NUREG-1486

Final Safety Evaluation Report
To License the Construction and Operation of a Facility To Receive, Store, and Dispose of 11e.(2) Byproduct Material Near Clive, Utah

Docket No. 40-8989
Envirocare of Utah, Inc.

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards

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ABSTRACT

The Final Safety Evaluation Report (FSER) summarizes the U.S. Nuclear Regulatory Commission (NRC) staff's review of Envirocare of Utah, Inc.'s (Envirocare's) application for a license to receive, store, and dispose of uranium and thorium byproduct material (as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended) at a site near Clive, Utah. Envirocare proposes to dispose of high-volume, low-activity Section 11e.(2) byproduct material in separate earthen disposal cells on a site where the applicant currently disposes of naturally occurring radioactive material (NORM), lowl-level waste, and mixed waste under license by the Utah Department of Environmental Quality. The NRC staff review of the December 23, 1991, license application, as revised by page changes dated July 2 and August 10, 1992, April 5, 7, and 10, 1993, and May 3, 6, 7, 11, and 21, 1993, has identified open issues in geotechnical engineering, water resources protection, radon attenuation, financial assurance, and radiological safety. The NRC will not issue a license for the proposed action until Envirocare adequately resolves these open issues.

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ABBREVIATIONS

ACDE	annual committed dose equivalent
ACL	alternate concentration limit
AEA	Atomic Energy Act
ALARA	as low as is reasonably achievable
AMAD	activity median aerodynamic diameter
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BAR	Basin and Range Province
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
CFR	*Code of Federal Regulations*
CRSO	corporate radiation safety officer
DAC	derived air concentration
DOE	Department of Energy, U.S.
DOT	Department of Transportation, U.S.
DSER	Draft Safety Evaluation Report
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency, U.S.
FGEIS	Final Generic Environmental Impact Statement
FR	*Federal Register*
FRSO	field radiation safety officer
FSER	Final Safety Evaluation Report
HMR	Hydrometeorological Report
ICRP	International Commission on Radiological Protection
ISB	Intermountain Seismic Belt
LLW	low-level waste
MCE	maximum credible earthquake
MCL	maximum concentration limit
NARM	naturally occurring and accelerator-produced radioactive material
NCRP	National Council on Radiation Protection and Measurements
NGS	National Geodetic Survey
NMSS	Nuclear Material Safety and Safeguards, Office of
NOAA	National Oceanographic and Atmospheric Administration
NOR	notice of receipt
NORM	naturally occurring radioactive material
NRC	Nuclear Regulatory Commission, U.S.
NVLAP	National Voluntary Laboratory Accreditation Program
ORNL	Oak Ridge National Laboratory
PMF	probable maximum flood
PMP	probable maximum precipitation
PNL	Pacific Northwest Laboratory
POC	point of compliance
QA	quality assurance
QAP	quality assurance program
QC	quality control
RCRA	Resources Conservation and Recovery Act
RSO	radiation safety officer
RSR	radiation waste shipment and disposal record
RWP	radiation work permit
SI	saturation index
SOP	standard operating procedure
SSC	Superconducting Supercollider
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TEDE	total effective dose equivalent
TLD	thermoluminescence dosimeter
TP	technical position
UBRC	Utah Bureau of Radiation Control
UMTRA	uranium mill tailings remedial action
UMTRAP	uranium mill tailings remedial action project
UMTRCA	Uranium Mill Tailings Radiation Control Act
USGS	U.S. Geological Survey
USPCI	United States Pollution Control, Inc.
VPO	vice president of operations
WL	working level
WLM	working level month

1 INTRODUCTION

1.1 Background

The U.S. Nuclear Regulatory Commission (NRC) received the license application for the commercial disposal of 11e.(2) byproduct material from Envirocare of Utah, Inc. (applicant) in November 1989. In December 1989, NRC informed Envirocare that a notice of receipt (NOR) would be published in the *Federal Register* and that, until that was accomplished, it would not be appropriate to begin review of the license application. The NOR would document the basis of the NRC's review of the license application and was originally estimated to be complete by February 1990. The NOR was actually published in the *Federal Register* on January 25, 1991, upon Commission approval (56 *FR* 2959).

As presented by Envirocare in 1989, the proposed facility would be the first of its kind, a commercial facility accepting wastes from other generators, similar in some respects to low-level waste facilities regulated under Part 61 of Title 10 of the *Code of Federal Regulations* (10 CFR). However, the waste to be accepted was classified as byproduct material under Section 11e.(2) of the Atomic Energy Act of 1954, as amended, and its disposal was regulated under 10 CFR Part 40. As a result, the staff was involved in resolving many unique and complex legal, policy, and technical issues that could affect the licensing of the facility. The staff technical review of the license application resulted in several rounds of questions. The applicant has revised the license application to respond to these questions. The staff prepared the Draft Safety Evaluation Report (DSER) to document the review of the license application and identify unresolved open issues. In order to resolve the DSER open issues, Envirocare submitted several revisions to the license application dated April 2, 6, 7, and 10, 1993 and May 3, 6, 11 and 21, 1993. As a result of this evaluation, the NRC staff has concluded that, although all the open issues have not been completely resolved, the applicant has provided sufficient information to support the preparation and issuance of this Final Safety Evaluation Report (FSER). However, the NRC staff will not issue a license to Envirocare of Utah, Inc., until such time as all the open issues are adequately resolved. The remaining open issues will be closed through a supplement to this FSER. The FSER open issues are listed in Table 1.

1.2 Review Scope

By the notice of receipt, the Commission established the applicability of its regulations to this specific application for the commercial disposal of Section 11e.(2) byproduct material. The notice stated:

1. The Commission has determined that 10 CFR Part 40, including Appendix A, applies to the review of this application to dispose of Section 11e.(2) byproduct material. The applicant may request an exemption from any requirements in 10 CFR Part 40 that it believes should not apply.

2. The NRC staff and its contractors (Pacific Northwest Laboratory (PNL) and Oak Ridge National Laboratory (ORNL)) will prepare an environmental impact statement (EIS) pursuant to the requirements of 10 CFR Part 51. The EIS will be based on the staff evaluation of an environmental report to be prepared by the applicant.

3. Certain administrative and recordkeeping requirements delineated in 10 CFR Part 61, Subpart G, must be included in the license. These requirements are given in 10 CFR 61.80 and 61.82.

4. The waste manifest requirements contained in 10 CFR 20.311 will be made applicable by a license condition. The licensee will be allowed to accept waste only if it is accompanied by a manifest prepared according to 10 CFR 20.311. Based on the application, the NRC staff may consider, as part of the licensing process, exemptions for certain specific packaging, classification, and labeling requirements contained in 10 CFR 20.311, for land burial, that may not be germane to Section 11e.(2) byproduct material waste shipped to the facility. The staff will also require that more information be obtained from the generator on the chemical constituents and the "principal chemical form," as specified in 10 CFR 20.311(b), in order to address the data and ground water protection requirements of Appendix A to 10 CFR Part 40.

5. The general requirements of other Commission regulations: 10 CFR Part 19—"Notices, Instructions, and Reports to Workers: Inspections and Investigations"; 10 CFR Part 20—"Standards for Protection Against Radiation"; and 10 CFR Part 21—"Reporting of Defects and Noncompliance," will apply according to their terms."

Table 1 FSER Open Issues*

FSER Open Issue	Open Issue Status
F1	The applicant has not adequately demonstrated compliance with the stability of the cell cover design as required by Criterion 6 of Appendix A to 10 CFR Part 40 with regard to the effect of frost penetration (May 21, 1993, revisions). Specifically, the applicant must (1) verify their intention of modifying the thickness of the riprap/filter layer in cell cover design by making the appropriate modifications to the design in the entire application, (2) demonstrate that the proposed design will be effective for 1000 years with regard to frost protection, to the extent reasonably acheivable, and, in any case for at least 200 years, and (3) clearly demonstrate that frost penetration will not adversely impact the infiltration or radon emanation properties of the cover. (FSER Section 3.2.2.4) (D7)
F2	The applicant needs to demonstrate that bathtubbing due to the *transient* moisture buildup in the disposal cell will not occur in the postclosure period. The staff agrees that a sustained bathtubbing condition is not expected to prevail after a steady state has been reached, because the liner will have a higher hydraulic conductivity than the embankment cover (refer to Section 3.2.2.5 of this FSER), and the seepage rate from the cell will therefore exceed the rate of new moisture infiltration into the cell due to precipitation. However, transient buildup of the moisture in the cell cannot be ruled out because moisture already in the tailings embankment may accumulate in the lower part of the cell at a higher rate than the seepage rate through the liner. The resulting buildup of the moisture in the cell may be further exacerbated due to consolidation and reduction in the effective porosity of the tailings. (FSER Section 3.4.3.3) (D8)
F3	The applicant is required to demonstrate the compatibility of the waste solution and the material proposed for use as a bottom liner, as required by Criterion 5E of Appendix A to 10 CFR Part 40. (FSER Section 3.4.3.2) (D17)
F4	To comply with Appendix F to 10 CFR Part 20, the applicant needs to specifically ensure: (1) waste manifests include identification of the principal chemical form, solidification agent, and wastes containing more than 0.1 percent chelating agents by weight, with the weight percentage of the chelating agent estimated; (2) receipt of the waste is acknowledged within a week of receipt by returning a signed copy of the manifest or equivalent documentation; and (3) the provisions for recordkeeping and tracking are met. (FSER Section 6.1.2.1)
F5	The applicant's values for radon fluxes are not conservative and may be unrealistic. Therefore, the applicant must justify their proposed values or provide realistic values for the uncovered waste. (FSER Section 6.2.1.1.1)
F6	The applicant's reported estimates for annual radon and thoron releases are not conservative and may be unrealistic. Therefore, the applicant needs to re-examine and verify the estimates of radon and thoron release rates. (FSER Section 6.2.1.1.1)
F7	The applicant needs to justify eliminating the decay constant and time parameters from the equations for thoron releases and reassess potential thoron releases from unloading operations. (FSER Section 6.2.1.1.1)
F8	The applicant needs to reassess the estimated release rate for thoron from waste in storage and justify the basis of their calculations. (FSER Section 6.2.1.1.1)
F9	The applicant needs to revise calculations of radon and thoron specific flux for the high-activity waste and employ conservative assumptions or justify appropriate factors on a site-specific basis. (FSER Section 6.2.1.1.1)
F10	The applicant must add the contribution of airborne releases of radon from the covered portions of the disposal cell to the dose assessment. (FSER Section 6.2.1.1.1)

*See footnote at end of table.

Table 1 (continued)

FSER Open Issue	Open Issue Status
F11	The applicant has neglected the high-activity waste contribution to the release rate at the rollover and storage pads. Therefore, the applicant must account for these shortages in the assessment of particulate release rates from high-activity waste disposal operations. (FSER Section 6.2.1.1.2)
F12	The applicant is required to comply with the air effluent concentration limits. Therefore, the applicant must make modifications to the proposed operations in order to demonstrate compliance with the limits in Appendix B of Part 20. (FSER Section 6.2.1.1.3)
F13	The applicant must show that sufficient funds have been included in the financial surety arrangements to carry out any potential decontamination and decommissioning activities associated with ground-water compliance and corrective action at the Envirocare byproduct disposal cell. These funds should cover the costs of performing ground-water decommissioning and corrective action activities as if they were performed by an independent contractor. The decommissioning costs should include all costs associated with monitoring well and piezometer abandonment and/or replacement that will be needed during the term of the license. Corrective action costs should include all costs associated with restoring ground-water quality to the regulatory standards in the event of noncompliance during the term of the license, as described in Criterion 5D. (FSER Section 9) (D85)

*The FSER open issues listed in this table are either issues carried over from the DSER because additional information is still needed for their resolution or new open issues that resulted from new or additional information provided by the applicant. Nevertheless, the open issues listed here do not hinder the issuance of the FSER. It will be necessary for the applicant to resolve the FSER open issues before the NRC staff can issue a license. The resolution of these open issues will be documented in supplements to this FSER.

Therefore, the NRC staff review was performed in accordance with the above notice and consisted of a comprehensive assessment of the license application to ensure the applicant has demonstrated compliance with the applicable regulations.

1.3 Description of the Proposed Action

Envirocare has applied for a license to receive, store, and dispose of uranium and thorium byproduct material, as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended, at a site in Clive, Tooele County, Utah (Figure 1). The applicant proposes to dispose of high-volume, low-activity 11e.(2) byproduct material received in bulk by rail and truck in one of two disposal cells or embankments constructed largely above grade (Figure 2). The applicant proposes, in the long term, for the disposal site to have a maximum total design capacity of 7.6 million cubic meters (m^3) (10 million cubic yards (cy)) and a design life of up to 1000 years. The current application, however, is to initially allow disposal of 2.3 million m^3 (3 million cy) in two triangular disposal cells. The embankments will be constructed in a continuous "cut and cover" operation, as follows:

(1) Existing terrain will be excavated to a depth of approximately 2.4 meters (m) (8 feet (ft)) with overburden stockpiled for future use in capping the embankments.

(2) A 0.6-m (2-ft) clay liner will be constructed under all areas where waste material will be placed. The clay liner will consist of 0.3 m (1 ft) of scarified and recompacted in situ clay and 0.3 m (1 ft) of processed clay. The clay liner is to provide a seepage liner/retardant on the bottom of the embankments.

(3) The 11e.(2) byproduct material will be placed on the liner, in lifts, and compacted in place to a maximum height of 11.3 m (37 ft) above original ground elevation.

(4) A 2.1-m (7-ft)-thick layer of clay (the overburden mentioned in (1) above) will be placed on top and compacted to form a radon barrier.

(5) An erosion protection barrier consisting of a 0.46-m (1.5-ft)-thick layer of specification-sized rock will be placed over a 0.15-m (0.5-ft)-thick filter zone of small-diameter rock.

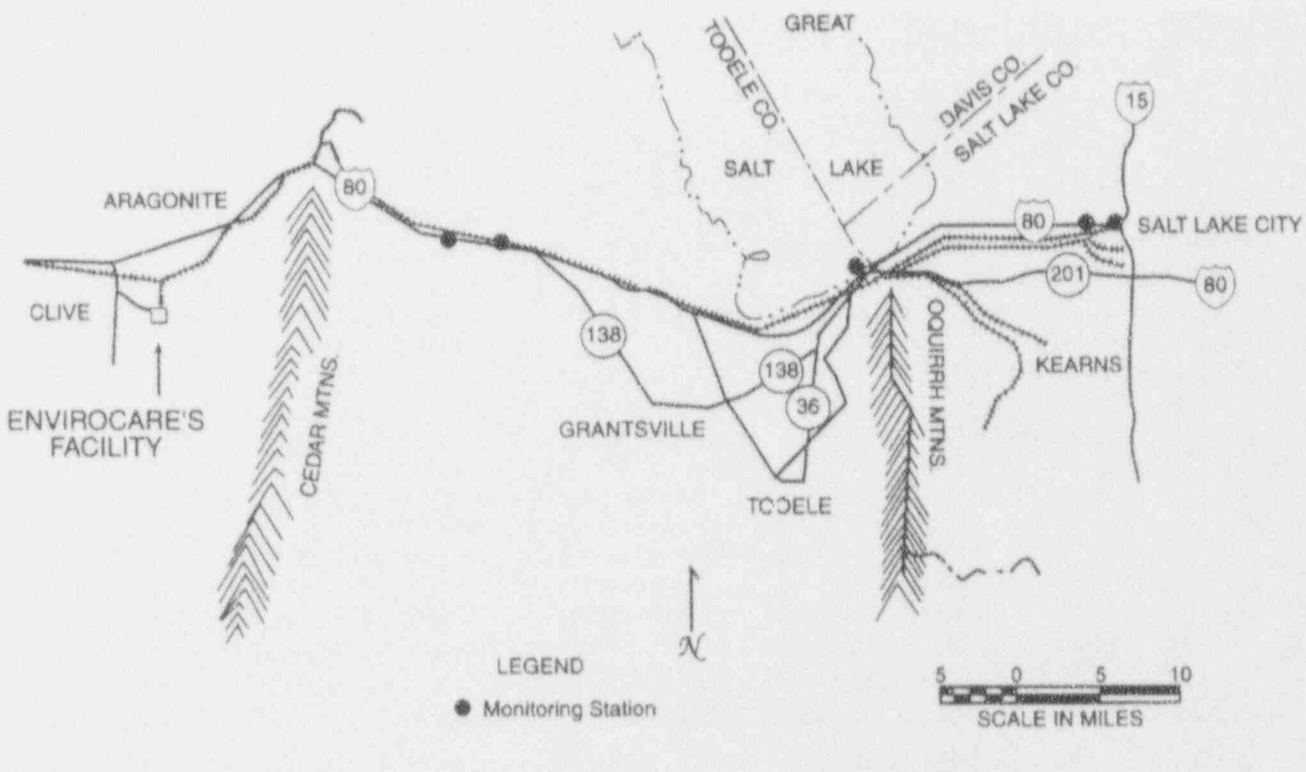


Figure 1 General Site Location

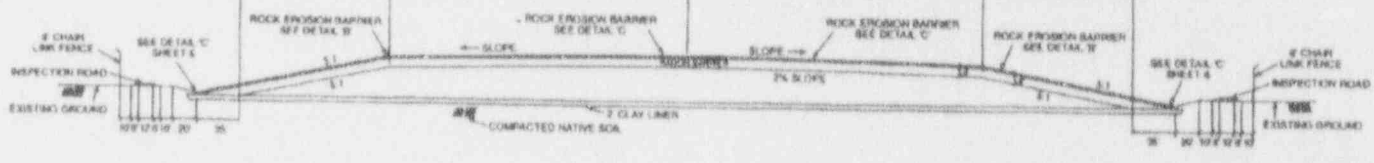


Figure 2 General Embankment Design

The applicant proposes to conduct the 11e.(2) byproduct material disposal operation at its site in Clive, where it is currently disposing of naturally occurring radioactive material (NORM), low-level radioactive waste, and mixed waste under separate license by the Utah Department of Environmental Quality.

1.4 Open Issues

The NRC staff review of the Envirocare revised license application identified a number of open issues that have not been adequately resolved in the applicant's responses to the DSER open issues or additional open issues that resulted from new or modified information provided in the revised license application. These open issues are listed in Table 1. Until these open issues are adequately resolved, the NRC cannot support the issuance of a license to Envirocare for the receipt, storage, and disposal of 11e.(2) byproduct material.

1.5 Criteria Compliance Summary

The major technical portion of the NRC staff review of the Envirocare license application is to ensure compliance with Appendix A to 10 CFR Part 40. However, Envirocare is responsible for meeting the applicable regulations of 10 CFR Parts 19, 20, 21, and 61, Subpart G.

2 AUTHORIZED ACTIVITIES

2.1 Location

The proposed disposal site is located approximately 120 kilometers (km) (75 miles (mi)) west of Salt Lake City in the Great Salt Lake Desert, about 4 km (2.5 mi) south of Interstate 80 and 1.6 km (1 mi) south of a switch point called Clive on the tracks of the Union Pacific railroad system in Tooele County, Utah (Figure 1). The entire parcel of land containing all of Envirocare's operations consists of Section 32, Township 1 South, and Range 11 West of the Salt Lake Base and Meridian, with the exception of approximately 404,687 square meters (m^2) (100 acres) containing the Vitro Remedial Action Project. Most of the land within a 16.1-km (10-mi) radius of the proposed site is public domain land administered by the Bureau of Land Management.

2.2 Facility Description

Envirocare of Utah, Inc., has applied for a license to receive, store, and dispose of uranium and thorium byproduct material, as defined in Section 11e.(2) of the Atomic Energy Act, as amended, at a site in Clive, Tooele County, Utah. The applicant proposes to dispose of high-volume, low-activity 11e.(2) byproduct material received in bulk by rail and truck in one of two disposal cells or embankments constructed largely above grade. Figure 3 shows the proposed layout of the facility and the proposed location of the disposal cells.

Envirocare's proposed facility is located adjacent to the closed disposal cell containing approximately 1.91 million m^3 (2.5 million cy) of uranium mill tailings reclaimed by the U.S. Department of Energy (DOE) pursuant to Title I of the Uranium Mill Tailings Radiation Control Act (UMTRCA). This facility, called the Vitro Remedial Action Project, is currently owned by the State of Utah, but will be transferred to DOE after NRC concurs that remedial action at that site has been completed in accordance with Environmental Protection Agency (EPA) standards in 40 CFR 192, Subparts A–C. The DOE will then become a licensee of the NRC under 10 CFR 40.27 for long-term care of the site.

In addition, Envirocare also currently operates other disposal operations adjacent to the proposed 11e.(2) byproduct material disposal site (see Figure 3). These include:

(1) An active disposal cell for the disposal of NORM material, operated by Envirocare under license from the Utah Bureau of Radiation Control (UBRC).

(2) A disposal cell for the disposal of mixed waste/NORM material, to be operated by Envirocare under appropriate State regulatory authority. The total estimated quantity of mixed waste to be disposed of is 688,140 m^3 (900,000 cy).

(3) A low-level waste disposal cell for byproduct, source and certain quantities of special nuclear materials, which Envirocare operates under a license from UBRC. The total estimated quantity of low-level waste to be disposed of is 1,758,580 m^3 (2,300,000 cy).

2.3 General Facility Operation

Envirocare will be accepting for disposal 11e.(2) byproduct material transported to the site by truck and/or rail from customers that could be located anywhere in the United States. The waste transported to the site for disposal will be placed in disposal cells or embankments constructed largely above grade. The applicant proposes, in the long term, for the disposal site to have a maximum total design capacity of 7.6 million m^3 (10 million cy) for 11e.(2) byproduct material and a design life of up to 1000 years. The current application, however, is to initially allow disposal of 2.3 million m^3 (3 million cy) in two triangular disposal cells. The proposed 11e.(2) byproduct material disposal cell will be constructed in a continuous "cut and cover" operation:

(1) The existing terrain will be excavated to a depth of approximately 2.4 m (8 ft). The excavated overburden will be stockpiled for use in capping the embankments in the future.

(2) A 0.6-m (2-ft)-thick clay liner will be placed in the cell. The liner will consist of 0.3 m (1 ft) of in situ clay scarified and recompacted to 95 percent of a standard Proctor and 0.3 m (1 ft) of processed clay.

(3) The material for disposal will be placed on the liner in 0.3-m (1-ft) lifts and compacted in place to a maximum height of 11.3 m (37 ft) above original ground elevation.

(4) When an embankment is filled to the maximum height, a constructed cover will be placed over the waste. This cover will consist of a 2.1-m (7-ft)-thick layer of clay that will be placed on top and compacted to form a radon barrier. Overlying the clay cover will be a 0.15-m (0.5-ft)-thick filter zone of small-diameter rock. The final layer of the embankment cover is the erosion protection layer consisting of 0.45 m (1.5 ft) of specification-sized rock. A cross-section of the proposed disposal cell is provided in Figure 2.

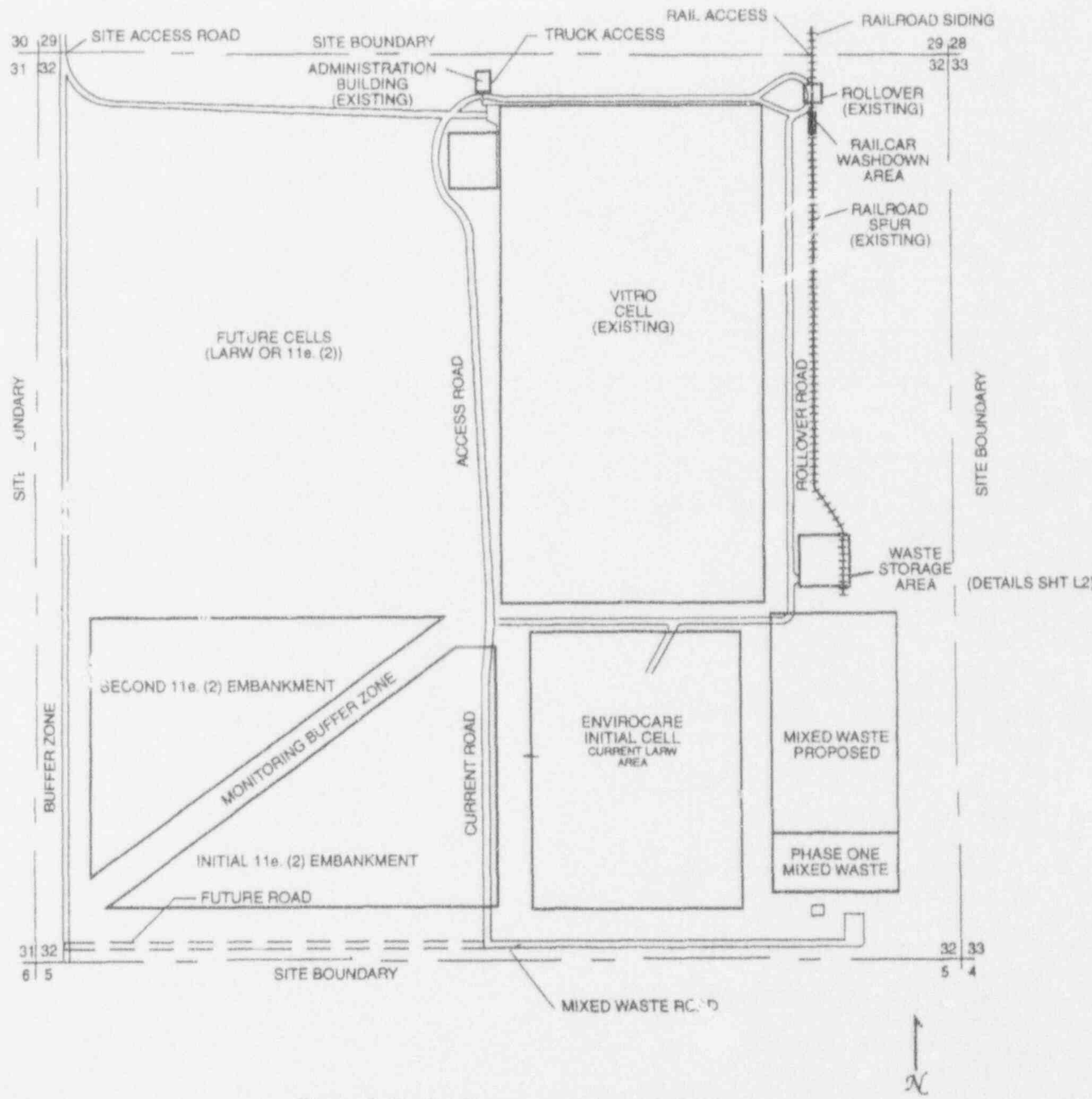


Figure 3 Facility Layout and Disposal Cell Location

Public access to the site will be controlled by fences during construction and after operation.

2.4 Site and Byproduct Material Ownership

At the present time, Envirocare owns the property to be used for the proposed disposal facility and will be responsible for site closure, as well as the long-term maintenance and monitoring of the disposal cell. Envirocare has also obtained the water rights at the site and has applied for the mineral rights. An affidavit has been filed with Envirocare's land ownership records in Tooele County stating that the land is being used to manage radioactive and hazardous waste and the postclosure use of the land is restricted under 40 CFR 264.117(c).

Upon termination of Envirocare's Part 40 license, in accordance with 10 CFR 40.28, the ownership of the land will be transferred to DOE, another Federal agency as designated by the President, or the State of Utah. At that time, Envirocare will transfer the land to DOE or the State without cost to that government except administrative and legal costs incurred in carrying out such transfer. DOE, another designated agency, or the State will be responsible, under the general license in 10 CFR 40.28, for custody of and long-term care of the site, including monitoring, maintenance, and emergency measures necessary to protect the public health and safety and other actions necessary to comply with the standards.

3 TECHNICAL SITING AND DESIGN EVALUATION

3.1 Geology and Seismology

This section of the FSER documents the staff's review of the geologic and seismic information for the proposed 11e.(2) byproduct material disposal facility. Background geologic and seismic information is derived from Envirocare's license application (Envirocare, 1993), supplementary information provided during the review process, staff site visits, and independent sources, as cited.

3.1.1 Geology and Seismologic Characterization

Appendix A to 10 CFR Part 40 contains the NRC regulations against which this site is being licensed. These regulations do not specifically require a comprehensive characterization of generic and site-specific geologic or seismic conditions at such facilities. This information is necessary, however, in order to meet the specific requirements of Appendix A, Criteria 1, 3, 4, 5A(3), and 5G(2). In addition, Appendix A to 10 CFR Part 40 requires that control shall be designed to be effective for up to 1000 years, to the extent achievable, and in any case for at least 200 years. NRC staff has interpreted this standard to mean that certain geologic and seismic conditions must be met in order to have reasonable assurance that the long-term performance objectives will be achieved.

3.1.1.1 Geologic and Stratigraphic Setting

The proposed site is located in the extreme eastern margin of the Great Salt Lake Desert (see Figure 1) that is part of the Basin and Range Province (BAR) of North America. The BAR topography is typified by block-faulted mountain ranges that generally trend north to south separated by alluvial filled basins. The block-faulted mountains mainly consist of Paleozoic limestones, dolomite, shales, quartzite, and sandstones. The basins consist mainly of sediments originating from Quaternary lacustrine Lake Bonneville deposits and Quaternary and Tertiary colluvial and alluvial materials eroded from adjacent mountains. Tertiary extrusive igneous rocks of basaltic lava flows and pyroclastics are also found in isolated areas of the Great Salt Lake Desert. Table 2 shows the stratigraphic units expected to be found within the region of the proposed site.

The unconsolidated to semiconsolidated valley fill is about 244 to 305 m (800 to 1000 ft) thick throughout the central portions of the valleys in the Great Salt Lake Desert. The unconsolidated and semiconsolidated materials comprising the valley fill consist of intercalated colluvium, alluvium, lacustrine, and fluvial deposits with some deposits of eolian material. Thick beds of alluvial fans fringe the mountain ranges. The colluvial and coarse alluvial deposits are near the mountain ranges where they contain a wide range of grain sizes, varying from boulders to clay. Extending to the center of the valleys, the deposits grade into well-sorted beds of sand and gravel interlayered with alluvial and lacustrine silt and clay. The alluvial fans grade laterally into fine-grained alluvium and thin toward the center of the valleys where it is present as a veneer overlying and adjacent to fine-grained Lake Bonneville lakebed deposits.

The site area is located in, and is bounded by the Great Salt Lake Desert to the west at approximate elevations of 1295 to 1311 m (4250 to 4300 ft). To the north of the site are the Grayback Hills, composed of Tertiary volcanic rocks, consisting mainly of basalt lava flows and pyroclastics. To the west are low-lying hills containing outcrops of Paleozoic limestones and dolomites that rise 15 to 30.5 m (50 to 100 ft) from the desert floor. To the east and southeast, the site is bounded by the north-south trending Lone Mountain, which is a peak on the west flank of Cedar Mountain. These mountains, which rise to a height of 1634.3 m (5362 ft), also consist of Paleozoic limestones, dolomites, and shales. At the base of Lone Mountain, alluvial fans slope gently toward the west at a gradient of approximately 7.6 m/km (40 ft/mi). The site has topographic relief of approximately 3.4 m (11 ft), sloping in a southwest direction at a gradient of approximately 0.0019.

The site rests on Quaternary lakebed deposits of Lake Bonneville and the subsurface logs indicate that these lacustrine deposits extend to a depth of approximately 76.2 m (250 ft). The underlying Tertiary and Quaternary age valley fill is composed of semiconsolidated clays, sands, and gravel where it comes in contact with bedrock. Although the exact depth to and relationships of various bedrock units are unknown, the presence of nearby outcrops and the regional block-faulted basins suggest that the valley-fill deposits are thin within the area of the site. Estimated down-dip projections from bedrock outcrop on the southwest corner of Section 31 and bedrock found at depth in Aptus wells suggest that the contact may dip to the east about 3 degrees.

The U.S. Soil Conservation Service mapped the soil of the South Clive site as Iosepa Silt Loam. A horizon of clay and alkali (sodium) has accumulated near the surface. Relatively high clay content at depths of 4 to 37.5 centimeters (cm) (1.6 to 15 inches (in)) and sodium content combine to give the South Clive site soils an impervious nature.

The NRC staff reviewed the details of the regional and site-specific stratigraphy as provided by the applicant in the license application. As a result of this review, the NRC staff concludes that the characterization of the site

Table 2 Stratigraphic Units

Era	Period/Epoch	Formation	Thickness (ft)	Lithology
CENOZOIC	Quaternary/ Pleistocene	Lake Bonneville Gp	500-800	Lakebed deposits and older alluvium deposits.
PALEOZOIC	Permian	Pequop Fm	2800	Limestone, dolomite, shale and quartzite.
	Devonian	Pilot Shale	330	
		Guilmette Fm	2840	
		Simonson Dolomite	600	
	Silurian	Laketown Dolomite	1310	
	Ordovician	Fish Haven Dolomite	350	
		Eureka Quartzite	490	
		Crystal Peak Dolomite	150	
		Swan Peak Quartzite	540	
		Kanosh Shale	400	
		Garden City Limestone	3590	
	Cambrian	"Notch Peak" Fm	1000 + /–	
		Worm Creek Quartzite	60	
		Undiff. Middle and Upper Cambrian	1000 + /–	

Note: 1 ft = 0.3048 m.

adequately establishes the regional and site-specific stratigraphy to support the applicant's assessment of geologic stability.

3.1.1.2 Structural Setting

The proposed site is located near the eastern margin of the BAR, which consists of a system of high-angle normal faults separated by the horsts and grabens, with fault displacements in excess of 1524 m (5000 ft). The BAR is an extensional environment with a northwest direction of crustal extension in the site area, as determined from stress studies (Zoback and Zoback, 1980) and earthquake focal mechanisms with an extensional direction of about N80E–S80W. The northern portion of the BAR is estimated to have undergone about 190 km (118 mi) of extension since mid-Miocene.

Geodetic measurements in the Great Basin indicate ongoing tectonic uplift of the region from 1 to 2 mm/yr (0.04 to 0.08 in/yr) between central Nevada and the Wasatch Front. Additional uplift of $\pm$1.5 0.5 mm/yr (0.06 $\pm$ 0.02 in/yr) in western Utah occurs from isostatic crustal adjustment from unloading, the result of the desiccation of ancient Lake Bonneville about 10,000–13,000 years ago.

The site is on the far reaches of the alluvial apron extending from the western flank of Cedar Mountain. Regional gravity surveys of the northern portion of the Great Salt Lake Desert indicate that the BAR horst and graben topography exists below the surface of the nearly flat desert. Extensive high-angle normal faulting bounds the buried structures and has gravity-determined displacement of hundreds of meters (Cook, 1964). The site is in a transition zone between buried to exposed BAR topography.

The proposed site is located approximately 112.7 km (70 mi) to the west of the boundary between the BAR and the Middle Rocky Mountains. This margin coincides with the Wasatch fault. This fault is a 370-km (230-mile)-long active normal fault zone along which young mountain blocks have been uplifted to form a prominent west-facing topographic escarpment known as the "Wasatch Front." This margin is also associated with the Intermountain Seismic Belt (ISB).

The ISB is a coherent belt of earthquake activity extending more than 1300 km (808 mi) from southern Nevada and northern Arizona to northwestern Montana (see Smith and Sbar, 1974; Smith, 1978). In general, the ISB is characterized by late Quaternary normal faulting, diffuse shallow seismicity (focal depths <15-20 km (11.5-12.4 mi)), and episodic scarp-forming earthquakes (M~6.5-7.7) associated with the complex interaction of subplates within the western North American plate (e.g., Smith and Sbar, 1974; Smith, 1978). The ISB follows the boundary between the relatively thin crust and lithosphere of the BAR and the thicker, more stable crust and lithosphere of the Middle Rocky Mountain and Colorado Plateau Provinces.

In the immediate site area, reports by Arabasz and others (1987) and Barnhard and Dodge (1988) thoroughly assessed and mapped evidence of surface faulting in late Quaternary time. Barnhard and Dodge mapped all fault scarps on unconsolidated sediments in the Tooele 1 degree by 2 degree Quadrangle, which includes all area within 72.4 km (45 mi) of the South Clive site. Because unconsolidated sediments (primarily Lake Bonneville lacustrine deposits) cover about 80 percent of the area, the inventory is relatively complete. The latest stage of Lake Bonneville occurred about 10,000 years ago; thus, all sediment surfaces offset by recognizable faulting in the past 10,000 years are noted on their map. Arabasz and others (1987) further evaluated the faults in the region and noted all faults that have moved or are suspected of movement in the late Quaternary time (last 500,000 years).

Faults that could pose a hazard to the site include fault zones along the east flank of Cedar Mountain, the west flank of the Lakeside Mountains, the east flank of the Newfoundland Mountains, the west flank of the Stansbury Mountains, and Puddle Valley (see Figure 4). Active Holocene faulting is not known to have occurred in the vicinity of the site. Most of the faulting occurred between 1 million and 25 million years ago.

The NRC staff has reviewed the details of the regional and site-specific structural setting as provided by the applicant in the license application. As a result of this review, the NRC staff concludes that the characterization of the site adequately establishes the regional and site-specific structural geology to support the applicant's assessment of geologic stability.

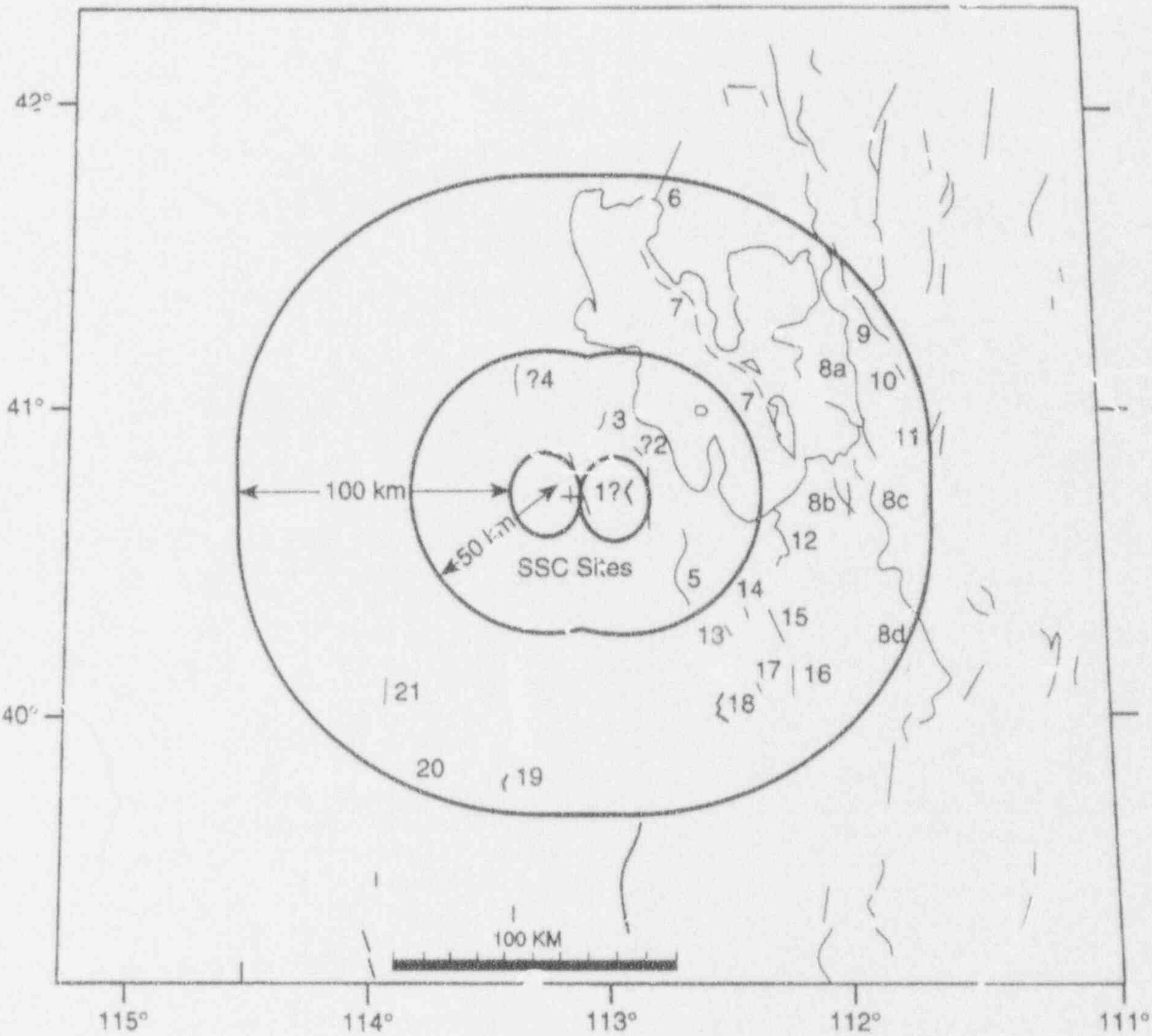
3.1.1.3 Geomorphic Setting

The geomorphology of the proposed site is typical of a semi-arid to arid desert setting. At the boundary of the Great Salt Lake Desert, the ranges are affected by mass-wasting and fluvial erosion resulting from ephemeral streams entering the desert basin and depositing their load as they evaporate or infiltrate. The perimeter of the desert basin is therefore impacted by the deposition and erosional processes of alluvial fans along the desert mountains. The central portion of the basin, as in the site area, has a relatively flat topographic relief and is unaffected by surface fluvial activities. In addition mechanical and chemical weathering processes advance at very slow rates. The NRC staff has reviewed the details of the regional and site-specific geomorphology as provided by the applicant in the license application. As a result of this review, the NRC staff concludes that the characterization of the site geomorphology is adequate to support the applicant's assessment of geologic stability.

3.1.1.4 Seismicity

Regional seismicity maps have been compiled for Utah based on available historical data from 1850 through 1987. The epicenter maps show that earthquakes of about magnitude 2.5 and larger have not occurred in the site area since 1962. The local seismograph networks have provided information in the site area since about 1962; prior to that the seismicity of the site region is based on either the worldwide seismographic network or "felt" reports. These earlier maps do not have the definable lower detection limits for earthquake size in the area. However, the database is probably sufficient to define all earthquakes above magnitude 5.5. Figure 4 shows no epicenters in the left Superconducting Supercollider (SSC) ring, the area in which the South Clive site lies (Arabasz et al., 1987).

The only historical earthquake in Utah with surface rupturing occurred in Hansel Valley in 1934. The site is about 100 km (62 mi) north of the proposed site. The 1934 Hansel Valley event is the only moderate to large historical earthquake to pose significant hazard to the site, but this hazard is less than that associated with nearer seismogenic structures.



FAULTING LEGEND

1. E. Flank of Cedar Mtn.
2. W. Flank of Lakeside Mtns.
3. NW Puddle Valley
4. E. Flank of Newfoundland Mtns.
5. W. Flank of Stansbury Mtns.
6. Hansel Valley Fault
7. E. Great Salt Lake Fault

8a. Wasatch Fault, Ogden Segment
8b. West Valley Fault
8c. Wasatch Fault, SLC Segment
8d. Wasatch Fault, Provo Segment

9. Ogden Valley Fault Zone
10. Morgan Fault
11. E. Canyon Fault
12. N. Oquirrh Mtns.
13. Clover, NE Onaqui Mtns.
14. St. John Station
15. Mercur, SW Onaqui Mtns.
16. Topliff Hill
17. Vernon Hills
18. E. Flank of Sheeprock Mtns.
19. E. Flank of Fish Springs Mtns.
20. SE Flank of Deep Creek Mtns.
21. NW Flank of Deep Creek Mtns.

Figure 4 Site Area Faulting

Recent seismic activity is believed to be the result of rebound from the dewatering of ancient Lake Bonneville over 15,000 years ago. The principal evidence for this hypothesis is the dates that have been assigned to the various fault scarps in this area. Many of those dates cluster in the period of time that the valleys were being dewatered. For example, all of the Quaternary fault features listed in Table 4.1 of Appendix K that are located west of the Wasatch fault have ruptures dated older than 8000 years, except for two faults: the Hansel Valley fault (100 km (62 mi)) north of the South Clive site) that ruptured 55 years ago and the fault on the east flank of the Fish Spring Mountains (88.5 km (55 mi) south of the site) that ruptured about 2000 years ago. Thus, it appears there was much more seismic activity in western Utah 8000 years to 15,000 years ago, when Lake Bonneville fell from the Provo level to the present dewatered condition, than in the more recent millennia. Nevertheless, because of the ongoing crustal extension in the BAR, there is a continuing low level of seismic activity as evidenced by the more recent fault features and occasional earthquakes.

The NRC staff has reviewed the details of the regional and site-specific seismicity as provided by the applicant in the license application. As a result of this review, the NRC staff concludes that the characterization of the site adequately establishes the regional and site-specific seismicity to support the applicant's assessment of geologic stability.

