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United States Department of Energy

REMEDIAL ACTION PLAN AND SITE DESIGN FOR STABILIZATION OF THE INACTIVE URANIUM MILL TAILINGS SITES AT SLICK ROCK, COLORADO

**Attachment 4, Water Resources
Protection Strategy**

Draft

July 1993

**Appendix B of the
Cooperative Agreement
No. DE-FC04-81AL16257**

Uranium Mill Tailings Remedial Action Project

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**REMEDIAL ACTION AND SITE DESIGN FOR STABILIZATION
OF THE INACTIVE URANIUM MILL TAILINGS SITES
AT SLICK ROCK, COLORADO**

**ATTACHMENT 4
WATER RESOURCES PROTECTION STRATEGY**

Draft

July 1993

**Prepared for
U.S. Department of Energy
UMTRA Project Office
Albuquerque, New Mexico**

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LIST OF ACRONYMS AND ABBREVIATIONS

<u>Acronym</u>	<u>Definition</u>
ac	acre
cm	centimeter
cm/s	centimeters per second
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet
gpd	gallons per day
ha	hectare
in	inch
km	kilometer
L/s	liters per second
m	meter
m ³	cubic meters
MCL	maximum concentration limit
mg/L	milligrams per liter
mi	mile
NC	North Continent
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
pCi/L	picocuries per liter
POC	point of compliance
RAP	remedial action plan
RRM	residual radioactive material
TAC	Technical Assistance Contractor
UC	Union Carbide
UMTRA	Uranium Mill Tailings Remedial Action
yd ³	cubic yards

1.0 WATER RESOURCES PROTECTION STRATEGY SUMMARY

To achieve compliance with the proposed U.S. Environmental Protection Agency (EPA) groundwater protection standards (Subpart A of 40 CFR 192), the U.S. Department of Energy (DOE) proposes to apply supplemental standards for Class III (limited use) groundwater because of low yield [less than 150 gallons per day (gpd) (7×10^{-3} liters per second (L/s))] in the uppermost aquifer (upper sandstone unit of the Burro Canyon Formation). Groundwater in the uppermost aquifer is not a current or potential source of drinking water because of the aquifer's low yield. As a result, the proposed remedial action will ensure protection of human health and the environment. A summary of the principal features of the water resources protection strategy for the Burro Canyon disposal site follows.

- Uranium tailings and associated contaminated materials at the Union Carbide (UC) and North Continent (NC) mill sites will be consolidated and relocated to the Burro Canyon disposal site. These materials will be placed in a partially belowgrade disposal cell designed to reduce radon emanation, resist degradation, reduce infiltration, and withstand differential settlement.
- The location of the site and the disposal cell foundation optimize favorable hydrogeologic and geochemical conditions of the site, as will the multiple-component cover. The design for the disposal embankment cover consists of the following layers, in descending order from the top: 1) riprap to prevent erosion of the disposal cell by surface water runoff; 2) a sand and gravel bedding layer to prevent displacement of large diameter rock, protect the underlying frost protection layer from erosion, and drain water laterally; 3) a frost protection layer (fine-grained soil with some sand) to protect the radon/infiltration barrier from the effects of freezing and thawing; and 4) a thick sandy clay radon barrier to inhibit radon emanation and infiltration through the underlying contaminated material.
- The proposed groundwater protection compliance strategy applies supplemental standards. Based on aquifer performance (pumping tests), the demonstrated quantity of water available from the uppermost aquifer is less than 150 gpd (7×10^{-3} L/s), and groundwater is classified as Class III (limited use). Class III groundwater refers to groundwater that is not a current or potential source of drinking water.
- Groundwater in lithologic units underlying the upper sandstone unit of the Burro Canyon Formation (uppermost aquifer) is protected from potential site-related contamination by hydrogeologic isolation. Low-permeability mudstone units and steady state upward vertical hydraulic gradients in the lower and middle sandstone units of the Burro Canyon Formation inhibit the downward migration of water.

Demonstration of cleanup and control of existing processing-related groundwater contamination at the UC and NC sites will be addressed under a separate DOE Uranium Mill Tailings Remedial Action (UMTRA) Project, which will include compliance with the National Environmental Policy Act (NEPA). The proposed surface remedial action will not preclude or interfere with active groundwater restoration at the processing site, should it be required, because the tailings will be relocated to a remote disposal site.

