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Canonie Environmental

As-Built Report

Central Cell Final Reclamation

Church Rock Site
Gallup, New Mexico

Prepared For:

UNC Mining and Milling
A Division of United Nuclear Corporation
Gallup, New Mexico

As-Built Report

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UNITED NUCLEAR CORPORATION
CHURCH ROCK FACILITY
GALLUP, NEW MEXICO

1.0 INTRODUCTION

This report describes the construction of the final reclamation cover for the Central Cell of the uranium tailings disposal area at United Nuclear Corporation's (United Nuclear's) Church Rock facility. The site is located northeast of Gallup, New Mexico, along State Highway 566, as shown on Sheet 1. United Nuclear is continuing reclamation of the site as scheduled, in accordance with the "Tailings Reclamation Plan as Approved by the NRC March 1, 1991, License Number SUA-1475" (Reclamation Plan) [Canonie Environmental Services Corp. (Canonie), 1991].

Final reclamation of the Central Cell consisted of completing the radon attenuation soil cover, placing the erosion protection cover and constructing drainage swales over the reclaimed surface. The reclamation was performed from May to October 1994 and encompassed approximately 40 acres of the Central Cell and surrounding areas. Work also continued on the upper reach of the Runoff Control Ditch located west of the tailings disposal area.

Construction of the final cover for the Central Cell represents the second stage of final reclamation for the tailings disposal area. Final reclamation of the North Cell was previously completed in 1993 as documented in the "As-Built Report, North Cell Final Reclamation" (Canonie, 1994). Interim stabilization of the entire tailings disposal area was previously completed from 1989 to 1991 and consisted of regrading the tailings and placing the interim soil cover. As-built reports for interim stabilization include the North Cell (Canonie, 1990), Central Cell [Western Technologies, Inc. (WT), 1991], South Cell (Canonie, 1992a) and Central Cell Addendum (Canonie, 1992b).

Sheet 2 shows the design plan view and Sheet 3 shows the design details and cross sections for the installation of the final cover over the Central Cell. Construction activities for this phase of the reclamation included:

1. Grubbing of the Central Cell area to remove vegetation from the interim soil cover

2. Placing and compacting 12 inches of soil to complete the radon attenuation barrier

3. Covering the radon attenuation barrier with a minimum of 3 inches of rock

4. Placing and compacting soil over the rock cover

5. Constructing drainage swales and channels to control surface water runoff

These construction activities were performed in accordance with the design drawings (Sheets 2 and 3) and the specifications provided in Appendix B of the Reclamation Plan. A minor modification to the soil cover design was developed by Canonie in accordance with Nuclear Regulatory Commission (NRC) guidelines and is documented in this report. This modification consisted of the placement of an additional 3 inches of radon attenuation cover.

Sheet 4 shows the as-built plan view of the final cover, surface water controls for the Central Cell and the section of the Runoff Control Ditch constructed in 1994. Backfilling of Borrow Pit No. 2, located east of the Central Cell, was also completed during the 1994 construction season. Final reclamation of the borrow pit, including completion of Branch Swales A, B and C, will be completed in the future.

Construction services for the reclamation activities were provided to United Nuclear by Nielson's General Contractors (Nielson's). Table 1 lists the equipment used by Nielson's during construction. The crushed rock for the erosion protection cover and the riprap and bedding material for the drainage swales and channels were provided by Hamilton Brothers, Inc. (Hamilton). WT provided geotechnical sampling and testing services.

Appendix A provides WT's field reports of daily construction activities and a summary of the geotechnical tests performed for the project.

The following sections of this document describe the construction activities and quality control procedures implemented during construction of the radon attenuation layer, erosion protection cover and surface water controls. Copies of the geotechnical test results and design evaluations for minor field modifications are provided in the appendices.

2.0 RADON ATTENUATION LAYER

The radon attenuation layer over the Central Cell consists of 21 inches of compacted soil and is designed to reduce the long-term radon flux from the underlying tailings to 20 picoCuries per square meter per second (pCi/m^2/sec). The 21-inch layer consists of the soil cover placed during interim stabilization activities in 1990 and 1991 (WT, 1991, and Canonie, 1992b) plus the final lift of soil added during this phase of reclamation activities.

The Reclamation Plan (Canonie, 1991) design specified only 18 inches of compacted soil for the radon attenuation layer. However, radon exit flux measurements conducted after completion of interim stabilization indicated that some areas of the Central Cell had higher than anticipated radon flux values. To compensate for these higher flux values, the thickness of the radon attenuation layer was increased from 18 to 21 inches in the Central Cell. Section 2.2.1 and Appendix B provide the details of the soil radon barrier evaluation performed in making this field modification.

The soil radon attenuation layer constructed during final reclamation activities was placed, compacted and tested as described below.

