-		-		-		4.4	1.5
IRON	MG/L	0.04		< 0.03		0.04		< 0.03		0.04	
K (TOTAL)	MG/L	-		-		-		4.94		5.11	
LEAD	MG/L	< 0.01		-		-		-		-	
MAGNESIUM	MG/L	1.81		2.50		3.54		4.97		5.26	
MANGANESE	MG/L	< 0.01		< 0.01		0.02		0.01		< 0.01	
MERCURY	MG/L	-		-		-		-		-	
MG (TOTAL)	MG/L	-		-		-		8.74		4.73	
MN (TOTAL)	MG/L	-		-		-		0.48		0.11	
MOLYBDENUM	MG/L	-		-		-		-		-	
NA (TOTAL)	MG/L	-		-		-		18.6		4.52	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	11.00		13.00		10.		10.		10.4	
NO2 & NO3	MG/L	-		3.00		-		-		-	
ORG. CARBON	MG/L	-		-		-		-		-	
PB-210	PCi/L	-		-		-		-		-	
PH	SU	9.52		8.65		9.18		7.68		8.37	
PHOSPHATE	MG/L	< 0.10		0.90		-		-		-	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	8.01		6.60		5.33		4.94		5.10	
RA-226	PCI/G	-		-		-		-		-	
RA-226	PCI/L	-		-		-		0.4	0.3	0.9	0.4
RA-228	PCI/L	-		-		-		0.1	1.1	0.0	0.8
SR (TOTAL)	MG/L	-		-		-		< 0.003		< 0.003	
SELENIUM	MG/L	< 0.005		-		-		-		-	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/85 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE									
		514-01 03/09/85		514-01 07/09/85		514-01 12/18/85		514-01 09/30/86		514-01 01/31/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
SILCON	MG/L	32.00		-		-		-		-	
SILICA	MG/L	-		57.00		68.		-		-	
SILVER	MG/L	-		-		-		-		-	
SODIUM	MG/L	11.90		8.20		19.4		18.6		32.5	
STRONTIUM	MG/L	0.10		0.10		-		-		-	
SULFATE	MG/L	6.00		< 5.00		5.		3.7		0.2	
TEMPERATURE	C - DEGREE	9.50		12.00		10.		11.		3.	
TH-230	PCI/G	-		-		-		-		-	
TH-230	PCI/L	-		-		-		0.0	0.4	0.1	0.6
TIN	MG/L	-		-		-		-		-	
TOTAL SOLIDS	MG/L	184.00		200.00		171.		180.		196.	
TOX	MG/L	-		-		-		-		-	
U (TOTAL)	MG/L	-		-		-		0.0025		0.0008	
U-234	PCI/L	-		-		-		-		-	
U-238	PCI/L	-		-		-		-		-	
URANIUM	MG/L	< 0.003		-		-		0.0001		< 0.0003	
VANADIUM	MG/L	-		-		-		-		-	
ZINC	MG/L	< 0.005		0.026		-		0.010		0.022	
ZN (TOTAL)	MG/L	-		-		-		0.089		0.499	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

LOCATION ID - SAMPLE ID AND LOG DATE

PARAMETER	UNIT OF MEASURE	514-01 04/25/87		514-01 08/10/87		514-01 12/12/87		514-01 03/17/88		515-01 10/03/84	
		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	80.		86.		113.		160.		142.00	
ALUMINUM	MG/L	-		-		-		-		< 0.10	
AMMONIUM	MG/L	< 0.1		0.1		< 0.1		< 0.1		0.20	
ANTIMONY	MG/L	< 0.003		< 0.003		< 0.003		< 0.003		< 0.003	
ARSENIC	MG/L	0.005		< 0.01		< 0.01		< 0.01		< 0.01	
AS (TOTAL)	MG/L	0.005		< 0.01		< 0.01		< 0.01		-	
BARIUM	MG/L	-		-		-		-		0.01	
BORON	MG/L	-		< 0.1		< 0.1		< 0.1		0.03	
CA (TOTAL)	MG/L	23.3		24.		32.		29.		-	
CADMIUM	MG/L	0.003		< 0.001		< 0.001		0.001		< 0.001	
CALCIUM	MG/L	23.3		24.		29.		29.		36.80	
CD (TOTAL)	MG/L	0.003		< 0.001		< 0.001		0.001		-	
CHLORIDE	MG/L	1.9		2.5		1.9		2.5		3.00	
CHROMIUM	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
COBALT	MG/L	-		-		-		-		< 0.05	
CONDUCTANCE	UMHO/CM	115.		125.		175.		160.		310.00	
COPPER	MG/L	-		-		-		-		< 0.02	
CR (TOTAL)	MG/L	0.01		< 0.01		< 0.01		< 0.01		-	
FE (TOTAL)	MG/L	3.31		1.64		0.09		< 0.03		-	
FLUORIDE	MG/L	-		0.1		< 0.1		< 0.1		0.10	
GROSS ALPHA	PCI/L	0.0	1.5	0.6	1.6	0.6	1.3	0.0	1.4	-	
GROSS BETA	PCI/L	4.3	1.4	4.8	1.8	4.0	1.7	4.6	1.7	-	
IRON	MG/L	0.10		< 0.03		< 0.03		< 0.03		< 0.03	
K (TOTAL)	MG/L	3.21		3.9		4.5		4.4		-	
LEAD	MG/L	-		-		-		-		< 0.01	
MAGNESIUM	MG/L	4.76		5.6		7.2		6.3		9.53	
MANGANESE	MG/L	0.03		0.01		< 0.01		< 0.01		< 0.01	
MERCURY	MG/L	-		-		-		-		< 0.0002	
MG (TOTAL)	MG/L	4.77		6.1		7.2		6.3		-	
MN (TOTAL)	MG/L	0.30		0.07		< 0.01		< 0.01		-	
MOLYBDENUM	MG/L	-		-		-		-		< 0.01	
NA (TOTAL)	MG/L	9.18		8.1		10.0		8.9		-	
NICKEL	MG/L	-		-		-		-		< 0.04	
NITRATE	MG/L	4.5		11.5		9.1		9.8		4.00	
NO2 & NO3	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	-		-		-		-		1.00	
PB-210	PCI/L	-		-		-		-		< 1.10	
PH	SU	6.88		8.06		7.84		8.23		7.14	
PHOSPHATE	MG/L	-		-		-		-		0.59	
PO-210	PCI/L	-		-		-		-		< 1.00	
POTASSIUM	MG/L	3.19		3.8		4.3		4.4		7.12	
RA-226	PCI/G	-		-		-		-		< 1.00	
RA-226	PCI/L	0.2	0.2	0.9	0.2	0.0	0.1	0.0	0.1	-	
RA-228	PCI/L	0.0	0.9	0.5	0.5	0.0	2.3	0.9	1.4	< 1.00	
SB (TOTAL)	MG/L	< 0.003		< 0.003		< 0.003		< 0.003		-	
SELENIUM	MG/L	-		-		-		-		< 0.005	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE									
		514-01 04/25/87		514-01 08/10/87		514-01 12/17/87		514-01 03/17/88		515-01 10/03/84	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
SILICON	MG/L	-		-		-		-		37.00	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		-		-		< 0.01	
SODIUM	MG/L	9.17		8.1		9.9		8.9		13.80	
STRONTIUM	MG/L	-		-		-		-		0.20	
SULFATE	MG/L	7.		6.0		10.1		12.8		8.00	
TEMPERATURE	C - DEGREE	11.0		11.0		10.0		10.0		14.00	
TH-230	PCI/G	-		-		-		-		< 1.00	
TH-230	PCI/L	0.0	0.9	0.1	0.2	0.1	0.3	0.2	0.3	-	
TIN	MG/L	-		-		-		-		< 0.005	
TOTAL SOLIDS	MG/L	185.		187.		218.		201.		188.00	
TOX	MG/L	-		-		-		-		-	
U (TOTAL)	MG/L	0.0024		0.009		< 0.003		< 0.003		-	
U-234	PCI/L	-		-		-		-		< 1.00	
U-238	PCI/L	-		-		-		-		< 1.00	
URANIUM	MG/L	0.0006		< 0.003		< 0.003		< 0.003		-	
VANADIUM	MG/L	-		-		-		-		0.01	
ZINC	MG/L	< 0.005		< 0.005		< 0.005		< 0.005		0.014	
ZN (TOTAL)	MG/L	0.086		0.035		0.013		< 0.005		-	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE				
		515-01 03/10/85	515-01 07/11/85	515-02 07/11/85	515-03 07/11/85	515-04 07/11/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	133.00	136.00	136.00	136.00	136.00
ALUMINUM	MG/L	< 0.10	-	-	-	-
AMMONIUM	MG/L	< 0.10	< 0.10	< 0.10	< 0.10	0.30
ANTIMONY	MG/L	< 0.003	-	-	-	-
ARSENIC	MG/L	< 0.01	0.01	< 0.01	< 0.01	< 0.01
AS (TOTAL)	MG/L	-	-	-	-	-
BARIUM	MG/L	-	-	-	-	-
BORON	MG/L	< 0.01	-	-	-	-
CA (TOTAL)	MG/L	-	-	-	-	-
CADMIUM	MG/L	< 0.001	< 0.001	< 0.001	< 0.001	0.001
CALCIUM	MG/L	32.70	31.00	31.00	31.00	31.00
CD (TOTAL)	MG/L	-	-	-	-	-
CHLORIDE	MG/L	2.20	2.00	2.00	2.00	2.00
CHROMIUM	MG/L	< 0.01	-	-	-	-
COBALT	MG/L	< 0.05	-	-	-	-
CONDUCTANCE	UMHO/CM	190.00	190.00	190.00	190.00	190.00
COPPER	MG/L	< 0.07	-	-	-	-
CR (TOTAL)	MG/L	-	-	-	-	-
FE (TOTAL)	MG/L	-	-	-	-	-
FLUORIDE	MG/L	0.01	0.10	0.10	0.10	0.10
GROSS ALPHA	PCI/L	-	-	-	-	-
GROSS BETA	PCI/L	-	-	-	-	-
IRON	MG/L	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
K (TOTAL)	MG/L	-	-	-	-	-
LEAD	MG/L	< 0.01	-	-	-	-
MAGNESIUM	MG/L	8.11	7.80	7.90	7.80	7.90
MANGANESE	MG/L	< 0.01	< 0.01	0.01	0.01	< 0.01
MERCURY	MG/L	-	-	-	-	-
MG (TOTAL)	MG/L	-	-	-	-	-
MN (TOTAL)	MG/L	-	-	-	-	-
MOLYBDENUM	MG/L	-	-	-	-	-
NA (TOTAL)	MG/L	-	-	-	-	-
NICKEL	MG/L	-	-	-	-	-
NITRATE	MG/L	5.00	9.00	10.00	10.00	10.00
NO2 & NO3	MG/L	-	2.00	2.40	2.30	2.20
ORG. CARBON	MG/L	-	-	-	-	-
PB-210	PCI/L	-	-	-	-	-
PH	SU	7.00	6.61	6.61	6.61	6.61
PHOSPHATE	MG/L	0.27	0.50	0.40	0.40	0.40
PO-210	PCI/L	-	-	-	-	-
POTASSIUM	MG/L	5.74	5.40	5.50	5.40	5.40
RA-226	PCI/G	-	-	-	-	-
RA-226	PCI/L	-	-	-	-	-
RA-228	PCI/L	-	-	-	-	-
SB (TOTAL)	MG/L	-	-	-	-	-
SELENIUM	MG/L	< 0.005	-	-	-	-

