U.S. Department of Energy
200 Grand Avenue
Grand Junction, CO 81501

September 13, 2010

Ms. Kimberly Conway, Project Manager
FSME Division of Waste Management and Environmental Protection
U.S. Nuclear Regulatory Commission
Mail Stop T8F5
Washington, DC 20555-0001

Subject: Proposed Changes to the Moab Uranium Mill Tailings Remedial Action (UMTRA) Project Remedial Action Inspection Plan

Dear Ms. Conway:

Pursuant to our teleconference on August 11, 2010, the U.S. Department of Energy (DOE) submits for your review and approval a red line/strike out version of the Remedial Action Inspection Plan (RAIP) indicating proposed changes. The RAIP is Addendum E of the Moab UMTRA Project Remedial Action Plan.

DOE would like to amend the document to update the RAIP to reflect field practices that are currently in use by the Moab UMTRA Project. Examples of the proposed changes are the selection of the type of equipment used for placement or compaction, a specification change for radon barrier particle size, as well as numerous editorial changes.

Four copies of the RAIP with the proposed changes indicated are enclosed for your review and approval.

Thank you for considering this request. If you have any questions feel free to call me (970) 257-2115.

Sincerely,

Donald R. Metzler
Moab Federal Project Director

Additional copies
Sent to PM

FSME20

cc w/enclosure:
J. Berwick, DOE
K. Wethington, DOE
C. Nakahara, UDEQ
B. Anderson, RAC
L. Brede, RAC
K. Turvy, RAC
Moab Records CRJ 2.12 (C. Smith)

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ADDENDUM E – REMEDIAL ACTION INSPECTION PLAN (RAIP)

STATEMENT OF POLICY

This Remedial Action Inspection Plan (RAIP) identifies the means by which the remedial action activities associated with the disposal cell at Crescent Junction, Utah are controlled, verified, and documented. This plan has been developed within the scope of the ~~EnergySolutions~~ Moab UMTRA Project Quality Assurance Plan for the Remedial Action Contractor (RAC), DOE-EM/GJ1766, and complies with the applicable parts of American Society of ~~mechanical~~ Mechanical ~~engineers~~ Engineers (ASME) NQA-1-~~2000~~2004, and addenda through 2007, *Quality Assurance Program for Nuclear Facilities,* Title 10, *Code of Federal Regulations* (CFR) 830 Subpart A, *Quality Assurance*, and DOE O 414.1C, *Quality Assurance.*

The procedures defining Organization, Quality Control (QC) Personnel Qualification & Certification, Quality Assurance Records Control, Control of Measuring and Test Equipment, and Conditions Reports are in accordance with the applicable section of the Quality Assurance Plan as follows: Organization – Section 1, Organization, QC Personnel Qualification & Certification – Section 2, Quality Assurance Program, Quality Assurance Records Control – Section 17, Quality Assurance Records, Control of Measuring and Test Equipment – Section 12, Control of Measuring and Testing Equipment, and Conditions Reports - Sections 15, Nonconforming Materials, Parts or Components and Section 16, Corrective Action.

This Remedial Action Inspection Plan and the Quality Assurance Plan describe the means by which ~~EnergySolutions~~ the RAC will ensure that the U.S. Environmental Protection Agency's requirements which have the concurrence of the U.S. Nuclear Regulatory Commission (NRC) and the selected remedial action guidelines for Testing and Inspection Plans During construction of DOE's *Remedial Action Plan and Site Design for Stabilization of Moab Title I Uranium Mill RRM at the Crescent Junction, Utah, Disposal Site (RAP)* are satisfied.

TITLE: TESTING AND INSPECTION

1.0 PURPOSE

To describe the methods by which the construction activities will be tested and inspected to verify compliance with the Design Specification requirements.

2.0 SCOPE

This procedure defines the testing and inspection of remedial action construction activities at Crescent Junction, Utah. Types of tests, test frequencies and acceptability, and documentation and reporting requirements are contained in this procedure. Procedures for performing the individual tests shall be in accordance with the applicable ASTM International sStandards, the referenced or other approved methods and the Design Specifications.

3.0 ~~DEFINITIONS~~ ACRONYMS

ASTM American Society for Testing and Materials

CAES Computerized Aided Earthmoving System

GPS Global Positioning System

RRM Residual Radioactive Material

M&TE Measuring and Test Equipment

4.0 ATTACHMENTS

CAES Brochure

5.0 REFERENCES

1. ASTM C88 – Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

~~1.~~2. ASTM C 117 – Standard Test Method for Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing

~~2.~~3. ASTM C-136 – Standard Test Method for Sieve Analysis of Fine and Course Aggregates

~~3.~~4. ASTM D 422 – Standard Test Method for Particle-Size Analysis of Soils

~~4.~~5. ASTM 698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu ft)

~~5.~~6. ASTM D 1140 – Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve.

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~~6.~~7. ASTM D 1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

~~7.~~8. ASTM D 2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

~~8.~~9. ASTM D 4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

~~9.~~10. ASTM D 4643 – Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

~~10.~~11. ASTM D 4944 – Standard Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester.

~~11.~~12. ASTM D 4959 – Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.

~~12.~~13. ASTM D 6938 ~~-~~, Standard Test Method for In-Place Density and Water content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

14. Schmidt Rebound Hardness – ISRM Method

15. Splitting Tensile Strength – ISRM Method

~~13.~~16. 10 CFR 50 Appendix B

~~14.~~17. Computerized Aided Earthmoving System (CAES) Office User Guide

~~15.~~18. Energy*Solutions* Quality Assurance Plan

~~16.~~19. Energy*Solutions* QA/QC Work Procedures

~~17.~~20. Crescent Junction Design Specifications

21. NQA-1-2000

22. 10 CFR 830 Subpart A

23. DOE O 414.1C

24. DOE Moab UMTRA Project Remedial Action Plan

25. DOE-EM/GJ1545 "Records Management Manual"

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6.0 GENERAL REQUIREMENTS

6.1 GENERAL APPROACH TO SOIL COMPACTION AND COMPACTION TESTING

Typically, soil is tested in a laboratory to determine the maximum density that the particular soil can achieve. The maximum density will be achieved at the optimum moisture content for that soil. The laboratory maximum density and optimum moisture content for the soil becomes the basis of comparison for the compaction of the soil in the field.

In the field, the soil is placed in layers, compacted with specialized compaction equipment, and tested to confirm that the soil density is close to the previously determined laboratory maximum density. A variety of field tests have been used to

determine soil density, including sand cone, rubber balloon, drive cylinder and nuclear gauge methods. Moisture content tests are also needed to determine the in-place soil density. All of these test methods determine the density of a small quantity of soil at a single point in a large quantity of placed and compacted soil. A number of tests are required to infer that an entire layer of soil is adequately compacted. The documentation of soil compaction has typically consisted of a visual inspection report combined with a map of the compacted layer and the field test results.

6.1.1 Computer Aided Earthmoving System (CAES)

Global positions system (GPS) and computer terrain modeling technology have been combined to provide a new method of performing soil compaction. The equipment is called Computer Aided Earthmoving System (CAES). The system works as follows:

- A digital terrain model of the site to receive fill material is fed into an on-site computer linked to a computer in the cab of the compaction equipment. A GPS receiver is also linked to the compaction machine's on-board computer. When the machine moves across the site, the GPS equipment provides the exact position and elevation of the equipment at all times.
- Soil is dumped and spread into a layer of fill. As the compaction machine spreads and compacts the layer of soil, the position of the machine is compared to the original terrain model to determine the location and thickness of the fill layer being installed. The on-board computer assists the equipment operator to place the material in a layer with uniform thickness by informing the operator of thick or thin areas of the fill.
- After a layer has been placed with uniform thickness, the compaction equipment makes multiple passes over the fill to compact the fill. A compaction machine, compacting material at the correct moisture content, will eventually compact the fill to near its maximum density such that additional compaction passes produce negligible change. The computer recording the GPS location data interprets the passes that produce no vertical change to indicate that the soil is at its maximum density.
- A record of each soil layer's location, thickness, and compaction is generated by the computer.