2.1 Construction Methods and Materials

Prior to placement of the final lift of the radon attenuation cover, the Central Cell interim soil cover was grubbed of vegetation using scrapers and a motor grader. The grubbing removed an average of approximately 3 inches of soil from the top of the existing 12-inch interim cover, leaving an average of 9 inches of compacted soil cover in place. The top of the remaining interim cover was then scarified and moisture conditioned prior to placing the final soil cover to provide for adequate bonding between the interim and final soil covers. The thickness of the final cover averaged 12 inches, thereby bringing the total thickness of the radon attenuation cover to 21 inches.

The soil used to construct the final lift of the radon attenuation cover was obtained from the Borrow Pit No. 2 soil stockpile (Sheet 4), which is located immediately south of the backfilled borrow pit. The soil within the stockpile ranges from a silty clay to a sandy lean clay and meets the soil classification requirements specified on Figure B-1 of the technical specifications presented in the Reclamation Plan. The soil was excavated and transported to the Central Cell area using scrapers. Fine grading of the soil cover was performed using a motor grader. This grading is called "blue topping" in the field reports (Appendix A) in reference to the blue grade stakes used to designate final cover elevations.

The soil cover was conditioned to meet construction specifications by adding water and compacting. This process consisted of scarifying the soil with a roame plow and/or motor grader and spraying water on top of the soil using a water wagon. A sheepsfoot compactor was used to obtain primary compaction. Afterwards the top of the soil layer was sealed using a smooth-drum roller.

The total volume radon attenuation cover placed over the Central Cell, excluding swale areas, was approximately 54,000 cubic yards (cy). This estimate is based on 33.4 acres of Central Cell tailings area and an average final soil cover of 12 inches. The radon attenuation cover placed in the swale areas (3.2 acres) was inspected and tested separately as described in Section 4.0 of this report. The 54,000 cy of soil cover was placed, moisture conditioned and compacted in 20 work days between June 21 and July 31, 1994, at an average rate of 2,700 cy per work day.

2.2 Specifications and Testing

Construction specifications for placement of the radon attenuation cover as stipulated in the Reclamation Plan are listed below. Adherence to these specifications was maintained through strict survey control and geotechnical testing of soil properties and field density.

1. A total of 18 inches of soil cover shall be placed over the regraded tailings.

2. Soil used for the cover shall be clays, silts and fine-grained sands which fall within the gradation envelope shown on Figure B-1 of Appendix B.

3. The soil cover over the tailings is to be compacted to a minimum of 95 percent of the maximum dry density at a moisture content of within 2 percent above the optimum moisture content as determined by the Standard Proctor Compaction Method [American Society for Testing and Materials (ASTM) D 698].

4. The areas surrounding the tailings that are incorporated into the reclamation work, such as drainage swales in native soils, will be excavated and regraded in accordance with the construction drawings, and compacted to a minimum of 90 percent of the maximum dry density as determined by the Standard Proctor Compaction Method (ASTM D 698).

A field modification consisting of increasing the total soil cover thickness from 18 to 21 inches was also implemented. This modification was based on evaluations of as-built parameters for the interim cover using the NRC-approved RAECOM radon attenuation model as described in Section 2.2.1 below. Subsequent sections discuss the survey control and geotechnical testing performed to verify that the radon attenuation cover was constructed in accordance with specifications.

2.2.1 Field Modification

Radon exit flux measurements conducted after completion of interim stabilization indicated that some areas of the Central Cell had higher than anticipated radon flux values. To identify the source of the elevated radon flux, samples of the regraded coarse tailings and interim cover were collected to a depth of 7 feet and tested for radium-226, emanation coefficients, diffusion coefficients and physical parameters. The results, presented in Appendix B, indicated that fine tailings with higher radium-226 activity levels had been mixed in with the coarse tailings during regrading in portions of the Central Cell.

The soil radon barrier and the exit flux were reevaluated by inputting the data from the sampling program into the RAECOM model. The modeling results indicated that the average radon flux for the entire tailings disposal area would remain below 20 pCi/m^2/sec without modifying the radon attenuation layer design thickness of 18 inches of soil (i.e., 1 foot of interim cover plus an additional 6 inches of final cover). To provide an additional margin of safety however, the soil cover was increased by 3 inches to a total of 21 inches. This resulted in an average calculated exit flux of 17.6 pCi/m^2/sec in the RAECOM model.

