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ATTACHMENT 4

WATER RESOURCES PROTECTION STRATEGY

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1.0 WATER RESOURCES PROTECTION STRATEGY SUMMARY

The DOE proposes to achieve compliance with the proposed EPA groundwater protection standards (Subparts A and B of 40 CFR 192) by meeting the EPA maximum concentration limits (MCLs) or background concentrations for designated hazardous constituents in groundwater in the uppermost aquifer (alluvium/weathered granodiorite) at the point of compliance (POC) at the Lowman disposal site near Lowman, Idaho. The proposed remedial action in conjunction with existing hydrogeological conditions at the Lowman site will ensure sufficient protection of human health and the environment. The DOE has concluded that the EPA groundwater protection standards will be met at the POC because, with the exception of antimony, none of the hazardous constituents that exceed laboratory method detection limits within the radioactive sand pore fluids were above the proposed concentration limits. The DOE has demonstrated that antimony will meet the proposed concentration limits at the POC through attenuation in subsoils beneath the disposal cell and by dilution in groundwater underflow. The Lowman processing site is in compliance with Subpart B of 40 CFR 192 because statistical analyses of groundwater samples indicate no groundwater contamination. To support these arguments further, a detailed discussion is presented in Section 3.0 of this document. However, a summary of the principal features of the water resources protection strategy for the Lowman disposal site is presented here.

- The disposal option prepared for the Lowman uranium processing site involves consolidation of radioactive sands and associated contaminated materials at the Lowman site. The materials will be placed in an above-grade disposal cell designed to reduce radon emanation, resist erosion, preclude differential settlement, and remain stable against static and dynamic forces.

- Design features in conjunction with existing conditions at the Lowman disposal site will ensure protection of human health and the environment. To achieve compliance with the proposed EPA groundwater protection standards at the Lowman disposal site, the DOE proposes to meet MCLs or background concentrations for the designated hazardous constituents in groundwater at the POC in the uppermost aquifer hydraulically downgradient from the disposal unit. The alluvium/weathered granodiorite is the uppermost aquifer at the Lowman disposal site.

- Selection of hazardous constituents was based on hydrogeologic characterization at the Lowman site. These hazardous constituents resulted from the uranium processing operations and will be present in materials stabilized at the Lowman disposal site. The hazardous constituents were identified from descriptions of the uranium recovery process, characterization of the contaminated materials, and evaluation of groundwater quality data. Based on chemical analyses of pore fluids from suction lysimeters placed at or near the base of the radioactive sands, the following hazardous constituents exceeded the laboratory method detection limits: antimony, barium, molybdenum, net gross alpha activity, nitrate, and uranium. Chromium, lead, and radium-226 and -228 activities also exceeded the laboratory method detection limits in neutral pH batch-leach tests. No concentrations of hazardous constituents exceed the MCLs.

- Pore fluid concentrations of antimony in radioactive sands exceed the statistical maximum for background groundwater quality. Antimony is a designated hazardous constituent with a sufficiently high source concentration to affect groundwater quality. Aluminum, copper, fluoride, strontium, vanadium, and zinc are not designated as hazardous constituents even though their elemental concentrations exceeded laboratory method detection limits in radioactive sand pore fluids. Copper and zinc were not designated as hazardous constituents because they are not reasonably expected to exist as the cyanide species listed in Appendix VIII of 40 CFR 261. Similarly, aluminum, fluoride, and vanadium were not designated because they cannot exist in solution as the hazardous constituent compounds aluminum phosphide, carbon oxyfluoride, and vanadium pentoxide. Strontium sulfide is not designated as a hazardous constituent because it cannot be reasonably expected to exist in groundwater at the Lowman site due to the highly oxidizing environment. All of these hazardous constituent compounds are anthropogenic and are not attributable to the physical separation of placer sands at the Lowman site. Therefore, they are not designated as hazardous constituents that exceed laboratory method detection limits.

- Concentration limits for the hazardous constituents that exceed laboratory method detection limits were selected based on proposed EPA groundwater protection standards (MCLs), and the statistical maximum background concentrations (for constituents without MCLs) in groundwater in the alluvium/weathered granodiorite at the Lowman disposal site. The statistical maximum is represented as the 99 percent confidence maximum for constituents with normal and log-normal distributions. In some cases, based on the distribution, statistics were not appropriate and the maximum observed concentration or the method detection limit was chosen as the concentration limit. (See Attachment 3, Section 3.5.) The proposed concentration limits for barium, chromium, lead, molybdenum, net gross alpha activity, nitrate, radium-226 and -228 activities, and uranium will be the EPA MCLs. The proposed concentration limit for antimony will be the statistical maximum (in this case, the maximum observed background groundwater concentrations).

- The POC at the Lowman disposal site will be the downgradient western edge of the disposal unit in the uppermost aquifer, which is the alluvium/weathered granodiorite.

- To demonstrate compliance of the proposed disposal cell design with the EPA groundwater protection standards, design parameters were evaluated in conjunction with hydrogeologic characteristics of the Lowman site to determine the distribution of hazardous constituents in groundwater under steady state conditions. The following are the hydrogeologic characteristics important to the performance assessment of the proposed disposal cell: 1) concentrations of all hazardous constituents in radioactive sand pore fluids are below concentration limits, except antimony; 2) presently, groundwater beneath the site is not contaminated by hazardous constituents moving downward from the processed or unprocessed radioactive sand piles; 3) both the processed and unprocessed radioactive sands are physically and chemically inactive; 4) infiltration through the disposal cell will be limited; 5) pore fluids in upgradient native soils contain higher concentrations of soluble metals, including antimony; 6) control of construction water will produce negligible

transient drainage to pore fluids from the radioactive sands; and 7) concentrations of antimony can be achieved at the POC by dilution of seepage from the radioactive sands by groundwater underflow. Because concentrations of antimony in groundwater are already in geochemical equilibrium with native soil concentrations, the presence of radioactive sands will not influence groundwater quality.