Visual inspection, correct placement and compaction techniques, and good moisture control are still required to ensure that fill is properly placed, but the CAES method has distinct advantages over traditional field density testing. Lift thicknesses are computer controlled and are more uniform than when layers are installed based on visual estimates by the equipment operators. The computer checks compaction over the entire surface of every layer, whereas the in-place test methods only check a few points on each layer. See Attachment 1 for vendor data on the CAES system.

Soil density verification tests and independent land surveys will be performed to demonstrate the effectiveness of the CAES System. In the following sections of this plan, the verification testing and surveying will be described in detail for each element of the cell in which fill is placed.

6.2 CELL EXCAVATION

Part of the proposed waste cell will be below the ground surface in an excavation. The excavation will be constructed in phases with interim dikes that will be removed as operations require or as subsequent phases are constructed. The overall cell floor and side slopes are as described below.

6.2.1 Floor and side slopes

The cell floor slopes 2.3% from ~~northwest~~ northeast to ~~southeast~~southwest. The cut slopes on the north, west, and south sides of the cell slope at 2:1 or 3:1.

6.2.2 Final floor and embankment elevations

The cell floor coordinates and elevations are shown on the design plans. When each section of the cell is excavated to the elevations indicated on the plans, a verification survey shall be performed to confirm that the excavation is to the proposed lines and grades. The verification survey shall be signed by the Contractor and submitted to the RAC Construction Manager.

6.2.3 Floor of cell is in the weathered Mancos Shale

The cell floor elevation has been set based on test pit and soil boring data and is at least two feet below the top of the Mancos Shale at each data point. The cell floor shall be visually inspected to confirm that it is in the Mancos Shale formation. If an area is observed where the overburden soil extends below the cell floor, the area will be undercut, backfilled with prepared Mancos Shale, and compacted.

6.2.4 Inspection and Testing

~~The Quality Control (QC) Inspector~~ shall visually inspect the material and ground preparation. ~~The~~ QC ~~Inspector~~ shall verify that the cell floor is constructed in accordance with Plans and Specifications by checking and confirming:

- Floor and side slopes are per the design plans;
- Final floor and side slopes survey match the coordinates and elevations in the plans; and
- The floor is weathered Mancos Shale or low spots have been compacted with Mancos Shale.

6.3 EMBANKMENT CONSTRUCTION

Part of the proposed waste cell will be below the existing ground surface in an excavation and part will be above the existing ground surface within a constructed embankment. The proposed embankment will have 3:1 or 2:1 interior slopes, 5:1 exterior slopes, and a

minimum 30 ft wide level top. Excavated material from the cell excavation will be used to construct the waste cell perimeter embankment.

6.3.1 Material

Excavated material from the cell excavation shall be segregated into four types of soil, topsoil, weathered Mancos Shale, common fill, and unsuitable material. Materials shall be stockpiled separately. The perimeter and spoil embankments will be constructed of common fill. The fill shall be tested to determine its maximum dry density in accordance with ASTM D 698 and the moisture content shall be modified to bring the fill to its optimum moisture for compaction.

6.3.2 Ground Preparation

The ground beneath the proposed perimeter and spoil embankments shall be prepared by stripping vegetation and loose soil from the site, scarifying and compacting the top six inches of soil.

6.3.3 Lift Placement and Thickness

The embankment shall be constructed of fill materials placed in continuous and approximately horizontal lifts. The method of dumping and spreading fill shall result in loose lifts of nearly uniform thickness, not to exceed 12". At the ~~Contractor's~~ RAC's option, the compactor may be equipped with a ~~Computer Aided Earthmoving System~~CAES and soil placement and compaction shall be controlled by the CAES. The contractor may use the CAES to determine and document compaction, or perform soil density tests in accordance with the Inspection and Testing, section below.

6.3.4 Inspection and Testing Waste Cell Perimeter Embankment

~~The Quality Control (QC) Inspector~~ shall visually inspect the material preparation, ground preparation, and fill placement operations. ~~The~~ QC ~~Inspector~~ shall perform in-place density tests with companion moisture tests to verify at least 95% of the laboratory maximum dry density in accordance with ASTM D 698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. ~~The~~ QC ~~Inspector~~ shall verify that the perimeter embankment is constructed in accordance with Plans and Specifications by checking and confirming:

- Interior slopes are 3:1, and exterior slopes are 5:1 and a minimum 30 ft wide level top verified one time at the end of excavation;
- Fill material is properly moisture conditioned near optimum moisture.

- Fill material is placed in continuous and approximately horizontal lifts. The method of dumping and spreading material shall result in loose lifts of nearly uniform thickness, not to exceed 12".
- Embankment construction soil is common fill;
- Compaction is properly performed.
- Compaction – Embankment fill shall be compacted with a minimum 45,000 lb static weight compactor. The compactor shall be a footed roller capable of kneading compaction, with feet a minimum of 6 inches in length.
- Compaction Verification Tests – Perform in-place density and moisture content tests on compacted fill material in accordance with the In-Place Density Testing sections below.
- Verification tests of in-place density shall be performed on initial layers of soil placed, and on any specific type of material in which the CAES is used.

Testing and verification frequencies for lifts constructed without the CAES system shall be in accordance with the following:

Testing of Waste Cell Perimeter Embankment

- For material compacted by other than hand-operated machines: One test per 50,000 square feet or 1,850 cubic yards of material placed, or fraction thereof, a minimum of one test for each lift of fill or backfill, and a minimum of two tests per day that fill is compacted in accordance with ASTM D 6938.
- One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas for material compacted by hand-operated machines.

In place density and moisture content tests shall be performed in accordance with the following methods:

- ASTM D 1556 – Density and Unit Weight of Soil in Place by the Sand-Cone Method
- ASTM D 2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D 6938 - In-Place Density and Water content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

Check Tests on In-Place Densities

If ASTM D 6938 is used, check in-place densities by ASTM D 1556 as follows:

- One check test for each 20 tests per ASTM D 6938, of fill or backfill compacted by other than hand-operated machines.
- One check test for each 20 tests per ASTM D 6938, of fill or backfill compacted by hand-operated machines.

- ***Optimum Moisture and Laboratory Maximum Density***

Perform Laboratory Density and Moisture Content tests (ASTM D 698 and ASTM D 2216) for each type of fill material to determine the optimum moisture (optimum moisture content plus or minus 5%) and laboratory maximum density values. One representative density test per material type and every 20,000 cubic yards there after or when any change in material occurs which may affect the optimum moisture content or laboratory maximum dry density. One correlation test for moistures every 10 tests per ASTM 6938 will be performed in accordance to ASTM D 4643 or ASTM D 2216.In the stockpile, excavations, or borrow areas, perform moisture tests to control the moisture content of material being placed as fill. Control of moisture content of fill shall be performed by conducting routine testing of moisture content by one of the following tests:

- ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (Oven Moisture)
- ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating
- ASTM D 4944 - Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
- ASTM D 4959 - Determination of Water (Moisture) Content of Soil by Direct Heating

During unstable weather, perform tests as dictated by local conditions and approved by the Construction Manager.