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE				
		515-01 03/10/85	515-01 07/11/85	515-02 07/11/85	515-03 07/11/85	515-04 07/11/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
SILICON	MG/L	30.80	-	-	-	-
SILICA	MG/L	-	55.00	49.00	39.00	49.00
SILVER	MG/L	-	-	-	-	-
SODIUM	MG/L	11.50	13.00	13.00	13.00	13.00
STRONTIUM	MG/L	0.20	0.20	0.20	0.20	0.20
SULFATE	MG/L	6.10	< 5.00	< 5.00	< 5.00	< 5.00
TEMPERATURE	C - DEGREE	11.00	12.00	12.00	12.00	12.00
TH-230	PCI/G	-	-	-	-	-
TH-230	PCI/L	-	-	-	-	-
TIN	MG/L	-	-	-	-	-
TOTAL SOLIDS	MG/L	206.00	220.00	220.00	220.00	220.00
TOX	MG/L	-	-	-	-	-
U (TOTAL)	MG/L	-	-	-	-	-
U-234	PCI/L	-	-	-	-	-
U-238	PCI/L	-	-	-	-	-
URANIUM	MG/L	< 0.003	-	-	-	-
VANADIUM	MG/L	-	-	-	-	-
ZINC	MG/L	0.005	0.028	0.024	0.022	0.02
ZN (TOTAL)	MG/L	-	-	-	-	-

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/07/24 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE				
		515-05 07/11/85	515-01 12/18/85	516-01 10/02/84	516-01 03/09/85	516-01 07/08/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	136.00	135.	120.00	69.00	59.00
ALUMINUM	MG/L	-	-	< 0.10	< 0.10	-
AMMONIUM	MG/L	< 0.10	-	0.10	< 0.10	< 0.10
ANTIMONY	MG/L	-	-	< 0.003	< 0.003	-
ARSENIC	MG/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
AS (TOTAL)	MG/L	-	-	-	-	-
BARIUM	MG/L	-	-	< 0.01	-	-
BORON	MG/L	-	-	0.29	< 0.01	-
CA (TOTAL)	MG/L	-	-	-	-	-
CADMIUM	MG/L	< 0.001	-	< 0.001	0.017	< 0.001
CALCIUM	MG/L	31.00	20.6	15.60	18.30	14.00
CD (TOTAL)	MG/L	-	-	-	-	-
CHLORIDE	MG/L	2.00	3.	3.00	3.30	3.00
CHROMIUM	MG/L	-	-	< 0.01	< 0.01	-
COBALT	MG/L	-	-	< 0.05	< 0.05	-
CONDUCTANCE	UMHO/CM	190.00	180.	270.00	139.00	140.00
COPPER	MG/L	-	-	< 0.02	< 0.02	-
CR (TOTAL)	MG/L	-	-	-	-	-
FE (TOTAL)	MG/L	-	-	-	-	-
FLUORIDE	MG/L	0.10	0.1	0.20	< 0.10	0.10
GROSS ALPHA	PCI/L	-	-	-	-	-
GROSS BETA	PCI/L	-	-	-	-	-
IRON	MG/L	< 0.03	0.07	< 0.03	< 0.03	0.04
K (TOTAL)	MG/L	-	-	-	-	-
LEAD	MG/L	-	-	< 0.01	< 0.01	-
MAGNESIUM	MG/L	7.90	7.56	4.41	4.65	3.40
MANGANESE	MG/L	0.01	0.02	< 0.01	0.03	< 0.01
MERCURY	MG/L	-	-	0.0002	-	-
MG (TOTAL)	MG/L	-	-	-	-	-
MN (TOTAL)	MG/L	-	-	-	-	-
MOLYBDENUM	MG/L	-	-	< 0.01	-	-
NA (TOTAL)	MG/L	-	-	-	-	-
NICKEL	MG/L	-	-	< 0.04	-	-
NITRATE	MG/L	10.00	4.	7.00	9.00	6.00
NO2 & NO3	MG/L	2.20	-	-	-	1.50
ORG. CARBON	MG/L	-	-	1.70	-	-
PB-210	PCI/L	-	-	< 1.40	-	-
PH	SU	6.61	7.34	7.78	6.77	6.41
PHOSPHATE	MG/L	0.40	-	2.45	1.56	1.30
PO-210	PCI/L	-	-	< 1.00	-	-
POTASSIUM	MG/L	5.40	4.65	11.30	7.61	5.40
RA-226	PCI/G	-	-	< 1.00	-	-
RA-226	PCI/L	-	-	-	-	-
RA-228	PCI/L	-	-	< 1.00	-	-
SB (TOTAL)	MG/L	-	-	-	-	-
SELENIUM	MG/L	-	-	< 0.005	< 0.005	-

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE				
		515-05 07/11/85	515-01 12/18/85	516-01 10/02/84	516-01 03/09/85	516-01 07/09/85
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
SILCON	MG/L	-	-	34.60	38.30	-
SILICA	MG/L	41.00	71.	-	-	69.00
SILVER	MG/L	-	-	< 0.01	-	-
SODIUM	MG/L	13.00	26.3	24.19	8.00	5.80
STRONTIUM	MG/L	0.20	-	0.10	< 0.10	0.10
SULFATE	MG/L	< 5.00	8.	7.00	12.00	< 5.00
TEMPERATURE	C - DEGREE	12.00	10.	14.00	9.00	16.00
TH-230	PCI/G	-	-	< 1.00	-	-
TH-230	PCI/L	-	-	-	-	-
TIN	MG/L	-	-	< 0.095	-	-
TOTAL SOLIDS	MG/L	220.00	134.	164.00	194.00	170.00
TOX	MG/L	-	-	-	< 9.10	-
U (TOTAL)	MG/L	-	-	-	-	-
U-234	PCI/L	-	-	< 1.00	-	-
U-238	PCI/L	-	-	< 1.00	-	-
URANIUM	MG/L	-	-	-	< 0.003	-
VANADIUM	MG/L	-	-	0.01	-	-
ZINC	MG/L	0.033	-	0.999	0.016	1.90
ZN (TOTAL)	MG/L	-	-	-	-	-