- The DOE has assessed the performance of the proposed disposal cell at the Lowman site in conjunction with hydrogeologic system, and has shown that the disposal cell will minimize and control releases of the hazardous constituents to groundwater and surface water and radon emanations to the atmosphere to the extent necessary to protect human health and the environment. Natural, stable materials have been proposed for use in construction of the Lowman disposal cell so that long-term performance is ensured. The DOE has also demonstrated that design features necessary for compliance with the EPA groundwater protection standards minimize the need for further maintenance of the disposal site.

- A groundwater monitoring program will be carried out during and after the remedial action period to demonstrate that the initial performance of the disposal cell is in accordance with the design requirements, and to ensure compliance of the disposal site with the EPA groundwater protection standards. Groundwater in the uppermost aquifer will be monitored downgradient from the disposal cell at the POC, using existing DOE monitor wells and a spring. Some new monitor wells will be installed downgradient of the disposal cell at the POC. Background groundwater quality will also continue to be monitored upgradient and crossgradient from the disposal cell. Compliance wells will be sampled quarterly during the first and second years following completion of remedial action activities, semi-annually for years three through six, and annually thereafter until the end of the performance monitoring period. The constituents to be monitored will include designated hazardous constituents, major anions and cations, and a standard suite of field parameters.

- Demonstration of cleanup and control of existing processing-related groundwater contamination will not be necessary based on site characterization, which suggests that there is no contamination of groundwater and that groundwater cleanup will not be required.

2.0 CONCEPTUAL DESIGN FEATURES FOR WATER RESOURCES PROTECTION

The disposal option proposed for the Lowman processing site involves consolidation of the radioactive sand piles, windblown materials, and vicinity property materials into an above-grade disposal cell on the Lowman site. The above-grade disposal cell (with an approximate surface area of eight acres) will be covered with an 18-inch-thick radon barrier designed to reduce radon emanation. The Lowman disposal cell cover is designed to minimize infiltration throughout the cell life.

2.1 DESIGN CONSIDERATIONS

In terms of groundwater protection at the Lowman site, climate, infiltration and groundwater recharge, surface and subsurface drainage, and geochemical conditions are the design and performance items of most importance. These are discussed in the following sections.

2.1.1 Climate

Climate is an important design consideration because of its influence on the quantity of water available to percolate through the stabilized contaminated material, and its potential effect on the migration of hazardous constituents to groundwater. The climate in the vicinity of the Lowman site is humid continental with dry, warm summers and cold winters. The mean annual precipitation recorded at Lowman for the period of record from 1951 through 1973 was 24 inches (NOAA, 1984). Most of the precipitation occurs during the fall and winter months (November through February) with an average of 3.4 inches of precipitation falling each month. Precipitation in the form of snow accounts for about half of the annual total. Most of the snow falls in December, January, and February. The average annual snowfall is 93 inches per year. Most overland flow occurs in the spring, from snow melting over frozen ground. July and August are the driest months of the year with approximately 0.5 inch of precipitation per month. The mean annual daily maximum and minimum temperatures at Lowman for the period from 1951 through 1973 were 60° and 27°F, respectively, with a range from minus -35 to 107°F (NOAA, 1984). The average annual maximum and minimum temperatures for the same period ranged from 89 to 12°F although freezing temperatures have been measured every month of the year. Prevailing winds are most frequently from the west. Adjusted potential evapotranspiration at the Lowman site is approximately 22 inches per year (FBDU, 1983). The potential evapotranspiration at the Lowman site is over 90 percent of the average annual precipitation (FBDU, 1983). The climate at the Lowman site is discussed in more detail in Attachment 2.

2.1.2 Infiltration and groundwater recharge

Under natural surface conditions in the vicinity of the Lowman site, a small portion of the precipitation is expected to deep-percolate to recharge the underlying groundwater. Approximately five to 10 percent of the precipitation that falls over the proposed disposal site is discharged as surface runoff to the west toward Clear Creek (FBDU, 1983). The actual annual evapotranspiration in the vicinity of the Lowman site is approximately 17 inches (FBDU, 1983). The area around the site is generally covered with grass and conifers that enhance evapotranspiration. Approximately 23 percent of the annual precipitation percolates below the root zone (FBDU, 1983). Because the radioactive sands are chemically inactive and do not weather and release hazardous constituents, controlling infiltration through the disposal cell is not critical to the design of the disposal cell.

2.1.3 Surface and subsurface drainage

The disposal site lies on an upper glacial outwash terrace covered with a veneer of colluvium (see Figure 3.3 of Attachment 3) that receives drainage from the upland catchment area. Surface runoff from this catchment area will be diverted laterally off the disposal cell by a rock apron (see Figure 2.1). See Section 3.3.5 for design details.

In the steady state condition, the seepage rate from the base of the disposal cell will be a function of the infiltration rate through the radon barrier. Results of laboratory tests on materials that will be used in the radon barrier at the Lowman disposal site indicate that saturated hydraulic conductivities will be approximately 1×10^{-5} cm/s. Because this is greater than two orders of magnitude higher than the estimated rate of deep percolation (4×10^{-7} cm/s), the radon barrier will not limit infiltration.

The consolidated radioactive sands and associated contaminated materials will overlie undisturbed colluvium and alluvium. Laboratory test results indicate the saturated hydraulic conductivity of the alluvium is approximately 1×10^{-4} cm/s. This is sufficiently high to accept potential infiltration through the cover and the small amounts of transient drainage anticipated from construction water. The unsaturated hydraulic conductivity of the radioactive sands will be much lower than 1×10^{-3} cm/s at a moisture content of 14 percent, so that the subsoils should also accept transient drainage without creating mounding or perched water in the bottom of the disposal cell that could exit the cell as surface seepage and create a point of exposure.