6.3.5 Waste Cell Spoil Material Embankment (Wedge)

The Waste Cell Spoil Material Embankment is a fill embankment to be constructed north of the waste cell. The embankment will divert storm water from the Book Cliffs around the waste cell, and shall be constructed of surplus excavated material (spoil material) from the waste cell excavation. Prior to placement, spoil material shall be tested to determine its maximum dry density in accordance with ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort, and the moisture content shall be modified to bring the fill to near optimum for compaction.

Construct the Waste Cell Spoil Material Embankment as follows:

1) Prepare the ground beneath the proposed perimeter embankment by stripping vegetation and loose soil from the site.
2) Dump and spread fill in loose lifts of nearly uniform thickness, not to exceed 12". Compact material with rollers, equipment tracks, or successive passes of scrapers. Fill shall be compacted to a density of 90% of the laboratory determined maximum density in accordance with ASTM D 698.

~~The~~ QC ~~Inspector~~ shall verify that the spoil embankment is constructed in accordance with Plans and Specifications by checking and confirming:

- Exterior slopes are 3:1,

- Fill material is properly moisture conditioned near optimum moisture.
- Fill material is placed in continuous and approximately horizontal lifts. The method of dumping and spreading material shall result in loose lifts of nearly uniform thickness, not exceed 12"
- Embankment construction soil is common fill;
- Compaction is properly performed.
- Compaction – Embankment fill shall be compacted with rollers, equipment tracks, or successive passes of scrapers a minimum 45,000 lb static weight. ~~compactor. The compactor shall be a footed roller capable of kneading compaction, with feet a minimum of 6 inches in length.~~
- Compaction Verification Tests – Perform in-place density and moisture content tests on compacted fill material in accordance with the In-Place Density Testing sections below.
- Verification tests of in-place density shall be performed on initial layers of soil placed, and on any specific type of material in which the CAES is used.

Testing and verification frequencies for lifts constructed without the CAES system shall be in accordance with the following:

Testing of Waste Cell Spoil Material Embankment

- One test per 100,000 square feet or 3,700 cubic yards of material placed for material compacted by other than hand-operated machines
- One test per 500 square feet, or fraction thereof, of each lift of fill or backfill areas for material compacted by hand-operated machines

In place density and moisture content tests shall be performed in accordance with the following methods:

- ASTM D 1556 – Density and Unit Weight of Soil in Place by the Sand-Cone Method
- ASTM D 2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D 6938 - In-Place Density and Water content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

Check Tests on In-Place Densities

If ASTM D 6938 is used, check in-place densities by ASTM D 1556 as follows:

- One check test for each 20 tests per ASTM D 6938, of fill or backfill compacted by other than hand-operated machines.
- One check test for each 20 tests per ASTM D 6938, of fill or backfill compacted by hand-operated machines.

Optimum Moisture and Laboratory Maximum Density

Perform ~~Laboratory~~ laboratory ~~Density~~ density and ~~Moisture~~ moisture ~~Content~~ content tests (ASTM D 698 and ASTM D 2216) for each type of fill material to determine the optimum moisture (optimum moisture content plus or minus 5%) and laboratory maximum density values. One representative density test per material type and every 20,000 cubic yards there after or when any change in material occurs which may affect the optimum moisture content or laboratory maximum dry density. One correlation test for moistures every 10 tests per ASTM D6938 will be performed in accordance to ASTM D 4643 or ASTM D 2216.

In the stockpile, excavations, or borrow areas, perform moisture tests to control the moisture content of material being placed as fill. Control of moisture content of fill shall be performed by conducting routine testing of moisture content by one of the following tests:

- ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (Oven Moisture)
- ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating
- ASTM D 4944 - Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
- ASTM D 4959 - Determination of Water (Moisture) Content of Soil by Direct Heating
- During unstable weather, perform tests as dictated by local conditions and approved by the Construction Manager.

6.4 RESIDUAL RADIOACTIVE MATERIAL (RRM)

The objective is to place and compact the RRM in the waste cell to create a stable waste mass. ~~The~~ QC ~~Inspector~~ shall visually inspect the material preparation, ground preparation, and RRM placement operations, and shall perform in-place density tests with companion moisture tests for the CAES to verify that RRM compaction meets the compaction requirements. ~~The~~ QC ~~Inspector~~ shall verify that the RRM placement is performed in accordance with Plans and Specifications, and that the top of the placed waste matches the final grades identified in Section 6.4.5. RRM shall not be placed when frozen or over frozen subgrade. If rain water ponding has occurred, placement of RRM waste shall only be performed after the area is dewatered and approval of the Construction Manager~~,~~ and QC ~~Inspector or designee~~ to place is obtained.

6.4.1 Moisture Modification

RRM material should be shipped from the Moab site at or near optimum moisture for compaction. Some RRM may require minor moisture modification when received at Crescent Junction site.

6.4.2 RRM Placement

Scarify at a minimum the top one inch of subsoil or preceding RRM lift using a footed roller or a dozer prior to placement of subsequent RRM layers. Fill materials shall be placed in continuous and ~~approximately horizontal~~ planar lifts. The method of dumping and spreading RRM shall result in loose lifts of nearly uniform thickness, average thickness not to exceed 12". Compaction equipment shall consist of footed rollers or dozers. Footed rollers shall have a minimum weight of 45,000 pounds and at least one tamping foot shall be provided for each 110 square inches of drum surface. The length of each tamping foot from the outside surface of the drum shall be at least 6 inches. During compaction operations, the spaces between the tamping feet shall be maintained clear of materials which would impair the effectiveness of the tamping foot rollers. Dozers shall have a minimum ground pressure of 1,650 lbs per sq ft. The CAES ~~shall~~may ~~be~~ used to direct fill placement, monitor compaction, and record the location and thickness of each soil layer being placed.

6.4.3 Inspection and Testing

~~The Quality Control (QC) Inspector~~ shall visually inspect the ground preparation and fill placement operations. RRM shall be compacted to meet 90% of the laboratory determined maximum dry density as determined by (ASTM D 698). ~~The~~ QC ~~Inspector~~ shall verify that the RRM placement is constructed in accordance with Design Plans and Specifications by checking and confirming:

- Assessment tests shall be performed on RRM to assure compliance with specified requirements and to develop compaction requirements for placement. A minimum of three tests for maximum dry density (ASTM D 698) and optimum moisture content (optimum moisture plus or minus 3%) (ASTM D 2216) shall be performed for each type of RRM soil observed.
- Fill material is properly moisture conditioned, one moisture content quick test will be performed each day material is placed in accordance with (ASTM D 4643, ASTM D 4944, or ASTM D 4959) until a sufficient number have been performed to demonstrate a clear correlation allowing a reduction in testing.
- Fill material is placed in continuous and ~~approximately horizontal~~planar lifts. The method of dumping and spreading RRM shall result in loose lifts of nearly uniform thickness, average thickness of fill area not to exceed 12".
- Compaction meets specifications.
- Compaction by CAES ~~the~~ QC ~~inspector~~ shall monitor CAES compaction by visually inspecting the process and reviewing the computer records for each layer of soil placed.
- Verification tests of in-place density shall be performed on the initial layer of RRM and on any layers in which the CAES indicates that problems occurred obtaining compaction. In-place density will be taken every six months to verify the performance of the CAES.