3.1.1.5 Resource Development

Natural resources in Tooele County include limestone, metallic minerals, potassium, tungsten, salt, clays, and sand and gravel. Gravel quarries have been located in the alluvial fans that flank Cedar Mountain (DOE, 1984). Mineral extraction by evaporation of brine occurs near Knolls, about 16.1 km (10 mi) northwest of the site. Limestone is quarried in Cedar Mountain about 8 km (5 mi) east of the site. Oil and gas production does not take place in the site area. Although the area has been classified as prospectively valuable for oil and gas, that classification is based on very general criteria. Previous exploration near the west side of the Great Salt Lake revealed a low-grade product with little or no yield. There is no coal production in the area or geologic formations with coal resources. No active or pending mining claims or mineral leases are located on the site.

The NRC staff has reviewed the details of the regional and site area natural resources as provided by the applicant in the license application. As a result of this review, the NRC staff concludes that the applicant adequately and sufficiently characterized the natural resources of the region to support the applicant's assessment of geologic stability.

3.1.2 Geologic and Seismic Stability

Geologic and seismic conditions and processes are characterized to determine the ability of the site to meet the requirements of Appendix A to 10 CFR Part 40. In general, site lithologic, stratigraphic, and structural conditions are considered for their suitability as a disposal cell foundation and their potential interactions with tailings leachate and ground water. Geomorphic processes are considered for their potential impact on long-term tailings stabilization and isolation. Potential geologic hazards, including earthquakes, liquefaction, onsite fault rupture, ground collapse, and volcanism, are identified to ensure the long-term stability of the proposed disposal site and the success of the disposal cell design.

3.1.2.1 Geologic/Bedrock Stability

The historical earthquake record alone (Section 3.1.1.4) does not provide a complete guide to assessing seismic potential in the western United States—and indeed, in most seismically active regions of the world—and information from late Quaternary faulting is essential to consider (Arabasz et al., 1987). There is clear evidence of surface faulting during late Quaternary time (approximately the last 500,000 years) throughout parts of the BAR to the west of the Wasatch fault. However, there appear to be domains in which there is evidence of late Quaternary but not Holocene faulting, and significantly large areas of the BAR in which late Quaternary faulting is absent. Eastern Nevada and parts of western Utah are thus characterized.

Two first-order faults that form part of the seismotectonic framework of the region surrounding the site (Figure 4) are the Wasatch fault zone and the East Great Salt Lake fault. These faults are located in the Intermountain Seismic Belt, which corresponds to the eastern margin of the BAR where it comes in contact with the Rocky Mountain Seismotectonic Province.

The Wasatch fault is by far the best-studied fault depicted in Figure 4. Data from five trenches across the fault summarized by Schwartz and Coppersmith (1984) indicate late Quaternary slip rates of about 1 mm/yr (0.04 in/yr) and vertical displacements during prehistoric earthquakes of 1.6-2.7 m (5.2-8.8 ft), with an average displacement per event of about 2 m (6.6 ft). Average recurrence intervals determined at four trenching sites along the central part of the fault between about 39°25′N and 41°00′N range from 1700 to 3000 years.

A second major fault zone shown in Figure 4 is one beneath the Great Salt Lake. This fault zone, named the East Great Salt Lake fault zone by Cook (1964), can be clearly seen in seismic reflection profiles across the lake (Mikulich and Smith, 1974), indicating major subsidence during the past 2.5 million years.

The East Great Salt Lake fault cuts sediments identified as Quaternary on the basis of well data (Mikulich and Smith, 1974) and must be considered active. Seismic reflection data (Mikulich and Smith, 1974) indicate that the East Great Salt Lake fault appears to offset sediments to within at least a 0.015- to 0.025-sec two-way travel time beneath the lake bottom, which corresponds to an approximate depth of less than 14-23 m (46-75 ft). This implies that slip has occurred in the recent geologic past. Viveiros (1986, p. 72) estimated fault slip rates on the East Great Salt Lake fault of 0.96 mm/yr (0.04 in/yr) during the Pliocene and 1.48 mm/yr (0.06 in/yr) during the Quaternary from the thicknesses of sedimentary deposits—dependent upon an interpreted geometry of faulting. Pechmann* interpreted fault slip rates of about 0.4 mm/yr (0.0013 ft/yr) during the Pliocene and 0.5 mm/yr (0.02 in/yr) during the Quaternary from a true-scale cross-section. These slip rates are about half the recent slip rates along the Wasatch fault.

Within 50 km (31 mi) of the site area, the faults that could pose a hazard to the site include fault zones along the east flank of Cedar Mountain, the west flank of the Lakeside Mountains, the east flank of the Newfoundland Mountains, the west flank of the Stansbury Mountains, and Puddle Valley (Arabasz et al., 1987). Of the faults listed in Figure 4, Arabasz and others (1987) included faults 1, 2, and 4 only for the sake of argument and question the originator's data for the existence of these faults. Faults 3 and 5, however, are considered active and fault 3 may have ruptured as recently as latest Pleistocene or early Holocene time (9000 years ago). Late Quaternary faulting in the "western Desert" region is incomplete because of fluctuations of ancient Lake Bonneville, although the Holocene record of any significant surface faulting should be complete. Because of the presence of many single-event fault scarps in this region, the incomplete late Quaternary record, and the low slip rate (long recurrence), the possibility of future surface rupture cannot be confidently restricted to those fault sources identified in Figure 4 and Table 3.

*J. C. Pechmann, "Earthquake Design Considerations for the Inter-Island Piking Project, Great Salt Lake, Utah," unpublished technical report submitted to Rollins, Brown, and Gunnell, Provo, Utah, 1987.

The NRC staff has reviewed the data presented by Envirocare in their license application and concurs with their conclusions regarding the capability of the faults in the immediate site area. The effects of the capable faults on the design of the disposal facility are discussed in FSER Section 3.2.2.

3.1.2.2 Geomorphic Stability

As stated in Section 3.1.1.3, the regional geomorphology of the proposed site is typical of a semi-arid to arid desert environment. The geomorphic processes at the site are limited to microprocesses that occur in the soil. In the Great Salt Lake Desert precipitation is less than evaporation. As a result, water, available by lateral infiltration from the adjacent mountains, is drawn upward through the soil by capillary action and evaporates in the soil profile or at the ground surface. Calcium carbonate, gypsum, and alkali are precipitated out of the water during evaporation and are deposited in the soil. Macrogeomorphic processes are almost nonexistent where the general rate of weathering is very slow, due to the low precipitation, flat relief, and lack of fluvial activities.

As a result of its review of the information in the license application, the NRC staff has concluded that the regional and site-specific geomorphology do not impact the geologic stability of the proposed site.

3.1.2.3 Seismotectonic Stability

To assess the hazard to the site and to determine site design criteria, a maximum credible earthquake (MCE), as defined in Appendix A to 10 CFR Part 100, must be established for each seismogenic fault that could affect the site. In addition to the capable fault analysis, the applicant must analyze the regional seismicity and tectonics to determine the "floating earthquake" (an earthquake not associated with known faulting) in the BAR and

Table 3 Site Area Faulting

Fault No.	Name	Closest Approach km (mi)	Magnitude	Site Acceleration (g) Mean + 1 sig
1	E. flank of Cedar Mt.	19 (12)	6.6	0.34
2	W. flank of Lakeside Mts.	29 (18)	6.5	0.21
3	NW Puddle Valley	29 (18)	6.6	0.36
4	E. flank of Newfoundland Mts	42 (26)	6.8	0.17
5	W. flank of Stansbury Mts	54 (34)	7.3	0.17

the maximum earthquake associated with the closest approach of the Intermountain Seismic Belt (ISB). The earthquake resulting in the most conservative acceleration is the design earthquake for the proposed facility.

Capable Faulting—As discussed in FSER Section 3.1.2.1 and in the license application, known or suspected active or capable faults within 72.4 km (45 mi) of the South Clive site have maximum magnitudes of from 6.6 to 7.3 and yield maximum expected accelerations (mean plus one standard deviation) in bedrock at the site of from 0.17 g to 0.34 g. The capable fault closest to the site is located approximately 19.3 km (12 mi) east of the site on the flank of Cedar Mountain. The maximum magnitude event expected on this fault is 6.6 with a peak acceleration, calculated using the equations by Joyner and Boore (1988), of 0.34 g.

Floating Earthquake—In the license application, the applicant hypothesized a random local earthquake without surface rupture at 10 km (6 mi) from the site that would produce a peak acceleration of 0.42 g (mean plus one standard deviation). However, the applicant indicated that the probability of such an event and acceleration was less than one occurrence in each 50,000 years, and was thereby considered an extreme value.

As a result, the applicant assumed a magnitude 6.5 earthquake with a peak acceleration of 0.37 g to be the maximum earthquake not associated with known faulting in the BAR. By comparison with Figure 4.10 in Appendix K (Arabasz, 1987) the expected return period for an acceleration of 0.37 g at a point within the Superconducting Supercollider site ring, which includes the Clive site, is much greater than 10,000, by extrapolation about 50,000 years. The latter recurrence interval yields an estimated 90-percent probability that a 0.37 g design acceleration will not be exceeded in 5000 years at the Clive site. In addition, the 0.37 g proposed design value is consistent with the magnitudes on the nearby capable faults.

Maximum Event From the ISB—The applicant in their license application assessed the impact of an earthquake in the ISB on the site. Several large capable faults that lie near the western margin of the ISB are capable of producing earthquakes with magnitudes as great as 7.5. However, the peak ground acceleration expected at the South Clive site, due to a 7.5 magnitude event on the closest ISB fault, is 0.05 g.

As a result, the applicant proposed 0.37 g peak acceleration for the design value at the proposed facility. The NRC staff, on the basis of an analysis of the information provided in the license application, considers the applicant's selection of a 0.37 g design value acceptable. The use of this value in the design is discussed in FSER Section 3.2.

3.1.2.4 Impact of Natural Resource Development

Based on a lack of natural resources in the site vicinity, the NRC staff concurs with the applicant's conclusion that impacts to the site, due to natural resources development, do not exist for this site.

3.1.3 Conclusions

The NRC staff concludes that the geologic and seismic aspects of the design of the Envirocare facility as presented in the license application have been shown to comply with the long-term stability requirements of Appendix A to 10 CFR Part 40.

3.2 Geotechnical Engineering

3.2.1 Site and Material Characterization

3.2.1.1 Site Investigations

Geotechnical investigations were conducted by Bingham Environmental in 1991 and Delta Geotechnical Consultants in 1990 and 1988. In addition, studies conducted by Jacobs Engineering Group and Dames & Moore for DOE in 1984 were referenced. The studies were performed to verify the occurrence of and define the parameters for the subsurface materials. The scope of the investigations included test borings, monitoring wells, and test pits. The soil borings were drilled with hollow-stem augers. Sampling was by split-barrel sampler, Shelby tube, and continuous sampler.

Geotechnical engineering characteristics and certain radiological characteristics of the materials were determined through laboratory analysis of samples from these investigations. The drilling and sampling programs were conducted in general compliance with the applicable American Society for Testing and Materials (ASTM) standards and practice accepted in the geotechnical engineering profession. Site stratigraphy and ground-water conditions are discussed in Sections 3.1 and 3.4, respectively.

3.2.1.2 Testing Program

The staff reviewed the geotechnical engineering testing program data for the Envirocare site. For the most part, the soil test results utilized by Envirocare were those from previous DOE work related to the Salt Lake City Remedial Action Project (Vitro) cell. The DOE program included in situ moisture content/density, specific gravity, Atterberg limits, particle-size distribution, moisture-density relationships, shear strength, hydraulic conductivity, erodibility/dispersivity, and consolidation tests for samples taken from the proposed Vitro disposal site.

In addition, the applicant has provided information to support and verify the applicability of DOE's soil test data in Appendix AA, "Selected Previous Geotechnical Data." Table 1.11, "Comparison of Geotechnical Data" (Appendix AA to the license application), has also been provided and shows the correlation between soil test results from earlier studies and the more recent studies performed by Envirocare. In support of Table 1.11, the applicant has provided a plan drawing showing the comparative locations of the "SC," "SLC," and "GW" borings. The NRC staff considers the use of DOE's soil test data acceptable for use at the proposed 11e.(2) byproduct disposal facility at Clive.

3.2.2 Geotechnical Engineering Evaluation

3.2.2.1 Slope Stability Evaluation

The staff reviewed the exploration data relied upon by the applicant in the license application for slope stability, including soil strength parameters, slope characteristics, and methods of analyses.

The disposal cell cross-sections selected for the analysis of slope stability are based on Envirocare's proposed disposal cell configuration. Envirocare has evaluated stability of a representative disposal cell slope. Considering the uniformity of proposed cell configuration, the section evaluated is critical from the stability perspective in terms of geometry, stratigraphy, and strength characteristics of the materials within the slope. The staff finds that critical slope sections have been considered for the slope stability analysis.

The parameters required for the evaluation of stability of the slopes are based on previous testing of local materials by the DOE for the Vitro site. The stability of the disposal cell slopes was analyzed by determining the factor of safety against sliding along the critical slip circle using Bishop's Modified Method of Slices. The computer code PCSTABL5 was used in the evaluation. The analysis evaluated factors of safety against failure for long-term seismic loading conditions only. Seismic conditions were analyzed using the pseudostatic method. The value of the seismic coefficient used in the analysis was 0.37 g.

Based on computer analysis in Appendix V of the license application, the minimum factor of safety against failure of the slope was 1.049 for the pseudostatic condition, compared to the required minimum of 1.1. The critical failure surfaces passed through the berm and relocated materials in the disposal cell. The reported value of 1.049 fails to meet accepted minimums; however, the analysis and approach were considered sufficiently conservative to conclude that the factor of safety will be above 1.1. For example, cohesion was ignored for all materials except the natural clay, for which a value of 2087 kilonewtons per square meter (kN/m^2) (100 pounds per square foot (psf)) was used. Also, the computer analysis conservatively did not take into account that soft subgrade soils will be removed during construction. Short-term and static analyses would have substantially higher safety factor values for a similar analytical approach.

The staff concludes that appropriate methods of slope stability analysis have been used for the configuration and material parameters reported. The method of seismic stability analysis and the seismic coefficients used are acceptable. The selection of the critical cross-sections and the modeling of its stratigraphy are satisfactory. The staff considers the slope stability evaluation to be acceptable for the planned configuration. If cell geometry varies from that assumed in the analysis or if material strength parameters differ from those assumed, then additional analysis would be required.

3.2.2.2 Settlement

Envirocare has elected to utilize settlement calculations performed by others for the Vitro cell at the DOE site in Clive. These calculations were previously found acceptable by NRC for the Vitro cell. The Vitro calculations are based on placing recompacted uranium mill tailings within the cell. In addition, the applicant has further evaluated settlement and cracking issues by use of the computer program VSTRESS for numerical analysis. The NRC staff has reviewed the analytical basis for this code through the program documentation and the computer analysis. As a result of these evaluations, the NRC staff finds the analysis of settlement adequate.

3.2.2.3 Liquefaction Potential

The staff has reviewed the information presented on the potential for liquefaction at the site. The detailed analyses were performed for a seismic event of 6.5 magnitude and 0.37 g peak acceleration (design-basis seismic event).

The compacted dry density of the soil was assumed to be equal to 16.5 kilonewtons per cubic meter (kN/m^3) (105 pounds per cubic foot (pcf)). The fines content was assumed to equal 35 percent, and clay content assumed to be less than 15 percent. Based on a simplified procedure and a computer program written at Brigham Young University, it was concluded by the applicant that liquefaction would not likely cause an instability problem for an embankment at the site. Strata found to be potentially susceptible to liquefaction are sufficiently deep so that no disruption to the cell integrity should occur.

The results of the analysis are consistent with DOE's liquefaction analysis for the Vitro embankment that is currently in place. The proposed Envirocare cell is similar in design to the Vitro cell. The NRC staff finds the applicant's analysis of liquefaction potential acceptable.

3.2.2.4 Cover Design

The proposed conceptual cover design for the Envirocare disposal cell employs a multilayered system of earthen materials on top of the disposal cell and a riprap cover on top. In descending order from the surface, the soil cover will consist of (1) 0.46-m (1.5-ft)-thick rock erosion barrier, (2) 15-cm (6-in)-thick filter layer, and (3) 2.2-m (7-ft)-thick radon barrier. The rock erosion barrier is designed to prevent loss of material to the elements and to provide protection from burrowing animals. The filter layer will allow for removal of moisture from precipitation. The radon barrier limits the radon emanation from the cell to comply with EPA requirements and to further limit the infiltration of water into the disposal cell. The cover system provides a total of 2.7 m (9 ft) of cover over the contaminated materials.

Details of the staff review of the cover's performance related to limiting infiltration are addressed in Section 3.4 of this report, the review of the cover's erosion protection features is presented in Section 3.3.4, and the review of the radon attenuation aspects of the cover is presented in Section 3.5. Other aspects of the cover, such as frost protection and gradation/filter design, are addressed in this section.

The license application does not adequately address the frost protection aspect of the design. The staff considers the following deficiencies in the frost protection aspects of the facility design to be an ***open issue***. Envirocare has provided an analysis of frost penetration in Chapter 6 and Appendix BB of the license application. Specifically, the NRC has the following concerns with the applicant's analysis of the frost penetration issues:

(1) The combined erosion protection layer and the filter layer of the cell cover in Appendix BB of the license application is described as a 0.76-m (2.5-ft) layer. However, the rest of the application shows the cover design to be a combined thickness of 0.6 m (2 ft). The applicant must rectify this inconsistency in the application. If the applicant intends to modify the cell cover design, the entire application and all affected calculations and conclusions must be revised to reflect the change.

(2) The analysis of the frost penetration issue mentions "the required 200 year criteria." However, Criterion 6 of Appendix A to 10 CFR Part 40 specifically states that the design "be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years." Therefore the applicant must demonstrate that the proposed cover design is effective with regard to frost penetration for 1000 years, unless that design criterion can be shown to be impracticable.

(3) The applicant used the Modified Berggren Analysis for frost penetration. However, even with an assumed increase in thickness of the filter layer, the uppermost 10 cm (4 in) of radon barrier could potentially be affected. The applicant states that the slight increase in permeability for the upper 10 cm (4 in) should not significantly affect the infiltration or radon emanation; however, no calculations are provided in support. While it is probably true that the infiltration will not be significantly affected, it is likely that radon emanation will be significantly affected. The RADON or RAECOM code, or other similar code, should be used to estimate radon emanation with the proposed configuration.

3.2.2.5 Radon/Infiltration Barrier Hydraulic Conductivity

The hydraulic conductivity (permeability) of the compacted soil cover and the proposed liner have been addressed. The applicant states that the compacted cover will have a hydraulic conductivity less than or equal to that of the liner so that the long-term accumulation of moisture ("bathtubbing") will not occur. In addition the applicant will use specific field control methods, as specified in the quality assurance/quality control (QA/QC) plan, to ensure that the hydraulic conductivity of the radon barrier is less than that of the liner during placement.

It is noted that the applicant constructed a test embankment and reported base hydraulic conductivity values of 4.3×10^{-8}, 8.1×10^{-8}, and 5.5×10^{-8} cm/s (1.4×10^{-9}, 2.7×10^{-9}, 1.8×10^{-9} foot per second (ft/s)). These values were for tests performed above three 15.24-cm (6-in) lifts of native clay compacted to 95 percent of the standard Proctor maximum dry density. The applicant is advised that in order to construct a cover with a *lesser* hydraulic conductivity, the addition of blended bentonite to the cover would be required and will be considered a **license condition**. Alternate proposals by the applicant to meet this assurance would be considered by staff. If a bentonite-amended cover is selected for use, it will be necessary to design and construct a bentonite-amended cover which displays a design hydraulic conductivity at least one-half order of magnitude lower than that reported for the unamended liner. Such a margin of safety is considered appropriate since field construction techniques cannot ensure consistent production of a constant and predictable hydraulic conductivity. The applicant's commitment to comply with a QA/QC plan consistent with the above will be a **license condition**.

With respect to *transient* bathtubbing conditions, which could occur due to excess tailings moisture during placement, additional design input is required. This issue is discussed in the ground-water protection section.

3.2.3 Conclusions

The NRC staff concludes that the geotechnical engineering aspects of the design of the Envirocare facility as presented in the license application have not been shown to fully comply with the long-term stability requirements of Appendix A to 10 CFR Part 40.

3.3 Surface Water Hydrology and Erosion Protection

3.3.1 Hydrologic Description and Site Conceptual Design

The Envirocare site is located in flat terrain west of Cedar Mountain about 1.6 km (1 mi) south of the Clive railroad siding. Drainage from the immediate site area flows as sheet flow to the southwest. Drainage from a 124.3-square-kilometer (km^2)(48-square-mile (mi^2)) area in Cedar Mountain does not normally reach the site; there are no well-defined channels or streams in the area. Flood runoff from this drainage basin, which would be produced only by very heavy rainfall, would generally flow south of the site with some flow encroachment on the fringe of the Envirocare site. Drainage ditches will be constructed around the perimeter of the encapsulation cell and will convey runoff from the pile to a single discharge channel at the south end of the area.

In order to comply with the requirements of 10 CFR Part 40, Appendix A, Envirocare proposes to construct a disposal cell that is designed to be stable for a period of 1000 years. The engineered embankments will be protected from flooding and erosion by rock riprap erosion protection. Design criteria for the erosion protection included the probable maximum precipitation (PMP) and the probable maximum flood (PMF) events, both of which are considered to have very low probabilities of occurrence within the 1000-year stabilization period. The covers will have maximum slopes of 2 percent on the top and 20 percent on the sides. Disposal will be partially below grade, and the embankments, including the proposed 2.7-m (9-ft)-thick cover, will have a maximum height of 14 m (46 ft) above the original ground surface.

3.3.2 Flooding Determinations

The computation of peak flood design discharges for various design features at the site was performed by Envirocare in several steps. These steps included (1) selection of a design rainfall event, (2) determination of infiltration losses, (3) determination of times of concentration, and (4) determination of appropriate rainfall distributions, corresponding to the computed times of concentration. Input parameters were derived from each of these steps and were then used to determine the peak flood discharges to be used in water surface profile and velocity modeling and in the final determination of rock size for erosion protection.

3.3.2.1 Selection of Design Rainfall Event

One of the most disruptive phenomena affecting long-term stability is surface water erosion. It is very important to select an appropriately conservative rainfall event on which to base the flood protection designs. The staff has concluded (NRC, 1990) that the selection of a design flood event should not be based on the extrapolation of limited historical flood data, due to the unknown level of accuracy associated with such extrapolations. Accordingly, Envirocare utilized the PMP that is computed by deterministic (rather than statistical) method and is based on site-specific hydrometeorological characteristics. The PMP has been defined as the most severe, reasonably possible rainfall event that could occur as a result of a combination of the most severe meteorological conditions occurring over a watershed. No recurrence interval is normally assigned to the PMP; however, the NRC staff has concluded that the probability of such an event being equaled or exceeded during the 1000-year stability period is small. Therefore, the PMP is considered by the NRC staff to provide an acceptable design basis.

Prior to determining the runoff from the drainage basin, the flooding analysis requires the determination of PMP amounts for the specific site location. Techniques for determining the PMP have been developed for the entire United States, primarily by the National Oceanographic and Atmospheric Administration (NOAA), in the form of hydrometeorological reports for specific regions. These techniques are widely used and provide straightforward procedures with minimal variability. The staff, therefore, concludes that use of these reports to derive PMP estimates is acceptable.

PMP rainfall depths of approximately 24.3 cm (9.7 in) in 6 hours (for the 124.3-km^2 (48-mi^2) Cedar Mountain drainage) and 24.3 cm (9.7 in) in 1 hour (for the small local drainage areas) were used by Envirocare to compute the PMFs for the various drainage areas at the Clive disposal site. These rainfall estimates were developed by Envirocare using Hydrometeorological Report (HMR) 49 (Department of Commerce, 1977). The staff performed an independent check of the PMP values, based on the procedures given in HMR 49. Based on this check of the rainfall computations, the staff concludes that the PMP values have been acceptably derived for this site.

3.3.2.2 Infiltration Losses

Determination of the peak runoff rate is dependent on the amount of precipitation that infiltrates into the ground during the occurrence of the rainfall. If the ground is saturated from previous rains, very little of the rainfall will infiltrate and most of it will become surface runoff. The loss rate is highly variable, depending on the vegetation and soil characteristics of the watershed. Typically, all runoff models incorporate a variable runoff coefficient or variable runoff rates. Commonly used models such as the

Rational Formula (Bureau of Reclamation, 1977) incorporate a runoff coefficient (C); a C value of unity represents 100-percent runoff and no infiltration. Other models such as the U.S. Army Corps of Engineers Flood Hydrograph Package (HEC-1) separately compute infiltration losses with time to arrive at a runoff amount during that time period.

In computing the peak flow rate for the design of the rock riprap erosion protection at the proposed disposal site, Envirocare used the Rational Formula. In this formula, the runoff coefficient (C) was assumed by Envirocare to be unity; that is, Envirocare assumed that no infiltration losses would occur. Based on a review of the computations, the staff concludes that this is a very conservative assumption, as discussed above, and is, therefore, acceptable.

In computing the peak flow rate for the drainage from the Cedar Mountain area, Envirocare utilized a high value of soil moisture, as recommended by the Bureau of Reclamation (1977). This resulted in the use of nearly 100-percent runoff from the PMP storm. The staff concludes that this is acceptable.

3.3.2.3 Time of Concentration

The time of concentration (t_c) is the amount of time required for runoff to reach the outlet of a drainage basin from the most remote point in that basin. The peak runoff for a given drainage basin is inversely proportional to the t_c of that basin. If the t_c is computed to be small, the peak discharge will be conservatively large. Times of concentration and/or lag times are typically computed using empirical relationships such as those developed by Federal agencies (Bureau of Reclamation, 1977). Velocity-based approaches are also used when accurate estimates are needed. Such approaches rely on estimates of actual flow velocities to determine the t_c of a drainage basin.

The t_c's for the pile top and sides were estimated using the Kirpich Method (Bureau of Reclamation, 1977). Such a velocity-based method is considered by the staff to be appropriate for estimating t_c's. Based on the use of such a method, the staff concludes that the t_c's have been acceptably derived.

The staff further concludes that the procedures used for computing t_c represent the small steep drainage areas present at the Clive site. For very small drainage areas with very short times of concentration, Envirocare utilized t_c's as low as about 5 minutes; the staff considers such t_c's to be conservative.

3.3.2.4 Rainfall Distributions

After the PMP is determined, it is necessary to determine the rainfall intensities corresponding to shorter times of concentration. A typical PMP value is derived for periods of about 1 hour. If the time of concentration is less than 1 hour, it is necessary to extrapolate the data presented in the various hydrometeorological reports to shorter time periods. Envirocare utilized a procedure recommended by NOAA and endorsed by the NRC staff. This procedure involves the determination of rainfall amounts as a percentage of the 1-hour PMP, and computes rainfall amounts for a very short periods of time. The NRC staff has concluded that this procedure is conservative.

In the determination of peak flood flows, rainfall intensities for durations as short as about 5 minutes were used. Table 4 shows the distribution of PMP rainfall. These distributions were derived by plotting and extrapolating the following relationships that were recommended by the NRC staff and have been used by DOE at several other sites.

Table 4 Rainfall Intensities

Rainfall Duration (minutes)	Percentage of 1-hr PMP
2.5	27
5	45
15	74
30	89
45	95
60	100

The staff checked the rainfall amounts for the short durations associated with small drainage basins. Based on a review of this aspect of the flooding determination, the staff concludes that the computed peak rainfall intensities are conservative.

3.3.2.5 Computation of the PMF

3.3.2.5.1 Adjacent Waterways

The PMF for the perimeter drainage channel results from overflow of flood runoff from the Cedar Mountain drainage into the diversion channels. The peak water level resulting from this overflow into the ditch was based on the PMF from the Cedar Mountain drainage area. This PMF was estimated using standard triangular unit hydrograph procedures (Bureau of Reclamation, 1977). Envirocare assumed AMC-II soil moisture conditions and a runoff curve number of 89, as discussed above. The PMF was computed to be approximately 2124 cubic meters per second (m^3/s) (75,000 cubic feet per second (cfs)). To verify the adequacy of this estimate, the staff compared this estimate to the estimate of 2351 m^3/s (83,000 cfs) derived by DOE for the Title I site in the immediate vicinity. The estimate was further compared to enveloped values of historical maximum floods (Crippen and Bue, 1977). For a drainage area of this size, this reference indicates that the historical maximum flood flow is approximately 566 m^3/s (20,000 cfs), about 25 percent of the Envirocare estimate. Based on these comparisons and review of the calculations provided by Envirocare, the staff concludes that the PMF estimate of 2124 m^3/s (75,000 cfs) is acceptable.

3.3.2.5.2 Onsite Drainage

The PMF was estimated for the top and side slopes using the Rational Formula, which provides a standard method for estimating flood discharges for small drainage areas. For a maximum top slope length of 177.7 m (583 ft) and an additional side slope length of about 33.5 m (110 ft), Envirocare estimated the peak flow rate to be 0.074 $m^3/s/m$ (0.8 cfs/ft). Based on staff review of the calculations, the estimate is considered to be conservative.

3.3.2.6 Upstream Dam Failure

There are no embankments near the site whose failure could potentially affect the site.

3.3.3 Water Surface Profiles and Channel Velocities

Following the determination of the peak flood discharges, it is necessary to determine the resulting water levels, velocities, and shear stresses associated with that discharge. These parameters then provide the basis for the determination of the required riprap size and layer thickness needed to ensure stability during the occurrence of the design event.

In determining riprap requirements for this site, Envirocare computed various parameters, such as time of concentration, rainfall intensity, and flow velocity, for individual slope segments. The calculations assume the occurrence of sheet flow on a 0.3-m (1-ft)-wide strip of a given slope length. The Safety Factors Method is used for slopes less than 10 percent, and the Stephenson Method is used for slopes greater than 10 percent. The validity of these two design approaches was verified by the NRC staff through the use of flume tests at Colorado State University. It was determined that the selection of an appropriate design procedure depends on the magnitude of the slope (Abt et al., 1987). The staff, therefore, concludes that the procedures and design approaches used by Envirocare are acceptable and reflect state-of-the-art methods for designing riprap erosion protection.

3.3.3.1 Adjacent Waterways

The maximum depth of the Cedar Mountain PMF at the site was computed using normal depth procedures (Chow, 1959). Using a maximum discharge of 2132 m^3/s (75,300 cfs), a Manning's 'n' value of 0.03 and the natural ground slope in the area, Envirocare computed the depth of flow to be 0.5 m (1.8 ft) on the cell and 1.77 m (5.8 ft) in the diversion ditches. Based on a review of the calculations, the staff concludes that the computed flow depths are acceptable.

3.3.3.2 Drainage Ditches

The ditch layout is such that upland surface runoff and runoff from the tailings pile will be channeled into the ditch on both sides of the pile. As discussed above, a maximum depth of flow in the ditch of 1.77 m (5.8 ft) was estimated. Based on a check of the calculations, the staff concludes that the computed flow depths are acceptable.

Runoff from the DOE Salt Lake City Remedial Action Project (Vitro) cell will be channeled into a drainage ditch that will also convey flow from the Envirocare's disposal cells. This ditch is designed to have a flat slope and very low velocities. Based on an independent check of the ditch slope and velocity, the ditch is considered acceptable.

3.3.3.3 Top and Side Slopes

In determining riprap requirements for the top and side slopes, Envirocare utilized the Safety Factors Method (Stevens et al., 1976) and the Stephenson Method (Stephenson, 1979), respectively. The Safety Factors Method was used for relatively flat slopes, and the Stephenson Method was used for the side slopes. As discussed above, the staff, therefore, concludes that the procedures and design approaches used by Envirocare are acceptable.

3.3.4 Erosion Protection Design

3.3.4.1 Adjacent Waterways

It is necessary to check the design of the riprap on the cell side slopes for a flood from the Cedar Mountain drainage area. This flood results in the maximum water level on the side slopes and could be a critical case for riprap design. The Safety Factors Method was used to estimate the critical shear stress produced by this flood. Based on a review of the applicant's analyses, the rock size needed is about 3.75 cm (1.5 in). The proposed rock layer, with an average size of about 8.75 cm (3.5 in), is considered to be acceptable to withstand the maximum stress safely.

3.3.4.2 Drainage Ditches

The Safety Factors Method was used to determine average rock sizes in the drainage ditch. The minimum medium-sized rock size (D50) required is about 3 cm

(1.2 in). Since Envirocare proposes to use 8.75-cm (3.5-in) rock at this location, the design is considered by the staff to be adequate to resist the shear forces produced by overflow of offsite floods into the drainage ditch.

3.3.4.3 Top and Side Slopes

The layer of riprap on the top slope has been sized to withstand the erosive velocities resulting from an on-cell PMP, as discussed above. Envirocare proposes to use a 0.46-m (1.5-ft)-thick layer of rock with a minimum D50 of 2.5 cm (1.0 in). The riprap will be placed on a 0.15-m (0.5-ft)-thick bedding layer. The Safety Factors Method was used to determine the rock size.

The rock layer on the side slopes is also designed for an occurrence of the local PMP. Envirocare proposes to use a 0.46-m (1.5-ft)-thick layer of rock with a minimum D50 of approximately 8.75 cm (3.5 in). The rock layer will be placed on a 0.15-m (0.5-ft)-thick bedding layer. The Stephenson Method was used to determine the required rock size.

The rock layer on the top and side slopes is also capable of resisting wind erosion. Studies performed for the NRC staff by technical experts (Voorhees et al., 1983) have indicated that wind erosion can be adequately prevented by a surface layer of rock riprap over the soil cover. Therefore, the staff concludes that the design is acceptable to mitigate wind erosion effects.

Based on staff review of the applicant's analyses and the acceptability of using appropriate design methods, as discussed above, the staff concludes that the proposed rock sizes are adequate.

Further, Envirocare has proposed acceptable gradations for the rock riprap layers to be used at the site. The gradations suggested by the applicant are similar to standard gradations such as those of the U. S. Army Corps of Engineers and are, therefore, acceptable.

3.3.5 Rock Durability

NRC regulations require that control of residual radioactive materials be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. The previous sections of this report examined the capability of the erosion protection to withstand flooding events reasonably expected to occur in 1000 years. In this section, rock durability is considered to determine if there is reasonable assurance that the rock itself will survive and remain effective for 1000 years.

Rock durability is defined as the capability of a material to withstand the forces of weathering. Factors that affect rock durability are (1) chemical reactions with water, (2) saturation time, (3) temperature of the water, (4) scour by sediments, (5) windblown scour, and (6) wetting and drying.

Envirocare has identified an acceptable source of rock near the site. The suitability of the rock as a protective cover was then assessed by laboratory tests to determine the physical characteristics. The results of these tests were used to classify the rock's quality and to assess the expected long-term performance of the rock. The tests (ASTM, 1992) included:

(1) Bulk Specific Gravity (ASTM C127). The specific gravity of a rock is an indicator of its strength or durability; in general, the higher the specific gravity, the better the quality of the rock.

(2) Absorption (ASTM C127). A low absorption is a desirable property and indicates slow disintegration of the rock by salt action and mineral hydration.

(3) Sulfate Soundness (ASTM C88). In locations subject to freezing or exposure to salt water, a low percentage loss is desirable.

(4) Los Angeles Abrasion (ASTM C131 or C535). This test is a measure of rock's resistance to abrasion.

All samples for testing were taken in accordance with "Standard Practices for Sampling Aggregate" (ASTM D75). Envirocare used a step-by-step procedure for evaluating rock durability, in accordance with procedures recommended by the NRC staff (NRC, 1990), as follows:

Step 1—Test results from representative samples were scored on a scale of 0 to 10. Results of 8 to 10 are considered "good"; results of 5 to 8 are considered "fair"; and results of 0 to 5 are considered "poor."

Step 2—The score was multiplied by a weighting factor. The effect of the weighting factor is to focus the scoring on those tests that are the most applicable for the particular rock type being tested.

Step 3—The weighted scores were totaled, divided by the maximum score, and multiplied by 100 to determine the rating.

Step 4—The rock quality scores were then compared to the criterion that determines its acceptability, as defined in the NRC scoring procedures.

Envirocare provided results of several rock durability tests that were conducted on the proposed rock source by DOE for the Title I site located adjacent to this site. Using the NRC scoring methodology (NRC, 1990) on 18 samples, the rock achieved an average score of 79, indicating that the rock is of good quality and is acceptable for use as erosion protection.

Envirocare conducted petrographic examinations of thin sections of the rock, as suggested in NRC criteria (NRC, 1990). These examinations were used to establish that the rock did not contain chemically unstable minerals or volumetrically unstable materials. Envirocare has determined that the rock will be produced from a quarry near the site. Gradation and rock durability criteria were presented, including the results of the durability tests listed above. Using the criteria provided in the staff technical position on erosion protection (NRC, 1990), Envirocare has documented that the rock is of relatively good quality. Based on its review of the assessments, data, and criteria provided, the staff concludes that the rock proposed for use at the site will be acceptable.

3.3.6 Testing and Inspection for Erosion Protection

The staff reviewed and evaluated the testing and inspection quality control requirements for the erosion protection materials, as provided in the application. Envirocare has indicated that the rock will be tested for gradation and durability several times, as follows: (1) prior to rock placement; (2) once every 7646 m^3 (10,000 cy), or at the 1/3 and 2/3 points of material placement; and (3) at the end of placement activities. Envirocare has also indicated that rock placement will be inspected daily and will ensure there is no segregation or degradation of the rock layer; one in-place gradation test will be conducted for every 764.6 m^3 (1000 cy) of material placed.

Based on the results of the durability tests to characterize the proposed rock and review of the proposed requirements for inspection during placement, the staff concludes that the proposed testing program is acceptable. The staff, however, will need to review the final construction drawings and specifications to ensure that the proposed program has been implemented.

3.3.7 Conclusions

The NRC staff concludes that the erosion protection aspects of the design of the Envirocare facility as presented in the license application have been shown to comply with the requirements of Appendix A to 10 CFR Part 40.

3.4 Water Resources Protection

3.4.1 Hydrogeologic Characterization

3.4.1.1 Hydrogeologic Setting

The proposed disposal site is located in the eastern part of the semi-arid Great Salt Lake Desert. The site region is a sediment-filled basin characteristic of the Basin and Range physiography. The basin fill in the site area is estimated to have approximately 76 m (250 ft) of largely unconsolidated lacustrine and alluvial deposits underlain by semiconsolidated alluvial and fluvial gravel, sand and clay (Figure 5). The aquifer system that may impact or be impacted by the proposed disposal at the site occurs in the top 30.5 m (100 ft) of the basin fill. As consultants to the applicant, Bingham Environmental (Envirocare, 1993) identified two aquifers in the top 30-m (100-ft) interval of the basin fill, designated as a shallow unconfined aquifer and a deep confined aquifer in the license application. These aquifers are separated by confining clay and silt beds with the main confining bed located at a depth of about 13 m (40 ft). The unconfined aquifer has poor-quality, highly saline water with a total dissolved solids content of up to 60,000 parts per million (ppm) or more. Water in the confined aquifer has a total dissolved solids content of about 20,000 ppm (Envirocare, 1992b, 1993).

The local ground-water recharge from meteoric sources, in the site area and the Great Salt Lake Desert, is generally limited. The recorded annual pan evaporation is more than 200 cm (80 in), which is significantly higher than the recorded annual precipitation of less than 12 cm (5 in) (Envirocare, 1993). Because of a relatively higher precipitation and a more favorable lithology near the mountains, it is believed that the recharge occurs largely in the areas adjoining the mountain ranges and moves as subsurface flow toward the center of the basin. This is supported by the high salinity and the isotopic composition of the area ground water, which are indicative of long flow paths and/or long residence time.

The staff concluded, on the basis of the available data, that the site is located in a regional ground-water discharge setting, with largely upward flow and flow gradients. This is because (1) the physiographic and topographic settings of the general area of the site (i.e., regionally low topography) are characteristic of a regional ground-water discharge zone; (2) water level and density measurements in several wells completed to different depths in the site area indicate a consistent increase of the potentiometric head with depth; and (3) the salinity and isotopic composition of the ground water are indicative of long flow paths, long residence time, or both.

3.4.1.2 Hydrogeologic Units

The hydrogeologic units in the disposal site area were delineated based on data obtained from borehole and monitor-well drilling conducted at the site by Envirocare, and near the site by other parties. A map showing the locations of all the wells on record is provided in Figure 6.

Bingham Environmental (Envirocare, 1993) identified four lithostratigraphic units in the basin fill to about a 30-m (100-ft) depth beneath the site. These include from the top, a silty clay layer, a clayey sand layer with occasional silty to sandy clay lenses, a lower layer of clay, and a

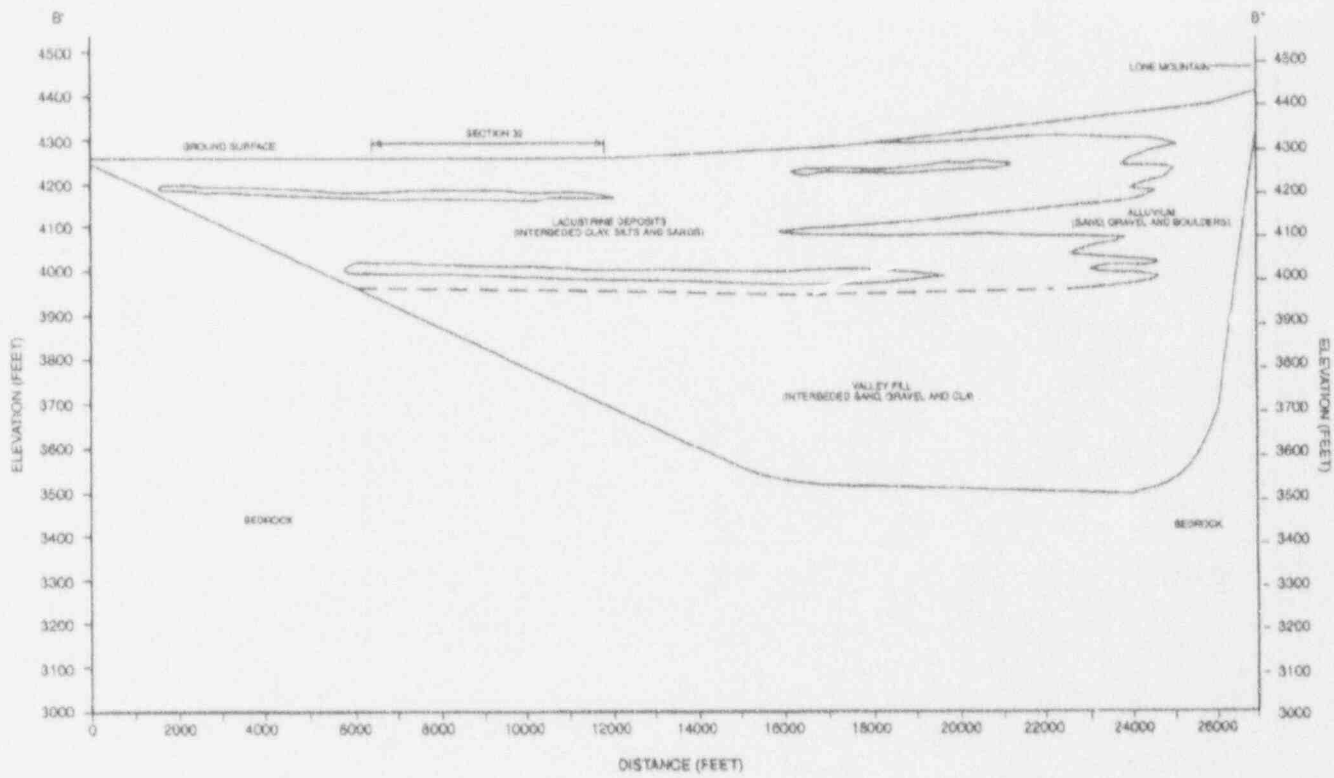


Figure 5 Stratigraphic Cross-Section

lower layer of sand. The layers dip gently westward and generally range from a few meters to 9 m (30 ft) in thickness, except for the lower sand layer, which has a thickness of up to 23 m (75 ft) or more (lithostratigraphic sections across the site are provided in Figures 4 through 9, Appendix D-1 of the license application (Envirocare, 1993)). There are no available data to delineate the lithostratigraphy below a 30-m (100-ft) depth.

Both of the sand layers in the lithostratigraphic profile constitute water-bearing units in the site area. Ground water occurs under unconfined conditions in the upper sand layer and under confined conditions in the lower sand layer. These units have been designated, for the purpose of this report, as shallow and deep aquifers, respectively. The top clay layer is unsaturated and the lower clay layer constitutes the most prominent confining bed separating the shallow and deep aquifers. Although the lower clay layer appears to be the most prominent confining bed between the sand layers, it is not necessarily the only one, as there are other less prominent clay and/or silt beds within the sand layers that may also be contributing to the confinement of the lower aquifer.