2.2.2 Survey Control

During previous reclamation activities in 1990, the top of the Central Cell tailings was graded to the design slope and 12 inches of interim soil cover (i.e., the initial lift of the radon attenuation cover) were placed and compacted in accordance with the construction drawings and specifications (WT, 1991). To insure that the final lift of soil cover was applied uniformly and that the required total cover thickness of 21 inches was achieved, the Central Cell was surveyed on a 100-foot by 100-foot grid system both prior to and after grubbing of vegetation. Subtraction of the second set of surveyed elevations from the initial set of elevations determined the thickness of soil removed by grubbing. The thickness of the soil removed averaged 3 inches. A final lift of soil cover averaging 12 inches was then added to the remaining 9-inch interim cover, thereby bringing the total thickness of the radon attenuation cover to 21 inches.

Elevations for the final lift were established in the field by placing wooden stakes at each grid location with the top-of-grade marked by a blue ribbon. These top-of-grade stakes were checked frequently and reestablished as necessary during placement of the final soil cover.

2.2.3 Soil Properties

The suitability of the borrow soil for use in the radon attenuation cover was verified by performing gradation and Atterberg tests at 67 locations distributed uniformly over the radon attenuation cover as the soil was placed. All of the tests indicated that the soil was within the specified gradation limits and met soil classification requirements. The testing frequency of 1 gradation test for every 800 cy of soil (i.e., 54,000 cy/67 gradation tests) exceeded the specified test rate of 1 test for every 1,000 cy placed. The laboratory reports documenting the results of the gradation and Atterberg tests for the radon attenuation layer are presented in Appendix C.

2.2.4 Field Density

In-place field moisture-density testing of the soil cover was conducted using the sand-cone method (ASTM D 1556). A total of 138 locations distributed uniformly over the tailings soil cover were tested, of which 134 met the required density and moisture specifications on the initial test. The remaining four locations were recompacted until additional testing confirmed that required minimum moisture-density standards were met. The test frequency of one moisture-density test for every 390 cy of soil (i.e., 54,000 cy/ 138 moisture-density tests) exceeded the specified test rate of one test for every 500 cy placed. The laboratory reports documenting the results of the sand cone testing are presented in Appendix D.

The average dry density and moisture content of the 138 passing tests were 116.4 pounds per cubic foot (pcf) and 14.7 percent, respectively. This average dry density and in-situ moisture content are higher than the values used in the Reclamation Plan design of 108.0 pcf and 12.9 percent, respectively. The average values from the testing correspond to an in-situ porosity of 0.28 and a saturation of 98 percent, as compared to the design values of 0.33 and 68 percent for porosity and saturation, respectively. The higher density and degree of saturation of the radon attenuation layer will provide improved radon attenuating properties as compared to the cover modeled in the Reclamation Plan.

2.2.5 Proctor Tests

A total of 22 Standard Proctor tests and 28 One-Point Proctor tests were conducted during completion of the radon attenuation cover over the Central Cell. The results of these tests are presented in Appendix E. The Standard Proctor tests were performed in accordance with ASTM D 698A to determine the relationship between moisture and density in the soil over a range of moisture and density values. The One-Point Proctor tests were performed in accordance with testing procedures in ASTM D 698 and were performed to verify a moisture-density relationship at a specific moisture content. When a moisture-density curve was found for which the One-Point Proctor could be plotted on or near the curve, that moisture-density curve was considered to be representative of the soil tested.

The Reclamation Plan specifies that Standard Proctor tests be conducted for every 15 field density tests, and One-Point Proctor tests be performed for every 5 field density tests. Based on 138 test locations, this specification was adequately met with 1 Standard Proctor test performed for every 6.3 field density tests, and 1 One-Point Proctor test performed for every 4.9 field density tests.

3.0 EROSION-PROTECTION COVER

The erosion-protection cover consists of 6 inches or more of a soil/rock matrix placed on top of the radon attenuation soil cover. The soil/rock matrix is designed to promote surface water runoff and protect the underlying radon attenuation soil layer from wind and water erosion. The erosion-protection cover was constructed over the entire area of the Central Cell except for the drainage swales which were riprapped in accordance with the Reclamation Plan (refer to Section 4.0 for drainage swale construction). Construction methods, materials and testing for the erosion-protection cover are described below.

3.1 Construction Methods and Materials

The soil/rock matrix was constructed by placing a minimum of 3 inches of rock mulch over the completed radon attenuation soil cover, then placing a 4- to 6-inch layer of random soil material over the rock mulch. The soil was then forced into the rock mulch voids to form the soil/rock matrix.

The rock mulch consisted of a basaltic aggregate with a D_{50} of 1.5 inches. This same rock was also used as riprap in the Runoff Control Ditch and portions of the drainage swales described in Section 4.0. Construction of the rock mulch layer consisted of dumping the rock directly from haul trucks and scrapers onto the top of the completed radon attenuation cover in a series of wind rows. A motor grader was then used to spread the rock to the required thickness of 3 inches or greater.