Note: Companion sand cone tests and ~~oven~~-moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

If CAES is not used the following testing requirements shall be followed:

- Compaction Verification Tests – Perform in-place density and moisture content tests on compacted fill material in accordance with the following requirements:
    - When verification a representative sample from each principal type or combination of blended RRM materials shall be tested to establish compaction curves using ASTM D 698. A minimum of one set of compaction curves shall be developed per 10,000 cubic yards of RRM material. In-place density and moisture content tests are performed on a soil layer; a minimum of two tests shall be performed per 5,000 cubic yards or 135,000 square feet of fill material placed.

- Compaction and moisture content tests shall be performed in accordance with the following methods:
    - ASTM D 1556 - Density and Unit Weight of Soil in Place by the Sand-Cone Method
    - ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (Oven Moisture)
    - ASTM D 6938 - In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
    - ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating
- After lift placement, moisture content shall be maintained until the next lift is placed.
- Erosion that occurs in the RRM layers shall be repaired and grades re-established.
- Freezing and desiccation of the RRM soil shall be prevented. If freezing or desiccation occurs, the affected soil shall be reconditioned as directed.
- Areas that have been repaired shall be retested as directed. Repairs to the RRM layers shall be documented including location and volume of soil affected, corrective action taken, and results of retests.

6.4.4 Demolition Debris

Demolition debris will be placed in the waste cell along with RRM material. Each container of demolition debris shall be spread in a single layer, not stacked, and placed in a manner that results in a minimum of voids around the debris. The following materials will be placed in the waste cell:

- Wood, Concrete, Masonry: Cut or break up to a maximum 3-foot size measured in any dimension.

- Structural Steel Member, Pipes, Ducts, Other Long Items: Cut into maximum 10-foot lengths.
- Concrete, Clay Tile, and Other Pipes: Crush concrete and clay tile pipes. Crush other pipes and ducts that are 6 inches or greater in diameter or, if crushing is impractical, cut pipes and ducts in half longitudinally. Do not crush asbestos-cement pipe.
- Rubber Tires Excavated at the Site: Cut into two halves around the circumference.
- Geomembranes and Other Sheet Material: Cut into strips a maximum of 4 feet wide by 4 feet long.
- Tree Limbs 4 inches in Diameter and Larger: Cut into lengths of 8 feet or less.

6.4.5 Final RRM Geometry

The top surface of the RRM shall be no greater than 2 inches above the lines and grades shown on the drawings and verified by survey or the use of the CAES. No minus tolerance will be permitted.

6.5 INTERIM COVER

After a section the RRM have been placed in the waste cell to final grade and verified by survey, an interim cover consisting of 1 ft of clean, compacted soil shall be placed over the RRM. Interim cover material will be placed and compacted directly on top of RRM to provide a buffer of uncontaminated soil prior to the placement of the final multi-layer cap.

6.5.1 Material

Interim Cover Soil will be soil from the excavation of the Crescent Junction waste cell. It will be material that has been produced on site by modifying the existing overburden soil and weathered Mancos Shale excavated on site. Overburden and weathered Mancos Shale shall be excavated, pulverized, wetted, and mixed to produce a uniform fine-grained soil near optimum moisture content for compaction. Soil shall be free of roots, debris, and organic or frozen material, ~~, and shall have a maximum clod size of 2 inch based on visual at the time of compaction~~.

6.5.2 Ground Preparation

The RRM beneath the proposed interim cover shall be prepared by scarifying to a minimum depth of one inch prior to the placement of the initial lift of interim cover soil.

6.5.3 Lift Placement and Thickness

The interim cover shall be constructed of fill materials placed in continuous lifts of uniform thickness. The method of dumping and spreading Interim Cover Soil over the RRM shall result in loose lifts average thickness not to exceed 12". ~~The CAES shall be~~

~~used to direct fill placement, monitor compaction, and record the location and thickness of each soil layer being placed.~~

6.5.4 Inspection and Testing

The ~~Quality Control (QC) Inspector~~ shall visually inspect the ground preparation and fill placement operations. Interim Cover Layer shall be compacted to meet 90% of the laboratory determined maximum dry density as determined by (ASTM D 698). ~~The~~ QC ~~Inspector~~ shall verify that the interim cover is constructed in accordance with Plans and Specifications by checking and confirming:

- A representative sample from each type or combination of stockpiled excavated soil for use as Interim Cover soil shall be tested to establish compaction curves using ASTM D 698.

- Interim Cover is properly moisture conditioned, one moisture content test will be performed each day material is placed in accordance with (ASTM D 4643, ASTM D 4944, or ASTM D 4959) moisture content shall be plus or minus 5%;
- Interim Cover is placed in continuous and approximately horizontal lifts. The method of dumping and spreading interim cover shall result in loose lifts of nearly uniform thickness, average thickness not to exceed 12".
- Compaction is properly performed.
- Compaction by CAES – ~~the~~ QC ~~inspector~~ shall monitor CAES compaction by visually inspecting the process and reviewing the computer records for each layer of soil placed.
- Verification tests of in-place density shall be performed on the first 5,000 cubic yards of Interim Cover and on any layers in which the CAES indicates that problems occurred obtaining compaction.

Note: Companion sand cone tests and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

If CAES is not used the following testing requirements shall be followed:

- Compaction Verification Tests – Perform in-place density and moisture content tests on compacted fill material in accordance with the following requirements:
  - ~~Verification tests of in-place density shall be performed on the first 5,000 cubic yards of Interim Cover and on any layers in which the CAES indicates that problems occurred obtaining compaction.~~
  - When verification in-place density and moisture content tests are performed on a soil layer, a minimum of two tests shall be performed per 5,000 cubic yards or 135,000 square feet of fill material placed.
  -

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- o A representative sample from each type or combination of stockpiled excavated soil for use as Interim Cover soil shall be tested to establish compaction curves using ASTM D 698.
- o Interim Cover is properly moisture conditioned, one moisture content test will be performed each day material is placed in accordance with (ASTM D 4643, ASTM D 4944, or ASTM D 4959) moisture content shall be plus or minus 5%;
- o Interim Cover is placed in continuous and approximately horizontal lifts. The method of dumping and spreading interim cover shall result in loose lifts of nearly uniform thickness, average thickness not to exceed 12".
- o Compaction is properly performed.
- o Compaction and moisture content tests shall be performed in accordance with the following methods:
  - ASTM D 1556 - Density and Unit Weight of Soil in Place by the Sand-Cone Method
  - ASTM D 2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass (Oven Moisture)
  - ASTM D 6938 - In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
  - ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating
  - ASTM D 698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort

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Note: Companion sand cone tests and ~~oven~~-moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