2.0 CONCEPTUAL DESIGN CONSIDERATIONS AND FEATURES FOR WATER RESOURCES PROTECTION

2.1 DESIGN CONSIDERATIONS

2.1.1 Climate and infiltration

Climate is an important design consideration. It influences the quantity of water available to percolate through the cover of the disposal cell and through stabilized residual radioactive materials (RRM), and it has a potential effect on the migration of hazardous constituents to groundwater.

The Burro Canyon site has an arid, continental climate with low precipitation and humidity, large temperature variations, and high evaporation (DOE, 1993). Because of the high plateau of the Dolores anticline immediately overlooking the UC, NC, and Burro Canyon sites from the south and east, the climate is typically drier and warmer than the nearby communities of Egnar, Dove Creek, Monticello, and Cortez that lie on this plateau (Shawe *et al.*, 1968).

High-intensity thunderstorms occur in the Slick Rock area. In the past, these storms have resulted in erosion of the tailings piles at the UC and NC sites (DOE, 1993). The average annual precipitation has been 7 to 10 inches (in) [18 to 25 centimeters (cm)] per year. Thunderstorm activity and precipitation are greatest during August and September. The average wind speed in the Slick Rock area is estimated to be 3.4 miles (mi) per hour [5.5 kilometers (km) per hour] (FBDU, 1981).

2.1.2 Surface drainage

The relation of surface topography to disposal cell location and final grading should enhance the ability of the proposed design to divert surface flow around the disposal cell (thereby limiting the quantity of water available for infiltration) by shedding surface flow from the disposal cell.

The average elevation of the Burro Canyon disposal site is 5900 feet (ft) [1800 meters (m)] above mean sea level. The disposal site is located on a small mesa that is completely isolated from runoff from upland drainages. The drainage to the north and east of the site is the Nicholas Wash Basin. The disposal site and basins south of the site drain into Joe Davis Canyon. Runoff in the two shallow drainages located in the center of the site (mesa) drains by sheet flow until reaching the south edge of the mesa, where the flow concentrates into a well-defined gully that incises the rim. Flooding is not considered a hazard at the Burro Canyon disposal site because of its distance from and elevation above the closest stream channel.

2.1.3 Subsurface drainage

The ability of the disposal cell foundation to accept transient drainage of excess moisture from the tailings without adversely impacting groundwater or surface water resources is an important design consideration.

The saturated and unsaturated hydraulic conductivity characteristics of the subsoils beneath the proposed disposal cell have been evaluated; this evaluation is presented in detail in Attachment 3. A cross section of the stratigraphic units underlying the Burro Canyon disposal site is provided in Figure 3.11 of Attachment 3. The foundation material consists of low-permeability carbonaceous shale and mudstone of the lowest unit of the Dakota Sandstone Formation and interbedded mudstones, siltstones, and sandstones of the Burro Canyon Formation. These materials are capable of accepting tailings drainage without creating a perched saturated surface in the foundation soils. The unsaturated zone is approximately 50 ft (15 m) thick below the proposed disposal cell. The average hydraulic conductivity of the Dakota Sandstone foundation is 4.3×10^{-1} ft/day [1.5×10^{-4} centimeters per second (cm/s)], and the average horizontal hydraulic conductivity of the Burro Canyon mudstones is 6.5×10^{-3} ft/day (2.3×10^{-6} cm/s). The average hydraulic conductivity of the uppermost aquifer (upper sandstone unit of the Burro Canyon Formation) is 4.0×10^{-2} ft/day (1.4×10^{-5} cm/s) and is comparable to the overlying mudstone.

2.2 DESIGN FEATURES

This section describes the principal design features of the proposed disposal cell at the Burro Canyon disposal site. The design features will ensure compliance and do not rely on active maintenance to ensure adequate long-term performance. Additional details and specifications of the conceptual design are provided in Attachment 1 of this remedial action plan (RAP).

The disposal cell will hold approximately 620,000 cubic yards (yd^3) [470,000 cubic meters (m^3)] of contaminated material. It will cover an area approximately 610 ft (190 m) wide and 905 ft (276 m) long along the southwest face of the mesa (Figure 2.1). The height of the cell will range from 30 ft (9 m) to 50 ft (15 m) above the existing ground surface. The base of the cell will be excavated to prepare for emplacement of the contaminated materials. An 8-ft (2.4-m) clay liner will be placed on the sideslopes of the excavated cell to act as a seepage barrier. The purpose of the barrier will be to prevent seepage from the cell entering the sandstone stringers in the Dakota Sandstone Formation and then leaving the site or developing surface expressions. The estimated seepage flux through the cover is expected to be less than 10^{-7} cm/s. Some of the excavated materials will be used as fill along the embankment sides and for the upper portion of the cover. The remaining excavated material will remain on the site.