The 4 to 6 inches of soil placed on top of the rock mulch were obtained from the Borrow Pit No. 2 stockpile. This soil was excavated, transported and placed using scrapers. Afterwards, a pneumatic compactor was used to force the soil into the underlying rock mulch, thereby creating the required soil/rock matrix. Finish grading of the top of the completed cover was performed using a motor grader.

3.2 Specifications and Testing

Construction specifications for construction of the erosion protection cover as stipulated in the Reclamation Plan include:

1. The rock mulch is to be dense limestone or other suitable rock and is to meet the following criteria: specific gravity = 2.6 or greater; absorption = 1.8 percent or less; and sodium sulfate loss = 10 percent or less. Alternatively, the rock source shall have a minimum score of 50 using the scoring criteria shown in Table D1 of the August 1990 Staff Technical Position (STP), "Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites" or equivalent, and shall be oversized, if needed, in accordance with the procedures provided in Appendix D of the August 1990 STP.

2. The rock mulch is to be placed a minimum of 3 inches thick and have a nominal D_{50} of 1.5 inches with the following size gradations: 100 percent passing a 3-inch screen; 8 to 37 percent passing a 1-inch screen; and, 0 to 8 percent passing a No. 4 screen.

3. The soil for the soil/rock matrix is to be a clayey sand to sandy clay with no more than 25 percent of the soil greater than 1/2-inch in diameter. The soil is to be placed in a 4- to 6-inch lift over the rock mulch and compacted a minimum of 2 inches into the rock mulch. After compaction, the top of the soil layer is to be a minimum of 3 inches and a maximum of 4.5 inches above the rock mulch.

Adherence to the specifications was maintained through geotechnical testing of the rock mulch and by measuring the rock mulch thickness, soil layer thickness, and the depth of soil penetration into the rock mulch as described below.

3.2.1 Rock Mulch Quality

The rock used to construct the rock mulch was a dense basaltic rock with durability characteristics superior to the criteria stipulated in the technical specifications. A total of 3 tests were performed to verify the rock's quality. The test results are presented in Appendix F. The average test values for the rock included a specific gravity of 2.75, an absorption of 1.8 percent, a sodium sulfate loss of 2.1 percent, and an L.A. Abrasion percentage of 4.58. The rock quality score for the 3 tests, using the scoring criteria provided in the August 1990 STP, ranged from 82 to 92 with an average score of 86.

The specifications require that a series of rock durability tests be performed initially and for each additional 10,000 cy of rock placed. More frequent testing is also required if the rock characteristics in the rock borrow source vary significantly from the rock that was previously tested. United Nuclear records show that a total of 19,220 cy of rock was placed as rock mulch and riprap during final reclamation of the Central Cell. No change in rock characteristics was noted by the quality control technician. Therefore, the rock quality testing rate of 1 series of tests per 6,400 cy of rock placed (i.e., 19,220 cy/3 tests) exceeded the test rate required by the specifications.

3.2.2 Rock Mulch Thickness and Size Gradation

The basaltic rock with a D_{50} of 1.5 inches that was used to construct the rock mulch and to riprap the surface water control structures was subjected to sieve analyses to determine if gradation requirements were being met. A total of 7 samples were tested at the quarry and 2 at the site prior to spreading. The 4 initial samples collected and tested at the quarry did not meet gradation specifications and this material was not used. The final 3 tests at the quarry and the 2 samples collected and tested at the site all met the gradation requirements. The results of the sieve analysis testing are presented in Appendix G.

The thickness of the rock mulch was checked and recorded on 50-foot centers over the entire extent of the Central Cell tailings area. Areas having a measured thickness of less than 3 inches or greater than 5 inches were regraded by Nielson's and then rechecked to verify that a rock mulch thickness between 3 and 5 inches had been achieved. The recorded measurements are presented in Appendix H.

3.2.3 *Soil Thickness and Penetration*

The soil used to construct the soil/rock matrix was obtained from the Borrow Pit No. 2 soil stockpile. Gradation analyses performed for constructing the radon attenuation barrier (see Appendix C) indicates that this soil ranges from silty clay to sandy lean clay with an average of only 1 to 2 percent of the material greater than 1/2-inch in diameter. This soil is slightly finer than the clayey sand to sandy clay called for in the specifications. Use of the finer soil is an improvement on the design specification because it allows for greater penetration of the soil into the rock mulch and increases the cohesion of the soil/rock matrix.

The thickness of the soil layer and the depth of penetration of the soil into the rock mulch was checked on a uniform basis over the entire extent of the soil/rock matrix cover. The measurements were performed on staggered 100-foot centers. The results of the measurements are presented in Appendix I and show that the soil layer above the rock mulch was a minimum of 3 inches in all areas, and a maximum of 4.5 inches in most areas. In some areas adjacent to the branch swales, the soil layer thickness was increased above 4.5 inches to provide adequate surface drainage. The depth of soil penetration into the rock mulch exceeded 2 inches in all areas.