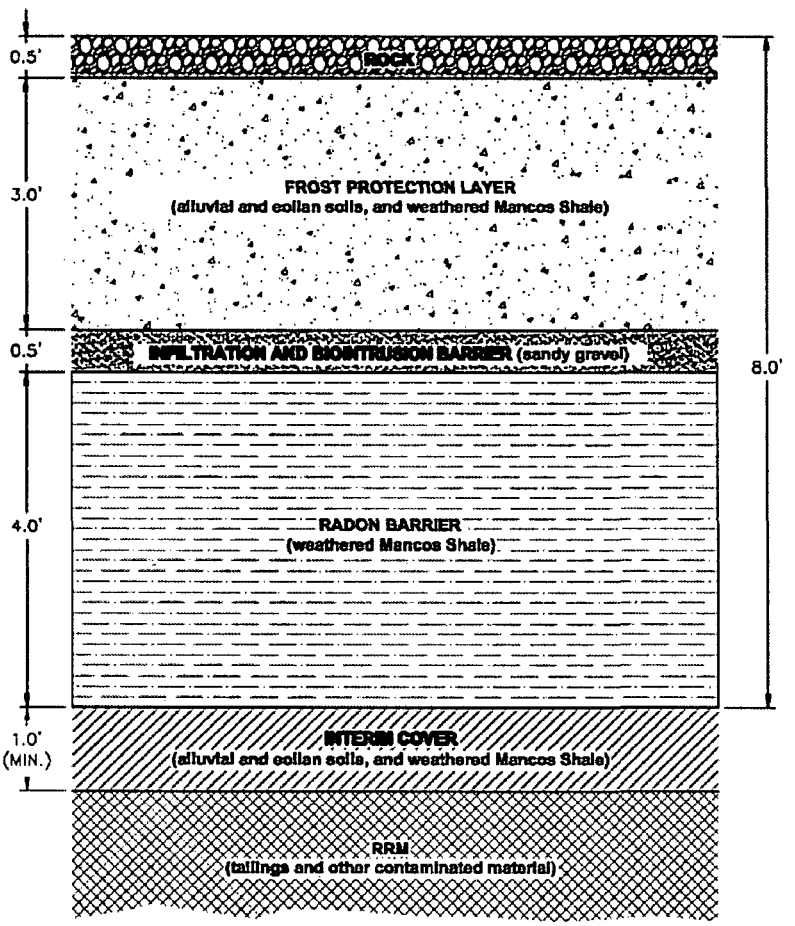
- After lift placement, moisture content shall be maintained until the next lift is placed.
- Erosion that occurs in the Interim Cover layer shall be repaired and grades re-established.
- Freezing and desiccation of the Interim Cover soil shall be prevented. If freezing or desiccation occurs, the affected soil shall be reconditioned as directed.
- Areas that have been repaired shall be retested as directed. Repairs to the Interim Cover layer shall be documented including location and volume of soil affected, corrective action taken, and results of retests.

6.5.5 Final Interim Cover Geometry

Proof roll the interim cover with rubber-tired construction equipment, such as a loaded dump truck or loaded scraper, with a minimum weight of 45,000 lbs to produce a smooth compacted surface on the top of the completed interim cover layer, such that direct rainfall causes minimal erosion. The top surface of the Interim Cover shall be no greater than 2 inches above the lines and grades shown on the drawings. No minus tolerance will be permitted

6.6 CAP CONSTRUCTION

An UMTRA cover, a multi-layer cap, will be constructed over the RRM waste and ~~interim~~ Interim ~~cover~~Cover. The cap materials and configuration are intended to protect the RRM waste from exposure due to water erosion, wind erosion, and burrowing animals for a design-life of 1,000 years. The proposed cap layers are shown in the following figure:



UMTRA COVER DESIGN

6.7 RADON BARRIER LAYER

The initial cap layer is a 4 ft thick Radon Barrier Layer constructed of compacted clay soil. The Radon Barrier will be a low-permeability clay layer that limits radon emissions from the RRM and limits the infiltration of water from above.

6.7.1 Material

The Radon Barrier Layer will be constructed of processed Mancos Shale soil. The clay soil will be produced on site by processing excavated Mancos Shale into a fine-grained soil and adding water to bring the Mancos Shale soil to near optimum moisture content for compaction.

Assessment tests shall be performed on radon barrier material to assure compliance with specified requirements and to develop compaction requirements for placement. A minimum of three tests for maximum dry density (ASTM D 698), optimum moisture content (ASTM D 2216) shall be performed for each type of soil observed to establish the optimum moisture for radon barrier material placement. Mancos Shale soil produced for Radon Barrier fill shall be tested to determine its maximum dry density and the optimum moisture content. The moisture content shall be modified to bring the fill to optimum for compaction. As a minimum, perform the following soil tests on each 10,000 cu yds of soil:

ASTM D 4318, Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 1140, Amount of Material in Soils Finer than the No. 200 Sieve
ASTM D 422, Standard Test Method for Particle-Size Analysis in Soil
ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
ASTM D 2216, Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass and/or ASTM D 4643, Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

6.7.2 Ground Preparation

The ~~I~~interim Ceover layer beneath the proposed Radon Barrier Layer shall be prepared by scarifying to a minimum depth of one inch prior to the placement of the initial lift of Radon Barrier soil.

6.7.3 Lift Placement and Thickness

The Radon Barrier Layer shall be constructed of fill materials placed in continuous lifts of uniform thickness. The method of dumping and spreading radon barrier shall result in loose lifts not to exceed 12". ~~The CAES shall be used to direct fill placement, monitor compaction, and record the location and thickness of each soil layer being placed.~~ Compaction equipment shall consist of rubber tired or footed rollers compaction equipment which have a minimum weight of 45,000 pounds. ~~and at least one foot for each 110 square inches of drum surface. The length of each tamping foot shall be at least~~

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~~6 inches, from the outside surface of the drum. During compaction operations, the spaces between the tamping feet shall be maintained clear of materials which would impair the effectiveness of the tamping foot rollers.~~ The in-place material may contain particles up to four inches.

Placement of mancos shale will be visually inspected to make sure there are no locations where rock type particles accumulate in a concentrated location. Particles found in a concentrated location will be removed or reworked per QC direction.

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6.7.4 Inspection and Testing

~~The Quality Control (QC) Inspector~~ shall visually inspect the processing of Mancos Shale into clay soil, ground preparation, and fill placement operations. ~~The~~ QC ~~Inspector~~ shall perform in-place density tests with companion moisture tests ~~(~~to verify optimum moisture plus or minus 3%~~,) to verify that the CAES compaction results in a density and~~~~of~~ at least 95% of the material's maximum dry density according to ASTM D 698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. ~~The~~ QC ~~Inspector~~ shall verify that the Radon Barrier is constructed in accordance with Plans and Specifications by checking and confirming:

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- Fill material is properly moisture conditioned, one moisture content test will be performed each day material is placed in accordance with (ASTM D 4643, ASTM D 4944, or ASTM D 4959~~);~~) moisture content plus or minus 3%.
- Material is placed in continuous uniform thickness lifts. The method of dumping and spreading radon barrier shall result in loose lifts not to exceed 12".
- Radon Barrier soil is processed Mancos Shale;
- Tests have been performed on the processed shale soil to determine its maximum dry density and optimum moisture content.
- Compaction – Radon Barrier fill is ~~spread and~~ compacted with rubber tired or~~a~~ footed roller compaction equipment~~. The compactor shall be equipped with a Computer Aided Earthmoving System and soil placement and compaction shall be controlled by the CAES.~~
- Compaction by CAES ~~the~~ QC ~~inspector~~ shall monitor CAES compaction by visually inspecting the process and reviewing the computer records for each layer of soil placed.
- Verification tests of in-place density shall be performed on initial layer of radon barrier placed, and on any layers in which the CAES indicates that problems occurred obtaining compaction.
- Maximum particle size in the fill material shall be 4 inches
- Placement of mancos shale will be visually inspected to make sure there are no locations where rock type particles accumulate in a concentrated location

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Note: Companion sand cone tests and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

If CAES is not used the following testing requirements shall be followed:

