FINAL
TECHNICAL EVALUATION REPORT
for the
PROPOSED REMEDIAL ACTION
at the
SPOOK TAILINGS SITE
SPOOK, WYOMING

December 1989

Division of Low-Level Waste Management
and
Decommissioning
U. S. Nuclear Regulatory Commission

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1.0 INTRODUCTION

The Spook, Wyoming site was designated as one of the 24 abandoned uranium mill tailings piles to receive remedial action by the U.S. Department of Energy (DOE) under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). UMTRCA requires in part, that the U.S. Nuclear Regulatory Commission (NRC) concur with DOE's selection of remedial action, such that the remedial action meets standards promulgated by the U.S. Environmental Protection Agency (EPA). This final Technical Evaluation Report (TER) documents NRC staff's review of the DOE remedial action plan and outlines the conclusions and outstanding issues/items resulting from this review.

1.1 EPA Standards

As required by UMTRCA, remedial action at the Spook site must comply with standards established by the EPA in 40 CFR Part 192, Subparts A-C. These standards may be summarized as follows:

1. The disposal site shall be designed to control the tailings and other residual radioactive material for 1000 years to the extent reasonably achievable and, in any case, for at least 200 years [40 CFR 192.02(a)].

2. The disposal site design shall prevent radon-222 fluxes from residual radioactive materials to the atmosphere from exceeding 20 picocuries/square meter/second or from increasing the annual average concentration of radon-222 in air by more than 0.5 picocuries/liter [40 CFR 192.02(b)].

3. The remedial action shall ensure that radium-226 concentrations in land that is not part of the disposal site averaged over any area of 100 square meters do not exceed the background level by more than 5 picocuries/gram averaged over the first 15 centimeters of soil below the surface and 15 picocuries/gram averaged over any 15-centimeter thick layer of soil more than 15 centimeters below the land surface [40 CFR 192.12(a)].

On September 3, 1985, the U.S. Tenth Circuit Court of Appeals remanded the groundwater standards (40 CFR Part 192.2(a)(2)-(3)) and stipulated that EPA promulgate new groundwater standards. EPA proposed these standards in the form of revisions to Subparts A-C of 40 CFR Part 192 in September 1987. The proposed standards consist of two parts; a first part governing the control of any future groundwater contamination that may occur from tailings piles after remedial action, and a second part that applies to the cleanup of contamination that occurred before the remedial action of the tailings.

1.2 Site and Proposed Action

The Spook mill and tailings site is in Converse County; 48 miles northeast of Casper, Wyoming,. and 36 miles northwest of Douglas Wyoming (Figure 1.1). The site is currently part of a remote, active sheep and cattle ranch.

The Spook site consists of an abandoned open pit uranium mine, a mill site area at the edge of the pit, and several miscellaneous contaminated areas (Figure 1.2). Tailings are along the southeast pit wall and on the ground surface adjacent to the pit. Several small ore reserve piles and a depleted acid pond are north and south, respectively, of the pit.

The designated site, which includes the tailings and former mill area encompasses about five acres. The windblown contamination and ore reserve piles are outside of the designated site but will be included in the remedial action. Also, while the depleted acid pond south-west of the designated Spook site will be remediated as a vicinity property, a significant amount of its contaminated material will be placed in the UMTRA Project tailings disposal cell. The total volume of contaminated materials is estimated to be about 290,000 cubic yards (cy). Adjacent to the site are 9 piles of overburden material removed from the pit during mining. These piles contain an estimated 1.6 million cy of material.

The remedial action plan for the Spook site consists of a joint effort between the DOE Uranium Mill Tailings Remedial Action (UMTRA) Project and the State of Wyoming Abandoned Mined Lands (AML) Program. The AML Program is authorized under the Surface Mining Control and Reclamation Act of 1977, Public Law 95-87, and administered by the participating state. The DOE portion of this joint remedial action will consist of the cleanup, consolidation, and stabilization of all "residual radioactive materials" in the Spook pit. The AML Program responsibilities will consist of backfilling the pit with overburden material, recontouring the disturbed area, and revegetating the final cover. Both portions of the design will be constructed by a single contractor. NRC staff's review focuses on the UMTRA Project portion of the site remediation and those portions of the AML Program work which may affect the UMTRA Project design (Reference 20).

The concurrent UMTRA Project/AML Program design is comprised of the following major phases:

- DOE (UMTRA Project) preparation of the embankment foundation at EL 5020 in the bottom of the Spook pit (approximately 15 feet above the groundwater level).
- State (AML Program) placement and compaction of a 3-foot thick leachate reduction layer over the bottom of the pit.

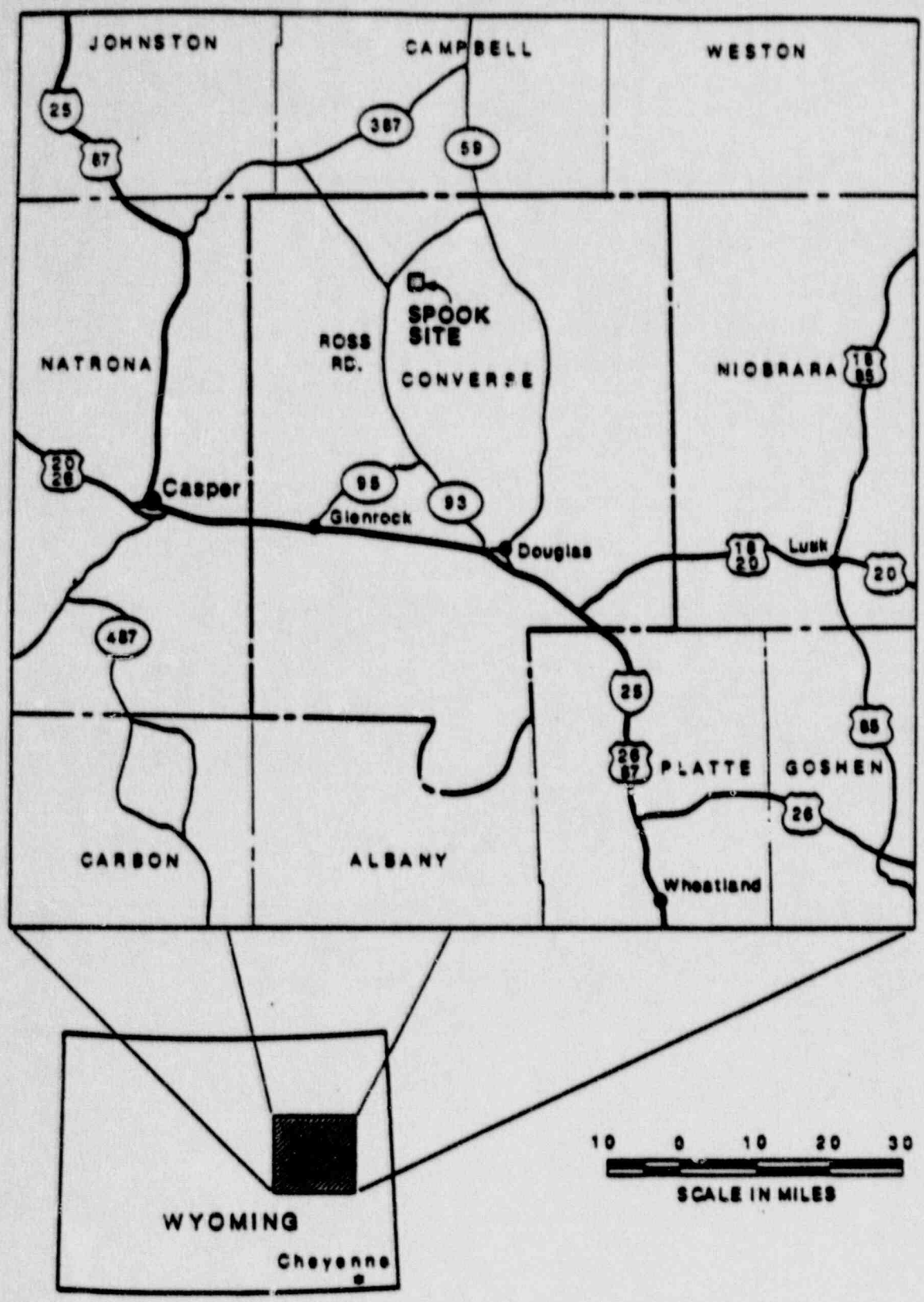

FIGURE 1.1 (SOURCE: REFERENCE 2)

LOCATION OF THE SPOOK SITE IN CONVERSE COUNTY, WYOMING

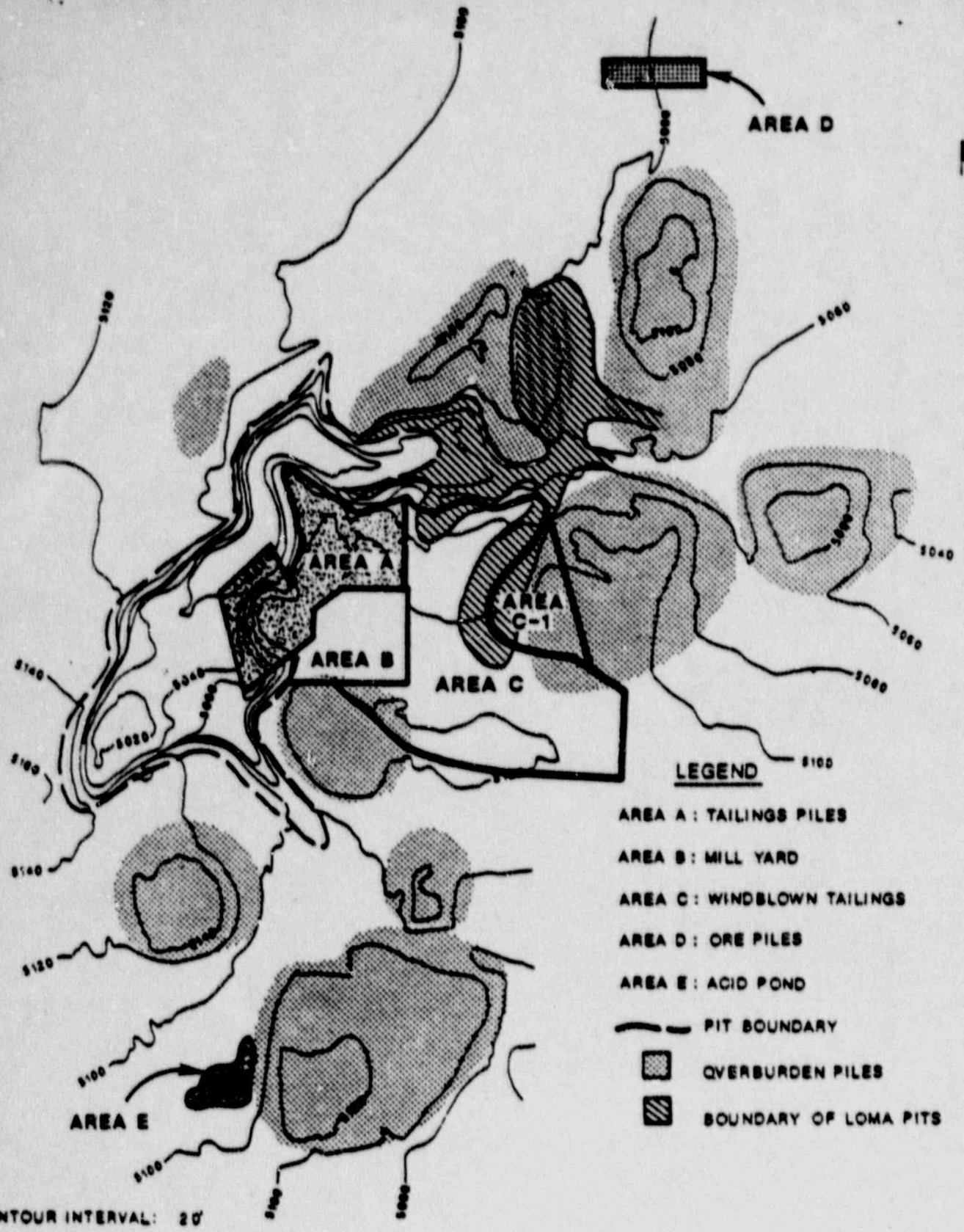

FIGURE 1.2 (SOURCE: REFERENCE 2)

LIMITS OF TAILING CONTAMINATION,
SPOOK SITE - CONVERSE COUNTY, WYOMING

- DOE stabilization of the tailings, millyard, windblown and demolition debris in an embankment at the bottom of the Spook pit; the base of which will be approximately hexagonal and cover five acres in area. The average depth of the embankment will be about 32 feet (with a maximum depth of 53 feet). On the north and south ends of the pile, the sides will be constructed at a 1 vertical to 2 horizontal slope; the east and west sides of the pile will be vertical. The top slopes will be constructed at a three to eight percent grade.