The completed disposal cell will occupy an area of 12 acres (ac) [4.9 hectares (ha)]. A buffer area of 53 ac (21 ha) will bring the total to 65 ac (26 ha)

removed from future use. The DOE will be responsible for scheduled long-term surveillance of the disposal area.

2.2.1 Disposal cell cover components

The disposal cell cover will have a riprap surface layer and additional components below the rock. Figure 2.2 is a diagrammatic cross section through the disposal cell. A more detailed schematic of the cover is shown in Attachment 1, Drawings SRK-DS-10-0335 and SRK-DS-10-0336.

The design for the disposal embankment cover consists of the following layers, descending from the top:

- Erosion protection layer. A layer of riprap [8 to 12 in (20 to 30 cm) thick] will prevent erosion of the disposal cell by surface water runoff.
- Bedding layer. A 6-in (15-cm)-thick sand/gravel bedding layer will prevent displacement of large-diameter rock, protect the underlying frost protection layer from erosion, and drain water laterally.
- Frost protection layer. A 2-ft (0.6-m)-thick frost protection layer, consisting of fine-grained soil with some sand, will protect the radon/infiltration barrier from the effects of frost.
- Radon barrier layer. A 2-ft (0.6-m)-thick sandy clay radon barrier will inhibit radon emanation and water infiltration through the underlying contaminated material.

The material properties and available quantities for the cover materials have been adequately defined in a manner that generally conforms with the applicable provisions of the standard review plan (NRC, 1985). In addition, the performance of the cover system has been evaluated using both state-of-the-art techniques and standard engineering methods. The results show that the cover will remain effective for a time period that complies with the EPA standard for long-term performance (40 CFR Part 192.02).

2.2.2 Transient drainage and control of construction water

Subsurface drainage could potentially result from transient drainage of excess moisture from the tailings. The tailings consist of sand and poorly graded sand with silt. The tailings have a saturated hydraulic conductivity of approximately 140 ft/day (5×10^{-2} cm/s), which is characteristic of a clean, free-draining sand (Freeze and Cherry, 1979). As a result, the tailings will have a low moisture content when they are placed in the disposal cell. Moisture will be added to contaminated materials only for environmental dust control requirements.

FIGURE 2.2
DIAGRAMMATIC CROSS SECTION
OF THE BURRO CANYON DISPOSAL CELL
SLICK ROCK, COLORADO

2.2.3 Subsidence

Because mining may take place beneath the Burro Canyon site in the future, the potential exists for subsidence of the foundation soil of the disposal cell footprint. The potential effect on the stability of the disposal cell due to subsidence was assessed in Technical Assistance Contractor (TAC) Calculation SRK-04-90-03-03-00 (see Appendix to Attachment 2). Based on previous mining practices in the area and conservative assumptions for analysis, future uranium and vanadium mining of the Upper Salt Wash Formation would not adversely affect the long-term stability of the disposal cell at Burro Canyon.

2.2.4 Disposal cell longevity

Natural, stable materials have been proposed for use in construction of the Burro Canyon disposal cell to ensure long-term performance. Materials for the rock erosion protection layer have been selected, based on durability, suitability, and size, that will perform adequately over the design life of the disposal cell. The compacted radon barrier material will be protected from erosion by the overlying cover components.

3.0 DISPOSAL AND CONTROL OF RADIOACTIVE MATERIALS AND NONRADIOACTIVE CONTAMINANTS

The proposed EPA standards in Subparts A and C of 40 CFR 192 require information and assessments to demonstrate that the disposal of RRM complies with groundwater protection and performance standards. The required information and assessments can be categorized as follows: the groundwater protection standard (Section 3.1), a performance assessment (Section 3.4), a closure performance standard (Section 3.5), and a monitoring and corrective action program (Sections 3.6 and 3.7). The purpose of the groundwater protection and performance standards is to establish the minimum acceptable performance of the disposal and control of RRM to prevent or control future releases of hazardous constituents. The performance assessment confirms the adequacy of the disposal cell and provides corrective action that may be necessary if the disposal cell does not perform adequately (NRC, 1989). The following sections detail the four components of the groundwater protection and performance standards noted above.