- Compaction Verification Tests – Perform in-place density and moisture content tests on compacted fill material in accordance with the following requirements:
  - When verification a representative sample from each principal type or combination of blended Radon Barrier materials shall be tested to establish compaction curves using ASTM D 698. A minimum of one set of compaction curves shall be developed per 10,000 cubic yards of Radon Barrier material.
  - In-place density and moisture content tests are performed on a soil layer; a minimum of two tests shall be performed per 5,000 cubic yards or 135, 000 square feet of fill material placed.
  - Fill material is properly moisture conditioned, one moisture content test will be performed each day material is placed in accordance with (ASTM D 4643, ASTM D 4944, or ASTM D 4959) moisture content plus or minus 3%.;
  - Material is placed in continuous uniform thickness lifts. The method of dumping and spreading radon barrier shall result in loose lifts not to exceed 12".
  - Radon Barrier soil is processed Mancos Shale;
  - Tests have been performed on the processed shale soil to determine its maximum dry density and optimum moisture content.
  - Compaction – Radon Barrier fill is compacted with rubber tired or footed roller compaction equipment.
  - Maximum particle size in the fill material shall be 4 inches
  - Placement of mancos shale will be visually inspected to make sure there are no locations where rock type particles accumulate in a concentrated location

~~- Compaction Verification Tests – Perform in-place density and moisture content tests on compacted fill material in accordance with the following requirements:~~

  - ~~Verification tests of in-place density shall be performed on initial layer of radon barrier placed, and on any layers in which the CAES indicates that problems occurred obtaining compaction.~~
  - ~~When verification in-place density and moisture content tests are performed on a soil layer, a minimum of one test shall be preformed a minimum of 2 tests per 5,000 cubic yards of material placed.~~
  - Compaction and moisture content tests shall be performed in accordance with the following methods:

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- ASTM D 1556 – Density and Unit Weight of Soil in Place by the Sand-Cone Method
- ASTM D 2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D 6938 - In-Place Density and Water content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth
- ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating
- ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

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Note: Companion sand cone tests and ~~oven~~ moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

- After placement, moisture content shall be maintained or adjusted to meet criteria.
- Erosion that occurs in the fill layers shall be repaired and grades re-established.
- Freezing and desiccation of the Radon Barrier ~~l~~Layer shall be prevented. If freezing or desiccation occurs, the affected soil shall be removed or reconditioned as directed.
- Areas that have been repaired shall be retested as directed. Repairs to the Radon Barrier ~~l~~Layer shall be documented including location and volume of soil affected, corrective action taken, and results of retests.

6.7.5 Initial and Confirmatory Surveys

Verification of the thickness of the Radon Barrier Layer will be performed by comparing before and after surveys of the Layer by surveying or using CAES. Prior to placement of the Radon Barrier Layer, an initial survey shall be performed of the section to be capped. The initial survey will document the pre-cap geometry of the site. After the Radon Barrier Layer has been installed, a post-installation survey will be performed on the top of the Radon Barrier fill to confirm that the total fill thickness is in accordance with the plans and specifications.

6.8 INFILTRATION AND BIOINTRUSION BARRIER (GRAVEL)

Above the Radon Barrier ~~l~~Layer, a 6 inch thick Infiltration and Biointrusion Layer of gravel will be placed to provide a barrier to burrowing animals, and a pathway for drainage of water that has infiltrated through upper layers of the cap. The gravel will be a sandy gravel with a gradation in accordance with project plans and specifications. Rock shall be spread to the thickness indicated on the drawings or in accordance with oversizing due to scoring criteria. Rock placement shall be guided by ~~the Computer Aided Earthmoving System~~ GPS grade control to ensure that the appropriate thickness

has been placed at all locations. ~~Stone with a D50 of 2 inches or less~~The Biointrustion Layer -shall be compacted with a vibratory steel drum.

6.8.1 Erosion Protection Materials Testing

Rock for the infiltration and biointrusion barrier layer shall be tested by a commercial testing laboratory during production in accordance with the following:

Riprap Type A and B, and Bedding Material	Reference
Specific Gravity (SSD)	ASTM C-127
Absorption	ASTM C-127
Sodium Sulfate Soundness (5 cycles)	ASTM C-88 (course aggregate)
L.A. Abrasion (100 cycles)	ASTM C-131

Riprap Type C and D	Reference
Schmidt Rebound Hardness	ISRM Method
Splitting Tensile Strength	ISRM Method

Test results shall be submitted to ~~MK Environmental Services~~a commercial testing lab for analysis and subsequent acceptance or rejection or the material represented by the test results, based on engineering calculations.

Rock for the infiltration and biointrusion barrier layer shall be tested for gradation in accordance with ASTMs C-117 and C-136, and other approved testing methods. Test results shall be in accordance with the Design Specification.

Rock for the infiltration and biointrusion barrier layer shall be tested a minimum of four times. The materials shall be tested- initially prior to the delivery of any of the materials to the site ~~and at the beginning of placement~~. Thereafter, the tests shall be performed in place at a minimum frequency of one test for each ~~10~~5,000 cubic yards or fractions thereof produced/placed (durability tests for materials produced/gradation tests for materials placed). A final set of durability tests shall be performed near completion of production for each type material. A final gradation test shall be performed near completion of placement for each type material.

Rock for the infiltration and biointrusion barrier layer shall be material that has long-term chemical and physical durability. The material shall achieve an acceptable score for its intended use, in accordance with the rock scoring and acceptance criteria.

6.8.2 Rock Acceptance Criteria

An acceptable rock score depends on the intended use of the rock. The rock's score must meet the following criteria:

- For occasionally saturated areas, which include the top and sides of the final cover, the rock must score at least 50% or the rock is rejected. If the rock scores between 50% and 80% the rock may be used, but a larger D50 must be provided (oversizing). If the rock score is 80% or greater, no oversizing is required.
- For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65% or the rock is rejected. If the rock scores between 65% and 80%, the rock may be used, but must be oversized. If the rock score is 80% or greater, no oversizing is required.

Oversize rock as follows:

- Subtract the rock score from 80% to determine the amount of oversizing required. For example, a rock with a rating of 70% will require oversizing of 10 percent (80% - 70% = 10%).
- The D50 of the stone shall be increased by the oversizing percent. For example, a stone with a 10% oversizing factor and a D50 of 12 inches will increase to a D50 of 13.2 inches.
- The final thickness of the stone layer shall increase proportionately to the increased D50 rock size. For example, a layer thickness equals twice the D50, such as when the plans call for 24 inches of stone with a D50 of 12 inches, if the stone D50 increases to 13.2, the thickness of the layer of stone with a D50 of 13.2 should be increased to 26.4 inches.

QC ~~Inspector~~ shall verify that the Infiltration and Biointrusion Layer is installed in accordance with Plans and Specifications by checking and confirming:

- Gravel material gradation matches the gradation required in the specifications.
- Gravel material is placed and compacted to produce a continuous uniform thickness of at least 6 inches.
- Compaction is performed by a vibratory steel drum roller, and that the roller makes a minimum of 2 passes over the placed gravel fill.