The water table is approximately 40 feet below the bottom of the disposal cell under the upland side of the disposal cell as shown in Figure 3.4, Attachment 3. Furthermore, no springs or seeps have been observed in the vicinity of the disposal cell footprint. It is, therefore, highly improbable that groundwater will come into contact with radioactive sands in the disposal cell.

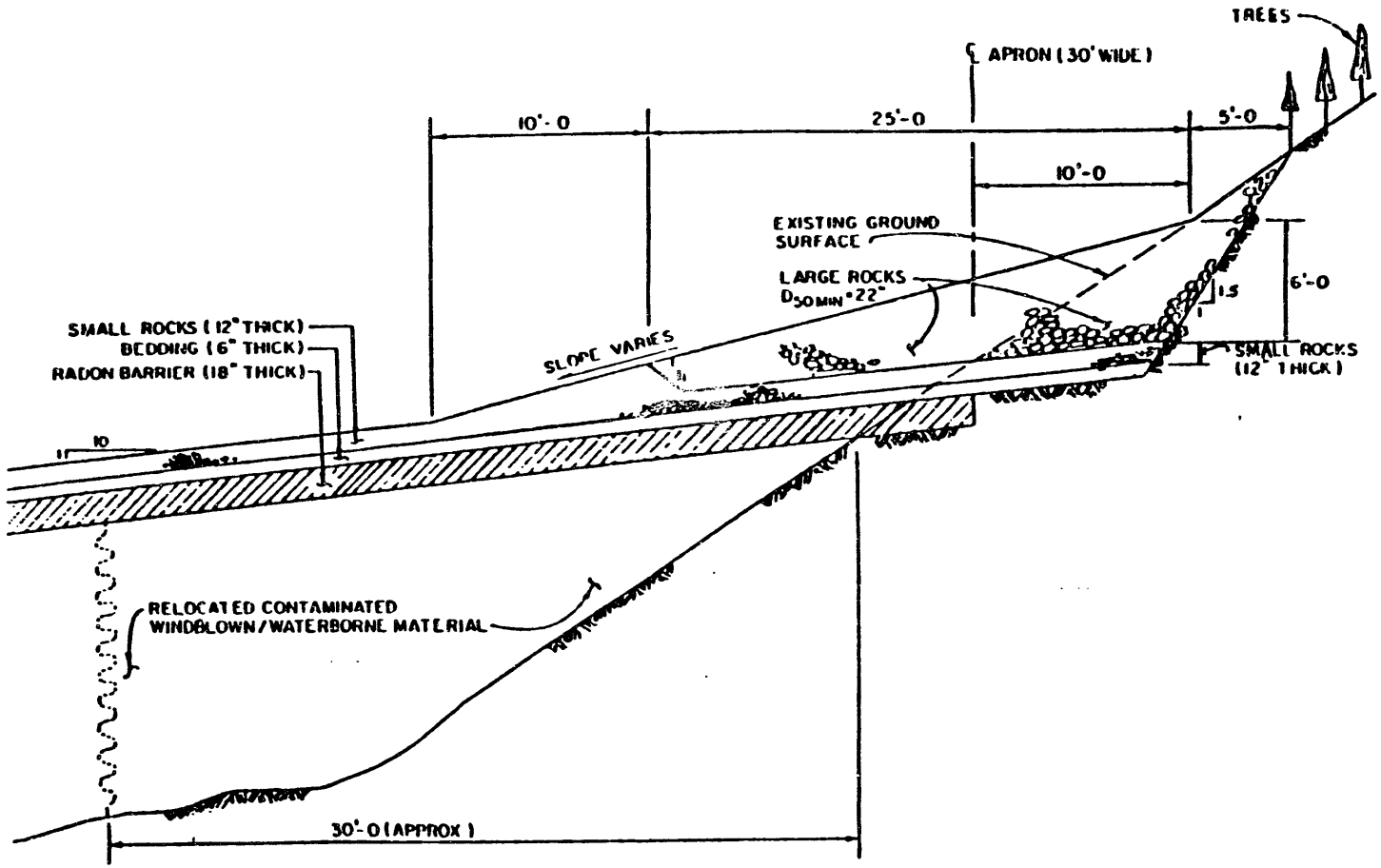


FIGURE 2.1
DISPOSAL CELL COVER SYSTEM
LOWMAN DISPOSAL SITE NEAR LOWMAN, IDAHO

2.1.4 Geochemical conditions

Geochemical design considerations include the chemical reactivity of the radioactive sands to infiltration, the geochemical properties of native soils with regards to their potential for weathering and releasing dilute concentrations of hazardous constituents, and the potential for geochemical attenuation of hazardous constituents in subsoils between the base of the consolidated radioactive sands and the water table. A detailed discussion of geochemistry is provided in Attachment 3. Geochemical issues that effect disposal cell design are discussed here.

The geochemical environment in the alluvium/weathered granodiorite is characterized as neutral pH and oxidizing. The radioactive sands are relatively stable under these geochemical conditions. Because the mill feed stock was a placer mining concentrate, few, in any, reactive minerals were transported to the Lowman processing site. Results from laboratory batch-leach testing on the radioactive sands using neutral pH deionized water demonstrate that the radioactive sands are chemically inactive under a neutral pH environment (see Attachment 3).

Concentrations of antimony in samples from suction lysimeters completed in background soils are higher than in samples from lysimeters completed in the radioactive sands (see Attachment 3).