3.1 GROUNDWATER PROTECTION STANDARD

The Burro Canyon disposal cell is designed to control radioactive materials and nonradioactive contaminants as required by the proposed EPA groundwater protection standards in 40 CFR 192.02(a)(3). The proposed groundwater protection compliance strategy applies supplemental standards for Class III (limited use) groundwater. Protection of human health and the environment will be achieved because the uppermost aquifer has low yield [less than 150 gpd (7×10^{-3} L/s)] as demonstrated in on-site aquifer performance tests. No known potable supply wells exist within the uppermost aquifer in a 2-mi (3-km) radius of the disposal site. The uppermost aquifer is hydrogeologically isolated from underlying saturated units by thick [25- to 75-ft (8- to 23-m)] mudstone units and by significant upward vertical hydraulic gradients. A narrative supplemental standard is provided in Section 3.2.

The groundwater protection standard consists of three components: 1) a list of hazardous constituents, 2) a corresponding list of concentration limits for the constituents, and 3) a point of compliance (POC) (NRC, 1989). The DOE has identified hazardous constituents in the tailings pore fluids measured in lysimeter samples and in shallow alluvial groundwater at the processing sites. For this narrative supplemental standard application, no concentration limits or POCs have been established for the identified potentially hazardous constituents because the uppermost aquifer at the proposed Burro Canyon disposal site meets the insufficient yield criteria of Class III (limited use) groundwater, as defined in 40 CFR 192.11(e) of the EPA proposed groundwater standards. There is no historic or current beneficial use of groundwater in the upper sandstone unit of the Burro Canyon Formation. As a result, defining concentration limits and a POC would not further protect human health and the environment (see Section 3.1.2). A demonstration that the remedial action is as close as reasonable to meeting the otherwise applicable standard is presented in Section 3.2.2.

3.1.1 Hazardous constituents

Hazardous constituents at the Burro Canyon disposal site were identified from characterization of the tailings materials. A description of the uranium recovery process and an evaluation of groundwater quality data are included in Attachment 3.

Hazardous constituents potentially of concern at the Burro Canyon site have been determined, based on two criteria: 1) they must be present in, or reasonably expected to be present in, or derived from the RRM to be stabilized at the disposal site; and 2) they must be constituents listed in the proposed EPA groundwater protection standards (EPA, 1987).

Average concentrations or activities of eight inorganic hazardous constituents with maximum concentration limits (MCL) that are related to uranium processing activities and exceeded laboratory method detection limits in the lysimeter pore fluid samples from the NC or UC sites include arsenic, cadmium, lead, molybdenum, net gross alpha, nitrate, selenium, and uranium. Six additional hazardous constituents without MCLs that exceeded the laboratory method detection limits are antimony, copper, thallium, tin, vanadium, and zinc. Table 3.1 summarizes the hazardous constituents identified at the Slick Rock processing sites.

The groundwater at the Slick Rock processing sites was screened for organic hazardous constituents. One organic screening groundwater sample was collected from a DOE monitor well at the NC processing site and another was collected from a DOE monitor well at the UC processing site. No organic hazardous constituents were detected in the monitoring well sample collected from the UC processing site. Two organic compounds were detected in the NC groundwater sample; however, the concentrations of the detected organic compounds are believed to be the result of laboratory contamination, rather than from the processing operations at the NC processing site. Additional discussion is provided in Section 3.1.6 of Attachment 3.

The DOE has evaluated the potential effects of relocating the tailings to the Burro Canyon disposal site and has determined that, because the uppermost aquifer has a low yield [less than 150 gpd (7×10^{-3} L/s)] and is not a current or potential source of water, hazardous constituents from the tailings source term will not affect human health and the environment. Furthermore, the disposal cell design will minimize release of the potentially hazardous constituents identified in Table 3.1 (to the extent needed to protect human health and the environment). Approximately 50 to 65 ft (15 to 20 m) of low-permeability [2.3×10^{-6} cm/s (6.5×10^{-3} ft/day)] interbedded mudstone and siltstone sequences will separate the base of the disposal cell from the uppermost aquifer (upper sandstone unit of the Burro Canyon Formation). As a result, if any potentially hazardous constituents are released below the disposal cell foundation, the low-permeability mudstone and siltstone sequences are expected to limit further migration. Details regarding the potential points of exposure are presented in