4.0 SURFACE WATER CONTROL STRUCTURES

Surface water control structures associated with the Central Cell include:

1. Branch Swales A, B, C, D and H
2. Runoff Control Ditch

Sheets 2 and 3 show the design details for these structures. Sheet 4 shows the as-built conditions for those portions completed during Central Cell reclamation in 1994.

Branch Swales A, B, C, D and H are shallow, riprapped ditches located on top of the Central Cell designed to convey runoff from the reclaimed tailings area. The North Cell Drainage Channel, constructed in 1993, is located along the east side of the North Cell (see Sheet 2) and is designed to carry the runoff from North Cell Branch Swales E, F and G and Central Cell Branch Swales A, B, C and D. Swale H is designed to carry runoff to the South Cell Drainage Channel, which will be constructed in the future.

In conjunction with Central Cell reclamation activities, work also continued on the upper reach of the Runoff Control Ditch (see Sheet 4), located west of the tailings area. This ditch is designed to intercept runoff from the west embankment of the North and Central Cells. The lower reach (i.e., southern portion) of the Runoff Control Ditch is scheduled to be completed in subsequent years.

4.1 Branch Swales A, B, C, D and H

Branch Swales A, B, C, D and H were constructed on top of the Central Cell at the locations shown on Sheet 4. These swales are designed to collect surface water runoff while minimizing erosion on the rock mulch cover. As shown on Sheet 3, the swales consist of shallow, trapezoidal ditches with 3H/1V sideslopes. Both the bottom and sideslopes of the swales are armored with riprap.

Sheet 4 presents the extent of swale completion at the end of 1994 construction activities. Swale D was completed in 1994 while Swales A, B, C and H were partially completed. Swales A, B and C are designed to extend further to the east and north across reclaimed Borrow Pit No. 2, and Swale H will extend to the south toward the present location of the evaporation ponds.

4.1.1 Construction Methods and Materials

The initial step in swale construction was to excavate down to the required subgrade elevation. Swale excavation was performed using scrapers and included removal of the underlying material along the length of each swale. The swales were excavated to a designed bottom width of 10 or 20 feet with 3H/1V sideslopes. A motor grader was used for fine grading to achieve the required final subgrade elevations. During excavation of the swales, the following 3 types of subgrade material were found below the interim cover:

1. Fill soil which had been placed during interim reclamation activities to achieve the design grade for the base of the interim soil cover.

2. Native soils located along the southern edge of the Central Cell (i.e., Swales A and B located beyond the extent of the tailings area).

3. Coarse tailings sands which were used as the initial cover over the fine tailings sands. These coarse tailings, when encountered, were overexcavated and replaced with fill soil from the Borrow Pit No. 2 soil stockpile. The excavated tailings were disposed of in Borrow Pit No. 2 in compacted lifts as specified in the Reclamation Plan.

The soil comprising the subgrade was tested to verify its in-place density. Any areas not meeting density requirements were subjected to additional compaction until the required density was achieved. After completion of the subgrade, the radon attenuation layer was placed in 2 lifts over the bottom and sideslopes of Swales C, D and H. The total thickness of the radon attenuation layer in these swales, including the interim cover, measures 21 inches. Each lift of the radon attenuation layer was conditioned by adding water and compacted with a sheepsfoot compactor followed by a smooth-drum pneumatic roller. Placement of a radon attenuation layer was not required in Swales A and B because they were constructed in native soils and bedrock south of the tailings area.

Prior to installation of the riprap, a 3-inch-thick bedding layer having a D_{50} of 0.02 inch was placed in the swales. This bedding layer or filter blanket is designed to prevent undercutting and piping beneath the riprap during surface runoff events. An additional 3-inch bedding layer having a D_{50} of 0.35 inch was placed in Swale H in accordance with the design specifications. All bedding layers were placed using a front-end loader and spread to a uniform thickness using hand rakes. A minimum of 3 inches of riprap was then placed on top of the bedding material in Swales A, B, C and D. A minimum of 6 inches of riprap was placed in Swale H. The riprap was placed using a front-end loader and hand rakes.

4.1.2 Specifications and Testing

Construction specifications for construction of the branch swales as stipulated in the Reclamation Plan include:

1. The swales are to be constructed as shown on Sheets 2 and 3 and in accordance with the design parameters listed in Table 2.

2. The subgrade is to be compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM D 698.

3. A total of 18 inches of soil cover shall be placed over the subgrade within the tailings area. This soil cover is to have gradation characteristics within the gradation envelope shown on Figure B-1 (see Appendix B) and compacted to a minimum of 95 percent of the maximum dry density at a moisture content of within 2 percent above the optimum moisture content as determined by ASTM D 698.