- DOE placement and compaction of a 1.5-foot thick, low-permeability layer over the tailings embankment to minimize infiltration.

- State placement of a 15-foot thick layer of selected granular material over the low-permeability layer to promote lateral drainage around the tailings embankment.

- State backfill of the pit with compacted overburden material. The average depth of overburden above the tailings will be 56 feet, with the least contaminated portion near the finished surface and the most contaminated at the bottom of the pit.

- State completion of site reclamation by recontouring the disturbed area and revegetating the final cover to provide a stable topographic condition similar to the pre-mining ground surface.

The final UMTRA site area will cover 13 acres. This area corresponds to the surface area of the pit plus a 100-foot wide perimeter buffer zone. After completion of the joint remedial action, DOE will implement the surveillance and maintenance responsibilities for the final UMTRA site area in accordance with an NRC license, to be issued following adequate completion of the remedial action.

1.3 Review Process

NRC staff's review was performed in accordance with the Standard Review Plan for UMTRCA Title I Mill Tailings Remedial Action Plans ("SRP"; Reference 1) and consisted of comprehensive assessments of DOE's proposed preliminary final and final remedial action plan/design.

The information assessed by NRC staff during this review was primarily provided in the following documents, submitted by DOE for review (References 2 through 11).

1. Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings at Spook, Wyoming; final, dated July 1989 (including text and appendices A, B, C, D, and E).-- "RAP".

2. Uranium Mill Tailings Remedial Action Project (UMTRAP-AML), Spook, Wyoming; Information for Reviewers, dated November 1988.

3. Uranium Mill Tailings Remedial Action Project (UMTRAP-AML), Spook, Wyoming; Subcontract Documents, dated November 1988.

4. Uranium Mill Tailings Remedial Action Project (UMTRAP-AML), Spook, Wyoming; Information for Bidders, dated November 1988 (2 volumes).

5. Uranium Mill Tailings Remedial Action Project (UMTRAP-AML), Spook, Wyoming; Calculations, dated November 1988 (2 volumes).

6. Letter dated December 12, 1988, from W. J. Arthur of DOE to P. H. Lohaus of NRC enclosing DOE responses to NRC comments on the draft RAP, preliminary Design, and draft Environmental Assessment for the UMTRA Site at Spook, Wyoming.

7. Project Interface Document (PID) No. 15-S-02, Revision 1, transmitted by letter from Mark Matthews to Myron Fliegel dated August 28, 1989.

8. Project Interface Document (PID) No. 15-S-03, transmitted by letter from Mark Matthews to Myron Fliegel dated August 25, 1989.

9. Letter from Mark Matthews to Paul Lohaus dated October 19, 1989; RAP page changes.

10. Letter from Mark Matthews to Paul Lohaus dated November 20, 1989; RAP page changes.

1.4 TER Organization

The purpose of this final TER is to document NRC staff's review of DOE's remedial action plan and design for the Spook site and to address the open issues resulting from this review. The following sections of this report have been organized by technical discipline relative to the EPA standards in 40 CFR Part 192, Subparts A-C. Sections 2, 3, and 4 provide the technical basis for NRC staff's conclusions and identification of any remaining open items with respect to the long-term stability standard in 192.02(a). Section 5, Water Resources Protection, summarizes NRC staff's conclusions and any remaining open items regarding the adequacy of DOE's demonstration of compliance with respect to EPA's groundwater protection requirements in 40 CFR Part 192. Section 6 provides the basis for the staff conclusions and identification of any open items with respect to the radon control standards in 192.02(b).

1.5 Summary of Open Issues

NRC staff's review of DOE's remedial action plan and design has identified only one open issue, which is addressed in Section 5.7 of this TER. The issue relates to DOE's deferral of groundwater cleanup until after promulgation of EPA's final groundwater protection standards. NRC staff considers DOE's deferral to be acceptable for conditional concurrence. When this issue is addressed, NRC will provide final concurrence on the remedial action at this site.

2.0 GEOLOGIC STABILITY

2.1 Introduction

This section of the TER documents NRC staff's review of geological information for the proposed remedial action at the Spook uranium mill tailings disposal site. Background information for this section of the TER is derived primarily from DOE's RAP (Reference 2), DOE's Final Design for Review, subcontract documents and calculations (References 4 and 6), the State of Wyoming's Abandoned Mine Lands Report of Investigations (Reference 12), staff's observations during the site visits, and independent sources, as cited.

2.2 Location

The Spook site is located along an unnamed tributary of the Dry Fork, a headwater tributary to the Cheyenne River in the western Great Plains, Wyoming. The tributary, called Spook Wash in this report, drains about 1.3 km^2. About 40 percent of the basin has been disturbed by mining activity. The channel is blocked by the open pit which extends southward (Figure 2.1) to the basin divide. The channel is also blocked by three of nine overburden piles, and by an older refilled open pit mine (the Loma pits). The next watershed to the south is partially disturbed by the Spook pit and three overburden piles, one of which blocks its channel. Site characterization was conducted for an area including an abandoned open-pit mine, a mill area and tailings pile, as well as overburden piles and other mine areas to be reclaimed by the State of Wyoming.

2.3 Geology

EPA standards in 40 CFR 192 do not include generic or site-specific requirements for characterization of geological conditions at UMTRA Project sites. Rather, 40 CFR 192.02(a) requires control shall be designed to be effective for up to 1,000 years, to the extent achievable, and in any case for at least 200 years. NRC staff has interpreted this standard to mean that certain geological conditions must be met in order to have reasonable assurance that long-term performance objectives will be achieved. Guidance regarding these conditions is specified in NRC's SRP (Reference 1).

2.3.1 Stratigraphic Setting

DOE characterized regional and site stratigraphy, referencing published work and original field investigations as recommended in SRP section 2.2.2.1 (Reference 1). The Spook site is situated on broad rolling plains developed in Eocene Wasatch Formation rocks. The Wasatch is one of a thick sequence of continental strata in the Powder River Basin. The Wasatch underlies the site to a depth of approximately 340 feet. In the central basin, it is composed of

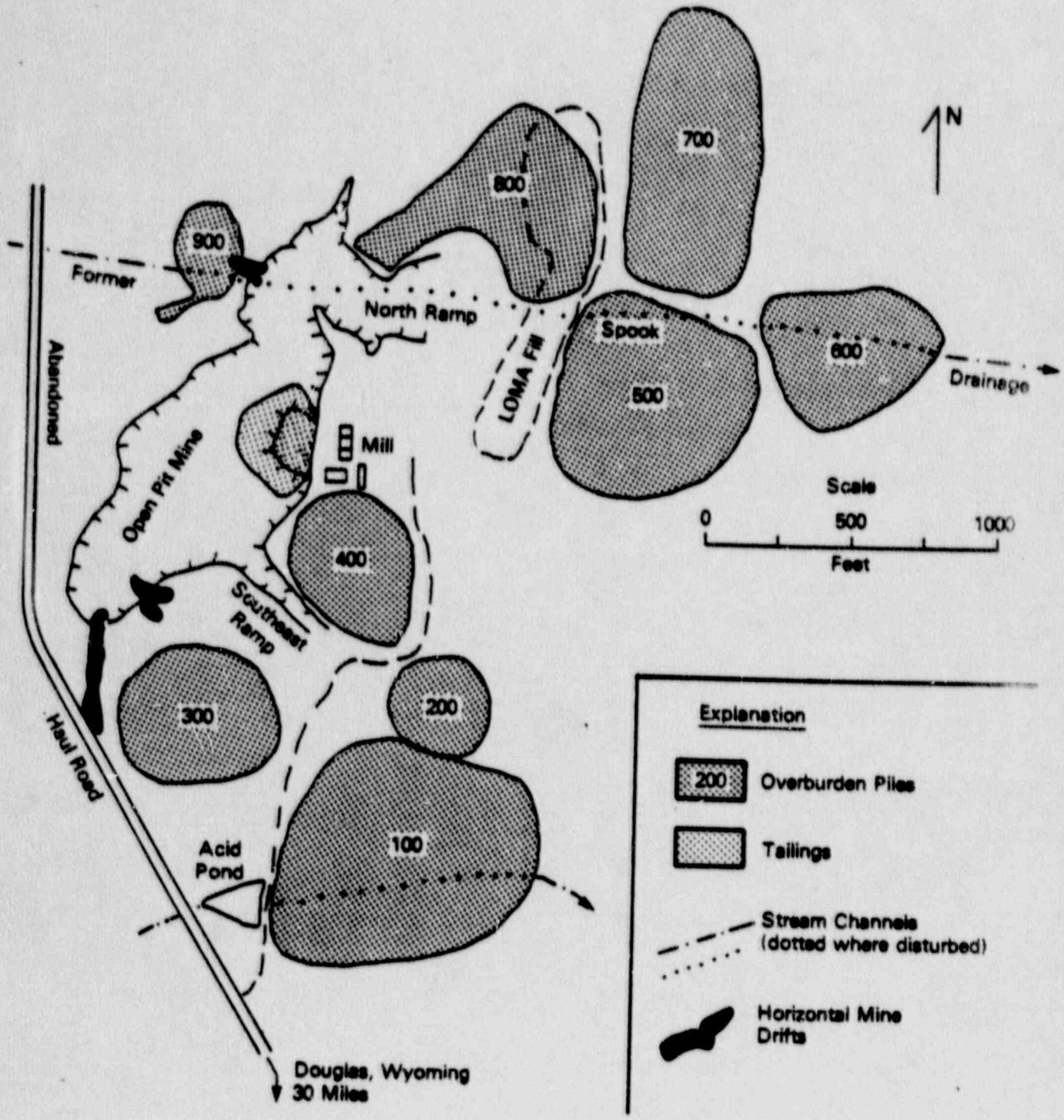

FIGURE 2.1

Index map of Spook pit, tailings, overburden, and mill.

thick lenticular sandstones interbedded with siltstone, shale, and coal. The Wasatch apparently was derived from the Laramie Range, uplifted to the south during Laramide time. The Wasatch grades to clayey and silty facies laterally and northward across the basin (Reference 13). Uranium deposits in the Powder River Basin are found in sandstones of the Wasatch.

The Wasatch is underlain by the Paleocene Fort Union Formation. The two units are similar in appearance and conformable through most of the basin. However, they are separated due to unconformable relations observed on the flanks of the basin (Reference 13). The Fort Union exceeds 3,000 feet of thickness in the Spook area. Fort Union rocks are in turn underlain by Cretaceous and older rocks, which are not of importance to the remedial action. NRC staff finds reasonable assurance that detailed subsurface stratigraphic conditions at Spook will not affect the site's ability to meet remedial action standards.

The abandoned mill tailings are piled on Wasatch Formation rocks along the eastern face of Spook pit. Locally, the unit is coarse-grained arkosic yellow and red sandstone. The sandstone has a fluvial origin, is mainly cross-bedded, and is poorly cemented. Cements in the rock include clay and iron oxides. Thin and discontinuous stringers of coal, petrified wood, sparse interbeds of dark mudstone and yellow uranium mineralization are observed in the pit.

Quaternary deposits occur at the top edge of the pit, but were extensively disturbed by mining. Alluvium adjacent to the disposal area is as thin as two feet, and bedrock occurs very near the surface. However, it thickens to 40 feet along the north end of the pit. The State's drilling data and shallow reflection seismic surveys suggest the thickest alluvium occurs along paleochannels. The alluvium-bedrock contact north of the disposal area occurs at an elevation slightly lower than the top of the proposed tailings pile. Surficial deposits are mainly sandy loam and probably consist of fluvial sediment derived from local bedrock and reworked eolian sediment.

Details of the area's stratigraphy, as it influences hydrogeological and geotechnical conditions of the site and ability of the remedial action to meet UMTRA Project groundwater standards, are discussed in other sections of this TER. The staff finds reasonable assurance that stratigraphic conditions at Spook will not directly affect the site's ability to meet long-term stability standards.