On the basis of the available lithostratigraphic and ground-water data, four "hydrogeologic" intervals have been identified by the applicant for consideration in analyzing the seepage and flow path of moisture and leachate from the disposal cell in the disposal site area. These include (1) an unsaturated zone from the bottom of the cell to the water table at about 3 m (10 ft) below the disposal cell, encompassing the upper clay layer and the unsaturated part of the upper sand layer; (2) a saturated zone under unconfined conditions, encompassing the saturated part of the upper sand layer; (3) a confining zone consisting mainly of the lower clay layer at about a 12-m (40-ft) depth; and (4) a confined zone encompassing the confined aquifer.

3.4.1.3 Hydraulic and Transport Properties

The hydraulic properties of the various hydrogeologic units were determined by the applicant based on field and laboratory tests. The field testing by the applicant involved conducting slug-injection tests in 24 wells to determine the hydraulic conductivity for the saturated lithostratigraphic units; namely, the upper and lower sand layers and the lower clay layer. The laboratory tests were conducted on selected samples obtained from the upper clay and upper sand layers to determine the field bulk density, water content, porosity, water retention characteristics, and unsaturated hydraulic conductivity.

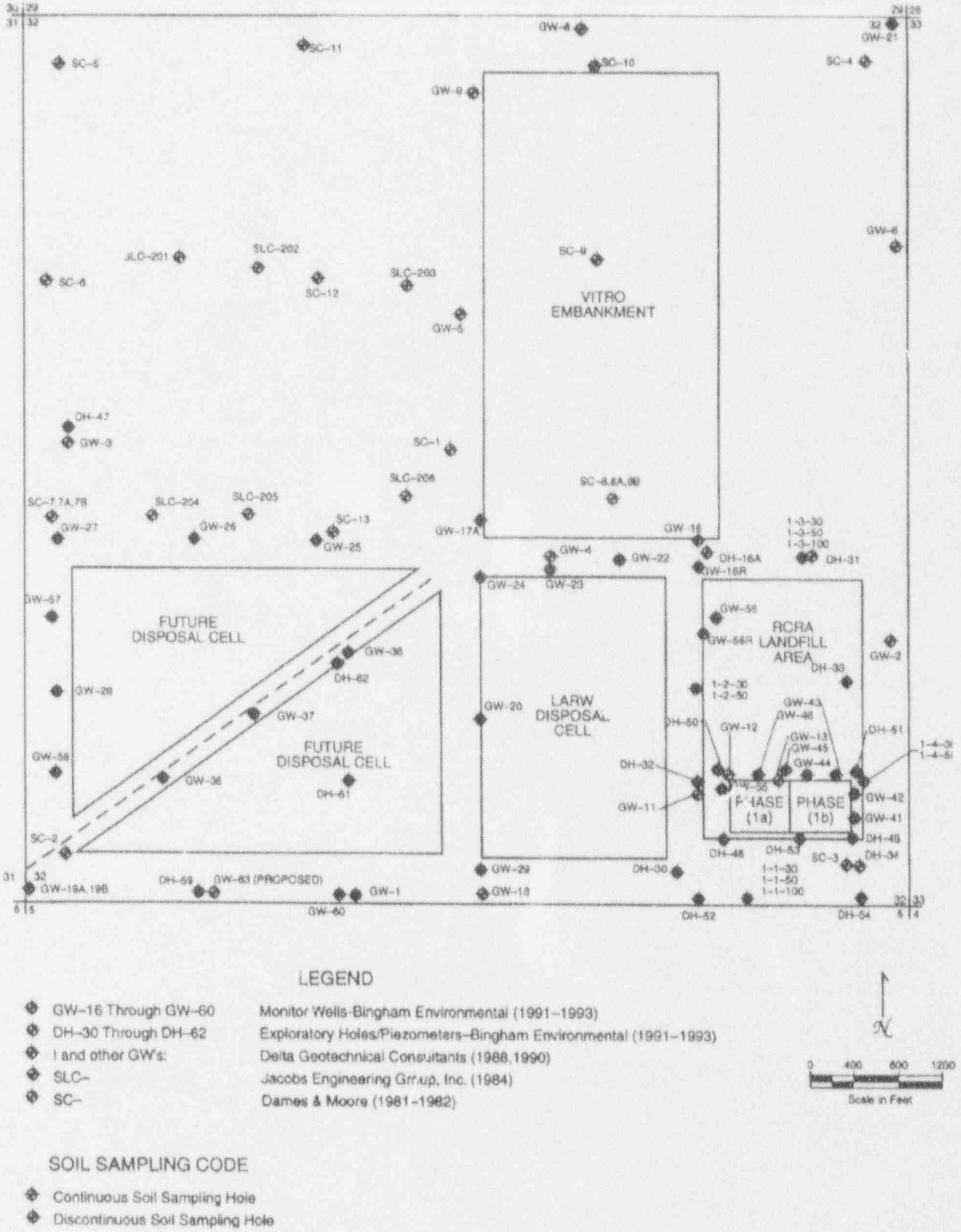


Figure 6 Well Locations

The saturated hydraulic conductivities obtained from the slug-injection tests are provided in the license application documents (pages A-69 and A-70 of Appendix A to Appendix D-1 of the license application (Envirocare, 1993)). The slug-injection test data indicate that the hydraulic conductivity is about 1.9×10^{-3} centimeter per second (cm/s) (6.2×10^{-5} foot per second (ft/s)) for the upper sand layer (i.e., shallow aquifer); 2.8×10^{-5} to 4.4×10^{-4} cm/s (9.0×10^{-7} to 1.4×10^{-5} ft/s) for tested intervals intersecting both the shallow aquifer and the underlying confining bed; 5.0×10^{-5} to 1.7×10^{-4} cm/s (1.6×10^{-6} to 5.5×10^{-6} ft/s) for the lower clay layer (i.e., confining bed); and 1.2×10^{-3} cm/s (3.9×10^{-5} ft/s) for the lower sand layer (i.e., confined aquifer).

Tests to measure the moisture content were conducted by the applicant on a total of 50 lithologic samples obtained at different intervals from the ground surface to a maximum depth of 11 m (36 ft). The total porosity was computed for 25 samples from the moisture-content data. The results are provided in the license application (pages B-16 and B-17 of Appendix B to Appendix D-1 of the license application (Envirocare, 1993)). The computed total porosity ranged between 0.36 and 0.58 for the top clay layer (10 samples); between 0.36 and 0.57 for the upper sand layer (7 samples); and between 0.38 and 0.59 for the lower clay representing the main confining bed (8 samples). In addition, Bingham Environmental (Envirocare, 1993) derived the effective porosity from the total porosity and residual moisture-content values obtained from laboratory testing of four samples of Unit 3 (uppermost aquifer). The effective porosity thus determined was 0.30.

3.4.1.4 Ground-Water Flow

3.4.1.4.1 Lateral Flow

Lateral Ground-Water Flow—Bingham Environmental (Envirocare, 1993) evaluated the total potentiometric heads in freshwater-equivalent heads from the water-level and specific-gravity data. The specific gravity was either measured or estimated for individual wells from the total dissolved solids content and/or the electrical conductivity of the water.

The computed freshwater-equivalent heads were used by Bingham Environmental to prepare potentiometric-head contour maps for February, May, and October 1991, January 1992, and February 1993. Figure 7 provides the potentiometric-head contour map for February 1993; the other potentiometric-head contour maps are provided in the license application documents (Figures 14 through 16, Addendum 1 to Appendix D of the license application (Envirocare, 1993)). The applicant, on the basis of the computed freshwater-equivalent heads for the unconfined aquifer used by Bingham Environmental (Envirocare, 1993), concluded that there is a high potentiometric-head anomaly in the vicinity of well GW-38, and that the lateral subsurface flow in the area of the disposal site is generally toward the west, north, and east.

The high potentiometric-head anomaly in the vicinity of well GW-38 in the disposal site area could be attributed to a significant recharge that the unconfined aquifer may be receiving at that location from the underlying confined aquifer. However, there are no other data to corroborate this finding. In addition, the applicant used estimated specific gravity values in evaluating the freshwater-equivalent heads for some wells, and groundwater gradients in the area of the site are generally small. The staff has determined that the applicant did not provide conclusive evidence as to the direction of ground-water flow in the uppermost aquifer.

Nevertheless, by concluding that ground water flows in virtually all directions from the disposal cell, the applicant has located the point of compliance (POC) and provided POC wells for monitoring around the entire perimeter of the disposal area. Accordingly, the NRC staff is satisfied that the proposed monitoring will be adequate for timely determination of contaminants that may reach the water table from the disposal cell.

Lateral Flow Velocity in the Uppermost Aquifer—The maximum lateral flow velocity (v) in the uppermost aquifer was evaluated by the applicant at 4 m/yr (13 ft/yr), using the following standard form of Darcy's Law:

$$v = Ki/n,$$

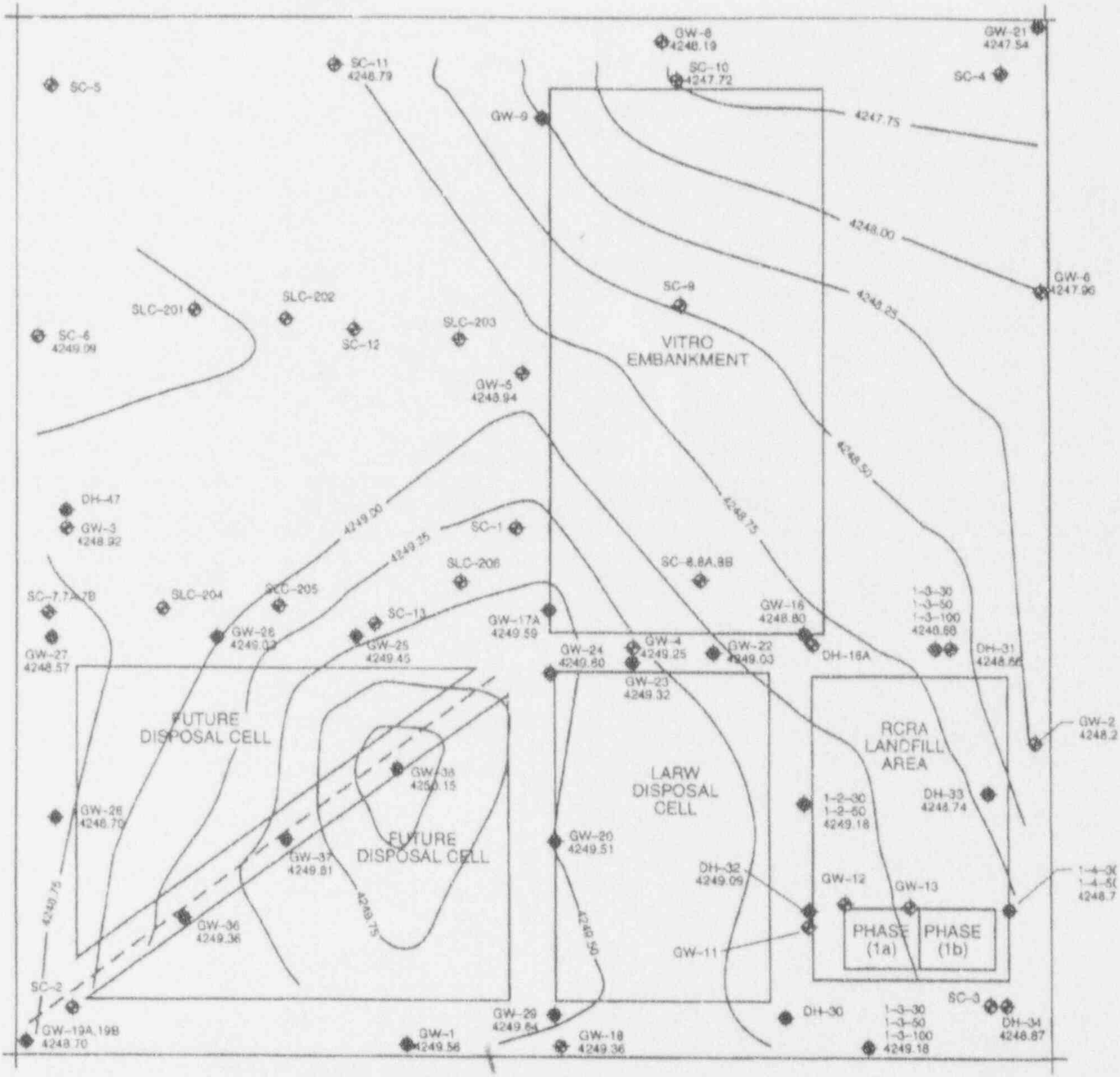
where

- v = linear flow velocity
- K = lateral hydraulic conductivity
- i = lateral hydraulic gradient
- n = effective porosity

Bingham Environmental (Envirocare, 1993) used a hydraulic conductivity of 1.9×10^{-3} cm/s (6.2 ft/s) to determine the flow velocity, based on a slug-test measurement made in the upper sand layer (slug-test results can be found in the license application documents on pages A-69 and A-70 of Appendix A to Appendix D-1 (Envirocare, 1993). The value of the hydraulic gradient (0.002) used in the computation was based on the available potentiometric-head data for the site (Envirocare, 1993) The effective porosity value used in computing the flow velocity was 0.30, based on laboratory measurements of samples from the uppermost aquifer.

3.4.1.4.2 Vertical Flow

The applicant used the potentiometric-head and water-quality data to conclude there is a vertical upward flow in



LEGEND

———4247.5——— Freshwater Equivalent Head (Jan. 15, 1992)

Freshwater Equivalent Head Elevation Included Adjacent to Well I.D.

GW-16 Through GW-38	Monitor Wells-Bingham Environmental (1991-1992)
DH-30 Through DH-47	Exploratory Holes/Piezometers-Bingham Environmental (1991-1992)
I and other GW's	Delta Geotechnical Consultants (1988,1990)
SLC-	Jacobs Engineering Group, Inc. (1984)
SC-	Dames & Moore (1981-1982)

0 400 800 1200

Scale in Feet

SOIL SAMPLING CODE

- Continuous Soil Sampling Hole
- Discontinuous Soil Sampling Hole

Figure 7 Potentiometric-Head Contour Map the disposal site area, from the confined aquifer to the unconfined aquifer. The NRC staff agrees with this conclusion because the available data indicate that the total potentiometric head in the confined aquifer is greater than that in the overlying unconfined aquifer.

The significance of the upward flow in the site area is that it indicates that the confined aquifer is a source of recharge for the unconfined aquifer, and not the other way around. Although the upward flow may directly impact the position of the water table and potentially contribute to the moisture content in the disposal cell, it can virtually halt the downward flow from the unconfined aquifer. The upward flow velocity across the confining bed(s) was evaluated by the applicant (Envirocare, 1993) at between 0.05 and 0.03 m/yr (0.16 and 0.10 ft/yr).

The staff noted that the applicant may have underestimated the upward flow velocity and flow from the confined aquifer to the unconfined uppermost aquifer. The hydraulic conductivity and effective porosity values used by the applicant to determine the flow velocity across the confining beds were not consistent with the recorded data. The applicant used a vertical hydraulic conductivity for the confining bed(s) of 10^{-6} cm/s (3×10^{-7} ft/s), but the data from slug tests conducted in the main confining bed (Unit 2) in four wells show the hydraulic conductivity to range between 5×10^{-5} and 1.7×10^{-4} cm/s (1.6×10^{-6} and 5.6×10^{-6} ft/s). Other less prominent confining beds can be expected to have even higher hydraulic conductivities. Also, the vertical flow gradients at some well locations are much higher than the value used by the applicant (0.05), and the effective porosity used by the applicant for the confining zone (i.e., 0.30) appears to be an overestimate considering the prevailing lithology of the main confining bed, which consists of silt and/or clay.

Accordingly, the staff concluded that the applicant may have underestimated the vertical flow velocity across the confining bed. This should not entail any serious implications for the proposed disposal facility, however, because the potentiometric-head gradient in the confining bed decreases upward and therefore effects an upward flow from the confined aquifer to the unconfined, uppermost aquifer. Furthermore, the upward flux (i.e., recharge) from the confined aquifer is already reflected in the existing position of the water table, which is not expected to rise significantly or reach the disposal cell in response to potentiometric-head fluctuations in the confined aquifer in the future (the disposal cell liner is about 3 m (10 ft) above the water table).

3.4.1.4.3 Hydrogeologic Boundaries

The applicant indicated that the only known hydrogeologic boundaries in the general area of the site are those associated with the nearby north-south trending mountain ranges, which constitute different outcrops, topography, lithology/rock types, and structure than does the basin fill. These include Lone Mountain, which rises about 290 m (950 ft) above the basin floor east of the disposal site, and Grayback Hills, which rise about 152.4 and 70.1 m (500 and 230 ft) to the north and west of the site, respectively.

The NRC staff agrees with the applicant's assessment and notes that no other hydrogeologic boundaries can be identified from the available database for the proposed disposal site.

3.4.1.5 Geochemistry and Ground-Water Quality

Ground-water quality data are available as the result of sampling and analysis of water samples from the disposal site area by the applicant, as well as other previously collected data from nearby sites, including data collected for the DOE Vitro disposal site and for the Aptus Corporation approximately 11.3 km (7 mi) away.

The applicant has conducted ground-water sampling and analysis in the proposed 11e.(2) disposal site area on a monthly/bimonthly basis since January 1992. The results indicate that the ground water is of a poor quality and unsuitable for most known uses. The total dissolved solids content ranges from 20,000 ppm in the confined aquifer, to as much as 60,000 ppm or more in the unconfined aquifer. Sodium is the most predominant cation and chloride is the most predominant anion, as shown on the Stiff and Trilinear diagram plots of the water quality provided in the license application and reproduced in Figures 8 and 9, respectively. The NRC staff further notes that the high levels of total dissolved solids and sodium and chloride concentrations in the water are characteristic of long flow paths or long residence time or both.

In addition, the applicant has collected and analyzed quarterly water samples from onsite wells for several years to meet the requirements of the existing permits. A total of seven onsite wells have been used in this monitoring, and six new wells have been installed near the proposed disposal cell. Water samples from these wells were analyzed for inorganic constituents, radioactive constituents, and selected solute and stable/unstable isotope ratios. The results of the analyses to date are provided for individual wells in Appendix C to Appendix D of the license application (Envirocare, 1993).

The radionuclide analysis by the applicant included determination of gross alpha, gross beta, ^{226}Ra, ^{228}Ra, ^{222}Rn, ^{210}Pb, ^{210}Po, ^{137}Cs, ^{230}Th, and total uranium on samples obtained from seven onsite wells. Plots of the concentrations of selected radionuclides (gross alpha, gross beta, ^{226}Ra, and total uranium) showing the change in the radionuclide concentrations during the past several years, apparently based on existing and new data, are provided in

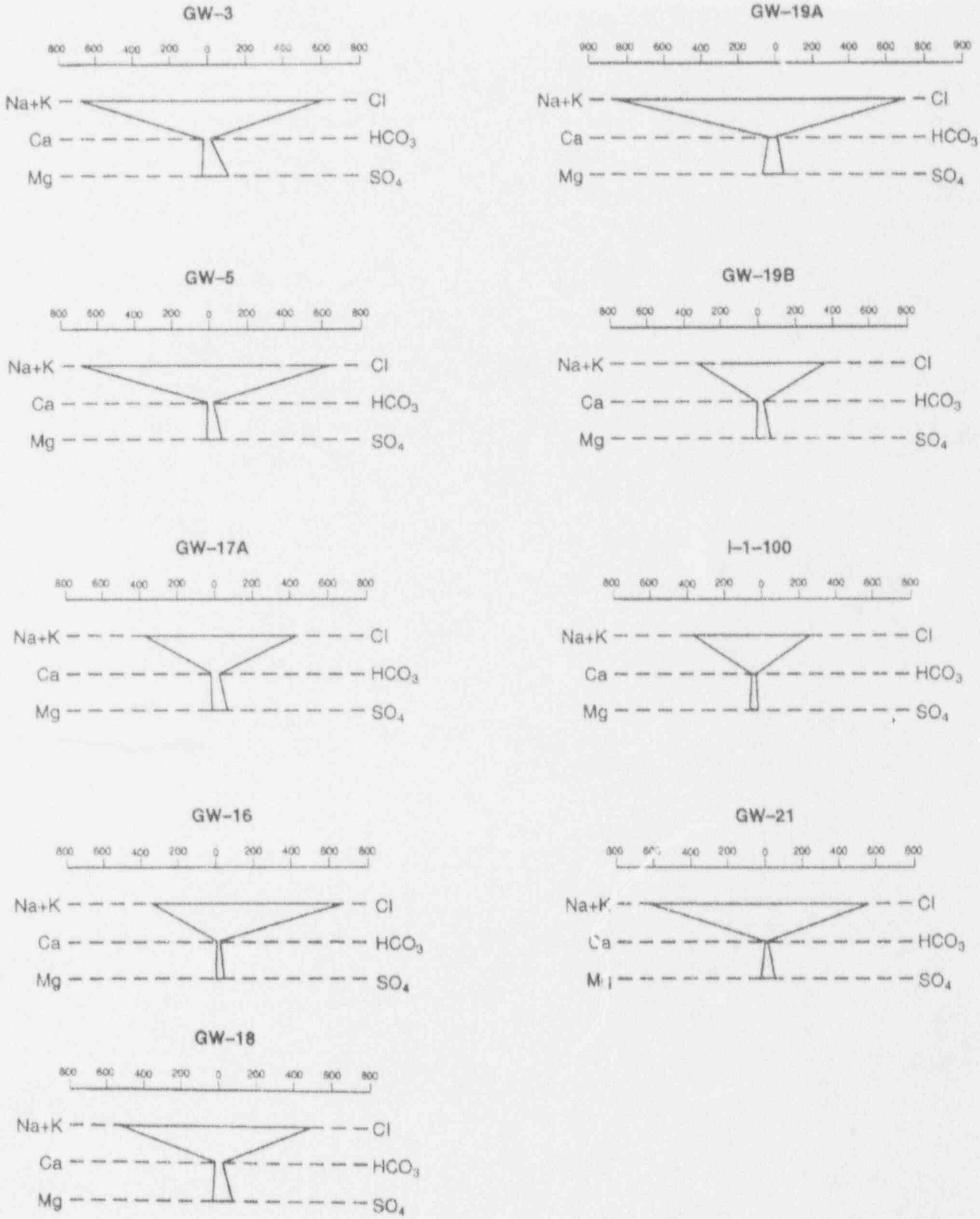


Figure 8 Stiff Diagram of Water Quality Data

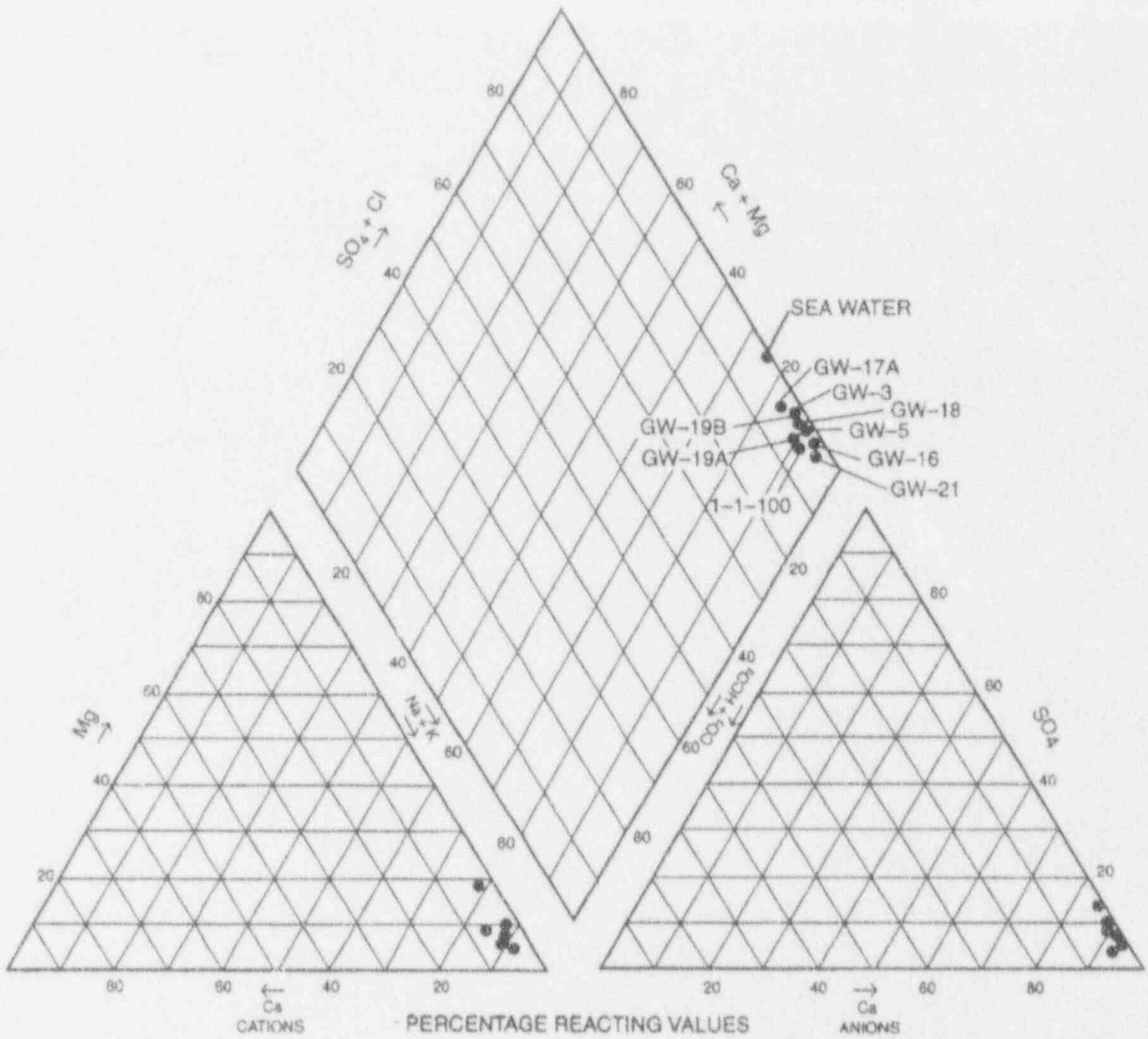


Figure 9 Trilinear Water Quality Plot

the license application (Envirocare, 1993). These plots indicate that above normal concentrations were recorded for some radionuclides (^{226}Ra and total uranium in monitoring well GW-3, for example), but above normal levels could not apparently be confirmed in repeat analyses to date, although the analysis of water samples from this well is continuing.

The applicant determined the stable/unstable ratios for selected isotopes, mainly to characterize ground-water recharge sources. The following isotopes were analyzed: hydrogen (H-2/H-1), oxygen (O-18/O-16), carbon (C-13/C-12), and sulfur (S-34/S-32); tritium (H-3) and carbon 14 (C-14) were also determined for selected wells to evaluate the age of the water. The results show that there are low tritium concentrations of 1.8–4.9 in the ground water, which suggests a pre-1953 recharge and subsequently long subsurface flow paths, long residence time, or both. The radiocarbon dating of the water was inconclusive.

The ground-water quality assessment by the applicant also involved determining the saturation index (SI) for selected minerals, a measure of the water's tendency to precipitate (positive SI) or dissolve (negative SI) a mineral. The applicant concluded that ground water in the site area has a tendency to precipitate such minerals as aragonite, calcite, dolomite, fluorite, and magnesite, and a tendency to dissolve such minerals as halite, gypsum, anhydrite, and mirabilite, but the dissolution/precipitation tendencies of some minerals are complex. The staff considers the solution and precipitation of minerals in the ground water in the site area to be controlled generally by complex mineralogical and geochemical factors.

3.4.1.6 Water Use

The applicant indicated that the natural ground water in the disposal site area is unsuitable for most uses. This is largely due to the very high total dissolved solids (TDS) content in both the confined and unconfined aquifers. Also, the concentrations of many of the inorganic constituents are above their designated maximum concentration limits (MCLs) in the EPA standards (Table 5C, Appendix A to 10 CFR Part 40).

Figure 5.1 and Table 1.8 of the license application (Envirocare, 1993) provide information on the existing and abandoned wells located within a 15-km (5-mi) radius from the disposal site. The nearest known wells are located approximately 3 km (2 mi) northeast and 5 km (3 mi) north/northwest of the site. In the Bonneville Salt Flats, approximately 48.3 km (30 mi) to the west of the site, highly saline water (i.e., typically with a TDS concentration of about 300,000 ppm) is used for mineral extraction.

The NRC staff is in general agreement with the applicant that based on the available data, the ground water in the site area is of a poor quality and unsuitable for most uses.

3.4.2 Conceptual Design Features for Water Resources Protection

The applicant's proposed layout and design drawings for the disposal cell are documented in Sections 3 and 4 of the license application and Section 3.2 of this FSER. The proposed construction and operation procedures are documented in Section 4 of the license application and in Sections 3.2, 4, and 5 of this FSER. A plan for ground-water protection during the facility operation is provided in Appendix Z of the license application (Envirocare, 1992c).

As stated in Section 2.3 of this FSER, the applicant proposes, in the long term, for the disposal site to have a maximum total design capacity of 7.6 million m^3 (10 million cy) of 11e.(2) byproduct material and a design life of up to 1000 years. The current application, however, is to initially allow disposal of 2.3 million m^3 (3 million cy) in two triangular disposal cells. The proposed embankments would occupy a total area of about 607,030 m^2 (150 acres). The principal objective of the proposed design is to isolate, stabilize, and contain the waste and effectively control the radioactive release from the site throughout the design life of the disposal facility. Furthermore, the disposal cells are designed and will be constructed and operated in conformance with all of the applicable standards and/or regulations of the EPA, NRC, and the State of Utah. The applicant has indicated a commitment to meet the design objective as well as all of the regulatory requirements.

The construction/operation of the disposal cell would mainly involve excavation of soils and other natural materials to prespecified design depths, construction of the clay liner, placement and compaction of the waste in 30-cm (12-in)-thick layers, and placement of the embankment cover. The applicant has developed a plan for protection of ground water during the facility construction and operation (Envirocare, 1992c). The plan includes quality control/quality assurance measures that will be employed during construction to ensure that the waste is properly compacted, preventive measures to control entry of the precipitation and runoff water into the cell, and preventive and corrective measures to prevent contamination of surface and ground water in the event of a spill or inadvertent entry of excess water into the cell during construction.

The proposed largely above-grade embankment design does not represent the prime option for disposal, that is, below grade, as defined in Criterion 3 of Appendix A to 10 CFR Part 40. However, the applicant indicated that the proposed design was selected over two other design alternatives, including one partially below grade and another fully below grade. The selection was made by the applicant considering factors relating to environmental protection, waste isolation, geotechnical stability, construction cost, and economics (i.e., in terms of the design capacities that can be attained or the volume of waste that can be disposed of per acre).

In selecting the disposal embankment design, the applicant identified and evaluated two factors that are directly related to water-resource protection. These are the position of the water table and potential infiltration of rainfall and runoff water into the disposal cell. The license application indicates that both of these factors favored the proposed largely above-grade embankment design over the other design alternatives, because (1) above-grade design provides maximum thickness of unsaturated natural material between the waste and the water table and thereby offers maximum protection against seepage from the disposal cell into ground water or water table rise into the cell and (2) less infiltration of precipitation and runoff water would be expected to take place into an above-grade embankment than a below-grade embankment because the former is less likely to be inundated.

In addition, the applicant indicated that the embankment design includes two key features that will contribute to water-resource protection at the disposal site. These include an embankment cover and a bottom liner that are designed to contain the waste and minimize the mobility of contaminants. The embankment cover consists of a 2.1-m (7-ft)-thick radon cover, a 15-cm (6-in)-thick filter zone, and a 45-cm (18-in)-thick graded-rock cover for protection against erosion. The radon cover is designed to minimize the infiltration of precipitation and runoff water into the cell; the filter zone is designed to redirect moisture away from the cell; and the rock cover provides protection against water and wind erosion.

The bottom liner is included in the design to minimize seepage of contaminants from the disposal cell to the water table, and retard upward flow of moisture and subsurface water into the cell. It will consist of 0.6 m (2 ft) of compacted clay. The bottom 0.30 m (1 ft) will consist of native clay, compacted to 95 percent of standard Proctor maximum clay density (ASTM D-698) and tested to ensure that the required compaction has been achieved. The top 0.30 m (1 ft) will consist of processed clay, thoroughly mixed and kneaded until a homogeneous mixture is obtained. The top 0.30 m (1 ft) of the liner will be placed in two 15-cm (6-in) lifts, each compacted to 95 percent of standard Proctor maximum clay density (ASTM D-698) and tested to ensure the standard is met. Envirocare has conducted tests to ensure that the design compaction and densities of this clay are attainable. Furthermore, field permeability tests were performed for Envirocare on the compacted clay; these included three single-ring tests and one sealed double-ring test. The permeability determined by these tests ranged from 4.3×10^{-8} to 8.1×10^{-8} cm/s (7.6×10^{10} to 2.7×10^{-11} ft/sec) (Envirocare, 1992a). The staff notes, however, that Envirocare has not conducted any tests to verify the compatibility of the clay that will be used to construct the bottom liner with the waste solution, as required by the ground-water protection standards in Appendix A to 10 CFR Part 40. Envirocare will be required to conduct these tests (see Section 3.4.3.2).

The staff concluded that from the ground-water resource-protection standpoint, the applicant has demonstrated that the proposed conceptual embankment design is appropriate for the prevailing hydrogeologic conditions in the proposed site area.

3.4.3 Ground-Water Protection Standards and Regulatory Requirements

The regulatory requirements for ground-water protection at UMTRCA Title II sites, including 11e.(2) byproduct material disposal sites, are provided in Appendix A to 10 CFR Part 40. Ground-water protection standards are provided in Criterion 5, a closure-performance demonstration in Criterion 6, ground-water monitoring requirements in Criterion 7, and a list of hazardous constituents in Criterion 13. Other provisions that contribute to ground-water protection indirectly, such as those in Criteria 1, 3, 4, 9, and 10, are covered in other sections of this report.

For the purposes of this report, provisions for ground-water protection in the regulations can be divided into the following four categories: ground-water protection standards, other provisions for ground-water protection, performance assessment including closure-performance demonstration, and ground-water monitoring requirements. These provisions are discussed and the applicant's proposed measures to meet these requirements are evaluated in the following sections.

3.4.3.1 Ground-Water Protection Standards

The standards applicable to ground-water protection at the proposed disposal site are provided in Criteria 5 and 13 of Appendix A to 10 CFR Part 40. They include (1) defining a list of hazardous constituents; (2) establishing concentration limits for these constituents in the ground water; (3) locating a point of compliance (POC), where compliance with the established standards can be verified; and (4) defining a period during which compliance is required. These standards are discussed in more detail in the following sections.

Hazardous Constituents—The regulatory standards require that hazardous constituents entering ground water from the disposal area be designated and their concentration limits established (Criterion 5B(1)). The standards also provide (Criterion 5B(2)) three specific tests to be met in order to designate a constituent as hazardous and to establish a concentration limit for that constituent at a particular site. These tests are: (1) the constituent is reasonably expected to be in or derived from the byproduct material, based on consideration of the full range of the waste characteristics; (2) the constituent has been detected in the ground water in the uppermost aquifer; and, (3) the constituent is listed in Criterion 13. Furthermore, the standards include provisions (Criterion 5B(3)) for a possible exclusion by NRC of a hazardous constituent on a site-specific basis, if it is found that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment.

Contaminants may be designated as hazardous at the disposal site by NRC on the basis of the above criteria, after the contaminants have been detected at the POC. However, as discussed subsequently in the monitoring section, preoperational monitoring to establish background baseline ground-water quality, and detection monitoring require the development of a list of site-specific hazardous constituents on the basis of the waste characteristics and the hazardous-constituent list in Criterion 13.

The applicant has provided a list of hazardous constituents to be used for establishing background baseline ground-water quality and for detection monitoring (Envirocare, 1993). This list is provided in Table 5 and includes 13 metals, 5 radionuclides, and 9 volatile and semivolatile organic constituents, and is based on hazardous constituents detected at uranium mill tailings embankments in Wyoming, New Mexico, and South Dakota. The applicant has further indicated that additional hazardous constituents would be added to the initial list in the future, if

Table 5 Initial List of Hazardous Constituents
(Source: Envirocare, 1993)

Metal	Radionuclide	Volatile Organics	Semivolatile Organics
Arsenic	Radium-226	Acetone	Diethylphthalate
Barium	Radium-228	2-butanone	2-methylnaphthalene
Beryllium	Thorium-230	Chloroform	
Cadmium	Thorium-232	Carbon disulfide	
Chromium	Uranium	1,2-dichloroethane	
Cyanide		Methylene chloride	
Flourine		Naphtha	
Lead			
Mercury			
Molybdenum			
Nickel			
Selenium			
Silver			

warranted on the basis of a complete characterization of the waste received at the disposal facility.

By a **license condition**, the applicant will be required to analyze and characterize the incoming waste and identify any new hazardous constituents that should also be monitored. It will be assumed that the background concentrations for all such new constituents are below their detection levels, unless the applicant demonstrates to NRC staff's satisfaction that the constituents cannot possibly reach the water table in 1 year and proceeds to establish background values based on direct monitoring of these constituents in the POC wells for one full year. In addition, the applicant will assume responsibility for meeting the standards established at the POC by NRC for all of the site-specific hazardous constituents, including those additional constituents designated in the future on the basis of waste characterization and detection at the POC, as discussed in the following paragraph.

Concentration Limits—The standards require that the concentration limits be established for the designated hazardous constituents in accordance with Criterion 5B(5) as (1) background limits representing predisposal background ground-water quality, (2) drinking water limits as defined in Table 5C of Appendix A to 10 CFR Part 40, or (3) alternate concentration limits (ACLs). ACLs for specific constituents may be approved if the background limits and drinking water limits are not practically achievable, if the proposed limits are as low as is reasonably achievable considering practicable corrective actions, and if the contaminants will not pose a substantial present or potential hazard to human health or the environment, as long as the ACLs are not exceeded at the POC (Criterion 5B(6)).

The concentration limits will be established by NRC if hazardous constituents are identified during detection monitoring. As discussed further in Section 3.4.3.4, the background baseline ground-water quality data will need to be established for the disposal site based on one full year of preoperational monitoring.

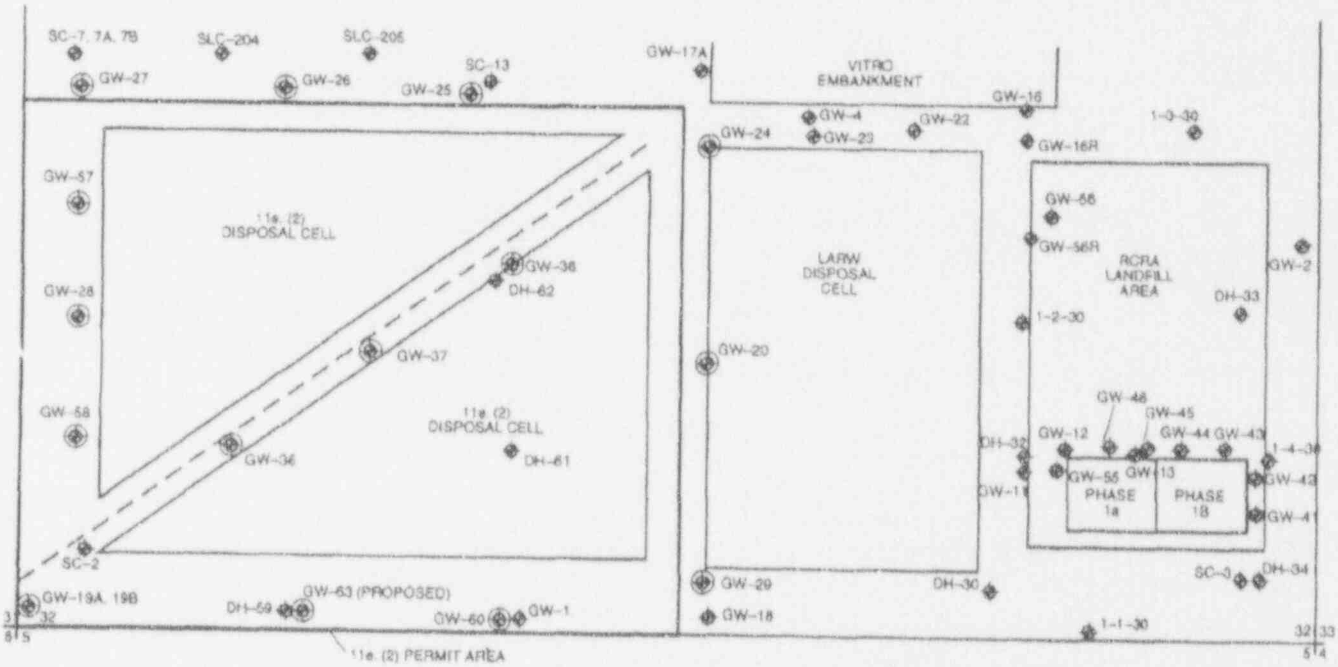
Point of Compliance—The POC is the site-specific location where the ground-water protection standard must be met. The POC must be so located as to provide prompt indication of any ground-water contamination in the uppermost aquifer on the hydraulically downgradient edge of the disposal area (Criterion 5B(1)).

The applicant conducted onsite field investigations and measurements in order to determine the direction of ground-water flow and the POC location. Onsite investigations involved drilling and water level measurements in monitoring wells and test holes. The measured water levels were converted to freshwater-equivalent heads to delineate the potentiometric-head distribution in the uppermost aquifer. The data indicated that there is a high potentiometric-head anomaly in the site area, in the vicinity of well GW-38, and that ground water flowed in nearly all directions from the vicinity of this well.

Although the applicant did not offer a satisfactory explanation for the high potentiometric-head anomaly in the vicinity of well GW-38, the resulting potentiometric-head contours required that the applicant define the point of compliance and provide monitoring in virtually all directions around the disposal embankment, to provide for timely detection of any contaminants reaching the water table from the disposal cell.

Acc.. dingly, the applicant defined the POC in nearly all directions and proposed to include a total of 15 POC monitoring wells that are so located to permit detection of contaminants in virtually all directions from the disposal site (Figure 10). The NRC staff finds the applicant's placement of POC wells to be acceptable and in compliance with the requirements of 10 CFR Part 40, Appendix A, Criterion 5B(1).

Compliance Period—In accordance with 10 CFR Part 40, Appendix A, Criterion 5B(1), if hazardous constituents are identified in the POC wells on the basis of detection monitoring, the NRC will through license condition or order set the compliance period. The applicant has noted an understanding of this criterion in the license application.



LEGEND

⊕ Monitor Wells Included in Network

OTHER WELLS AND EXPLORATORY HOLES:

GW-16 Through GW-60:	Monitor Wells-Bingham Environmental (1991-1993)
DH-30 Through DH-62:	Exploratory Holes/Piezometers-Bingham Environmental (1991-1993)
I and other GW's:	Delta Geotechnical Consultants (1988,1990)
SLC-	Jacobs Engineering Group, Inc. (1984)
SC-	Dames & Moore (1981-1982)

11e. (2) POINT OF COMPLIANCE MONITOR WELLS

GW-19A	GW-25	GW-28	GW-37	GW-58
GW-20	GW-26	GW-29	GW-38	GW-60
GW-24	GW-27	GW-36	GW-57	GW-63

Figure 10 Point-of-Compliance Wells

3.4.3.2 Other Provisions for Ground-Water Protection

In addition to the ground-water protection standards, the regulations also include the following provisions for ground-water protection.

Site Characterization—Criterion 5G requires that the disposal site be adequately characterized by delineating the underlying soils, stratigraphy, water-bearing and hydraulic characteristics of formations and hydrologic boundaries; conducting borehole lithologic and geophysical logs; and evaluating ground-water uses.

Except for the outstanding issues identified elsewhere in this report, the NRC staff agrees that the requirements of the above criterion have largely been met. Onsite drilling and testing were carried out by the applicant, and the database thus generated was used to delineate the lithostratigraphic and hydrogeologic units and ground-water quality in the site area (Envirocare, 1993). No borehole geophysical logging was carried out, but this deficiency can be overlooked since the availability of lithologic and water quality records from a fairly large number of boreholes and monitoring wells are located in the area of the site.

Compatibility of Liner Material and Waste Solution—Criterion 5E requires that the applicant conduct compatibility tests using representative waste solutions and liner material in advance of construction. These tests are needed to demonstrate that the integrity of the liner will not be impaired.

No tests have been conducted to date to verify the compatibility of the waste solutions and the material that the applicant proposes to use for construction of the bottom liner, as required by Criterion 5E. As discussed in Section 4.1.4 of the license application, Envirocare proposed to use native clays, from Unit 4, to construct the liner. The applicant indicated that the compatibility of the waste solution and the liner material was evaluated considering the results of tests that had been carried out by Kerr-McGee, using a tailings solution and a clay bed (designated as the F-Stratum) in the vicinity of their tailings site in northern Illinois. The Kerr-McGee tests had concluded that the West Chicago tailings solution would not cause any degradation of the clay obtained from the F-Stratum. The applicant indicated that Envirocare will probably be receiving and disposing of Kerr-McGee West Chicago tailings, and concluded that the results of the Kerr-McGee test would be applicable in the proposed disposal site area. The applicant provided information and pointed out similarities in the mineralogical composition of the F-Stratum at Kerr-Mcgee's site and Unit 4 at Envirocare's site. The applicant concluded that the proposed liner material should be compatible with the tailings solution, but that Envirocare will still provide laboratory test data on the compatibility of Unit 4 material with the waste solution.