Table 3.1 Summary of hazardous constituents identified at the Slick Rock processing sites^a

Parameter	Source term concentration (NC site)	Source term concentration (UC site)	Laboratory detection limit	MCL	Background ^b	
					Average	Stat. maximum
Constituents with MCLs						
Arsenic	0.068 ^c	0.022 ^c	0.01	0.05	0.01 ^d	0.01 ^d
Cadmium	0.045 ^c	0.084 ^c	0.001	0.01	0.001 ^d	0.001 ^d
Gross alpha (excluding radium and uranium) ^e	-1142.18 ^c	-21.19	1.0	15.0	0.845 ^c	6.96 ^c
Lead	0.03 ^c	0.01 ^c	0.01	0.05	0.01 ^d	0.01 ^c
Molybdenum	0.31 ^f	3.63 ^g	0.01	0.1	0.01 ^d	0.02 ^c
Nitrate (as NO ₃)	--	210.0	1.0	44.0	1.6 ^c	4.4 ^c
Selenium	4.73 ^f	2.78 ^g	0.005	0.01	0.005 ^d	0.012 ^c
Uranium	1.77 ^g	0.257 ^f	0.003	0.044	0.003 ^d	0.019 ^c
Constituents without MCLs						
Antimony	0.015 ^c	0.011 ^c	0.003	None	0.003 ^d	0.003 ^d
Copper	0.06 ^f	0.42 ^g	0.02	None	0.02 ^d	0.02 ^d
Thallium	0.02 ^c	0.01 ^d	0.01	None	0.01 ^d	0.01 ^d
Tin	0.099 ^c	0.009 ^c	0.005	None	0.005 ^d	0.005 ^d
Vanadium	4.83 ^g	0.18 ^g	0.01	None	0.01 ^d	0.02 ^c
Zinc	0.038 ^c	0.236 ^g	0.005	None	0.005 ^d	0.010 ^c

^aAll units are milligrams per liter (mg/L) unless otherwise noted. Source term concentrations are based on lysimeter samples collected from January 1989 to October 1992.

^bBackground groundwater quality in the Burro Canyon Formation, upper unit (uppermost aquifer).

^cNonparametric distribution.

^dStatistical values are below laboratory detection limits in Table 8.1 of the *Technical Approach Document* (DOE, 1989).

^eUnits are picocuries per liter (pCi/L).

^fNormal distribution, mean is arithmetic.

^gLognormal distribution, mean is geometric.

Section 3.3. The uppermost aquifer is hydrogeologically isolated from the underlying water bearing units by low-permeability mudstones and upward vertical gradients, as discussed in Attachment 3.

3.1.2 Proposed concentration limits

To achieve compliance with the proposed EPA groundwater protection standards at the disposal site, the DOE proposes to apply a narrative supplemental standard based on Class III (limited use) groundwater due to insufficient yield in the uppermost aquifer. A narrative supplemental standard is reasonable for the Burro Canyon disposal site for the following reasons:

- The quantity of water available is less than 150 gpd (7×10^{-3} L/s) [40 CFR 192.11(e)(3)], as demonstrated by on-site aquifer performance testing.
- There is no historic or existing beneficial use of the groundwater in the uppermost aquifer, due to limited yield.
- The proposed disposal cell foundation will be separated from the uppermost aquifer by a thick layer of low-permeability mudstone [25 to 75 ft (8 to 23 m)].
- Groundwater in the sandstone units underlying the uppermost aquifer is protected from potential site-related contamination by the low-permeability mudstone units that inhibit the downward migration of water and steady state upward vertical hydraulic gradients in the lower and middle sandstone units of the Burro Canyon Formation.
- There is no evidence of discharge anywhere in the vicinity of the site; therefore, there is no point of exposure.
- The proposed remedial action at the Burro Canyon disposal site comes as close to meeting the otherwise applicable standards (40 CFR 192) as is reasonable under the circumstances (see Sections 2.1 and 2.2 for a discussion of disposal cell design features for protection of groundwater). A discussion of how the remedial action at the Burro Canyon disposal site will protect human health and the environment is provided in Section 3.3.

3.1.3 Point of compliance

A POC has not been established for the proposed Burro Canyon disposal site for the reasons discussed in Section 3.1.2.