The working hypothesis for the higher concentrations of metals in the native soils is that the reactive minerals, ferromagnesians, sulfides, and carbonates are chemically weathering and releasing their metallic constituents into solution. As the batholith weathers into the regolith to form soils, metals will be continuously released into the soil water. The placer deposits from which the ore dredge product was derived had not only gone through chemical and physical weathering, but had also been eroded (transported) by fluvial processes to a new site of deposition. During this process, the reactive minerals were decomposed and their metallic hazardous constituents were flushed out of the system. Pore fluids within soils forming on the granodiorite of the Idaho Batholith will have higher concentrations of metals than will the placer ore dredge product.

Pore fluid concentrations of antimony and vanadium observed in both the native soils and radioactive sands are measured at concentrations significantly lower in on-site/downgradient and background groundwater samples (see Attachment 3). The decrease in concentrations from the vadose zone to the groundwater beneath the site is probably due to a combination of geochemical attenuation in the subsoils and dilution with groundwater underflow. Because concentrations of antimony in groundwater are already in a geochemical equilibrium system with native soil concentrations, the presence of radioactive sands will not influence groundwater quality.

2.2 DESIGN FEATURES

This section describes the principal design features of the proposed disposal cell at the Lowman site that will ensure compliance with the EPA groundwater protection standards, and will demonstrate that the design features do not rely on active maintenance to ensure adequate long-term performance. Additional details and specifications of the conceptual design are provided in Section 3.3.5 of the RAS.

2.2.1 Disposal cell components

A plan view of the cover and components of the cover design are presented in Figures 2.1 and 2.2, respectively. The disposal cell is designed to stabilize the contaminated materials at the Lowman site, minimize radon emanations, and protect groundwater resources.

Disposal cell geometry

The disposal cell will be approximately 500 feet by 800 feet and will cover approximately eight acres. The cell will rise to a maximum elevation of 4020 feet (averaging 30 feet thick with 20 percent sideslopes and a 10 percent topslope. The disposal cell configuration, typical cross section, and cover detail are shown in Figures 2.2, 2.3, and 2.1, respectively. Above-grade disposal of the contaminated materials is most suitable at the Lowman site because of slope stability and the prevention of unsaturated groundwater flow from intercepting the cell.

Radon barrier

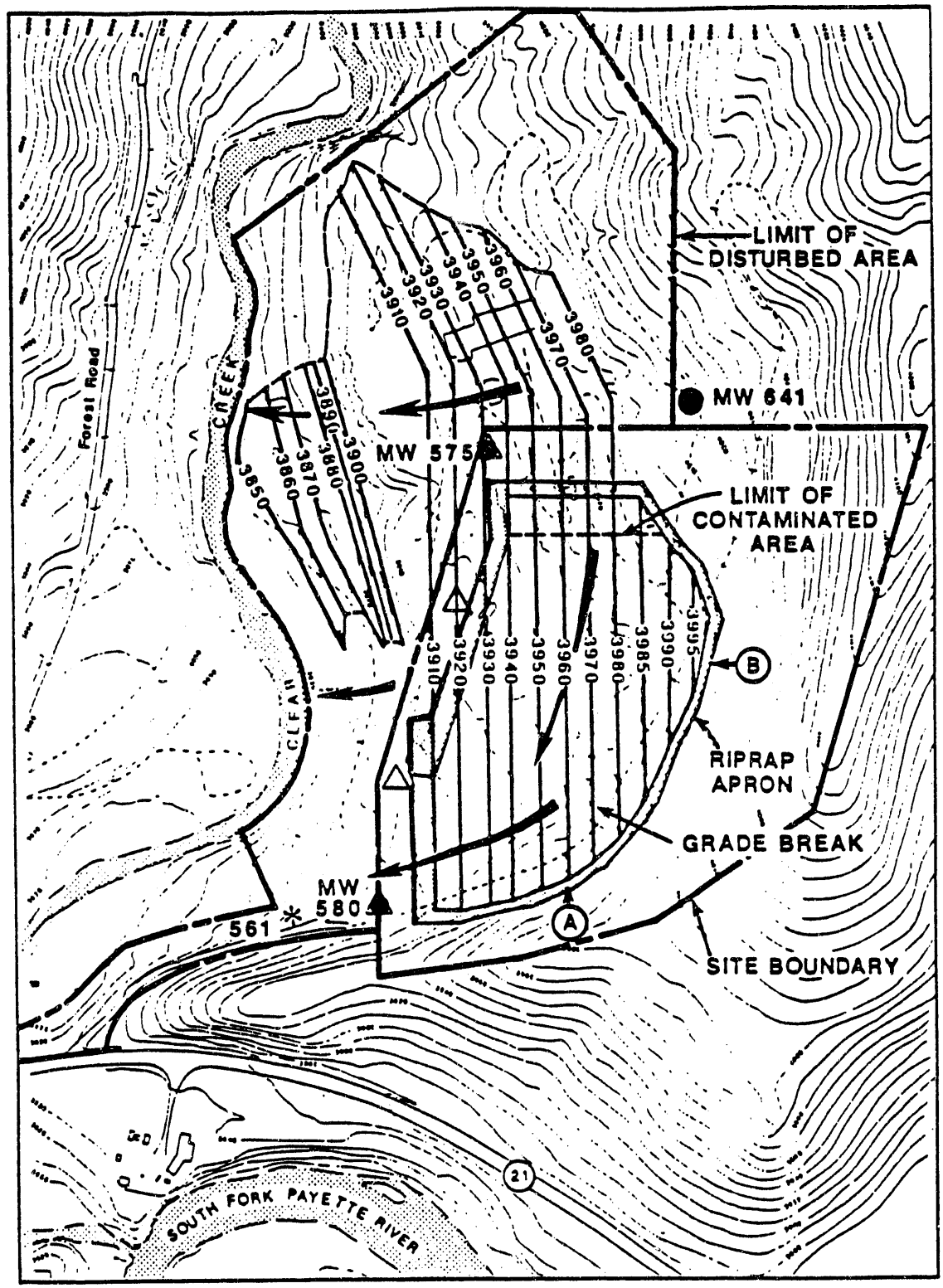
The purpose of the radon barrier is to inhibit radon emanation. The radon barrier will consist of an 18-inch-thick layer of clayey, sandy soil obtained on the site.