2.3.2 Structural Setting

DOE characterized the region's structural setting referencing published regional geological maps and their field observations of features critical to assuring long-term stability of the remedial action. These studies were recommended in SRP Section 2.2.2.3 (Reference 1). The Spook area lies near the axis of the Powder River Basin. The area occurs as both a structural and physiographic basin and is surrounded by structural highlands. The basin lacks major structural features in the Wasatch and Fort Union formations, and appears to have been stable since Eocene time. Wasatch beds near the site are nearly

flat lying, and dip only one degree to 2½ degrees in most of the basin. The structural axis on basement rocks does not coincide with the surficial axis, suggesting the basin has experienced deformation since early Tertiary time.

Fractures are mapped in Wasatch rocks east of the site, and are interpreted as tension fractures associated with incipient anticlinal warping of the Powder River Basin (Reference 13). Differential movement along the fractures is not observed in the field. Similar fractures were also observed in the site area. On aerial photographs they appear in bedrock exposures, but can also be observed in a few areas even though overlain by shallow surficial deposits. Their appearance through soil results from concentration of vegetation, and suggests the fractures help maintain higher soil moisture. The features are difficult to recognize in the field and are not observed in the walls of Spook pit. Like their regional counterparts, they do not exhibit fault displacement. The staff finds reasonable assurance that structural conditions at Spook will not affect the site's ability to meet remedial action standards.

2.3.3 Geomorphic Setting

DOE characterized regional physiography referring to published literature and topographic maps, as recommended in SRP Section 2.2.2.2 (Reference 1). Site geomorphic conditions were characterized by aerial photographic interpretation and field observations. The area is located in the Cheyenne River basin in the western Great Plains physiographic province (Reference 14). The Big Horn Mountains to the northwest and Laramie Mountains to the south form the bordering Rocky Mountain province.

The Spook site occurs along the southern slope of a small drainage basin, called Spook Wash in this TER. The drainage channel is intersected by the pit and blocked by several overburden piles, and much of the basin has been disturbed. Runoff from about 260 acres (1.05 km^2) once drained through the area affected by mining. Surficial deposits are mainly 2 to 10 feet thick, but go as deep as 40 feet in paleochannels exposed in Spook pit. Quaternary deposits form a relatively continuous mantle in the area.

Bedrock outcrops typically occur along hillslopes and drainage divides. Outcrops occur preferentially on ridge crests oriented perpendicular to prevailing wind direction. AML Program site investigators concluded that these outcrops resulted from eolian deflation because the ridge crests provide surficial deposits with minimal protection from wind.

Under ordinary conditions, a major remedial action concern is protection of tailings from catastrophic flood erosion. At Spook, however, placement of the tailings below grade in the abandoned pit lessens this concern. The Spook site is at greater risk from long-term erosion, channel changes, and drainage basin development. Therefore, staff analyzed the potential depth of channel erosion

during the performance period of the remedial action. Three aspects of the site's characteristics and design have been emphasized by DOE for protection of the tailings from deep erosion: (1) protection from base-level lowering by bedrock, (2) deep burial of the tailings, (3) surface recontouring by the State. These aspects are reviewed in the Geomorphic Stability section of this report.

2.3.4 Seismicity

DOE characterized regional seismicity by obtaining data bases provided by the National Oceanographic and Atmospheric Administration (NOAA), by applying accepted techniques to determine earthquake magnitudes, and by employing methods suggested in SRP Section 2.2.2.3 (Reference 1) for calculating peak horizontal ground accelerations generated by a design-basis event.

The Spook site is located in a relatively stable border area between the middle Rocky Mountain and Black Hills seismotectonic provinces. Historical and instrumental seismic activity has been sparse, and is concentrated at distances greater than 80 km away in the Laramie Range, the Black Hills, and beyond (Reference 2). DOE characterized regional seismicity and faults in adjacent seismotectonic provinces, and determined that the design seismic ground acceleration for the site is 0.21g (Reference 2). However, because the tailings will be buried below grade, they are susceptible to minimal risk of failure due to seismic shaking. The staff concludes that only on-site fault rupture intersecting the tailings would result in a potential failure to meet the standards (Reference 2). Therefore, the staff finds that detailed analysis of seismic risk for this site is not necessary.

2.4 Geologic Stability

Geologic conditions and processes at the site are characterized to determine the ability to meet 40 CFR 192.02(a). In general, site lithologic, stratigraphic and structural conditions are considered for their suitability as a disposal foundation and their potential interaction with tailings leachate and ground water. The effect of the site's bedrock geology on hydrogeological and geotechnical conditions is discussed in other sections of this TER. NRC staff considered geomorphic processes for their potential impact upon long-term tailings stabilization and isolation. Our geomorphic review was based on the proposed AML Program design (References 4, 6 and 12). Potential geologic hazards, including seismic shaking, liquefaction, on-site fault rupture, ground collapse, and volcanism were reviewed for the purpose of assuring the long-term stability of the disposal cell and success of the remedial action.

2.4.1 Geomorphic Stability

Stabilization of mill tailings in their present location or in an above-grade pile would require constant maintenance and repair of erosion control features, and would impede the State's efforts to reclaim the abandoned mine. The

proposed burial of Spook's tailings will result in elimination of the site's major geomorphic hazard -- erosion of tailings during a catastrophic flood event in the Spook Wash basin. Burial of the tailings will also eliminate hazards resulting from eolian deflation of contaminated materials.

The staff has carefully reviewed the State's proposed mine reclamation plan, its relationship to DOE's remedial action and the proposed restoration of geomorphic features at the site. Our review was aimed to ensure that proposed burial of the tailings will provide protection from long-term geomorphic processes at the site. Based upon our review, we conclude that DOE places reliance for meeting long-term geomorphic stability requirements on the following three aspects of the site and design (Reference 2).

Protection of the tailings by bedrock

DOE asserts that bedrock occurs higher than the proposed tailings pile, and will provide a stable base level to prevent future downcutting and erosion of pit fill. The RAP and design provides an east-west cross-section to show the relations (Figure 2.2). The staff's review indicates that a more likely orientation of eroding channels would be from Spook Wash southward through the pit backfill (Figure 2.3). In this orientation, no bedrock occurs higher than the elevation of the proposed tailings pile. In addition, the staff observed (trip report, Reference 29) that the Wasatch sandstone rock appears to be poorly cemented and probably lacks the induration needed to provide a stable base level for long time periods. The staff concludes that the bedrock may not provide significant erosion protection, and that reasonable assurance of long-term stability of the tailings pile should be based on other aspects of the site and design.

Mine reclamation: surface contouring and basin stability

The State's mine reclamation plan includes two design features intended to increase the site's long-term geomorphic stability. The first feature is topographic mounding of backfill over Spook pit (Drawing No. SPK-AML-PS-10-0203; Reference 4). The design should result in runoff away from the pile. Preferential erosion will occur in areas away from the pile. Gullies forming near the pile will not have enough basin area to support headward erosion to the area overlying tailings.

Second, the State will reconstruct Spook Wash and a small tributary to the north with channel patterns and hydraulic geometry designed to minimize erosion. The constructed channel pattern will be meandering to increase channel length, and therefore decrease channel gradient.

NRC staff compared an arbitrary drainage basin, whose mouth lies at the downstream end of the area affected by mining and mine reclamation, with

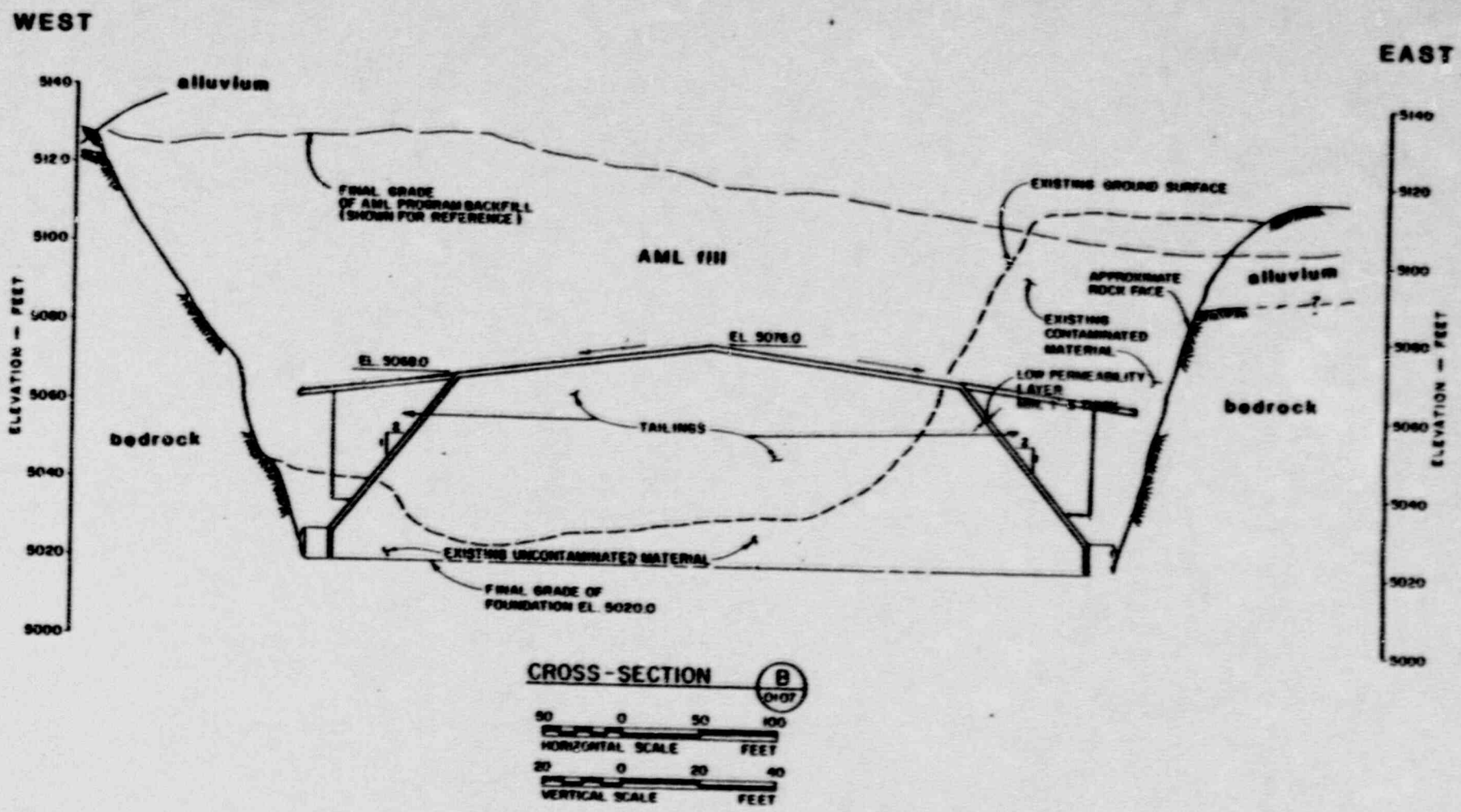

FIGURE 2.2

East-west topographic profile and geologic cross-section of Spook pit showing location of tailings and the elevation of the alluvium-bedrock contact. Note the contact occurs above the peak of the tailings pile. Profile is parallel to Spook Wash. (Simplified from DOE design drawing SPK-PS-10-0109.)