The staff did not accept the applicant's argument that the results of the Kerr-McGee test are applicable to the disposal site area. The Kerr-McGee West Chicago tailings may or may not be transferred to the Envirocare facility and will not, in any case, constitute the only waste received by Envirocare. The leachate solution generated at the Envirocare site may not, therefore, be identical or even similar to that generated by West Chicago tailings. More importantly, the mineralogical analyses provided by the applicant indicate that there are notable and important differences in the compositions of the F-Stratum at West Chicago and Unit 4 at the Envirocare site. These are: (1) the clay minerals (kaolinite, illite/mica, and smectite) constitute 39 percent of the F-Stratum, compared to only 18 percent for Unit 4; (2) silicate minerals (quartz, plagioclase, and feldspar) constitute 38 percent of the F-Stratum, compared to 18 percent for Unit 4; and (3) carbonate minerals (calcite, dolomite, and aragonite) constitute 65 percent of Unit 4, compared to 17 percent for the F-Stratum. These data indicate that while the F-Stratum depicts a typical clay composition (a high content of clay and silicate minerals), Unit 4 does not. The high content of carbonate minerals in Unit 4 is of particular concern since these minerals can dissolve as the pH declines below 7, which can be expected to take place in the waste solution.

On the basis of the above, the staff considers this as an ***open issue***. The applicant will be required to establish and verify, through proper testing, the compatibility of the liner material and the waste solution as required by Criterion 5E of Appendix A to 10 CFR Part 40.

Control of Moisture Content in the Disposal Cell—Criterion 5E requires that dewatering be provided when and where necessary during placement of the waste to control the liquid and moisture content in the disposal cell. Furthermore, Criterion 6 requires that the embankment cover be designed and constructed so that the infiltration of precipitation through the cover is adequately controlled to minimize or eliminate the escape and/or transmittal of contaminants from the disposal cell to the ground water or surface water, after the closure of the facility.

The NRC staff agrees that the proposed embankment design and construction plan will provide the required protection during the placement of the waste in the disposal cell. As noted previously, the embankment design includes an embankment cover designed to minimize the infiltration of precipitation and runoff water into the cell, and a bottom liner designed to control downward seepage of contaminants into the water table. Also, the applicant has developed a plan for protection of ground water during the construction/operation period (Envirocare, 1992c). The plan includes quality control/quality assurance measures to ensure that the waste is properly compacted, preventive measures to control entry of the precipitation and runoff water into the cell, and preventive and corrective measures to prevent contamination of surface and ground water in the event of a spill or inadvertent entry of excess water into the cell during construction. However, effective control of the moisture buildup in the disposal cell after the facility closure must be assessed as discussed in Section 3.4.3.3.

Corrective Action Plan—Criterion 5D requires that if the established ground-water protection standards are exceeded, the licensee will develop and submit for NRC approval a corrective action plan to remedy the situation and the plan can be put into operation as soon as possible and in no event later than 18 months after a standard is exceeded.

While the regulations do not require that the applicant develop a corrective action plan prior to a finding that the standards are exceeded, the detection of hazardous constituents in the future could present some difficulties that are unique to the proposed disposal site. The NRC staff notes there may be future disagreements involving the applicant and the Federal and State Governments as to the source or sources of contaminants that are detected at the proposed site. This is bec[illegible] the proposed site adjoins other existing and plan[illegible] [illegible]osal facilities (i.e., DOE's Vitro embankment and [illegible] existing and planned facilities on the applicant's property that are licensed by the State of Utah) and because the flow gradients are low and the direction of ground-water flow has not been delineated definitively. Such disagreements may not be resolved in time to implement a corrective action within the timeframe specified in the regulations (i.e., a maximum of 18 months after a finding that standards are exceeded).

By a **license condition**, the applicant will assume full responsibility for cleaning up all of the hazardous constituents that are detected at the POC in concentrations that exceed the concentration limits established for them by NRC, on the presumption that they were generated at the 11e.(2) disposal facility, unless it can be demonstrated, on the basis of field and laboratory data and to the satisfaction of NRC, that the proposed facility is not the source of such constituents. NRC will make the final decision on any claim and data provided by the applicant in the future indicating that the 11e.(2) facility is not the source of contamination. The applicant will be obligated to undertake corrective action to clean up contamination if required, no later than 18 months from the date when it has first been discovered that a standard has been exceeded, and without taking credit for any delays caused by disagreements as to the source of contamination.

3.4.3.3 Performance Assessment

Performance During Operation—Satisfactory performance of the proposed facility during the operation period will be largely affected by enforcement through several conditions placed on the license.

In particular, **license conditions** pertaining to ground-water protection will be used to ensure that the licensee (1) adheres to the approved design, construction, and operation procedures, and the provisions of the ground-water protection plan included in Appendix Z of the license application; (2) adheres to the ground-water monitoring and quality assurance measures for monitoring specified in Appendix Z of the license application, as approved by NRC; (3) conducts periodic monitoring at the POC to ensure a timely detection and designation of the hazardous constituents and establishment of their concentration limits for the disposal site based on site-specific data; and (4) develops and implements proper and timely corrective actions if the established standard for any of the designated hazardous constituents is exceeded.

Closure-Performance Demonstration—A **license condition** will include provisions for proper termination of the license and transfer of the facility to the DOE, another Federal agency as designated by the President, or the State in which the disposal site is located for long-term custody in accordance with 10 CFR 40.28, as well as Part 40, Appendix A, Criterion 11. Specifically, the license will include provisions so the license termination does not take effect unless (1) the concentrations of all of the designated hazardous constituents at the POC are within their designated concentration limits (standards); (2) a corrective action program is carried out to remedy ground-water contamination above the designated limits, attributed to the disposal facility; and (3) the facility has been properly decontaminated and decommissioned according to an NRC-approved plan and in accordance with the decontamination and decommissioning plan proposed by the applicant in the license application (Envirocare, 1992a).

Postclosure Performance—The applicant conducted a postclosure performance assessment. This essentially involved evaluating the infiltration rate, contaminant travel time from the disposal cell into the water table, and the flow velocity in the uppermost aquifer.

Three models were used by the applicant in this analysis: a one-dimensional, unsaturated flow model designated UNSAT-H, a quasi two-dimensional water budget model designated HELP, and a contaminant transport model designated PATHRAE. These models are described and the results of their application to the proposed disposal site are provided in Appendix M and Appendix P of the license application, which were prepared by Bingham Environmental for the applicant (Envirocare, 1993).

The rate of infiltration into the water table was evaluated by the applicant considering the infiltration of precipitation water through the embankment cover into the disposal cell, and from the disposal cell through the unsaturated zone into the water table. The infiltration rate was evaluated using the UNSAT-H and HELP models, and used as input to the PATHRAE model to evaluate the contaminant travel time from the disposal cell into the water table.

The applicant conducted a performance assessment to assess postclosure contaminant transport for the adjoining low-level waste disposal facility and considered these modeling results applicable to the 11e.(2) byproduct material disposal site. The findings of this assessment, which were reported in 1993 (Envirocare, 1993), superseded previously submitted reports by the applicant. The assessment indicated that, based on the modeling results using the UNSAT-H and PATHRAE models, the contaminant travel time from the disposal cell to the water table was determined to be 630 years. The report also indicated that the travel time was sensitive to the hydraulic conductivities of the bottom liner and the radon cover, and that increasing the hydraulic conductivity value by one order of magnitude would reduce the contaminant travel time from 630 to 192 years.

The staff has reservations on the postclosure performance assessment carried out by the applicant to date. The staff does not agree with some of the input parameters used in the UNSAT-H model, and the infiltration rates determined by this model are not consistent with those obtained previously (using the HELP model). The staff further noted that the applicant had taken credit for soil/rock attenuation. The distribution coefficients used in this analysis for some of the constituents were less conservative than those recommended by the EPA for arid site conditions.

The staff noted also that the applicant did not include the dispersion process in the contaminant-transport analysis. The inclusion of this process in the analysis can result in a portion of the radionuclide inventory migrating at a faster rate than the rate predicted by the PATHRAE model to date.

However, despite the staff's reservations about the details of the applicant's performance assessment and except for the bathtubbing issue, which remains open as discussed in the following paragraphs, the staff is not in disagreement with the applicant's general conclusion about the performance of the disposal cell. The staff considers that the proposed cell design is satisfactory to contain the waste solution and that any seepage of contaminants from the cell will take place at a very slow rate because of the low hydraulic conductivity of the proposed liner and the underlying clay/silt bed. Contaminant travel time can be expected to be long in both the unsaturated zone and the uppermost aquifer after it reaches the water table. More importantly, the staff notes that the license will have adequate safety provisions requiring the applicant to (1) monitor ground-water quality in the uppermost aquifer on a regular basis for timely detection of contaminants at the POC, (2) ensure compliance with the site-specific concentration limits established for individual constituents by NRC, and (3) undertake corrective action if the standards are exceeded. The staff concludes, therefore, that except for the open issues identified in this and other sections of this FSER, deficiencies in the applicant's performance assessment do not compromise the safety of the proposed facility.

The staff considers that potential bathtubbing due to transient moisture buildup in the disposal cell in the postclosure period is an ***open issue***. The staff agrees that a sustained bathtubbing condition is not expected to prevail after a steady state has been reached, because the liner will have a higher hydraulic conductivity than the embankment cover (see Section 3.5 of this FSER), and the seepage rate from the cell will, therefore, exceed the rate of new moisture infiltration into the cell due to precipitation. However, transient buildup of the moisture in the cell cannot be ruled out because moisture already in the tailings embankment may accumulate in the lower part of the cell at a higher rate than the seepage rate from the liner. The resulting buildup of the moisture in the cell may be further exacerbated because of consolidation and reduction in the effective porosity of the tailings.

To close this issue, the applicant will be required to conduct and document calculations to determine the maximum hydraulic head that can be expected in the cell, and to demonstrate that the embankment cover will be so designed and constructed to withstand the hydraulic pressures so generated. The applicant will be expected to use conservative assumptions about moisture accumulation in the cell. All possible sources of moisture will need to be considered in this determination, including the moisture added to the tailings to control dust and for proper compaction, accumulated precipitation that cannot be removed prior to placement of the embankment cover, and infiltration due to precipitation after the cover has been constructed. In addition, conservative projections of the compaction/ consolidation of the 11e.(2) byproduct material over time and the expected reduction in the tailings effective porosity will need to be considered.

3.4.3.4 Ground-Water Monitoring Requirements

Criterion 7 of Appendix A to 10 CFR Part 40 requires that license applicants/licensees undertake the following ground-water monitoring activities: (1) establish a "preoperational monitoring program" and conduct preoperational ground-water monitoring for one full year prior to the start of operation of the disposal facility, (2) establish a "detection monitoring program" and conduct detection monitoring as disposal at the facility begins, (3) establish a "compliance monitoring program" and conduct compliance monitoring if leakage of contaminants is detected at the facility and if detected contaminants are designated as "hazardous constituents" and their concentration limits are set by NRC, and (4) establish a "corrective action monitoring program" and conduct corrective action monitoring when one or more constituents are detected in concentrations that exceed established standards and corrective action has been initiated. The latter three programs are "operational" monitoring programs, and may be established based on existing monitoring programs to the extent that the existing programs can meet the stated objectives of the new program.

The objectives of these monitoring requirements, the obligations they impose on the applicants and licensees, and the response of the current applicant to these requirements to date are discussed in the following paragraphs.

Preoperational Monitoring—Criterion 7 of Appendix A to 10 CFR Part 40 requires that a preoperational monitoring program be established and preoperational monitoring conducted for one full year before the disposal facility operation begins. The purpose of the preoperational monitoring is to develop and fully document a complete preoperational baseline background water quality that can be approved by NRC and that can be used to confirm the water quality and its potential uses, and possibly complement the hydrogeologic characteristics of the disposal site area, as required by Criterion 5G.

To meet the above requirement, a license applicant normally needs to establish a network of monitoring wells that are located and designed specifically for baseline background monitoring and to develop an initial list of hazardous contaminants to be monitored for this purpose. The list of hazardous constituents thus developed will be also useful for detection monitoring, after the facility becomes operational.

The applicant has used data from a fairly large number of wells to characterize the ground-water quality in the proposed disposal site area, as described in Section 3.4.1.2. In addition, the applicant developed a network of monitoring wells for preoperational monitoring that includes a total of 15 POC wells (Figure 10). The staff concluded that the preoperational monitoring network established is sufficient in areal and vertical extent to meet the requirements of Criterion 7. The applicant has also developed a ground-water monitoring quality assurance plan (Appendix Z of the license application; Envirocare, 1992b) that is acceptable to the staff.

As indicated in Section 3.4.3.1, the applicant has provided a satisfactory list of hazardous constituents to be used initially for establishing background baseline ground-water quality and for detection monitoring (Table 5). The applicant has further indicated that additional hazardous constituents would be added to the initial list in the future, if warranted, on the basis of complete characterization of the waste received at the disposal facility.

Detection Monitoring—Criterion 7A requires the establishment of a "detection monitoring program" and the conduct of detection monitoring for (1) timely detection of hazardous constituents that leak into ground water from the disposal area; (2) designation of site-specific hazardous constituents if necessary as decided by NRC; and (3) generation of site-specific data and information that can be used to (a) establish the concentration limits for those constituents designated as hazardous on the basis of the detection and other tests specified in Criterion 5B(2), (b) set the period of compliance required under Criterion 5B(1), and (c) adjust the location of the POC, if necessary.

As discussed in the previous section, the list of hazardous constituents used in the preoperational monitoring will also be used for detection monitoring. The hazardous constituents and their corresponding baseline water quality values for each POC used for detection monitoring are a standard license condition. Background concentrations for the hazardous constituents that are not initially included on the applicant's list will be assumed to be below detection levels, unless the applicant demonstrates that the constituents cannot possibly reach the water table in 1 year. In the latter case, the applicant will proceed, with NRC staff approval, to establish background values based on direct monitoring of the POC wells for one full year. The applicant/licensee will submit changes to the hazardous constituents by proposed license amendment.

Compliance Monitoring—When the ground-water protection standards have been established pursuant to Criterion 5B, a licensee is required to establish a "compliance monitoring program" pursuant to Criterion 7A, in order to ensure that the release of hazardous constituents to the ground water does not exceed established site-specific standards.

In accordance with 10 CFR Part 40, Appendix A, Criterion 5B(1), if hazardous constituents are identified in the POC wells on the basis of detection monitoring, the NRC will set the compliance period through license condition or order. The applicant has noted an understanding of this criterion in the license application.

Corrective Action Monitoring—Criterion 7A requires that if ground-water protection standards have been set pursuant to Criterion 5B, a compliance monitoring program has been established pursuant to Criterion 7A, and the concentration limits are exceeded thereby triggering the implementation of corrective action pursuant to Criterion 5D, a licensee must establish and implement a corrective action monitoring program in order to demonstrate the effectiveness of the corrective action.

Postoperational Monitoring—Postoperational monitoring will be carried out after the facility ceases to operate and will be continued until the operator's license is terminated and the site is transferred, for long-term care, to either the DOE, another Federal agency as designated by the President, or the State where the disposal site is located (10 CFR 40.28). Postoperational monitoring will involve a continuation of detection and compliance monitoring, and corrective action monitoring if corrective action is required to bring the concentrations of hazardous constituents to established limits (standards).

3.4.4 Conclusions

The NRC staff concludes that the ground-water resources protection program, as presented in the license application, has not been shown to fully comply with the ground-water protection requirements of Appendix A to 10 CFR Part 40.

3.5 Radon Attenuation

Criterion 6 of Appendix A to 10 CFR Part 40 states that the licensee shall place an earthen cover over tailings or wastes at the end of milling operations, and shall close the waste disposal area in accordance with a design that provides reasonable assurance of control of radiological hazards to (1) be effective for 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, and (2) limit releases of ^{222}Rn from uranium byproduct materials, and ^{220}Rn from thorium byproduct materials, to the atmosphere so as not to exceed an average release rate of 20 picocuries per square meter per second ($pCi/m^2/s$) to the extent practicable throughout the effective design life determined pursuant to (1) above.

Envirocare proposes to construct a multilayered earthen cover to control release of radon, to limit infiltration to ground water, and to provide erosion protection for the embankment. This section evaluates the radon barrier layer of the applicant's proposed cover for conformance with the radon release requirement in Criterion 6. The capability of the cover to protect the embankment and the radon barrier from freeze/thaw effects, drying and cracking, and erosion is discussed in Sections 3.2 and 3.3 of this FSER.

Envirocare proposes to construct a 2.1-m (7-ft) radon barrier of native clays. The NRC staff evaluated the capability of the proposed barrier to limit radon emanation to 20 $pCi/m^2/s$ by evaluating the parameters used by the applicant in the analysis and the model used to estimate the radon release from the cover.

3.5.1 Evaluation of Parameters

The thickness of an earthen cover required to control radon emission within allowable limits depends on the characteristics of the radon barrier soils and the underlying contaminated materials. Radioactive decay of radium (Ra) in the 11e.(2) byproduct material will occur for many thousands of years and continually produce radon (Rn). Radon is an inert radioactive gas that diffuses through the soil pore space over distances restricted, in part, by its short half-life (3.8 days for ^{222}Rn). The flux of radon reaching the atmosphere is reduced by restricting radon movement long enough so that it decays to a solid daughter that remains in the cover.

Parameters needed to characterize the cover soils and waste materials include density, specific gravity, porosity, moisture, and radon diffusion coefficient. Additionally, for the contaminated materials, the thickness, radium concentration, and radon emanation fraction are required.

Density and specific gravity can be used to calculate porosity, which is the ratio of the volume of interstices (pore spaces between soil particles) to the total volume. A denser soil would be less porous and, therefore, allow less radon to move. Similarly, increasing soil moisture fills the pore space with water and tends to restrict the flux of radon. The radon diffusion coefficient (D) characterizes radon movement in the pore space, with a small coefficient indicating little movement of radon. The amount of radon available to diffuse through the cover depends on the amount of radium present in, and the radon emanation fraction of, the contaminated material. This latter number is the fraction of radon produced that is released from the material into the pore space, rather than being trapped within a solid grain of the material.

The most significant parameter affecting the calculation of required thickness of the radon barrier is the D of the radon barrier material. The value of D is very sensitive to the availability of interconnected air-filled pores and, at moderate to high moisture, to cover soil moisture content and porosity. The parameter that introduces the greatest uncertainty into the calculation is the cover soil moisture content (NRC, 1989a).

Parameter values used to design the earthen cover should represent long-term (1000 years, to the extent reasonably achievable, and, in any case, at least 200 years) conditions, and should consider construction conditions, such as design compaction. Also, in computing cover thickness, there is the restriction in Criterion 6 of Appendix A to 10 CFR Part 40 that precludes consideration of moisture values in excess of that normally found in similar soils in similar circumstances.

The NRC staff reviewed the values chosen by the applicant for the physical and radiological parameters of the contaminated materials and the radon barrier soils as discussed below.

3.5.1.1 Contaminated Material

Waste characteristics are discussed in Section 6.1.1.2 of this FSER. Since parameter values for contaminated materials are only estimates of the characteristics of material anticipated to be received, the values should be conservative, since any material exceeding these values may be excluded from the embankment by license condition.

In the calculation of radon flux, Envirocare used an average concentration of 500 pCi/g ^{226}Ra to characterize the contaminated material. This is consistent with the applicant's other characterizations of contaminated material expected to be placed in the embankment. In the application, maximum concentrations of 2000 pCi/g ^{226}Ra and 2000 pCi/g ^{230}Th are assumed, with an average radium concentration of 500 pCi/g assumed for the contaminated material that will be placed in the disposal cell. Additionally, Appendix A, Section 3.2.2-a.2, of the application indicates that material with more than 1000 pCi/g of any radionuclide would not be placed in the top 3.3 m (10 ft) of the cell. Since only the upper 3-5 m (1.2-2 ft) of waste contribute to radon flux from the tailings (radon produced in lower levels of the embankment will decay before reaching the surface), limiting higher activity material to lower levels in the pile should essentially eliminate its contribution to radon flux. However, the depth below which contributions to radon flux can be ignored is dependent primarily on the diffusion coefficient of the contaminated material. This will have to be considered in modeling radon flux.

Envirocare indicated that the thorium chain radionuclides are not important in the radon barrier evaluation because ^{220}Rn has a short half-life (only 52 seconds), so under expected conditions, most of the ^{220}Rn will decay to a solid in the first 10 cm (4 in) of cover soil. The NRC staff agrees that ^{220}Rn attenuation is not a critical element in the design of the Envirocare cell. However, ^{226}Ra ingrowth from ^{230}Th was apparently not considered in calculations of ^{222}Rn attenuation.

The only stated limit for ^{230}Th concentration in the upper part of the cell is that it will not exceed 1000 pCi/g. Since the model should represent the 1000-year design, the radon flux estimate must consider the contribution from the ^{226}Ra that will result from the decay of ^{230}Th. If, for example, the upper 3.3 m (10 ft) of contaminated material contained 500 pCi/g ^{226}Ra and 1000 pCi/g ^{230}Th, then in 1000 years there would be approximately 675 pCi/g ^{226}Ra. For the radon attenuation model, the applicant must consider the long-term ingrowth of radium from thorium. The applicant can propose an average concentration of thorium in the upper portion of the embankment.

The average concentration of ^{226}Ra and ^{230}Th (and thereby the 1000-year ^{226}Ra concentration) in the upper portions of the embankment will be controlled by **license condition**. Not only must the concentration of ^{226}Ra and ^{230}Th be limited for the upper layer of waste, but these radionuclides must be fairly evenly distributed in this layer to be consistent with model assumptions. This also would be enforced by a **license condition**.

The distribution of these radionuclides is important because if the upper portion of waste were layered so that material with above-average ^{226}Ra concentration was near the barrier material, the flux standard could be exceeded. For example, if the material was in 1.5-m (5-ft) layers, so that the layer next to the barrier contained 750 pCi/g ^{226}Ra, the next 250 pCi/g, then 750 pCi/g, and the next 250 pCi/g ^{226}Ra, the average concentration would be 500 pCi/g. But the radon flux from the cover would increase about 30 percent compared to the flux produced by material at a uniform ^{226}Ra content of 500 pCi/g.

The applicant provided justification for most of the other selected parameter values. However, the NRC staff concludes that those values may not be representative of all the contaminated material disposed of in the upper portion of the embankment. Therefore, the values will be controlled by **license condition**. Alternatively, Envirocare can use parameter values that the NRC staff concludes would be reasonably representative of most of the material likely to be received for disposal, as discussed below.

The value used by Envirocare for porosity was 0.3. The staff considers this value to be optimistic. Based on data from Uranium Mill Tailings Remedial Action Project (UMTRAP) sites, a porosity of 0.38 would be more representative of compacted uranium mill tailings. Regulatory Guide 3.64 (NRC, 1989a) uses a default value of 0.4 to encompass most tailings material and use of that value would be acceptable.

The applicant used an emanation fraction of 0.25. While this may approximate an average value for some contaminated material, it may not encompass the majority of the contaminated material likely to be accepted for disposal at Envirocare. Regulatory Guide 3.64 uses a default value of 0.35 for the emanation fraction of uranium tailings in the calculation of radon attenuation by earthen covers. The applicant should consider using a value more conservative than 0.25.

The diffusion coefficient of 2.5×10^{-3} cm^2/s (2.7×10^{-6} ft^2/s) that the applicant used for the contaminated material is not conservative when compared to values seen for UMTRAP contaminated materials. Values as low as 6×10^{-3} cm^2/s (6.6×10^{-6} ft^2/s) have been measured for tailings with high slimes content and moisture content of 20 percent, while tailings with high sand content and low moisture level of 5 percent had a measured *D* of 4.8 x 10^{-2} cm^2/s (5.3 x 10^{-5} ft^2/s). The applicant did not follow the procedures described in Regulatory Guide 3.64, which indicates that if measurements for the radon diffusion coefficient are not available, the coefficient should be estimated using the correlation function. The NRC staff calculated the diffusion coefficient using a saturation fraction of 0.24 (calculated by assuming a porosity of 0.4, bulk density of 1.6 g/cm^3 (100 pounds per cubic foot (lb/ft^3)), and moisture content of 6 percent and using Equation 8 of Regulatory Guide 3.64). Based on these assumptions, the calculated value for the diffusion coefficient is 3.1 x 10^{-2} cm^2/s (3.4 x 10^{-5} ft^2/s). Use of that value would be acceptable.

Envirocare did not mention the long-term moisture content they assumed for the contaminated materials. The applicant should specify and justify the long-term moisture content of the contaminated materials. Values used for UMTRAP tailings range from 2 to 25 percent. Regulatory Guide 3.64 uses a default value of 6 percent for tailings material, and use of that value would be acceptable.

3.5.1.2 Radon Barrier Materials

The applicant proposes to stockpile the clay soil obtained during excavation of the cell and use it for the radon barrier material. The parameter values used in the application are not based on measurements of this soil. The chosen porosity of 0.25 and *D* value of 0.0025 cm^2/s (2.7 x 10^{-6} ft^2/s), may not be representative of the local soil that will be used for the cover. The applicant does not mention if these values take into account the effects of long-term conditions such as drought and maximum frost. Also, moisture content of the barrier soil is not specified. Since a test embankment was apparently constructed, moisture content values should be available.

For radon flux evaluation, a soil density value of 1.6 g/cm^3 (100 lb/ft^3) is representative of much of the native soil that will be used for the radon cover. There also appear to be some natural clay soils with densities closer to 1.4 g/cm^3 (87.5 lb/ft^3). In any case, the porosity value of 0.25 is judged to be low. Based on data from UMTRAP sites, actual porosities are expected to be closer to 0.4. The applicant should verify the actual porosity that can be attained in constructing the radon barrier. Alternatively, the default value of 0.4 used in Regulatory Guide 3.64 would be acceptable.

3.5.2 Calculational Methodology and Design Results

The applicant modeled radon flux from the top of the radon barrier as discussed in Section 6. The results of the modeling indicated a radon flux of 11.1 $pCi/m^2/s$. The applicant therefore concluded that its proposed radon barrier design meets the requirement in Criterion 6 of 10 CFR Part 40, Appendix A.

The NRC staff did not perform a detailed review of the applicant's model. Instead, the staff ran the RADON computer code (Regulatory Guide 3.64) with the applicant's values for parameters, as discussed in the previous section. The RADON code is a modification of the RAECOM computer code, which is a one-dimensional, steady-state radon diffusion code written in FORTRAN. The code determines radon fluxes and concentrations in multilayer uranium tailings and cover systems using the mathematical formulation given in Appendix A of NUREG/CR-3533 (Rogers et al., 1984), and can optimize the cover thickness to satisfy a given flux constraint.

The NRC staff used the applicant's input values where available. However, since moisture content was not specified by Envirocare for either the contaminated material or the radon barrier, the NRC staff used conservative values for those parameters. Parameter values used in this analysis are presented in Table 6A. The resulting flux estimate was 0.22 $pCi/m^2/s$, which is considerably less than the 11.1 $pCi/m^2/s$ flux calculated by the applicant using their model. Therefore, it appears the applicant is using a more conservative calculational methodology than the RADON code.

The NRC staff also estimated radon flux through the cover with parameter values that conservatively represent the properties of the proposed radon barrier and the contaminated material that might be disposed of. The values used are shown in Table 6B. Most of these values are discussed in the previous section. The resulting flux was 21.8 $pCi/m^2/s$. In order to account for radon barrier damage from frost penetration, as discussed in FSER Section 3.2.2.4, the upper 23 cm (9 in) of the radon barrier has been treated as a separate layer with different parameter values, as shown in Table 6B. The radon flux calculated by the staff was 24.9 $pCi/m^2/s$, which is above the value specified in Criterion 6. Additionally, the staff calculated radon flux assuming a concentration of 675 pCi/g of ^{226}Ra to account for long-term ingrowth from ^{230}Th, as discussed in Section 3.5.1.1. The calculated radon flux was 33.6 $pCi/m^2/s$, which is well above the value specified in Criterion 6. The staff therefore cannot conclude that the proposed radon barrier will limit radon flux to 20 $pCi/m^2/s$, as required by Criterion 6 of 10 CFR Part 40, Appendix A.

3.5.3 Conclusions

The NRC staff concludes that the current design of the radon barrier and the parameter values chosen for modeling the radon flux may not be representative of the material that the applicant might accept for disposal. Therefore,

Table 6 Radon Input Parameters

A - APPLICANT'S VALUES

Input Parameter	Waste	Radon Barrier
Radium (pCi/g)	500	0
Emanation (fraction)	0.25	
Bulk dry density (g/cm^3) (lb/ft^3)	1.6 (100)	1.6 (100)
Porosity	0.30	0.25
Thickness (cm) (in)	1000 (394)	213 (84)
Rn diffusion coefficient (cm^2/s) (ft^2/s)	0.0025 (0.0000026)	0.0025 (0.0000026)
Moisture (percent dry weight)	6*	10*

*Assumed by NRC staff in absence of applicant's value

B - STAFF'S VALUES

Input Parameter	Waste	Radon Barrier	Frost Damage
Radium (pCi/g)	500	0	0
Emanation (fraction)	0.35		
Bulk dry density (g/cm^3) (lb/ft^3)	1.6 (100)	1.7 (106)	1.5 (94)
Porosity	0.40	0.40	0.42
Thickness (cm) (in)	1000 (394)	190 (75)	23 (9)
Rn diffusion coefficient (cm^2/s) (ft^2/s)	0.04 (0.00004)	0.01 (0.00001)	0.015 (0.00016)
Moisture (percent dry weight)	6	10	8

the applicant should select conservative physical parameters or a **license condition** will require testing of contaminated material accepted by Envirocare that would be placed in the upper levels of the cell. Material that could cause that layer to exceed the parameter values indicated in the radon barrier model would have to be excluded from placement in the upper levels of the cell. The radon barrier soil would also be required to meet the parameter limits specified by this model.

3.6 Geography, Demography, and Land Use

3.6.1 Site Physiography and Description

The proposed 11e.(2) byproduct disposal site is located in the extreme eastern margin of the Great Salt Lake Desert in western Utah. The site is in a very dry and arid desert area with an average rainfall of approximately 12.5 cm

(5 in) per year. This desert is part of the Basin and Range Province of North America with topography that is typified by block-faulted mountain ranges and alluvial filled basins that generally trend north to south. The site rests on Quaternary lakebed deposits of Lake Bonneville that extend to a depth of at least 76.2 m (250 ft) beneath the site. The site has an approximate elevation of 1295.4 to 1311 m (4250 to 4300 ft) and a topographic relief of 3.4 m (11 ft) sloping in a southwest direction at a gradient of approximately 0.0019.

3.6.2 Population Distribution

The estimated population within 80.5 km (50 mi) of the proposed site was 26,972 people at the time of the 1990 Census. Most of the area is actually uninhabited, with the closest residents living 24.2-32.2 km (15-20 mi) to the northeast of the site. The largest number live 48.4-80.5 km (30-50 mi) to the east and southeast of the site in the Tooele-Grantsville area. Table 3.6.1 of the application presents the preliminary 1990 Census data on the population within 80.5 km (50 mi) of the South Clive site by compass direction and radial distance.

Envirocare estimates that, on the basis of Bureau of Economic and Business Research data, Tooele County will show an increase in its population at an annual rate of 1.4 percent until the year 2000. The largest expected growth was predicted for the Tooele City, Grantsville, and Wendover areas.

3.6.3 Land Use

Most of the land within a 16.1-km (10-mi) radius of the proposed disposal facility is public domain administered by the Bureau of Land Management. Until the U.S. Department of Energy (DOE) moved the Salt Lake City Uranium Mill Tailings Remedial Action Site materials to Clive for disposal, there were no industrial, residential, or municipal activities in the site vicinity. The land was used solely for sheep grazing, jackrabbit hunting, and occasional recreational vehicle driving.

Since the DOE Vitro site was established, several hazardous waste industries have been located in the Clive area. Tooele County has designated the area around and including the proposed 11e.(2) byproduct material disposal facility as Hazardous Industrial District MG-H Zoning. This designation limits, through zoning, the future use of the land in the area of the Envirocare facility to heavy industrial processes and to industries dealing with hazardous wastes, by issuance of conditional use permits. The Hazardous Industrial District MG-H designation does not provide for any other type of land use. For example, United States Pollution Control, Inc. (USPCI) is constructing, and Aptus, Inc. has constructed, hazardous waste incinerators 1.61 km (1 mi) to the west and 11.3 km (7 mi) to the east, respectively, of Envirocare's location.

Envirocare has concluded that the remoteness of the proposed site from the urbanized areas of Tooele County makes the surrounding area an improbable location for any other significant industrial use that might be impacted by the proposed disposal project.

3.6.4 Conclusions

The NRC staff concludes, on the basis of site physiography, population distribution, and land-use aspects of the proposed site area, that the site complies with Criterion 1 of Appendix A to 10 CFR Part 40 with respect to remoteness from populated areas.

4 CONSTRUCTION CONSIDERATIONS

4.1 Methods and Features

The applicant proposes to construct the embankment as a partially below-grade facility. Natural clay soils would be stripped to approximate depths of 2.4 m (8 ft) using backhoes, scrapers, or other conventional earth-moving equipment (see Section 4.2, below). The excavated soils would be either stockpiled or placed directly on a completed portion of the waste embankment as radon barrier.

After excavation to specified depths, the exposed subgrade would be scarified to a depth of 0.3 m (1 ft) and compacted. An additional 0.3-m (1-ft) compacted clay layer will be constructed on the prepared base. Soil density tests will be conducted by Envirocare to verify that 95-percent standard Proctor compaction has been attained. Project specifications will cite lift thicknesses and density requirements for the processed clay to be used as the seepage liner/retardant. Compacted lifts 15.2 cm (6 in) thick will be used; thus, maximum loose lift thicknesses of 20.3 cm (8 in) should be specified.

The disposal material will be placed on the prepared subgrade and will be compacted in loose lifts not exceeding 30.48 cm (12 in). Thinner lifts will be required if necessary to meet compaction requirements. The waste will be mechanically manipulated to ensure uniform density. Moisture will be controlled to permit compaction in accordance with ASTM standards. Soil density tests will be made with sand-cone equipment to verify the compaction levels of 90 percent of standard Proctor maximum dry density. A minimum of one test per 764.6 m^3 (1000 cy) for waste soils (382.3 m^3 (500 cy) for other embankment soils), with all lifts tested, will be made. A minimum of two tests per construction day will be made. Frozen material will be prohibited for incorporation into the waste cell.

Large debris, in excess of 30 cm (12 in) in diameter, and degradable materials will be restricted to placement in the deeper portions of the cell (lower 75 percent). The oversized debris, which cannot be tested for density, will be broken down where possible and placed with care to prevent nesting and formation of voids. Drums will be crushed prior to burial. Since project specifications have not yet been presented, the NRC will address the applicant's commitments, in the license application and stated above, regarding material placement properties, methods, and restrictions through a **license condition**.

A 2.1-m (7-ft)-thick compacted clay radon barrier will be constructed on top of the compacted disposal material. Filter and erosion barriers will be constructed to protect the radon barrier. The filter will consist of a 0.15-m (6-in) layer of fine gravel. The erosion barrier will consist of a 0.5-m (18-in) layer of coarse riprap. Maximum embankment heights of 11.27 m (37 ft) (above the original ground elevation) will be specified. Further discussion of the filter and erosion protection layers is presented in Section 3 of this FSER.

4.2 Equipment

The applicant has estimated that the equipment shown in Table 7 will be utilized at the site during the busiest work period anticipated. The equipment may be provided by a contractor. Routine maintenance and equipment replacement programs were specified. Table 7 provides a reasonable estimate of the equipment needs for the planned operations.

Table 7 Construction Equipment

Type of Equipment	Number
Scraper (Cat 631 or equivalent)	6
Dozer (Cat D-8 or equivalent)	2
Front end loader (Cat 980 or equivalent)	2
Compactor (Rex 910 and Cat 825 or equivalent)	3
Water truck	3
Onsite truck	8
Grader (Cat 14)	2
Forklifts	2

4.3 Construction Engineering Considerations

4.3.1 Geotechnical

4.3.1.1 Construction Methods and Features

The staff has reviewed and evaluated the geotechnical construction criteria provided in the license application. Based on this review, the staff concludes that the plans and drawings clearly convey the proposed schematic design features. In addition, the proposed excavation and placement methods are in accordance with accepted standard practice.

4.3.1.2 Testing and Inspection

The staff has reviewed and evaluated the testing and inspection quality control requirements provided in the license application. The application is found to provide a program for testing and inspection that is consistent with the staff technical position on testing and inspection (NRC, 1989b). The NRC will make the applicant's commitment to these testing and inspection procedures a **license condition**.

4.3.2 Surface Water Hydrology and Erosion Protection

Envirocare has proposed a testing and inspection program for rock production and placement. As discussed in detail in Section 3.3.6, this program includes measures for ensuring that the rock will be adequately graded and that the final placement of rock will be free of voids and areas of segregation of finer materials. The rock will also be tested frequently to ensure that it is durable and meets NRC guidelines (NRC, 1990). The overall quality assurance/quality control program for erosion protection is comparable to programs used by DOE and approved by the NRC in the Uranium Mill Tailing Remedial Action Project and is, therefore, acceptable. The NRC staff will make the applicant's commitment to the testing and inspection procedures described in the license application a **license condition**.

During construction and placement of contaminated material, any onsite erosion and transport of tailings will not result in offsite releases. Envirocare proposes to accomplish this using a series of berms. The areas where tailings will be placed will be completely surrounded by berms, which will be sequentially constructed to prevent local runoff from being released to the environment and to prevent offsite runoff from entering the contaminated areas. The berms will have sufficient height and freeboard to safely store the runoff from the local PMP event and to prevent offsite runoff from the Cedar Mountain PMF from reaching the contaminated areas. Based on the information provided by the applicant, the staff concludes that the design is acceptable to prevent releases of contaminated material and meets the operational hydrologic criteria suggested in NRC Staff Technical Position WM-8201 (NRC, 1982).

4.4 Conclusions

The NRC staff concludes that the construction aspects of the disposal facility, as presented in the license application, have been adequately characterized and meet applicable requirements.

5 FACILITY OPERATIONS

5.1 Nonradiological Administrative Procedures

5.1.1 Organizational Structure

The organizational structure for operations at the Envirocare site is discussed in Section 18 of the license application and shown on Figure 18.1. The organization as it relates to the radiological safety program is discussed in FSER Section 6.5.

The president is the highest ranking corporate official and is physically located at the applicant's Salt Lake City corporate office. The application indicated that the president will visit the site and observe operations at least quarterly and will review audit and inspection reports to ensure that operations are being properly conducted.

The vice president of operations (VPO) will report to the president and will be responsible for the operation of the disposal site. Specifically, the VPO will be responsible for site structural and hydraulic engineering, soil mechanics, quality assurance, and operations support. The VPO will be a registered professional engineer with at least 3 years of experience in earth-moving construction projects.

The site manager will report to the VPO and will be responsible for the day-to-day operation of the facility. The site manager will work closely with the field radiation safety officer (FRSO) to ensure that all aspects of site operation are conducted in accordance with regulatory requirements. The site manager also will be responsible for the facility maintenance and fire protection programs.

The site engineer also will report to the VPO and will be responsible for the daily supervision of construction and disposal activities. The construction contractor will be responsible for performing all construction and disposal activities and will report to the site manager. The site engineer and the construction contractor will work closely together on a daily basis to ensure that disposal activities are properly conducted.

The NRC staff review of the applicant's proposed organizational structure for the operations staff indicated it was acceptable.

5.1.2 Administrative and Operating Procedures

Envirocare states that written procedures are considered essential and that the procedures manual for the existing low-activity radioactive waste disposal site is currently being expanded to make it more complete. Envirocare further states that procedures prescribing how activities affecting the quality of operations at the site are conducted are controlled during their preparation, distribution, and revision to ensure that corrected copies are available for use. The corporate radiation safety officer (CRSO) will periodically check all field and recordkeeping procedures to ensure proper quality assurance and will be responsible for maintaining site procedures as part of the quality assurance program.

However, the information provided by the applicant does not contain adequate detail regarding the types of procedures to be maintained or how the procedures will be established. The applicant will be required by **license condition** to establish and adhere to standard operating procedures (SOPs) for all activities that involve the handling, storage, or disposal of 11e.(2) byproduct material, and to keep current copies of the SOPs accessible to all employees. Further, all SOPs will be reviewed and approved by the CRSO before implementation or revision, and all SOPs will be reviewed by the CRSO at least annually.

The applicant did not address the program to be implemented to ensure adequate management control of nonroutine work activities. The applicant will be required by license condition to issue a radiation work permit (RWP) for all nonroutine jobs where the potential for exposure to radioactive material exists and for which no SOP has been established. The RWP will describe the work to be performed, precautions to be taken to reduce exposure, and the radiological monitoring to be performed. The staff will further require that RWPs be reviewed and approved by the FRSO, or his or her designee, prior to the start of work.

As required by 10 CFR 19.2 and 21.2, the applicant has demonstrated that their program complies with the requirements of 10 CFR Part 19 dealing with notices, instructions, and reports to the workers and Part 21 dealing with reporting of defects and noncompliance.

5.1.3 Audits and Inspections

The applicant's audit and inspection program is discussed in Section 14 of the license application. Envirocare states that a quality assurance audit will be performed by an outside contract auditor on at least a quarterly basis. This audit will address all quality assurance activities performed at the site, including required testing and certification of materials and procedures.

The applicant will also utilize an internal quality assurance auditor to provide regular quality assurance guidance. The auditor will not have production responsibilities and will report directly to the CRSO or the president, at the president's discretion.

The site engineer will be in charge of all field inspections during construction and operation and will coordinate all quality assurance and quality control activities. Field inspections will be performed by the operations quality/safety technician and the field testing inspector on a daily basis. Persons filling both of these positions will report to the site engineer.

The applicant states that the CRSO will perform and document inspections of all facilities associated with the byproduct material disposal site at least weekly. The CRSO will also make periodic checks of the site with the site engineer, technician, and inspector. To ensure good coordination, the staff will require that the CRSO and the site engineer perform and document joint inspections of all work areas at least monthly. This will be accomplished by **license condition**.

In addition to the inspections discussed above, daily inspections of all work areas will be performed using checklists. Among the items to be observed daily are site fencing and postings. In addition, disposal areas are to be checked for blowing material and berms are to be evaluated for signs of instability. A more thorough inspection will be performed each day that the disposal facility is operating, which is defined as receiving shipments of waste or adding or removing waste from the disposal or storage areas. This inspection will include a check of facility communications systems, an inventory of personal protective equipment and first aid stations, and checks of fire extinguishers and safety showers. Truck sampling and unloading areas also will be inspected for signs of a spill or leak.

Based on the staff's analysis, the applicant has demonstrated that their program complies with the requirements of 10 CFR Part 40, Appendix A, Criterion 8A dealing with facility inspections. Therefore, the NRC staff will make the applicant's commitment a **license condition**.

Envirocare has stated that problems identified during an inspection that threaten human health or the environment will be corrected as soon as possible, but no later than 24 hours after discovery. Problems that do not pose a threat to human health or the environment will be corrected within 72 hours. If a longer time period is required to correct the problem, the applicant has committed to notify the NRC at the end of the 72-hour period and to propose a time schedule for correcting the problem.

The applicant did not address training to be provided to the individuals responsible for these inspections. This requirement for training is a routine component of a quality assurance program to ensure that individuals performing embankment inspections are trained to competently perform the tasks important to the NRC. The NRC staff will ensure adequate training through **license condition**. The applicant will therefore be required to conduct annual training that covers all areas included in this inspection for the employees who will be performing these inspections.

5.1.4 Training Program

The applicant's proposed training program is described in Section 17.5.6.3 of the license application. The radiation safety training program will be under the direction of the CRSO. Radiation safety training will be provided to all individuals before they enter the controlled area. The amount of training will depend on whether the individual is a permanent employee (hired for more than 20 days), a temporary worker, or a visitor. Permanent employees will be given a 3-hour training course taught by the CRSO, the FRSO, or a contractor. The training will include a discussion of ionizing radiation and its biological effects; radiation safety standards, principles, and procedures; emergency procedures; and methods used to minimize exposure to radioactive materials.

A written examination will be given to all employees following the training. One hour of refresher training will be given to all permanent employees every 6 months. All employees also will be required to attend at least 20 hours of additional training annually. This training will cover such topics as occupational safety, radiation safety, new procedures, or safety deficiencies.

The training program proposed by Envirocare is generally acceptable, although operations training was only generally addressed. However, the use of SOPs to accomplish training ensures consistency and thoroughness in operational training. The staff will ensure adequate operational training through **license condition**. The applicant will therefore be required to use the SOPs discussed in Section 5.1.2 for job-specific training and certification.