4. A minimum 3-inch-thick bedding layer consisting of well-graded crushed rock with a D_{50} of 0.02 inch is to be placed on the bottom and sideslopes of each swale.

5. A second bedding layer consisting of a minimum 3-inch thickness of well-graded crushed rock with a D_{50} of 0.35 inch is to be placed on the bottom and sideslopes of Swale H.

6. A minimum of 3 inches of riprap consisting of durable rock with a D_{50} of 1.5 inches is to be placed on top of the bedding layer in Swales A, B, C and D.

7. A minimum of 6 inches of riprap consisting of durable rock with a D_{50} of 3 inches is to placed on top of the bedding layer in Swale H.

Adherence to the specifications was maintained through strict survey control, geotechnical testing of soil and rock properties, and measuring of in-place densities and depths of cover. As discussed in Section 2.2, a field modification consisting of increasing the total soil cover from 18 to 21 inches was also implemented for the Central Cell of the tailings area and associated branch swales.

4.1.2.1 Survey Control

Survey control for construction of the branch swales consisted of installing grade stakes through the middle of each swale and at 10-foot offsets on each side of the swale. Grade stakes were installed on 100-foot centers and cuts and fills were determined by subtracting the thickness of the radon attenuation layer (where appropriate), bedding layer and riprap from the final required elevation. Surveying was performed within a precision level of plus or minus 0.05 foot.

After the initial excavation was completed, each swale was resurveyed and blue grade stakes were installed indicating the cuts and fills required to achieve final grade elevations. Installation of these "blue topped" finish grade stakes were necessary because the swales slopes are extremely flat having average grades of less than 1 percent. After the finish-grading was completed, the elevations of the subgrade were checked at each survey station to verify that positive drainage was being maintained.

Swales C, D and H were again surveyed after placement of the radon attenuation layer. This survey served two purposes: it verified that a minimum of 21 inches of radon attenuation soil cover had been placed, and that positive drainage was being maintained in each swale. Surveying of the bedding layer and riprap in each swale was not necessary because the thickness of these components was verified by measurements made on 100-foot centers as described in Sections 4.1.2.4 and 4.1.2.5.

4.1.2.2 Subgrade Density Testing

In-place field density testing of the swale subgrade was conducted using the sand cone method (ASTM D 1556). The subgrade consisted of both fill soils and native soils. A total of 32 locations spaced uniformly over the 5 swales were tested, of which 31 met the required density of 90 percent of the maximum dry density as determined by ASTM D 698 on the initial test. The remaining location was subjected to additional compaction and met density requirements on the retest.

The Reclamation Plan specifies that Standard Proctor tests be conducted for every 15 field density tests, and One-Point Proctor tests be performed for every 5 field density tests. A total of 10 Standard Proctor tests were performed on the subgrade material resulting in a testing frequency of 1 Standard Proctor test performed for every 3.3 field density tests. No One-Point Proctor tests were performed. The increased frequency of the Standard Proctor tests more than compensates for the lack of One-Point Proctor testing because the Standard Proctor tests are more valuable in monitoring soil compaction characteristics compared to One-Point Proctor testing.

The results of the Standard Proctor and field density tests for the subgrade material are presented in Appendix J.

4.1.2.3 Radon Attenuation Layer Testing

As required in the Reclamation Plan, the radon attenuation layer was placed over Swales C, D and H. Swales A and B did not require a radon attenuation layer because of their location beyond the limits of tailings. Construction of the radon attenuation layer over Swales C, D and H required the placement and compaction of approximately 9,000 cy of soil from the Borrow Pit No. 2 soil stockpile. The volume of soil used in constructing the radon attenuation layer in these swales was estimated by multiplying the area of Swales C, D and H (3.2 acres) by the depth of the compacted soil cover (21 inches). After soil placement and compaction, the radon attenuation layer was tested to verify that the soil met gradation requirements and that density and moisture specifications were also being met. These test results are summarized below and presented in detail in Appendix J.

A total of 14 gradation tests were performed on the soils, all of which were within the gradation requirements illustrated on Figure B-1 in Appendix B of the Reclamation Plan. The test frequency of 1 test per 640 cy of soil placed (i.e., 9,000 cy/14 tests) exceeded the specified test frequency of 1 test per 1,000 cy of soil placed.

Thirty-seven in-place field moisture-density tests of the soil cover in Swales C, D and H were performed using the sand cone method (ASTM D 1556). These tests were spaced uniformly over the swales and, based on the Standard Proctor results, 26 of the tests met the requirement for a minimum of 95 percent of the maximum dry density at a moisture content of within 2 percent above the optimum moisture content. The remaining 11 locations were subjected to additional compaction and conditioning, and met the density/moisture requirements on the retest. The test frequency of 1 test for every 243 cy of soil (i.e., 9,000 cy/37 tests) exceeded the specified test frequency of one test for every 500 cy of soil.