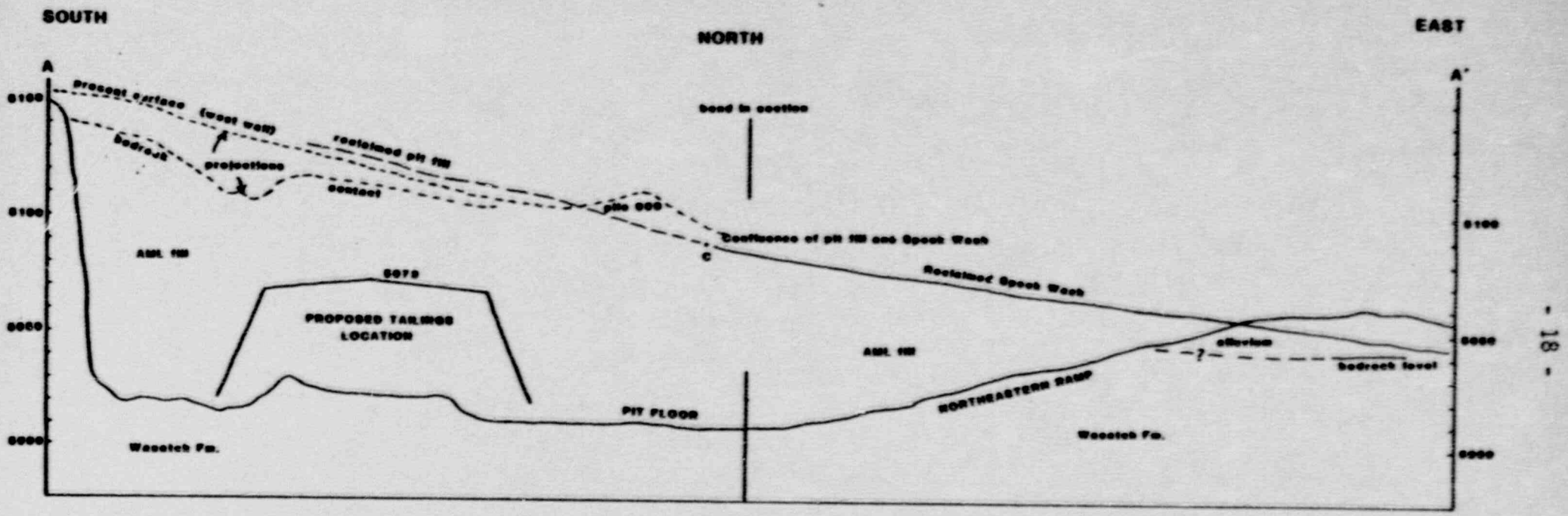

FIGURE 2.3

Topographic profile and geologic cross-section along Spook pit and Spook Wash. Even though tailings will lie below bedrock exposures in the pit walls, no bedrock will occur between Spook Wash and the tailings following remedial action. Bedrock will not impede erosion of Spook Wash, through reclaimed fill, to the tailings. Stability of the tailings relies upon stability and gradient of reclaimed Spook Wash, and the depth of fill overlying the pile. (Tailings layout is based upon MGE design drawing SPK-PS-10-0100. Topography of the pit, reclamation elevations, and geological relations are taken from ASL maps

others in the western United States for which gully threshold conditions have been established (Reference 15; Figure 3.9). Our analysis shows that the Spook basin is similar to other semiarid basins which have not experienced gully formation. The basin's area and gradient also lie below a statistically derived threshold for gullying determined from those semiarid basins. The staff concludes that while hillslope and channel erosion are likely to occur over the long term, widespread gully growth is unlikely. Therefore, the design provides reasonable assurance that drainage channels will not affect the long-term stabilization of the tailings pile.

Depth of burial of the Spook tailings pile

According to the UMTRA Project/AML Program design for pile location and surface reclamation, the Spook tailings will lie beneath 50 feet of fill where they approach closest to Spook Wash. The tailings pile peak will lie 48 feet beneath the surface. Regardless of the mode of erosion, this depth of fill should exceed any depth of downcutting which could occur over the next 1,000 years. Gullies elsewhere in the western United States are known to exist to depths of about 30 feet. These gullies, however, drain larger basins and required hundreds or thousands of years to develop. Based on these criteria, NRC staff has reasonable assurance that channels at Spook will not erode through pit backfill and expose tailings during the performance period of the remedial action.

In conclusion, NRC staff finds that site characteristics and the proposed surface reclamation plan should result in the long-term stability required by the EPA standards.

2.4.2 Seismotectonic Stability

DOE must provide reasonable assurance that the remedial action design will not be affected by seismicity. Proposed remedial action at Spook provides assurance that the tailings will not be affected by seismic shaking, liquefaction, or ground collapse during seismic events. On-site fault rupture, however, could potentially intersect the tailings pile, and affect the backfill and the surface of the site.

No faults are mapped in the vicinity of the site, and DOE's site characterization did not result in discovery of unknown structures. Bedrock fractures observed near the disposal site, and in the region (Reference 13), appear to result from regional tectonic stress, but are not associated with crustal faults. Differential movement along the fractures is not observed. Furthermore, the fractures are not observed intersecting Spook pit. Therefore, NRC staff finds there is reasonable assurance that seismic activity in the Spook region will not affect the remedial action.

2.5 Conclusions

Based upon review of the RAP and supporting information for the Spook, Wyoming site, NRC staff has reasonable assurance that regional and site geologic conditions have been characterized adequately to meet 40 CFR 192. While long-term erosion is likely to occur at the site, landscape restoration and depth of burial will provide adequate erosion protection during the performance period of the remedial action.

3.0 GEOTECHNICAL STABILITY

3.1 Introduction

This section presents NRC staff's review of the geotechnical engineering aspects of the proposed remedial actions at the Spook site. The review consists primarily of evaluations of site characterization and slope stability aspects of the stabilized tailings embankment and the cover design. The object of this review was to determine whether the proposed remedial actions would result in the stabilized embankment complying with the long-term stability. requirements of the EPA standard in 40 CFR Part 192.02(a), Subpart A, from the perspective of slope stability, liquefaction and settlement.

The proposed remedial action at the Spook site involves two programs: (1) the DOE portion, dealing with cleanup of the residual radioactive materials under the UMTRA Project; and (2) the State of Wyoming portion, dealing with reclamation of the abandoned mine wastes under the AML Program. Both DOE and State work will be performed concurrently, by a single subcontractor as both UMTRA and AML Program materials will be disposed in the Spook pit.

In summary, to stabilize the tailings and meet the EPA standards, DOE's proposed remedial action involves placement and compaction of all contaminated materials in a single pile within the south end of the Spook pit. This stabilized tailings pile will have side slopes of 50 percent on the north and south ends, and vertical sides on the east and west ends. The top slopes will be constucted at a three to eight percent grade. The base of the stabilized pile will be nearly hexagonal and cover five acres inside the pit. The pile will have an average depth of about 32 feet with a maximum depth of 53 feet.

The tailings and contaminated materials will be covered with a 1.5-foot thick low-permeability layer to inhibit infiltration of water into and through the contaminated materials. This low-permeability layer also serves as a radon barrier. The upper surface of the material will be crowned to promote positive drainage, thereby reducing infiltration. This tailings pile embankment with its cover is also referred to as a "disposal cell" in this TER.

The vertical slopes on the east and west sides of the pile represent a design change resulting from discovery of an additional 50,000 cubic yards of contaminated material at the site (Reference 8). To remain within the existing cell footprint and not increase the piles's elevation (to accommodate geomorphic considerations), the additional material will be placed along the east and west sides of the pile (see Figure 2.2). The low-permeability layer will be extended at a three percent slope across the top of the additional contaminated material to 20 feet beyond the cell footprint.

Prior to placing the tailings materials, the State will cover the entire bottom of the Spook pit with a 3-foot thick leachate reduction layer of sandy material (under the AML Program). Then the State will proceed with the reclamation of

the pit, concurrent with the construction of the stabilized tailings pile. The reclamation/restoration will involve placing and compacting stockpiled overburden material in the pit, filling the backfilled pit to the level of the original surrounding ground surface. The backfill will average about 56 feet thick above the top of the tailings and will serve as an additional radon barrier for the tailings as well as eliminate the need for erosion protection rock. The pit, former mill yard, and windblown areas will be restored to original ground surface contours and revegetated under the AML Program.

NRC staff's review of the geotechnical aspects of the proposed remedial actions at the Spook pit focused on the DOE/UMTRA portion of the project and only relevant portions of the proposed AML Program work that may affect the UMTRA Project design.

3.2 Site Characterization Evaluation

3.2.1 Site Description

The Spook mill site and tailings pile are in Converse County, 48 miles northeast of Casper, Wyoming. Figures 1.1 and 1.2 (see Section 1 of this TER), present the location and limits of the areas designated for remedial action under the UMTRA Project and reclamation under the AML Program.

The tailings, which were originally dumped near the edge of the Spook pit have numerous erosion gullies. The eroding water has transported some of the tailings down along the east wall and into a portion of the pit bottom. The bottom of the pit is approximately 100 feet below the eastern edge of the pit. The former mill area and the windblown contaminated area are relatively flat and are sparsely vegetated.

3.2.2 Site Investigations

Subsurface explorations at the site were performed by the following investigators.

1. Mountain States Research and Development (MSRD) Program -- These investigations were conducted by Sergent, Hauskins & Beckwith in 1981. They consisted of drilling 62 shallow borings in the tailings found on the edge of the pit and in the windblown contaminated area to determine the volume and radioactivity of the materials to be stabilized under the UMTRA Project.

2. Jacobs Engineering Group, Inc., the Technical Assistance Contractor (TAC) for DOE -- This investigation, conducted in 1987, consisted of digging 20 test pits to determine the extent and volume of tailings and contaminated materials present on the eastern edge of the pit and at the bottom of the Spook pit, the proposed disposal site. Bulk samples of soil were obtained to perform the laboratory tests to determine their geotechnical properties.

3. Morrison-Knudsen Engineers, Inc., the Remedial Action Contractor (RAC) for DOE -- This investigation, conducted in 1988, consisted of drilling 37 borings and digging 12 test pits to obtain additional confirmatory data on the site conditions and additional samples of various materials for laboratory tests to determine their geotechnical design parameters.

Information for Bidders, Volume I, (Reference 5) presents information on the geotechnical investigations such as location of borings and test pits, logs of borings and test pits, and laboratory test data on the soil samples obtained from the above investigations.

3.2.3 Site Stratigraphy

The general stratigraphy within the project limits consists of tailings occurring over insitu overburden material which in turn is underlain by bedrock. The tailings at this site are sandy tailings with less than 20 percent passing the No. 200 sieve and can be classified as predominantly silty sands.

The stratigraphy adjoining the eastern rim of the pit consists of tailings underlain by a six- to nine-foot thick layer of sandy clays or clayey sands, which in turn overlies the sandstone bedrock. During the proposed remedial action, the tailings will be removed from this area and placed at the bottom of the pit. This area will be backfilled and graded to the original contours of the general area, under the AML Project. Water was not encountered either in the tailings or in the bedrock, within the depths of investigations.

The stratigraphy at the bottom of the pit, the proposed disposal site, consists of residuals of milling and mining operations of the sandstone ore body occurring as overburden over the sandstone bedrock. This residual overburden soil is a fine to medium sand with some silt and gravel. The depth of this residual soil is highly variable, ranging from five feet to more than 30 feet. In some areas, cobbles to large boulder-sized rocks are mixed with the sands. The elevation of the sandstone bedrock surface within the Spook pit is irregular and varies more than 25 feet, due to the manner in which the pit was mined. The top of the bedrock varies from elevation 5025 feet to 5000 feet, the lowest point being at the northern end of the pit. The groundwater was encountered at an estimated elevation of 5005 feet, which is generally in the bedrock throughout most of the mine pit. This is approximately 15 feet below the proposed bottom elevation of the stabilized tailings pile. Section 5 of this report presents the groundwater conditions at the site. Figure 3.7 of the final RAP (Reference 2), presents the generalized stratigraphy and cross section of the Spook pit disposal site.

The low-permeability material proposed for the radon/infiltration barrier over the tailings pile is clayey silt or silty clay from the overburden pile No. 700. This overburden pile also contains sandy material, and the stratigraphy is not simple and uniform. Therefore, the low-permeability material to be used

as the radon barrier will be selectively removed from this pile, as DOE has indicated.

NRC staff has reviewed the logs of the borings and test pits, as well as the scope of the geotechnical exploration program. The staff concludes that the execution of the geotechnical investigations, as documented on these logs, are in keeping with accepted standards in the geotechnical engineering profession. Further, the scope of the investigations, including the number of borings and test pits, conducted at the Spook mill site is adequate to establish the stratigraphy and soil conditions as required to assess the geotechnical design aspects of the proposed stabilization of the tailings and contaminated materials in the Spook pit. The geotechnical explorations, conducted in connection with the characterization of the site, are in accordance with the applicable provisions of Chapter 2 of the SRP (Reference 1).

3.2.4 Testing Program

NRC staff reviewed the geotechnical engineering testing program for the Spook site. The testing program included physical properties tests, compaction tests, triaxial shear strength tests, and permeability tests on samples of tailings, other contaminated materials, and material intended for the radon/infiltration barrier. The staff finds that the tests were conducted in accordance with the American Society for Testing Materials (ASTM) test procedures and that the design parameters were established using procedures acceptable in the geotechnical engineering profession. The staff finds that the testing program employed to define the material properties was appropriate for supporting the engineering analyses described in the following sections. Furthermore, the scope of the testing program and utilization of the resulting data to define the material properties are consistent with the applicable provisions of the SRP (Reference 1).

3.3 Geotechnical Engineering Evaluation

3.3.1 Stability Evaluation

The remedial action involves the following activities:

1. Preparing the subgrade at the bottom of the pit by removing and replacing unsuitable or low-density material not readily capable of in-place compaction, and proof rolling the subgrade to ensure a minimum density of 90 percent standard proctor density (ASTM D698). The groundwater table will be a minimum of 15 feet below the bottom of this foundation; therefore, the tailings and the backfill material will be in an unsaturated condition.

