International Uranium (USA) Corporation

SOURCE MATERIALS LICENSE
SUA-1358, DOCKET No. 40-8681

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Additional Clarifications to White Mesa Mill Reclamation Plan

April 15, 1999

Drawings in Files

INTERNATIONAL
URANIUM (USA)
CORPORATION

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April 15, 1999

Via Fax and Overnight Federal Express Mail

Mr. N. King Stablein, Acting Branch Chief
High Level Waste and Uranium Recovery
Projects Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
2 White Flint North, Mail Stop T-7J9
11545 Rockville Pike
Rockville, MD 20852

Re: Source Materials License SUA-1358, Docket No. 40-8681
Additional Clarifications to White Mesa Mill Reclamation Plan

Dear Mr. Stablein:

Enclosed please find responses and clarification to several items related to the White Mesa Mill Reclamation Plan. These items were discussed with NRC staff during a meeting held March 24, 1999, at the White Mesa Mill site, as well as several informal follow-up conference calls. Responses to NRC questions related to the potential of the tailings sands to liquify under earthquake loading, and clarifications to the QA/QC plans for cleanup of windblown contamination will be submitted under separate cover. Included in this submittal are the following items:

1) Details of a soil sampling program to characterize the materials to be used for Random Fill and Frost Barrier. The results of this program should be available within 30 days.

2) Revisions to Attachment A of the Construction Specifications for the reclamation work. This revision details the changes and modification to the QA/QC testing program, as discussed with NRC staff, and modifies the nomenclature for the different reclamation layers.

3) Revised Figure A-5.1-1, Reclamation Cover Grading Plan, adding cross section locations for the breach of Cell 4A Dike.

4) Sections D and E to Figure A-5.1-1, details the cross sections to the breach of Cell 4A Dike.

5) Revised Rational Method Calculation of PMF Peak Discharge, Velocity, Depth, and Scour through Cell 4A Breach, with breach widened to 200 feet.

6) Revised details to the Rock Apron at Toe of Cell Outslope. This drawing has been previously submitted to the NRC in response to Question 19 of the August 28, 1998 Submittal to NRC.

7) Results of a rerun of the Radon Emanation Calculations to take into account revisions to inconsistent variables and more conservative approach to the assumptions used in cover design, as per NRC staff suggestions,

As mentioned earlier, additional responses will be submitted to NRC under separate cover.

Very truly yours,

For HRR

Harold R. Roberts
Executive Vice President

HRR:pl
Enclosures

cc: William N. Deal
David C. Frydenlund
Robert A. Hembree
Earl E. Hoellen
Michelle R. Rehmann
Central Files

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Soil Sampling and Testing Program – White Mesa Mill

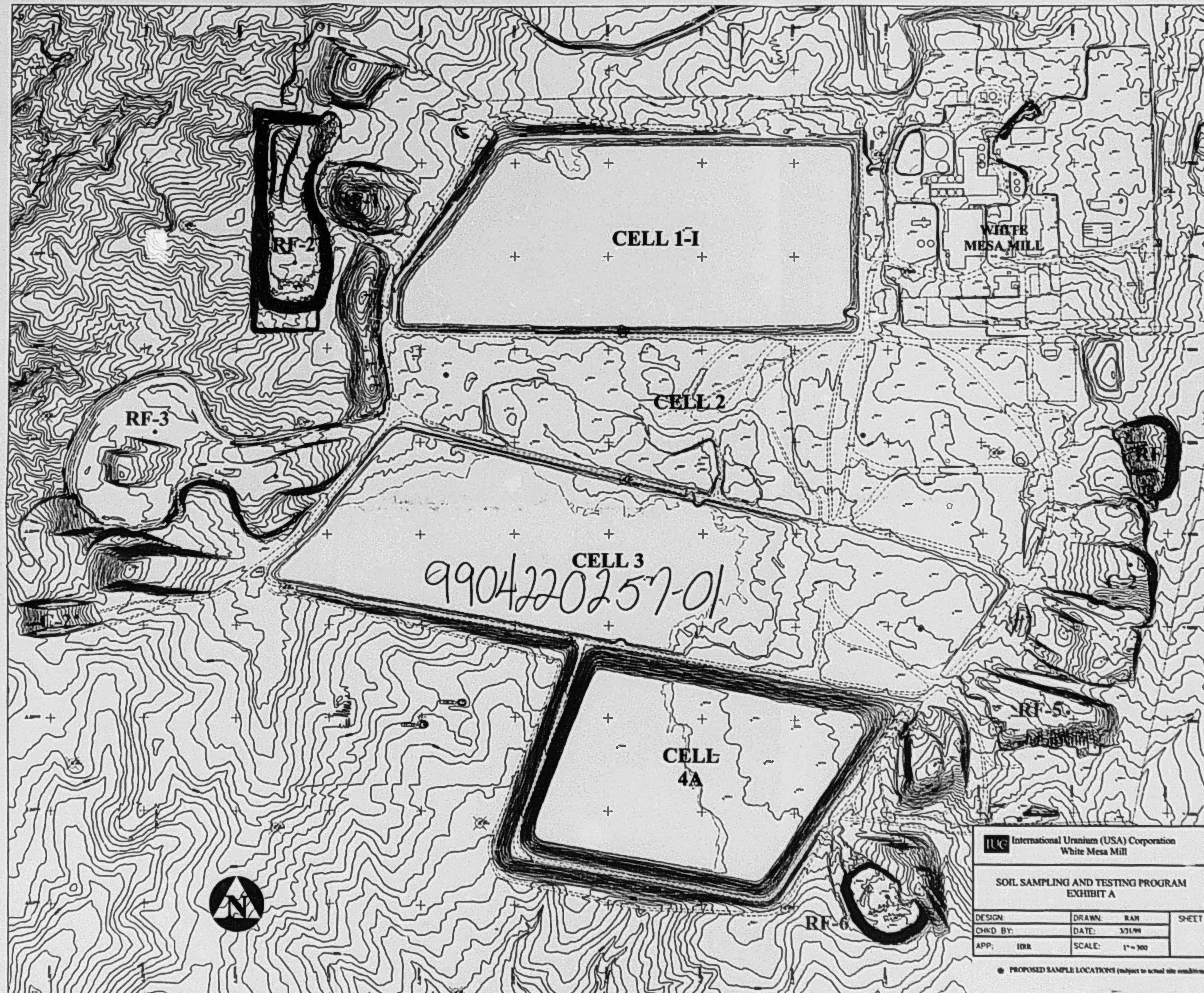
The purpose of this Soil Sampling and Testing Program is to verify the soil classification. gradation and compaction characteristics (standard proctor) of the stockpiled random fill and clay materials that will be used for cover materials on the tailings cells at the White Mesa Mill. Additionally this program will verify the compaction characteristics and gradation of the random fill materials utilized in the platform fill previously placed on Cells 2 and 3.

Sampling

Sampling will take place on each of six stockpiles of random fill (designated RF-1 through RF-6 on Exhibit A). two clay material stockpiles (C-1 and C-2 on Exhibit A). and on platform fill areas in Cells 2 & 3. A total of 9 samples will be taken from the random fill stockpiles. Two (2) samples will be taken from the clay stockpiles and three (3) samples will be taken from the covered areas of the cells. Samples will be taken from test pits excavated by a backhoe. Samples will be taken from a depth of 8 feet in stockpiles and from 2 foot depth in cells. One backhoe bucket full of material will be taken from the test pit at the specified depth and dumped separately. This sample will be quartered and one quarter will be screened to minus 2" (rocks over 8" will be removed prior to screening). Two five gallon sample buckets will be filled with sample randomly selected from the screened fraction. Oversized material remaining after the screening of the sample will be visually classified and then weighed. Sample locations will be indicated on a site map and sample descriptions will recorded and maintained in the facility's records. A total of fourteen samples will be submitted for testing during this program.

Testing

Samples will be packaged and shipped to a certified commercial testing laboratory for testing. Tests will be run on each sample for standard proctor (ASTM D698). particle size analysis (ASTM C117 and ASTM C136), soil classification (ASTM D2487) and plasticity index (Atterberg limits ASTM D4318).


RF-2
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IUC International Uranium (USA) Corporation
White Mesa Mill
SOIL SAMPLING AND TESTING PROGRAM
EXHIBIT A
DESIGN:
DRAWN: RAN
SHEET
CHKD BY:
DATE: 3/31/99
APP: HRR
SCALE: 1" = 300
PROPOSED SAMPLE LOCATIONS

ATTACHMENT A

PLANS AND SPECIFICATIONS

FOR

RECLAMATION

OF

WHITE MESA FACILITIES

BLANDING, UTAH

PREPARED BY

INTERNATIONAL URANIUM (USA) CORP.

INDEPENDENCE PLAZA

SUITE 950, 1050 17TH STREET

DENVER, CO 80265

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1.0 GENERAL

The specifications presented in this section cover the reclamation of the White Mesa Mill facilities.

2.0 CELL 1-I RECLAMATION

2.1 Scope

The reclamation of Cell 1-I consists of evaporating the cell to dryness, removing raffinate crystals, synthetic liner and any contaminated soils. A sedimentation basin will then be constructed and a drainage channel provided.