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE														
		516-01 12/16/85			516-01 10/02/86			516-01 01/31/87			516-01 04/24/87			516-01 08/19/87		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY		
ALKALINITY	MG/L CACO3		76.			67.			78.			53.			50.	
ALUMINUM	MG/L		-			-			-			-			-	
AMMONIUM	MG/L		-		<	0.1		<	0.1		<	0.1			0.2	
ANTIMONY	MG/L		-		<	0.003		<	0.003			0.005		<	0.003	
ARSENIC	MG/L	<	0.01		<	0.01			0.001			0.003		<	0.01	
AS (TOTAL)	MG/L		-		<	0.01			0.001			0.004		<	0.01	
BARIUM	MG/L		-			-			-			-			-	
BORON	MG/L		-		<	0.1		<	0.1			-			0.1	
CA (TOTAL)	MG/L		-			13.4			12.9			15.6			13.2	
CADMIUM	MG/L		-		<	0.001		<	0.001			0.003		<	0.001	
CALCIUM	MG/L		9.06			13.0			14.3			15.4			11.7	
CD (TOTAL)	MG/L		-		<	0.001		<	0.001			0.003			0.001	
CHLORIDE	MG/L		3.			3.			3.4			4.5			5.5	
CHROMIUM	MG/L		-			0.02		<	0.01		<	0.01		<	0.01	
COBALT	MG/L		-			-			-			-			-	
CONDUCTANCE	UMHO/CM		115.			1000.			87[illegible]			98.			90.	
COPPER	MG/L		-			-			-			-			-	
CR (TOTAL)	MG/L		-			0.02			0.02		<	0.01		<	0.01	
FE (TOTAL)	MG/L		-			9.43			7.11			2.70			6.2	
FLUORIDE	MG/L		0.1			0.2			0.1			-			0.1	
GROSS ALPHA	PCI/L		-			-			0.0	1.6		0.0	1.5		2.3	1.6
GROSS BETA	PCI/L		-			-			4.6	1.5		4.3	1.4		3.6	1.7
IRON	MG/L		0.08		<	0.03			0.03			0.03			3.31	
K (TOTAL)	MG/L		-			5.02			4.32			3.36			4.1	
LEAD	MG/L		-			-			-			-			-	
MAGNESIUM	MG/L		4.57			3.53			4.01			3.50			3.8	
MANGANESE	MG/L		0.02			0.01			0.02			0.03			0.01	
MERCURY	MG/L		-			-			-			-			-	
MG (TOTAL)	MG/L		-			5.66			3.61			3.54			5.1	
MN (TOTAL)	MG/L		-			0.34			0.23			0.21			0.27	
MOLYBDENUM	MG/L		-			-			-			-			-	
NA (TOTAL)	MG/L		-			37.4			2.90			8.90			9.5	
NICKEL	MG/L		-			-			-			-			-	
NITRATE	MG/L		7.			5.			5.0			2.0			6.2	
NO2 & NO3	MG/L		-			-			-			-			-	
ORG. CARBON	MG/L		-			-			-			-			-	
PB-210	PCI/L		-			-			-			-			-	
PH	SU		7.05			7.06			6.80			6.63			6.51	
PHOSPHATE	MG/L		-			-			-			-			-	
PO-210	PCI/L		-			-			-			-			-	
POTASSIUM	MG/L		5.37			5.02			4.32			3.36			3.7	
RA-226	PCI/G		-			-			-			-			-	
RA-226	PCI/L		-			0.0	0.3		0.2	0.2		0.0	0.1		0.3	0.2
RA-228	PCI/L		-			-0.2	1.3		0.3	0.8		0.9	1.1		1.7	0.8
SB (TOTAL)	MG/L		-		<	0.003		<	0.003			0.005		<	0.003	
SELENIUM	MG/L		-			-			-			-			-	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE									
		516-01 12/16/85		516-01 10/02/86		516-01 01/31/87		516-01 04/24/87		516-01 08/10/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
SILCON	MG/L	-		-		-		-		-	
SILICA	MG/L	89.		-		-		-		-	
SILVER	MG/L	-		-		-		-		-	
SODIUM	MG/L	19.1		37.4		12.5		8.90		8.6	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	5.		6.2		9.2		14.		14.	
TEMPERATURE	C - DEGREE	10.		10.		3.		10.0		11.0	
TH-230	PCI/G	-		-		-		-		-	
TH-230	PCI/L	-		0.2	0.6	0.0	0.4	0.0	0.3	0.1	0.1
TIN	MG/L	-		-		-		-		-	
TOTAL SOLIDS	MG/L	380.		202.		173.		172.		162.	
TOX	MG/L	-		-		-		-		-	
U (TOTAL)	MG/L	-		0.0021		< 0.0003		0.0034		0.007	
U-234	PCI/L	-		-		-		-		-	
U-238	PCI/L	-		-		-		-		-	
URANIUM	MG/L	-		< 0.0003		< 0.0003		0.0008		< 0.003	
VANADIUM	MG/L	-		-		-		-		-	
ZINC	MG/L	-		0.020		0.483		< 0.005		0.010	
ZN (TOTAL)	MG/L	-		0.060		0.745		0.251		0.067	

GROUND WATER QUALITY DATA BY LOCATION
SITE: PHILLIPS RANCH
10/02/84 TO 03/17/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

LOCATION ID - SAMPLE ID AND LOG DATE

PARAMETER	UNIT OF MEASURE	516-01 12/12/87 PARAMETER VALUE+/-UNCERTAINTY		516-01 03/17/88 PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	50.		41.				
ALUMINUM	MG/L	-		-				
AMMONIUM	MG/L	< 0.1		< 0.1				
ANTIMONY	MG/L	< 0.003		< 0.003				
ARSENIC	MG/L	< 0.01		< 0.01				
AS (TOTAL)	MG/L	< 0.01		< 0.01				
BARIUM	MG/L	-		-				
BORON	MG/L	< 0.1		< 0.1				
CA (TOTAL)	MG/L	11.6		12.7				
CADMIUM	MG/L	< 0.001		0.001				
CALCIUM	MG/L	11.5		11.8				
CD (TOTAL)	MG/L	< 0.001		0.001				
CHLORIDE	MG/L	3.3		3.5				
CHROMIUM	MG/L	< 0.01		< 0.01				
COBALT	MG/L	-		-				
CONDUCTANCE	UMHO/CM	90.		85.				
COPPER	MG/L	-		-				
CR (TOTAL)	MG/L	< 0.01		< 0.01				
FE (TOTAL)	MG/L	0.30		2.42				
FLUORIDE	MG/L	< 0.1		0.1				
GROSS ALPHA	PCI/L	0.0	0.8	0.0	0.8			
GROSS BETA	PCI/L	3.4	1.6	1.5	1.4			
IRON	MG/L	< 0.03		< 0.03				
K (TOTAL)	MG/L	3.3		3.6				
LEAD	MG/L	-		-				
MAGNESIUM	MG/L	3.6		4.2				
MANGANESE	MG/L	< 0.01		< 0.01				
MERCURY	MG/L	-		-				
MG (TOTAL)	MG/L	3.7		4.9				
MN (TOTAL)	MG/L	0.02		0.11				
MOLYBDENUM	MG/L	-		-				
NA (TOTAL)	MG/L	6.9		5.8				
NICKEL	MG/L	-		-				
NITRATE	MG/L	4.3		5.0				
NO2 & NO3	MG/L	-		-				
ORG. CARBON	MG/L	-		-				
PB-210	PCI/L	-		-				
PH	SU	6.24		6.44				
PHOSPHATE	MG/L	-		-				
PO-210	PCI/L	-		-				
POTASSIUM	MG/L	3.3		3.2				
RA-226	PCI/G	-		-				
RA-226	PCI/L	0.0	0.1	0.1	0.7			
RA-228	PCI/L	6.3	2.3	2.9	1.5			
SB (TOTAL)	MG/L	< 0.003		< 0.003				
SELENIUM	MG/L	-		-				

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
10/02/81 TO 03/17/88
REPORT DATE: 05/25/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

		LOCATION ID - SAMPLE ID AND LOG DATE			
		516-01 12/12/87		516-01 03/17/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
SILCON	MG/L	-		-	
SILICA	MG/L	-		-	
SILVER	MG/L	-		-	
SODIUM	MG/L	6.9		5.8	
STRONTIUM	MG/L	-		-	
SULFATE	MG/L	1.9		12.1	
TEMPERATURE	C - DEGREE	10.5		10.5	
TH-230	PCI/G	-		-	
TH-230	PCI/L	0.9	0.5	0.1	0.7
TIN	MG/L	-		-	
TOTAL SOLIDS	MG/L	165.		158.	
TOX	MG/L	-		-	
U (TOTAL)	MG/L	< 0.003		< 0.003	
U-234	PCI/L	-		-	
U-238	PCI/L	-		-	
URANIUM	MG/L	< 0.003		< 0.003	
VANADIUM	MG/L	-		-	
ZINC	MG/L	0.009		< 0.005	
ZN (TOTAL)	MG/L	0.015		0.030	