2. Placing a 3-foot thick leachate reduction layer of sandy material, compacted to a minimum density of 90 percent standard proctor density.

3. Placing tailings and other contaminated materials in the proposed disposal cell area at a minimum density of 90 percent standard proctor density. The AML Program operation to backfill the pit will be carried out by the same subcontractor, so that the placement of the tailings, low-permeability cover over the tailings disposal cell, and backfill will be carried out concurrently (see Section 3.4.1 for discussion on concurrent construction). The backfill will result in an average overburden thickness of 56 feet above the topslopes of the tailings pile.

This construction sequence (placing the tailings, cover material, and AML Program fill material concurrently in 12-inch lifts) will result in a minimal difference in height between the tailings and adjoining materials during construction (approximately a foot or so); therefore, the stability of the slopes of the tailings pile should not be a problem. NRC staff concludes that the tailings pile slopes will be stable during construction and a more detailed evaluation of the slope stability is not warranted. In the long term, the tailings pile will be buried within the AML Program backfill and, therefore, will not pose any slope stability problem. NRC staff concurs with DOE that both the short-term and long-term stability of the slopes of the buried tailings pile will not be a problem at this site, and does not warrant further evaluation.

3.3.2 Liquefaction

The tailings, contaminated material, and the backfill material will all be placed at a minimum of 90 percent standard proctor density and will be in an unsaturated condition. The groundwater table is at a minimum depth of 15 feet below the bottom of the tailings material. The disposal cell containing the tailings and contaminated material will be covered by the AML Program backfill within the Spook pit. Because of the placement density, unsaturated condition, and physical confinement within the Spook pit, the tailings and contaminated materials will not be susceptible to liquefaction during a seismic event.

NRC staff concludes that the stabilized tailings and contaminated materials will not be susceptible to liquefaction.

3.3.3 Settlement

Long-term settlement of the tailings and backfill materials, which could result in either local depressions on top of the cover or cracks in the cover, is of concern. Depressions in the cover would initiate erosion gully pathways, and severe deep erosion of the cover might result in exposing the tailings material. A crack in the cover might open up a pathway for surface water to infiltrate into or through the tailings material.

Since the tailings and most of the contaminated materials in the disposal cell are sandy materials, a major portion of the settlement will be instantaneous, taking place during construction, and can be compensated for before completion of the construction. Therefore, instantaneous settlement should not have any

deleterious effect on the performance of compacted fills. However, time dependent or delayed settlement may occur due to compression of the low-permeability cover layer and any virgin compression of the sandy material, as a result of a higher overburden pressure than preconsolidation stress. Because of this potential delayed effect, the staff considered DOE's evaluation of the impact of time dependent settlement on the performance of the compacted fill.

DOE estimates that the total settlement may range between 14 to 16 inches, out of which eight inches of instantaneous settlement would take place during construction and only six to eight inches would show up as time dependent or delayed settlement. NRC staff used conservative assumptions and independently evaluated the total settlement to be approximately 20 inches, out off which 12 inches of instantaneous settlement would take place during construction and eight inches would show up as time dependent or delayed settlement. The difference in the settlement values that were calculated by DOE and NRC are within the normally acceptable range for two independent evaluations.

The parameters used in DOE's evaluations were determined by appropriate laboratory tests, and the method of evaluation used is accepted in the geotechnical engineering profession. Because of the large areal extent and engineered placement of the tailings pile and cover, a delayed settlement of approximately six to eight inches would not be expected to result in a crack (caused by differential settlement in the cover), but would likely show up as a gradual depression in the cover. The surface of the cover will be graded to promote quick runoff of the surface water, and therefore, this minor depression would not be expected to significantly affect the surface water runoff pattern and initiate any significant erosion gullies. This aspect is addressed in detail in Section 4 of this TER.

NRC staff concludes that the long-term or delayed settlement of the tailings pile will not result in any adverse effects on the ability of the tailings pile, stabilized under the UMTRA program, to meet the EPA standards.

3.3.4 Cover Design

The proposed cover for the tailings pile is a 1.5 feet thick layer of low-permeability material, selectively taken from one of the overburden piles (pile No. 700). The cover material is a silty clay or clayey silt, which when compacted to a density of 95 percent standard proctor (ASTM D698) is expected to have a saturated hydraulic conductivity of 10E-6 cm/sec. DOE has performed laboratory tests on representative samples to demonstrate the achievability of the hydraulic conductivity assumed in the design.

In addition to the low-permeability material cover, the AML Program will backfill the pit, placing overburden material on top of the tailings disposal cell. The average thickness of the AML Program material on top of the tailings disposal cell will be approximately 56 feet. The AML Program design calls for placing an approximately 10-foot-thick layer of relatively more permeable

material immediately above the low-permeability cover on top of the tailings disposal cell. This is intended to promote a quick drainage of any infiltration, away from and down the slope of the cover. The AML Program design also calls for placing a 10-foot-thick layer of relatively clean material (with respect to the level of radioactive contamination) at the very top of the AML Program backfill. This cover is designed to limit the release of Radon-222 to the atmosphere from the residual radioactive materials to within the EPA standards. The evaluation of the radon attenuation aspects of the cover is addressed in Section 6.2, and the evaluation of the infiltration barrier aspects of the cover is addressed in Section 5 of this TER.

3.4 Geotechnical Construction Criteria

3.4.1 Constructing the Low-Permeability Layer

The low-permeability cover layer will be 1.5 feet thick and will be placed on the tailings disposal cell as shown in Figure 2.2. The disposal cell will be surrounded by and buried in the AML Program backfill. The contract documents state that both the UMTRA Project and AML Program work will be constructed by a single subcontractor. The compaction requirement for the cover is 95 percent standard proctor, whereas the requirements for the tailings and AML Program backfill are 90 percent standard proctor. Placing a thin layer (cover layer) between two different materials and maintaining a 50 percent slope for the thin layer will require special care during construction. The planned construction sequence as DOE has shown on Drawing SPK-PS-10-0109 (Reference 4), is acceptable to the staff, as a means for assuring the required minimum thickness of the low-permeability cover layer.

3.4.2 Placement of AML Backfill Above the Tailings Disposal Cell

The backfill above the tailings disposal cell will be placed under the AML Program by the same subcontractor working on the UMTRA Project portion of the work. In addition to assuring that the UMTRA portion of the project complies with the EPA standards, DOE must also assure that the AML material placed above the tailings disposal cell will not adversely affect the ability of the disposal cell to meet the EPA standards.

In response to a question on this item posed by NRC staff (Question No. 26; Reference 7), DOE has agreed to ensure that the backfill would be placed according to specifications that are similar to that of DOE's. The specifications as presented in the Division 2-Sitework-AML section of Reference 4, regarding the placement requirements and testing frequencies for backfill material appear to be adequate and consistent with the UMTRA specifications.

3.5 Conclusions

Based on review of the design for the Spook site project as presented in the remedial action plan documents (References 2, 4, 5 and 6), NRC staff concludes

that the geotechnical engineering aspects of site characterization and design are consistent with the applicable provisions of the SRP, and that the design should result in the stabilized disposal cell complying with the geotechnical aspects of the long-term stability requirements of the EPA standard (40 CFR Part 192.02(a)).

4.0 SURFACE WATER HYDROLOGY AND EROSION PROTECTION

4.1 Introduction

This section presents NRC staff's review of the surface water hydrology and erosion protection aspects of the proposed remedial actions for the Spook, Wyoming UMTRA Project site. These aspects of the review were minimal, due to the unique below grade design proposed for stabilization of the residual radioactive material at this site. Any below grade design, where the tailings are stabilized well below the natural ground surface, would generally result in a configuration extremely stable with respect to erosion potential.

4.2 Hydrologic Description and Site Conceptual Design

The site is located near the head of an unnamed drainage channel which drains to the Dry Fork of the Cheyenne River. Surface runoff in the immediate vicinity of the pit is either intercepted by the pit itself or by several adjacent ephemeral stream channels. The channels of three such streams are blocked by stockpiled materials, and one of the streams flowed through the northeast portion of the pit area before it was disturbed by mining. The land surface adjacent to the Spook pit is moderately sloped.

In order to stabilize the tailings in accordance with EPA standards, all of the contaminated materials will be placed in a single pile in the south end of the Spook pit. The pile will then be covered with backfill material in accordance with the AML Program, which provides an average of 56 feet of overburden material directly over the tailings in the pit. The channel of the ephemeral stream in the northeast area of the pit will be restored to flow directly over the backfilled material in the northeast portion of the pit. This channel will be located a sufficient distance away from the tailings, in the southern end of the pit, so that any erosion in the channel should have no effect on the stability of the tailings pile.

4.3 Flooding and Water Surface Profiles

In order to determine site impacts from flooding, the State evaluated peak flows and velocities, including the need for erosion protection designs. Since the design events were developed in accordance with the AML Program, they do not necessarily conform to previously-approved criteria at other UMTRA Program sites. However, for reasons explained below, stability with respect to erosion should be assured due to the placement of the tailings in a pit with 56 feet of overburden placed over the tailings; it is not dependent on the use of other specific erosion protection designs.

Flooding estimates, based on a frequency of occurrence of the design rainfall of once in 1000 years, were used by the State to design various erosion protection features at the site. Based on review of the rainfall estimates, infiltration losses, times of concentration, rainfall distributions, and flood

computations, the staff concludes that the resulting flood estimates may not be reasonable estimates of the 1000-year flood event. The rainfall estimate was developed by extrapolation of limited rainfall data, a technique that the staff concludes is not generally appropriate for estimation of such rare events. However, for the purposes of this tailings configuration (which is below grade), the magnitude of the rainfall or flood event should not affect the stability of the tailings.

NRC staff emphasizes that there are no credible flood events or series of flood events at this site which could affect the physical stability of the tailings in a 1000-year period. First, the tailings will be stabilized below grade in the Spook pit and covered with an average of 56 feet of overburden. As indicated in the staff's review of geomorphic stability (see Section 2.4.1 of this TER), it is not reasonable for 56 feet of erosion to occur in 1000 years or less. Second, even if erosion were to occur directly over the tailings, the tailings would continue to remain in the pit, due to the physical configuration of the pit. Under such conditions where erosion of the overburden material occurs, it is likely that the eroded area would eventually become a depositional area (low point).

With the above factors in mind, NRC staff did not perform a detailed review of the design as relates to erosion protection. Even if proper consideration has not been given by DOE to expected flood events and erosional processes in a 1000-year period, the stability of the tailings is assured by their location in the pit. Some erosion at the ground surface is to be expected and could even occur directly over the tailings or in adjacent channel and watercourses. However, such erosion will be minimal and should not extend to a depth of 56 feet.

4.4 Conclusions

Based on review of the information submitted by DOE, NRC staff concludes that the site design will meet EPA requirements as stated in 40 CFR Part 192 with respect to long term erosion protection and stability. An adequate design has been provided to reasonably assure stability of the tailings at Spook for a period of up to 1000 years.

5.0 WATER RESOURCES PROTECTION

5.1 Introduction

The NRC staff has reviewed the final Remedial Action Plan and Site Conceptual Design (RAP) for the Spook, Wyoming UMTRA site for compliance with EPA's proposed groundwater protection standards in 40 CFR Part 192, Subparts A-C (52 FR 36000). The NRC staff used the NRC Draft Technical Position on Information Needs to Demonstrate Compliance with EPA's Groundwater Protection Standards in 40 CFR Part 192 Subparts A-C (Reference 16) as guidance for the review.

The remedial action plan for the Spook site consists of a joint effort between the DOE and the State of Wyoming AML Program to stabilize all residual radioactive material on site and reclaim the abandoned open pit uranium mine. The DOE portion of the joint remedial action consists of stabilization of approximately 290,000 cubic yards of residual radioactive material in a single pile in the bottom of the pit, and placement of a low-permeability cover over the stabilized pile (see Figure 2.2). The AML Program will backfill the pit with approximately 56 feet (1.6 million cubic yards) of overburden material excavated from the pit during mining, and will recontour the land surface and revegetate the final cover.

DOE has proposed application of supplemental standards under the provisions of 40 CFR Part 192 Subpart C for groundwater protection because the aquifer contains Class III ground water. Based on our review, NRC staff considers that DOE has provided adequate information to demonstrate that supplemental standards are applicable at the Spook site, and that the proposed remedial action complies with the site-specific supplemental standards. We also consider that DOE has adequately justified that the proposed supplemental standards are protective of human health and the environment and demonstrated that the proposed remedial action comes as close to meeting the otherwise applicable standards as is reasonable under the circumstances.