2.2 Removal of Contaminated Materials

2.2.1 Raffinate Crystals

Raffinate crystals will be removed from Cell 1-I and transported to the tailings cells. It is anticipated that the crystals will have a consistency similar to a granular material when brought to the cells, with large crystal masses being broken down for transport. Placement of the crystals will be performed as a granular fill, with care being taken to avoid nesting of large sized material. Voids around large material will be filled with finer material or the crystal mass broken down by the placing equipment. Actual placement procedures will be evaluated by the QC officer during construction as crystal materials are brought and placed in the cells.

2.2.2 Synthetic Liner

The PVC liner will be cut up, folded (when necessary), removed from Cell 1-I, and transported to the tailings cells. The liner material will be spread as flat as practical over the designated area. After placement, the liner will be covered as soon as possible with at least one foot of soil, crystals or other materials for protection against wind, as approved by the QC officer.

2.2.3 Contaminated Soils

The extent of contamination of the mill site will be determined by a scintillometer survey. If necessary, a correlation between scintillometer readings and U-nat/Radium-226 concentrations will be developed. Scintillometer readings can then be used to define cleanup areas and to monitor the cleanup. Soil sampling will be conducted to confirm that the cleanup results in a concentration of Radium-226 averaged over any area of 100 square meters that does not exceed the background level by more than:

- 5 pCi/g averaged over the first 15 cm of soils below the surface, and
- 15 pCi/g averaged over a 15 cm thick layer of soils more than 15 cm below the surface.

Where surveys indicate the above criteria have not been achieved, the soil will be removed to meet the criteria. Soil removed from Cell 1-I will be excavated and transported to the tailings cells. Placement and compaction will be in accordance with Section 4.0 of these Plans and Specifications.

2.2.4 Sedimentation Basin

Cell 1-I will then be breached and constructed as a sedimentation basin. All runoff from the mill area and immediately north of the cell will be routed into the sedimentation basin and will discharge onto the natural ground via the channel located at the southwest corner of the basin. The channel is designed to accommodate the PMF flood.

A sedimentation basin will be constructed in Cell 1-I as shown in Figure A2.2.4-1. Grading will be performed to promote drainage and proper functioning of the basin. The drainage channel out of the sedimentation basin will be constructed to the lines and grades as shown.

INSERT FIGURE A-2.2.4-1

SEDIMENTATION BASIN DETAILS

3.0 MILL DECOMMISSIONING

The following subsections detail decommissioning plans for the mill buildings and equipment; the mill site; and windblown contamination.

3.1 Mill

The uranium and vanadium processing areas of the mill, including all equipment, structures and support facilities, will be decommissioned and disposed of in tailings or buried on site as appropriate. All equipment, including tankage and piping, agitation equipment, process control instrumentation and switchgear, and contaminated structures will be cut up, removed and buried in tailings prior to final cover placement. Concrete structures and foundations will be demolished and removed or covered with soil as appropriate. These decommissioned areas would include, but not be limited to the following:

- Coarse ore bin and associated equipment, conveyors and structures.
- Grind circuit including semi-autogeneous grind (SAG) mill, screens, pumps and cyclones.
- The three preleach tanks to the east of the mill building, including all tankage, agitation equipment, pumps and piping.
- The seven leach tanks inside the main mill building, including all agitation equipment, pumps and piping.
- The counter-current decantation (CCD) circuit including all thickeners and equipment, pumps and piping.
- Uranium precipitation circuit, including all thickeners, pumps and piping.

- The two yellow cake dryers and all mechanical and electrical support equipment, including uranium packaging equipment.
- The clarifiers to the west of the mill building including the preleach thickener (PLT) and claricone.
- The boiler and all ancillary equipment and buildings.
- The entire vanadium precipitation, drying and fusion circuit.
- All external tankage not included in the previous list including reagent tanks for the storage of acid, ammonia, kerosene, water, dry chemicals, etc. and the vanadium oxidation circuit.
- The uranium and vanadium solvent extraction (SX) circuit including all SX and reagent tankage, mixers and settlers, pumps and piping.
- The SX building.
- The mill building.
- The office building.
- The shop and warehouse building.
- The sample plant building.

The sequence of demolition would proceed so as to allow the maximum use of support areas of the facility such as the office and shop areas. It is anticipated that all major structures and large equipment will be demolished with the use of hydraulic shears. These will speed the process, provide proper sizing of the materials to be placed in tailings, and reduce exposure to radiation and other safety hazards during the demolition. Any uncontaminated or decontaminated equipment to be considered for salvage will be released in accordance with the terms of License Condition 14. As with the equipment for disposal, any contaminated soils from the mill area will be disposed of in the tailings facilities in accordance with Section 4.0 of the Specifications.

3.2 Mill Site

Contaminated areas on the mill site will be primarily superficial and include the ore storage area and surface contamination of some roads. All ore will have been previously removed from the ore stockpile area. All contaminated materials will be excavated and be disposed in one of the tailings cells in accordance with Section 4.0 of these Plans and Specifications. The depth of excavation will vary depending on the extent of contamination and will be based on the criteria in Section 2.2.3 of these Plans and Specifications.

All ancillary contaminated materials including pipelines will be removed and will be disposed of by disposal in the tailing cells in accordance with Section 4.0 of these Plans and Specifications.

Disturbed areas will be covered, graded and vegetated as required. The proposed grading plan for the mill site and ancillary areas is shown on Figure 3.2-1.

3.3 Windblown Contamination

Windblown contamination is defined as mill derived contaminants dispersed by the wind to surrounding areas. The potential areas affected by windblown contamination will be surveyed using scintillometers taking into account historical operational data from the Semi-annual Effluent Reports (Appendix A) and other guidance such as prevailing wind direction and historical background data.

INSERT FIGURE A3.2-1

MILL SITE AND ORE PAD FINAL GRADING PLAN

3.3.1 Guidance

The necessity for remedial actions will be based upon an evaluation prepared by IUC, and approved by the NRC, of the potential health hazard presented by any windblown materials identified. The assessment will be based upon analysis of all pertinent radiometric and past land use information and will consider the feasibility, cost-effectiveness, and environmental impact of the proposed remedial activities and final land use. All methods utilized will be consistent with the guidance contained in NUREG-5849: "Manual for Conducting Radiological Surveys in Support of License Termination."

3.3.2 General Methodology

The facility currently monitors soils for the presence of Ra-226, such results being presented in the second semi-annual effluent report for each year. Guideline values for these two materials will be determined and will form the basis for the cleanup of the White Mesa Mill site and surrounding areas. For purposes of determining possible windblown contamination, areas used for processing of uranium ores as well as the tailings and evaporative facilities will be excluded from the initial scoping survey, due to their proximity to the uranium recovery operations. Those areas include:

- The mill building, including CCD, PLT area, uranium drying and packaging, clarifying, and preleach.
- The SX building, including reagent storage immediately to the east of the SX building.
- The ore pad and ore feed areas.
- Tailings Cells No. 2, 3, and 4A.
- Evaporative cell No. 1-I.

The remaining areas of the mill will be divided up into two areas for purposes of windblown determinations:

- The restricted area, less the above areas; and,
- A halo around the restricted area.

The restricted area, as shown on Figure A3.2-1 will be initially surveyed on a 30 x 30 meter grid as described below in Section 3.3.3. The halo around the restricted area will also be initially surveyed on a 50 x 50 meter grid using methodologies described below in Section 3.3.3. Any areas which are found to have elevated activity levels will be further evaluated as described in Sections 3.3.4 and 3.3.5.

3.3.3 Scoping Survey

The scoping survey will be conducted using a calibrated Mount Sopris Model SC-132 scintillometer (or equivalent) capable of detecting radiation at levels less than or equal to 25 percent of the guideline value. The meter will be swung from side to side at an elevation of six (6) inches above the ground level while walking a path within the grid shown in Figure A-3.3-1. These paths will be designed so that a minimum of 10 percent of the area within the grid sidelines will be scanned, using an average coverage area for the scintillometer of one (1) meter wide. Grids where hotspots are encountered or where readings of 75 percent of the guideline level are found will be reclassified as affected areas, and will be subject to further characterization as described below. Grids where no readings exceed 75 percent of the guideline value will be classified as unaffected, and therefore will not require remediation. It is assumed that by following methodologies that would be utilized during the final survey, that the classification of these areas would stand and would require no further survey confirmation.

A sufficient quantity of QA samples will be taken to provide a correlation between the meter readings and the actual Ra-226 concentrations in the soil.

3.3.4 Characterization and Remediation Control Surveys

After the entire subarea has been classified as affected or unaffected, the affected areas will be further scanned to identify areas of elevated activity requiring cleanup. Such areas will be flagged and sufficient soils removed to, at a minimum, meet activity criteria. Following such remediation, the area will be scanned again to ensure compliance with activity criteria. A calibrated Mount Sopris SC-132 scintillometer (or equivalent) capable of detecting activity levels of less than or equal to 25 percent of the guideline values will be used to scan all the areas of interest.