Staff training as it relates to the radiological safety program is discussed in FSER Section 6.5.3.

5.2 Waste Handling

5.2.1 Identification and Classification of Waste

Waste contracted for disposal at the site must be byproduct material as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended (11e.(2) byproduct material). Envirocare has not described in detail procedures to ensure that only such material will be disposed of in an NRC-licensed 11e.(2) byproduct material trench at the site. In particular, Envirocare has not described in detail procedures to ensure that wastes that could be classified as low-level waste (LLW), naturally occurring and accelerator-produced radioactive material (NARM) wastes, or mixed wastes will not be disposed of in NRC-licensed 11e.(2) byproduct material disposal locations at the site.

11e.(2) byproduct material is defined as "tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content." The definition is thus based upon the history and process that produced the waste, rather than any physical or chemical characteristic that can be measured, validated, or reconfirmed. Most 11e.(2) byproduct material can be described in general terms. It is typically crushed rock containing uranium, thorium, and radium in concentrations of several hundreds to approximately a thousand picocuries per gram, chemicals (some of which would fall under Resources Conservation and Recovery Act (RCRA) regulation if the material were not 11e.(2) byproduct material) and mill rubble. However, (1) wastes of very different characteristics will also be 11e.(2) byproduct material if they meet the definition and (2) other radioactive wastes, such as some LLW, naturally occurring radioactive material (NORM) wastes, and mixed wastes may be physically and chemically indistinguishable from 11e.(2) byproduct material. As a result, 11e.(2) byproduct material cannot be identified or classified by its characteristics.

Envirocare has to institute procedures that will be used to ensure that radioactive wastes other than 11e.(2) byproduct material are precluded from disposal in the NRC-licensed disposal areas. Envirocare has committed to obtain from the generator or owner of the wastes, certification by a responsible company authority that the material is 11e.(2) byproduct material and is not and does not contain other radioactive waste or hazardous waste. The certification should be based on generator or owner documentation on the source or origin of the waste. The requirement for this certification will be a **license condition**.

5.2.2 Receipt and Inspection of Waste

Before receipt of any waste, Envirocare will require the generator to provide a description of the waste that includes a certification that the material is within license specifications and is not classified as a hazardous waste by the Environmental Protection Agency. The information must include a list of all radionuclides and chemical constituents present in the waste, as well as the estimated activities of each radionuclide.

Waste will be received at the site either in bulk shipments or in containers approved by the Department of Transportation (DOT) and may be shipped by rail or highway. Upon receipt of the waste, Envirocare personnel will review the shipping manifest to ensure that all required information has been provided and will perform radiation surveys of shipping containers to ensure conformance with DOT and NRC requirements.

Envirocare will visually inspect the waste material to verify that the waste does not contain freestanding liquid. If the waste is suspected of containing freestanding liquids, the Environmental Protection Agency's paint filter liquids test (SW-846, Method 9095) will be performed at a frequency of one test per 764.6 m^3 (1000 cy) of waste. Any container having more than 1 percent freestanding liquid will be rejected and returned to the generator.

Samples of the waste material will then be collected for analysis by a certified independent laboratory. One sample will be collected for each of the first 76.5 m^3 (100 cy) of material up to 764.6 m^3 (1000 cy), with the frequency then decreasing to one sample for each additional 382.3 m^3 (500 cy) of material. All samples will be composites of aliquots collected to ensure that the samples are representative. The samples will be counted using gamma spectrometry to quantify gamma-emitting radionuclides present.

Results of the analyses will be received by Envirocare within 45 days of the arrival of the shipment. If results show the waste exceeds parameters specified in the license and if the waste was placed in the disposal area, Envirocare will notify the NRC and submit a plan proposing how the material will be managed for NRC review and approval. If the waste has not been placed in the disposal area, it will be returned to the generator.

The procedure for receipt and acceptance of incoming waste is generally acceptable. As stated in the previous section, the applicant will be required by license condition to obtain certification from the generator that the waste is byproduct material as defined in the Atomic Energy Act (AEA) of 1954, as amended, and information regarding the license(s) under which the waste was generated.

5.2.3 Waste Handling and Interim Storage

Once a shipment is accepted for disposal, the material will be unloaded and either moved directly to the disposal area or placed in storage. Bulk shipments will be either stored in bulk at a location on the unexcavated portion of the disposal area or placed into containers for storage.

If the material is to be stored in bulk, the soils in the storage area will first be scarified and recompacted to the specifications for the disposal cell bottom and a synthetic liner placed over the soil. A polymer dust suppressant will be applied to the storage piles to minimize blowing.

Materials either received in storage containers such as drums or placed into such containers upon receipt will be stored on pallets and stacked no more than two high. The container storage area will be inspected monthly to ensure the structural integrity of the containers. Containers found to be deteriorating will have their contents transferred into another container or will be placed inside a larger container.

Envirocare has stated that wastes will be transferred to either the disposal or storage area within 24 hours of receipt. The transfer of bulk wastes to containers will take place only on asphalt or concrete surfaces at the railway rollover or the storage area to avoid contact with natural soils. During periods of high winds, the applicant will cease the loading, hauling, or dumping of bulk wastes. The applicant has defined high winds as those in excess of 64.4 km (40 mi) per hour.

The NRC staff finds the waste handling and the interim storage procedures to be acceptable.

5.2.4 Waste Disposal Operations

The 11e.(2) byproduct material disposal cell will be a continuous cut and cover operation. The cell will be constructed as a partially below-grade facility. Existing terrain in a new portion of the disposal area will be excavated to a depth of about 2.4 m (8 ft). The excavated overburden will either be stockpiled or placed on a completed section of the disposal cell as a radon barrier.

The excavated area will be scarified to a depth of 0.30 m (1 ft). The soil will then be compacted to a density of at least 95 percent of the maximum density as determined by the standard Proctor method (ASTM D-698). The soil will be tested to ensure that the compaction requirement has been met.

Two 15-cm (6-in) lifts of processed clay will be placed on the recompacted soil. These lifts also will be compacted to 95 percent of standard Proctor. The first lift must be tested and approved before the second lift can be placed. Similarly, the second lift must be tested and approved before waste can be placed on the lift.

Waste material will be placed in the disposal cell in layers not exceeding 30-cm (12-in) uncompacted thickness and compacted before the next layer is placed. Compactable debris will be limited to 25 percent of the total volume of the lift, while noncompactable debris will be limited to 10 percent of the lift. Noncompactable debris is defined as materials that could degrade over time, such as paper, wood, and degradable plastics. The specifications therefore limit not only the total amount of debris per lift, but also the amount of degradable debris that could result in void space.

All debris will be uniformly distributed throughout the lift. Further, all debris will be less than 25 cm (10 in) in at least one dimension and no longer than 2.4 m (8 ft) in any dimension. Drums and metal containers will be emptied and crushed before being placed in a lift. No debris will be placed within 60 cm (24 in) of the top or side slopes of the disposal cell.

The staff concludes that the disposal procedure proposed by Envirocare is acceptable and will result in a minimization of void space within the disposal cell.

5.3 Records and Manifest Management

Before a shipment may be accepted for disposal, a shipping manifest must be received by Envirocare. The manifest must comply with the requirements of 10 CFR 20.2006 and will describe the types and volumes of waste as well as the number of items, if applicable. The information also will include the estimated activities and the isotopes of material present. The manifest must contain the generator's certifications of the packaging, classification, and RCRA status of the material.

Following the review of the manifest and the inspection of the wastes discussed previously, the shipment may be accepted or rejected. If rejected, the NRC will be notified and management of the material discussed. If accepted, an incoming shipment form will be completed. The manifest and the acceptance form will be retained on file.

Envirocare will implement a program to track the location of all waste at the facility. This program will make it possible to retrieve any material that becomes a concern. The program will utilize a waste coordinates sheet that will be completed by the site manager or his or her designee as the waste is placed in the disposal area. Data on the form include the zone, tier, and date of placement.

At least semiannually, the disposal embankment will be surveyed to document the exact coordinates of the waste. The survey information will be combined with the waste coordinates sheets to prepare zone summary drawings, which will contain cross-sectional and plan views of the disposal cell and show the location of waste by generator. These records also will be maintained by the applicant.

The applicant has stated their commitment to comply with the recordkeeping, reporting, testing, and inspection requirements of 10 CFR Parts 20 and 40 and 10 CFR 61.80. The NRC staff will make this commitment by the applicant a **license condition**.

5.4 Restricted Area Markings and Access Control

The applicant's proposed program for restricted area markings and access control is discussed in Appendix X of the application. Access to the restricted area at the disposal facility will be restricted by a 1.8-m (6-ft) chain link fence topped by three strands of barbed wire. The fencing will be posted with warning signs indicating the presence of radioactive materials within the restricted area. The signs will be posted on all gates and at 61-m (200-ft) intervals on the fence. The gates will be furnished with locks or locking devices that will remain locked at all times unless an attendant is stationed at the gate.

Envirocare employs security guards to provide security 24 hours per day. The guards are trained to handle emergency situations involving security and are instructed to report any problems to site management.

The NRC staff considers the program for restricted area markings and access control as discussed in the license application to be acceptable.

5.5 Emergency Procedures and Preventative Measures

Envirocare has prepared a contingency plan to cover site emergencies. This plan will be implemented in the event of accidents involving radioactive materials or the unplanned release of radioactive materials into the environment, and includes a site evacuation plan. The contingency plan is discussed in Appendix C of the license application.

The contingency plan is activated upon the discovery by any site employee of an emergency situation. The first step is notification of a site emergency coordinator. A list of emergency coordinators, who are members of facility management, and their home addresses and telephone numbers is posted near each site telephone.

The emergency coordinator is responsible for notifying other employees that there has been an emergency and that the facility is now operating under the contingency plan. The emergency coordinator directs facility efforts in the areas of information gathering, response logistics, internal and external communication requirements, and public relations.

A list of emergency telephone numbers is maintained to assist in notification of outside organizations. These include hospitals, law enforcement agencies, the Environmental Protection Agency, the National Response Center, and the NRC. Envirocare states that all releases of radioactive materials to areas other than the controlled area will be reported to the NRC in accordance with 10 CFR Part 20.

An emergency equipment storage area is maintained in the administration building. Among the equipment available is a first aid kit, flares, shoe covers, coveralls, blankets, rope, and tape. These items are kept in a foot locker that can be transported to the vicinity of the emergency. As discussed previously, the contents of the emergency response kit will be checked against an inventory list during the daily site inspection to verify that all required equipment is available.

The NRC staff considers the proposed emergency procedures and preventative measures as discussed in the license application to be acceptable.

6 RADIATION SAFETY AND HEALTH PHYSICS

6.1 Introduction

This section of the FSER provides the staff's review and assessments of the overall radiation safety and health physics aspects of the Envirocare license application and the applicant's compliance with applicable regulations. The major issues to be addressed in this review include sources of radiation exposure; procedures, methods, and instrumentation to be employed; dose assessment and compliance with dose limits; and details of radiation survey and monitoring programs. The overall assessment, in this respect, will be generally concerned with protection of onsite workers and offsite members of the public, and possible contamination of the surrounding natural environment from releases of radioactive materials. Since the site-specific conditions and waste characteristics are crucial information in the overall safety assessment, such information will also be addressed in this review.

6.1.1 Waste Volume and Characteristics

6.1.1.1 Embankment Capacity and Waste Volume

The applicant has provided the following information with regard to embankment capacity and waste volume:

(1) The 11e.(2) byproduct material will be disposed of in two cells or embankments. The first is the northern cell; it has a right angle triangular shape with ultimate dimensions of 634 m (2080 ft) x 457 m (1500 ft). The total area for this cell is calculated to be 144,869 m^2 (1,560,000 ft^2). The second disposal cell is the southern cell; it also has a right angle triangular shape with ultimate dimensions of 669 m (2195 ft) x 481 m (1580 ft). The area for the southern cell is calculated to be 160,895 m^2 (1,734,050 ft^2). The maximum depth of the waste in the embankment is 2.1 m (7 ft) below ground elevation; the maximum height is 11.3 m (37 ft) above ground elevation. The average thickness of the waste material was assumed by the applicant to be 10 m (32.8 ft).

(2) The design capacity of these embankments, as reported by the applicant, is 2,523,031 m^3 (3,300,000 yd^3).

(3) The average bulk density of the 11e.(2) waste was assumed by the applicant to be 1.6 g/cm^3 (100 lb/ft^3).

(4) The projected annual disposal area will be 229 m (751 ft) x 168 m (551 ft), which is equivalent to 38,472 m^2 (413,800 ft^2). The 11e.(2) waste will be disposed of in about one-third of the annual area at any one time.

(5) The maximum volume of waste that can be processed (i.e., received, stored, and disposed) annually is 2.835 x 10^5 m^3.

(6) The maximum volume of waste that can be disposed of annually within the embankment is 3.658 x 10^5 m^3 (1.292 x 10^7 ft^3).

(7) The maximum volume of waste accepted for disposal, but kept unloaded in transportation containers, is 4.572 x 10^3 m^3 (1.61 x 10^7 ft^3).

(8) The maximum volume of waste that may be stored on site prior to disposal is 2.743 x 10^4 m^3 (9.687 x 10^5 ft^3).

The NRC staff has reviewed the above specifications provided for embankment and operational capacity. The staff compared the specifications listed above with capacity, area, and volume estimates based on the design drawings of the embankment. The NRC staff calculated the total surface area of the northern cell at 144,869 m^2 (1,560,000 ft^2) and the total surface area of the southern cell at 160,895 m^2 (1,734,050 ft^2). Thus, the total surface area of the two cells was 305,764 m^2 (3,294,050 ft^2). Considering the total design capacity provided by the applicant of 2,523,031 m^3 (3,300,000 yd^3), the NRC staff calculated the average waste thickness in the embankment to be 8.25 m (27 ft). The total capacity of the northern cell would be 1,195,169 m^3 (42,207,064 ft^3) and the total capacity of the southern cell would be 1,327,384 m^3 (46,876,192 ft^3). Considering a bulk waste density of 1600 kg/m^3 (100 lb/ft^3) (NRC, 1980a, 1989a), the total bulk waste mass to be disposed of in both cells would be 4,036,027 tonnes (4,448 958 tons).

The NRC staff concludes from this review that the applicant's design specifications and design waste capacity are generally consistent with the design drawings for the embankment and facility plans. However, the following discrepancies were noted:

(1) The average waste thickness in the embankment is calculated at 8.25 m (27.1 ft), while an assumed average depth of disposed waste of 10 m (32.8 ft) was used for estimation of radon release rates.

(2) The conversions of waste volumes from English to metric units are inaccurate.

(3) The maximum volume of waste that may be processed (received, stored, or disposed) annually given as 2.835 x 10^5 m^3 (4.536 x 10^5 tonnes) is inconsistent with the maximum volume of waste to be disposed of annually within the embankment given as 3.658 x 10^5 m^3 (1.26 x 10^7 ft^3).

(4) The annual average thickness of the waste calculated for disposal is less than the average waste thickness in the embankment.

(5) The 11e.(2) waste embankment disposal capacity is inconsistently given as both 3,000,000 yd^3 and 3,300,000 yd^3 in the license application.

None of the above discrepancies significantly impact worker or public exposure. However, since the applicant has based estimates of worker and public exposures on calculations that employed the above parameters, the applicant should not deviate from these design specifications. To ensure consistency, the NRC staff will make the design specification regarding waste volumes binding by license conditions. Therefore, deviations from these specifications will require a revised radiological dose assessment that considers the potential impacts associated with design and operational changes submitted in the form of a license amendment. In particular, these **license conditions** are:

(1) The maximum bulk mass of waste disposed of annually will not exceed 4.536 x 10^5 tonnes (5 x 10^5 tons).

(2) The maximum annual disposal area will not exceed 229 m x 168 m (751 ft x 551 ft) (equivalent to 38,472 m^2 (413,801 ft^2)).

(3) The 11e.(2) waste will be disposed of in no more than about one-third of the annual disposal area at any one time. (This value was derived from the applicant's figure for total mass of waste processed annually and waste density.)

(4) The total embankment capacity will not exceed 2.52 x 10^6 m^3 (3.3 x 10^6 yd^3).

(5) The maximum volume of waste that may be stored on site prior to disposal will not exceed 2.743 x 10^4 m^3 (9.687 x 10^5 ft^3).

6.1.1.2 Nonradiological Characteristics of the Waste

The applicant stated that 11e.(2) byproduct material is expected to contain constituents similar to those found in uranium mill tailings, regardless of the source. The applicant provided information in the license application to show the typical chemical and radiological properties of tailings wastes (dry solids and liquids) generated by a model uranium mill. The applicant also provided information on elements present in tailings from acid-leach uranium mills.

Envirocare also provided upper ranges of elemental concentrations in mill tailings based on Environmental Protection Agency (EPA) reports and compared those ranges with average elemental crustal concentrations (see Table 17.5 in the license application). The applicant assumed that 90 percent of the waste arriving at the proposed 11e.(2) waste disposal facility will be less than or equal to average concentrations of the constituents in the earth's crust. As a result of this comparison, Envirocare pointed out that arsenic, barium, and lead would cause the waste to fail the Toxicity Characteristic Leaching Procedure (TCLP) under 40 CFR 261.24, EPA's hazardous waste regulations. Envirocare indicated that most of the highest concentrations were found only at one mill site and, therefore, the applicant expected the average concentrations of nonradiological constituents to be lower. Envirocare anticipates (based on rough estimates) that actual concentrations of nonradiological constituents may be less than half of the maximum observed concentrations.

Envirocare indicated in the application that low concentrations of hazardous volatile and semivolatile organic compounds could also be present in thorium 11e.(2) byproduct materials. Examples of organic constituents include acetone; 2-butanone; chloroform; carbon disulfide; 1,2-dichloroethane; methylene chloride; naptha; diethylphthalate; and 2-methylnaphthaline.

The NRC staff reviewed Envirocare's characterization of the nonradiological constituents in the 11e.(2) byproduct material that would be disposed of at the proposed facility. Based on its review, the NRC staff concluded that Envirocare may not have sufficiently estimated the nonradiological characteristics of the waste in terms of constituent concentrations. Specifically, the applicant did not present an assessment or references to justify the assertion that 90 percent of the waste arriving at the proposed 11e.(2) waste disposal facility would be at concentrations that approximated average concentrations of the constituents in the earth's crust. Therefore, the NRC staff will require the applicant to include in the certification procedures, required by license condition in FSER Section 5.2.1, an assessment by the shipper of the nonradiological constituents in the 11e.(2) byproduct material.

6.1.1.3 Radiological Characteristics of the Waste

The applicant has described the radiological characteristics of the 11e.(2) waste using available waste characteristics data for operating and nonoperating uranium mill sites and three 11e.(2) waste sites where other uranium and thorium processing has taken place. The applicant provided data on the radiological characteristics of generic uranium mill tailings from Uranium Mill Tailings Remedial Action Project (UMTRAP) sites; the UMTRAP disposal site at Clive, Utah; the raffinate pits at Weldon Spring, Missouri; the Kerr-McGee Rare Earths Facility in West Chicago, Illinois; and the Maywood Stepan Chemical site in Maywood, New Jersey. Using data from these sites, Envirocare generically described the physical form of the waste to be disposed of in the proposed disposal facility. For example, the applicant stated that building debris, contaminated soils, and mill tailings (low specific activity waste) will constitute approximately 80 percent of the waste. The average total activity of such waste was estimated by the applicant to be below 1000 pCi/g for any waste generator site, with the most probable average activity close to 400 pCi/g.

The applicant has also generically described another waste category designated as high specific activity waste. Such waste is generated from tailing waste concentrates such as sludges, slimes, and raffinate concentrates. Envirocare indicated that the weighted average ^{226}Ra concentrations in such waste must not exceed 2000 pCi/g and average ^{232}Th concentration must not exceed 6000 pCi/g. The applicant assumed in the dose assessments for the proposed facility that the average concentration for any radionuclide in the high specific activity waste is 1000 pCi/g. However, the applicant did not provide a rationale for this assumption. The applicant has assumed in the dose assessments that the high specific activity waste represents 10 percent of the 11e.(2) waste. The applicant did not specify a maximum concentration for each radionuclide or the total activity in the high specific activity waste.

Based on such radiological data, the applicant proposed the following radiological characteristics of the 11e.(2) waste:

(1) The average bulk concentration (for the disposal site) for any radionuclide in the uranium and thorium decay chains will be 500 pCi/g or less. It should be noted that the applicant has analyzed occupational and public doses based on the assumption that 90 percent of the waste will have an average bulk-specific activity of 500 pCi/g for each radionuclide in the uranium and thorium decay series.

(2) Individual shipments of waste may contain higher average concentrations of ^{226}Ra and ^{232}Th. The applicant emphasized, however, that the weighted average concentrations (by weight) in a shipment would not exceed 2000 pCi/g for ^{226}Ra or 6000 pCi/g for ^{232}Th. Both radionuclides may be present in the shipment at these concentrations.

(3) Assuming that the total bulk mass of waste to be handled annually is 451,500 tonnes (500,000 tons), and considering an average concentration of 500 pCi/g each for ^{226}Ra and ^{232}Th, the total annual activity for each radionuclide was estimated by the applicant at 227 Ci.

(4) The applicant has assumed that all decay products of ^{226}Ra and ^{232}Th are in secular equilibrium. Thus, there would be 227 Ci of each radionuclide (such as ^{228}Ra and ^{224}Ra) in the two decay chains. However, this assumption was not apparently applied when the applicant calculated radon and thoron releases.

(5) The concentration of ^{238}U in the waste was assumed to be less than 25 percent of the ^{226}Ra concentration, and the average ^{230}Th concentration is assumed to be equal to the ^{226}Ra concentration. The applicant based this estimate of the ^{238}U concentration on isotopic ratios observed at UMTRAP sites (as discussed below). The applicant estimated the ^{230}Th concentration on the basis of the assumption that ^{230}Th was in secular equilibrium with ^{226}Ra.

The NRC staff reviewed the applicant's analysis of waste characteristics by comparing proposed characteristics with the characteristics of wastes from the facilities at West Chicago, Weldon Spring, Maywood, and Clive and from UMTRAP tailings. All of these sites contain 11e.(2) byproduct material or similar material. The NRC staff has summarized the radiological characteristics for these sites in Table 8.

Considering the radiological characteristics presented in Table 8 and the data presented by the applicant, the NRC staff concluded the following:

(1) The ^{226}Ra mean concentration will in most cases be less than 500 pCi/g. Thus, the average ^{226}Ra concentration in the waste should not exceed 500 pCi/g. Because radiological impacts will depend largely on this average concentration, the applicant will be required to maintain the ^{226}Ra concentration, averaged over the bulk waste disposed of in any one year, below 500 pCi/g.

(2) ^{226}Ra concentrations may vary over a wide range, with concentration levels of 2000 pCi/g or possibly higher encountered for certain categories of 11e.(2) waste. Therefore, the NRC staff finds acceptable the applicant's commitment not to accept average concentration of ^{226}Ra above 2000 pCi/g in any shipment.

(3) The license application did not specify an upper limit on the average radionuclide concentration in the high-activity waste, establish lower/upper concentration limits to segregate the waste from the low-activity waste, or explicitly identify the maximum total concentration limits for the high-activity waste. Nevertheless, the applicant assumed in the radiological assessment that the average radionuclide concentration in the high-activity waste will be 1000 pCi/g. Since the applicant has restricted the maximum weighted average concentration in a shipment to 2000 pCi/g ^{226}Ra and 6000 pCi/g ^{232}Th, and restricted the yearly average concentration for the site at 1000 pCi/g, the staff considers this assumed limit acceptable.

Table 8 Radiological Characteristics of Mill Tailings

Site	Mean ^{226}Ra (pCi/g)	Standard Deviation ^{226}Ra (pCi/g)	Range ^{226}Ra (pCi/g)	Other Radionuclides	
UMTRAP sites	464	509	45-2315	^{230}Th:	Up to 10^4 pCi/g in slime, raffinates, and evaporation ponds
					Sitewide ^{230}Th is equal to ^{226}Ra
				^{238}U:	8 percent of ^{226}Ra
Active mills	319	230	87-981	na*	
UMTRA site at Clive, Utah	670	na*	460-900 (100-2000)**	^{230}Th: ^{238}U:	Equal to ^{226}Ra 8 percent of ^{226}Ra
Weldon Spring site, Missouri	343	216	11-460	^{230}Th: ^{232}Th: ^{238}U: ^{234}U: ^{228}Ra:	12448 pCi/q 118 pCi/q 556 pCi/q 598 pCi/q 157 pCi/q
Kerr-McGee W. Chicago, Illinois	300 (47)	na*	1.8-7526	^{238}U: ^{230}Th: ^{232}Th: ^{228}Ra:	43-135 (83)** pCi/q Equal to ^{226}Ra 6.6-5284 (900)** pCi/q 549 pCi/q
Stepan Chemical Maywood, New Jersey	na*	na*		^{232}Th: ^{238}U chain:	6000 pCi/q Less than Th

*na: not available
**Concentration ranges reported in the reference, followed by the average in parentheses.

(4) The applicant's estimate of 10 percent of the bulk waste being high-activity waste is reasonable considering the restrictions on the average concentration per shipment and per year at the site. However, since it is an estimate based on projected waste sources, the applicant will be required to verify this number during operations.

(5) The applicant has not shown that yearly average concentrations of low-activity radionuclides other than ^{226}Ra will not exceed 500 pCi/g. Since the applicant has already provided a yearly average ^{226}Ra concentration and an average concentration per shipment of 500 pCi/g, the staff considers a restriction of the maximum average concentration of low-activity waste to 500 pCi/g for any radionuclide in the uranium/thorium series acceptable.

Since the applicant has based estimates of worker and public exposure on calculations that employed the above parameters, the staff will make these parameters **license conditions**. Deviations from these specifications will require a revised radiological dose assessment that considers the potential impacts associated with design and operational changes submitted in the form of a license amendment.

6.1.2 Facility Operations

6.1.2.1 Generic Description of Waste Handling Operation

The procedure for accepting, inspecting, receiving, handling, storing, and disposing of incoming waste at the facility has been described fully in Chapter 16 of the license application. This section provides an overview of waste handling operations; a more detailed description and review of the waste handling operations follow.

The 11e.(2) byproduct material will be received either by truck or by railcar. The railcar will be directly unloaded using the "rollover" facility or a specially designed front-end loader. Trucks will be directly unloaded at the storage or disposal facility. Envirocare will use a dust abatement technique, consisting of a water spray application, when receiving the waste at the rollover facility. In addition, Envirocare will mitigate dusting prior to rollover and after relocation of the waste to the disposal area by applying water to dry waste.

Envirocare will also use respiratory protection for individuals unloading waste in the rollover facility. Thus, all individuals directly involved with the rollover procedure will use half-face respirators with a protection factor of 10 (in accordance with Appendix A to 10 CFR Part 20) or greater respiratory protection from airborne particulates (i.e., full-face mask respirator) for unloading higher activity waste. Envirocare emphasized that front-end loader operators will wear a half-face dust mask with a minimum protection factor of 10 during removal and loading operations. The truck drivers will also wear a half-face respirator during the loading and unloading operations.

The applicant has established certain procedures on waste handling based on the radiologic characteristics of the wastes. Since these procedures are considered in the estimate of worker and public exposure, the NRC staff will make these procedures conditions of the license. These **license conditions** include:

(1) Wastes will be segregated into two categories of specific activities: lower activity and higher activity. Envirocare will dispose of the higher activity wastes (those with average concentrations of 1000 pCi/g for any radionuclide) within 10 days of acceptance. Envirocare will place such waste in the embankment region at depths more than 3.3 m (10.8 ft) below the elevation of the radon barrier. Consequently, the higher activity waste will be located closer to the bottom of the embankment. The applicant will also cover the higher activity waste with either lower specific activity material or soils.

(2) If high-activity waste is stored, it will be covered with an additional 15 cm (6 in) of low-activity waste or clean fill material to reduce gamma exposures and radon emissions.

(3) Only solid waste will be received and accepted for disposal. Any containers having more than 1 percent freestanding liquid will be rejected and returned to the originator. The applicant proposed to determine the amount of freestanding liquid by using EPA's Paint Filter Liquid Test (SW-846, Method 9095).

(4) Prior to shipment of the waste to the proposed disposal facility, Envirocare will obtain from the generator a description of the waste to be managed at the Envirocare facility. The description of the waste will include concentrations of radionuclides present in the waste to ensure that these concentrations are within the acceptable limits of the license.

The applicant described waste handling procedures for the proposed disposal facility as follows:

(1) *Transportation*—Waste will be loaded at the generator site and shipped to the proposed dipsosal facility using either rail or highway transportation vehicles. The waste will be contained in either bulk rail, bulk highway shipments, or boxes with a capacity of 15.3 or 2.6 m^3 (20 or 3.5 yd^3). Drums, barrels, and/or bags may also be used to contain waste during shipment.

(2) *Radioactive Characteristics of the Waste*—Envirocare has indicated that the first step in receiving the waste is to obtain, in advance of the waste shipment, assurance from the waste generator (a form of certification) declaring that the material to be delivered for disposal at the site is within the parameters of the license. Lists of laboratory analytical data for all radionuclides present in the waste will also be provided. The generator will also certify that the 11.e(2) byproduct material does not contain hazardous waste as defined by 40 CFR 261.3 or any other EPA-regulated material.

(3) *Sampling of Incoming Shipment*—The next step is independent sampling of incoming waste shipment by Envirocare. For each waste stream, the minimum number of samples to be analyzed is:

   (a) one representative sample for each of the first ten shipments (rail or highway cars of waste volume approximately 76.4 m^3 (100 yd^3))

   (b) one representative sample for each 100 yd^3 up to 764 m^3 (1000 yd^3)

   (c) thereafter, one representative sample for each additional 382.3 m^3 (500 yd^3) following the first ten shipments or following the first 1000 yd^3

Envirocare will analyze the samples to determine concentrations of principal radionuclides in the waste to compare with reported waste concentrations.

(4) *Waste Acceptance Criteria*—The third step is the determination by Envirocare whether the incoming shipment meets the waste acceptance criteria. The waste acceptance criteria include:

   (a) Proper manifests will accompany each waste shipment in accordance with Appendix F, 10 CFR Part 20.

   (b) Each shipment of low specific activity waste will not exceed a maximum average for each radionuclide concentration in the shipment of 500 pCi/g.

   (c) Marking, labeling, and placarding will comply with DOE requirements.

(d) The generator will have certified that the waste is 11e.(2) waste and that it does not contain RCRA hazardous waste as defined by 40 CFR Part 261.

(e) Average concentration in each individual shipment will not exceed 2000 pCi/g of ^{226}Ra and 6000 pCi/g of ^{232}Th.

(g) Laboratory results of radiological analysis will be received from the generator within 45 days of the arrival of the shipment.

(h) The waste will not contain freestanding liquid in excess of 1 percent.

The applicant has provided a comprehensive description of the procedure to be followed by Envirocare in the event the waste received or disposed of was found to be "nonconforming waste" (e.g., from laboratory results). The applicant has assumed that the average time required for processing a shipment prior to disposal (i.e., the difference between arrival time of shipment and the time when shipment is ready for disposal or storage) will not exceed 10 days.

(5) *Radiation Waste Shipment and Disposal Record (RSR)*—The RSR will serve as the means of complying with the requirements outlined in 10 CFR 20.2006. The RSR will include the following information:

(a) description of container type, volume, and number

(b) estimated weights and activities for all materials and isotopes

(c) generator's certification of packaging, classification, markings, labels, conditions of container, and compliance with the applicable regulations and license terms

(d) generator's warranty that information provided in the RSR is correct

(e) checklist for inspection

(f) generator's certification that the waste is 11e.(2) waste and does not contain RCRA hazardous waste as defined by 40 CFR Part 261

(g) identification of parameters to be analyzed by an independent third party

(h) documentation of Envirocare's acceptance or rejection of the shipment

(6) *Container Survey and Inspection*—The freight container will be externally surveyed for gamma radiation with a micro-R meter to ensure compliance with Department of Transportation (DOT) regulations. The external radiation exposure should not exceed 1000 μR/hr at any point of the surface. The ^{226}Ra concentration (pCi/g) in the shipment will be estimated roughly as 2.5 x μR/h. Each container will also be smear tested to ensure that any removable contamination on any portion of the surface will not exceed 0.01 μCi/100 cm^2. Visual inspection will be conducted to ensure compliance with DOT regulations in 49 CFR and to verify integrity of the container and absence of any physical damage.

The NRC staff has reviewed Envirocare's proposed procedures for inspecting and accepting incoming waste shipments by comparing them with applicable NRC regulations and provisions in 10 CFR Part 20, Subparts H, I, J, K, and L. The staff also compared the applicant's procedures with practices at other operating, licensed waste disposal facilities. The staff concludes that Envirocare's protocols and procedures are consistent and comply with NRC regulations.

However, with regard to Appendix F to 10 CFR Part 20, the NRC staff noted that the following information was not addressed by the applicant:

(1) Waste manifests should include identification of the principal chemical form, solidification agent, and wastes containing more than 0.1 percent chelating agents by weight, with the weight percentage of the chelating agent estimated.

(2) Envirocare should acknowledge receipt of the waste within a week of receipt by returning a signed copy of the manifest or equivalent documentation.

(3) Envirocare should comply with the provisions for recordkeeping and tracking.

The applicant needs to address the above-stated requirements of Appendix F to 10 CFR Part 20. The staff considers this an ***open issue***.

6.1.2.2 Disposal Site Preparation and Site Services

The applicant has described disposal site preparation activities, which entail excavation of the disposal site, preparation of the clay liner, and construction of the embankment. The site service activities include application of wetting agents, cleaning of trucks and trains after unloading, maintenence of equipment, and laboratory characterization of waste. Other activities included in site services are sampling and engineering control measurements. Individuals performing these activities will not be directly involved in waste processing for disposal. However, these individuals would be exposed to radiation from direct exposure to adjacent sources and from inhalation of airborne radioactive materials, as discussed in more detail in FSER Section 6.2.1.2.

6.1.2.3 Waste Handling, Interim Storage, and Disposal

The applicant has described waste handling activities as the processing of accepted shipments of two different categories of wastes:

(1) Low-activity waste—waste with radioactivity less than 1000 pCi/g of ^{226}Ra, ^{230}Th, or ^{232}Th or that has a gamma exposure rate no greater than background levels when measured at 1 m (3.3 ft) from any surface of the container

(2) High-activity waste—waste with radioactivity above 1000 pCi/g or that has a gamma exposure rate in excess of background levels measured at 1 m from the surface

Waste disposal in the embankment involves spreading and compacting the waste using specialized heavy mechanical equipment. Envirocare has specified the types and use of such equipment for waste disposal in the license application. Placement and compaction of waste in the embankment will generate dust. The applicant has committed that equipment operators involved in the waste disposal will wear half-face respirators with a protection factor of 10 for radioactive particulates in accordance with the requirements of Appendix A to 10 CFR Part 20. Full-face respirators may be used, as necessary, to provide greater protection during the waste disposal operations, particularly for high-activity waste. After emplacement of the waste in the embankment, the applicant proposes to place a soil cap (i.e., radon barrier) on top of the compacted waste once the embankment is filled to design height. This operation will generate dust during spreading and compaction of the soil to be placed over the waste.

Low-Activity Waste Handling

(1) A railcar of waste may be emptied (dumped) using the onsite railcar dumper. The dumped waste may be hauled by truck or backhoe to the disposal embankment or may be collected and placed in containers for storage. The applicant did not specify the type of containers to be used for storage.

(2) A railcar may be unloaded by a backhoe at the unloading ramp. The unloaded material may be loaded into trucks and hauled to the disposal embankment or may be placed in containers for storage.

(3) A dump truck or sea-van may dump the material directly into the cell or the sea-van may be stored.

(4) A railcar or a trailer with containers may be off-loaded at the rollover facility and transported for either storage or direct disposal.

(5) Unloaded bulk shipments may be stored in bulk form or in containers.

(6) Off-loaded containers may be stored or emptied into the cell where the waste will be compacted in place and the container may be cleaned and released or smashed and compacted in the disposal cell.

High-Activity Waste Handling

(1) The railcars or trucks will be identified by placing a "Caution, Radiation Area" sign, as described in 10 CFR 20.1902, on both sides of the transporation container (e.g., railcar, truck).

(2) If there will be a delay of more than 24 hours in emptying the load, the container will be roped off to control access to the radiation area associated with the high-activity shipment.

(3) All workers involved in the unloading or emplacement of the high-activity waste will be required to wear full-face respirators providing a respiratory protection factor of 50.

(4) If there is a need for storage of the high-activity waste, the bulk waste will be covered with additional 15 cm (6 in) of low-activity waste or clean fill.

(5) When placed in the disposal cell, high-activity waste will be covered with low-activity waste or 15 cm (6 in) of clean fill after the final compaction.

(6) High-activity waste will not be placed closer than 3.3 m (10 ft) below the base elevation of the radon barrier.

The applicant proposed to store waste in bulk form (e.g., waste piles) or in containers (e.g., drums and barrels). The bulk material may be stockpiled or unloaded and stored in waste piles prior to emplacement. Storage will be located on the unexcavated portion of the disposal area near the working area, where waste is being actively emplaced. The storage area must be scarified and recompacted and a liner placed on the compacted clay prior to placement of waste for storage. The applicant has proposed application of a polymer dust suppressant on waste piles in storage to minimize resuspension of radioactive particulates. Containers will be placed on pallets and stacked no higher than two high. The applicant has proposed to visually inspect containers in storage on a monthly basis. The applicant has committed in Appendix A that the waste will not be stored on site for longer than 90 days.

The applicant has proposed to locate and mark the embankment using four permanent survey monuments (U.S. Geological Survey (USGS) "brass caps"). These monuments will be surveyed into the USGS and the National Geodetic Survey (NGS) control networks and the State Plane Coordinate system. No site markers will be placed during the operational phase of the embankment. However, upon completion of either disposal cell in the embankment, the site will be marked by one site marker at the entrance to the site and one site marker near the center of the crest of the embankment. Detailed descriptions of the markers are provided in Section 16.2.4.3 of the license application.

The applicant has also committed to prepare and retain records on the details of disposal material location using a grid location (N-S, E-W and depth coordinates) and waste description (specifically, radionuclide concentration, name of generator, and transport vehicles used). Envirocare has committed to maintain records in compliance with the disposal recordkeeping requirements of 10 CFR 61.80(f).

The NRC staff has reviewed the applicant's proposed procedures for waste handling, storage, emplacement, and embankment marking. The proposed procedures were compared against the requirements in 10 CFR Part 20 and pertinent sections of 10 CFR Part 61 (with respect to recordkeeping and site markers). The staff compared Envirocare procedures and approaches with 10 CFR Part 20, Subparts G, H, I, J, K, L, and M. The NRC staff also compared the proposed procedures with conventional industry practice at other licensed radioactive waste management facilities to ensure protection of occupational workers and the environment. Based on this review, the staff concluded that the proposed procedures are acceptable and comply with NRC requirements in 10 CFR Parts 20 and 61.

6.1.2.4 Decontamination and Release of Vehicles and Equipment

The applicant has committed that all vehicles and equipment will be visibly clean before leaving the site. All potentially contaminated materials will be removed by a broom, shovel, or other means (e.g., high-pressure water). The CRSO will supervise the release surveys (using alpha activity and gamma exposure rate measurements) and quality control to ensure that all items to be released are in compliance with the release policy.

Envirocare proposes to classify vehicle and equipment releases into two categories: limited release and unlimited release. The limited release applies to equipment or vehicles that are frequently used on and off the site. For example, such equipment includes ground-water sampling equipment, water trucks, dedicated railcars, and closed boxes used for waste shipment. The unlimited release, however, applies to equipment that will leave the site and will probably not be used again on the site. Examples of such equipment are construction equipment (other than dedicated heavy equipment for waste transportation, unloading, and placement) and other vehicles, packages, and equipment not identified for limited release.

The applicant indicated that any equipment or packages for limited release will meet DOT standards. With respect to releasing materials from the site, the applicant commits to ensuring that all materials (except for rejected waste shipments) are "visibly clean" prior to release.

The NRC staff considers compliance with DOT standards acceptable. However, release of equipment, vehicles, or packages off the licensed site should only occur after the applicant ensures that contamination on the surfaces of the equipment, vehicles, or packages has been reduced to acceptable levels in order to comply with the provisions of Subpart I of 10 CFR Part 20.

For the unrestricted release limits (unlimited), the applicant committed to release limits on the basis of Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors" (NRC, 1974). NRC Branch Technical Position WM-7601, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material" (NRC, 1984), is the corresponding guidance appropriate for the proposed activity. Release limits are the same in both documents.

The NRC staff has reviewed the proposed procedures for decontamination and release of equipment, vehicles, and packages. Based on this review, the NRC staff concludes the proposed procedures are adequate with respect to radiation protection aspects of the decontamination and release procedures. The NRC staff will make the requirement that equipment, packages and vehicles are decontaminated for release in accordance with Branch Technical Position WM-7601 a **license condition**.