~~**6.8INFILTRATION AND BIOINTRUSION BARRIER (GRAVEL)**~~

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~~Above the Radon Barrier layer, a 6 inch thick Infiltration and Biointrusion Layer of gravel will be placed to provide a barrier to burrowing animals, and a pathway for drainage of water that has infiltrated through upper layers of the cap. The gravel will be a sandy gravel with a gradation in accordance with project plans and specifications. Rock shall be spread to the thickness indicated on the drawings or in accordance with oversizing due to scoring criteria. Rock placement shall be guided by the Computer Aided Earthmoving System to ensure that the appropriate thickness has been placed at all locations. Stone with a D50 of 2 inches or less shall be compacted with a vibratory steel drum.~~

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~~**6.8.1 Biointrusion Layer Materials Testing**~~

~~Rock for the infiltration and biointrusion barrier layer shall be tested by a commercial testing laboratory during production in accordance with the following:~~

~~Biointrusion Layer Material~~	~~Reference~~
~~Specific Gravity (SSD)~~	~~ASTM C-127~~
~~Absorption~~	~~ASTM C-127~~
~~Sodium Sulfate Soundness (5 cycles)~~	~~ASTM C-88 (course aggregate)~~
~~L.A. Abrasion (100 cycles)~~	~~ASTM C-131~~
~~Schmidt Rebound Hardness~~	~~ISRM Method~~

~~Test samples shall be submitted to a commercial testing lab for analysis and subsequent acceptance or rejection or the material represented by the test results, based on engineering calculations.~~

~~Rock for the infiltration and biointrusion barrier layer shall be tested for gradation in accordance with ASTMs C-117 and C-136, and other approved testing methods. Test results shall be in accordance with the Design Specification.~~

~~Rock for the infiltration and biointrusion barrier layer shall be tested a minimum of four times. The materials shall be tested initially prior to the delivery of any of the materials to the site and at the beginning of placement. Thereafter, the tests shall be performed at a minimum frequency of one test for each 10,000 cubic yards or fractions thereof produced/placed (durability tests for materials produced/gradation tests for materials placed). A final set of durability tests shall be performed near completion of production for each type material. A final gradation test shall be performed near completion of placement for each type material.~~

~~Rock for the infiltration and biointrusion barrier layer shall be material that has long-term chemical and physical durability. The material shall achieve an acceptable score for its intended use, in accordance with the rock scoring and acceptance criteria.~~

~~**6.8.2 Rock Acceptance Criteria**~~

~~An acceptable rock score depends on the intended use of the rock. The rock's score must meet the following criteria:~~

~~-For occasionally saturated areas, which include the top and sides of the final cover, the rock must score at least 50% or the rock is rejected. If the rock scores between 50% and 80% the rock may be used, but a larger D50 must be provided (oversizing). If the rock score is 80% or greater, no oversizing is required.~~

~~-For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65% or the rock is rejected. If the rock scores between 65% and 80%, the rock may be used, but must be oversized. If the rock score is 80% or greater, no oversizing is required.~~

~~Oversize rock as follows:~~

~~-Subtract the rock score from 80% to determine the amount of oversizing required. For example, a rock with a rating of 70% will require oversizing of 10 percent (80% - 70% = 10%).~~

~~-The D50 of the stone shall be increased by the oversizing percent. For example, a stone with a 10% oversizing factor and a D50 of 12 inches will increase to a D50 of 13.2 inches.~~

~~-The final thickness of the stone layer shall increase proportionately to the increased D50 rock size. For example, a layer thickness equals twice the D50, such as when the plans call for 24 inches of stone with a D50 of 12 inches, if the stone D50 increases to 13.2, the thickness of the layer of stone with a D50 of 13.2 should be increased to 26.4 inches.~~

~~QC Inspector shall verify that the Infiltration and Biointrusion Layer is installed in accordance with Plans and Specifications by checking and confirming:~~

~~-Gravel material gradation matches the gradation required in the specifications.~~

~~-Gravel material is placed and compacted to produce a continuous uniform thickness of at least 6 inches. As a minimum depth verification will be performed every 10,000 cu yds.~~

~~-Compaction is performed by a vibratory steel drum roller, and that the roller makes a minimum of 2 passes over the placed gravel fill.~~

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~~6.10~~6.9 FROST PROTECTION LAYER

Above the Infiltration and Biointrusion Layer a 3 feet thick Frost Protection Layer will be installed. This soil layer will provide protection for the low-permeability Radon Barrier Layer beneath. The Frost Protection Layer will consist of 3 ft of clean, compacted soil shall be placed directly on the gravel Infiltration and Biointrusion Layer.

6.9.1 Material

The Frost Protection Layer will be constructed of common fill. The fill shall ~~be produced from stockpiled excavated common fill~~come from the cell excavation, tested to determine

its maximum dry density, and the moisture content modified to bring the fill to optimum for compaction in accordance with ASTM D 698.

6.9.2 Ground Preparation

The Frost Protection Layer will be placed directly on the gravel Infiltration and Biointrusion Layer.

6.9.3 Lift Placement and Thickness

The Frost Protection Layer shall be constructed of fill materials placed in continuous lifts of uniform thickness. The method of dumping and spreading of the frost protection layer shall result in loose lifts average thickness not to exceed 12". Scarification shall be performed on all areas of the upper surface of each underlying soil layer prior to placement of the next lift. ~~Scarification shall be accomplished with approved equipment.~~ The final lift of soil shall not be scarified. The final lift shall be smooth rolled with at least 3 passes of the approved smooth steel wheeled roller weighing a minimum of 20,000 pounds.

6.9.4 Inspection and Testing

~~The Quality Control (QC) Inspector~~ shall visually inspect the material preparation, ground preparation, and fill placement operations. ~~The~~ QC ~~Inspector~~ shall perform in-place density tests with companion moisture tests ~~(~~optimum moisture plus or minus 5%~~)~~ ~~to verify that the CAES compaction results in a density of~~and at least 90% of the material's maximum dry density according to ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort on the initial layer. ~~The~~ QC ~~Inspector~~ shall verify that the frost protection layer is constructed in accordance with Plans and Specifications by checking and confirming:

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- Frost Protection Layer soil is common fill;
- Tests have been performed on the common fill to determine its maximum dry density and optimum moisture content per ASTM D 698.
- Fill material is properly moisture conditioned to near optimum moisture;
- Fill material is placed in continuous and approximately horizontal lifts. The method of dumping and spreading the frost protection layer shall result in loose lifts of nearly uniform thickness, average thickness not to exceed 12".
- Compaction is properly performed.
- Compaction – Frost Protection fill will be compacted with rubber tired or footed roller compaction equipment.~~Fill shall be compacted with a minimum 45,000 lb static~~

~~weight compactor. The compactor shall be a footed roller capable of kneading compaction, with feet a minimum of 6 inches in length. The compactor shall be equipped with a Computer Aided Earthmoving System and soil placement and compaction shall be controlled by the CAES.~~

- Compaction by CAES —~~the~~ QC ~~inspector~~ shall monitor CAES compaction by visually inspecting the process and reviewing the computer records for each layer of soil placed.
- Verification tests of in-place density shall be performed on initial layers of soil placed, and on any layers in which the CAES indicates that problems occurred obtaining compaction.

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Note: Companion sand cone tests and moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

If CAES is not used the following testing requirements shall be followed:

- Compaction Verification Tests – Perform in-place density and moisture content tests on compacted fill material in accordance with the following requirements:
  - ~~Verification tests of in-place density shall be performed on initial layers of soil placed, and on any layers in which the CAES indicates that problems occurred obtaining compaction.~~
  - When verification in-place density and moisture content tests are performed on a soil layer, a minimum of ~~one test shall be preformed a minimum of~~ 2 tests per 5,000 cubic yards or 135,000 square feet of fill material placed.
  - Frost Protection Layer soil is common fill;
  - Tests have been performed on the common fill to determine its maximum dry density and optimum moisture content per ASTM D 698.
  - Fill material is properly moisture conditioned to near optimum moisture;
  - Fill material is placed in continuous and approximately horizontal lifts. The method of dumping and spreading the frost protection layer shall result in loose lifts of nearly uniform thickness, average thickness not to exceed 12".
  - Compaction is properly performed.
  - Compaction – Frost Protection fill will be compacted with rubber tired or footed roller compaction equipment.
  - Compaction and moisture content tests shall be performed in accordance with the following methods:
    - ASTM D 1556 – Density and Unit Weight of Soil in Place by the Sand-Cone Method
    - ASTM D 698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
    - ASTM D 2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
    - ASTM D 2922 - Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

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- ASTM D 6938 - In-Place Density and Water content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- ASTM D 4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating

Note: Companion sand cone tests and ~~oven~~ moisture tests must be performed along with nuclear tests until a sufficient number have been performed to demonstrate a clear correlation.