3.3.5 Final Survey

After remediation, the affected areas deemed to be in compliance with standards will then undergo a final survey, utilizing a 10 x 10 meter grid system with sample point locations as shown in Figure A-3.3-2. Again a calibrated Mount Sopris SC-132 scintillometer (or equivalent) capable of detecting activity levels of less than or equal to 25 percent of the guideline values will be used, and will be held at a one meter distance above the systematic sample locations. As with the scoping survey, a statistically significant quantity of QA samples will be taken at randomly selected points to provide a correlation between the meter readings and the actual Ra-226 concentrations in the soil.

Figure A3.3-1

Figure A3.3-2

4.0 PLACEMENT METHODS

4.1 Scrap and Debris

The scrap and debris will have a maximum dimension of 20 feet and a maximum volume of 30 cubic feet. Scrap exceeding these limits will be reduced to within the acceptable limits by breaking, cutting or other approved methods. Empty drums, tanks or other objects having a hollow volume greater than five cubic feet will be reduced in volume by at least 70 percent. If volume reduction is not feasible, openings will be made in the object to allow soils, tailings and/or other approved materials to enter the object at the time of covering on the tailings cells. The scrap, after having been reduced in dimension and volume, if required, will be placed on the tailings cells as directed by the QC officer.

Any scrap placed will be spread across the top of the tailings cells to avoid nesting and to reduce the volume of voids present in the disposed mass. Stockpiled soils, contaminated soils, tailings and/or other approved materials will be placed over and into the scrap in sufficient amount to fill the voids between the large pieces and the volume within the hollow pieces to form a coherent mass. It is recognized that some voids will remain because of the scrap volume reduction specified, and because of practical limitations of these procedures. Reasonable effort will be made to fill the voids. The approval of the Site Manager or a designated representative will be required for the use of materials other than stockpiled soils, contaminated soils or tailings for the purpose of filling voids.

4.2 Contaminated Soils and Raffinate Crystals

The various materials will not be concentrated in thick deposits on top of the tailings, but will be spread over the working surface as much as possible to provide relatively uniform settlement and consolidation characteristics of the cleanup materials.

4.3 Compaction Requirements

The scrap, contaminated soils and other materials for the first lift will be placed over the existing tailings surface to a depth of up to four feet thick in a bridging lift to allow access for placing and compacting equipment. The first lift will be compacted by the tracking of heavy equipment, such as a Caterpillar D6 Dozer (or equivalent), at least four times prior to the placement of a subsequent lift. Subsequent layers will not exceed two feet and will be compacted to the same requirements. During construction, the compaction requirements for the crystals will be reevaluated based on field conditions and modified by the Site Manager or a designated representative, with the agreement of the NRC Project Manager.

The contaminated soils and other cleanup materials after the bridging lift will be compacted to at least 80 percent of standard Proctor maximum density (ASTM D-698).

5.0 CELLS 2,AND 3

5.1 Earth Cover

A multi-layered earthen cover will be placed over tailings Cells 2, and 3. The general grading plan is shown on Drawing 5.1-1. Reclamation cover cross-sections are shown on Drawings 5.1-2 and 5.1-3.

5.2 Materials

5.2.1 Physical Properties

The physical properties of materials for use as cover soils will meet the following:

Random Fill (Platform Fill and Frost Barrier)
These materials will be mixtures of clayey sands and silts with random amounts of gravel and rock size material. In the initial bridging lift of the platform fill, rock sizes of up to 2/3 of the thickness of the lift will be allowed. On all other random fill lifts, rock sizes will be limited to 2/3 of the lift thickness, with at least 30 percent of the material finer than 40 seive. For that portion passing the No. 40 sieve, these soils will classify as CL, SC, MC or SM materials under the Unified Soil Classification System. Oversized material will be controled through selective excavation at the stockpiles and through the utilization of a grader, bulldozer or backhoe to cull oversize from the fill.

Clay Layer Materials
Clays will have at least 40 percent passing the No. 200 sieve. The minimum liquid limit of these soils will be 25 and the plasticity index will be 15 or greater. These soils will classify as CL, SC or CH materials under the Unified Soil Classification System.

A5.1-1

5.2.2 Borrow Sources

The sources for soils for the cover materials are as follows:

1. Random Fill (Platform and Frost Barrier) - stockpiles from previous cell construction activities currently located to the east and west of the tailing facilities.

2. Clay - will be from suitable materials stockpiled on site during cell construction or will be imported from borrow areas located in Section 16, T38S, R22E, SLM.

3. Rock Armor - will be produced through screening of alluvial gravels located in deposits 1 mile north of Blanding,Uath, 7 miles north of the mill site.

5.3 Cover Construction

5.3.1 General

Placement of cover materials will be based on a schedule determined by analysis of settlement data, piezometer data and equipment mobility considerations. Settlement plates and piezometers will be installed and monitored in accordance with Section 5.4 of these Plans and Specifications.

5.3.2 Placement and Compaction

5.3.2.1 Methods

Platform Fill

An initial lift of 3 to 4 feet of random fill will be placed over the tailings surface to form a stable working platform for subsequent controlled fill placement. This initial lift will be placed by pushing random fill material or contaminated materials across the tailings in increments, slowly enough that

the underlying tailings are displaced as little as possible. Compaction of the initial lift will be limited to what the weight of the placement equipment provides. The maximum rock size, as far as practicable, in the initial lift is 2/3 of the lift thickness. Placement of fill will be monitored by a qualified individual with the authority to stop work and reject material being placed. The top surface (top 1.0 feet) of the platform fill will be compacted to 90% maximum dry density per ASTM D 698.

Frost Barrier Fill

Frost barrier fill will be placed above the clay cover in 12- inch lifts, with particle size limited to 2/3 of the lift thickness. Frost barrier material will come from the excavation of random fill stockpiles. If oversized material is observed during the excavation of fill material it will be removed as far as practicable before it is placed in the fill.

In all layers of the cover the distribution and gradation of the materials throughout each fill layer will be such that the fill will, as far as practicable, be free of lenses, pockets, streaks or layers of material differing substantially in texture, gradation or moisture content from the surrounding material. Nesting of oversized material will be controled through selective excavation of stockpiled material, observation of placement by a qualified individual with authority to stop work and reject material being placed and by culling oversized material from the fill utilizing a grader. Successive loads of material will be placed on the fill so as to produce the best practical distribution of material.

If the compacted surface of any layer of fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it will be moistened and/or reworked with a harrow, scarifier, or other suitable equipment to a sufficient depth to provide relatively uniform moisture content and a satisfactory bonding surface before the next succeeding layer of earthfill is placed. If the compacted surface of any layer of earthfill in-place is too wet, due to precipitation, for proper compaction of the earthfill material to be placed thereon, it will be reworked with harrow, scarifier or other suitable

equipment to reduce the moisture content to the required level shown in Table 5.3.2.1-1. It will then be recompacted to the earthfill requirements.

No material will be placed when either the materials, or the underlying material, is frozen or when ambient temperatures do not permit the placement or compaction of the materials to the specified density, without developing frost lenses in the fill.

5.3.2.2 Moisture and Density Control

As far as practicable, the materials will be brought to the proper moisture content before placement on tailings, or moisture will be added to the material by sprinkling on the earthfill. Each layer of the fill will be conditioned so that the moisture content is uniform throughout the layer prior to and during compaction. The moisture content of the compacted fill will be within the limits of standard optimum moisture content as shown in Table 5.3.2.1-1. Material that is too dry or too wet to permit bonding of layers during compaction will be rejected and will be reworked until the moisture content is within the specified limits. Reworking may include removal, re-harrowing, reconditioning, rerolling, or combinations of these procedures.

Density control of compacted soil will be such that the compacted material represented by samples having a dry density less than the values shown in Table 5.3.2.1-1 will be rejected. Such rejected material will be reworked as necessary and rerolled until a dry density equal to or greater than the percent of its standard Proctor maximum density shown in Table 5.3.2.1-1.

To determine that the moisture content and dry density requirements of the compacted fill are being met, field and laboratory tests will be made at specified intervals taken from the compacted fills as specified in Section 7.4, "Frequency of Quality Control Tests."

5.4 Monitoring Cover Settlement

5.4.1 Temporary Settlement Plates

5.4.1.1 General

Temporary settlement plates will be installed in the tailings Cells. At the time of cell closure, a monitoring program will be proposed to the NRC. Data collected will be analyzed and the reclamation techniques and schedule adjusted accordingly.

5.4.1.2 Installation

At the time of cell closure or during the placement of interim cover temporary settlement plates will be installed. These temporary settlement plates will consist of a corrosion resistant steel plate 1/4 inch thick and two foot square to which a one inch diameter corrosion resistant monitor pipe has been welded. The one inch monitor pipe will be surrounded by a three inch diameter guard pipe which will not be attached to the base plate.

The installation will consist of leveling an area on the existing surface of the tailings, and placing the base plate directly on the tailings. A minimum three feet of initial soil or tailings cover will be placed on the base plate for a minimum radial distance of five feet from the pipe.

5.4.1.3 Monitoring Settlement Plates

Monitoring of settlement plates will be in accordance with the program submitted to and approved by the NRC. Settlement observations will be made in accordance with Quality Control Procedure QC-16-WM, "Monitoring of Temporary Settlement Plates."

INSERT TABLE 5.3.2.1-1

6.0 ROCK PROTECTION

6.1 General

The side slopes of the reclaimed cover will be protected by rock surfacing. Drawings 5.1-1, 5.1-2, and 5.1-3 show the location of rock protection with the size, thickness and gradation requirements for the various side slopes.