A total of 9 Standard Proctor tests and 1 One-Point Proctor test were conducted during completion of the radon attenuation cover over Swales C, D and H. The test frequency of 1 Standard Proctor test per 4.1 field density tests exceeded the specified frequency of 1 Standard Proctor test for every 15 field density tests. The 1 One-Point Proctor test was less than the specified frequency of 1 test for every 5 field density tests but the higher frequency for the Standard Proctor tests made such testing redundant.

4.1.2.4 Bedding Layer Testing

Bedding material was placed at a minimum thickness of 3 inches on the bottom and sides of all the swales. The bedding material consisted of crusher fines from Hamilton's stockpile and had a nominal D_{50} of 0.02 inch. The bedding layer thickness was verified in the field by measuring the depth of the bedding layer on the swale bottom and sides every 100 feet. The results of these measurements are presented in Appendix J and show that the bedding layer ranged from 3 to 3.5 inches thick in all 5 swales.

In accordance with the Reclamation Plan, a second bedding layer was placed on top of the D_{50} 0.02-inch bedding layer in Swale H. The second layer of bedding material consisted of crushed basaltic aggregate from Hamilton's pit and had a nominal D_{50} of 0.35 inch. A minimum of 6 inches total of bedding material in Swale H was verified in the field by measuring the total depth of both bedding layers on the swale bottom and sides every 100 feet. The results of these measurements are presented in Appendix J and show that the total depth of the bedding layers ranged from 6 to 7.5 inches thick in Swale H.

Four sieve analyses were performed to determine the gradation characteristics of the D_{50} 0.02-inch bedding material used in constructing the branch swales and the upper reach of the Runoff Control Channel. The results of the sieve analyses are presented in Appendix K and confirm that the bedding material met the gradation specifications of 100 percent passing a 3-inch screen, 85 to 100 percent passing a 3/4-inch screen, 65 to 100 percent passing a No. 4 screen, 47 to 94 percent passing a No. 10 screen, 23 to 70 percent passing a No. 40 screen, and 15 to 30 percent passing a No. 200 screen.

Five sieve analyses were performed to determine the gradation characteristics of the D_{50} 0.35-inch bedding material used in constructing Branch Swale H. The results of the sieve analyses are presented in Appendix K and the blended values confirm that the bedding material met the gradation specifications of 65 to 100 percent passing a 3-inch screen, 43 to 80 percent passing a 3/4-inch screen, 22 to 60 percent passing a No. 4 screen, 15 to 38 percent passing a No. 10 screen, 5 to 12 percent passing a No. 40 screen, and 0 to 10 percent passing a No. 200 screen.

4.1.2.5 Riprap Testing

Two sizes of riprap were used during construction of the branch swales associated with the Central Cell. In accordance with the reclamation plan, riprap with a D_{50} of 1.5 inches was used in Branch Swales A, B, C and D, and a riprap with a D_{50} of 3 inches was used in branch Swale H.

1.5-Inch Riprap

Riprap consisting of a basaltic rock with a D_{50} of 1.5 inches was placed at a minimum thickness of 3 inches on the bottom and sides of Swales A, B, C, and D. Riprap thickness was verified by measuring the depth of the riprap on the swale bottom and sides every 100 feet. The results of these measurements are presented in Appendix J and show that all measurement were in excess of the 3-inch minimum.

The rock used for the riprap was the same basaltic rock used to construct the rock mulch. As discussed in Section 3.2.1, this rock has superior durability characteristics with an average rock quality score of 86. Sieve analyses of this rock were also performed as discussed in Section 3.2.2, to maintain the size gradation in conformance with the specifications. Rock quality and gradation test results for the riprap are provided in Appendices F and G, respectively.

Three-Inch Riprap

In accordance with the specifications of the reclamation plan, riprap consisting of a basaltic rock with a D_{50} of 3 inches was placed at a minimum thickness of 6 inches on the bottom and sides of Swale H. Riprap thickness was verified by measuring the depth of the riprap on the swale bottom and sides every 100 feet. The results of these measurements are presented in Appendix J and show that all measurements met or exceeded the 6-inch minimum.

The rock used as riprap in Swale H was a dense basaltic rock with durability characteristics superior to the criteria stipulated in the technical specifications. The specifications for rock quality characteristics of the D_{50} 3-inch rock are identical to those for the D_{50} 1.5-inch rock outlined in Section 3.2. One test was performed to verify the rock's quality. The test results are presented in Appendix F. The test values for the rock included a specific gravity of 2.73, an absorption of 1.48 percent, a sodium sulfate loss of 0.3 percent, and an L.A. Abrasion percentage of 4.72. The rock quality score for the test, using the scoring criteria provided in the August 1990 STP, was 92.