3.2 NARRATIVE SUPPLEMENTAL STANDARD

The U.S. Nuclear Regulatory Commission (NRC) must consider the following four items before granting supplemental standards (NRC, 1989): 1) the criteria for applicability, 2) description of the supplemental standard, 3) demonstration that the remedial action satisfies the proposed supplemental standard, and

4) demonstration that the supplemental standard is as low as reasonable under the circumstances. Items 1, 3, and 4 are discussed in Sections 3.2.1 through 3.2.3. Item 2 is discussed in Section 3.1.

3.2.1 Applicability criteria

To achieve compliance with the proposed EPA groundwater protection standards, the DOE proposes the application of a narrative supplemental standard (Subpart C of 40 CFR 192) at the Burro Canyon disposal site. Groundwater in the uppermost aquifer meets the definition of Class III (limited use [40 CFR 192.11(e)] based on 1) insufficient yield, and 2) groundwater use. A detailed analysis is presented below.

Insufficient yield

The EPA defines "sufficient yield" as a quantity of water from a well or spring sufficient to meet the long-term needs of an average family (EPA, 1986). The yield must be sustainable into the future. The EPA has estimated that the lowest quantity that meets this requirement is 150 gpd (7×10^{-3} L/s). Groundwater yielding less than this criterion is defined as Class III.

The groundwater protection standards in 40 CFR 192.02(a)(3) apply to the uppermost aquifer hydraulically downgradient from the disposal unit. The upper sandstone unit of the Burro Canyon Formation is the uppermost aquifer at the Burro Canyon disposal site. Groundwater in this unit occurs under semiconfined conditions at constant levels and does not show seasonal fluctuations. The upper sandstone unit is not a current or potential source of drinking water because the quantity of water available is less than 150 gpd (7×10^{-3} L/s), as evidenced by on-site aquifer performance tests. As a result, the groundwater in the upper sandstone unit is limited use, or Class III groundwater, as defined in 40 CFR 192.11(e) of the EPA's proposed groundwater standards. Furthermore, the upper sandstone unit is hydrogeologically isolated from the underlying middle and lower sandstone units, as discussed in Section 3.2.3 of Attachment 3.

Groundwater use

No known registered or private wells are actively used within the upper sandstone unit of the Burro Canyon Formation in a 2-mi (3-km)-radius of the Burro Canyon disposal site, because of limited yield.

By definition, Class III (limited use) groundwater is not a current or potential source of drinking water. No development is currently planned adjacent to the proposed Burro Canyon disposal site. Furthermore, groundwater development in the vicinity of the disposal site should not increase over the next 50 years, because there is not enough water available to support development on any time scale.

3.2.2 Demonstration that remedial action satisfies the proposed supplemental standard

This section describes potential impacts of groundwater use to human health and the environment. There are no historic or existing beneficial uses of groundwater in the upper sandstone unit of the Burro Canyon Formation, based on the applicability criteria discussed in Section 3.2.1.

Human health and the environment will be protected for the following reasons:

- The quantity of water available is less than 150 gpd (7×10^{-3} L/s) [40 CFR 192.11(e)(3)], preventing future groundwater development and use.
- Groundwater in the uppermost aquifer beneath the proposed Burro Canyon disposal site is not a current or potential source of drinking water.
- The proposed disposal cell foundation will be separated from the uppermost aquifer by 25 to 75 ft (8 to 23 m) of low-permeability mudstone.
- The uppermost aquifer is hydrogeologically isolated from the underlying water-bearing units.
- There is no point of exposure downgradient of the disposal site. Details are provided in Section 3.3.

3.2.3 As low as reasonable under the circumstances

The proposed disposal cell design meets the as low as reasonable under the circumstances criterion. The design features, described in Section 2.2, will ensure that human health and the environment are protected. Active maintenance will not be required to ensure long-term performance. The proposed disposal embankment cover will use natural, stable materials to prevent surface erosion, provide protection against freezing and thawing, and inhibit radon emanation and seepage, by incorporating design features that are as close to meeting the otherwise applicable standards as are reasonable under the circumstances.

3.3 POINT OF EXPOSURE

Pursuant to 40 CFR 192, this section assesses the potential for human and environmental exposure and concludes that the probability of exposure is low enough to prevent adverse impacts from groundwater contamination. For this discussion, points of exposure can be divided into two categories: 1) surface expressions where water enters the uppermost aquifer as precipitation and outflows as surficially exposed drainage, and 2) subsurface drainage.