A riprap layer was designed for erosion protection of the tailings soil cover. According to NRC guidance, the design must be adequate to protect the soil/tailings against exposure and erosion for 200 to 1,000 years (NRC, 1990). Currently, there is no standard industry practice for stabilizing tailings for 1,000 years. However, by treating the embankment slopes as wide channels, the hydraulic design principles and practices associated with channel design were used to design stable slopes that will not erode. Thus, a conservative design based on NRC guidelines was developed. Engineering details and calculations are summarized in the Tailings Cover Design report (Appendix D).

Riprap cover specifications for the top and side slopes were determined separately as the side slopes are much steeper than the slope of the top of the cover. The size and thickness of the riprap on the top of the cover was calculated using the Safety Factor Method (NUREG/CR-4651, 1987), while the Stephenson Method (NUREG/CR-4651, 1987) was used for the side slopes. These methodologies were chosen based on NRC recommendations (1990).

By the Safety Factor Method, riprap dimensions for the top slope were calculated in order to achieve a slope "safety factor" of 1.1. For the top of the soil cover, with a slope of 0.2 percent, the Safety Factor Method indicated a median diameter (D_{50}) riprap of 0.28 inches is required to stabilize the top slope. However, this dimension must be modified based on the long-term durability of the specific rock type to be used in construction. The suitability of rock to be used as a protective cover must

be assessed by laboratory tests to determine the physical characteristics of the rocks. The gravels sourced from pits located north of Blanding require an oversizing factor of 9.35%. Therefore, riprap created from this source should have a D_{50} size of at least 0.306 inches and should have an overall layer thickness of at least three inches on the top of the cover. From a practical construction standpoint the minimum rock layer thickness may be up to six (6) inches.

Riprap dimensions for the side slopes were calculated using Stephenson Method equations. The side slopes of the cover are designed at 5H:1V. At this slope, Stephenson's Method indicated the unmodified riprap D_{50} of 3.24 inches is required. Again assuming that the gravel from north of Blanding will be used, the modified D_{50} size of the riprap should be at least 3.54 inches with an overall layer thickness of at least 8 inches.

6.2 Materials

Materials utilized for riprap applications will meet the following specifications:

Location	D_{50} Size	D_{100} Size	Layer Thickness
Top Surface	0.3"	0.6"	6"
Slope Surface	3.5"	7"	8"
Toe Apron	6.4"	12"	24"

Riprap will be supplied to the project from gravel sources located north of the project site. Riprap will be a screened product.

Riprap quality will be evaluated by methods presented in NUREG/1623 Design of Erosion Protection for Long-Term Stabilization Size adjustment will be made in the riprap for materials not meeting the quality criteria.

6.3 Placement

Riprap material will be hauled to the reclaimed surfaces and placed on the surfaces using belly dump highway trucks and road graders. Riprap will be dumped by trucks in windrows and the grader will spread the riprap in a manner to minimize segregation of the material. Depth of placement will be controled through the establishment of grade stakes placed on a 200 x 200 foot grid on the top of the cells and by a 100 x 100 foot grid on the cell slopes. Physical checks of riprap depth will be accomplished through the use of hand dug test pits at the center of each grid in addition to monitoring the depth indicated on the grade stakes. Placement of the riprap will avoid accumulation of riprap sizes less than the minimum D_{50} size and nesting of the larger sized rock. The riprap layer will be compacted by at least two passes by a D-7 Dozer (or equivalent) in order to key the rock for stability.

7.0 QUALITY CONTROL/QUALITY ASSURANCE

7.1 Quality Plan

A Quality Plan has been developed for construction activities for the White Mesa Project. The Quality Plan includes the following:

1. QC/QA Definitions, Methodology and Activities.
2. Organizational Structure.
3. Surveys, Inspections, Sampling and Testing.
4. Changes and Corrective Actions.

5. Documentation Requirements.
6. Quality Control Procedures.

7.2 Implementation

The Quality Plan will be implemented upon initiation of reclamation work.

7.3 Quality Control Procedures

Quality control procedures have been developed for reclamation and are presented in Attachment B of this Reclamation Plan. Procedures will be used for all testing, sampling and inspection functions.

7.4 Frequency of Quality Control Tests

The frequency of the quality control tests for earthwork will be as follows:

1.

The frequency of the field density and moisture tests will be not less than one test per 1,000 cubic yards (CY) of compacted contaminated material placed and one test per 500 CY of compacted random fill, radon barrier or frost barrier. A minimum of two tests will be taken for each day that an applicable amount of fill is placed in excess of 150 CY. A minimum of one tesf per lift and at least one test for every full shift of compaction operations will be taken.

Field density/moisture tests will be performed utilizing a nuclear density gauge (ASTM D-2922 density and ASTM D-3017 moisture content). Correlation tests will be performed at a rate of one for every five nuclear gauge tests for compacted contaminated materials (one

per 2,500 CY placed) and one for every ten nuclear gauge tests for other compacted materials (one per 5,000 CY of material placed). Correlation tests will be sand cone tests (ASTM D-1556) for density determination and oven drying method (ASTM D-2216) for moisture determination.

2. Gradation and classification testing will be performed at a minimum of one test per 2,000 CY of upper platform fill and frost barrier placed. A minimum of one test will be performed for each 1,000 CY of radon barrier material placed. For all materials other than random fill and contaminated materials, at least one gradation test will be run for each day of significant material placement (in excess of 150 CY).

3. Atterberg limits will be determined on materials being placed as radon barrier. Radon barrier material will be tested at a rate of at least once each day of significant material placement (in excess of 150 CY). Samples should be randomly selected.

4. Prior to the start of field compaction operations, appropriate laboratory compaction curves will be obtained for the range of materials to be placed. During construction, one point Proctor tests will be performed at a frequency of one test per every five field density tests (one test per 2,500 CY placed). Laboratory compaction curves (based on complete Proctor tests) will be obtained at a frequency of approximately one for every 10 to 15 field density tests (one lab Proctor test per 5,000 CY to 7,500 CY placed), depending on the variability of materials being placed.

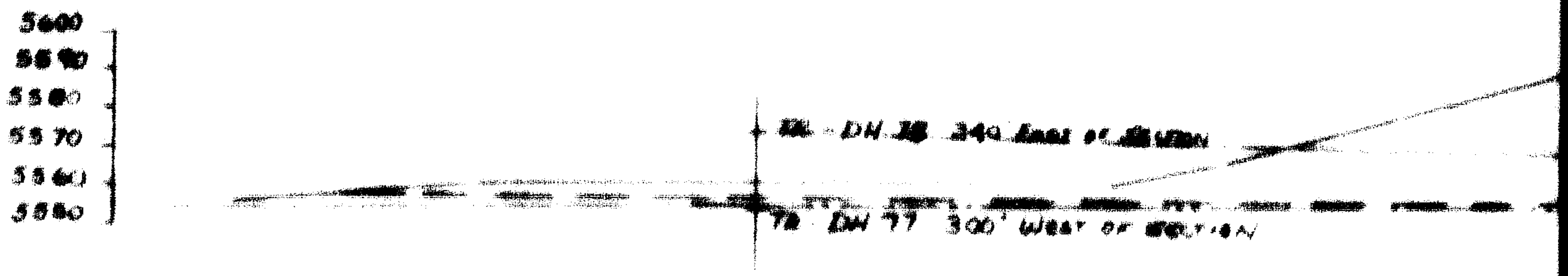
5. For riprap materials, each load of material will be visually checked against standard piles for gradation prior to transport to the tailings piles.

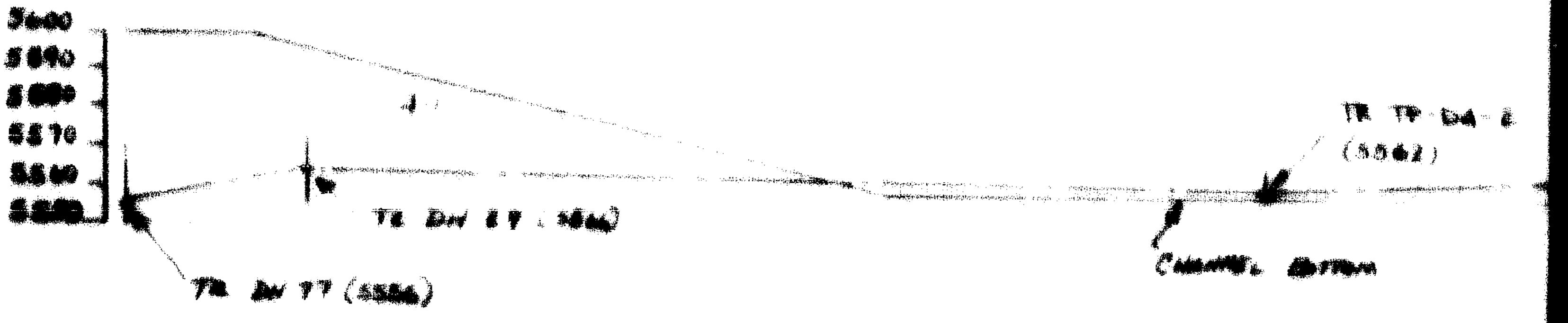
   Prior to delivery of any riprap materials to the site rock durability tests will be performed for each gradation to be used. Test series for riprap durability will include specific gravity,

absorption, sodium soundness and LA abrasion. During construction additional test series and gradations will be performed for each type of riprap when approximately one third (1/3) and two-thirds (2/3) of the total volume of each type have been produced or delivered. For any type of riprap where the volume is greater than 30,000 CY, a test series and gradations will be performed for each additional 10,000 CY of riprap produced or delivered.