5.2 Hydrogeologic Characterization

5.2.1 Hydrostratigraphy and Groundwater Occurrence

NRC considers that DOE has characterized the hydrogeologic characteristics in the vicinity of the disposal site using acceptable techniques, methods and approaches, and the assessment of hydrogeologic characteristics is adequate to support DOE's performance assessment to demonstrate compliance with the proposed supplemental standards.

Based on DOE's hydrogeologic characterization activities, DOE determined that ground water below the Spook site occurs in two sandstone units within the Tertiary Formation. Ground water is unconfined in the uppermost unit and confined in the lower sandstone unit. The sandstone aquifers are separated by a thick, laterally extensive, silty shale unit. Based on inspection of cores from lithologic logs, results of water quality analysis, and inferred

gradients, the shale unit appears to serve as an aquitard, effectively precluding hydraulic communication between the two sandstone units.

Uppermost Aquifer

Based on lithologic logs from borings and monitor wells, the uppermost aquifer unit consists of fine to coarse-grained sandstone containing silty shale lenses. The average thickness of the uppermost unit is approximately 110 feet. Depths to the water table range from 40 to 120 feet from the land surface, and approximately 20 feet below the excavated pit. DOE observed seasonal fluctuations in ground water elevations of less than one foot in wells measured over a 1.5 year period. The observed saturated thickness of the aquifer is approximately 20 feet in the vicinity of the site.

Based on measured ground water elevations in 27 wells screened in the upper sandstone unit, DOE constructed potentiometric surface maps to determine the direction and rate of flow. Examination of the potentiometric surface indicates that the predominant direction of groundwater flow is to the northeast under an average hydraulic gradient of 0.005. The gradient steepens to the northeast of the site, and a southeast component of flow under a very steep gradient is observed to the south of the site, based on data from two wells.

DOE conducted pump tests in two wells located in the bottom of the pit and east of the pit to determine aquifer properties and evaluate hydrologic boundary conditions. DOE estimated the average hydraulic conductivity to be approximately 15 ft/day. Using Darcy's Law, and assuming an average effective porosity of 0.20 for a porous medium, DOE calculated an average linear groundwater velocity of 0.38 ft/day. This velocity is consistent with the observed migration rate of the contaminant plume emanating from the tailings pile over the past 25 years.

DOE indicates that ground water in the uppermost aquifer is recharged by groundwater underflow, infiltration, and seepage from intermittent streams, and that groundwater discharge occurs as groundwater underflow. DOE indicates that groundwater discharge to the land surface or nearby surface water bodies has not been observed within a two mile radius of the site, which was the extent of DOE's survey. This contention is based on DOE's field observations, and conversations with local ranchers. Although NRC staff visited the Spook site during the dry season in October, 1988, no groundwater discharge was observed at the surface or along stream channels of the Dry Fork of the Cheyenne River. DOE also indicates that projection of the potentiometric surface of the upper sandstone unit would indicate that the elevation of the water table is below the surface elevation of drainages in the site vicinity. NRC staff considers that the lack of evidence of groundwater discharge in the site vicinity supports DOE's contention that there is a low probability that humans or the environment will be exposed to hazardous constituents from the disposal unit.

Middle Shale Unit

DOE has determined that the middle shale unit is composed of well consolidated silty shale and shale, and ranges in thickness from 40 feet in the site vicinity to greater than 150 feet thick in the downgradient direction of the site. DOE indicates that this unit is saturated and functions as an aquitard.

Lower Sandstone Aquifer

Based on lithologic logs, DOE has determined that the lower sandstone unit consists of moderately cemented fine to coarse grained sandstone. Based on borings and hydraulic head measurements from six monitor wells, DOE has characterized the lower sandstone unit as a confined aquifer, occurring in excess of 160 feet below the surface near the site. The potentiometric surface ranges between 60 to 140 feet below the unexcavated land surface. DOE constructed potentiometric maps based on water level measurements from the six wells screened in the lower unit to determine groundwater flow directions and gradients. Examination of the maps reveals a groundwater flow direction predominately to the southeast, under a hydraulic gradient of 0.01.

5.2.2 Geochemical Conditions and Water Use

Uppermost Aquifer

Based on results of water quality analyses from up- and down-gradient wells in the uppermost aquifer, DOE has determined that ambient concentrations of selenium and uranium are highly variable, and tend to increase downgradient of the Spook pit. DOE contends that the observed variability in ambient ground water is due to the presence of a zone of uranium mineralization underlying the Spook site. DOE concludes that downgradient concentrations of uranium and selenium are elevated because ground water has passed through the zone of highest grade ore, and uranium and selenium have become mobilized due to the presence of oxidizing conditions. The observed oxidizing conditions downgradient of the site are likely due to the introduction of water during closely spaced exploration drilling done adjacent to the pit, and mining activities within the Spook pit and Loma pit to the northeast.

A total of six downgradient monitor wells and two upgradient wells were used to examine the variability of ambient water quality. Downgradient background wells were selected using the extent of observed nitrate contamination as a tracer to define the extent of tailings related contamination. Representative background wells located outside the contaminant plume include wells 931, 933, 934, 943, 944, 922 and 939. Downgradient uranium concentrations range from 0.97 to 2.9 mg/l, which is 22 to 66 times the proposed EPA Maximum Concentration Level (MCL) of 0.044 mg/l, and the downgradient selenium concentrations range from 0.05 to 0.83 mg/l, which is from 5 to 83 times the

EPA MCL of 0.01 mg/l. Upgradient ambient uranium concentrations range from 0.11 to 0.15 mg/l, which is 3 times the EPA proposed MCL, and upgradient selenium concentrations range from 0.03 to 0.18 mg/l, or 3 to 18 times the EPA MCL.

Based on an inventory of groundwater use within a two mile radius of the Spook site, groundwater in the uppermost aquifer is not used as a source of drinking water or for any other purpose due to the natural poor water quality.

Middle Shale Unit

Based on a single downgradient well screened 30 feet below the base of the upper sandstone unit, observed background concentrations are below the EPA MCLs for all constituents.

Lower Sandstone Aquifer

DOE selected two upgradient wells to determine background water quality. Analyses of the samples showed that the average background concentrations for all constituents were below the proposed EPA MCLs. In general, water quality is good, with an average Total Disolved Solids (TDS) concentration of 450 mg/l. The lower aquifer does not appear to have been affected by the uranium roll front deposit or by the existing contaminant plume.

Based on the well inventory conducted within a two-mile radius of the site, as many as eleven wells exist in the site vicinity which obtain water from the lower sandstone aquifer or deeper units. The wells are used for both stock watering and domestic purposes. Several of these wells are flowing artesian wells. Based on a conversation between DOE and the Converse County Planning Commissioner, future demand for water supplies are not expected to increase because of the lack of anticipated development (Reference 2).

5.2.3 Extent of Contamination

Based on existing characterization information, the extent of downgradient contamination caused by seepage of leachate is confined to the uppermost aquifer. The contaminant plume extends approximately 4000 feet downgradient and is approximately 2500 feet wide. Elevated concentrations of selenium, uranium, nitrate, chromium, and radium-226/228 have been observed in the plume.

5.2.4 Tailings Characterization

DOE estimated existing source concentrations in tailings materials from a pore water sample and a batch leach test run on a composite tailings solid sample.

Measured source concentrations for hazardous constituents for each method are presented in Table 5.1.

Table 5.1

Constituent	Pore Water Sample Concentrations (mg/l)	Leach Test Results (mg/l)
Uranium	0.36	0.42
Selenium	3.55	6.3
Nitrate	470.0	64.0

Based on NRC staff review, DOE's characterization of the source term is incomplete because it did not attempt to characterize the solid phases of the tailings, or the source concentrations in the tailings for radium-226/228 and chromium, concentrations of which are elevated in the contaminant plume. However, because there is a low probability that humans or the environment would be exposed to contaminated ground water (see Sections 5.4.1.1 and 5.5) NRC staff considers that DOE's characterization of source concentrations in the tailings is adequate.

5.3 Conceptual Design Features For Water Resources Protection

In accordance with draft 40 CFR Part 192.02(a)(3), DOE has specified the features of the disposal unit design needed for groundwater protection, which include: a) placement of a contoured cover to promote sheet flow off the pile; b) revegetating the pile surface to promote evapotranspiration; c) placement of a leachate reduction layer over the pit bottom to enhance retardation of tailings constituents; d) placement of the tailings at zero to three percent dry of optimum conditions and limiting amount of water used for dust control; e) placement of a 1.5-foot clay cap over tailings having a hydraulic conductivity of 1 E-6 to 1 E-7 cm/s (See Figure 2.2 for design modification to accommodate additional contaminated material); f) placement of 56 feet of compacted overburden material over the tailings. DOE has also demonstrated that the design does not rely on active maintenance to assure acceptable performance, as discussed in Section 5.4.2 of the TER, Closure Performance Standard.

5.4 Disposal and Control of Residual Radioactive Material

5.4.1 Groundwater Protection Standard

Under Title I of the Uranium Mill Tailings Radiation Control Act of 1978, as amended, EPA's proposed groundwater protection standards in 40 CFR Part 192 Subparts A and C require that disposal units be designed to control residual radioactive material in conformance with site-specific groundwater protection standards. EPA's proposed standards in Subpart C of 40 CFR Part 192 include provisions for supplemental standards as an exemption from the primary

standards in Subpart A in special cases where compliance with the primary standard is not necessary to protect human health and the environment.

DOE may propose implementation of supplemental standards for groundwater protection if it determines that any of the criteria in 40 CFR Part 192.21 apply. In order to propose supplemental standards, DOE should: 1) demonstrate that supplemental standards are applicable using the criteria in 40 CFR Part 192.21; 2) specify the supplemental standards that it proposes in lieu of the primary standard in Subpart A; 3) demonstrate that the proposed remedial action complies with the proposed supplemental standards; and 4) demonstrate that the proposed remedial action comes as close to meeting the otherwise applicable standard as is reasonable under the circumstances (Reference 16).

5.4.1.1 Applicability of Supplemental Standards

DOE has proposed application of supplemental standards for the Spook, Wyoming UMTRA site in lieu of the primary standard based on the "Class III" applicability criterion in EPA's proposed standards in 40 CFR Part 192.21(g). As defined in the standards, Class III ground water is not a current or potential source of drinking water because of any of three reasons, including widespread, ambient contamination not due to activities involving residual radioactive materials from a designated processing site that cannot be cleaned up using treatment methods reasonably employed in public water supply systems (40 CFR Part 192.11(e)). DOE determined that the upper sandstone of the Wasatch Formation beneath the site contains Class III ground water because of widespread contamination associated with naturally-occurring uranium mineralization and extensive uranium mining activities.

DOE's determination is based on the following:

1) Representative background concentrations of selenium and uranium range spatially from 0.05 to 0.83 mg/l and 0.97 to 2.90 mg/l, respectively. These background levels exceed their respective MCLs by as much as 5 to 83 times and 22 to 66 times, respectively.

2) The elevated levels of selenium and uranium were caused by natural water-rock interactions and mining activities, rather than activities involving residual radioactive materials at the Spook site. The elevated concentrations exist upgradient from the Spook site and in other areas of the uppermost aquifer that have not been impacted by seepage from the Spook uranium tailings.

3) Background concentrations of selenium and uranium in groundwater in the upper sandstone of the Wasatch Formation cannot be cleaned up using treatment methods reasonably employed in public water-supply systems.

4) Ground water in the uppermost aquifer satisfies the Class VI definition in the Wyoming State Groundwater Quality Regulations (Reference 17) based on the elevated concentration of selenium.

NRC staff independently verified the Class III groundwater designation using the EPA classification methodology in Reference 18 and the proposed definition in 40 CFR Part 192. The staff determined that the upper sandstone unit of the Wasatch Formation contains Class IIIB ground water based on the following conclusions:

1) Background concentrations of selenium and uranium in ground water in the uppermost aquifer exceed EPA's MCL for selenium in 40 CFR Part 141 and proposed concentration limit for uranium in 40 CFR Part 192. Treatment of the ground water would be necessary prior to distribution to public consumers.