MAPPER DATA FILE NAME: LKV02*UDPGWQ101613

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/86 TO 03/16/88
REPORT DATE: 05/25/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		521-01 09/29/86		521-01 02/02/87		521-01 03/24/87		521-01 08/11/87		521-01 12/12/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
AG (TOTAL)	MG/L	-		-		-		-		-	
ALKALINITY	MG/L CACO3	88.		145.		118.		82.		85.	
AMMONIUM	MG/L	0.2		< 0.1		< 0.1		< 0.1		< 0.1	
ANTIMONY	MG/L	< 0.003		< 0.003		0.009		< 0.003		< 0.003	
ARSENIC	MG/L	< 0.01		< 0.001		0.005		< 0.01		< 0.01	
AS (TOTAL)	MG/L	< 0.01		0.014		0.095		< 0.01		< 0.01	
BORON	MG/L	< 0.1		< 0.1		-		< 0.1		< 0.1	
CA (TOTAL)	MG/L	9.94		12.1		23.8		14.1		14.2	
CADMIUM	MG/L	< 0.001		< 0.001		0.002		< 0.001		< 0.001	
CALCIUM	MG/L	9.90		12.2		23.6		14.1		14.2	
CD (TOTAL)	MG/L	< 0.001		< 0.001		0.003		0.001		< 0.001	
CHLORIDE	MG/L	3.		9.5		2.2		1.8		1.1	
CHROMIUM	MG/L	0.02		< 0.01		< 0.1		< 0.01		< 0.01	
CONDUCTANCE	UMHO/CM	108.		145.		125.		110.		95.	
CR (TOTAL)	MG/L	0.02		< 0.01		0.02		0.01		0.01	
FE (TOTAL)	MG/L	3.00		2.11		12.9		2.27		0.66	
FLUORIDE	MG/L	0.1		< 0.1		-		0.1		< 0.1	
GROSS ALPHA	PCI/L	-		0.0	1.7	1.4	1.8	0.0	1.3	0.0	0.9
GROSS BETA	PCI/L	-		4.6	1.5	6.4	1.5	1.1	1.6	4.1	1.6
IRON	MG/L	< 0.03		< 0.03		0.06		0.07		< 0.03	
K (TOTAL)	MG/L	3.93		4.61		4.55		4.5		4.4	
MAGNESIUM	MG/L	5.80		5.57		5.37		6.1		6.7	
MANGANESE	MG/L	0.04		< 0.01		0.04		0.02		< 0.01	
MG (TOTAL)	MG/L	6.00		5.59		5.39		6.8		6.7	
MN (TOTAL)	MG/L	0.10		0.07		0.93		0.09		0.03	
NA (TOTAL)	MG/L	21.0		9.27		14.9		10.1		9.3	
NITRATE	MG/L	2.		1.4		1.3		1.3		1.7	
PH	SU	6.70		7.68		7.68		7.29		7.07	
POTASSIUM	MG/L	3.93		4.60		4.51		4.5		4.4	
RA-226	PCI/L	2.7	0.7	0.1	0.3	0.0	0.1	0.8	0.2	0.0	0.1
RA-228	PCI/L	0.2	0.8	0.0	0.9	0.0	1.2	0.5	0.7	0.2	1.6
SB (TOTAL)	MG/L	< 0.003		< 0.003		0.009		< 0.003		< 0.003	
SILVER	MG/L	-		-		-		-		-	
SODIUM	MG/L	21.0		39.2		14.7		10.1		9.2	
SULFATE	MG/L	0.4		0.2		2.		9.4		0.3	
TEMPERATURE	C - DEGREE	10.5		6.0		11.0		13.0		9.0	
TH-230	PCI/L	0.2	0.6	0.0	0.5	0.3	0.5	2.5	0.3	0.2	0.3
TOTAL SOLIDS	MG/L	156.		138.		202.		152.		153.	
U (TOTAL)	MG/L	0.0020		< 0.0003		0.0063		0.003		< 0.003	
URANIUM	MG/L	< 0.0003		< 0.0003		0.0011		< 0.003		< 0.003	
ZINC	MG/L	0.025		0.582		< 0.005		0.009		0.005	
ZN (TOTAL)	MG/L	0.039		0.670		0.073		0.037		0.027	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/86 TO 03/16/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		521-01 03/16/88		522-01 09/29/86		522-02 09/29/86		522-03 09/29/86		522-04 09/29/86	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
AG (TOTAL)	MG/L	-		< 0.01		-		-		-	
ALKALINITY	MG/L CACO3	83.		90.		90.		90.		90.	
AMMONIUM	MG/L	0.1		0.2		0.1		0.1		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	
AS (TOTAL)	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
BORON	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		< 0.1	
CA (TOTAL)	MG/L	14.0		14.5		14.5		14.4		14.4	
CADMIUM	MG/L	0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	13.7		14.3		14.2		14.2		14.1	
CD (TOTAL)	MG/L	0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CHLORIDE	MG/L	1.6		3.		3.		2.		3.	
CHROMIUM	MG/L	< 0.01		0.02		0.02		0.02		0.02	
CONDUCTANCE	UMHO/CM	110.		118.		118.		118.		118.	
CR (TOTAL)	MG/L	< 0.01		0.02		0.02		0.02		0.02	
FE (TOTAL)	MG/L	0.68		3.00		3.00		3.00		3.00	
FLUORIDE	MG/L	< 0.1		0.1		0.1		0.1		0.1	
GROSS ALPHA	PCI/L	0.0	0.9	-		-		-		-	
GROSS BETA	PCI/L	4.1	1.6	-		-		-		-	
IRON	MG/L	< 0.03		< 0.03		< 0.03		< 0.03		< 0.03	
K (TOTAL)	MG/L	4.4		4.00		4.00		4.00		4.00	
MAGNESIUM	MG/L	6.6		5.30		5.30		5.30		5.30	
MANGANESE	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
MG (TOTAL)	MG/L	6.6		6.0		6.0		6.0		6.0	
MN (TOTAL)	MG/L	0.03		0.10		0.10		0.10		0.10	
NA (TOTAL)	MG/L	9.4		20.5		20.6		20.5		20.7	
NITRATE	MG/L	1.2		2.		2.		2.		2.	
PH	SU	7.62		7.85		7.85		7.85		7.85	
POTASSIUM	MG/L	4.4		4.00		4.00		4.00		4.00	
RA-226	PCI/L	0.1	0.2	1.2	0.5	1.1	0.5	0.6	0.3	0.4	0.3
RA-228	PCI/L	2.5	2.0	-0.4	0.8	0.0	0.9	-0.2	1.0	-1.1	1.1
SB (TOTAL)	MG/L	< 0.003		< 0.003		< 0.003		< 0.003		< 0.003	
SILVER	MG/L	-		< 0.01		-		-		-	
SODIUM	MG/L	9.4		20.5		20.6		20.5		20.7	
SULFATE	MG/L	2.2		0.4		0.4		0.4		0.4	
TEMPERATURE	C - DEGREE	11.5		12.5		12.5		12.5		12.5	
TH-230	PCI/L	0.2	0.4	0.6	0.7	1.8	1.0	0.0	0.7	0.0	0.4
TOTAL SOLIDS	MG/L	150.		159.		146.		143.		148.	
U (TOTAL)	MG/L	< 0.003		0.0026		0.0031		0.0027		0.0016	
URANIUM	MG/L	< 0.003		0.0002		0.0003		0.0003		0.0003	
ZINC	MG/L	< 0.005		0.020		0.020		0.020		0.020	
ZN (TOTAL)	MG/L	0.006		0.040		0.040		0.040		0.040	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/86 TO 03/16/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE														
		522-CS 09/29/86			522-01 02/01/87			522-02 02/01/87			522-03 02/01/87			522-04 02/01/87		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY		
AG (TOTAL)	MG/L		-			-			-			-			-	
ALKALINITY	MG/L CACO3		99.			86.			86.			86.			86.	
AMMONIUM	MG/L		0.1		<	0.1		<	0.1		<	0.1		<	0.1	
ANTIMONY	MG/L	<	0.003		<	0.003		<	0.003		<	0.003		<	0.003	
ARSENIC	MG/L	<	0.01			0.002			0.002		<	0.001			0.003	
AS (TOTAL)	MG/L	<	0.01			0.021			0.029			0.031			0.028	
BORON	MG/L	<	0.1		<	0.1		<	0.1		<	0.1		<	0.1	