6.2 Potential Radiation Exposure

The potential doses from intake of radioactive materials and exposure to external radiation need to be assessed in evaluating the safety and environmental protection performance of the proposed facility. NRC requirements in 10 CFR 20.1302(b) require that licensees show compliance with the annual dose limit to members of the public in 10 CFR 20.1301 by either (1) demonstrating by measurements or calculations that the effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the

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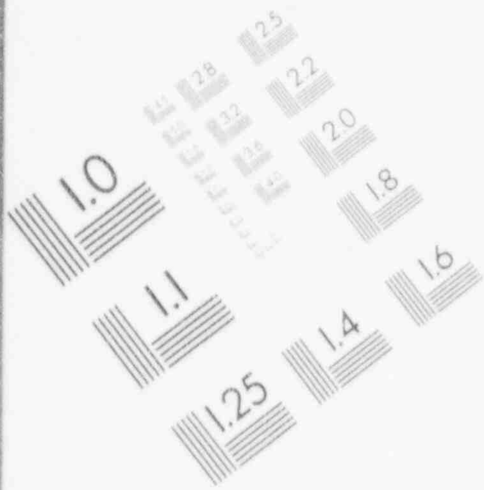
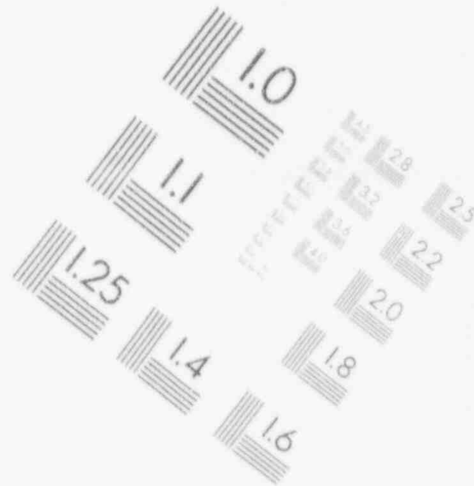
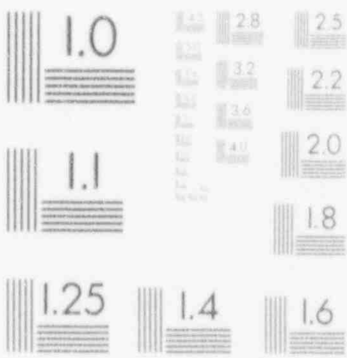
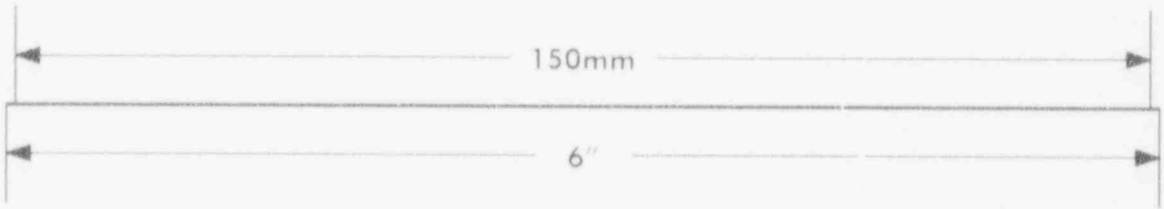
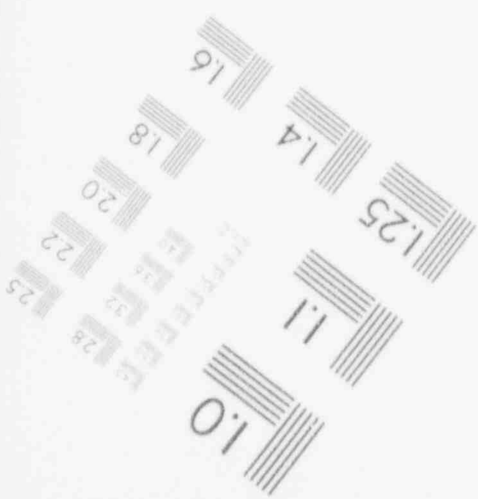
IMAGE EVALUATION TEST TARGET (MT-3)











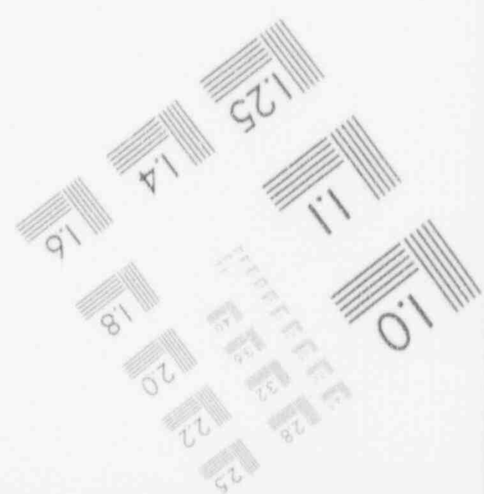


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IMAGE EVALUATION TEST TARGET (MT-3)

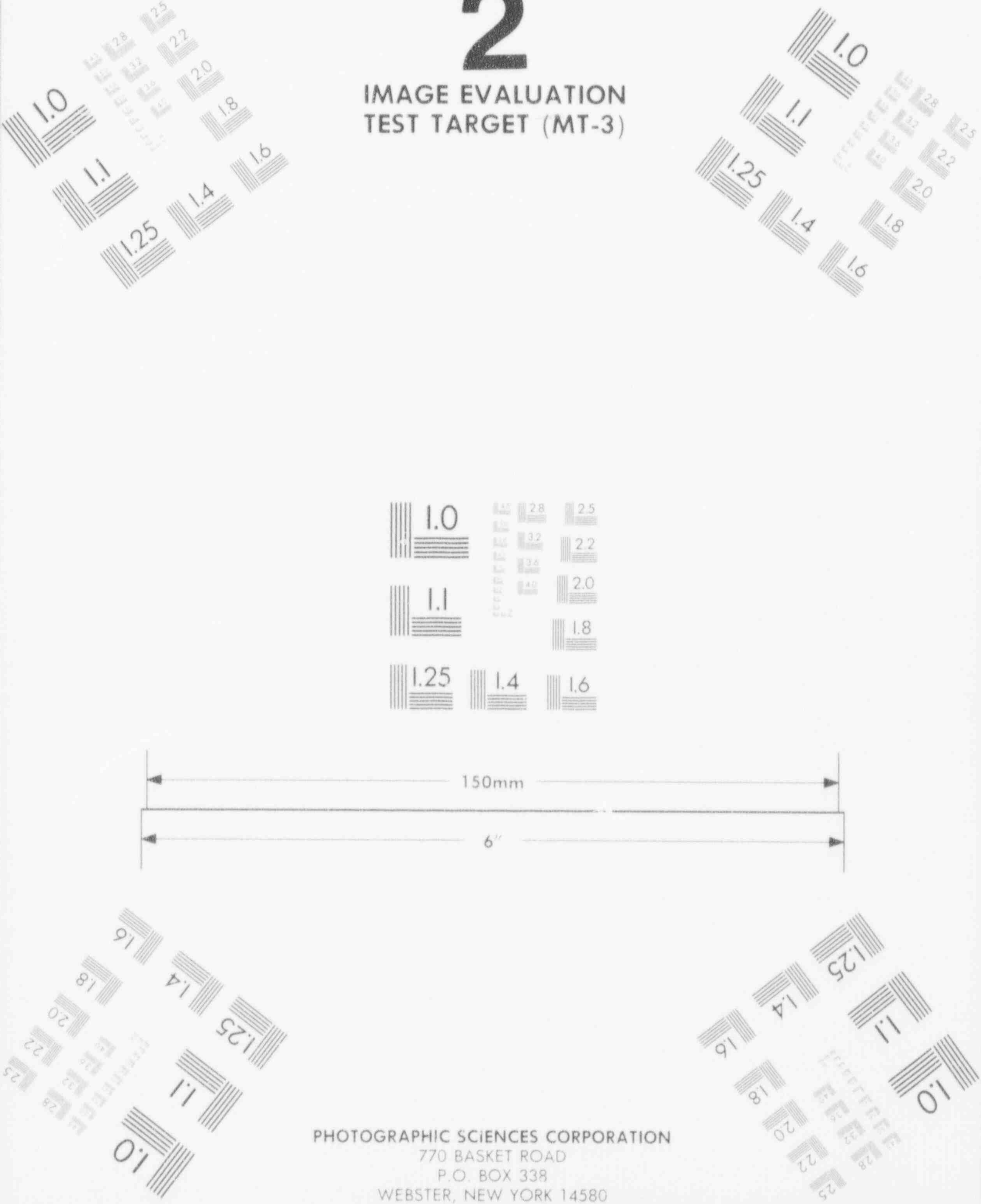

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IMAGE EVALUATION
TEST TARGET (MT-3)

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annual dose limit in 20.1301, or (2) demonstrating that the annual average concentration of radioactive materials released at the unrestricted area boundary does not exceed the values specified in Table 2 of Appendix B to 10 CFR Part 20. In addition, licensees need to comply with the occupational dose limits in Subpart C of 10 CFR Part 20.

Although compliance with the occupational dose limits is routinely demonstrated through the use of personnel dosimetry, radiological dose assessment may be used prospectively to evaluate the safety aspects of proposed activities. For both occupational and public protection, assessment of potential radiation exposure is also useful in selecting appropriate operational conditions and design parameters.

The potential radiation exposures at the proposed facility may be classified into two categories based on the type of radionuclide releases and exposure. The first category is associated with normal operational conditions where exposures are caused from normal releases of radioactive materials or gamma exposure at the site. The second category of radiation exposure results from unusual operational conditions or accidents at the site. NRC requirements in 10 CFR Part 20 apply to normal operating conditions. The staff also reviewed potential exposures from the second category to ensure that such events are unlikely or their consequences have been appropriately mitigated.

6.2.1 Exposures From Normal Operating Conditions

6.2.1.1 Potential Doses to Members of the Public

The applicant has presented in Appendix A of the license application a comprehensive analysis of potential environmental pathways of public exposure at the site boundary and in the surrounding area within an 80-km (50-mi) radius. This section presents Envirocare's analysis of mechanisms of radiation exposure at the site boundary (for individual members of the public) from environmental pathways, such as atmospheric releases of radioactivity, atmospheric transport, and particulate deposition or inhalation.

Envirocare depicted two mechanisms of potential radiation exposure to members of the public: (1) internal exposure resulting from inhalation of airborne materials and ingestion of contaminated food (specifically meat consumed from livestock grazing on contaminated soils), and (2) external exposure resulting from exposure to the airborne materials and to ground-deposited contamination. The applicant has considered the direct gamma exposure mechanism, from waste on site, as insigificant because the direct gamma exposure rate is greatly attenuated by the great distance between the waste embankment and the boundary of the site. The applicant also considered that ingestion of contaminated drinking water and exposure pathways resulting from soil irrigation are also not viable because of the inferior quality of ground water and the unlikely potential for recharge at the site.

The major sources of exposures resulting from radionuclide releases under normal operating conditions, as presented by the applicant, include:

(1) exposures from inhalation of radon (^{222}Rn) and thoron (^{220}Rn) released from uncovered waste, covered waste, and waste processing (e.g., waste unloading, storage, and emplacement)

(2) exposures from inhalation of radioactive particulates released into the atmosphere from waste unloading, waste storage, high-activity waste emplacement, and low-activity waste emplacement

(3) exposures from direct external radiation emitted from ground-deposited radionuclides, and airborne radioactive particulates

(4) internal exposure from ingestion of contaminated foods

The applicant has employed six assessment steps in estimating the total effective dose equivalent (TEDE) to an individual member of the public at the site boundary and the population dose to the public residing within 80 km (50 mi) from the proposed disposal facility. NRC's requirements in 10 CFR Part 20 limit individual doses, but do not specifically restrict population doses. Therefore, population dose estimates will not be considered in this assessment.

The six assessment steps include:

(1) estimation of radon (^{222}Rn) and thoron (^{220}Rn) release rates

(2) estimation of rate of radioactive particulate releases

(3) estimation of the concentration of airborne radioactive particulates due to atmospheric transport

(4) calculation of surface activity from ground deposition of airborne radioactive particulates

(5) calculation of radiation doses for individual pathways of exposure

(6) calculation of the TEDE by summing doses from all pathways of exposure

Each assessment step mentioned above will be discussed separately.

6.2.1.1.1 Estimation of Radon (^{222}Rn) and Thoron (^{220}Rn) Release Rates

Radon (^{222}Rn) and thoron (^{220}Rn) gases will be released in the atmosphere from decay of ^{226}Ra and ^{224}Ra, respectively. The applicant has analyzed radon and thoron releases for each of the following sources:

(1) Uncovered Waste in the Embankment

Radon and thoron releases from uncovered waste in the disposal cell are largely dependent on the following parameters:

(a) Physical Characteristics of the Waste

The applicant has provided justifications for selection of parameters that affect the release of radon and thoron by comparing such parameters with measured values for tailings in different sites. The applicant selected the values shown in Table 9 for the major physical parameters of the 11e.(2) byproduct material. In addition, the applicant selected a 90-percent and 95-percent compaction coefficient for the tailings and the cover, respectively, and a 10-m (33-ft) thickness for the waste being disposed of.

The NRC staff reviewed the physical parameters selected by the applicant and compared them with the generic parameters reported in Regulatory Guide 3.64 (NRC, 1989a), parameters that are commonly selected for the generic assessments of radon and thoron releases from uranium milling (NRC, 1980a), and parameters selected in the design and analysis of the proposed embankment design for the uranium tailings from the Vitro site (DOE, 1983, 1984). Based on this information, the staff prepared Table 9, which compares the physical parameters selected by the applicant with the referenced parameters.

From the comparison, the NRC staff concluded that some of the parameters selected by the applicant are not sufficiently conservative or necessarily representative of 11e.(2) byproduct material likely to be placed at the proposed disposal facility. The applicant's proposed values are acceptable for bulk density, emanation power, and radioactive decay coefficients. The remaining parameters, specifically moisture content, porosity, and diffusion coefficient, however, are not sufficiently conservative nor have they been justified based on site-specific analysis. These parameters are discussed in FSER Section 3.5.1.1.

(b) Concentrations of ^{226}Ra and ^{224}Ra in the Waste

As stated previously, the applicant has assumed that 90 percent of the waste (categorized by the applicant as low-activity waste) will have an average bulk-specific activity of 500 pCi/g for ^{226}Ra and ^{224}Ra. The remaining 10 percent of the waste is categorized as high-activity waste with bulk-specific activity of 1000 pCi/g of any radionuclide in the uranium or thorium decay chains. This waste will not be placed within 3.3 m (10.8 ft) of the elevation of the radon barrier.

Table 9 Parameters for Radon and Thoron Releases

Parameter/Unit	Regulatory Guide 3.64	Envirocare	Vitro Site	NUREG–0706 (FGEIS)
Bulk density (g/cm^3) (lb/ft^3)	1.6 (100)	1.6 (100)	1.5 (94)	1.6 (100)
Decay coefficient (s^{-1})				
Radon	2.1E-6	2.1E-6	2.1E-6	2.1E-6
Thoron	1.27E-2	1.27E-2	1.27E-2	1.27E-2
Emanation power (dimensionless)	0.35	0.25	0.22	0.2
Moisture content (wt. percent)	6.0	10.0	10.0	10.0
Porosity (dimensionless)	0.4	0.3	0.43	na*
Diffusion coefficient (cm^2/s) (ft^2/s)	na*	2.5E–3 (2.6E–6)	2.3E–2 (2.5E–5)	1.4E–2 (1.5E–5)

*na: not available.
Note: 2.1E-6 = 2.1 x 10^{-6}, for example.

methodology to confirm the applicant's calculations. Using the release rates given in the license application of 2.45 and 192 μCi/s, the annual releases of radon and thoron would be 77.26 and 6.05×10^3 Ci, respectively. Thus, the annual release rate input values to the TDAD code should be nearly twice the input value used by the applicant. Further, the NRC staff considers the applicant's selection of one-third of the annual disposal area to calculate the annual release rate for radon and thoron is not conservative because the applicant has not proposed specific procedures that would restrict the open area of the embankment. In addition, radon and thoron would continue to be released over the inactive, exposed portions of the embankment wherever the final radon barrier has not been placed. Indeed, the applicant used an annual disposal area of 38,000 m^2 (409,029 ft^2) for radon and thoron atmospheric concentration calculations (using MILDOS-AREA and TDAD). However, for calculation of the input values of the annual release rate of the source, only one-third of that area was accounted for. The NRC staff made a rough estimate of ^{222}Rn releases based on a generic value of radon flux for bulk waste of 1 pCi/s per pCi/g of ^{226}Ra (NRC, 1980a; DOE, 1983, 1984). Considering an annual disposal area of 38,300 m^2 (412,258 ft^2) and assuming an average concentration of ^{226}Ra of 500 pCi/g, the total annual radon release would be around 600 Ci. Assuming one-third of the area will be exposed at any one time, annual radon releases would be a minimum of 200 Ci (in contrast to the applicant's estimates of 77.5 and 38.4 Ci). Therefore, the applicant's reported estimates for annual radon releases are not conservative and may be unrealistic. Therefore, the applicant needs to reexamine and verify the estimates of radon and thoron release rates. The NRC staff considers this an ***open issue***.

(2) Receiving and Unloading the Waste

The applicant has employed the following assumptions in calculating radon and thoron release rates at the rollover pad: (1) the time period between receiving and unloading the waste is 10 days; (2) the total mass of waste to be handled annually at the rollover pad is 4.5×10^{11} g (9.9×10^8 lb); (3) the fraction of radon or thoron generated is 1.0 (i.e., all radon and thoron produced via decay is released); (4) the emanation powers of radon and thoron are 0.25 and 0.1, respectively; (5) the decay factors (λ) for radon and thoron are 0.181 d^{-1} and 1.09×10^3 d^{-1}, respectively; and (6) the ^{226}Ra and ^{224}Ra concentration in 90 percent of the waste is 500 pCi/g and in 10 percent of the waste it is 1000 pCi/g.

The NRC staff reviewed the above assumptions based on the conventional practices in mill tailings operations (NRC, 1980a) and on the generic assumptions made by the applicant for the facility operation. Based on this review, the applicant's assumptions appear to be reasonably conservative, especially in assuming that the fraction of radon and thoron released is 1.0.

The applicant calculated the radon and thoron release from unloading the waste to be 119.96 and 24.75 Ci/yr for radon and thoron, respectively. The NRC staff reviewed the calculated release rates by conducting the calculations using the same equations and assumptions proposed by the applicant. The NRC staff compared the applicant's approach for calculating the release rates with the approach used by NRC (1989a). Based on this review, the NRC staff confirmed the estimated release rate for radon from the unloading operation. In addition, the NRC staff also examined the use of the applicant's values as input in the dose assessment codes MILDOS-AREA and TDAD for annual radon and thoron releases from the waste unloading operations. The applicant used 115 Ci/yr for radon releases in the MILDOS-AREA code and 25 Ci/yr for thoron releases in the TDAD code. The NRC staff review indicates that the applicant's calculations for radon release are correct and consistent with values estimated using the methodology presented by NRC (1989a). Therefore, the annual radon release rates from the unloading operation are accepted by the NRC staff.

However, for calculating the thoron release, the NRC staff noted that the ratio of releases for radon and thoron appeared to be inverted and may have been caused by the applicant's manipulation of the equations. The staff expects that thoron releases would exceed those of radon given the ratio between the decay constants and the specific fluxes for the two radionuclides. Therefore, the applicant needs to justify eliminating the decay constant and time parameters from the equations and reassess potential thoron releases from unloading operations. The NRC staff considers this an ***open issue***.

(3) Storage

For estimating radon and thoron releases from waste storage, the applicant assumed that 10 percent of the waste (equivalent to 4.4×10^{10} g (9.7×10^7 lb) annually) will be stored on site awaiting disposal or processing. The applicant also assumed the storage period would not exceed 90 days. The applicant presented, without analysis, estimated release rates of radon and thoron during the waste storage period as 5.62 and 2.3 Ci/yr for radon and thoron, respectively. The applicant also stated in the application that the annual release rates during storage were 86.9 Ci/yr for radon and 1600 Ci/yr for thoron. The applicant

(c) Calculation of the Specific Flux

The applicant calculated radon and thoron specific fluxes for various assumed values of emanation power, diffusion coefficient, density, and porosity using the mathematical formulation reported by Kraner et al. (1964), Momeni et al. (1979), and Rogers et al. (1980). The following formulation was used by the applicant for the uncovered waste:

$$\Phi_t(Z) = \frac{10^4 \, \epsilon \varrho_t \, [Ra] \sqrt{\lambda D_t / P_t}}{\tanh \, (Z) \sqrt{\lambda P_t / D_t}}$$

Where $\Phi(Z)$ is the flux at the surface of the waste of thickness Z, ϵ is the emanation power, ϱ_t is the bulk density of the tailings, $[Ra]$ is the concentration of ^{226}Ra in the waste (pCi/g), λ is the decay constant of ^{222}Rn, D_t is the bulk diffusion coefficient of radon in the tailings, and P_t is the bulk porosity of the tailing (see Table 9 for dimensions).

The equation used to calculate radon flux from the bare (uncovered) tailings in Regulatory Guide 3.64 (NRC, 1989a) is:

$$J_t = 10^4 R_t \varrho_t E_t \sqrt{\lambda D_t} \, \tanh \, (x_t \sqrt{\lambda / D_t})$$

Where J_t is the radon flux from the bare tailings source (pCi/m^2/s); R_t is the specific activity of ^{226}Ra in the tailings (pCi/g); ϱ_t is the dry bulk density of the tailings; λ is the ^{222}Rn decay constant; D_t is the diffusion coefficient of radon in the total pore space of the tailings (cm^2/s) (ft^2/s); and x_t is the thickness of the tailings (see Table 9 for dimensions). The two equations are not consistent. Therefore, the applicant needs to explain the derivations of the equation and compare this equation with Equation 9 of Regulatory Guide 3.64 (NRC, 1989a).

The applicant used the physical parameters, as discussed above, and the differing mathematical formulation to calculate radon and thoron fluxes. The applicant's calculated values for the average specific fluxes for radon and thoron are 0.51 pCi/m^2/s and 78 pCi/m^2/s, respectively.

The applicant also calculated the radon and thoron specific fluxes for various waste thicknesses containing 1 pCi/g of ^{226}Ra. In these calculations, the applicant varied the diffusion coefficient in the range 2 x 10^{-3} to 6 x 10^{-3}, the porosity in the range 0.25 to 0.5, and the emanation power in the range 0.2 to 0.3. The radon flux calculated under these variable conditions was in the range 0.48 to 0.77 pCi ^{222}Rn/m^2/s per pCi/g ^{226}Ra. Thoron specific flux calculated for 0.4-cm (0.016-in)-thick waste containing 1 pCi/g of ^{224}Ra was determined in the range 44 to 76 pCi ^{222}Rn/m^2/s.

The NRC staff calculated that radon and thoron fluxes may be more than two times larger than that estimated by the applicant. For example, using the standard relationship between ^{226}Ra concentration and radon flux of approximately 1 pCi/m^2/s per pCi/g, the estimated radon flux for 500 pCi/g ^{226}Ra would be about 500 pCi/m^2/s (NRC, 1980a; DOE, 1983, 1984). Therefore, the NRC staff considers the radon flux values for the uncovered waste an ***open issue***.

(d) Calculation of Release Rates

Finally, the applicant calculated the radon and thoron annual release rates using the average radon and thoron specific fluxes of 0.51 and 78 pCi/m^{2}s, respectively. The applicant also assumed only one-third of the disposal area will be uncovered at any one time and the disposal operation will be carried out 9 months per year. Thus, the area (12,767 m^2) (137,423 ft^2) was multiplied by a factor of 9/12 to obtain a figure of 9582 m^2 (103,140 ft^2) for the uncovered area, which emanates radon and thoron. For the radon release rate calculation, this figure was multiplied by the specific flux (0.51 pCi/m^{2}s) and then by the average concentration of ^{226}Ra (500 pCi/g). The release rate was then calculated at 2.45 μCi/s. For thoron, the same methodology (assuming an average thoron specific flux of 78 pCi/m^2 and uncovered area of 9.582 x 10^3 m^2) was applied, and the release rate was calculated at 192 μCi/s. Using this approach, the applicant concluded that the annual expected radon and thoron releases from uncovered waste in the embankment would be 38.4 and 3000 Ci ^{222}Rn and ^{220}Rn, respectively.

The applicant used more conservative release rates for radon and thoron in modeling atmospheric transport using the MILDOS-AREA and TDAD codes, respectively. For ^{222}Rn releases, the applicant assumed a value of 77.5 Ci/yr in the MILDOS-AREA code. The applicant used a value of 3408 Ci/yr for ^{220}Rn in the TDAD code.

The NRC staff reviewed the applicant's calculations of estimated radon and thoron release rates by using the same calculational assumed that storage of waste increases releases of radon and thoron into the environment. The applicant did not explain the origin or the discrepancy between the two sets of values for the release rates of radon and thoron during storage.

The NRC staff reviewed the applicant's release rates above and compared them with estimated release rates calculated using the approach used in the Final Generic Environmental Impact Statement (FGEIS) (NRC, 1980a). The NRC staff examined the consistency of the release rate inputs in the dose assessment codes (MILDOS-AREA and TDAD) and those reported by the applicant. The applicant used annual release rates of 100 and 1600 Ci/yr for radon and thoron, respectively, in assessments of atmospheric transport using the MILDOS-AREA and TDAD computer codes.

The NRC staff independently calculated the release rates using the same assumptions and formulations as the applicant and obtained a comparable value for the radon release rate. The NRC staff calculated an annual radon release rate of about 92 Ci/yr. This value is close to the value of 86.9 Ci/yr reported by the applicant. For thoron release, the applicant reported a release rate of 1600 Ci/yr. NRC's estimate of the thoron release rate, however, is considerably different. The staff used the above two equations to calculate thoron release rate and obtained values of 2.2×10^5 Ci/yr (using the equation $Q = \epsilon [Ra] Mf\lambda T$). Therefore, it is apparent that the applicant is not consistent in their assumptions for calculation of the thoron release rates. The applicant needs to reassess the estimated release rate for thoron from waste in storage and justify the basis of the calculations. Because estimates of thoron releases from storage may significantly affect worker and public exposures, the NRC staff considers this an ***open issue***.

(4) High-Activity Waste

The applicant estimated annual radon and thoron release rates from disposal of high-activity waste at 15.4 Ci/yr ^{222}Rn and 120 Ci/yr ^{220}Rn. The applicant did not provide an explanation of how these estimates were derived.

The NRC staff analyzed the release rates by considering the data presented in Table 3.8 of Appendix A to the license application. The applicant provided a radon release rate of 4.9 μCi/s for a radon flux of 510 pCi/m^{2}s assuming a ^{226}Ra concentration of 1000 pCi/g. Multiplying this release rate (4.9 μCi/s) by 3.15×10^7 (s/yr) to convert the time from seconds into 1 year and dividing by a factor of 10 (since the high-activity waste is assumed to represent 10 percent of the bulk waste), the annual release of radon from the high-activity waste will be about 15.5 Ci. This figure is consistent with the value reported by the applicant.

For thoron annual release rate estimation, the NRC staff used the same approach with the release rate of 384 μCi/s. The staff calculated an annual thoron release rate of 121 Ci for the high-activity waste, which is consistent with the value reported by the applicant.

The NRC staff also examined the input values used in the computer models of atmospheric transport. The applicant assumed annual release rates of 34.2 and 150 Ci/yr for radon and thoron, respectively, in the MILDOS-AREA and TDAD codes. Thus, it is apparent that the applicant used higher release rates as input values to the codes than the values estimated in the text. It should be noted, however, that the above release rates were based on a calculated specific flux rate. The calculation of specific flux rate was based on nonconservative assumptions as discussed above. For example, the applicant used a nonconservative diffusion coefficient value of 2.5×10^{-3} cm^2/s (2.6×10^{-6} ft^2/s) rather than 3.1×10^{-2} cm^2/s (3.3×10^{-5} ft^2/s). Using a more conservative diffusion coefficient value would increase the annual release rate for radon and thoron from the high-activity waste by a factor of 10 or more. Therefore, as previously discussed, the applicant needs to revise calculations of radon and thoron specific flux and employ conservative assumptions or justify appropriate factors on a site-specific basis. The NRC staff considers this an ***open issue***.

(5) Covered Waste

The applicant assessed radon and thoron releases after the waste has been covered by a radon barrier to demonstrate compliance with NRC requirements in 10 CFR Part 40, Appendix A, Criterion 6. Appendix A requires "reasonable assurance of control of radiological hazards to limit releases of radon-222 from uranium byproduct materials and radon-220 from thorium byproduct materials, to the atmosphere so as to not exceed 20 pCi/m^{2}s." Compliance with the specifications for the radon barrier is addressed in Section 3.5 of this FSER.

The applicant did not calculate radon and thoron annual release rates from the disposal facility after placing the cover and also did not conduct any dose assessment in this regard. Releases of radon from the covered portions will continue to contribute to airborne releases of radon, which could affect workers and the public. This contribution must be added to the dose assessment. The NRC staff considers this an ***open issue***.

6.2.1.1.2 Estimation of Radioactive Particulate Releases

Envirocare estimated the rates of radioactive particulate releases into the atmosphere from four sources:

(1) Waste Unloading

In estimating radionuclide particulate releases from waste unloading, the applicant assumed an average dust load in the vicinity of the earth moving equipment of 10 mg/m^3 (7.8 lb/ft^3). The applicant selected this value for airborne particulates based on an EPA assessment of fugitive dust emissions from coal mines (EPA, 1978). The applicant also assumed that the average bulk specific activity is 500 pCi/g for each radionuclide, and that 30 percent of the dust load is respirable (i.e., less than 10 microns in diameter). Further, the applicant considered that the respirable fraction would have a 2.4-times-higher specific activity (NRC, 1980a). Based on these assumptions, the applicant estimated the rate of release of the respirable fraction at 1.6 x 10^{-2} Ci/yr for each radionuclide. For the remainder of dust particles larger than 10 microns, but less than 100 microns, the applicant estimated a release rate of 1.6 x 10^{-2} Ci/yr. The high-activity waste contribution for particles less than 100 microns was estimated at 1.3 x 10^{-2} Ci/yr. The applicant concluded that the estimated total release rate from the waste unloading operation is 3.2 x 10^{-2} Ci/yr. However, the applicant did not show how the release rates were derived for the high-activity wastes.

The NRC staff reviewed the applicant's estimates of release rates using the information provided by the applicant, considering the annual mass of waste to be handled (4.5 x 10^{11} g (9.9 x 10^8 lb)), the average radionuclide concentration in the waste (500 pCi/g), and the assumed dust loading factor. NRC's estimates confirmed the particulate release estimates calculated by the applicant for waste unloading operations. The NRC staff also considered the estimated release of 0.1 g per kilogram of waste processed based on the combined actions of wind and machinery (NRC, 1980a; EPA, 1973, 1978). Thus, the NRC staff estimated an annual particulate release rate (Q) in curies as follows:

$$Q = \text{waste mass (g)} \times \text{radionuclide concentration (Ci/g)} \times 0.001\ \text{(kg/g)} \times 0.1\ \text{(g/kg)}$$

The factor 0.001 is used to convert the mass in grams to kilograms, and the factor 0.1 is the dust loading factor. The annual release rate calculated using the above equation is 2.25 x 10^{-2} Ci. Using the applicant's assumption that 30 percent of the airborne particulates are < 10 microns in diameter, and a 2.4-times-higher specific activity (NRC, 1980a), the annual particulate release rate at this size fraction would be 1.62 x 10^{-2} Ci. Using the same approach, the remainder of the dust loading (10-100 microns in diameter) contribution to the annual particulate release in the unloading operation would be 1.58 x 10^{-2} Ci. This figure is also consistent with the applicant's release figure. Therefore, the total airborne particulate releases from unloading operations would be about 3.2 x 10^{-2} Ci/yr.

(2) Waste Storage

The applicant estimated the release rate of radioactive particulates from waste storage to be 2 x 10^{-2} Ci/yr. However, the applicant did not provide information on how this release rate was estimated. The NRC staff developed an independent estimate of particulate releases using the approach that was discussed previously for estimating particulate releases from unloading. Based on these calculations, the staff estimates that annual release rates of radioactive particulates will be less than 0.01 Ci for ^{226}Ra, ^{230}Th, ^{232}Th, and other important radionuclides in the ^{226}Ra and ^{232}Th decay chains. Therefore, the staff concluded that the applicant's estimate of annual release rate of radioactive particulates from storage appears reasonable, even though Envirocare did not justify this estimate.

(3) High-Activity Waste Emplacement

The applicant estimated particulate release rates from emplacement of high-activity wastes at 2 x 10^{-3} Ci/yr. The applicant used this release rate in the MILDOS-AREA and TDAD codes as the only release source from the high-activity waste. Thus, although the applicant stated that the release rate from high-activity waste at the rollover pad would contribute 1.3 x 10^{-2} Ci/yr, this contribution was not accounted for in the rollover pad source or the high-activity source. In addition, the applicant did not account for any releases associated with high-activity waste storage. Apparently the applicant assumed that high-activity waste will be emplaced directly in the embankment. The applicant assumed that the area designated for disposal of high-activity waste will be a small portion of the active waste emplacement area. The applicant also assumed that high-activity waste will be covered by a thin layer of clean soil or low-activity waste. Using the MILDOS-AREA and TDAD codes, the applicant calculated airborne concentrations from four sources: rollover pad, waste storage, high-activity waste emplacement, and low-activity waste emplacement.

The NRC staff reviewed the applicant's proposed estimate of particulate release rates and concluded that these estimates are crude and not based on justified calculations or on data derived from operational experience. Further, the applicant's neglect of the high-activity waste contribution to the release rate at the rollover and storage pads is inappropriate. Therefore, the applicant must account for these shortages in the assessment of particulate release rates from high-activity waste disposal operations. The NRC staff considers this an ***open issue***.

(4) Waste Emplacement

The applicant did not specifically identify or estimate an annual release of radioactive particulates from the emplacement of waste in the active disposal area. The applicant, however, calculated the airborne concentrations of radionuclides in the ^{226}Ra and ^{232}Th decay chains (along with ^{230}Th and lesser amounts of ^{238}U and ^{234}U) using the computer codes MILDOS-AREA (Yuan et al., 1989) and TDAD (Momeni et al., 1993). The two codes are modifications of the UDAD code (Momeni et al., 1979). The applicant justified the use of these codes on the basis that the same methodology and procedure were used by NRC in the preparation of the FGEIS on uranium milling (NRC, 1980a). The applicant calculated the projected airborne concentrations (pCi/m^3) of radionuclides in the uranium decay chain using an input concentration value of 500 pCi/g for each of the radionuclides: ^{238}U, ^{230}Th, ^{226}Ra, and ^{210}Pb. The applicant used the TDAD code (Momeni et al., 1993) to estimate particulate releases from emplacing waste at the same concentration value (500 pCi/g) for each of the major radionuclides in the thorium decay chain: ^{232}Th, ^{228}Ra, ^{228}Th, and ^{224}Ra. The projected airborne concentrations of the radionuclides and associated doses from inhalation and ground deposition are discussed below.

The NRC staff independently estimated the annual particulate release rates from the emplacement of waste in the active disposal area. The staff calculated the estimates using the methodology described above for estimating particulate releases from unloading operations at the proposed facility. The calculations assumed a resuspension rate of 0.1 g per kilogram of waste emplaced in the embankment based on the FGEIS (NRC, 1980a). The staff estimates that the total particulate release rates will be less than 2.2×10^{-2} Ci/yr for each radionuclide in the uranium and thorium decay chains.

6.2.1.1.3 Estimation of Concentration of Airborne Radionuclides

The applicant estimated concentrations of airborne radionuclides in the uranium and thorium series by modeling atmospheric transport using the MILDOS-AREA and TDAD codes. The MILDOS-AREA code (Yuan et al, 1989) is derived from MILDOS (Strenge and Bander, 1981) and Version III of UDAD (Momeni et al., 1979). The applicant used this code to calculate particulate and radon releases and transport in the atmosphere for radionuclides in the uranium decay chain at the 11e.(2) byproduct material disposal facility. MILDOS-AREA provides an improved capability for handling large-area sources to compute environmental radiation doses from uranium recovery operations. It estimates the radiological impacts of airborne emissions from uranium mining and milling facilities or any other large-area sources involving emissions of radionuclides in the ^{238}U decay series.

The applicant used the TDAD code (Momeni et al., 1993) to estimate radiation doses to individuals and to the general population from the airborne release and transport of radioactive particulates and thoron from processing and disposal of wastes for radionuclides in the thorium decay series. The code was developed for Envirocare from Version IX of the UDAD code, as described in NUREG/CR-0553 (Momeni et al., 1979). The UDAD code was used by the NRC Office of Nuclear Materials Safety and Safeguards for calculation of potential radiological impacts of uranium milling for individual mills and for the FGEIS on uranium milling (NRC, 1980a).

In applying the two codes, the applicant made the following assumptions:

(1) Radioactive particulates have a range of particle sizes, 30 percent have an aerodynamic diameter of less than 7.7 microns and 70 percent have an aerodynamic diameter of 54 microns.

(2) The specific gravity of the fine particle fraction is 2.4 g/cm^3 (150 lb/ft^3); hence, the specific activity is 2.4 times the bulk-specific activity of the waste (which is assumed to have a density around 1.6 g/cm^3 (100 lb/ft^3)).

(3) The annual mass of waste will be 4.5×10^5 tonnes (5×10^5 tons).

(4) The annual disposal area will be 38,472 m^2 (413,959 ft^2). The active disposal area for the 11 e.(2) waste will not exceed one-third of the annual disposal area at any one time.

(5) Waste disposal will continue for 16 years at the above annual rate. For the MILDOS-AREA modeling, the applicant has divided the disposal operation into eight phases; each phase (a 2-year period) terminates with the completion of the radon barrier over a portion of the embankment, and the placement of the surface erosion barrier. For the modeling using the TDAD code, the operation was assumed to be continuous for 16 years.

(6) There are no other sources of airborne particulate releases above background at the site. The applicant did not consider any particulate releases from the adjacent waste disposal facilities (Envirocare NORM and MIXED waste disposal facilities, and the disposal facility for the VITRO waste) in evaluating projected doses from the disposal facility for 11e.(2) waste.

(7) The radionuclides included in the analysis for the uranium decay series included ^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{222}Rn, ^{214}Bi, ^{214}Pb, ^{210}Po, and ^{210}Pb. Radionuclides in the thorium decay series included ^{232}Th, ^{228}Ra, ^{224}Ra, ^{220}Rn, ^{216}Po, ^{212}Pb, ^{212}Bi, ^{212}Po, and ^{208}Tl.

(8) All radionuclides in the uranium and thorium decay series will be present in secular equilibrium with the

bulk-average concentration for each radionuclide being 500 pCi/g. Ingrowth and decay of all radionuclides were accounted for during transport in the atmosphere.

The applicant estimated airborne particulate concentrations (using MILDOS-AREA code (Yuan et al., 1989)) in five directions from the site (N, E, W, S, and maximum transport direction) and at 12 distances up to 80 km (50 mi). Table 10 lists the distances and coordinates (x, y) of these locations with respect to the SW corner of the facility as the point of origin. The applicant used the TDAD code to calculate particulate concentrations at 15 specific distances. The applicant also calculated radon and thoron decay product concentrations in working level (WL) units using both codes.

Table 10 Receptor Locations for Codes

Receptor Location	Grid Location X (km)	Grid Location Y (km)	Distance From Site (km)
East boundary	1.6	0.9	1.84
West boundary	0.0	0.9	0.9
North boundary	0.9	2.7	2.85
South boundary	0.9	0.0	0.9
Administration building	0.9	1.6	1.84
Guard trailer	0.8	1.2	1.44
USPCI facility	-1.6	0.6	1.71
Industrial location	10.4	6.8	12.43

The applicant's results indicated that the maximum ^{226}Ra particulate concentration in air of 2.4×10^{-3} pCi/m^3 would be at the guard trailer location. Concentrations of ^{226}Ra at four locations at the site boundary were in the range of 3.0×10^{-4} to 8.5×10^{-4} pCi/m^3. The concentration of ^{226}Ra at the administration building was 1.5×10^{-3} pCi/m^3. Particulate concentrations of the other radionuclides in the uranium decay series (e.g.,^{238}U, ^{230}Th, and ^{210}Pb) were similar to the ^{226}Ra concentration. The code also calculated airborne particulate concentrations of ^{222}Rn and decay products (e.g., ^{218}Po, ^{214}Pb, ^{214}Bi, ^{210}Pb, ^{210}Bi, and ^{210}Po) at the above-mentioned eight receptor locations. The ^{222}Rn concentrations also reached a maximum value at the guard trailer at 21.5 pCi/m^3 and at the administration building at 12.0 pCi/m^3. The concentration of ^{222}Rn at the site boundary was in the range of 3.0 to 10.4 pCi/m^3.

Airborne particulate concentrations of radionuclides in the thorium chain (^{232}Th, ^{228}Ra, and ^{224}Ra) were all similar. The ^{224}Ra concentration was in the range of 1.26×10^{-3} to 9.7×10^{-6} pCi/m^3. The maximum estimated particulate concentration of 1.26×10^{-3} pCi/m^3 for ^{224}Ra was estimated at the administration building. The guard trailer receptor location was projected to have a particulate concentration of 8.0×10^{-4} pCi/m^3. Thoron (^{220}Rn) and thoron decay products (^{216}Po, ^{212}Pb, ^{212}Bi, ^{210}Pb, and ^{210}Po) concentrations were much higher; thus, the ^{220}Rn concentration at the guard trailer site was the highest at 36.2 pCi/m^3, and the concentration at the site boundary was in the range of 0.07 to 20.1 pCi/m^3. It should be pointed out that concentrations of other radionuclides in the uranium decay chain (e.g., ^{238}U, ^{234}Th, ^{230}Th, and ^{210}Pb) and in the thorium decay chain (e.g., ^{232}Th, ^{228}Ra, and ^{224}Ra) were assumed to be equivalent to ^{226}Ra and ^{232}Th concentrations, respectively. The applicant concluded that particulate releases of radionuclides (including radon and thoron) in the uranium and thorium decay chains to the air associated with 11e.(2) waste disposal operations would not exceed background levels at all distances beyond 1 km (0.62 mi) from the site. Further, the applicant concluded that the projected airborne concentrations of ^{226}Ra at the site boundary would be of the same order of magnitude as those detected elsewhere in the western United States.

The NRC staff reviewed the applicant's airborne particulate modeling and results. The review included assessment of the assumptions and input values to the codes, assessment of limited validation of the code, and comparison of modeling results with rough estimates of releases based on the calculational methodologies presented in the FGEIS (NRC, 1980a) and estimates of radioactive particulate releases for the Vitro site (DOE, 1983, 1984). Based on this review, the NRC staff concluded the following:

(1) The applicant has assumed a nonconservative particle-size distribution for airborne radioactive particulates; namely, 30 percent of the particulates are less than 7.7 microns and 70 percent are greater than or equal to 54 microns. The NRC staff believes that selection of this particle size is nonconservative and may not adequately represent the particle-size fractions that will be observed at the proposed disposal facility. Particle-size fractions may significantly affect doses via inhalation by controlling the depositional location of the particulates within the pulmonary system.

NRC's limits on airborne effluent releases in Appendix B to 10 CFR Part 20 (based on International Commission on Radiological Protection (ICRP) Publication 30 (ICRP, 1981)) are based on a standard particulate size of 1-micron "activity median aerodynamic diameter" (AMAD) for use in calculating doses from inhalation (see the introduction to Appendix B to Part 20). In the absence of specific justifications of alternative particulate-size distributions, the applicant should either assume 1-m AMAD or justify alternative particle-size distribution based on site-specific measurements.

(2) The applicant did not include any particulate releases, in the calculations of airborne particulate concentrations, from Envirocare's adjacent waste disposal facilities for NORM, low-level waste, and mixed wastes, or the disposal embankment for the Vitro uranium mill tailings. Although particulate releases from the Vitro embankment are likely to be negligible because the residual radioactive materials have already been covered, particulate releases from the other active waste facilities could be significant. If they are significant, operations at the proposed disposal facility for 11e.(2) waste may have to be curtailed or modified to account for occupational and public doses resulting from these operations to ensure that cumulative exposures from licensed and unlicensed operations do not exceed the dose limits in 10 CFR Part 20. In addition, these particulate releases could also mask monitoring data collected for the proposed 11e.(2) waste disposal facility because the same radionuclides are expected to be contained in the wastes. Therefore, the applicant needs to estimate airborne particulate releases and associated doses from adjacent waste disposal operations to demonstrate compliance with the dose limits in 10 CFR Part 20 and to avoid any masking effects on environmental monitoring data.

(3) The MILDOS-AREA and TDAD codes used in the calculation of airborne particulate concentrations may produce estimated concentrations with large uncertainties for short distances (e.g., < 1 km (0.62 mi)). As discussed above, the codes are anticipated to produce results with large uncertainties at such locations. The NRC staff anticipates the uncertainties associated with calculated concentrations of airborne particulates may be more than 50 percent based on the results of the previous validation studies against available monitoring data. Several of the most important receptor locations (e.g., guard trailer, administration building, and the [illegible] boundary) are within a distance of 0.9 to 2.6 km (0.56 to 1.4 mi) from the embankment area.

A validation study was conducted for the MILDOS-AREA program (Yuan et al., 1989). In this study, airborne ^{222}Rn concentrations and working levels were calculated with the MILDOS-AREA program and compared with both measured concentrations and with results from the AIRDOS-EPA code (Moore et al., 1979). The site selected for the validation study was the uranium mill tailings embankments area in Monticello, Utah. The validation effort indicated the MILDOS-AREA results generally agreed within ± 50 percent with measured ^{222}Rn concentrations at the Monticello site. Comparison with the AIRDOS-EPA code shows that the concentrations calculated by the two codes are in very good agreement for distances greater than 1 km (0.62 mi) from the origin. At distances very close to the origin, however, AIRDOS-EPA results are much higher for some locations because of the source analysis limitations inherent in the code.

(4) The applicant did not compare the estimated airborne particulate concentrations for the different radionuclides with the air effluent concentrations listed in Table 2, Column 1, of Appendix B to 10 CFR Part 20. The NRC staff compared the applicant's estimated particulate concentrations with the concentration limits in Appendix B. Table 11 compares the projected concentrations for ^{226}Ra, ^{222}Rn, and ^{220}Rn at four locations: east boundary, west boundary, administration building, and guard trailer.

It is evident that ^{226}Ra calculated concentrations are well below the effluent concentration limits of Appendix B. In addition, calculated ^{222}Rn concentrations are also below the limits by a small margin. However, calculated concentrations of ^{220}Rn are either very close to or exceed the limit. Considering the nonconservative assumptions in the applicant's calculations (e.g., particle size, selection of location for the source origin, estimation of annual release rates), additional particulate releases from adjacent waste disposal facilities, and large uncertainties associated with the model results close to the source, the applicant has not adequately demonstrated compliance with the air effluent concentration limits in Appendix B to 10 CFR Part 20. The applicant is required to comply with the air effluent concentration limits. Therefore, the applicant must make modifications to the proposed operations in order to demonstrate compliance with the limits in Appendix B to Part 20. The NRC staff considers this an ***open issue***.

6.2.1.1.4 Calculation of Surface Activity

The applicant used MILDOS-AREA and TDAD codes for calculating radioactive particulate ground deposition of the uranium and thorium decay chains, respectively. Using the MILDOS-AREA code, the applicant calculated total annual deposition rate (pCi/m^2) as a function of distance for ^{238}U, ^{230}Th, ^{226}Ra, and ^{210}Pb. The applicant also calculated the ground-deposited activities for ^{232}Th, ^{228}Th, and ^{228}Ra using the TDAD code. The applicant calculated ground-deposited activities for each particulate radionuclide in 5 directions and at 12 distances.

Table 11 Calculated Particulate Concentrations

Radionuclide	Location	Calculated Concentration (pCi/m^3)	Calculated Concentration ($\mu Ci/ml$)	Part 20 Appendix B Limit ($\mu Ci/ml$)
^{226}Ra	East boundary	8.5E-4	8.5E-16	9E-13
^{226}Ra	West boundary	5.5E-4	5.5E-16	9E-13
^{226}Ra	Administration building	1.5E-3	1.5E-15	9E-13
^{226}Ra	Guard trailer	2.4E-3	2.4E-15	9E-13
^{222}Rn	East boundary	10.4	1.0E-11	1E-10
^{222}Rn	West boundary	4.8	4.8E-12	1E-10
^{222}Rn	Administration building	12.0	1.2E-11	1E-10
^{222}Rn	Guard trailer	21.5	2.2E-11	1E-10
^{220}Rn	East boundary	6.7	6.7E-12	3E-11
^{220}Rn	West boundary	20.1	2.0E-11	3E-11
^{220}Rn	Administration building	4.6	4.6E-12	3E-11
^{220}Rn	Guard trailer	36.2	3.6E-11*	3E-11

*Value exceeds the effluent concentration limit of 10 CFR Part 20, Appendix B, Table 2, Column 1.
Note: 8.5E-4 = 8.5×10^{-4}, for example.