CELL 1 (EVAPORATION)
7 FOOT WIDE ROCK APRON AT TOE OF SLOPE
PROJECTED APPROXIMATE CATCH POINT (SEE NOTE 1)
CELL 2
SLOPE 0.2%
CELL 3
SLOPE 0.2%
CELL 4A
SLOPE TO DRAIN
SLOPE TO DRAIN
BREACH TO PROVIDE CELL 4A DRAINAGE (SEE NOTE 5)
TOPSOIL
RANDOM FILL
CLAY
5619
5618.5
5618
5617.5
5617
5614.5
5614
5613.5
5613
LEGEND
EXISTING SPOT ELEVATION
5603.5 ELEVATION OF TOP OF COVER
-5560- EXISTING GROUND CONTOUR
NOTES
1. THE COVER WILL MEET THE GROUND WITH A DOWNWARD SIDE SLOPE OF 5H:1V.
2. ELEVATION OF THE BERMS SHOULD BE ADJUSTED TO MATCH WITH THOSE OF THE COVER.
3. CELL #1 WILL BE REMOVED DURING RECLAMATION.
4. TOPOGRAPHY BY KLH ENGINEERING FROM AERIAL PHOTOGRAPHY DATED AUGUST 23, 1993. CONTOUR INTERVAL IS 2 FT.
5. CELL 4A BOTTOM SHALL BE GRADED TO DRAIN THROUGH BREACH AREA. BREACH AREA SHALL BE CONSTRUCTED WITH SMOOTH TRANSITIONS INTO EXISTING GROUND AREAS. BREACH AREA SIDESLOPES TO BE GRADED TO A MAXIMUM 5H:1V.
6. SEE FIGURES 3 AND 4 FOR CROSS SECTIONS AND DETAILS.
7. EXISTING GROUND SURFACES SHALL BE REGRADED TO CONSTRUCT THE COVER WITH A FINAL SURFACE THAT IS CONSISTENT WITH THE RECLAMATION COVER GRADING PLAN.
SCALE
200 0 200 400 FEET
9904220257-02
After Titan Environmental, 1996
REV. No
DATE
BY
REVISIONS
APERTURE CARD
International Uranium (USA) Corporation
White Mesa Mill
FIGURE A-5.1-1
Reclamation Cover Grading Plan for Cells 2 and 3
DESIGN:
DRAWN:
CHK'D BY:
DATE: Feb., 1997
APP:
SCALE:
SHEET

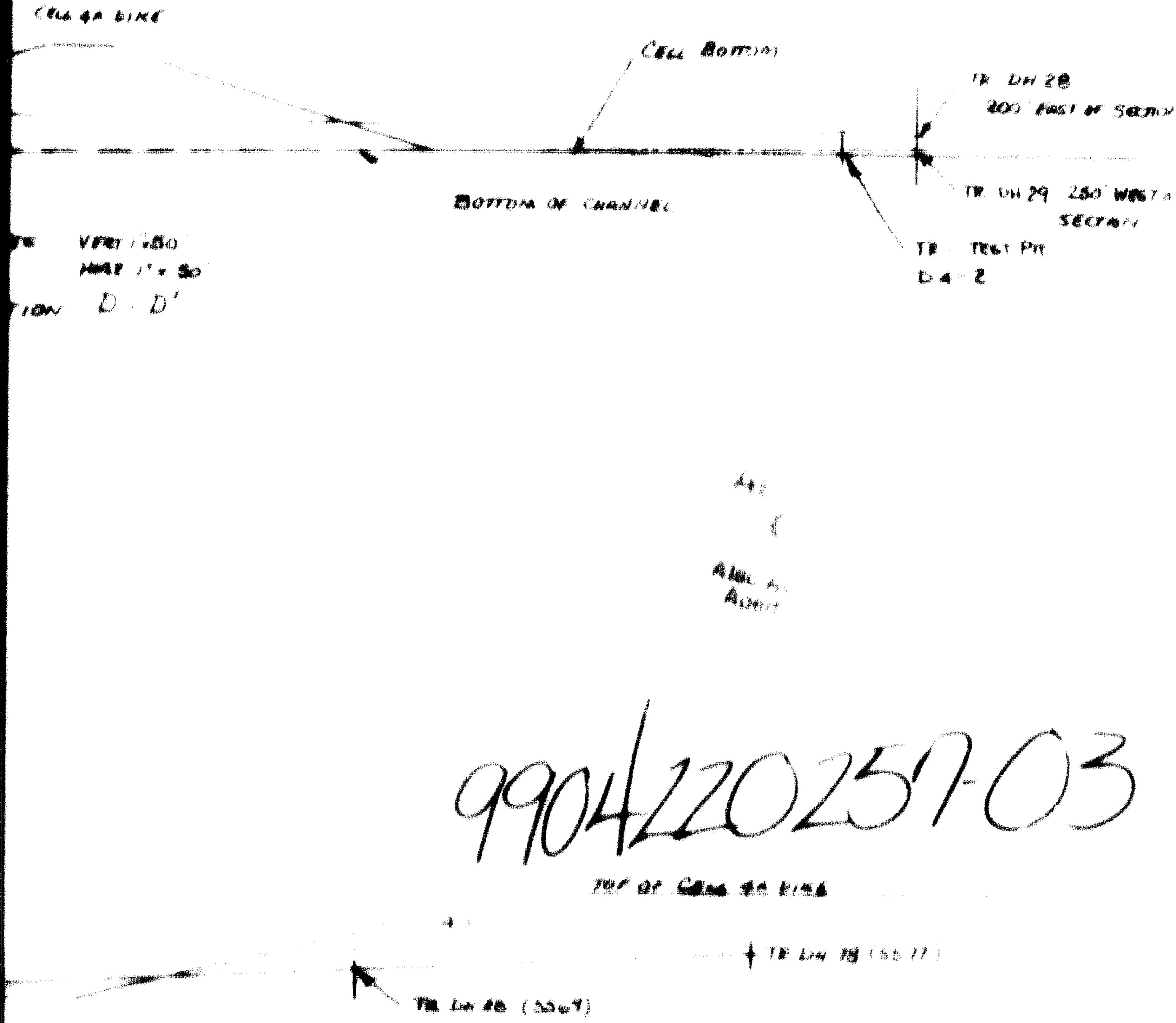
TR = TOP OF ROCK





SCALE VERT
HORIZ

SECTION E -



9904220257-03

REV No.	DATE	BY	REVISIONS

International Uranium (USA) Corporation
White Mesa Mill

Sections D-D' & E-E' from Figure A-5.1-1 of Reclamation Plan

DESIGN	RAH	DRAWN	RAH	SHEET
CHKD BY		DATE	4/3/99	of
APP		SCALE	as shown	

RATIONAL METHOD CALCULATION OF PMF PEAK DISCHARGE, VELOCITY, DEPTH AND SCOUR THROUGH CELL 4A BREACH WITH BREACH WIDENED TO 200 FEET - IUC WHITE MESA

FLOW PATH ELEMENT	ELEMENT LENGTH ft	MAX ELEV	MIN ELEV	GRADIENT S	SLOPE ANGLE degrees	tc hours	RAINFALL WITHIN tc (1)	i in/hr	SURFACE AREA acres	PEAK DISCHARGE Q cfs
CELL 2 COVER	1250	5619.5	5617	0.0020	0.12	0.34	6.53	19.20	41.30	637
CELL 2/3 BERM	10	5617	5615	0.2000	11.31	0.34	6.54	19.24	1.10	654
CELL 3 COVER	900	5615	5613.2	0.0020	0.11	0.61	7.30	12.01	35.12	992
CELL 3/4A BERM	180	5613.2	5577.2	0.2000	11.31	0.62	7.40	11.92	6.40	1063
CELL 4A	1400	5577.2	5562	0.0109	0.62	0.82	7.70	9.42	27.70	1262
CELL 4A INSLOPES	80	5599	5560	0.4875	25.99	0.04	2.00	47.62	5.68	216
CELL 4A BREACH	275	5562	5560	0.0073	0.42	0.92	7.80	8.44	0.38	1481

FLOW PARAMETERS IN CELL 4A BREACH AT PEAK PMF DISCHARGE

	Breach Bottom Width b ft	Breach Side Slopes	Breach Channel Gradient s ft/ft	Manning Coeff n	Qn/1.49*s^.5	Flow Depth, y ft	Cross Section Area of Flow a ft^2	Hydraulic Radius R ft	a(R)^.67	Velocity v fps	Allowable Peak velocity fps (COE 1970)	Riprap Size D50 inches (ref 1)
Soil (SM) Channel	200	3:1	0.0073	0.03	350	1.38	283.8	1.36	348.59	5.20	2.4	4.00
Rock Channel	200	3:1	0.0073	0.025	291	1.26	254.7	1.23	291.78	5.82	8.10	N/A