2) Ground water in the uppermost aquifer cannot be cleaned up using treatment methods reasonably employed in public water-supply systems. Treatment methods such as desalination, ozonation, ion exchange, and chemical precipitation and filtration are used to some extent in EPA's Region VIII, which includes Wyoming (Reference 18). However, use of these treatment methods in public water supply systems near the Spook site would not be economically viable because it would cost consumers more than the $300/household/year ($1986) economic viability threshold estimated by EPA in Reference 18.

3) The uppermost aquifer is bounded below by a Type 2 boundary beneath because it is underlain by a laterally-extensive, low-permeability, thick, silty shale unit. The hydraulic gradient across this confining unit is directed upwards towards the uppermost aquifer. In addition, the aquifer does not discharge to surface water within the 2-mile classification review area around the Spook site. Therefore, the uppermost aquifer has a low degree of interconnection with adjacent ground water and surface water units.

4) Elevated background concentrations of selenium and uranium have been caused by natural leaching of mineralized deposits in the aquifer and by induced leaching caused by mining exploration and excavation, rather than activities involving the residual radioactive materials at the Spook site.

Therefore, the NRC staff concludes that DOE is eligible to apply for supplemental standards in lieu of the primary standards in Subpart A of 40 CFR Part 192 because the upper sandstone of the Wasatch Formation at the Spook, Wyoming, UMTRA site contains Class IIIB ground water.

5.4.1.2 Proposed Supplemental Standards

In lieu of the otherwise applicable standards for the Spook site, DOE indicates that for the proposed supplemental standards, the remedial action will ensure that concentrations of hazardous constituents released downgradient from the disposal facility will not exceed concentrations which would adversely affect human health or the environment.

NRC staff considers DOE's proposed supplemental standards for the Spook site to be acceptable and adequate to protect public health and the environment.

5.4.1.3 Compliance Demonstration

In accordance with 40 CFR Part 192 Subparts A and C, DOE is required to demonstrate that the overall performance of the proposed disposal unit and disposal unit design is adequate to comply with the site-specific groundwater protection standard discussed in Section 5.4.1.2, above. The demonstration should consist of an integrated analysis of the performance of the natural and engineered features of the disposal site, and include the following components: 1) an assessment of the hydrogeologic characteristics of the disposal site sufficient to support analysis of the disposal unit designs and disposal performance (Section 5.2); 2) a design analysis of the disposal unit (Section 5.3); and 3) a performance assessment of the disposal unit (Reference 17).

Performance Assessment

In support of demonstrating that the proposed remedial action complies with the proposed site-specific supplemental standards, DOE estimated concentrations of hazardous constituents in ground water for various rates of infiltration through the low-permeability layer above the tailings. The MOC groundwater transport model developed by Konikow and Bredehoeft was used to estimate the effects of dilution and dispersion on source concentrations leaching from the stabilized pile at various rates of infiltration ranging from 1 E-8 cm/s to 6 E-8 cm/s.

Regional values of infiltration estimated from climatological data and water budget studies are on the order of 6 E-8 cm/s. Based on the regional estimate of infiltration, and the contoured cover designed to enhance surface runoff, DOE assumed a site-specific infiltration rate of 3 E-8 cm/s to be realistic in its performance analysis, and a value of 6 E-8 cm/s to be a worst-case situation. Assuming these values are representative of site-specific conditions at the Spook design, seepage from the stabilized tailings would not significantly increase concentrations of uranium and selenium above observed background levels. The predicted concentration for nitrate for the lower rate is below the MCL of 44 mg/l at the base of the pile, and below the MCL at an arbitrary distance of 4000 feet downgradient of the pile for the higher rate of 6 E-8 cm/s. These results indicate that concentrations contributed from the disposal cell comply with the proposed supplemental standard.

However, NRC staff considers that DOE has not provided adequate justification for use of regional estimates (6 E-8 cm/s) and even lower values (3 E-8 cm/s) of infiltration in its analysis because the disposal cell represents a disturbed environment relative to regional conditions. NRC staff considers that a worst-case value for infiltration would be on the order of 1 E-6 cm/s, which is the higher value of saturated hydraulic conductivity of the clay cover over the tailings under a unit gradient, rather than the regional recharge

value of 6 E-8 cm/s. Because DOE's estimates of infiltration are not supported by site specific data or a quantitative analysis, a justifiably conservative value to assume for infiltration would be more on the order of 1 E-7 cm/s.

While NRC staff considers that DOE did not use defensible infiltration values to demonstrate compliance with the proposed supplemental standards, results of independent staff calculations based on an infiltration rate of 1 E-7 cm/s indicate that predicted concentrations of selenium and uranium are still within the range of observed background values, and concentrations for nitrate are less than 2.5 times the MCL at the pile base. Because the probability of exposure of contaminated water to humans or the environment is low, these concentrations are acceptable and protective of human health and the environment. Thus NRC staff considers that DOE's proposed remedial action for groundwater protection complies with the proposed supplemental standards.

5.4.2 Closure Performance Standard

In accordance with the closure performance standard of 40 CFR Part 192.02(a)(4), DOE is required to demonstrate that the proposed disposal design: 1) minimizes the need for further maintenance as required in 40 CFR Part 264.111(a); and 2) controls, minimizes, or eliminates releases of hazardous constituents to ground water as required in 40 CFR Part 264.111(b).

Relative to 40 CFR Part 264.111(a), DOE has adequately demonstrated compliance with the long term stability standards in 40 CFR Part 192.02(a), as described in Sections 2.0, 3.0, and 4.0 of this draft TER. Further, DOE has demonstrated that the design features needed to comply with the site-specific groundwater protection standard do not rely on active maintenance to ensure satisfactory performance. The barriers are composed of earthern materials that are likely. to remain stable and maintain their integrity during the 1000 year design life (see Section 4). In addition, if an increase in available infiltration occurs, the potential increase in seepage from the disposal unit would not adversely affect human health or the environment because the probability of human or environmental exposure to ground water is low. NRC considers that DOE has demonstrated that the need for further maintenance of the disposal site has been minimized.

Relative to 40 CFR Part 264.111(b), DOE has adequately demonstrated compliance with the proposed supplemental standards (Section 5.4.1.3). Thus, DOE has demonstrated that the proposed design controls and minimizes release of hazardous constituents to groundwater to the extent necessary to protect human health and the environment.

5.4.3 Groundwater Monitoring and Corrective Action

DOE is required to describe an integrated monitoring program to be conducted before, during, and after completion of the disposal action to demonstrate that the initial disposal performance complies with the groundwater protection and closure performance standards under 40 CFR Parts 192.02(a)(3) and (4).

NRC staff considers that DOE has adequately fulfilled the preoperational monitoring requirements of the proposed EPA groundwater protection standards. However, DOE has proposed not to monitor the performance of the disposal unit at the Spook site due to unique site and situation specific characteristics. DOE contends that monitoring the ground water would be pointless because of the the low probability of human and environmental exposure to contaminated ground water, and because contaminant leachate concentrations approximate background concentrations. NRC staff finds that DOE's proposal to not monitor ground water at the Spook site is acceptable given the unique site conditions.

Because of the low probability of exposure, credible failure scenarios of the disposal unit have little significance with respect to protection of human health and the environment. Therefore, NRC considers no corrective actions need to be planned at this time. However, if conditions at the site change significantly such that exposure becomes significantly more likely, then monitoring and corrective actions may be needed. The need for such action will be evaluated from time to time under the NRC custodial license.

5.5 Demonstration of "As Close as is Reasonable"

DOE has proposed supplemental standards in lieu of the primary groundwater protection standard in Subpart A in 40 CFR 192.02(a)(3). Based on information provided in the final RAP and a telephone conversation between L. Deering, NRC, and R. Heidenberg, DOE/TAC on January 4, 1989, DOE has indicated that the otherwise applicable standard would be the site-specific groundwater protection standard in 40 CFR 192.02(a)(3), which would identify uranium, selenium, and nitrate as hazardous constituents. The concentration limits would be downgradient background concentration limits for uranium and selenium, and an MCL for nitrate. Appropriate background concentrations would be selected from the range of observed downgradient background concentrations for uranium and selenium, which range from 0.97 to 2.9 mg/l, 0.05 to 0.83 mg/l, respectively. The proposed point of compliance would be the downgradient edge of the disposal cell.

NRC staff considers that for the otherwise applicable standards, DOE should include as hazardous constituents the fifteen constituents that were detected in seventeen tailings ponds sampled by the NRC URFO staff, which are listed in Table 5.2. These constituents are reasonably expected to be in the tailings and are listed in Appendix VIII of 40 CFR Part 264.

Table 5.2

Arsenic	Cadmium	Fluoride	Molybdenum	Selenium
Barium	Chromium	Lead	Nickel	Thorium
Beryllium	Cyanide	Mercury	Radium	Uranium

DOE indicates that the proposed remedial action at the site comes reasonably close to meeting the otherwise applicable standard because:

1) Predicted concentrations of hazardous constituents approximate observed background concentrations for uranium and selenium, and are less than 2.5 times higher than the nitrate MCL at the base of the pile. The predicted nitrate concentration is justifiably higher than the MCL considering that a) predicted nitrate concentrations are conservative, b) the ambient water quality is unfit for use, and 3) the probability of exposure is very low because there are no known discharge locations in the site vicinity.

2) Alternative supplies of good quality water are readily available from deeper aquifers.

3) Irrigation of crops as a potential exposure pathway is not likely because the land surrounding the Spook site vicinity is used for range land.

4) Considering that the probability of exposure of contaminated groundwater to humans or the environment is low, DOE's low-permeability cover placed over the tailings is a conservative design feature to ensure that concentrations are as low as is achievable under the circumstances.

5) Nitrate concentrations in groundwater could be reduced further by employing more costly, alternative designs, such as the use of a CLAYMAX cover over the tailings; however, considering the low probability of exposure to contaminated groundwater, alternative designs such as a CLAYMAX cover would increase project costs without contributing any significant additional benefits.

Based on the information provided by DOE, NRC staff considers that DOE has adequately demonstrated that the proposed design comes as close to meeting the otherwise applicable standard under the circumstances.

5.6 Groundwater Protection Aspects of Design Modification

As a result of discovery of an additional 50,000 cubic yards of contaminated material, DOE proposed a modification to the cell design. Placement of the additional material was limited by the need to remain within the existing cell footprint and the need to accommodate geomorphic considerations by not increasing the pile's elevation. The proposed modification consisted of placement of the additional material on the east and west sides of the pile and extending the low-permeability cover across the top of the material to 20 feet beyond the cell footprint (see Figure 2.2 and Section 3.1).

A review of this modification as it relates to groundwater protection yields the same conclusion as detailed in Section 5.5 above, i.e., that the proposed design comes as close to meeting the otherwise applicable standard as is reasonable under the circumstances. The low-permeability layer is still to be placed over all the contaminated material. Although there is no

low-permeability material on the vertical east and west sides, the extended 20-feet of cover will direct water beyond the additional contaminated material. Since the AML material adjacent to the contaminated material is as permeable or more permeable than the contaminated material, it is unlikely for 20 feet of lateral flow to take place as the water moves downward through the AML backfill. In addition, the points discussed in Section 5.5 (ambient water quality, potential for exposure, etc.) remain applicable.

5.7 Cleanup and Control of Existing Contamination

DOE is required to demonstrate compliance with proposed EPA standards in 40 CFR Part 192, Subparts B and C for cleanup and control of existing contamination. DOE's cleanup evaluation should consist of a 1) groundwater cleanup standard, 2) cleanup demonstration, and 3) cleanup monitoring program (Reference 16). NRC may allow deferral of cleanup if DOE demonstrates that the disposal may proceed independently of cleanup.

DOE has not addressed in the RAP how groundwater cleanup will comply with EPA requirements in Subparts B and C of 40 CFR Part 192 because the present level of site characterization is not sufficient to address groundwater cleanup. DOE indicates that aquifer restoration will be addressed under the next task of the UMTRA Project as part of a separate National Environmental Policy Act (NEPA) process because of additional characterization needs.

DOE indicates in the RAP that construction of the proposed disposal unit will not preclude or preempt future evaluation and implementation of groundwater cleanup or control activities because of the limited size of the pile footprint. If necessary, perimeter drilling for restoration could be done in a manner that will result in a radius of influence exceeding the pile's radius, thereby allowing pumping of the aquifer under the pile, without causing significant disturbance of the pile.

NRC staff concludes that DOE's deferral of groundwater cleanup is acceptable until after EPA promulgates final groundwater protection standards. This finding is based on the fact that the existing contaminant plume is slow moving; there is a low probability of exposure to existing contaminated water because the water in the affected aquifer is not used for any purpose, there are no known nearby groundwater discharge locations, and the area is sparsely populated; exposure to contaminated water would present a chronic rather than an acute hazard; and DOE and the state of Wyoming could implement temporary institutional controls of the affected portion of the aquifer.