The ground-deposited activity ranged from more than 10,000 pCi/m^2 on soil at the site to approximately 2 pCi/m^2 on soil at a distance of 20 km (12.4 mi) downwind from the site. The maximum ^{226}Ra ground-deposited activity was calculated at the guard trailer at 2.6×10^4 pCi/m^2. At the boundary of the site, ground-deposited activity ranged from 2.7×10^3 to 8.6×10^3 pCi/m^2. The applicant concluded that the ground-deposited thorium activities would be similar to ground-deposited activities for radionuclides in the ^{238}U decay chain.

The NRC staff reviewed the applicant's modeling approach and estimated ground deposition rates for airborne particulates. Except for the nonconservative parameters and other omissions and uncertainties noted above for atmospheric releases of particulates, the staff concluded that the applicant's estimates for ground deposition of particulates were acceptable.

6.2.1.1.5 Calculation of Doses for Each Pathway

The applicant used the estimated radon and thoron concentrations, airborne particulate concentrations, and ground deposition rates described above to estimate potential doses to members of the public from operation of the proposed disposal facility. The applicant used the computer codes MILDOS-AREA and TDAD to model the transport of the radioactive materials and estimate dose conversion factors for each exposed individual organ. The applicant calculated total effective dose equivalents by multiplying the organ doses by the appropriate organ weighting factors (10 CFR 20.1003) and then summing the products to yield a total effective dose equivalent. The applicant considered exposures from the following pathways:

(1) inhalation of airborne radionuclides (radon, thoron, and airborne particulates)

(2) ingestion of contaminated food (from consumption of meat of livestock that had grazed on contaminated forage)

(3) external exposure

The applicant calculated the annual dose commitments and annual population dose commitments for each of these exposure pathways. In a similar approach, as discussed above for particulate releases, the applicant assessed potential exposure for eight different phases of waste disposal operation, for each pathway of exposure, and for each source of release of radioactivity. The applicant did not include exposure via ingestion of contaminated ground water or use of the water to irrigate crops or water livestock for the reasons discussed in Chapter 3 of the FSER.

The MILDOS-AREA and TDAD codes calculate dose conversion factors for radionuclides in the uranium and thorium decay chains, respectively, for individual organs and estimate the annual committed dose equivalent (ACDE) for each organ. The integration period for the calculation of the committed dose is 50 years. The applicant assessed ACDEs for different ages: infant, child, teenager, and adult. For the uranium series, dose calculations were made (using MILDOS-AREA) for bone, average-lung, bronchi, liver, kidney, and effective whole body. For the thorium series radionuclides, the applicant calculated ACDEs (using TDAD) for nine organs: skin, ovaries, testes, small intestines, lung, red marrow, skeleton, spleen, and whole body. Table 12 summarizes the results of ACDE calculations for selected organs in mrem per year from inhalation of airborne radionuclides in the uranium and thorium series in adult individuals.

The applicant calculated an ACDE of 22.6 mrem/yr from thoron decay products at the guard trailer and of 31.6 mrem/yr from the radon decay products. Considering the 12-percent organ weighting factor for the lung (10 CFR 20.1003), the annual committed effective dose equivalent (CEDE) would be 2.7 and 3.8 mrem/yr for thoron and radon, respectively. Thus, a person located continuously at the security guard trailer (according to calculations) would receive a CEDE dose from particulate inhalation of 6.5 mrem/yr. The NRC staff believes this calculation is nonconservative because a large particle size for particulates in the atmosphere was assumed. Therefore, the applicant should use a more conservative particle size (1 micron) as discussed above.

The applicant assessed potential exposures via the ingestion pathway. The NRC staff reviewed the applicant's ingestion pathway analysis and concluded it is generally acceptable. This potential exposure pathway is considered of negligible significance at the proposed facility because of the absence of good-quality surface water, poor-quality ground water, limited existing and projected future agricultural land use, and remoteness of this arid site. Thus, the NRC staff considers it unlikely that members of the public may be exposed to radionuclides in the near vicinity of the site via the ingestion pathway.

The applicant assessed potential external exposure to members of the public due to radiation emitted from the airborne and ground-deposited radionuclides. The applicant has also calculated (using MILDOS-AREA and TDAD codes) the dose conversion factors for exposure to airborne (cloud) and ground-deposited (ground) radionuclides. This analysis was conducted for each phase of the

Table 12 Annual Committed Dose Equivalent (ACDE) Rates*

Series	Location	Bone	Lung**	Liver	Kidney	Bronchi	ACDE Rates (mrem/yr)
		(mrem/yr)					
Uranium	East boundary	7.2E0	2.9E0	4.6E-1	3.3E-1	na***	1.5E1
	West boundary	4.6E0	1.8E0	3.0E-1	2.1E-1	na***	7.2E0
	Administration building	1.3E1	5.0E0	8.0E-1	5.8E-1	na***	1.8E1
	Guard trailer	2.0E1	8.0E0	1.3E0	9.4E-1	na***	3.2E1
Thorium	East boundary	8.9E1	2.5E-2	3.45E0	1.7E1	3.1E-3	4.2E0
	West boundary	5.5E1	1.5E-2	2.1E0	1.0E1	1.9E-3	1.3E1
	Administration building	1.5E2	4.0E-2	5.9E0	2.8E1	5.1E-3	2.9E0
	Guard trailer	2.4E2	6.6E-2	9.2E0	4.4E1	8.1E-2	2.3E1

*Doses to epithelium tissues from radon and thoron decay products are not listed in this table. These doses are listed on pages 285-289 of Attachment C of the license application and page 156 of Attachment D, respectively.
**Pulmonary region alone.
***na: not available.
Note: 7.2E0 = 7.2×10^0, for example.

waste disposal operation and for only the adult age group. The applicant's results indicated that at the location of the guard trailer the external whole-body dose rate for an adult individual exposed to airborne and ground-deposited radionuclides in the uranium series is about 4.7 mrem/yr. These calculated rates did not include the contribution from direct gamma radiation from the waste and sky-shine (e.g., reflection and scattering of gamma radiation in the atmosphere above the waste embankment).

The direct exposure rate from the exposed waste (containing 500 pCi/g ^{226}Ra) at the edge of the waste embankment was estimated by the applicant to be about 13.6 R/yr. At 90 m (295 ft), the distance to the closest boundary from the embankment, the direct gamma exposure rate would decrease to less than 2 mR/yr. The applicant estimated the total external dose rate at the nearest site boundaries (the southern and western boundaries) would be 2.0 mrem/yr from waste containing radionuclides in the uranium series only. The direct exposure from radionuclides in the thorium series was estimated by the applicant to be of the same order of magnitude as that for the uranium series radionuclides.

The NRC staff reviewed the applicant's assessment of projected doses from exposure to direct gamma radiation from the waste handling and emplacement operations, from atmospheric transport of radioactive particulates, and from ground-deposited activity. The staff confirmed the applicant's estimates of direct gamma exposure rates by calculating projected doses at various distances using the inverse square formula (i.e., exposure rate decreases proportionally to the square of the separation distance). Although the applicant used several nonconservative assumptions in the transport calculations, as described above, the staff generally concluded that the applicant's estimates of direct gamma exposures were reasonable and representative for projected conditions at the site. The staff particularly notes that the applicant did not include estimates of direct gamma exposures associated with potential exposures from waste handling and disposal activities at the adjacent waste disposal facilities for NORM, low-level waste, and mixed wastes, or the disposal embankment for the Vitro uranium mill tailings. However, the staff considers contribution from this source to be minor.

6.2.1.1.6 Calculation of the TEDE to a Member of the Public

The applicant has provided estimates of the total effective dose equivalent (TEDE) at various locations surrounding the proposed facility in the license application. The applicant based these estimates on the results of the modeling using the MILDOS-AREA and TDAD computer codes as described above. The applicant's estimated TEDE from the uranium series radionuclides at the guard trailer location was 12 mrem/yr (this dose includes doses from radon and decay products). The TEDE at the same location from exposure to airborne, ground-deposited, and inhaled radionuclides in the thorium decay series was estimated to be 11.6 mrem/yr (direct gamma exposure was not considered by the applicant). The applicant summarized the TEDE estimates from the uranium and thorium series as shown in Table 13. (Note: The doses listed in the table are different from the applicant's values listed in the text.)

Table 13 Total Effective Dose Equivalent (TEDE)

Location*	Projected Doses to Members of the Public TEDE (mrem/yr)
East boundary	22.2
West boundary	12.7
South boundary	17.1
Administration building	40.8
Guard trailer	75.4
USPCI facility	18.9
Industrial location	0.7

*See Table 9 for distances.

Based on the above results from modeling using the MILDOS-AREA and TDAD codes, the applicant concluded that the proposed facility should be able to comply with the public dose limit in 10 CFR 20.1301 (as provided in 10 CFR 20.1302(b)(1)) because the projected dose to members of the public should be less than 100 mrem/yr.

The NRC staff has reviewed the applicant's dose assessment and projected doses to members of the public at the proposed facility. NRC's public dose limits in 10 CFR Part 20 are intended to protect the most exposed member of the public. As such, the requirements are written in terms of protecting an actual individual. Members of the public (i.e., persons other than individuals who are employed by Envirocare and who are exposed to radiation incident to their occupation) do not live in the immediate vicinity (i.e., within 1 km (0.62 mi)) of the proposed facility. The security guard who resides at the guard trailer is considered a worker and is protected by the occupational dose limits in 10 CFR Part 20 because the guard is exposed to radiation incident to performing assigned duties. However, any individual who might live or visit with the guard at the guard trailer would be considered a member of the general public, except to the extent that that individual might also be employed by Envirocare as a radiation worker. Consequently, the NRC staff determined that the location of the maximum exposed individual member of the public, if one existed near the site, would be the guard trailer.

The NRC staff reviewed each step of the applicant's dose assessment and identified numerous deficiencies, limitations, and uncertainties associated with the assessment methodology and results, as described in the preceding sections. Based on this review, the staff concluded the following:

(1) In spite of several nonconservative assumptions, the applicant demonstrated that radionuclide releases to the atmosphere near the site boundary either barely meet or exceed the effluent concentration values as listed in Appendix B to 10 CFR Part 20. Therefore, the applicant will be required to conduct sufficient monitoring at the closest locations where individuals would be likely to receive the highest doses from the 11e.(2) disposal operations.

(2) The applicant did not assess the total projected doses from releases of all radionuclides by summing the projected contribution of each radionuclide. In addition, the applications of the MILDOS–AREA and TDAD codes to this facility at distances close to the source may produce results with large uncertainties. Coupled with the nonconservative assumptions discussed previously and the omission of any doses from waste emplacement and handling operations at adjacent facilties, the applicant has not demonstrated compliance with the public dose limits in 10 CFR 20.1301.

Therefore, the applicant will be required by **license condition** to monitor unrestricted areas at the site boundary to demonstrate that the TEDE to an individual member of the public that would result at that location would not exceed 100 mrem/yr.

6.2.1.2 Occupational Exposure

NRC's regulations in 10 CFR 20.1201 require that licensees control the occupational dose to individual adults to the more limiting of the total effective dose equivalent of 5 rem (0.05 Sv) or other dose limits described therein. The regulations in 10 CFR 20.1201(d) allow licensees to demonstrate compliance with the occupational dose limits using the derived air concentrations (DACs) in Table 1 of Appendix B to 10 CFR Part 20. In addition to the annual dose limits, Part 20 requires licensees to limit the soluble uranium intake by an individual to 10 mg (0.0003 oz) per week to avoid chemically toxic effects on workers (10 CFR 20.1201(e)). This section describes and assesses the applicant's program for protecting workers against radiological hazards and toxic effects associated with uranium intake.

The principal pathways of occupational exposure at the applicant's proposed disposal facility for 11e.(2) waste include:

(1) direct external exposure to waste and ground-deposited dust

(2) internal exposure from inhalation of airborne radioactive particulates and radon and thoron and their decay products released from the waste during receipt, storage, processing, and disposal of the waste.

6.2.1.2.1 Direct Gamma Exposure

The applicant did not employ any model or code to assess direct gamma exposure to workers. The applicant determined that it would not be practical to project potential external exposure for each planned activity. The applicant would prefer to rely on personnel monitoring to demonstrate compliance with the occupational dose limit of 10 CFR 20.1201 after facility operations and waste handling commence. The applicant intends to issue dosimeters to measure external radiation exposures (thermoluminescence dosimeters (TLDs)) to all staff working within the boundary of the site of the proposed disposal facility for 11e.(2) waste. Personnel will not be monitored for doses from beta radiation directly. Instead, Envirocare intends to measure beta radiation intensity at the working environment using appropriate radiation survey instruments, such as thin-window Geiger-Mueller probes, ion chambers, and scintillation detectors. Envirocare proposes to measure radiation intensity with open and closed windows and estimate the beta radiation intensity from the difference between the measurements.

The applicant has proposed that personnel monitoring not be segregated into each type of activity. In other words, Envirocare plans to use the same personnel dosimetry for each radiation worker regardless of the type of job activities and will not distinguish sources of worker external exposure. The applicant clearly stated that some of the radiation worker activities will be associated with disposal work at the NORM and mixed-waste disposal facilities located adjacent to the applicant's proposed disposal facility for 11e.(2) waste. However, the applicant also commits to ensure that the dose to any worker will not exceed the occupational dose limits in 10 CFR 20.1201, regardless of the alleged source of the exposure.

The applicant analyzed gamma exposure rates to workers based on operational activities at the Envirocare facility. The predicted average occupational exposure rate (mrem/yr) for each of the three activities (unloading, storing, and placing waste) was the same for the projected deep dose equivalent of about 400 mrem/yr. Details of occupational exposure rates based on activity type were provided by the applicant in the license application.

The applicant estimated gamma exposure rates (at a distance of 1 m (3.3 ft)) from receiving the waste containing

500 pCi/g of ^{226}Ra and ^{228}Ra as 4.2×10^{-4} and 2.6×10^{-4} μR/hr, respectively. (These values, as shown on page 126 of Appendix A to the license application, seem to be in error.) The applicant projected gamma exposure rates up to 5 mR/hr. However, the applicant expects that the average exposure rate would be about 0.2 mR/hr. Based on 2000 hours of annual working time, the estimated deep dose equivalent from receiving the waste is about 0.4 rem/yr.

In estimating the dose to the front end loader operator in unloading and transporting the waste, the applicant assumed a distance of 4 m (13.1 ft) between the operator and the waste. The applicant estimated a gamma exposure rate to the front end loader operator of about 400 mrem/yr.

The applicant estimated an external radiation dose rate to the equipment operator, involved in waste storage, of 100 mrem/yr. The waste disposal process requires spreading and compacting of the waste in the embankment using specialized heavy equipment. The applicant estimated an exposure rate of 400 mrem/yr for an individual operating heavy machinery over the waste surface. The applicant assumed a shielding factor of 10 times because of the steel construction of the equipment.

The NRC staff reviewed the applicant's estimates of worker doses from direct gamma exposures during unloading, transporting, storage, and emplacement of the waste. At the average concentrations assumed for the facility (i.e., 500 pCi/g ^{226}Ra and other associated radionuclides), the staff estimates that the direct gamma doses may be greater than those projected by the applicant. For example, using the conversion factor provided in National Council on Radiation Protection and Measurements (NCRP) Report No. 50 (1976), the exposure rate 1 m (3.3 ft) above the surface of the embankment where waste was being emplaced would be expected to be about 2500 μR/hr. If an individual were exposed continuously while working at the site at that location for 2000 hours per year, the approximate estimated dose would be 5 rem (0.05 Sv). In addition, the NRC staff considers that the applicant's assumed shielding factor is nonconservative and leads to underestimated doses from direct gamma exposure. Nevertheless, in accordance with 10 CFR 20.1502(a), the applicant will monitor doses from external gamma exposure to workers and is required to comply with the dose limits in 10 CFR Part 20. Therefore, the applicant may need to implement controls and additional protective measures (e.g., greater shielding, restricted access, time constraints) to limit external doses based on personnel dosimetry and other monitoring.

6.2.1.2.2 Internal Dose From Inhalation

The applicant has estimated annual intakes of radionuclides via inhalation by workers using the following relationship:

$$\text{Intake (pCi/yr)} = \text{activity concentration (pCi/m}^3) \times \text{inhalation rate (m}^3\text{/hr)} \times \text{work period (hr/yr)}$$

The activity concentration was calculated by the applicant by assuming a dust loading of 1 mg/m^3 (2.8×10^{-5} lb/ft^3) (EPA, 1978; NRC, 1980a). The activity of each radionuclide in the waste is assumed to be 500 pCi/g for ^{226}Ra, ^{232}Th, and decay products in secular equilibrium. Thus, the airborne activity in the dust loading would be 0.5 pCi/m^3 for each radionuclide, which corresponds to an airborne concentration of 5.0×10^{-13} μCi/ml. The applicant, however, incorrectly calculated a concentration of 0.05 pCi/m^3 and converted it to an airborne concentration of 5.0×10^{-14} μCi/ml. The inhalation rate of the worker was assumed to be 1.2 m^3/hr (42.4 ft^3/hr); assuming that an occupational worker spends 2000 hr/yr on the job, the total amount of air inhaled would be 2.4×10^3 m^3/yr (8.5×10^4 ft^3/yr), which corresponds to an intake rate of 1.2×10^{-4} μCi/yr. Using this relationship, the applicant estimated the average worker intake at 120 pCi/yr. However, using the above relationship and proper conversions this intake should be 1200 pCi/yr (1.2×10^{-3} μCi/yr).

The DAC limits in Table 1 of 10 CFR Part 20, Appendix B are listed in Table 14 for comparison with the calculated airborne concentrations. Even though the applicant projected air concentrations less than the DAC values, Envirocare proposed standard operational procedures that would require using respiratory protection with a protection factor of at least 10 in the dust-forming areas. In the dose assessment of inhalation exposure to radionuclides in the ^{232}Th and ^{226}Ra decay chains, the applicant assumed use of respiratory protection with a protection factor of at least 10. The applicant concluded that the annual committed effective dose equivalent (CEDE) from inhalation of airborne particulates would be 325.2 mrem/yr. Without respiratory protection, the projected CEDE from inhalation alone would be estimated at 3252 mrem/yr. However, the applicant did not explain how these doses were derived.

The applicant's dose assessment only considered particulate releases from the low-activity waste (500 pCi/g). For handling the high-activity waste, the applicant estimated an additional dose of 130 mrem/yr. Thus, the applicant's total estimated CEDE from inhalation of airborne particulates from handling and emplacement of the combined waste would be about 4553 mrem/yr without respiratory protection and 455 mrem/yr with respiratory protection.

The applicant also estimated doses from radon and thoron releases from the waste by calculating concentration levels as a function of distance and direction from the waste.

Table 14 Comparison of Derived Air Concentrations (DACs)

Radionuclide	10 CFR Part 20 DACs (μCi/ml)	Applicant's Estimated Airborne Concentrations (μCi/ml)*	Estimated DAC-Hours (assuming 2000 hours per year)
^{220}Rn	1.0 WL	4E-3 WL	8
^{222}Rn	0.33 WL	2.4E-4 WL	0.47
^{226}Ra	3E-10	5E-13	3.4
^{228}Ra	5E-10	5E-13	2
^{230}Th	3E-12	5E-13	340
^{228}Th	7E-12	5E-13	140
^{232}Th	5E-13	5E-13	2000

*Based on corrected conversion of the dust loading from 0.05 to 0.5 pCi/m^3.
Note: 4E-3 = 4 x 10^{-3}, for example.

The applicant employed the same procedure for calculation of exposure in terms of working level (WL) and working level month (WLM) as that detailed in the UDAD code manual. The applicant calculated the average thoron exposure to workers (assuming continuous occupation) at 0.1 and 0.5 km (0.062 and 0.31 mi) from the embankment to be about 6.1 x 10^{-3} and 3.2 x 10^{-3} WLM, with an average of 4.6 x 10^{-3} WLM for the facility. Considering a working period of 2000 hours per year, the applicant estimated the average occupational exposure to each worker would be 1.1 x 10^{-3} WLM. The applicant assumed each WLM corresponded to a 5-rem dose to the bronchial epithelium to estimate the radiation dose rate to workers. Thus, the committed dose equivalent (CDE) to the bronchial epithelium of individual workers was estimated to be 13.4 mrem/yr. Similarly, the applicant estimated the average dose rate to the bronchial epithelium of workers from radon decay products would be 45.0 mrem/yr. Thus, the applicant's predicted CDE to the bronchial epithelium for the average radiation worker from inhalation of radon and thoron at the Envirocare facility was about 58 mrem/yr.

The applicant committed in the license application to ensure compliance with the occupational dose limits in 10 CFR Part 20 by estimating the sum of the committed effective dose equivalents from each inhaled radionuclide and showing compliance with:

$$\Sigma_i C_i/(DAC)_i \leq \text{criteria or } \Sigma_i \text{ intake}/ALI_i \leq 1 \text{ criteria}$$

Where C_i is the concentration (μCi/ml) of radionuclide i and $(DAC)_i$ is the derived annual concentration (μCi/ml) inhalation limit of radionuclide i listed in 10 CFR Part 20, Appendix B, Table 1, Column 3. The ALI_i is the annual limit on intake (μCi) for radionuclide i as listed in 10 CFR Part 20, Appendix B, Table 1, Column 2. The applicant will also limit the duration of worker exposure during operations that result in heavy airborne dust releases and will use respiratory protection for all workers involved in the operation of dust-generating machines. The applicant also reiterated that during receiving, relocating, and disposing of higher specific activity waste, workers involved in such operations will use full-face respirators with a protection factor of 50.

With respect to intake of radioactive material by inhalation, NRC states in 10 CFR 20.1202(b) that the total effective dose equivalent limit will not be exceeded if the sum of the deep dose equivalent divided by the total effective dose equivalent limit and one of the following does not exceed unity:

(1) the sum of the fractions of the inhalation ALI for each radionuclide

(2) the total number of DAC-hours for all radionuclides divided by 2000

(3) the sum of the calculated committed effective dose equivalents to all significantly irradiated organs or tissues calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit

The NRC staff compared the applicant's estimated internal exposures against the DACs for the different radionuclides. The applicant claimed that the estimated radioactive particulate concentrations are at the most 10 times lower than the DACs in Table 1 of Appendix B to 10 CFR Part 20. Using the corrected airborne activity concentration value of 0.5 pCi/m^3 and the above relationships, however, the applicant's estimated airborne concentrations would be either at or slightly above the DACs for ^{230}Th and ^{232}Th. By summing the DAC-hours listed in the table above, the total exposure would be in excess of 2400 DAC-hours, which exceeds the limits in 10 CFR 20.1202(b). This calculation assumed continuous exposure at the calculated airborne concentrations for a 2000-hour work year, which is unlikely. Nevertheless, the calculations are based on a modeling effort that used nonconservative parameter values and has several significant uncertainties, especially close to the waste handling areas as described above. In particular, doses from inhalation of radon and thoron decay products in the immediate vicinity of the disposal embankment are expected to be significantly greater than those estimated by the applicant.

Therefore, the use of respiratory protection and other controls (such as restricting the amount of exposure time) will likely be necessary in accordance with the provisions in 10 CFR 20.1702 to limit airborne intakes of radioactive material. The applicant committed to measure the dust loading and airborne radioactive particulate concentrations, and radon and thoron and decay products, at the disposal site using portable generators and particulate and gas sampling. The applicant should follow Revision 1 to Regulatory Guide 8.25 (NRC, 1992a) for appropriate guidance on the design and implementation of an effective air sampling program in the work place. The applicant also committed to certain measures to mitigate dust suspension. These controls and measures may have to be adjusted based on operational experience, variations in waste concentrations, and personnel monitoring (including bioassay) to ensure that worker doses do not exceed the radiation protection and uranium toxicity limits in 10 CFR Part 20. The NRC staff will make the applicant's commitment to develop an effective air sampling program a **license condition**.

In addition, the applicant did not address the issue of the soluble uranium intake by workers, which must be less than 10 mg (0.0003 oz) soluble uranium in a week in accordance with 10 CFR 20.1201(e). The applicant did not assess the solubility of the uranium that may be released from handling the waste or show that cumulative uptake of uranium via inhalation will not exceed the 10-mg weekly limit. Therefore, the applicant will be required by **license condition** to address this issue and propose specific actions that will be taken if uranium intakes are projected to exceed the 10-mg limit.

6.2.1.2.3 Total Dose

The applicant will have to limit the sum of the deep dose equivalent and committed effective dose equivalent to no more than 5 rem per year from all sources under the applicant's control at the site. The analysis of doses from inhalation of radioactive materials above indicates that doses via this pathway may alone be close to the 5 rem per year limit. In addition, direct gamma doses also may be significant depending on the effectiveness of the applicant's control program. Further, operation of adjacent disposal facilities for low-level radioactive waste, mixed waste, and naturally occurring radioactive material may also contribute doses to individuals who work at the proposed site. Consequently, the applicant will be required by **license condition** to implement an effective combination of procedural controls, mitigative measures, and personnel and environmental monitoring to ensure that total dose to workers does not exceed the occupational dose and chemical toxicity limits in 10 CFR Part 20.

6.2.2 Exposures Resulting From Accidental or Unusual Operating Conditions

Accidental or unusual releases of radioactive material could occur at the proposed facility. Although the radiation protection standards in 10 CFR Part 20 do not specifically apply to such conditions, the applicant assessed the radiological consequences for several accident scenarios. These scenarios included the following: (1) onsite truck turnover or collision, (2) train derailment, and (3) tornado or severe winds.

6.2.2.1 Onsite Truck Turnover or Collision

The applicant used the methodology described in the FGEIS (NRC, 1980a) in assessing the accidental exposure due to a truck turnover or collision on site. The probability selected for the truck accident was 1.3×10^{-6} per kilometer (8×10^{-7} per foot) based on the FGEIS (NRC, 1980a). The applicant assumed the number of truckloads per day was 53 and the travel distance was 1 km (1.6 mi). Thus, the probability of an accident in any one year was calculated at 1.8×10^{-2} or 1.8 percent. Envirocare assumed 18 kg (40 lb) or less of 11e.(2) waste might become airborne immediately and, if the spill was not contained or otherwise controlled, the release fraction over a 24-hour period might increase to 163 kg (360 lb). A comparison was made in the license application (page 17–18) with a truck accident involving a yellow-cake shipment in an area with a population density of 7.5 persons per square mile. For such an accident, the 50-year dose commitment to the lungs was estimated at 0.7 to 9 person-rem. Since the specific activity for Envirocare waste is far less than for the yellow cake (at least 20 times lower), the applicant estimated the dose to the public from a truck accident involving a spill of 11e.(2) waste would be between 0.03 and 0.4 person-rem. The applicant further stressed that the actual offsite population dose would be zero because there are no residents in the nearby area.

The applicant also estimated projected doses to workers resulting from an accident with a waste shipment concentration of 15,000 pCi/g. The applicant assumed a 3-hour period for the cleanup with no use of respiratory protection. The projected maximum TEDE to the radiation worker involved in such an accident was 1032 mrem (over 3 hours). The applicant concluded that such doses are within the annual dose limit for radiation workers (10 CFR 20.1201).

The NRC staff reviewed Envirocare's assessment of the potential adverse consequences of a truck accident on site. Although the applicant did not specifically justify each of the parameter values assumed in the assessment, the staff considers the analogy to a yellow-cake spill and qualitative assessment of radiological releases from onsite truck turnover appropriate because the concentration of the 11e.(2) waste and population density are expected to be far less than values assumed in the analysis. Use of representative values for both of these factors would reduce the projected population doses associated with a truck accident. In addition, the applicant has committed to use respiratory protection in any activities involving release of radioactive particulates at the proposed facility. Consequently, projected doses to workers should be well within the dose limits of 10 CFR Part 20 for this accident scenario because of the protective measures that the licensee has committed to in the license application.

Train Derailment

Envirocare used the argument that the probability of a train derailment is far less than that for a truck accident at the site. As in the case of the truck accident, Envirocare assumed there is no population in the nearby area and hence there should be negligible dose to the public. The dose to workers was not estimated or calculated, although the applicant stated that "no significant dose to workers for the same reasons discussed under truck accidents." The applicant, however, referred to the truck accident scenario to estimate doses from such an accident.

The NRC staff has reviewed the applicant's brief assessment of potential doses to workers associated with a train derailment. Although the probability of a train derailment may be less than was calculated for the truck accident (i.e., less than 2×10^{-2} per year), the derailment would probably involve a much larger quantity of contaminated material. The typical number of railcars in a train at the Envirocare facility, other than proposed shipments of contaminated materials from the West Chicago site, is three to four cars. Consequently, the potential releases to the environment, airborne concentration values, and doses to the workers could also be considerably greater than were estimated for the truck accident. However, the probable extent of a spill of waste from train derailment at the proposed site would likely be limited for the following reasons: (1) the distance of the rail spur on site is less than the road length; (2) the railcars are typically covered, so a derailment may not result in a spill of contaminated material; and (3) the speed of the trains on the rail spur is limited, so it is unlikely that the train would be moving faster than a nominal speed (e.g., less than 8.0 km/hr (5 mi/hr)). If a derailment did result in a large spill of contaminated material, the licensee would be required to remove the waste in accordance with release limits for unrestricted areas and dispose of the waste within the embankment. The doses to workers from activities involved in cleaning up the spill would be similar to projected doses associated with unloading and emplacement of the 11e.(2) waste in the disposal embankment. The applicant has committed in the license application to limit such doses to ensure compliance with 10 CFR Part 20. Therefore, the staff concluded that the applicant's assessment of the truck accident scenario provides a reasonable estimate for the probable impacts associated with a train derailment.

Tornado and Severe Winds

The applicant assessed potential consequences associated with severe weather at the proposed facility. The applicant employed the probability figure of 1 to 5×10^{-4} from the FGEIS (NRC, 1980a) for tornados in Utah. Envirocare also used NRC's estimates from the FGEIS for uranium milling (NRC, 1980a), which predicts a maximum exposure at 4 km (2.5 mi) (50-year dose commitment) of 0.83 μR from the release of yellow cake from a model uranium mill. Considering population of zero density in the nearby areas and low specific activity of the waste, Envirocare concluded that the dose for offsite residents resulting from a tornado would be zero. The applicant also concluded that doses to workers caught in the tornado would be trivial compared to physical hazards associated with the severe weather, without providing any estimates for the doses.

The applicant also assessed potential consequences of severe wind using the predicted airborne exposure resulting from tornados (50-year dose commitment at 4 km (2.5 mi) was estimated at less than 1 μrem). Appendix I of the license application estimated a continuous exposure to a plume from a 3-m/s (9.8-ft/s) wind at a 500-m (1640-ft) distance to the nearest resident. Envirocare concluded that the anticipated dose to an offsite resident as a result of infrequent severe winds would be on the order of microrem/yr.

The NRC staff reviewed the applicant's assessment of potential consequences of severe winds and tornados and concluded that Envirocare's assessment is reasonably conservative and appropriate. The applicant assumed yellow cake in the assessment, which would tend to overestimate potential doses because of the high concentration of uranium in the yellow cake compared with the concentrations of radionuclides in the 11e.(2) waste at the proposed facility. Although the yellow cake would not contain as high concentrations of decay products from uranium and the radionuclides in the thorium decay chain, the differences in projected doses would not be significant because the much higher concentration of uranium in the yellow cake should compensate. In addition, the staff concurs with the applicant's determination that physical hazards associated with tornados would likely overwhelm concerns about projected radiological doses to workers during the severe weather.

6.3 Instrumentation, Methods, and Equipment

NRC regulations in 10 CFR Part 20 require that licensees conduct radiation surveys and apply process or other engineering controls to ensure that workers and members of the public are protected in accordance with the dose limits of Part 20. For example, 10 CFR 20.1501(a) requires licensees to conduct surveys to evaluate the extent of radiation levels, concentrations, and quantities of radioactive materials, and potential radiological hazards that could be present. In addition, 10 CFR 20.1701 requires licensees to use engineering or other process controls to control concentrations of radioactive materials in the air, including control of access, limitation of exposure times, and use of respiratory protection. The applicant has proposed to use radiation protection instrumentation, methods, and equipment in accordance with the provisions of Part 20.

The applicant proposed portable and laboratory equipment for surveying and detecting radiation and radioactive materials. The survey and detection equipment includes a full range of instruments and detectors that are consistently used throughout the industry. The applicant has also committed to use respiratory protection equipment and protective clothing to ensure protection of workers and limit the internal and external exposures to radioactive materials.

Envirocare should describe its quality controls for waste sampling, characterization, and classification as high-activity or low-activity specific activity waste. The applicant needs to provide controls for the quality of the protective equipment (e.g., anticontamination clothing and equipment that meets the American National Standards Institute (ANSI) Z88.2 guidance (ANSI, 1980)) and respiratory protection equipment, including a respiratory protection program that satisfies the guidance of Regulatory Guide 8.15 (NRC, 1976) and NUREG-0041 (NRC, 1975). The NRC staff will require compliance with these quality controls by **license condition**.

Envirocare indicated that all survey and monitoring equipment will be periodically calibrated by staff licensed by the State of Utah. The calibration will be performed within the tolerance sensitivity specified by the manufacturer of the equipment. The frequency of calibration will be daily for the multichannel-analyzers and associated equipment, and semiannually for the G-M survey meters, the Micro-R meters, and the alpha survey meters. The analytical balances and the dosimeters will be calibrated on monthly and yearly bases, respectively. Calibration records for all equipment will be kept at the site administration office and at the company main offices in Salt Lake City. All equipment will be identified by serial number, person performing calibration, date of previous calibration, and date for next calibration. A record of equipment damage will also be kept with the equipment file.

The NRC staff has reviewed the proposed health physics instrumentation and calibration procedures and concluded, in general, that the applicant's proposed approaches are appropriate and adequate to demonstrate compliance with 10 CFR Part 20. The NRC staff based its conclusion on a variety of observations, including the following: (1) the proposed methods generally represent state-of-the-art field instrumentation for radiological survey applications and monitoring of operating facilities, (2) the methods conform reasonably with standard industry practice for similar types of operations, and (3) the instrumentation will be adequate with respect to required sensitivity levels for their applications over the range of radionuclides and waste types to be received at the proposed facility.

The NRC staff considers the instrument calibration program proposed by Envirocare is adequate and in compliance with 10 CFR 20.1501(b). Envirocare indicated that calibration and management of monitoring equipment will be based on applicable guidance in NRC regulatory guides (e.g., Regulatory Guides 4.14 (NRC, 1980b) and 8.25 (NRC, 1992a). Based on the review of the type of equipment to be used for radiation surveys and measurements, the NRC staff suggests that the response of survey instruments be checked against a known source prior to each usage (see Regulatory Guide 8.30 (NRC, 1983a). This check should be supplemented at 6-month intervals by calibrating each instrument at two points separated by at least 50 percent of each linear scale or at one point near the midpoint of each decade on logarithmic scales that are routinely used. Air flow rates through filters should be determined by calibrating pumps with the filter paper in place at least once every 6 months to a ±20-percent accuracy. The fluorimetric analysis for uranium should be calibrated by running a known standard uranium, traceable to the National Institute of Standards and Technology, and a blank with each batch. Alpha counting systems used for radon decay product measurements should be calibrated at least monthly using a known, traceable standard alpha source.

6.4 Radiation Protection Program

Envirocare presented a radiation safety and environmental program (Section 17.4 of the license application) that included a variety of procedures and methods for ensuring protection of workers and members of the public. Envirocare addressed all of the applicable radiation protection standards in 10 CFR Part 20.

In general, the applicant's radiation protection program appears to be sufficiently developed to address the specific dose limits and radiation protection provisions in 10 CFR Part 20, including occupational dose limits for adults, summation of external and internal doses, determination of airborne doses and other internal exposures, planned special exposures, occupational dose limits for minors, protection of an embryo/fetus for a declared pregnant woman, and dose limits for members of the public (as described in Section 6.2 of this FSER).

6.4.1 Determining the Exposures and Intake of Radioactive Materials

The applicant described procedures and methods for personnel and occupational exposure monitoring; area radiation monitoring; environmental monitoring, including general exposure rate and radionuclide concentrations in soil, water, vegetables, and wildlife; and dose assessment.

6.4.1.1 Personnel and Occupational Exposure Monitoring

Envirocare committed to monitor radiation exposure of all personnel using the following methods as described in the license application:

(1) Permanent employees will be issued TLD badges which will be examined and exchanged on a quarterly basis. The radiation safety officer will keep quarterly dosimeter records for all staff. The dosimeters will be used primarily to assess direct gamma exposure.

(2) Individuals visiting the site on a short-term basis will be issued a self-reading pocket dosimeter to record exposure. The dosimeters will be read as the individual leaves the site and recorded in the site access log. A group of visitors may all use one TLD or one pocket dosimeter, if they will stay in one vicinity in the controlled area and are near the individual with the dosimeter.

(3) All exiting employees will be surveyed for skin, hand and foot, and clothing contamination prior to exiting the controlled area, using an instrument sensitive to alpha, beta, and gamma contamination. Records of names and number of contaminated employees and levels of contamination will be kept in the administration building.

(4) All permanent employees will participate in a bioassay program for assessment of possible internal deposition of radionuclides. Baseline urine samples will be collected upon employment and annually thereafter. The samples will be analyzed for gross alpha, ^{226}Ra, and total uranium. Sampling and analysis for ^{230}Th and ^{232}Th will be conducted upon finding an increase above baseline levels of radioactivity for gross alpha particle activity, ^{226}Ra, and total uranium.

Envirocare has also stated that they will comply with 10 CFR 20.1501(c) to ensure that all personnel dosimeters are processed and evaluated by a dosimetry processor who is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).

Further, the applicant noted that commercially available film badges and TLD personnel dosimetry often do not assess beta doses in the mixed beta-gamma field associated with uranium mill tailings and 11e.(2) byproduct material. Thus, the applicant has committed to follow NRC guidance in Regulatory Guide 8.30 (NRC, 1983a) by measuring worker beta dose indirectly from environmental measurements as explained in Section 6.2.2 of this FSER.

The applicant has presented their bioassay program that employs the methods recommended by NCRP Report No. 87 (NCRP, 1987). The applicant indicated that the bioassay program will also be based on the methodology described in Reif et al. (1992) for interpretation of the bioassay results.

The NRC staff has reviewed the applicant's proposed personnel monitoring program. The NRC staff compared the proposed program against standard industry practice, available regulatory guidance, and NRC requirements in 10 CFR Part 20. Based on this review, the NRC staff determined that the applicant's program should be adequate and sufficient to demonstrate compliance with the requirements of 10 CFR Part 20, particularly 10 CFR 20.1501 and 1502. The bioassay interpretation procedure proposed by the applicant is appropriate for screening purposes. The applicant should also consult Draft Regulatory Guide DG-8009 (NRC, 1991) to ensure appropriate interpretations of the bioassay measurements.

6.4.1.2 Area Radiation Monitoring

Envirocare described the area radiation monitoring program in the license application. The program includes the following aspects:

(1) *Gamma Exposure Rate*—Perimeters of all controlled areas, the office area, and the lunch/change area will be monitored on a weekly basis. Transport vehicles will also be monitored, for gamma exposure rate, upon arrival at the site and before departure. The applicant proposed to monitor gamma exposure rate quarterly in the administration building and in the security trailer. In addition, random external gamma surveys will be performed during daily operations as considered necessary by health physics personnel.

    Because the security guard will reside at the trailer on site and extended exposure to elevated direct gamma rates could result in significant doses to the guard at the trailer within the calendar quarter, the applicant needs to determine the exposure rate to the guard at the trailer location with high confidence. Therefore, the NRC staff will require the applicant by **license condition** to continuously monitor the exposure rate at the security guard trailer rather than monitor the exposure rate quarterly as proposed in the application.

(2) *Airborne Radioactivity*—Work areas and boundary areas will be monitored for airborne radioactive particulates using high-volume, fixed-head air samplers. Continuous airborne particulate sampling and monitoring will be conducted to provide overall average concentrations of radioactivity, at fixed locations of environmental monitoring. Samples will be analyzed for gross alpha particle activity, ^{226}Ra, ^{232}Th, ^{230}Th, and total uranium. Gross alpha levels will be

compared with the concentration limits in note 3 of Appendix B to 10 CFR Part 20. Envirocare committed to collect breathing zone samples for equipment operators involved in handling or disposing of waste. Passive environmental radon monitoring will be used at all environmental monitoring stations and in the administration building and the mobile home used by the security guard. For control of worker exposures via inhalation, the applicant proposed an administrative limit of 6 pCi/m^3 for airborne gross alpha activity.

Because the security guard will reside in the mobile home and elevated airborne particulates and concentrations of radon and thoron (with decay products) may cause significant doses to the guard, more frequent monitoring of airborne concentrations is justified at the location of the trailer. Therefore, the applicant will be required by **license condition** to conduct frequent or continuous monitoring for airborne radioactive particulates, radon (with decay products), and thoron (with decay products) at the security guard residence to ensure that the total dose to the guard does not exceed the occupational dose limits in Part 20 and that total doses to other inhabitants or visitors (other than radiation workers) do not exceed the public dose limits in Part 20.

(3) *Surface Contamination*—Routine wipe surveys for surface contamination will be conducted weekly for the eating areas, change area, office areas, railcar rollover and control shack, and all equipment and vehicles. The wipes will be analyzed for gross alpha particle activity using an appropriate instrument. The wipes will also be analyzed for gross beta particle activity contamination using an appropriate instrument (e.g., gas flow proportional counter). Surface contamination levels on equipment and clothing are provided in NRC Branch Technical Position WM-7601 (NRC, 1984).

The NRC staff reviewed the applicant's proposed program for area radiation monitoring and concluded that the applicant's program for conducting general area surveys and monitoring, as modified above, meets the requirement of 10 CFR 20.1501 and 10 CFR 20.1502.

6.4.1.3 Environmental Monitoring and Surveillance

Envirocare presented a radiological environmental monitoring program in the license application that covers the following areas:

(1) *Gamma Radiation Control*—The boundary of the site will be monitored for external gamma radiation exposure using a pressurized survey meter during periods of dry weather and using E-Perm Electric Ion Chambers or environmental thermoluminescence dosimeters (TLDs). The onsite monitoring stations will be located at A2, A3, A5, A6, A7, and A11 through A13 (see Table 7.1 of the license application for coordinates of these stations). Two offsite stations, B1 and B2 (Table 7.1), will be used to establish and monitor background exposure rates during site operations. Envirocare committed to measure gamma exposure rates at 150-m (492-ft) intervals along each of the eight compass directions out to a distance of 1500 m (4920 ft) from the center of the disposal facility in accordance with Regulatory Guide 4.14 (NRC, 1980b). Direct radiation measurements should be made in dry weather, not during periods after rainfall when soil is abnormally wet, to avoid any interference by soil moisture with gamma exposure rate measurements. The environmental TLDs at all monitoring stations will be exchanged and processed at quarterly intervals.

The applicant also committed to conduct routine external gamma surveys using gamma scintillation survey meters in areas involving disposal of 11e.(2) materials as a part of the general area surveys. These external surveys are discussed in Section 6.4.1.2 of this FSER.

The NRC staff has reviewed the applicant's proposed environmental monitoring program for gamma exposure rate and concluded that the program is generally acceptable. Envirocare stated in the license application that they will assume that all potential exposures detected above background rates at the monitoring station are associated with waste handling and emplacement activities at the proposed 11e.(2) disposal facility, even though the source of the gamma radiation may be from disposal operations adjacent to the proposed disposal facility. Detection of elevated exposure rates at the boundary environmental stations in unrestricted areas may necessitate additional controls, including limitations on waste emplacement activities or additional restrictions on the acceptable concentrations for disposal, even though the source of the elevated exposure rates may be the adjacent waste disposal facilities under the control of the applicant.

(2) *Airborne Radioactivity*—The applicant presented a sampling and monitoring program for radioactive air particulates at nine stations located at A2, A3, A5 through A7, and A10 through A13 (Table 7.1). Background samples will be collected at stations B1 and B2. The air samples will be analyzed initially for gross-alpha and gross-beta particle activity. In addition, quarterly composite samples (composed of all weekly samples collected at each specific station) will be analyzed by gamma spectrometry for identification of any gamma-emitting radionuclides.

Radiochemical analysis for total uranium, ^{226}Ra, ^{230}Th, ^{232}Th, and ^{210}Pb will also be conducted on all composite samples.

The applicant committed that analytical techniques used will provide a minimum detectable concentration of 5 percent or less of the applicable derived airborne concentrations (DACs) for radionuclides given in Table 2 of 10 CFR Part 20, Appendix B. Envirocare will establish restrictive limits on airborne concentrations of alpha emitters, such as ^{230}Th, to 0.08 pCi/m^3, and beta emitters, such as ^{210}Pb, to 4 pCi/m^3. Thus, in the proposed Envirocare monitoring program, concentrations of gross alpha greater than 0.08 pCi/m^3 or gross beta greater than 4 pCi/m^3 will be used as monitoring set points. Samples having gross activity measurements above these levels will be analyzed using gamma spectrometry for further identification of the radionuclides present.