NOTE: If rounded rock (river cobbles and gravel) is used, rock size should be increased by 33%, per Fig. 4.10, NUREG /CR 4651, Vol. 2

Reference 1: Fig 4.11, NUREG CR 4620

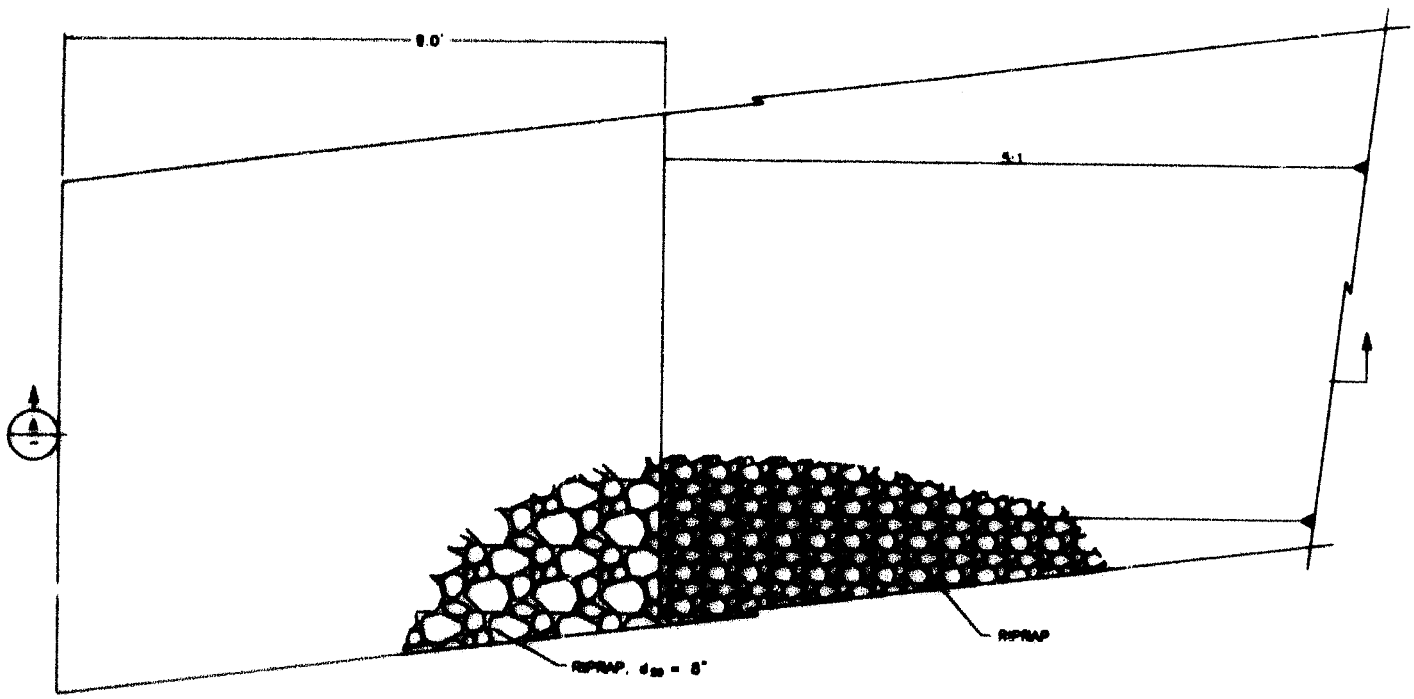
DEPTH OF SCOUR OF CELL 4A BREACH CHANNEL

All methods used are from Pemberton, E.L. and J.M. Lara, 1984, "Computing Degradation and Local Scour", Technical Guideline for Bureau of Reclamation

ds = depth of scour, ft
q = unit discharge, cfs/ft

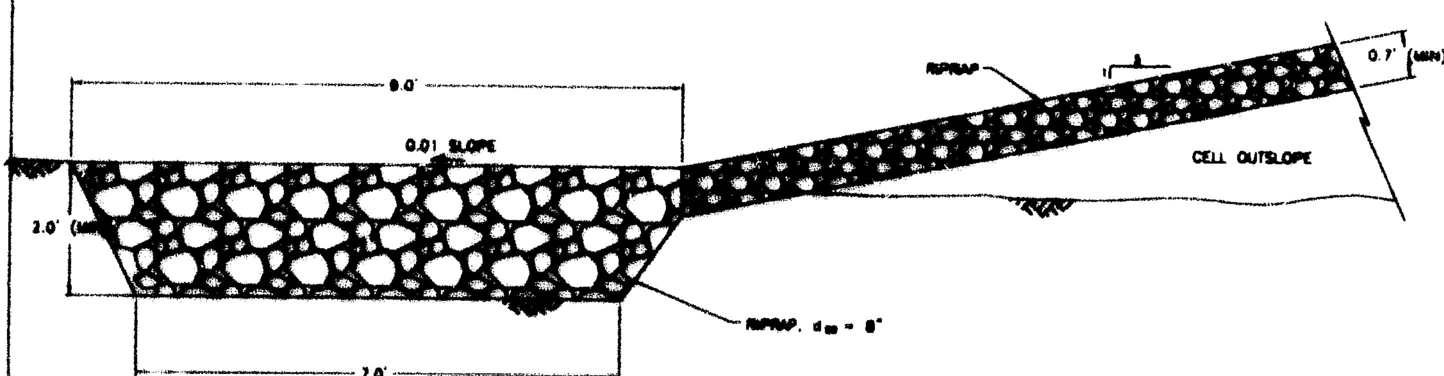
		Channel 200' wide
Method 1	ds=K*q^0.24	
	K = constant 2.45	
	q =	5.2
	ds =	3.64
Method 2	ds = 0.25 dm	
	dm = mean water depth at design discharge =	1.4
	ds =	0.34
Method 3	ds = 0.6*dfo	
	dfo = q^0.667/Fbo^0.333 =	3.00
	Fbo = zero bed factor = 1.0 ft/s^2 for fine sand	
	ds =	1.80
Method 4	ds = 0.25 * dms	
	dms = unit cross section of flow =	1.36
	ds =	0.34
Method 5	ds = dm*((Vm/Vc)-1)	
	Vm = mean velocity =	6.22
	Vc =	2
	ds =	2.11

AVERAGE SCOUR DEPTH, ft = 1.66



PLAN

NTS



International Uranium (USA) Corporation
White Mesa Mill

A ROCK APRON AT TOE OF CELL OUTSLOPE

NTS

DESIGN:		DRAWN:		SHEET 1 of 1
CHKD BY:		DATE:		
APP:		SCALE:	Not to Scale	

Knight Piésold

Memorandum

Date April 15, 1999 1626B

To File 1626B

From Roman Popielak and Pete Duryea

Re **Radon Emanation Calculations (Revised)**

At the request of International Uranium (USA) Corporation (IUC), we have completed a series of analyses of the expected levels of radon flux from the White Mesa uranium tailings facility for the tailings cover design These analyses accounted for recent comments from the United States Nuclear Regulatory Commission (NRC)

Analysis Methodology and Input Parameters

The analyses conducted and described herein adopted the methods and approach detailed in NRC Regulatory Guide 3 64 and more specifically the computer code RADON Version 1 2 The code, which considers one-dimensional steady state gas diffusion, requires input data including: layer thickness, porosity, dry density, radium activity, emanation coefficient, gravimetric water content and radon diffusion coefficient These input data were based exclusively on available data from previous work by others including Rogers and Associates Engineering Corporation, Advanced Terra Testing, Chen and Associates, D'Appolonia Consulting Engineers Inc and TITAN Environmental Key laboratory data and a summary of parameters selected for these analyses are presented in the attached Table 1

The current cover design includes 2 0 feet of random fill (frost barrier fill) over 1 0 foot of compacted clay which in turn overlies 3 0 feet of random fill (platform fill) In the analyses, the thickness of final cover was reduced by 6 8 inches to 1 4 feet to account for the depth of frost penetration as evaluated by TITAN Environmental The actual tailings thickness is on the order of 44 feet, which meets the NRC guidelines for an infinitely thick source, and hence it could be modeled in program RADON as a 500 0-centimeter thick layer Available data on the in-situ density of the tailing was used All available historical Proctor compaction results for the other materials were evaluated to select appropriate maximum dry densities for the clay and random fill

The clay layer and frost barrier fill, which are to be placed and compacted as engineered fill materials, were modeled with 95-percent standard Proctor compaction The platform fill material is dumped and spread directly on top of the tailing surface Once in place, the material is compacted by selective routing of equipment traffic, and it then provides a working surface for subsequent operations such as placement and compaction of the clay layer and frost barrier fill The compaction of material comprising the platform is expected to be higher at its top than at its contact with the tailings

Within the platform fill, the surficial material is likely to exhibit fairly high compaction given the influence of the contact stresses exerted by equipment traffic and later by the compaction of overlying material. Such stresses diminish with depth, so lower portions of the platform fill will not have experienced as significant a compactive effort. Compaction of the platform fill is therefore likely to range from about 80-percent of standard Proctor at the base of the random fill immediately above the tailing to 90- to 95-percent of standard Proctor compaction at the top of the platform fill immediately below the equipment loads just described.