Filter bedding layer

The filter bedding layer will consist of six-inch-thick layer of clean material and will have a high saturated hydraulic conductivity. This layer will serve as a drain for potential infiltration through the overlying rock layer.

Erosion protection barrier

The rock layer on the top and sideslopes of the cell is designed to prevent erosion due to surface runoff resulting from the probable maximum precipitation (PMP) event on the pile.



LEGEND

- EXISTING DOE MONITOR WELL
- DIRECTION OF GROUNDWATER FLOW
- PROPOSED POINT OF COMPLIANCE MONITOR WELLS
- POINT OF COMPLIANCE
- * ONSITE PERENNIAL SPRING

100 0 100 300
SCALE IN FEET

FIGURE 2.2

PLAN VIEW OF DISPOSAL CELL, POINT OF COMPLIANCE, AND GROUNDWATER MONITORING NETWORK, LOWMAN DISPOSAL SITE NEAR LOWMAN, IDAHO

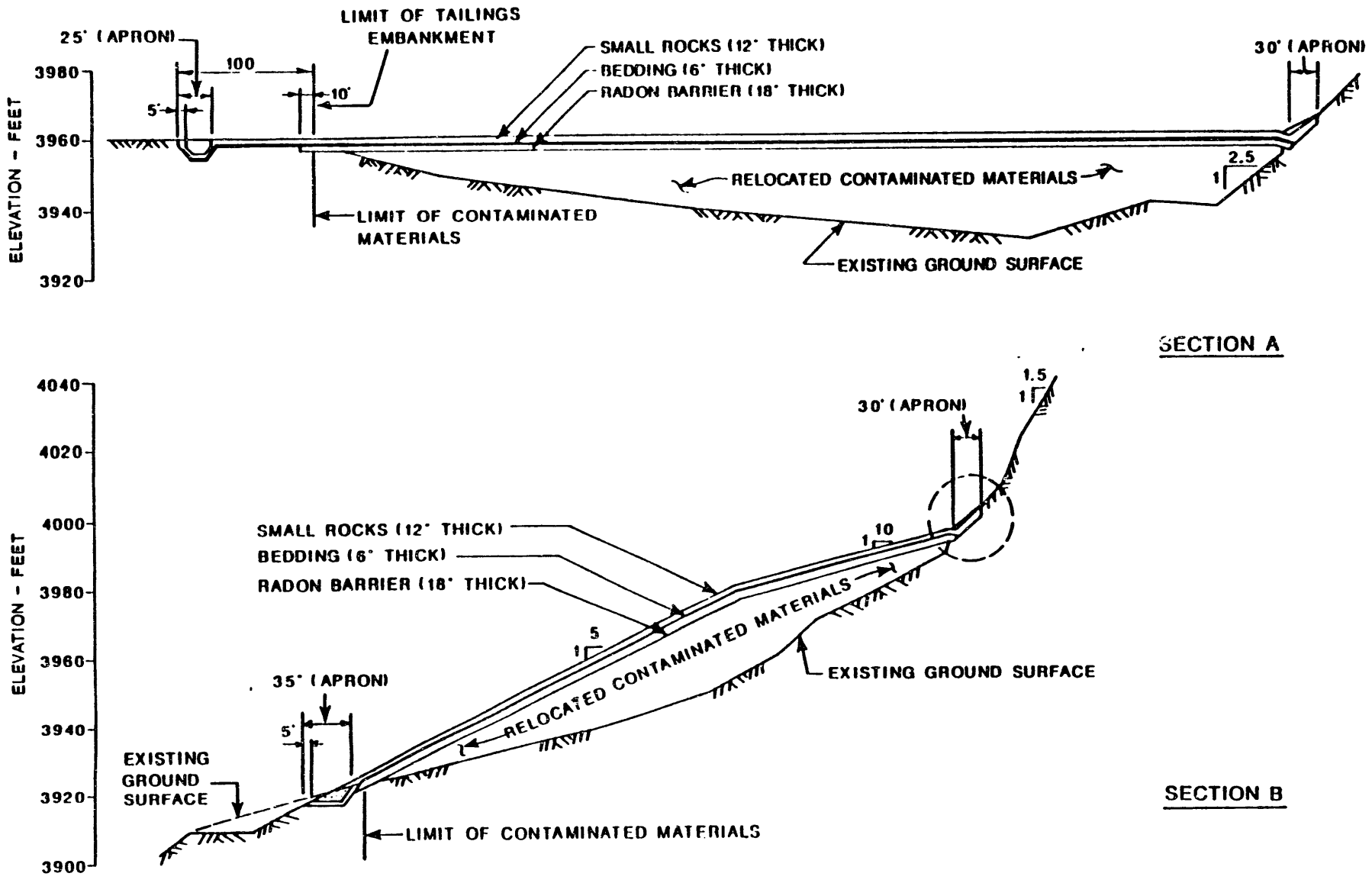


FIGURE 2.3
DIAGRAMMATIC CROSS SECTION OF PROPOSED DISPOSAL CELL
LOWMAN DISPOSAL SITE NEAR LOWMAN, IDAHO

2.2.2 Disposal cell longevity

The EPA standards require that the disposal cell be designed to stabilize the contaminated material and protect the environment for 1000 years where reasonably achievable, and in any case for at least 200 years. It must also be demonstrated that design features do not rely on active maintenance to ensure long-term performance and compliance with the standards.