CA (TOTAL)	MG/L		14.3			17.6			14.2			14.2			14.2	
CADMIUM	MG/L	<	0.001		<	0.001		<	0.001		<	0.001		<	0.001	
CALCIUM	MG/L		14.4			17.8			14.3			14.4			14.3	
CD (TOTAL)	MG/L	<	0.001		<	0.001		<	0.001		<	0.001		<	0.001	
CHLORIDE	MG/L		3.			0.5			1.7			2.2			2.8	
CHROMIUM	MG/L		0.02		<	0.01		<	0.01		<	0.01		<	0.01	
CONDUCTANCE	UMHO/CM		118.			100.			109.			100.			109.	
CR (TOTAL)	MG/L		0.02		<	0.01		<	0.01		<	0.01		<	0.01	
FE (TOTAL)	MG/L		3.00			2.85			2.17			2.12			2.04	
FLUORIDE	MG/L		0.1			0.1		<	0.1		<	0.1		<	0.1	
GROSS ALPHA	PCI/L		-			0.0	1.4		0.0	1.7		0.4	1.6		0.0	2.1
GROSS BETA	PCI/L		-			3.4	1.4		5.0	1.5		4.0	1.5		3.0	1.5
IRON	MG/L	<	0.03		<	0.03			0.03		<	0.03		<	0.03	
K (TOTAL)	MG/L		4.00			4.02			4.05			4.10			4.07	
MAGNESIUM	MG/L		5.30			4.55			4.05			4.08			4.01	
MANGANESE	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
MG (TOTAL)	MG/L		6.0			4.56			4.04			4.07			4.02	
MN (TOTAL)	MG/L		0.10			0.07			0.04			0.04			0.04	
NA (TOTAL)	MG/L		20.7			9.98			11.8			12.9			12.1	
NITRATE	MG/L		2.			1.4			1.0			0.7			0.5	
PH	SU		7.85			7.63			7.63			7.63			7.63	
POTASSIUM	MG/L		4.00			4.01			4.05			4.09			4.07	
RA-226	PCI/L		0.5	0.4		0.1	0.2		0.1	0.2		0.2	0.2		0.0	0.1
RA-228	PCI/L		-0.5	1.3		0.0	1.0		0.0	1.2		0.0	1.0		0.0	1.2
SB (TOTAL)	MG/L	<	0.003		<	0.003		<	0.003		<	0.003		<	0.003	
SILVER	MG/L		-			-			-			-			-	
SODIUM	MG/L		20.5			9.97			11.6			12.9			12.2	
SULFATE	MG/L		5.4			0.5			0.6			1.2			0.3	
TEMPERATURE	C - DEGREE		12.5			6.5			6.5			6.5			6.5	
TH-230	PCI/L		0.1	0.6		0.0	0.4		0.0	0.5		0.0	0.5		0.0	0.5
TOTAL SOLIDS	MG/L		172.			148.			135.			130.			138.	
U (TOTAL)	MG/L		0.0025		<	0.0003			0.0009		<	0.0003		<	0.0003	
URANIUM	MG/L	<	0.0003		<	0.0003		<	0.0003		<	0.0003		<	0.0003	
ZINC	MG/L		0.020			0.010		<	0.005		<	0.005		<	0.005	
ZN (TOTAL)	MG/L		0.040			0.051			0.019			0.039			0.034	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/86 TO 03/16/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		522-05 02/01/87		522-01 04/25/87		522-02 04/25/87		522-03 04/25/87		522-04 04/25/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
AG (TOTAL)	MG/L	-		-		-		-		-	
ALKALINITY	MG/L CACO3	86.		99.		99.		99.		99.	
AMMONIUM	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		< 0.1	
ANTIMONY	MG/L	< 0.003		0.012		< 0.003		< 0.003		< 0.003	
ARSENIC	MG/L	0.002		0.003		0.004		0.003		0.005	
AS (TOTAL)	MG/L	0.031		0.004		0.004		0.004		0.005	
BORON	MG/L	< 0.1		-		-		-		-	
CA (TOTAL)	MG/L	14.5		24.4		23.3		23.6		23.5	
CADMIUM	MG/L	< 0.001		0.002		0.002		0.002		0.002	
CALCIUM	MG/L	14.3		24.1		23.3		23.3		23.4	
CD (TOTAL)	MG/L	< 0.001		0.002		0.002		0.002		0.002	
CHLORIDE	MG/L	1.1		1.7		1.9		1.9		1.9	
CHROMIUM	MG/L	< 0.01		< 0.1		< 0.01		< 0.01		< 0.01	
CONDUCTANCE	UMHO/CM	100.		110.		110.		110.		110.	
CR (TOTAL)	MG/L	< 0.01		0.03		0.02		0.02		0.02	
FE (TOTAL)	MG/L	2.06		8.21		7.75		7.72		7.78	
FLUORIDE	MG/L	0.1		-		-		-		-	
GROSS ALPHA	PCI/L	0.0	1.0	0.0	1.5	0.0	1.5	0.0	1.5	0.0	1.1
GROSS BETA	PCI/L	1.8	1.2	4.2	1.4	3.5	1.4	3.6	1.4	2.5	1.3
IRON	MG/L	< 0.03		0.03		0.03		0.05		0.04	
K (TOTAL)	MG/L	4.17		3.32		3.19		3.19		3.18	
MAGNESIUM	MG/L	4.07		4.66		4.63		4.65		4.65	
MANGANESE	MG/L	< 0.01		0.05		0.03		0.03		0.04	
MG (TOTAL)	MG/L	4.07		4.68		4.65		4.65		4.67	
MN (TOTAL)	MG/L	0.04		0.38		0.37		0.37		0.39	
NA (TOTAL)	MG/L	11.7		8.40		9.29		9.21		9.20	
NITRATE	MG/L	1.3		1.8		4.5		4.5		4.5	
PH	SU	7.63		7.23		7.23		7.23		7.23	
POTASSIUM	MG/L	4.15		3.37		3.17		3.15		3.15	
RA-226	PCI/L	0.1	0.2	0.0	0.1	0.0	0.1	0.1	0.2	0.1	0.2
RA-228	PCI/L	0.0	1.3	0.5	1.4	0.0	1.3	0.2	1.2	0.0	1.1
SB (TOTAL)	MG/L	< 0.003		0.013		< 0.003		< 0.003		< 0.003	
SILVER	MG/L	-		-		-		-		-	
SODIUM	MG/L	11.5		8.69		9.19		9.19		9.18	
SULFATE	MG/L	0.3		9.		7.		7.		7.	
TEMPERATURE	C - DEGREE	6.5		12.0		12.0		12.0		12.0	
TH-230	PCI/L	0.0	0.5	0.0	0.4	0.1	0.3	-		0.4	0.5
TOTAL SOLIDS	MG/L	136.		185.		183.		183.		185.	
U (TOTAL)	MG/L	< 0.0003		0.0035		0.0044		0.0039		0.0041	
URANIUM	MG/L	< 0.0003		0.0010		0.0007		0.0003		0.0006	
ZINC	MG/L	0.005		< 0.005		< 0.005		< 0.005		< 0.005	
ZN (TOTAL)	MG/L	0.028		0.038		0.039		0.038		0.041	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/86 TO 03/16/89
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE														
		S22-05 04/25/87			S22-01 08/11/87			S22-02 08/11/87			S22-03 08/11/87			S22-04 08/11/87		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY		
AG (TOTAL)	MG/L		-			-			-			-			-	
ALKALINITY	MG/L CACO3		99.			94.			94.			94.			94.	
AMMONIUM	MG/L	<	0.1			1.8		<	0.1		<	0.1		<	0.1	
ANTIMONY	MG/L	<	0.003		<	0.003		<	0.003		<	0.003		<	0.003	
ARSENIC	MG/L		0.004		<	0.01		<	0.01		<	0.01		<	0.01	
AS (TOTAL)	MG/L		0.005		<	0.01		<	0.01		<	0.01		<	0.01	
BORON	MG/L		-		<	0.1		<	0.1		<	0.1		<	0.1	
CA (TOTAL)	MG/L		23.5			20.			20.			20.			20.	
CADMIUM	MG/L		0.002		<	0.001		<	0.001		<	0.001		<	0.001	
CALCIUM	MG/L		23.3			20.			20.			20.			20.	
CD (TOTAL)	MG/L		0.002		<	0.001		<	0.001		<	0.001		<	0.001	
CHLORIDE	MG/L		1.9			1.4			1.4			1.3			1.3	
CHROMIUM	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
CONDUCTANCE	UMHO/CM		110.			120.			120.			120.			120.	
CR (TOTAL)	MG/L		0.02		<	0.01		<	0.01		<	0.01			0.01	