Surface points of exposure

The upper sandstone unit is recharged by infiltration of water from the surface outcrop upgradient of the site. Sandstone beds outcrop along the east limb of the Disappointment syncline and intercept tributaries to the Nicholas Wash drainage system. Groundwater movement in the upper sandstone unit parallels the axis of the Disappointment syncline, and eventually dissipates (discharges) into the Burro Canyon Formation southeast of the disposal site (Figure 3.1).

The Burro Canyon Formation has a grade of approximately 3 percent. The Joe Davis Canyon is about 1 mi (2 km) south of the disposal site. Based on a cross section shown in Figure 3.2 (modified from Shawe *et al.*, 1968), the upper sandstone unit of the Burro Canyon Formation is present only as a cap at the top of the Joe Davis Canyon. Any potential seepage into the Joe Davis Canyon from the Burro Canyon Formation is expected to be from the middle and/or lower Burro Canyon sandstone units. Furthermore, based on the direction of groundwater movement, the Joe Davis Canyon is cross gradient from the Burro Canyon disposal cell. Therefore, any potential leachate from the disposal cell would never reach Joe Davis Canyon.

Additional potential points of exposure include two thin sandstone layers of the Dakota Sandstone Formation that outcrop at the base of the disposal cell mesa within 200 to 300 ft (60 to 90 m) of the toe of the disposal cell. The disposal cell is designed to mitigate lateral seepage potential with a low-permeability cover and the bottom of the excavation keyed to the low-permeability mudstone of the Burro Canyon Formation. Excavating into the Burro Canyon Formation mudstone effectively creates a bottom and continuous sidewall liner under and around contaminated material. Therefore, the relatively small volume of leachate from the dry sand tailings is not expected to move laterally through the Dakota Sandstone layers and create seeps at the base of the mesa at the proposed Burro Canyon disposal site.

Subsurface points of exposure

Subsurface drainage potentially could result from transient drainage of excess moisture from the tailings. The tailings at the Slick Rock sites consist of sand and poorly graded sand with silt. The tailings' saturated hydraulic conductivity is approximately 140 ft/day (5×10^{-2} cm/s), which is characteristic of a clean, free-draining sand (Freeze & Cherry, 1979). As a result, the tailings will have a low-moisture content when they are placed in the disposal cell. This low moisture content of the RRM's, coupled with a 2-ft (0.6-m)-thick radon barrier, will inhibit radon emanation and water seepage through the underlying contaminated material.

Approximately 50 to 65 ft (15 to 20 m) of low-permeability [6.5×10^{-3} ft/day (2.3×10^{-6} cm/s)] interbedded mudstone and siltstone sequences will separate the base of the disposal cell from the upper sandstone unit of the Burro Canyon Formation. Groundwater in lithologic units underlying the uppermost aquifer is also protected from potential water seepage from the disposal cell by

NOTE: PORTION OF SECTION B-B' SHOWN BELOW
SHADED ON LOCATION MAP.

FIGURE 3.2
REPRESENTATIVE DIAGRAMMATIC SECTION OF STRATA
OF BURRO CANYON FORMATION

REFERENCE: FROM SHAW, DR. et al, 1968.
ATTACHMENT 4

hydrogeologic isolation, which is provided by 1) the low-permeability Burro Canyon mudstone units that inhibit the downward migration of water, and 2) upward vertical hydraulic gradients in the lower and middle sandstone units of the Burro Canyon Formation.

3.4 PERFORMANCE ASSESSMENT

The DOE is required to demonstrate that the performance of the disposal cell will comply with the EPA groundwater protection standard [40 CFR 192.02(a)(3)]. To achieve compliance, the DOE proposes to apply supplemental standards, because the uppermost aquifer is not a current or potential source of drinking water due to limited yield.

Aquifer performance testing has been conducted at the proposed Burro Canyon disposal site to assess the hydraulic properties and amount of interconnection between the saturated units of the Burro Canyon Formation. The results of these and other site-specific hydrogeologic investigations (described in Attachment 3) demonstrate that groundwater is protected from potential site-related contamination in the upper sandstone unit of the Burro Canyon Formation (uppermost aquifer) and in the underlying sandstone units. Hydrogeologic isolation is provided by the low-permeability mudstone units above and below the uppermost aquifer and by upward vertical hydraulic gradients in the middle and lower sandstone units of the Burro Canyon Formation.