Natural, stable materials have been proposed for use in construction of the Lowman disposal cell so that long-term performance is ensured. Materials for the rock erosion layer have been selected, based on durability, suitability, and size, that will perform adequately over the design life of the disposal cell. Bedding materials for the filter layers have been selected using the same durability criteria as for the rock. Filter bedding materials will be sized to drain water rapidly. The compacted radon barrier material will be protected from erosion by the overlying layers. Uniformity of the compacted radon barrier will be verified by adherence to design specifications for placement and compaction of the materials at the disposal cell.

3.0 DISPOSAL AND CONTROL OF RADIOACTIVE MATERIALS AND NONRADIOACTIVE CONTAMINANTS

3.1 GROUNDWATER PROTECTION STANDARD

The proposed disposal cell at the Lowman disposal site is designed to control radioactive materials and nonradioactive contaminants in conformance with proposed EPA groundwater protection standards as required in 40 CFR 192.02(a)(3). The DOE proposes to achieve compliance with the proposed EPA groundwater protection standards (Subparts A and B of 40 CFR 192) by meeting the EPA MCLs or background concentrations for designated hazardous constituents in groundwater, in the uppermost aquifer (alluvial/weathered granodiorite) at the POC at the Lowman disposal site near Lowman, Idaho. The DOE has concluded that the EPA groundwater protection standards will be met at the POC because, with the exception of antimony, none of the hazardous constituents that exceed the laboratory method detection limits detected within the pore fluids of the radioactive sands were above the proposed concentration limits. The DOE has demonstrated that antimony will meet the proposed concentration limits at the POC through attenuation in the subsoils beneath the disposal cell and by dilution in the groundwater underflow. The Lowman processing site is in compliance with Subpart B of 40 CFR 192 because statistical analyses of groundwater samples indicate no groundwater contamination.

The EPA groundwater protection standards consist of three components: 1) a list of designated hazardous constituents; 2) a corresponding list of proposed concentration limits for the constituents; and 3) a POC (NRC, 1989). These three main components are discussed below.

3.1.1 Hazardous constituents

Hazardous constituents at the Lowman disposal site were identified based on characterization of the radioactive sands, associated contaminated materials related to uranium recovery operations in the mill yard, and vicinity property materials. A description of the uranium recovery process, and evaluation of groundwater quality data is discussed in Attachment 3.

Hazardous constituents must satisfy the following two criteria: 1) they are reasonably expected to be in or derived from residual radioactive material to be in or derived from the residual radioactive material to be stabilized at the disposal site; 2) they are radium-226 and -228, uranium-234 and -238, nitrate, molybdenum, net gross alpha activity, or other constituents listed in Table A of 40 CFR 192.02(a)(3)(i) or Table 1 in 40 CFR 264. Hazardous constituents listed in Appendix VIII of 40 CFR 261 must meet background concentration limits. Since no chemicals were used in the uranium recovery process at Lowman, no Appendix VIII organics were listed as hazardous constituents. An Appendix I of 40 CFR 264 hazardous constituent screening of samples from on-site monitor wells confirms that there are no organic hazardous constituents in groundwater.

Concentrations of inorganic hazardous constituents and elements contained in hazardous constituent compounds related to uranium processing activities that exceed laboratory method detection limits in processed and unprocessed radioactive sand pore fluids include antimony, barium, molybdenum, net gross alpha, nitrate, and uranium. Chromium, lead, and radium-226 and -228 also exceeded the laboratory method detection limits in neutral pH batch-leach tests. Water samples were chemically analyzed for all of these constituents at the Lowman site and all of the parameters listed in Table 8.1 of the Technical Approach Document (DOE, 1989) (see Attachment 3). Of the constituents analyzed, most have MCLs specified by the proposed EPA groundwater protection standards (40 CFR 192), antimony has no MCL (see Table 3.1).

Because radioactive sand pore fluid concentrations of antimony exceed the statistical maximum for background water quality, only antimony will be designated a hazardous constituent with the potential to impact groundwater quality. All of the other constituents are below the proposed EPA MCLs and are not designated hazardous constituents with the potential to impact groundwater quality at the Lowman site. Section 3.2, Performance Assessment, describes how the design of the disposal cell and hydrogeologic properties of the site will allow antimony to meet concentration limits at the POC.

3.1.2 Proposed concentration limits

To achieve compliance with the proposed EPA groundwater protection standards at the Lowman disposal site, the DOE proposes to meet MCLs or background concentrations in groundwater in the uppermost aquifer (alluvium/weathered granodiorite) at the POC for the hazardous constituents designated in Section 3.1.1 (see Table 3.1). Table 3.2 summarizes the proposed concentration limits based on EPA groundwater protection standards, MCLs, and the statistical maximum background concentrations in groundwater in the alluvium/weathered granodiorite beneath the Lowman site.

3.1.3 Point of compliance

The POC at the Lowman site will be the downgradient edge of the designed disposal cell in the uppermost aquifer, which is the alluvium/weathered granodiorite (Figure 2.2). The number of monitor wells at the POC and the frequency of sampling are discussed briefly in Section 3.4, and will be presented in detail in the forthcoming surveillance and maintenance plan for the Lowman site. Groundwater in the uppermost aquifer (alluvium/weathered granodiorite) beneath the site will be monitored at the POC by sampling the on-site perennial spring and the POC monitor wells.