6.9.5 Initial and Confirmatory Surveys

Verification of the thickness of the Frost Protection Layer will be performed by comparing before and after surveys of the Layer. Prior to placement of the Frost protection Layer, an initial survey shall be performed of the section to be capped. The initial survey will document the geometry of the top of the Infiltration and Biointrusion Layer. After the Frost Protection Layer has been installed, a post-installation survey will be performed on the top of the Frost Protection Layer to confirm that the total fill thickness is in accordance with the plans and specifications.

~~6.11~~6.10 ROCK ARMORING

The final cap layer is Rock Armoring, placed over the Frost Protection Layer. The Rock Armoring will vary in size and thickness at different locations on the cap, and shall be installed in accordance with the project plans and specifications Rock shall be spread to the thickness indicated on the drawings or in accordance with oversizing due to scoring criteria. Rock placement shall be guided by ~~the~~ a ~~Computer Aided Earthmoving System~~GPS system to ensure that the appropriate thickness has been placed at all locations. Stone ~~with a D50 of 2 inches or less~~ shall be compacted with a vibratory steel drum.

6.10.1 Erosion Protection Materials Testing

Rock for the final cover layers shall be tested by a commercial testing laboratory during production in accordance with the following:

Rock Armoring	Reference
Specific Gravity (SSD)	ASTM C-127
Absorption	ASTM C-127
Sodium Sulfate Soundness (5 cycles)	ASTM C-88 (course aggregate)
L.A. Abrasion (100 cycles)	ASTM C-131

Test samples shall be submitted to a commercial testing lab for analysis and subsequent acceptance or rejection or the material represented by the test results, based on engineering calculations.

Rock for the final cover layers shall be tested for gradation in accordance with ASTMs C-117 and C-136, and other approved testing methods. Test results shall be in accordance with the Design Specification.

Rock for the final cover layers shall be tested a minimum of four times. The materials shall be tested initially prior to the delivery of any of the materials to the site and at the beginning of placement. Thereafter, the tests shall be performed in place at a minimum frequency of one test for each 5,000 cubic yards or fractions thereof produced/placed (durability tests for materials produced/gradation tests for materials placed). A final set of durability tests shall be performed near completion of production for each type material. A final gradation test shall be performed near completion of placement for each type material. ~~Thereafter, the tests shall be performed prior to placement at a minimum frequency of one test for each 10,000 cubic yards or fractions thereof produced/placed (durability tests for materials produced/gradation tests for materials placed). Where the total volume is less than 30,000 cubic yards, the test frequency shall be one test for each type material when approximately one-third and two-thirds of the total volume of material has been produced/placed. A final set of durability tests shall be performed near completion of production for each type material. A final gradation test shall be performed near completion of placement for each type material.~~

Rock for the final cover layers shall be rock material that has long-term chemical and physical durability. Rock for final cover layers shall achieve an acceptable score for its intended use, in accordance with the rock scoring and acceptance criteria.

At the quarry operations periodically a geologist will inspect the stockpiles to ensure the percent of other than grey basalt does not exceed 10% for rock for the final cover layers. ~~At the quarry operations periodically a geologist will inspect the stockpiles to ensure the percent of other than grey basalt does not exceed 10% for rock for the final cover layers.~~

6.10.2 Rock Acceptance Criteria

An acceptable rock score depends on the intended use of the rock. The rock's score must meet the following criteria:

- For occasionally saturated areas, which include the top and sides of the final cover, the rock must score at least 50% or the rock is rejected. If the rock scores between 50%

and 80% the rock may be used, but a larger D50 must be provided (oversizing). If the rock score is 80% or greater, no oversizing is required.

- For frequently saturated areas, which include all channels and buried slope toes, the rock must score 65% or the rock is rejected. If the rock scores between 65% and 80%, the rock may be used, but must be oversized. If the rock score is 80% or greater, no oversizing is required.

Oversize rock as follows:

- Subtract the rock score from 80% to determine the amount of oversizing required. For example, a rock with a rating of 70% will require oversizing of 10 percent (80% - 70% = 10%).
- The D50 of the stone shall be increased by the oversizing percent. For example, a stone with a 10% oversizing factor and a D50 of 12 inches will increase to a D50 of 13.2 inches.
- The final thickness of the stone layer shall increase proportionately to the increased D50 rock size. For example, a layer thickness equals twice the D50, such as when the plans call for 24 inches of stone with a D50 of 12 inches, if the stone D50 increases to 13.2, the thickness of the layer of stone with a D50 of 13.2 should be increased to 26.4 inches.

QC ~~Inspector~~ shall verify that the Rock Armoring is installed in accordance with Plans and Specifications by checking and confirming:

- ~~Stone gradations match the gradation required in the specifications and based on visual verification, fines (material < 200 mesh) are dispersed evenly throughout the rock.~~
- Stone material is placed to produce the thickness required by the plans for each area. As a minimum, depth verification will be performed every 10,000 cu yds.

Cell Component	Material of Construction	Compaction Requirements	Lift Thickness max./ approx loose / compact	Frequency of Verification Tests
Cell Excavation	N/A	N/A	N/A	N/A
Perimeter Embankment	Common Fill	95%	12" / 10"	Initial layer / Section 6.3.4

RRM Placement	RRM	90%	Average thickness 12" / 10"	Initial layer / Section 6.4.3
Interim Cover	Common Fill	90%	Average thickness 12 / 10"	Initial layer / Section 6.5.4
Radon Barrier	Weathered Mancos Shale	95%	12" / 10"	Initial layer / Section 6.7.4
Infiltration and Bio-intrusion Barrier	Stone	N/A	N/A	N/A
Frost Protection	Common Fill	90%	Average thickness 12" / 10"	Initial layer / Section 6.9.4
Cap Armoring	Stone	N/A	N/A	N/A

Cell Construction Material Installation Summary Table

~~6.12~~6.11 SETTLEMENT MONITORING

A grid system shall be established for periodic surveys to monitor cell settlement. This system will be transferred to DOE Legacy Management (LM) for continued cell settlement monitoring.

7.0 RECORDS

7.1 Test and inspection records shall be reported and filed in a timely manner, consistent with the status of work performed. Inspection and test status shall be available at all times to prevent inadvertent by-passing of an inspection or test.

7.2 Test and inspection records shall contain, at a minimum, the following:

7.2.1 Items tested or inspected.

7.2.2 Date of test or inspection.

7.2.3 Tester/inspector.

7.2.4 Type of test or inspection.

7.2.5 Results and acceptability, including the test or inspection acceptance criteria.

7.2.6 Identification number of instrument used in performing the test or inspection.

7.2.7 Action taken in connection with any deviations noted.

7.2.8 Person evaluating test results, if different from person named in paragraph

7.3 Test and inspection records shall be filed and maintained in accordance with DOE-EM/GJT1545 "Records Management Manual."

7.4 Surveillances shall be performed by Quality Assurance of M&TE used by Quality Control.

7.5 Daily Inspection Reports shall be generated, describing the adequacy, discrepancies, progress, dispositions and details of each day's construction activities.

7.6 Permanent QA/QC records shall be periodically evaluated through internal and external surveillances and audits.

7.7 A weekly Quality Control Report shall be generated, summarizing the volume of in-placed materials and the number of field and laboratory tests performed for each type of material. A copy of the weekly QC Report shall be transmitted to the ~~ES~~ RAC Quality Manager.