Airborne particulate radioactivity concentrations will also be compared with the data accumulated from background measurements. For naturally occurring radionuclides, which are normally found in air samples, a concentration in excess of the mean plus two standard deviations will be considered significant. The applicant proposed an administrative limit of 0.24 pCi/m^3 for airborne gross-alpha particle activity concentration for site boundaries.

The NRC staff has reviewed the proposed environmental monitoring program for airborne radioactive particulates and determined that the program is generally acceptable under normal operating conditions. However, since the 11e.(2) facility is contiguous to other facilities that handle wastes that contain the same radionuclides (e.g., Envirocare's low-level waste (LLW) and mixed-waste and NORM disposal facilities), more frequent sampling of airborne radioactivity concentrations may be required to attempt to distinguish the radioactive emissions of the various facilities. The applicant has accepted the assumption that any detected environmental radioactivity, regardless of its source, is attributable to the 11 e.(2) waste disposal operation. Consequently, the applicant may need to take corrective measures if airborne concentrations exceed appropriate levels in accordance with 10 CFR Part 20, even though the source of the elevated airborne concentrations may be the adjacent waste disposal facilities under the control of the applicant.

(3) *Radon in Outdoor Air*—The applicant committed to monitor outdoor radon and decay product concentrations on a continuous basis using E-Perm Electret Ion Chambers. Radon monitoring detectors will be located at eight onsite stations (A2 through A7 and A11 through A13 (see Table 7.1 for locations)) and at two offsite stations (B1 and B2). The offsite stations will be employed to establish and monitor background levels of radon and decay products during site operations. Detectors located at these stations will be collected quarterly and analyzed to determine average radon and decay product concentrations. Any concentration levels in excess of the mean plus two standard deviation values of the background level will be considered significant. In 1986, the Utah Bureau of Radiation Control measured radon background concentrations using passive environmental radon monitors at four stations around the Clive-Vitro site boundary. The background data were collected during the period of October to November 1986 and the mean concentration was 0.54 pCi/l. The standard deviation for radon background level was in the range of 0.2 to 0.3 pCi/l. Therefore, the standard deviation values in that range would be considered significant.

The NRC staff reviewed the proposed program for monitoring ambient radon levels in outdoor air and determined that the program is generally sufficient to demonstrate compliance with 10 CFR Part 20. The applicant's approach is consistent with standard industry practice.

However, since the proposed 11e.(2) waste disposal facility is contiguous to other facilities that handle wastes that may also release radon, thoron, and their decay products (e.g., Envirocare's LLW and mixed-waste and NORM disposal facilities), the applicant will need to take corrective measures if airborne concentrations of these radionuclides exceed appropriate levels in accordance with 10 CFR Part 20, even though the source of the elevated airborne concentrations may be the adjacent waste disposal facilities under the control of the applicant.

In addition, the applicant should consider performing ^{222}Rn flux measurements in three separate months during normal weather conditions in accordance with Regulatory Guide 4.14 (NRC, 1980b). The purpose of the sampling is to assess the radon flux from the operating facility on a periodic basis for comparison against the radon measurements collected as part of the environmental monitoring program. The measurements are normally conducted at the center of the facility and at locations 750 and 1500 m (2460 and 4920 ft) from the center in each of the four compass directions.

(4) *Soil Contamination*—Soil samples will be collected quarterly and will be analyzed by gamma spectrometry to determine concentrations of gamma-emitting radionuclides and to infer, based on equilibrium

relationships, concentrations of other radionuclides in the decay chains that emit no or weak gamma emissions based on equilibrium relationships. The applicant will analyze all samples for ^{226}Ra and 10 percent of the samples for natural uranium, ^{230}Th, and ^{210}Pb. The purpose of the periodic sampling would be to detect any significant windblown transport of radioactive particulates from the disposal facility. Some selected samples will also be analyzed by alpha spectrometry for ^{230}Th, ^{232}Th, and total uranium. The applicant committed to collect and analyze samples from stations A2, A3, A5 through A7, A10 through A12, and B1 and B2 (Table 7.1 of the license application) using gamma spectrometry. The ^{230}Th, ^{232}Th, and total uranium will be analyzed in soil samples collected quarterly from the vehicle decontamination area, truck shipment staging area, road from rollover to the embankment, and stations 5, 31, 32, and A11 through A13. The applicant has committed to take surface soil samples at 300-m (984-ft) intervals to a distance of 1500 m (4920 ft) in each of the eight directions from the center of the disposal facility on a periodic basis. In addition, five samples will be taken at random at other locations around the site. A 1-m (3.3-ft)-deep sample will be taken at a distance 750 m (2460 ft) from the site boundary in each of the four compass directions and at the center of the disposal area.

The NRC staff has reviewed the applicant's proposed procedures for soil sampling and analysis. The applicant's program for soil sampling is in accordance with Regulatory Guide 4.14 (NRC, 1980b). Based on this review, the staff concluded that the procedures are generally appropriate and sufficient to comply with NRC requirements in 10 CFR Part 20. The applicant's proposed program should be adequate to detect any significant windblown transport of radioactive particulates from the disposal facility into the general environment.

(5) *Vegetation*—The applicant has committed to collect and analyze vegetation samples from local native plants twice a year. Samples will be collected from nine locations. One sample will be collected from stations A12, 30, 39, 55, and GW3 (see Table 7.1 of the license application for coordinates). Samples will also be collected at four remaining locations; these locations are 1.6 km (1 mi) east, west, north, and south of the site boundary. The latter four samples will serve as background monitoring samples. Gamma spectrometry analysis will be conducted for determination of gamma-emitting radionuclides and for total uranium, ^{210}Pb, ^{210}Po, ^{226}Ra, ^{230}Th, and ^{232}Th.

The NRC staff considers that the above vegetation monitoring program is adequate and in accordance with NRC regulations and guidance in Regulatory Guide 4.14 (NRC, 1980b).

(6) *Wildlife*—The applicant has committed to sample wild field mice (1 dozen/yr) from onsite stations A11, A12, 30, and 31 and from offsite station B3 (as an upwind control). The samples will be analyzed for total uranium, ^{210}Pb, ^{210}Po, ^{226}Ra, ^{230}Th, and ^{232}Th.

The NRC staff concludes that the wildlife monitoring program is adequate based on comparison with the acceptable programs described in Regulatory Guide 4.14. However, the staff also recommends that the applicant consider analyzing three samples from other predominant types of wildlife that may serve as food in the vicinity of the disposal facility (e.g., jackrabbits) within 3 km (1.9 mi) of the site. These wildlife samples should be analyzed for total uranium, ^{210}Pb, ^{210}Po, ^{226}Ra, ^{230}Th, and ^{232}Th (NRC, 1980b). Nonsacrificial sampling methods should be used to the maximum extent practical to avoid any significant impact on the diversity and number of wildlife species near the site.

6.5 Radiation Safety Program

NRC regulations in 10 CFR 20.1101(a) require each licensee to develop, document, and implement a radiation protection program commensurate with the scope and extent of licensed activities and sufficient to ensure compliance with the requirements in Part 20.

6.5.1 Organization and Responsibilities

The applicant has described the radiation protection responsibilities of various individuals within the Envirocare organization in Chapter 18 of the license application. In the applicant's program, overall responsibility for radiation protection resides with the corporate radiation safety officer (CRSO), who reports directly to the president of Envirocare.

The NRC staff reviewed the proposed organizational structure and responsibilities for the radiation safety program. The review indicated a potential problem with limited direct communication between the field radiation safety officer (FRSO) and the site manager. Nevertheless, the applicant has committed to close cooperation between the CRSO, site manager, and FRSO. Further, Envirocare will conduct weekly staff meetings, which will include the executive vice president, the CRSO, the operations supervisors, and other personnel. The applicant also stated that all Envirocare management and staff will have free access to each other to resolve immediate safety or operational issues. Therefore, the staff concluded that the applicant's proposed organizational structure and responsibilities should generally be adequate to ensure timely identification and resolution of issues affecting radiation safety and environmental protection.

The staff observed a potential problem area that the applicant should address on a continuing basis to ensure continued compliance with NRC requirements in 10 CFR Part 20. Many of the key radiation protection staff will only be committed half-time to the proposed 11.e(2) waste disposal facility. These staff positions included the CRSO and the FRSO. When not present at the 11e.(2) facility, the NRC staff understands that the CRSO and FRSO would be accessible at the adjacent disposal facilities for LLW, mixed waste, and NORM waste. Although this level of effort should be adequate under normal operating conditions, periodic events may arise that will require simultaneous attention of the radiation safety officers (RSOs) at both facilities. For example, injuries to workers could warrant the simultaneous attention of the FRSO at both the 11e.(2) disposal facility and one or more of the other waste disposal facilities. In addition, if the FRSO is detained at one facility, the FRSO may not be available for immediate determinations of safety hazards at the other facilities. The applicant should ensure adequate radiation protection support to the 11e.(2) waste disposal facility and adjacent facilities.

6.5.2 Staff Qualifications

Envirocare emphasized the importance of having qualified staff to manage and conduct operations of the 11e.(2) waste disposal facility because of the radiological nature of the waste. The applicant presented the qualifications of the radiation safety staff in the license application.

The NRC staff reviewed the proposed qualifications of key staff responsible for performing radiation safety functions. The staff compared the proposed qualifications with guidance provided in Regulatory Guide 8.31 (NRC, 1988a). Based on this review, the staff concluded that the proposed radiation safety staff qualifications are adequate.

6.5.3 Staff Training Program

The training program, as described by the applicant in Section 17.4.8 of the license application, will be implemented under the supervision of the CRSO. Radiation safety training will be provided for all persons before they enter the controlled area. The amount of radiation safety training for any person will depend on the function and purpose of the person and type of activities to be carried out. Persons entering the controlled area will be classified in three categories: permanent employee, temporary worker, and visitor. The permanent employee is an employee hired by Envirocare for a period of 20 days or longer. A temporary worker is a service contractor, who works inside the controlled area under a contract or a service order, but is not an employee on the payroll of Envirocare. A visitor is a person whose main interest is to communicate with personnel in the controlled area and/or to observe operation of the facility.

The applicant's proposed training program includes an appropriate combination of radiation worker training, entrance training, and radiation safety training. In addition to the above training courses, the applicant has committed that all Envirocare employees will be required to attend at least 20 hours of annual training in radiation protection and safety, which will be provided by qualified personnel. This training will be tailored to the specific needs and duties of the employees. It will cover areas of occupational safety, radiological safety, and health physics procedures and techniques. Details of specific training for radiation workers, radiation monitors, health physics technicians, and security guard/radiation monitor are given in the license application, Appendix B, pages 113–121.

The NRC staff has reviewed the applicant's proposed training program and determined that it is adequate for radiation workers and permanent employees. The staff compared the program with relevant guidance in Regulatory Guide 8.31 (NRC, 1988a), Regulatory Guide 8.13 (NRC, 1987), and Regulatory Guide 8.29 (NRC, 1981a). The proposed training program compared favorably with this guidance and appears to comply with NRC requirements for such training in 10 CFR 19.12.

6.5.4 Radiation Safety Posting, Access Control, Recordkeeping, and Reports

The applicant has stated that the entire site area will be fenced prior to receipt of 11e.(2) waste to ensure that intruders do not inadvertently gain access to the site. The fence will be posted with appropriate "Caution-Radioactive Materials" signs bearing the standard radiation symbol as required by 10 CFR 20.1901. Radiation warning signs will also be posted at all security gates and at 61-m (200-ft) increments on the permanent fencing. The signs will be visible and legible from a minimum distance of 7.6 m (25 ft). Any embankment that has been completed will be fenced and posted with appropriate signs (e.g., "Caution-Radioactive Materials," and other warning signs as applicable). The applicant will apply a 0.6-m (2-ft)-thick erosion barrier to severely limit, if not eliminate, intrusion and burrowing by small animals.

The applicant has committed that entrances into the work area will be opened only for the entrance and exit of equipment and waste. All persons working in the controlled area will be required to pass through an access control gate and enter their names in the access control log. They will also be required to adhere to the access regulations. All employees and visitors will be monitored by TLDs and pocket dosimeters, respectively (see Section 6.4.1.1 of this FSER). Persons who do not comply with safety and security regulations will be denied access to the controlled area of the site. Access to the site without prior training and any deviation from the dosimeter policy must have prior approval from the CRSO or the FRSO. The security guard will provide surveillance to prevent intrusion by any unauthorized persons.

The NRC staff has reviewed the proposed access control program and determined that the program is appropriate and in accordance with the provisions of 10 CFR 20.1901, 20.1902, 20.1903, and 20.1904.

6.5.5 ALARA Controls

NRC regulations in 10 CFR 20.1101(b) require that licensees use, to the extent practicable, procedures and engineering controls based on sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).

The applicant proposed an ALARA program that focuses on practical aspects of reducing potential exposures and releases via dust control. The applicant will investigate any reported personnel exposure in excess of an administrative limit of 50 mrem/month in an effort to maintain occupational exposures ALARA. Additional procedures and methods proposed by Envirocare to keep exposures ALARA included:

(1) Dust suppression on all operational roads using magnesium chloride or watering at 2-hour intervals. (This will be a **license condition**.)

(2) Use of respiratory protection (at least half-face mask respirators with a protection factor of 10) by workers in areas of potential high dust concentrations (e.g., in the rollover area and emplacement areas within the embankment).

(3) Prompt placement of the radon barrier on portions of the embankment as portions of the embankment are completed.

(4) Suspension of waste emplacement operations under high wind conditions (i.e., winds in excess of 64 km/hr (40 mi/hr)). The RSO may also stop the operation at lower wind speeds if dust conditions or other safety conditions warrant.

(5) Speed limits of 56 km/hr (35 mi/hr) on roads treated by dust suppressants and 16 km/hr (10 mi/hr) on infrequently used roads.

(6) Weekly conduct of radiation surveys of the area and investigation of increasing trends in exposure rates or concentrations.

(7) Preplanning of tasks that may have potential for higher than normal exposure to limit exposures through sufficient use of time and selection of appropriate procedures.

The applicant indicated also that the FRSO will document ALARA activities that include review of disposal contracts, monthly review of environmental air monitoring, adjustment of work procedures to reduce exposures, and review of gamma exposure rates in the working areas to reduce exposures to ALARA. Further, the applicant will conduct an audit of ALARA activities and document such activities on an annual basis.

The NRC staff has reviewed the applicant's proposed ALARA program as described in the application. The NRC staff compared the applicant's proposed program with relevant NRC guidance in Regulatory Guides 8.31 (NRC, 1988a) and 8.37 (NRC, 1993). Although the applicant has presented some practical procedures that attempt to implement the ALARA provisions of 10 CFR 20.1101(b), the details of the applicant's ALARA program and audit and inspection provisions are lacking in the license application (see also Section 6.4 of this FSER). In addition, the ALARA program is not complete. The applicant did not specifically address or propose adequate procedures for significant elements of an effective ALARA program, including ALARA philosophy and goals, responsibilities for overseeing and revising the ALARA program, ALARA program audit functions, respiratory protection, effluent controls, facility equipment design, ALARA training, and fire control. Therefore, the applicant will be required by **license condition** to submit for NRC review and approval a more complete ALARA program prior to receiving waste at the proposed disposal facility. Once approved, the ALARA program will be established as a license condition.

6.5.6 Personnel Contamination and Decontamination

Envirocare has committed in the license application to require all workers in the controlled areas to wear protective clothing or disposable coveralls to minimize any potential skin contamination and to control the spread of contamination. All permanent employees will be issued dedicated work boots that will be worn in the controlled areas. Supervisors and visitors to the site will not be required to wear protective clothing or to wash exposed skin. However, they must wear dedicated boots or boot covers and must use the hand and foot monitors prior to leaving the controlled area. Workers involved in handling material will be required to wash and survey skin (hands and face) before they leave the site. Showers will be provided in the change area for workers to be used before exiting the site. Personnel working in the embankment area will be required to be surveyed before leaving the access control area. A hand and foot monitor sensitive to both alpha and beta radiation, as well as gamma radiation, will be used for routine monitoring for contamination of personnel. All alpha contamination on skin and clothing will be considered by the applicant as removable. Envirocare will apply the limits of contamination for personnel and clothing as given in Section 6.4.1.2 of this FSER.

The NRC staff has reviewed the applicant's proposed procedures for controlling personnel contamination and for decontamination. Based on this review, the staff determined that the applicant has presented adequate and appropriate procedures, with the exception of controlling internal contamination from dust inhalation. Therefore, the applicant will be required by **license condition** to provide procedures for controlling internal contamination of workers from dust inhalation in accordance with 10 CFR 20.1702.

6.5.7 Emergency Procedures

The applicant provides in Appendix C of the license application a comprehensive Radioactive Material Accident or Emergency Contingency Plan. Envirocare proposed that the maximum credible accident at the site would be the accidental dumping of a load of radioactive waste at some location other than the disposal cell. The plan includes a description of the response procedures and responsibilities of Envirocare personnel.

The NRC staff has reviewe.l the proposed emergency response procedures for the proposed 11e.(2) waste disposal facility. The staff compared the licensee's response plan and procedures for responding to accidents to those required for uranium mills. Based on this review, the staff concluded that the applicant's proposed procedures are adequate with respect to the emergency scenario presented because it includes appropriate emergency notification and response procedures and is sufficiently flexible to accommodate the potential variability of site emergencies. Given the waste characteristics and proposed operational procedures at the proposed disposal facility, the staff considers it unlikely that other types of accidents may occur, such as a fire in the embankment, accidental criticality, or chemical explosions. Therefore, it does not appear necessary to require the applicant to develop more detailed plans to address such potential emergencies.

6.5.8 Quality Control

The applicant has described a quality control program for the radiation protection program in the license application. The applicant's organizational chart (Figure 18 of the license application) indicates that the quality assurance/quality control activities are conducted under the supervision of the field radiation safety officer (FRSO) and the internal quality assurance auditor. The quality control program for the health physics, environmental, and safety programs depends mainly on daily inspection of operations by the FRSO, the site manager (SM), or the radiation technician (RT) to ensure that radiation protection activities are conducted in a safe manner and in accordance with applicable requirements. These inspections cover all aspects of Section 7 of the license application and applicable regulations, including those of the NRC and the Utah Division of Radiation Control.

The applicant has also committed to routinely audit all radiological records, tests, and measurements. A contracted quality assurance auditor will report to the president of Envirocare about any unsatisfactory work and initiate, recommend, or provide solutions to address deficiencies. The radiation and safety audit will be performed at least quarterly. The site will also be inspected at least quarterly by an industrial hygiene consultant to ensure compliance of the site operation with the applicable standards of the Occupational Safety and Health Administration.

The NRC staff has reviewed the proposed quality control (QC) program element of the radiation safety program by comparing the applicant's program with NRC quality control guidance in Regulatory Guides 8.31 (NRC, 1988a), 4.14 (NRC, 1980b), 8.22 (NRC, 1988b), 8.25 (NRC, 1992a), and 8.37 (NRC, 1993). Based on this review, the staff determined that specific elements of the QC program that are applicable to the radiation protection program area appear reasonable and sufficient to ensure safety and protection of workers and offsite individuals.

7 DECOMMISSIONING AND POSTOPERATIONAL ENVIRONMENTAL MONITORING AND SURVEILLANCE

7.1 Decommissioning

7.1.1 Generic Description of the Decommissioning Process

The applicant described a decommissioning program for the proposed disposal facility; procedures for decontamination and release of vehicles, packages, and equipment from controlled areas; and radiological criteria for unlimited release of equipment and vehicles. The decommissioning activities will include a radiological survey for contamination at the site, on adjacent properties, and on the entire length of the railroad spur to determine the extent of any offsite migration of radioactive materials. The applicant will use appropriate survey instruments for decommissioning based on the type of radiological contamination identified in the contaminated areas.

As part of decontaminating equipment, the applicant committed to sample sediments in all potentially contaminated tanks. The samples will be analyzed for ^{226}Ra, ^{228}Ra, ^{238}U, ^{232}Th, ^{230}Th, and ^{228}Th. If the sediments contain concentrations exceeding 5 pCi/g for total radium or thorium (^{232}Th plus ^{230}Th and ^{228}Th), the tanks will be classified as contaminated and will be either decontaminated to the required guideline limits or placed in the disposal embankment.

The applicant proposed reduction of all radiological contamination to meet applicable radiological criteria for decommissioning for the entire facility at the completion of disposal activities at the site (Section 6.8 and Appendix HH of the license application). The applicant's proposed criteria are described in Section 7.1.3 of this FSER. After removal of any contaminated soil, the applicant committed to conduct an additional radiological survey to ensure that the soil has been cleaned up to the required radiological criteria for decommissioning. In the event certain structures remain on site, the applicant stated that a working level meter will be employed to assess the long-term average concentrations of radon decay products on a weekly basis for 1 year.

7.1.2 Decommissioning Plan

Before closure, the applicant will present a detailed decommissioning plan for NRC approval. The applicant committed that the plan will address the following decommissioning activities:

(1) Removal of contaminated soil off site and along the railroad spur in accordance with radiological criteria; the applicant will attempt to reduce residual radioactivity to ALARA levels.

(2) Removal of contaminated soil within the Envirocare property to ALARA levels and in accordance with applicable radiological criteria for decommissioning, excluding the disposal embankment.

(3) Removal of contamination from onsite structures such as the rollover facility, geotechnical laboratory, and rail spur to meet the unrestricted release criteria. Envirocare also committed to remove onsite support structures and their contents. The applicant proposed to dispose of all such structures in the disposal embankment before final closure.

(4) Performance of corrective action, if necessary, to reduce or control ground-water contamination at the site per license condition and in accordance with NRC requirements in Criterion 5 of 10 CFR Part 40, Appendix A.

7.1.3 Decommissioning Criteria

The applicant committed to reduce or remove residual radioactivity on surfaces and in soils, structures, and ground water so that surface or volume concentrations of radioactive materials are less than or equal to the following radiological criteria:

(1) The top 15-cm (5.9-in) soil layer (averaged over 100 m^2 (1076 ft^2)) will not exceed 5 pCi ^{226}Ra and ^{228}Ra per gram of soil above background concentrations. Soil in any 30-cm (11.8-in) layer below the uppermost 15-cm layer will not exceed 15 pCi/g above background for these two radionuclides. The specific concentrations of total thorium (^{230}Th, ^{232}Th, and ^{228}Th) in soil will also be limited to these levels (i.e., total thorium < 5 pCi/g above background in uppermost 15 cm of soil; total thorium < 15 pCi/g above background in any 30-cm layer below the uppermost 15 cm).

(2) Indoor gamma ray exposure rates will be limited to 20 μR/hr, and the limit for ^{222}Rn progeny will be 0.03 working level (WL) with a goal of 0.02 WL *(including* background).

(3) Radiological criteria for ground water, if necessary, will be established in accordance with Criterion 5 of Appendix A to 10 CFR Part 40.

(4) All solid radioactive waste generated from the decommissioning process will be disposed of in the

proposed disposal embankment for 11e.(2) waste using the same criteria as those used for the commercial disposal of the 11e.(2) waste.

(5) All levels of residual radioactivity will be ALARA and, in all cases, will not exceed applicable radiological criteria for decommissioning.

(6) Surface contamination on equipment and structures will be reduced in accordance with the levels prescribed in Table 17.6 (page 17-69) of the license application. The values in the table are consistent with values identified in Regulatory Guide 1.86 (NRC, 1974).

(7) For any radionuclide soil contamination, the applicant committed to ensure that potential future onsite residents would not receive a dose from all pathways in excess of 10 mrem/yr above average background radiation rate plus two standard deviations.

7.1.4 Decommissioning Methods and Equipment

The methods of decontamination will be determined and described in the applicant's decommissioning plan. In the license application, Envirocare generally described the types of methods available for removing contamination from structures, including washing with water, drying, steam cleaning, and sandblasting. The applicant's proposed method for removing and reducing soil contamination was excavation of the soil and disposal in the proposed 11e.(2) waste disposal embankment. Similarly, any contaminated railroad ballast and rubble will also be removed and disposed of in the proposed embankment for 11e.(2) waste.

The applicant also provided a generic description of equipment to be used in decommissioning activities, including construction equipment (bulldozers and scrapers) for initial stabilization of the site. The applicant will employ a track hoe equipped with a straight-edged bucket in the removal and disposal process. In the final decommissioning stage, the applicant expects to use backhoes with straight-edged buckets and hand equipment, such as shovels and brooms. The applicant also included the use of high-pressure water washing systems and portable steam generators to decontaminate construction equipment, train rails, and the train-car rollover/dumper area.

7.1.5 Conclusions

The NRC staff reviewed the applicant's proposed approach for decommissioning. The staff compared the approach with NRC requirements, guidance, and procedures for decommissioning materials facilities, such as those described in the "Action Plan To Ensure Timely Cleanup of Site Decommissioning Management Plan Sites," 57 *FR* 13389, April 16, 1992 (NRC, 1992b). Although the procedures described in the action plan are not strictly applicable to 11e.(2) waste disposal sites, the plan describes procedures and practices related to decommissioning that have been recently approved by the Commission for a group of materials facilities. The plan also identifies existing interim criteria to guide decommissioning actions.

In general, the applicant's description of plans for decommissioning at this stage is sufficient. The plan indicated that the applicant will comply with relevant NRC requirements under 10 CFR 40.42 and with Criterion 9 in Appendix A to 10 CFR Part 40. With a few minor exceptions, the applicant's proposed criteria and procedures for decommissioning comport with NRC requirements, guidance, and practices. The staff noted several exceptions, however, to existing NRC criteria for decommissioning, such as the proposed 20 μR/hr indoor exposure rate criterion (compared with a 5 μR/hr criterion for exposure rate above background indoors) and the proposed 10 mrem/yr above background levels plus two standard deviations. These issues will be addressed in the review of the applicant's decommissioning plan. The applicant has generally described commonly practiced approaches for stabilization and decommissioning of the facility and provided plans for reclaiming and restoring lands disturbed by the disposal activities. Technical and financial feasibility assessments of methods and costs of site decommissioning and reclamation were provided in Sections 9 and 10 of the license application.

However, the applicant's decommissioning plan will need to be far more detailed than the general descriptions provided in the license application. The decommissioning plan, when submitted, should include the most recent radiological criteria for decommissioning at the time it is submitted. The plan should be consistent with applicable guidance in Regulatory Guide 3.65 (NRC, 1992c). The NRC anticipates that the decommissioning plan, after it is submitted to the NRC and reviewed and approved, will be specifically included as a license condition to be implemented and completed prior to license termination.

7.2 Postoperational Environmental Monitoring and Surveillance

The applicant described a preliminary postoperational environmental monitoring program in Section 12.5 of the license application. Upon cessation of all operational activities (i.e., receipt and emplacement of 11e.(2) waste in the disposal embankment), Envirocare committed to decommission the site and conduct the postoperational environmental monitoring and surveillance program. The program will include the following activities:

(1) Airborne Particulate Monitoring

Air sampling for airborne particulates will be conducted immediately after cessation of operations at stations A-1, A-5, and A-11 through A-13 (Figure 12 in the license application). The postoperational sampling will be performed continuously for one quarter of a year. Air filters will be analyzed for gross alpha particle activity, total uranium, ^{226}Ra, ^{230}Th, ^{232}Th, ^{210}Pb, and ^{210}Po. Envirocare described radiological action levels and corrective action measures that would be triggered above the preoperational average concentration level plus three standard deviations. If monitored activity exceeds that action level, air sampling will continue for an additional calendar-year quarter, while additional gamma surveys are made to determine the source of the contamination. Assuming a source of contamination is found, it will be removed and placed in the proposed 11e.(2) waste disposal embankment. Sampling for radioactive airborne particulates would continue for another quarter after final closure. If no source is found and the second quarter monitoring results are consistent with the preoperational monitoring data, air sampling will be discontinued.

The NRC staff concludes that the applicant's postoperational airborne particulate monitoring program is adequate and in compliance with the requirements of Regulatory Guide 4.18 (NRC, 1883b). After cessation of activities involving waste receipt and emplacement in the disposal embankment, release of radioactive particulates to the air should be greatly diminished. Consequently, a reduction in the frequency of particulate sampling is appropriate. Sampling may need to continue throughout decommissioning, however, depending on the extent and nature of decommissioning activities. For example, if extensive areas of surface soil have been contaminated and will be remediated during decommissioning, the removal of the contaminated soil may create new sources for airborne releases of radioactive particulates. The need for continuation of particulates sampling should be assessed by the applicant in the decommissioning plan.

(2) Radon in Outdoor Air and Gamma Radiation Exposure

The applicant has committed to monitor radon and thoron (including decay products) concentrations in air and gamma exposure rates using passive environmental radon monitors and environmental TLDs at stations A-3, A-5, and A-11 through A13 and at the two offsite stations (Figure 12 of the license application). This postoperational monitoring program will continue for 1 year after cessation of waste receipt and emplacement operations. As with airborne particulate sampling after termination of waste emplacement operations, Envirocare did not indicate action levels for radon and gamma exposure rates that warrant corrective action. The applicant will use the emission rate of 20 pCi/m^2s from the surface of the closed embankment as the action level for radon emissions. The applicant will also measure radon flux through the radon barrier on the surface of the disposal embankment to confirm that the emissions are below 20 pCi/m^2s. If the emissions exceed the above radon flux level, when averaged over the area of the embankment, additional radon barrier will be placed to reduce the emissions and the area will be retested.

(3) Soil/Vegetation/Wildlife

The applicant committed to perform extensive area surveys using NaI scintillation and pressurized ion chamber survey meters for monitoring the soil contamination after cessation of waste disposal operations. If any of the gamma exposure rate monitors (TLDs) at the monitoring stations measure a quarterly dose more than 5 mrem above preoperational levels, the area will be surveyed to locate the source of radiation and will be remediated. Contaminated material will then be placed into the proposed 11e.(2) waste disposal cell.

The final set of vegetation samples will be collected during the first growing season following decommissioning. Samples will be collected at site boundaries and analyzed by gamma spectrometry after being washed. Gamma spectrometry results greater than the mean plus two standard deviation of background would indicate possible soil contamination and would require further monitoring and, potentially, corrective actions.

Wildlife samples (field mice or rabbits) will be collected from areas along the four sides of the site boundary during the first season following decommissioning. The applicant committed to analyze the samples using gamma spectrometry and radiochemical methods for possible contamination by radionuclides from the site. Additional wildlife sampling will be made from two offsite locations at least 0.62 km (1 mi) from the site and analyzed as above to serve as background samples. Any site boundary sample that contains radionuclides at concentrations greater than the mean plus two standard deviations will be of concern and will warrant further investigation.

(4) Postoperational Monitoring of Ground Water

The regulatory requirements in Appendix A to 10 CFR Part 40 include no special provisions for postoperational surveillance and monitoring of ground water. However, as stated in Sections 3.4.3.4 (Ground-Water Monitoring Requirements) and 7.1.2 (Decommissioning Plan) of this FSER, compliance monitoring will be continued and corrective action and corrective action monitoring will also be undertaken if necessary to bring the concentrations of hazardous constituents to established standards, before the disposal facility can be closed and turned over to the Federal or State Government for long-term custody. The license will not be terminated nor will the transfer of the facility to government custody be authorized unless and until the ground-water quality standards have been met.

The applicant has proposed to conduct compliance ground-water monitoring in the postclosure period according to the following schedule (Section 12, Envirocare, 1992a): quarterly during the first year after facility closure; semiannually for the following 5 years; and annually thereafter, until transfer of the disposal facility to government custody has been authorized by NRC.

In view of the above, the staff concludes that the provisions of the license are adequate to satisfy the ground-water monitoring requirements in the post-operational period before transfer of the disposal facility to the government for long-term custody.

The NRC staff has reviewed the applicant's proposed program for post-decommissioning monitoring and surveillance. The staff reviewed the program against the NRC requirements in 10 CFR 40.28(b) and Regulatory Guide 4.18 (NRC, 1983b). The staff concluded that the applicant's description is generally adequate for the present and addresses the necessary elements of NRC's requirements in 10 CFR 40.28. The NRC staff anticipates that the applicant would continue to revise and refine proposed procedures for postclosure surveillance based on actual operating experience and site conditions. Consequently, the applicant should describe the postclosure monitoring and surveillance program in the decommissioning plan. The applicant should consult additional guidance prepared by DOE (1992), which has been reviewed and approved by NRC, on the content and general format of long-term surveillance plans.

8 QUALITY ASSURANCE

The quality assurance program (QAP), described in Chapter 14 of the Envirocare license application, was evaluated by the NRC staff on the basis of information provided in NUREG-1293, "Quality Assurance Guidance for a Low-Level Waste Disposal Facility" (NRC, 1991b); NUREG 1200, "Standard Review Plans for the Review of a Low-Level Radioactive Waste Disposal Facility" (NRC, 1991a); and 10 CFR 61.12(j), as applicable. Although these documents were written for quality assurance at a low-level facility and are not directly applicable to this facility, some of the information provided in these documents is an essential element of any QAP and provides an acceptable basis for the staff evaluation. The primary focus of Chapter 14 of the license application is the quality assurance requirements for construction and operation of the facility.

The applicant has demonstrated that they retain responsibility for establishing and executing the QAP and have provided sufficient freedom and organizational authority to identify problems and initiate necessary actions to correct problems that may occur. The corporate radiation safety officer (CRSO) is responsible for the QAP and has direct access to the president of operations.

The applicant will implement the QAP prior to the start of construction. The QAP provides adequate controls to address design changes, monitoring, surveillance, and audits of construction activities to ensure the quality of work performed. In addition, the applicant has identified in the QAP national standard tests to be performed on the materials, calibration intervals for test equipment, calibration of equipment against equipment that is traceable to the National Institute of Standards and Technology, procedures for documenting the tests, and records that are to be maintained.

The applicant has provided for the documentation of quality-achieving and quality-assuring activities so that others may review the documentation to gain confidence in the quality of the product. In addition, the applicant has provided for the collection and retention of records during construction and transfer of those records to the manager of operations at the completion of construction. If the applicant properly implements the QAP, the records will be properly maintained and readily retrievable.

In conclusion, the applicant has provided a written plan that provides sufficient control to ensure the quality of work products. If effectively implemented, the applicant's quality assurance plan will result in acceptable quality products and appropriate records of work accomplished. The NRC staff will make the applicant's commitment to implement this quality assurance plan a **license condition**.

9 FINANCIAL ASSURANCE

Criterion 9 of Appendix A to 10 CFR Part 40 requires that Envirocare demonstrate that financial surety arrangements are established in an amount that is sufficient to carry out an NRC-approved plan for decontamination and decommissioning, as well as long-term surveillance of the disposal site prior to commencing operations, and that all of the financial surety arrangements meet the financial conditions outlined in this criterion. The NRC staff will make the applicant's commitment to maintain a financial surety a **license condition**. This license condition will include provisions for yearly review of the financial surety.

Criterion 10 requires that a minimum charge of $250,000 (1978 dollars) to cover the cost of long-term surveillance be paid prior to termination of the license. Envirocare has proposed to deposit assets into a trust fund amounting to $1,798,785, of which $500,000 (1991 dollars) would be for long-term surveillance and control as required by Criterion 10. The proposed trust agreement is between Envirocare of Utah, Inc., and the Keybank of Utah and is for the benefit of NRC. The specific nature of the assets has yet to be presented. The proposed trust agreement utilized the recommended wording for a trust fund agreement presented in Appendix D of "Technical Position [TP] on Financial Assurance for Reclamation, Decommissioning and Long-Term Surveillance and Control of Uranium Recovery Facilities" (NRC, 1988). Envirocare also utilized the TP, where applicable, in determining its detailed cost estimates.

The Envirocare cost estimate of $1,798,785 was compared to the unit cost estimates for reclamation and closure for Quivira's Ambrosia Lake Mill Disposal Area in New Mexico, the Mexican Hat site in Utah, and the Falls City site in Texas, and to unit cost estimates in "Means Site Work and Landscape Cost Data" (R.S. Means Company, Inc., 1992). The unit cost estimate comparison included unloading waste, placing cover material, placing a rock embankment, excavating ditches, placing ditches, and installing fences. Adjustments were made for regional differences. The staff found the Envirocare costs to be reasonable. The total cost per cubic yard for waste emplacement of $30.00 was found to be reasonable for the proposed "cut and cover" type of disposal. The cost estimate of $1,798,785 represents a reasonable estimate to close and maintain the site.

The cost estimate proposed by the applicant, however, does not include funds to permit postclosure ground-water restoration. The applicant must show that sufficient funds have been included in the financial surety arrangements to carry out any potential decontamination and decommissioning activities associated with ground-water compliance and corrective action at the proposed by-product disposal cell. These funds should cover the costs of performing ground-water decommissioning and corrective action activities as if they were performed by an independent contractor. The decommissioning costs should include all costs associated with monitoring well and piezometer abandonment and/or replacement that will be needed during the term of the license. Corrective action costs should include all costs associated with restoring ground-water quality to the regulatory standards in the event of noncompliance during the term of the license, as described in Criterion 5D. The staff considers this an ***open issue***.

Envirocare has utilized the recommended wording in the TP and has provided a proposed trust agreement that includes an acceptable Exhibit A. Exhibit A corresponds to Section 14 of the trust agreement that will assist the trustee in determining who may give orders, requests, or instructions to the trustee concerning the trust.

In addition, the proposed trust agreement will have to be signed, funded, and executed prior to the start of waste disposal. The NRC staff considers the following information requirement a **license condition**. The applicant should submit the trust agreement at least 120 days prior to accepting waste. The trust should be fully funded and executed. In accordance with the TP, when the applicant submits the executed and fully funded trust fund agreement, it should meet the following:

(1) The trust fund agreement should be worded as recommended in Appendix D of the TP.

(2) The trust agreement should be signed by Envirocare and the trustee and be properly notarized.

(3) Two Envirocare corporate officers, preferably the president and vice-president, should sign the agreement and should indicate their legal capacity.

(4) The trust fund will have to be funded. The trust must contain sufficient assets to accomplish decommissioning, reclamation, and long-term surveillance and control of the applicant's facility.

(5) Schedule A of the trust agreement should include the NRC license number and the cost estimate applicable to the agreement. Specification of this information is necessary to inform the trustee of essential terms of the agreement.

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APPENDIX
Preparers of FSER

The following individuals were responsible for the independent evaluation of the information provided by the applicant in the license application and were primarily responsible for preparing the FSER:

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Rateb (Boby) Eid is an environmental scientist for the Decommissioning and Regulatory Issues Branch of the Division of Low-Level Waste Management and Decommissioning. Dr. Eid's original education and experience are in the areas of geochemistry and radiological and environmental impacts studies. Dr. Eid was professor of geochemistry at Pahlavi University in Iran during 1975 and then worked for the University of Bonn (senior research associate) for 2 years. He then worked for 13 years for Kuwait Institute for Scientific Research (KISR) in the areas of waste treatment and remediation, materials characterization, radiological analysis, and radiation safety and health physics. He was the radiation safety officer for KISR and was on the Board of the High National Committee for Radiation Protection in Kuwait. Dr. Eid has been working with NRC for 2 years in the areas of dose assessment, site characterization, health physics and radiological impacts, residual contamination, and remediation technologies. He has been involved in the review of the Envirocare license application with respect to aspects of radiation safety and health physics, radiological monitoring, and decommissioning. Lately, he became involved in the radiological impacts assessments and review of the Envirocare Draft Environmental Impact Statement.

Education:

- B.Sc. degree (with honors) in chemistry and geology from Alexandria University in 1968
- Ph.D. degree in geochemistry (with nuclear chemistry) from Massachusetts Institute of Technology (MIT) in 1975

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Education:

- B.S. in biology from the University of Western Michigan in 1964
- M.S. in zoology from the University of Arizona in 1966
- Ph.D. in medical science from the College of Medicine, University of Florida, in 1971

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Education:

- B.Sc. in business administration from Ohio State University in 1954
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Myron Fliegel is the section leader of the Special Issues Section in the Uranium Recovery Branch of the Division of Low-Level Waste Management and Decommissioning where he is responsible for managing the oversight of NRC's uranium recovery licensing activities. He joined the U.S. Atomic Energy Commission in 1974 as a physical oceanographer, evaluating flood threats to, and environmental impacts of, coastal nuclear power plants. He has managed various aspects of NRC's waste management and uranium recovery programs since 1984. Since 1987, his primary responsibilities pertain to the uranium recovery program.

Education:

- B.S. degree in physics from City College of New York in 1965
- Ph.D. degree in physical oceanography and limnology from Columbia University in 1972

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U.S. Nuclear Regulatory Commission
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Pete Garcia is a senior project manager in NRC's Uranium Recovery Field Office (in Region IV), where he is responsible for licensing and operational data reviews to ensure that uranium recovery operations are being conducted in accordance with applicable requirements. Mr. Garcia has prepared numerous safety evaluation reports and environmental assessments during his 16 years with the NRC. He has also had extensive experience in the inspection of a variety of activities licensed by the NRC.

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- B.S. degree in civil engineering from Massachusetts Institute of Technology (MIT) in 1976.

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Education:

- B.S. in geology from Damascus University in 1964
- M.S. in geology (hydrogeology) from University of Illinois at Urbana/Champaign
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Terry Johnson is a senior surface water hydrologist/hydraulic engineer for the uranium recovery program in the Uranium Recovery Branch of the Division of Low-Level Waste Management and Decommissioning. He is responsible for reviewing and assessing surface water hydrology and erosion protection aspects of waste disposal facilities. He has more than 23 years of experience in hydraulic design and has participated in numerous safety and environmental reviews for nuclear power plants, low-level waste sites, and uranium mill tailings sites.

Education:

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Clayton Pittiglio is a project manager/civil engineer/quality assurance specialist in the Decommissioning and Regulatory Issues Branch of the Division of Low-Level Waste Management and Decommissioning. Mr. Pittiglio has developed quidance documents on the application of quality assurance to low-level radioactive waste disposal. He provides technical support and written material for policy positions, standards, regulatory guides, regulations, and Commission papers. Mr. Pittiglio has 24 years of experience in civil engineering and quality assurance matters.

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Education:

- B.C.E. degree in civil engineering from Georgia Institute of Technology in 1973
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Sandra Wastler is a project manager for the Envirocare licensing action. She is responsible for the management and coordination of the safety and environmental review of Envirocare of Utah, Inc.'s application for a license to receive, store, and dispose of 11e.(2) byproduct material. In addition, she participates as a reviewer in her technical area of expertise. Her original experience with the safety and environmental aspects of licensing was in NRC reactor projects, and she has most recently been involved in the licensing of uranium in situ facilities, including the development of safety evaluation reports and environmental assessments.

Education:

- B.S. in geology from Wright State University in 1971
- M.S. in structural geology from Wright State University in 1973

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U.S. Nuclear Regulatory Commission
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Michael Weber is the section leader of the Regulatory Issues Section in the Decommissioning and Regulatory Issues Branch of the Division of Low-Level Waste Management and Decommissioning. He is responsible for managing the technical interfaces with the Environmental Protection Agency and the Department of Energy on issues related to environmental protection, decommissioning, and waste management. Mr. Weber is also responsible for NRC's efforts to resolve technical and policy issues related to radioactive waste management and decommissioning and for managing regulatory oversight of decommissioning projects at several nuclear facilities. He began working for NRC in 1982 as a performance assessment analyst and hydrogeologist in the high-level radioactive waste program. Since the mid-1980s, he has worked on waste management, safety assessment, ground-water protection, and environmental protection aspects at uranium recovery sites, low-level and high-level waste disposal sites, nuclear materials facilities, and decommissioning projects. From 1989 to 1991, he was a technical assistant to the Chairman of the NRC in the areas of radiation protection, nuclear materials safety, waste management, environmental protection, decommissioning, and nuclear materials transportation. He assumed his present supervisory position in 1991.

Education:

- B.S. degree in geosciences from Pennsylvania State University in 1982
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11. ABSTRACT (200 words or less)

The Final Safety Evaluation Report (FSER) summarizes the U.S. Nuclear Regulatory Commission (NRC) staff's review of Envirocare of Utah, Inc.'s (Envirocare's) application for a license to receive, store, and dispose of uranium and thorium byproduct material (as defined in Section 11e.(2) of the Atomic Energy Act of 1954, as amended) at a site near Clive, Utah. Envirocare proposes to dispose of high-volume, low-activity Section 11e.(2) byproduct material in separate earthen disposal cells on a site where the applicant currently disposes of naturally occurring radioactive material (NORM), lowl-level waste, and mixed waste under license by the Utah Department of Environmental Quality. The NRC staff review of the December 23, 1991, license application, as revised by page changes dated July 2 and August 10, 1992, April 5, 7, and 10, 1993, and May 3, 6, 7, 11, and 21, 1993, has identified open issues in geotechnical engineering, water resources protection, radon attenuation, financial assurance, and radiological safety. The NRC will not issue a license for the proposed action until Envirocare adequately resolves these open issues.

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