Table 3.1 Comparison of hazardous constituents to radioactive sand pore fluids, native soil pore fluids, statistical maximums for background groundwater, MCLs, and proposed concentration limits, Lowman site, Lowman, Idaho

Hazardous constituents[a]	Volume-weighted means from radioactive sands pore fluid concentrations[b]	Background native soil pore fluid concentrations[c]	Statistical maximums in background groundwater quality concentrations[d]	MCL	Proposed concentration limits
Antimony	0.023	0.031	0.005	--	0.005
Barium	0.058	0.05	0.40	1.0	1.0
Chromium	0.005	<0.01	0.02	0.05	0.05
Lead	0.005	<0.01	0.01	0.05	0.05
Molybdenum	0.011	0.03	0.01	0.1	0.1
Net gross alpha (pCi/l)	5.57	NA	1.47	15	15
Nitrate (as N)	3.62[f]	NA	3.18	10	10
Radium-226 and -228 (pCi/l)	1.8[e]	NA	1.0	35	5
Uranium	0.003	0.0043	0.004	0.044	0.044

[a]In milligrams per liter except where noted; pCi/l = picocuries per liter.
[b]Taken from TAC Calculation LOW-12-90-12-06.
[c]Taken from Table 3.8 of Attachment 3.
[d]Taken from Table 3.7 of Attachment 3.
[e]Average concentration of 13 neutral batch leach tests, taken from Table 3.12 of Attachment 3.
[f]Nitrate (as N) is derived from the analytical data (Tables 3.4 through Tables 3.17 of Attachment 3) reported in the compound form nitrate (as NO_3^-) divided by 4.4.

Table 3.2 Summary of DOE proposed concentration limits for hazardous constituents at the Lowman disposal site, Lowman, Idaho

Hazardous constituent	DOE proposed concentration limit[a]
Antimony	0.005[b]
Barium	1.0[c]
Chromium	0.05[c]
Lead	0.05[c]
Molybdenum	0.1[c]
Net gross alpha	15 (pCi/l)
Nitrate (as N)	10[c]
Radium-226 and -228	5[c] (pCi/l)
Uranium	0.044[c]

[a]In milligrams per liter where noted; pCi/l = picocuries per liter.
[b]Statistical maximum background groundwater. See Attachment 3 for analysis of background groundwater quality.
[c]EPA MCL (40 CFR 192.02).

3.2 PERFORMANCE ASSESSMENT

The DOE is required to demonstrate that the performance of the disposal cell at the Lowman site will comply with the EPA groundwater protection standards for hazardous constituents (40 CFR 192.02(a)(3)). To achieve compliance with the proposed EPA groundwater protection standards, the DOE proposes to meet MCLs or the statistical maximum in background groundwater for the designated hazardous constituents (listed in Section 3.1.1) in groundwater in the alluvium/granodiorite at the POC at the Lowman site. As discussed in Section 3.1.1, only concentrations of antimony have the potential to influence groundwater quality with regards to proposed EPA groundwater protection standards. The performance assessment will demonstrate that several hydrogeologic characteristics and design features allow the remedial action to meet the concentration limits at the POC. The hydrogeologic characteristics and design features are:

- Low concentrations in radioactive pore fluids.
- Groundwater beneath the site is not contaminated.
- The radioactive sands are physically and chemically inactive.
- Infiltration through the disposal cell is limited.
- Native soils contain higher concentrations of soluble metals than radioactive sand pore fluids.
- Negligible transient drainage of pore fluids.
- Dilution of seepage from the radioactive sands by groundwater underflow.

The following describes each of these characteristics and design features.

Low concentrations in radioactive sand pore fluids

Concentrations of all hazardous constituents in radioactive sand pore fluids are below concentration limits, except antimony (TAC Calculations LOW-12-90-12-06, LOW-04-90-12-07, and LOW-12-90-14-10).

Groundwater beneath the site is not contaminated

Presently, no groundwater contamination exists beneath the Lowman site in the uppermost aquifer (see Attachment 3). Thirty years after the placement of radioactive sands into piles at the Lowman site, groundwater samples from background monitor wells and groundwater samples from on-site/downgradient monitor wells are of the same statistical population, indicating the radioactive sands have not influenced groundwater beneath the mill site.

The radioactive sands are physically and chemically inactive

Both the processed and unprocessed radioactive sands at the Lowman site are highly resistant to physical decomposition and are chemically inactive. This is because the placer deposits from which the ore dredge product was derived have been subject to very late stages of physical and chemical weathering processes. In addition, the radioactive sands have been eroded and transported by fluvial processes to a new site of deposition. During this process, the reactive minerals were separated, leaving a placer deposit of highly resistant and chemically inactive/stable detrital mineral assemblages. Batch-leach test data also have shown that the radioactive sands are chemically inactive (see Attachment 3).

Infiltration through the disposal cell is limited

The proposed disposal cell includes design features that will limit infiltration to a rate approximately equal to or less than the current infiltration rate. The disposal cell features which will limit infiltration include:

- A 10 to one topslope and five to one sideslopes to rapidly drain any surface water off of the pile.
- Large-size rock riprap and a filter bedding layer placed on top of a radon barrier. The contrast in hydraulic conductivity between the filter bedding and the radon barrier will promote runoff and drainage of any surface water off the pile.

The disposal cell features designed to limit infiltration through the pile are shown in Figures 2.1 and 2.3.

Native soils contain higher concentrations of soluble metals than radioactive sand pore fluids

Pore fluid concentrations of the hazardous constituent antimony in the natural soils at the Lowman site are higher than concentrations measured in the radioactive sands. This comparison demonstrates that natural soil-forming processes in the Idaho Batholith generate higher concentrations of soluble metals than are present in the ore dredge product from which the radioactive sands were derived. A complete discussion of the geochemistry of the natural soils and radioactive sands is in Section 3.8 of Attachment 3. Because concentrations of antimony in groundwater are already in a geochemical equilibrium with native soil concentrations, the presence of radioactive sands will not influence groundwater quality.