The porosity of each of the materials/sublayers was calculated from its dry density and specific gravity of soil solids. Radium activities and emanation coefficients were selected for each soil type from available lab data, and the long term water contents were selected for the analyses as follows. In the absence of other data, the tailing was modeled with a 6.0 percent by weight moisture content as the NRC recognizes that value as a practical lower bound for soils in the western United States. Long term moisture content can be conservatively modeled as the residual (or irreducible) water content from capillary moisture retention data since a lower value is more critical, that is it yields a higher radon flux. Such data was provided and used for the random fill and the clay.

The final, and one of the more critical parameters, was the radon diffusion coefficient. This parameter is dependent upon the porosity and degree of saturation of the soil, and although lab data was available, it was for conditions other than those modeled. So in the absence of diffusion coefficient data at the porosities and degrees of saturation of interest, a correlation provide by the NRC was employed to compute the diffusion coefficients adopted for the analyses. These values ranged from 0.0071 to 0.0507 cm^2/sec. It should be noted that the resultant values did seem to match well with the trends observed in the available laboratory data.

Results and Conclusions

Since there were not data available describing the degree and distribution of compaction in the platform fill, a series of analyses were conducted based on varying assumptions about the condition of that material. In each of those cases, the platform fill was divided into a series of sublayers whose thickness and degree of compaction were selected based upon engineering judgement and previous experience with similar situations.

The two cases of distribution of compaction considered to represent the conditions anticipated at White Mesa are presented in attached Figure 1 as Case I and Case II. The results of the radon flux evaluation for those two cases are attached. For the reasonably conservative input parameters listed herein and an interim cover comprising 1.0 foot each at 80-, 90 and 95-percent compaction as shown as Case I in Figure 1, a radon flux at the ground surface of 18.2 $pCi/m^2/sec$ is expected. For Case II with 0.5 foot of 95-percent compaction material overlying 1.0 feet of 90-percent compaction material and 1.5 feet of 85-percent compaction material, the radon flux at the ground surface is 19.8 $pCi/m^2/sec$. Both of these results are within the 20.0 pCi/m /sec limit specified by the NRC

Therefore, it appears that the cover design should be acceptable assuming that the conditions described herein do not vary significantly from those in the field.

In conclusion, empirical knowledge of the site conditions should be taken under consideration in evaluation of the model results. At present, approximately 80-percent of Cell No.2 is covered with the random fill (platform fill). This fill supports traffic of the heavy, 30 ton haulers. Hence the degree of compaction of the layer(s) as represented in the radon flux models (see Figure 1) may have already been achieved in certain locations within the cell. The platform fill has been very effective to date in attenuating the radon flux, which as currently recorded is 7.4 $pCi/m^2/sec$ which is well below the standard of 20.0 $pCi/m^2/sec$. Based on these observations, it would appear that the performance of the tailings cover, which will ultimately include the clay layer and frost barrier fill in addition to the fill currently in place, as a barrier controlling radon flux is anticipated to meet the regulatory requirements.

Table 1
Laboratory and Model Input Data

LABORATORY DATA

Material	Specific Gravity G_s	Max. Dry Unit Wt. $\gamma_{dry,max}$ (pcf)	Max. Dry Density $\rho_{dry,max}$ (g/cm^3)	95% Max. Dry Density $\rho_{dry,95\% max}$ (g/cm^3)	Porosity[1] n	Dry Density ρ_{dry} (g/cm^3)	Radium Activity (pCi/g)	Emanation Coefficient	Water Content w (% by wt.)	Diffusion[7] Coefficient D (cm^2/sec)	Saturation[2] S	Diffusion[3] Coefficient D (cm^2/sec)
Tailings	2.85	104.0	1.67	1.58	0.491	1.45	981.0	0.19	13.2	2.00E-02	0.390	2.07E-02
	2.85	104.0	1.67	1.58	0.495	1.44	981.0	0.19	19.1	8.40E-03	0.556	1.06E-02
Rnd. Fill (Comp.)	2.67	120.2	1.93	1.83	0.307	1.85	1.9	0.19	6.5	1.60E-02	0.392	1.63E-02
	2.67	120.2	1.93	1.83	0.311	1.84	1.9	0.19	12.5	4.50E-04	0.740	1.99E-03
Clay (Site #1)	2.69	121.3	1.94	1.85	0.312	1.85	2.2	0.20	8.1	1.60E-02	0.480	1.12E-02
	2.69	121.3	1.94	1.85	0.316	1.84	2.2	0.20	12.6	1.40E-03	0.734	2.13E-03
Clay (Site #4)	2.75	108.7	1.74	1.65	0.400	1.65	2.0	0.11	15.4	1.10E-02	0.635	5.48E-03
	2.75	108.7	1.74	1.65	0.400	1.65	2.0	0.11	19.3	4.20E-04	0.796	1.34E-03
Clay (UT-1)	2.39	113.5	1.82	1.73	0.280	1.72	1.5	0.22	14.5	9.10E-03	0.890	2.84E-04

SELECTED MODEL INPUT DATA

Material	Specific[6] Gravity G_s	Max. Dry[6] Unit Wt. $\gamma_{dry,max}$ (pcf)	Max. Dry Density $\rho_{dry,max}$ (g/cm^3)	Specified Dry Density $\rho_{dry,spec}$ (g/cm^3)	Porosity[1] n	Dry[4] Density ρ_{dry} (g/cm^3)	Radium[6] Activity (pCi/g)	Emanation[6] Coefficient	Water[5] Content w (% by wt.)	Diffusion[3] Coefficient D (cm^2/sec)	Saturation[2] S
Tailings	2.85	N/A	N/A	N/A	0.583	1.19	981.0	0.19	6.0	5.07E-02	0.122
Rnd. Fill @ 80% Std	2.67	120.2	1.93	1.54	0.423	1.54	1.9	0.19	9.8	2.12E-02	0.357
Rnd. Fill @ 85% Std.	2.67	120.2	1.93	1.64	0.387	1.64	1.9	0.19	9.8	1.62E-02	0.415
Rnd. Fill @ 90% Std	2.67	120.2	1.93	1.73	0.351	1.73	1.9	0.19	9.8	1.15E-02	0.484
Rnd. Fill @ 95% Std	2.67	120.2	1.93	1.83	0.315	1.83	1.9	0.19	9.8	7.05E-03	0.570
Clay @ 95% Std	2.72	100.0	1.60	1.52	0.440	1.52	1.9	0.18	14.1	1.30E-02	0.488

(1) $n=1-(\rho_{dry}/G_s/\rho_w)$

(2) $S=w*G_s*\rho_{dry}/\rho_w/(G_s*\rho_w-\rho_{dry})$

(3) $D=0.07\exp(-4(S-Sn^2+S^5))$ per NRC correlation

(4) Tailings based on 74.2 pcf. Rnd. Fill ranges from 80 to 95% Std. Proctor. Clay based on 95% Std. Proctor.

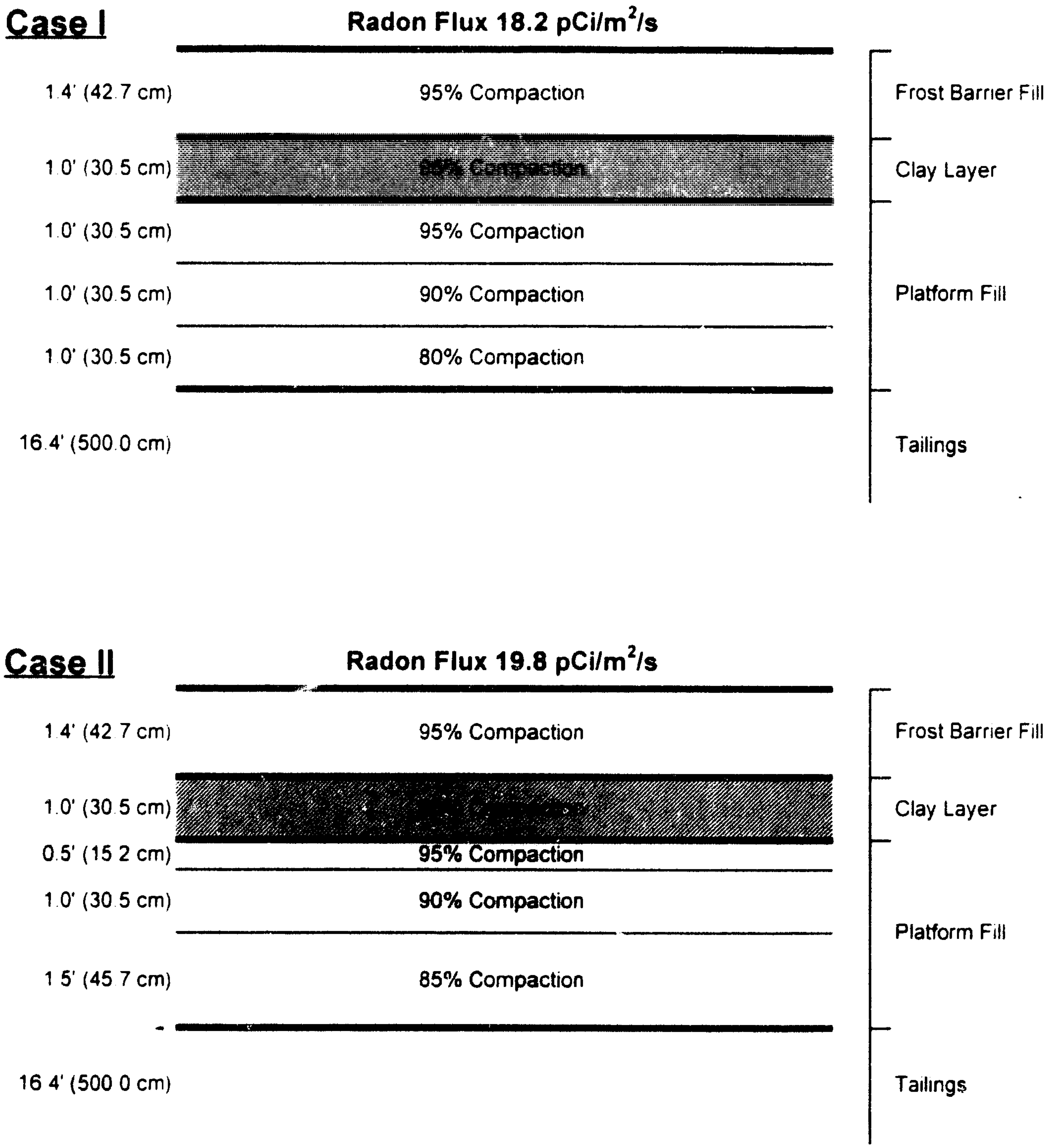
(5) Tailings based on w=6% per NRC. Others based on capillary moisture data. Rnd. Fill w=9.8% and Clay w=14.1% (average of two tests)