FE (TOTAL)	MG/L		7.75			1.80			1.30			1.32			1.26	
FLUORIDE	MG/L		-			0.1			0.1			0.1			0.1	
GROSS ALPHA	PCI/L		0.0	1.5		0.0	1.6		0.9	1.5		0.9	1.5		0.0	1.6
GROSS BETA	PCI/L		2.7	1.4		11.	2.1		3.5	1.7		2.6	1.7		3.6	1.7
IRON	MG/L		0.04		<	0.03		<	0.03		<	0.03		<	0.03	
K (TOTAL)	MG/L		3.18			3.6			3.5			3.7			3.5	
MAGNESIUM	MG/L		4.64			5.2			5.0			5.0			4.8	
MANGANESE	MG/L		0.04			0.01			0.01			0.01		<	0.01	
MG (TOTAL)	MG/L		4.67			5.3			5.2			5.1			5.0	
MN (TOTAL)	MG/L		0.38			0.05			0.04			0.03			0.03	
NA (TOTAL)	MG/L		9.21			9.4			9.2			9.4			9.4	
NITRATE	MG/L		4.5			0.1			1.3			1.8			1.8	
PH	SU		7.23			7.74			7.74			7.74			7.74	
POTASSIUM	MG/L		3.18			3.6			3.5			3.7			3.5	
RA-226	PCI/L		0.0	0.1		0.1	0.1		0.5	0.2		0.3	0.2		0.3	0.2
RA-228	PCI/L		0.0	0.9		1.4	0.8		1.9	0.9		0.4	0.7		0.5	0.8
SB (TOTAL)	MG/L	<	0.003		<	0.003		<	0.003		<	0.003		<	0.003	
SILVER	MG/L		-			-			-			-			-	
SODIUM	MG/L		9.20			9.4			9.2			9.4			9.4	
SULFATE	MG/L		7.			3.6			5.5			3.6			2.6	
TEMPERATURE	C - DEGREE		12.0			12.0			12.0			12.0			12.0	
TH-230	PCI/L		1.5	0.8		0.3	0.2		0.8	0.3		0.6	0.3		0.6	0.2
TOTAL SOLIDS	MG/L		185.			161.			164.			164.			165.	
U (TOTAL)	MG/L		0.0039			0.004			0.005		<	0.003			0.003	
URANIUM	MG/L		0.0009		<	0.003		<	0.003		<	0.003		<	0.003	
ZINC	MG/L	<	0.005			0.008		<	0.005		<	0.005			0.006	
ZN (TOTAL)	MG/L		0.036			0.028			0.026			0.027			0.023	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/86 TO 03/16/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE														
		522-05 08/11/87			522-01 12/12/87			522-01 03/16/88			523-01 09/29/86			523-01 02/01/87		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY		
AG (TOTAL)	MG/L		-			-			-			-			-	
ALKALINITY	MG/L CACO3		94.			95.			88.			85.			147.	
AMMONIUM	MG/L	<	0.1			0.1		<	0.1			0.1		<	0.1	
ANTIMONY	MG/L	<	0.003		<	0.003		<	0.003		<	0.0003		<	0.003	
ARSENIC	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.001	
AS (TOTAL)	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.001	
BORON	MG/L	<	0.1		<	0.1		<	0.1			3.6		<	0.1	
CA (TOTAL)	MG/L		20.			29.			29.5			15.9			14.7	
CADMIUM	MG/L	<	0.001		<	0.001			0.001		<	0.001		<	0.001	
CALCIUM	MG/L		20.			29.			19.5			13.1			16.3	
CD (TOTAL)	MG/L	<	0.001		<	0.001			0.001		<	0.001			0.003	
CHLORIDE	MG/L		1.2			1.2			1.2			4.			0.5	
CHROMIUM	MG/L	<	0.01		<	0.01		<	0.01			0.02		<	0.01	
CONDUCTANCE	UMHO/CM		120.			109.			125.			110.			98.	
CR (TOTAL)	MG/L	<	0.01		<	0.01		<	0.01			0.02			0.01	
FE (TOTAL)	MG/L		1.17			0.35			0.60			3.50			4.74	
FLUORIDE	MG/L		0.1		<	0.1		<	0.1			0.1		<	0.1	
GROSS ALPHA	PCI/L		0.0	1.5		0.9	1.3		5.2	1.9		-			0.0	1.5
GROSS BETA	PCI/L		2.6	1.7		1.7	1.5		8.7	1.9		-			3.0	1.4
IRON	MG/L	<	0.03		<	0.03		<	0.03		<	0.03		<	0.03	
K (TOTAL)	MG/L		3.6			3.4			3.4			4.00			4.19	
MAGNESIUM	MG/L		4.9			5.3			5.2			4.24			4.46	
MANGANESE	MG/L	<	0.01		<	0.01		<	0.01			0.01		<	0.01	
MG (TOTAL)	MG/L		5.2			5.3			5.4			4.85			4.01	
MN (TOTAL)	MG/L		0.03			0.02			0.02			0.10			0.09	
NA (TOTAL)	MG/L		9.2			9.4			9.4			24.7			9.07	
NITRATE	MG/L		1.8			1.4			1.2			2.			1.1	
PH	SU		7.74			7.53			8.00			7.88			7.83	
POTASSIUM	MG/L		3.6			3.4			3.4			4.00			4.18	
RA-226	PCI/L		0.2	0.2		0.0	0.1		0.1	0.2		0.0	0.2		0.5	0.5
RA-228	PCI/L		1.7	0.9		0.3	2.8		0.0	1.4		0.1	0.9		0.0	1.1
SB (TOTAL)	MG/L	<	0.003		<	0.003		<	0.003		<	0.0003		<	0.003	
SILVER	MG/L		-			-			-			-			-	
SODIUM	MG/L		9.2			9.4			9.3			24.5			37.6	
SULFATE	MG/L		1.5			5.0			2.8			1.2			0.3	
TEMPERATURE	C - DEGREE		12.0			9.9			10.5			11.			5.5	
TH-230	PCI/L		0.6	0.2		0.1	0.2		0.0	0.2		0.0	0.5		0.1	0.6
TOTAL SOLIDS	MG/L		159.			163.			158.			166.			132.	
U (TOTAL)	MG/L		0.006		<	0.003		<	0.003			0.0048			0.0030	
URANIUM	MG/L	<	0.003		<	0.003		<	0.003		<	0.0003			0.0008	
ZINC	MG/L	<	0.005		<	0.005		<	0.005			0.006			0.007	
ZN (TOTAL)	MG/L		0.022			0.009			0.006			0.036			0.132	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/86 TO 03/16/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE														
		523-01 04/25/87			523-01 09/10/87			523-01 12/12/87			523-02 12/12/87			523-03 12/12/87		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY		
AG (TOTAL)	MG/L		-			-			-			-			-	
ALKALINITY	MG/L CACO3		81.			82.			78.			78.			78.	
AMMONIUM	MG/L	<	0.1			0.2			0.1			0.1			0.6	
ANTIMONY	MG/L	<	0.003		<	0.003		<	0.003		<	0.003		<	0.003	
ARSENIC	MG/L		0.003		<	0.01		<	0.01		<	0.01		<	0.01	
AS (TOTAL)	MG/L		0.003		<	0.01		<	0.01		<	0.01		<	0.01	
BORON	MG/L		-		<	0.1		<	0.1		<	0.1		<	0.1	
CA (TOTAL)	MG/L		19.9			17.			17.1			17.4			17.6	
CADMIUM	MG/L		0.002		<	0.001		<	0.001		<	0.001		<	0.001	
CALCIUM	MG/L		19.8			17.			17.1			17.1			17.9	
CD (TOTAL)	MG/L		0.002		<	0.001		<	0.001		<	0.001		<	0.001	
CHLORIDE	MG/L		1.7			1.1			1.1			1.1			1.0	
CHROMIUM	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
CONDUCTANCE	UMHO/CM		105.			110.			115.			115.			1400.	
CR (TOTAL)	MG/L		0.02		<	0.01			0.01			0.01			0.01	
FE (TOTAL)	MG/L		6.23			3.50			1.62			2.62			1.96	
FLUORIDE	MG/L		-		<	0.1		<	0.1		<	0.1		<	0.1	
GROSS ALPHA	PCI/L		0.0	1.5		0.9	1.4		0.9	1.2		0.2	1.0		0.2	1.6
GROSS BETA	PCI/L		5.0	1.4		4.1	1.7		3.5	1.6		3.0	1.6		3.1	1.5
IRON	MG/L		0.05		<	0.03		<	0.03		<	0.03			0.14	