3.5 CLOSURE PERFORMANCE DEMONSTRATION

The DOE has demonstrated that the proposed RAP at the disposal site will comply with Subpart A (40 CFR 192) of the proposed groundwater protection standards. The disposal cell will minimize the release of hazardous constituents to groundwater and surface water and radon emissions to the atmosphere to the extent necessary to protect human health and the environment [40 CFR 192.02(a)(4)]. Natural, stable materials have been proposed for use in the construction of the disposal cell so that long-term performance is ensured (see Section 2.2.1). The DOE also has demonstrated that design features necessary for compliance with the groundwater protection standards minimize the need for further disposal site maintenance. Because sustainable amounts of groundwater are not available from the upper sandstone unit, no existing or potential users are in the area.

3.6 GROUNDWATER MONITORING PROGRAM

Pursuant to 40 CFR 192.02(a)(4)(b), this section addresses a groundwater monitoring plan to be carried out during and after the remedial action period. The DOE has determined that proposing concentration limits and monitoring a POC at the Burro Canyon disposal site would not further protect human health and the environment for the reasons listed in Section 3.1.2. An assessment of the potential for human health and environmental exposure and a determination

that the probability of exposure will be low enough to prevent adverse impacts from groundwater contamination are provided in Section 3.3. Points of exposure have been divided into two categories: 1) surface expressions where the source of recharge is precipitation and discharge is surficially exposed drainage, and 2) subsurface drainage. Groundwater monitoring would not be effective at the Burro Canyon disposal site, and is therefore not proposed, because insufficient yield in the uppermost aquifer will preclude its future use. The only point of exposure that could potentially affect human health or the environment would be surface seepage at the base of the disposal cell mesa. In lieu of groundwater monitoring, DOE will conduct long-term surveillance monitoring by conducting inspections to locate surface expressions of seepage at and in the vicinity of the Burro Canyon disposal site. These visual inspections will include looking for physical evidence of mineralization, phreatophyte vegetation, and the presence of saturated zones at sandstone outcrops.

3.7 CORRECTIVE ACTION PLAN

The DOE is required by 40 CFR 192.02(c) to evaluate alternative corrective actions that could be implemented if the disposal cell monitoring program indicates the unit is not performing adequately. The EPA's proposed standards (40 CFR 192) require that if initial performance of the disposal cell is not in compliance with the proposed EPA groundwater protection standards, a corrective action program to restore the disposal cell to design requirements will be implemented within 18 months. The DOE will notify the NRC before implementing any significant action(s) that may be required. If evaluative monitoring indicates that corrective action is necessary, the NRC will be notified within one month. The DOE will prepare and submit a corrective action plan to the NRC for review and approval. A copy of this plan will be transmitted to the state of Colorado. The corrective action plan may include a monitoring program to demonstrate the effectiveness of the corrective action. The DOE will implement corrective action when NRC approval has been granted.

In preparing a corrective action plan, a risk assessment may be conducted to evaluate the potential impact of corrective action on nearby populations or the environment. If the risk assessment demonstrates no potential harm to human health and the environment, the recommended corrective action may consist of "no action" except possible continued evaluative monitoring.

The Burro Canyon disposal cell has been designed and will be constructed to perform for the mandated design life of at least 200 years, and for up to 1000 years to the extent reasonably achievable, as required in 40 CFR 192. The design of the cell incorporates standard safety factors and should therefore perform for the mandated design life with minimal maintenance. It is not anticipated that the designed disposal cell will fail, because all-natural materials will be used and because the radon barrier will be adequately protected from disruption.

4.0 CLEANUP AND CONTROL OF EXISTING CONTAMINATION

The DOE is responsible for demonstrating that cleanup or control of existing processing-related groundwater contamination at the Slick Rock sites will comply with the proposed EPA groundwater protection standards in Subpart B of 40 CFR 192.

The current level of site characterization is sufficient to address only whether the remedial action will comply with the proposed EPA groundwater protection standards. The DOE has decided that groundwater cleanup will be addressed under a separate DOE program, which will comply with NEPA. Additional groundwater characterization may be conducted to include water quality, groundwater flow, and aquifer properties. A conceptual groundwater restoration strategy will be developed.

The current level of characterization at the Slick Rock processing sites is sufficient to address only whether the proposed remedial action will comply with Subpart A of the proposed EPA groundwater protection standards. Additional investigations will be conducted as necessary to determine the appropriate groundwater cleanup strategy for the Slick Rock processing sites. The proposed surface remedial action will not preclude or interfere with any potential groundwater remediation activities at the processing sites.

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