However, DOE's deferral of corrective action for existing contamination leaves this as an open issue.

5.8 Conclusions

In conclusion, DOE has proposed application of supplemental standards under the provisions of 40 CFR Part 192 Subpart C for groundwater protection because the

aquifer contains Class III groundwater. Based on our review, NRC staff concludes that DOE has provided adequate information to demonstrate that supplemental standards are applicable at the Spook site, and that the proposed remedial action complies with the site-specific supplemental standards. The staff also concludes that DOE has adequately justified that the proposed supplemental standards are protective of human health and the environment, and demonstrated that the proposed remedial action comes as close to meeting the otherwise applicable standard as is reasonable under the circumstances. The deferral of groundwater cleanup is acceptable to the staff, but will remain an open issue.

6.0 RADON ATTENUATION AND SOIL CLEANUP

6.1 Introduction

This section of the TER documents the staff evaluation of the radon attenuation design and the radiation survey plan for the planned remedial actions at the Spook, Wyoming UMTRAP site. The results of this review consist primarily of evaluations of the material characterization, radon barrier design, and soil cleanup aspects of the proposed remedial action, to assure compliance with the applicable EPA standards.

6.2 Radon Attenuation

The staff's review of the cover design for radon attenuation included evaluation of the pertinent design parameters for both the tailings and the radon barrier soils, and the calculations of the required radon barrier (earth cover) thickness (References 2, 5, 6, and 19).

The design parameters of the tailings and earth materials that were evaluated for acceptability included: long-term moisture content, material layer thickness, bulk density, specific gravity, porosity, and radon diffusion coefficient. In addition, radium content and radon emanation coefficient parameters were evaluated for the tailings materials only. These parameters were used in calculating the radon barrier thickness using the RAECOM computer code.

6.2.1 Evaluation of Parameters

To meet the EPA standards for limiting release of Radon-222 from residual radioactive materials to the atmosphere, the disposal cell containing tailings and contaminated materials will be covered with an earthen material (radon barrier). The radon barrier reduces the effluence of Ra-222 by reducing the diffusion rate to acceptable quantities, as per the EPA standards. The required thickness of the barrier depends on the properties of the barrier and tailings. At the Spook site the radon barrier consists of a 1.5-foot thick low-permeability material layer covering the disposal cell and an average of 56-foot thick overburden material placed above it. The low-permeability layer will be placed by DOE under the UMTRA Project, whereas the overburden material will be placed by the State of Wyoming under the AML Program; both the materials will be placed by a single subcontractor. NRC staff reviewed both the physical and radiological parameters of the tailings and radon barrier materials, used as input for the RAECOM code for their representativeness and validity.

The design assumes a long-term moisture content of 7.6 percent for the AML overburden material, 10.9 percent for low-permeability material, 11.4 percent for windblown material, 4.9 percent for contaminated material (mill yard, acid pond, and ore pile), and 6.3 percent for tailings. These values were selected considering the optimum moisture content, as determined in ASTM D698 test;

15-bar capillary moisture content, as determined in laboratory tests on representative samples; and moisture content as determined by an empirical method. Generally, the long-term moisture content value selected was the lowest of those obtained using the above three methods. This is a conservative approach. The selection of the long-term moisture content was performed in accordance with the guidance provided in the SRP (Reference 1) and is thus acceptable to staff.

The material thicknesses (layers) used in DOE's analyses are based on the volume of the tailings and other contaminated materials to be placed in the disposal cell, the configuration of the disposal cell, and the final ground surface contours of the Spook pit as reclaimed in the AML Program. These volumes were determined based on data obtained from field investigations (geotechnical, radiological and survey) and appear to be reasonable estimations of the volumes of the materials to be handled. There is no specific requirement for any selective placement of highly contaminated material at the bottom of the disposal cell because it will be buried in the pit under about 57.5 feet of earthen material, and the design is conservative. The design calculations use an average thickness of 56 feet for the AML Program cover material, 1.5 feet for low-permeability material cover, 18 feet for windblown material, six feet for other contaminated material, and 24 feet for tailings material. The material thicknesses used by DOE in their analyses are a reasonable representation of the expected field conditions.

Material properties such as bulk density and specific gravity were determined by field and laboratory tests, and the corresponding porosity was calculated. The average dry bulk density and porosity were 1.68 gm/cc and 0.360 for the AML Program overburden material, 1.684 gm/cc and 0.329 for low-permeability material, 1.627 gm/cc and 0.319 for windblown material, 1.675 gm/cc and 0.376 for contaminated materials, and 1.691 gm/cc and 0.370 for tailings. NRC staff has reviewed the geotechnical data and concludes that the above values of the parameters are a reasonable representation of the average conditions that should be used in the design computations.

Radon diffusion coefficients for the cover materials and tailings were derived from a correlation curve of moisture saturation versus radon diffusion coefficients for the estimated long-term moisture content of the materials. This curve was based on diffusion coefficient and moisture saturation data from laboratory measurements on samples of soil and tailings that are representative of the conditions in the disposal cell and Spook pit. The average values of the diffusion coefficient parameter used in the design were 0.0325 sq.cm/sec for AML Program cover material, 0.016 sq.cm /sec for low-permeability cover material, 0.004 sq.cm/sec for windblown material, 0.029 sq.cm/sec for contaminated materials, and 0.0285 sq.cm/sec for tailings material. NRC staff has reviewed the information used in determining the diffusion coefficient values for these materials and judges them to be reasonable.

The radium content (Ra-226) of several materials at the site were measured (References 5 and 6). The average radium content to be used in the analysis

was determined by weighted averaging with depth in a measurement hole and then averaging over an area at any given depth. The weighted average value of the radium content was 39 pCi/g for windblown material, 243 pCi/g for contaminated material, and 408 pCi/g for tailings material. These are average values for large volumes of materials, and the staff considers them to be reasonable and acceptable.

DOE's General Counsel has determined that the overburden material to be placed in the pit does not constitute "residual radioactive materials," as defined in UMTRCA (Reference 19). NRC's legal counsel has concurred with this finding and therefore, the radioactive contamination or radium content of the AML Program overburden materials was not considered in calculating the radon effluence from the disposal cell, using the RAECOM code.

The radon emanation coefficients were measured in the laboratory on samples representative of field conditions. Emanating coefficients of 0.6 for the windblown material and 0.32 for the contaminated and tailings materials were used in the design calculations. Based on the values of this parameter determined for similar materials at other UMTRAP sites, staff considers these values to be reasonable and acceptable.

The ambient air radon concentration was measured to be 1.1 pCi/liter. The locations of these measurements were away from the tailings and are expected to reflect the background conditions for the area. The technique used to measure this parameter has been previously approved by NRC. This is one of the input parameters for the RAECOM modeling calculation. The value of the measured ambient air radon concentration is reasonable and acceptable to NRC staff.

6.2.2 Evaluation of Radon Barrier

For a given assumed thickness of the radon barrier, the RAECOM code calculates the radon gas release rate. DOE used a radon barrier consisting of a 1.5-foot-thick low-permeability cover layer and 56-foot-thick AML Program overburden layer in their calculation and determined a radon effluence rate of 0.0059 picocurie per square meter per second potentially emitted from the top of the AML Program fill. The EPA standard requires that the release rate of radon-222 from the residual radioactive materials to the atmosphere not exceed an average release rate of 20 picocuries per square meter per second. The calculated radon release rate is a small fraction of that permitted in the EPA standards. DOE has performed parametric calculations to demonstrate that even under the most conservative and worst combination of critical parameters, the radon release rate is significantly less than that required under the EPA standards. The reason for this is the 56-foot thick overburden material cover, placed over the disposal cell, under the AML Program.

The determination of various parameters needed for the radon barrier design, and the method of analysis is in accordance with the guidelines in the SRP (Reference 1). NRC staff concurs with DOE that the radon release rate at the

top of the reclaimed Spook pit, within which the residual radioactive materials will be buried, will be well below the limits allowed under the EPA standards.

6.3 Site Cleanup

Site characterization surveys have been conducted at the site to identify the subsurface boundary of the tailings pile, as well as the depth and area of the mill yard, ore storage, and windblown contaminated areas. The results of these site characterization surveys are used to plan the control monitoring for excavation of the residual radioactive material that DOE is responsible for stabilizing. At most UMTRAP sites, residual radioactive material is easily distinguishable by its radioactivity, and the cleanup standard is based on radioactivity. At the Spook site, however, there is a great deal of material that is radioactive but is not residual radioactive material as defined in UMTRCA. This material is primarily ore that wasn't processed and will be cleaned up under the AML program. To delineate the boundary of the areas and depths subject to cleanup under the UMTRA Project from those that the AML Program is responsible for, DOE proposed a criterion based on radium to uranium ratios. When this ratio is used, ratios greater than or equal to 3.0 Ra-226 to U-238 equivalent (in pCi/g per pCi/g) will be considered tailings material. The staff concludes that the radiological characterization procedures used at the Spook site are appropriate and acceptable.

DOE has used this ratio method to determine that the windblown contamination in the area of the former Loma pits consists of a thin layer of contamination over variable layers of ore-related material not covered by the UMTRA Project (Reference 11). In this area, the proposed remedial action is to excavate to a six-inch depth, since the characterization indicates this will remove all windblown material. No verification measurements are planned, since the ore-related activity will not be distinguishable using Ra-226 measurement techniques. The NRC staff agrees that the conditions at the Spook site make this proposed remedial action acceptable in this area.

The Spook pit also has scattered tailings on the floor of the pit (see RAP page revisions, Reference 11). The remedial action will be to remove all of the visually identifiable tailings material with no verification measurements since the floor of the pit contains a significant amount of ore which has not been designated under the UMTRA Project. The tailings are visually different than the ore materials. This remedial action is considered acceptable to the NRC staff given the circumstances at the Spook site.

DOE has identified several circumstances at the Spook site which warrant the use of supplemental standards in addition to the land cleanup standards in 40 CFR 192.12 (see RAP page revisions, Reference 11). These situations are:

a. A supplemental standard of 15 pCi/g Ra-226 above background levels will be applied to all UMTRA Project contaminated areas outside of the designated Spook processing site, such as Area C in Figure D.2.1, (Reference 2), whether or not the area will be backfilled. The AML Program work that

will follow the UMTRA Project work in these areas will leave, under different criteria, contamination up to 20 pCi/g. Based on this, the staff concludes that additional expenditure and effort would result in no net positive environmental impact, and thus the use of supplemented standards under 40 CFR 192.21(c) is warranted.

b. A supplemental standard of not performing any cleanup will be applied for the walls of the mine pit, since such cleanup would pose a significant threat of injury to workers.

c. As required in 40 CFR 192.21(f), supplemental standards will be imposed for radiological hazards other than Ra-226 (uranium and Th-230) if they are encountered in significant concentrations after the Ra-226 has been removed to within EPA standards. For uranium contamination, a supplemental standard of 35 pCi/g total uranium will be used. For Th-230 contamination, a supplemental standard of either 15 pCi/g above background projected Ra-226 in 1000 years or a calculated projected radon daughter concentration of 0.02 WL in 1000 years in a hypothetical slab-on-grade house will be applied. These proposed supplemental standards are consistent with those applied and accepted previously at vicinity properties and other processing sites.

The NRC staff finds the above applications of supplemental standards acceptable.

Finally, the NRC staff's review of the procedures identified in the RAP for the final radiological verification survey finds them consistent with the generic procedures (RAC-015) that have been reviewed and approved of by the NRC staff. Therefore, the NRC staff concurs with the site cleanup aspects of the proposed remedial action.

6.4 Conclusions

The staff concludes that the radon barrier proposed for covering the residual radioactive materials at the Spook site will reduce the radon release rate from the surface of the Spook pit to less than that permitted under 40 CFR Part 192.02(b), and therefore, complies with the EPA standards. It is, therefore, acceptable to NRC staff. In addition, the NRC staff concurs with the site cleanup aspects of DOE's proposed remedial action for the Spook site.

7.0 SUMMARY

This Technical Evaluation Report (TER) summarizes NRC staff's review of the proposed remedial action for the inactive uranium mill tailings site at Spook, Wyoming. Based on this review, NRC staff has provided (through execution of RAP signature pages) conditional concurrence on the remedial action plan and site conceptual design. Complete concurrence will be provided when DOE has addressed cleanup of the existing groundwater contamination in accordance with EPA standards.

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