K (TOTAL)	MG/L		3.89			4.1			4.2			4.2			4.2	
MAGNESIUM	MG/L		3.95			4.2			4.0			4.1			3.9	
MANGANESE	MG/L		0.04		<	0.01		<	0.01		<	0.01		<	0.01	
MG (TOTAL)	MG/L		3.95			4.3			4.1			4.3			4.1	
MN (TOTAL)	MG/L		0.23			0.09			0.06			0.09			0.07	
NA (TOTAL)	MG/L		14.4			9.5			9.8			9.9			10.1	
NITRATE	MG/L		1.8		<	1.0			1.1			1.0			1.2	
PH	SU		7.74			7.96			8.17			8.17			7.75	
POTASSIUM	MG/L		3.86			4.1			4.1			4.0			4.0	
RA-226	PCI/L		0.9	0.2		0.3	0.2		0.9	0.1		0.9	0.1		0.1	0.1
RA-228	PCI/L		0.0	1.5		0.3	0.5		1.3	1.2		2.0	1.2		2.1	1.3
SB (TOTAL)	MG/L	<	0.003		<	0.003		<	0.003		<	0.003		<	0.003	
SILVER	MG/L		-			-			-			-			-	
SODIUM	MG/L		14.2			9.4			9.6			9.8			10.1	
SULFATE	MG/L		3.			1.0			5.0			5.3			5.1	
TEMPERATURE	C - DEGREE		11.5			12.5			10.5			10.5			10.0	
TH-230	PCI/L		0.6	0.6		0.0	0.2		0.7	0.5		1.0	0.7		1.0	0.9
TOTAL SOLIDS	MG/L		174.			142.			159.			149.			148.	
U (TOTAL)	MG/L		0.0040			0.007			0.006			0.005			0.003	
URANIUM	MG/L		0.0007		<	0.003		<	0.003		<	0.003		<	0.003	
ZINC	MG/L	<	0.005		<	0.005		<	0.005		<	0.005		<	0.005	
ZN (TOTAL)	MG/L		0.025			0.031			0.025			0.028			0.026	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/86 TO 03/16/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		523-04 12/12/87		523-05 12/12/87		523-01 03/16/88		523-02 03/16/88		523-03 03/16/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
AG (TOTAL)	MG/L	–		–		–		–		–	
ALKALINITY	MG/L CACO3	78.		78.		76.		76.		76.	
AMMONIUM	MG/L	0.3		0.2		< 0.1		1.1		1.1	
ANTIMONY	MG/L	< 0.003		< 0.003		< 0.003		0.011		0.013	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		0.08		0.08	
AS (TOTAL)	MG/L	< 0.01		< 0.01		< 0.01		0.09		0.08	
BORON	MG/L	< 0.1		< 0.1		< 0.1		44.		44.	
CA (TOTAL)	MG/L	17.4		17.5		17.5		280.		280.	
CADMIUM	MG/L	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CALCIUM	MG/L	16.8		16.8		17.4		279.		276.	
CD (TOTAL)	MG/L	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
CHLORIDE	MG/L	1.1		1.1		1.0		1230.		1220.	
CHROMIUM	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
CONDUCTANCE	UMHO/CM	600.		115.		110.		110.		110.	
CR (TOTAL)	MG/L	0.01		0.01		< 0.01		< 0.01		< 0.01	
FE (TOTAL)	MG/L	1.93		2.23		1.64		2.91		2.95	
FLUORIDE	MG/L	< 0.1		< 0.1		< 0.1		3.9		4.0	
GROSS ALPHA	PCI/L	2.9	1.4	0.0	0.9	0.0	0.9	0.0	43.	0.0	41.
GROSS BETA	PCI/L	4.9	1.7	1.3	1.4	3.7	1.6	15.	39.	10.	35.
IRON	MG/L	< 0.03		< 0.03		< 0.03		2.72		2.70	
K (TOTAL)	MG/L	4.2		4.2		4.0		16.8		17.9	
MAGNESIUM	MG/L	3.9		4.0		4.4		53.		53.	
MANGANESE	MG/L	< 0.01		< 0.01		< 0.01		10.6		10.7	
MG (TOTAL)	MG/L	4.1		4.1		4.7		53.		53.	
MN (TOTAL)	MG/L	0.06		0.07		0.06		10.6		10.7	
NA (TOTAL)	MG/L	9.8		10.1		9.4		1989.		1980.	
NITRATE	MG/L	1.9		1.1		1.0		< 1.0		< 1.0	
PH	SU	7.93		8.17		8.24		8.4		8.4	
POTASSIUM	MG/L	4.0		4.1		3.9		16.8		16.1	
RA-226	PCI/L	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.1
RA-228	PCI/L	4.6	1.8	1.2	1.0	0.0	1.4	0.0	1.2	0.0	1.2
SB (TOTAL)	MG/L	< 0.003		< 0.003		< 0.003		0.012		0.015	
SILVER	MG/L	–		–		–		–		–	
SODIUM	MG/L	9.6		10.1		9.4		1920.		1910.	
SULFATE	MG/L	5.4		5.8		< 0.1		3140.		3050.	
TEMPERATURE	C - DEGREE	10.5		10.5		10.0		10.0		10.9	
TH-230	PCI/L	1.0	0.7	1.4	1.2	0.0	0.2	0.8	0.3	1.6	0.4
TOTAL SOLIDS	MG/L	143.		147.		143.		7400.		7160.	
U (TOTAL)	MG/L	0.003		0.004		< 0.003		< 0.003		< 0.003	
URANIUM	MG/L	< 0.003		< 0.003		< 0.003		< 0.003		< 0.003	
ZINC	MG/L	< 0.005		< 0.005		< 0.005		< 0.005		< 0.005	
ZN (TOTAL)	MG/L	0.025		0.021		0.048		< 0.005		< 0.005	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
09/29/85 TO 03/16/88
REPORT DATE: 05/24/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE									
		523-04 03/16/88		523-05 03/16/88							
		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
AG (TOTAL)	MG/L	-		-							
ALKALINITY	MG/L CACO3	76.		76.							
AMMONIUM	MG/L	1.1		1.1							
ANTIMONY	MG/L	0.009		0.019							
ARSENIC	MG/L	0.07		0.07							
AS (TOTAL)	MG/L	0.08		0.07							
BORON	MG/L	44.		44.							
CA (TOTAL)	MG/L	277.		285.							
CADMIUM	MG/L	< 0.001		< 0.001							
CALCIUM	MG/L	272.		277.							
CD (TOTAL)	MG/L	< 0.001		< 0.001							
CHLORIDE	MG/L	1250.		1250.							
CHROMIUM	MG/L	< 0.01		< 0.01							
CONDUCTANCE	UMHO/CM	110.		110.							
CR (TOTAL)	MG/L	< 0.01		< 0.01							
FE (TOTAL)	MG/L	2.96		2.64							
FLUORIDE	MG/L	3.9		4.1							
GROSS ALPHA	PCI/L	15.	45.	61.	56.						
GROSS BETA	PCI/L	0.0	32.	59.	42.						
IRON	MG/L	2.58		2.56							
K (TOTAL)	MG/L	17.8		17.8							
MAGNESIUM	MG/L	53.		54.							
MANGANESE	MG/L	10.3		10.1							
MG (TOTAL)	MG/L	53.		56.							
MN (TOTAL)	MG/L	10.6		11.0							
NA (TOTAL)	MG/L	1970.		1990.							
NITRATE	MG/L	< 1.0		< 1.0							
PH	SU	8.4		8.4							
POTASSIUM	MG/L	16.1		16.9							
RA-226	PCI/L	0.0	0.1	0.0	0.1						
RA-228	PCI/L	0.0	1.3	0.0	1.3						
SB (TOTAL)	MG/L	0.015		0.013							
SILVER	MG/L	-		-							
SODIUM	MG/L	1960.		1910.							
SULFATE	MG/L	3100.		3110.							
TEMPERATURE	C - DEGREE	10.0		10.0							
TH-230	PCI/L	0.9	0.3	1.2	0.3						
TOTAL SOLIDS	MG/L	7140.		7110.							
U (TOTAL)	MG/L	< 0.003		< 0.003							
URANIUM	MG/L	< 0.003		< 0.003							
ZINC	MG/L	< 0.005		< 0.005							
ZN (TOTAL)	MG/L	< 0.005		0.009							