(6) Values for clay are an average of test results

(7) Individual lab test results

sum_tbl.xls

Figure 1
Cover Cross Sections for Radon Flux Models



Note: Percent compaction is based upon the maximum dry density by standard Proctor.

-----*****! RADON !*****-----

Version 1.2 - Feb. 2, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

WHITE MESA CASE I

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
DESIRED RADON FLUX LIMIT	20	pCi m^-2 s^-1
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	0	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1

THICKNESS	500	cm
POROSITY	.583	
MEASURED MASS DENSITY	1.19	g cm^-3
MEASURED RADIUM ACTIVITY	981	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	7.990D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.122	
MEASURED DIFFUSION COEFFICIENT	.0507	cm^2 s^-1

LAYER 2

THICKNESS	30.5	cm
POROSITY	.423	
MEASURED MASS DENSITY	1.54	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	2.760D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.8	%
MOISTURE SATURATION FRACTION	.357	
MEASURED DIFFUSION COEFFICIENT	.0212	cm^2 s^-1

LAYER 3

THICKNESS	30.5	cm
POROSITY	.351	
MEASURED MASS DENSITY	1.73	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	3.737D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.8	%
MOISTURE SATURATION FRACTION	.483	
MEASURED DIFFUSION COEFFICIENT	.0115	cm^2 s^-1

LAYER 4

THICKNESS	30.5	cm
POROSITY	.315	
MEASURED MASS DENSITY	1.83	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	4.404D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.8	%
MOISTURE SATURATION FRACTION	.569	
MEASURED DIFFUSION COEFFICIENT	.0071	cm^2 s^-1

LAYER 5

THICKNESS	30.5	cm
POROSITY	.44	
MEASURED MASS DENSITY	1.52	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.18	
CALCULATED SOURCE TERM CONCENTRATION	2.481D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	14.1	%
MOISTURE SATURATION FRACTION	.487	
MEASURED DIFFUSION COEFFICIENT	.013	cm^2 s^-1

LAYER 6

THICKNESS	42.7	cm
POROSITY	.315	
MEASURED MASS DENSITY	1.83	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	4.404D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.8	%
MOISTURE SATURATION FRACTION	.569	
MEASURED DIFFUSION COEFFICIENT	.0071	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
6	-1.000D+00	0.000D+00	0	2.000D+01	0.000D+00

LAYER	DX	D	P	Q	XMS	RHO
1	5.000D+02	5.070D-02	5.830D-01	7.990D-04	1.225D-01	1.190
2	3.050D+01	2.120D-02	4.230D-01	2.760D-06	3.568D-01	1.540
3	3.050D+01	1.150D-02	3.510D-01	3.737D-06	4.830D-01	1.730
4	3.050D+01	7.100D-03	3.150D-01	4.404D-06	5.693D-01	1.830
5	3.050D+01	1.300D-02	4.400D-01	2.481D-06	4.871D-01	1.520
6	4.270D+01	7.100D-03	3.150D-01	4.404D-06	5.693D-01	1.830

BARE SOURCE FLUX FROM LAYER 1: 6.938D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	1.417D+02	2.911D+05
2	3.050D+01	8.383D+01	1.976D+05
3	3.050D+01	5.158D+01	1.220D+05
4	3.050D+01	3.608D+01	5.146D+04
5	3.050D+01	2.274D+01	4.139D+04
6	4.270D+01	1.824D+01	0.000D+00

-----*****! RADON !*****-----

Version 1.2 - Feb. 2, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

RADON FLUX, CONCENTRATION AND TAILINGS COVER THICKNESS
ARE CALCULATED FOR MULTIPLE LAYERS

WHITE MESA CASE II

CONSTANTS

RADON DECAY CONSTANT	.0000021	s^-1
RADON WATER/AIR PARTITION COEFFICIENT	.26	
SPECIFIC GRAVITY OF COVER & TAILINGS	2.65	

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	6	
DESIRED RADON FLUX LIMIT	20	pCi m^-2 s^-1
LAYER THICKNESS NOT OPTIMIZED		
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	0	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1

THICKNESS	500	cm
POROSITY	.583	
MEASURED MASS DENSITY	1.19	g cm^-3
MEASURED RADIUM ACTIVITY	981	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	7.990D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	6	%
MOISTURE SATURATION FRACTION	.122	
MEASURED DIFFUSION COEFFICIENT	.0507	cm^2 s^-1

LAYER 2

THICKNESS	45.7	cm
POROSITY	.387	
MEASURED MASS DENSITY	1.64	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	3.213D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.8	%
MOISTURE SATURATION FRACTION	.415	
MEASURED DIFFUSION COEFFICIENT	.0162	cm^2 s^-1

LAYER 3

THICKNESS	30.5	cm
POROSITY	.351	
MEASURED MASS DENSITY	1.73	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	3.737D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.8	%
MOISTURE SATURATION FRACTION	.483	
MEASURED DIFFUSION COEFFICIENT	.0115	cm^2 s^-1

LAYER 4

THICKNESS	15.2	cm
POROSITY	.315	
MEASURED MASS DENSITY	1.83	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	4.404D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.8	%
MOISTURE SATURATION FRACTION	.569	
MEASURED DIFFUSION COEFFICIENT	.0071	cm^2 s^-1

LAYER 5

THICKNESS	30.5	cm
POROSITY	.44	
MEASURED MASS DENSITY	1.52	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.18	
CALCULATED SOURCE TERM CONCENTRATION	2.481D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	14.1	%
MOISTURE SATURATION FRACTION	.487	
MEASURED DIFFUSION COEFFICIENT	.013	cm^2 s^-1

LAYER 6

THICKNESS	42.7	cm
POROSITY	.315	
MEASURED MASS DENSITY	1.83	g cm^-3
MEASURED RADIUM ACTIVITY	1.9	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.19	
CALCULATED SOURCE TERM CONCENTRATION	4.404D-06	pCi cm^-3 s^-1
WEIGHT % MOISTURE	9.8	%
MOISTURE SATURATION FRACTION	.569	
MEASURED DIFFUSION COEFFICIENT	.0071	cm^2 s^-1

DATA SENT TO THE FILE `RNDATA' ON DRIVE A:

N	F01	CN1	ICOST	CRITJ	ACC
6	-1.000D+00	0.000D+00	0	2.000D+01	0.000D+00

LAYER	DX	D	P	Q	XMS	RHO
1	5.000D+02	5.070D-02	5.830D-01	7.990D-04	1.225D-01	1.190
2	4.570D+01	1.620D-02	3.870D-01	3.213D-06	4.153D-01	1.640
3	3.050D+01	1.150D-02	3.510D-01	3.737D-06	4.830D-01	1.730
4	1.520D+01	7.100D-03	3.150D-01	4.404D-06	5.693D-01	1.830
5	3.050D+01	1.300D-02	4.400D-01	2.481D-06	4.871D-01	1.520
6	4.270D+01	7.100D-03	3.150D-01	4.404D-06	5.593D-01	1.830

BARE SOURCE FLUX FROM LAYER 1: 6.938D+02 pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	1.382D+02	2.930D+05
2	4.570D+01	7.131D+01	1.485D+05
3	3.050D+01	4.602D+01	9.400D+04
4	1.520D+01	3.921D+01	5.586D+04
5	3.050D+01	2.469D+01	4.491D+04
6	4.270D+01	1.977D+01	0.000D+00