Negligible transient drainage of pore fluids

During construction of the disposal cell, moisture in the radioactive sands may increase above existing conditions because of construction water added for material compaction and dust control. Drainage through the contaminated materials is expected to be minimized by placing the materials as dry as possible. The amount of water introduced during construction for

compaction and dust control and from precipitation will be controlled and monitored during the construction period.

The amount of construction water that will be is added to the disposal cell is approximately 2,000,000 gallons (RAC Calculation 12-660-01-00). This volume of water is equal to a layer approximately nine inches thick over the footprint of the cell. The least permeable foundation material has a hydraulic conductivity of approximately 4 x 10^{-3} cm/s (RAC Calculation 12-624-01-01). If all the construction water were to drain to the bottom of the cell immediately, the underlying material would absorb it in approximately seven days. In actuality, the construction water will drain to the bottom of the cell at a much lower rate.

Long-term ponding will not occur because the hydraulic conductivity of the foundation material is approximately 20 times the annual rainfall. Furthermore, the permeability of the foundation material is insensitive to the consolidation resulting from the weight of the disposal cell.

Dilution of seepage from the radioactive sands by groundwater underflow

Concentrations of antimony in radioactive sand pore fluids can be diluted by groundwater underflow to the proposed concentration limits at the POC. The volume-weighted mean concentrations of these hazardous constituents in seepage from the radioactive sands in the disposal cell were mixed with groundwater underflow of median background concentrations using a calculation procedure described in the Technical Approach Document (DOE, 1989). The resulting concentrations of antimony were below the proposed concentration limits at the POC in the alluvium/weathered granodiorite (uppermost aquifer; TAC Calculation #LOW 02-91-15-03-00).

3.3 CLOSURE PERFORMANCE ASSESSMENT

The DOE has demonstrated that the proposed remedial action plan at the Lowman disposal site will comply with Subpart A and Subpart B (40 CFR 192) of the proposed EPA groundwater protection standards by meeting MCLs or background concentrations at the POC. The DOE has assessed the performance of the designed disposal unit at the Lowman site in conjunction with the hydrogeologic system, and has shown that the disposal cell will minimize and control releases of hazardous constituents to groundwater and surface water and radon emanations 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 construction of the Lowman disposal cell so that long-term performance is ensured (see Section 2.2.2). The DOE has also demonstrated that the design features necessary for compliance with the EPA standards minimize the need for further maintenance of the disposal site.

3.4 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, which will be adequate to demonstrate that initial performance

of the disposal cell is in accordance with the design requirements. A detailed groundwater monitoring program will be provided in the surveillance and maintenance plan for the Lowman site.

A program to monitor groundwater in the uppermost aquifer (alluvium/weathered granodiorite) downgradient from the Lowman disposal cell will consist of analyzing groundwater samples from a series of monitor wells downgradient from the disposal cell at the POC. Existing DOE monitor wells (575, 580), both completed in the weathered granodiorite, will be retained for future groundwater monitoring. In addition to the existing and future POC monitor wells, the on-site perennial spring (561) will be monitored for water quality. Background groundwater quality will also continue to be monitored upgradient (monitor well 641) from the disposal cell. Existing monitor wells will be used where applicable, and new monitor wells will be installed as necessary. The proposed monitor well network is shown in Figure 2.2.

Performance monitoring frequency is outlined in the surveillance and maintenance guidance document (DOE, 1986). Compliance monitor wells will be sampled twice during the construction period, quarterly during the first two years following completion of remedial action activities, semi-annually during years three through six, and annually thereafter until the end of the performance monitoring period. The constituents to be monitored include designated hazardous constituents (see Table 3.2), major anions and cations, and the standard suite of field parameters.

The definition of an excursion for the designated hazardous constituents at the Lowman disposal site will be based on the exceedance of the MCLs or statistical maximums in background groundwater in the alluvium/weathered granodiorite. Potential excursions will be discussed in detail in the surveillance and maintenance plan. A natural variability is associated with proposed concentration limits for the designated hazardous constituents at the Lowman disposal site. This natural variability must be considered when defining excursions, and the proposed concentration limits should be reviewed and updated annually (if required) to incorporate additional background water quality data. This approach is consistent with the surveillance and maintenance guidance document (DOE, 1986).

3.5 CORRECTIVE ACTION PLAN

The DOE is required by 40 CFR 192.02(c) to provide an evaluation of alternative corrective actions that could be implemented if the disposal cell monitoring program indicates that the unit is not performing adequately. The DOE should consider reasonable failure scenarios of the disposal unit and demonstrate that corrective actions could be implemented no later than 18 months after detecting an excursion, as per the EPA regulations.

The Lowman disposal cell has been designed and will be constructed to perform for the mandated design life of 1000 years. The design of the cell has incorporated standard safety factors, and should therefore perform for a period of greater than 1000 years with minimal maintenance. It is not anticipated that the designed disposal cell at the Lowman site will fail,

because all natural materials will be utilized, and 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 Lowman site will comply with the proposed EPA groundwater protection standards in Subpart B of 40 CFR 192.

The present level of site characterization is sufficient to comply with Subpart B of 40 CFR 192. The DOE has decided that aquifer restoration (groundwater cleanup) is not necessary because of the lack of existing contamination.

Based on the current level of characterization at the Lowman site, cleanup of groundwater in the uppermost aquifer (alluvium/weathered granodiorite) is not necessary because concentrations of the designated hazardous constituents in groundwater are at or below the proposed EPA MCLs, or the statistical maximum for background concentrations, and consequently do not represent a risk to human health or the environment.

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