MAPPER DATA FILE NAME: LK502*UDPGW0104644

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
03/16/88 TO 03/16/88
REPORT DATE: 09/22/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE														
		521-01 03/16/88			572-01 03/16/88			523-01 03/16/88			523-02 03/16/88			523-03 03/16/88		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY		
ALKALINITY	MG/L CACO3		83.			88.			76.			76.			76.	
AMMONIUM	MG/L		0.1		<	0.1		<	0.1		<	0.1		<	0.1	
ANTIMONY	MG/L	<	0.003		<	0.003		<	0.093		<	0.003		<	0.003	
ARSENIC	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
AS (TOTAL)	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
BORON	MG/L	<	0.1		<	0.1		<	0.1		<	0.1		<	0.1	
CA (TOTAL)	MG/L		14.0			20.5			17.5			17.8			17.5	
CADMIUM	MG/L		0.001			0.001		<	0.001		<	0.001		<	0.001	
CALCIUM	MG/L		13.7			19.5			17.4			17.7			17.7	
CD (TOTAL)	MG/L		0.001			0.001		<	0.001		<	0.001		<	0.001	
CHLORIDE	MG/L		1.6			1.2			1.0			1.2			1.2	
CHROMIUM	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
CONDUCTANCE	UMHO/CM		110.			125.			110.			110.			110.	
CR (TOTAL)	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
FE (TOTAL)	MG/L		0.68			0.60			1.64			2.01			2.05	
FLUORIDE	MG/L	<	0.1		<	0.1		<	0.1		<	0.1		<	0.1	
GROSS ALPHA	PCI/L		0.0	0.9		5.2	1.9		0.0	0.9		0.0	43.		0.0	41.
GROSS BETA	PCI/L		4.1	1.6		8.7	1.9		3.7	1.6		2.8	1.6		3.8	1.6
IRON	MG/L	<	0.03		<	0.03		<	0.03		<	0.03		<	0.03	
K (TOTAL)	MG/L		4.4			3.4			4.0			4.1			4.1	
MAGNESIUM	MG/L		6.6			5.2			4.4			4.7			4.6	
MANGANESE	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
MG (TOTAL)	MG/L		6.6			5.4			4.7			4.7			4.7	
MN (TOTAL)	M3/L		0.03			0.02			0.06			0.06			0.06	
NA (TOTAL)	MG/L		9.4			9.4			9.4			11.3			9.7	
NITRATE	MG/L		1.2			1.2			1.0			1.0			1.0	
PH	SU		7.62			8.00			8.24			8.4			8.4	
POTASSIUM	MG/L		4.4			3.4			3.9			4.0			3.9	
RA-226	PCI/L		0.1	0.2		0.1	0.2		0.0	0.1		0.0	0.1		0.0	0.1
RA-228	PCI/L		2.5	2.0		0.0	1.4		0.0	1.4		0.3	1.5		2.0	1.3
SB (TOTAL)	MG/L	<	0.003		<	0.003		<	0.003		<	0.003			0.003	
SODIUM	MG/L		9.4			9.3			9.4			10.2			10.7	
SULFATE	MG/L		2.2			2.8		<	0.1		<	0.1		<	0.1	
TEMPERATURE	C - DEGREE		10.5			10.5			10.0			10.0			10.0	
TH-230	PCI/L		0.2	0.4		0.0	0.2		0.0	0.2		0.2	0.2		1.1	0.6
TOTAL SOLIDS	MG/L		150.			158.			143.			152.			141.	
U (TOTAL)	MG/L	<	0.003		<	0.003		<	0.003		<	0.693		<	0.003	
URANIUM	MG/L	<	0.003		<	0.003		<	0.003		<	0.003		<	0.003	
ZINC	MG/L	<	0.005		<	0.005		<	0.005		<	0.005		<	0.005	
ZN (TOTAL)	MG/L		0.006			0.006			0.048		<	0.005			0.009	

GROUND WATER QUALITY DATA BY LOCATION
SITE: COLLINS RANCH
03/16/88 TO 03/16/88
REPORT DATE: 09/22/88

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

LOCATION ID - SAMPLE ID AND LOG DATE

PARAMETER	UNIT OF MEASURE	523-04 03/16/88 PARAMETER VALUE+/-UNCERTAINTY		523-05 03/16/88 PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	76.		76.				
AMMONIUM	MG/L	< 0.1		< 0.1				
ANTIMONY	MG/L	< 0.003		< 0.003				
ARSENIC	MG/L	< 0.01		< 0.01				
AS (TOTAL)	MG/L	< 0.01		< 0.01				
BORON	MG/L	< 0.1		< 0.1				
CA (TOTAL)	MG/L	17.4		17.6				
CADMIUM	MG/L	< 0.001		< 0.001				
CALCIUM	MG/L	17.9		17.9				
CD (TOTAL)	MG/L	< 0.001		< 0.001				
CHLORIDE	MG/L	1.1		1.0				
CHROMIUM	MG/L	< 0.01		< 0.01				
CONDUCTANCE	UMHO/CM	110.		110.				
CR (TOTAL)	MG/L	< 0.01		< 0.01				
FE (TOTAL)	MG/L	1.82		2.68				
FLUORIDE	MG/L	< 0.1		< 0.1				
GROSS ALPHA	PCI/L	15.	45.	61.	56.			
GROSS BETA	PCI/L	3.2	1.6	3.7	1.6			
IRON	MG/L	< 0.03		< 0.03				
K (TOTAL)	MG/L	4.0		4.1				
MAGNESIUM	MG/L	4.7		4.7				
MANGANESE	MG/L	< 0.01		< 0.01				
MG (TOTAL)	MG/L	4.7		4.8				
MN (TOTAL)	MG/L	0.06		0.09				
NA (TOTAL)	MG/L	9.8		9.8				
NITRATE	MG/L	1.1		1.0				
PH	SU	8.4		8.4				
POTASSIUM	MG/L	3.9		3.9				
RA-226	PCI/L	0.0	0.1	0.0	0.1			
RA-228	PCI/L	0.4	1.2	0.2	1.6			
SB (TOTAL)	MG/L	< 0.003		< 0.003				
SODIUM	MG/L	10.7		10.5				
SULFATE	MG/L	< 0.1		< 0.1				
TEMPERATURE	C - DEGREE	10.0		10.0				
TH-230	PCI/L	1.9	0.4	0.3	0.2			
TOTAL SOLIDS	MG/L	140.		150.				
U (TOTAL)	MG/L	< 0.003		< 0.003				
URANIUM	MG/L	< 0.003		< 0.003				
ZINC	MG/L	< 0.005		< 0.005				
ZN (TOTAL)	MG/L	0.013		< 0.005				

MAPPER DATA FILE NAME: LKV02*UDPGWQ101940

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                                                     GROUND WATER QUALITY DATA BY LOCATION
                                                      SITE: COLLINS RANCH
                                                             03/17/88 TO 03/17/88
                                                             REPORT DATE: 09/22/88

FORMATION OF COMPLETION: SAND OR GRAVELLY SAND, POORLY GRADED
HYDRAULIC FLOW RELATIONSHIP: BACKGROUND

                            ---------------------------------- LOCATION ID - SAMPLE ID AND LOG DATE ----------------------------------
                             514-01  03/17/88       516-01  03/17/88
                            ---------------------------------------------------------------------------------------------------------
              UNIT OF            PARAMETER              PARAMETER              PARAMETER              PARAMETER              PARAMETER
PARAMETER     MEASURE       VALUE+/-UNCERTAINTY    VALUE+/-UNCERTAINTY    VALUE+/-UNCERTAINTY    VALUE+/-UNCERTAINTY    VALUE+/-UNCERTAINTY
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ALKALINITY    MG/L CACO3       400.                   41.
AMMONIUM      MG/L          <    0.1              <    0.1
ANTIMONY      MG/L          <    0.003            <    0.003
ARSENIC       MG/L          <    0.01             <    0.01
AS (TOTAL)    MG/L          <    0.01             <    0.01
BORON         MG/L          <    0.1              <    0.1
CA (TOTAL)    MG/L              29.                   12.7
CADMIUM       MG/L               0.001                 0.001
CALCIUM       MG/L              29.                   11.8
CD (TOTAL)    MG/L               0.001                 0.001
CHLORIDE      MG/L               2.5                   3.5
CHROMIUM      MG/L          <    0.01             <    0.01
CONDUCTANCE   UMHO/CM          160.                   85.
CR (TOTAL)    MG/L          <    0.01             <    0.01
FE (TOTAL)    MG/L          <    0.03                  2.42
FLUORIDE      MG/L          <    0.1                   0.1
GROSS ALPHA   PCI/L              0.0     1.4           0.0     0.8
GROSS BETA    PCI/L              4.6     1.7           1.5     1.4
IRON          MG/L          <    0.03             <    0.03
K (TOTAL)     MG/L               4.4                   3.6
MAGNESIUM     MG/L               6.3                   4.2
MANGANESE     MG/L          <    0.01             <    0.01
MG (TOTAL)    MG/L               6.3                   4.9
MN (TOTAL)    MG/L          <    0.01                  0.11
NA (TOTAL)    MG/L               8.9                   5.8
NITRATE       MG/L               9.8                   5.0
PH            SU                 8.23                  6.66
POTASSIUM     MG/L               4.4                   3.2
RA-226        PCI/L              0.0     0.1           0.1     0.2
RA-228        PCI/L              0.0     1.4           2.0     1.5
SB (TOTAL)    MG/L          <    0.003            <    0.003
SODIUM        MG/L               8.9                   5.8
SULFATE       MG/L              12.8                  12.1
TEMPERATURE   C - DEGREE        10.0                  10.5
TH-230        PCI/L              0.2     0.3           0.1     0.2
TOTAL SOLIDS  MG/L             201.                  158.
U (TOTAL)     MG/L          <    0.003            <    0.003
URANIUM       MG/L          <    0.003            <    0.003
ZINC          MG/L          <    0.005            <    0.005
ZN (TOTAL)    MG/L          <    0.005                 0.030


  MAPPER DATA FILE NAME: LKV02*UDPGWQ101941
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