The specifications require that a series of rock durability tests be performed initially and for each additional 10,000 cy of rock placed. More frequent testing is also required if the rock characteristics in the rock borrow source vary significantly from the rock that was previously tested. United Nuclear records show that a total of 630 cy of rock have been placed as riprap in Swale H. No change in rock characteristics was noted by the quality control technician. Therefore, the rock quality testing rate meets the test rate required by the specifications.

The basaltic rock with a D_{50} of 3 inches that was used to riprap Swale H was also subjected to a sieve analysis to determine if gradation requirements were being met. One sample was tested and met the following size gradations: 100 percent passing a 6-inch screen; 45-80 percent passing a 4-inch screen; and 0-22 percent passing a 1-inch screen. The results of the sieve analysis testing are presented in Appendix G.

4.2 Upper Reach of Runoff Control Ditch

The Runoff Control Ditch is located immediately west of the tailings disposal area as shown on Sheet 4. During 1994, construction of the upper reach of the Runoff Control Ditch continued in a southerly direction from Stations 12+00 to 22+75. The upper reach of the Runoff Control Ditch from Stations -2+87 to 12+00 was completed in 1993 as part of the North Cell Final Reclamation. The ditch is designed to collect surface water runoff from the west embankment of the tailings area. As shown on Sheet 3, the Runoff Control Ditch is 2 feet deep with a 10-foot-wide bottom and 3H/1V sideslopes.

4.2.1 Construction Methods and Materials

The Runoff Control Ditch was excavated down to the required subgrade elevation using scrapers and dozers. A motor grader was used for fine grading to achieve the required final subgrade elevations. The native soils at the bottom and sides of the ditch were then compacted as necessary with a sheepsfoot compactor and a smooth drum roller to achieve the required soil density.

After the subgrade met the in-place density specifications, a minimum of 3 inches of bedding material having a D_{50} of 0.02 inch was placed in the ditch using a front-end loader. The bedding material was spread using hand rakes. A minimum of 3 inches of riprap was then placed on top of the bedding layer using the same methods.

4.2.2 Specifications and Testing

The specifications for construction of the upper reach of the Runoff Control Ditch as stipulated in the Reclamation Plan include:

1. The ditch is to be constructed as shown on Sheets 2 and 3.

2. The subgrade is to be compacted to a minimum of 90 percent of the maximum dry density as determined by ASTM D 698.

3. A minimum 3-inch-thick bedding layer consisting of well-graded crushed rock with a D_{50} of 0.02 inch is to be placed on the bottom and sideslopes.

4. A minimum of 3 inches of riprap consisting of durable rock with a D_{50} of 1.5 inches is to be placed on top of the bedding layer.

Adherence to the specifications was maintained through strict survey control, geotechnical testing of soil and rock properties, and measuring of in-place densities and depths of cover.

4.2.2.1 Survey Control

Survey control for construction of the upper reach of the Runoff Control Ditch from Station 12+0 to Station 22+75 consisted of installing grade stakes through the middle of the ditch and at 10-foot offsets on each side of the ditch. The grade stakes were installed on 100-foot centers and cuts and fills for the ditch bottom were determined by subtracting the profile elevations shown on Sheet 3 from the existing elevations. Cuts and fills to achieve the 3H/1V sideslopes of the ditch and 5H/1V slope of the protective bench were also marked at each station. Surveying was performed within a precision level of plus or minus 0.05 foot.

After the excavation was completed to the subgrade, the ditch was surveyed again to verify that the required grades had been achieved. Surveying of the bedding layer and riprap was not necessary because the thickness of these components were verified by measurements made on 100-foot centers as described in Sections 4.2.2.3 and 4.2.2.4.

4.2.2.2 Subgrade Density Testing

In-place field density testing of the ditch subgrade was conducted using the sand cone method (ASTM D 1556). A total of 6 locations spaced uniformly over the ditch bottom and east and west berms were tested, all of which met the required density of 90 percent of the maximum dry density as determined by ASTM D 698.

The Reclamation Plan specifies that Standard Proctor tests be conducted for every 15 field density tests, and One-Point Proctor tests be performed every 5 field density tests. A total of 2 Standard Proctor tests were performed on the subgrade material resulting in a testing frequency of one Standard Proctor test performed for every 3 field density tests. No One-Point Proctor tests were performed because the higher frequency for the Standard Proctor tests made such testing redundant.

The results of the Standard Proctor and field density tests for the subgrade material are presented in Appendix L.

4.2.2.3 Bedding Layer Testing

Bedding material was placed at a minimum thickness of 3 inches on the bottom and sides of the ditch prior to installation of riprap. The bedding material consisted of crusher fines from Hamilton's stockpile and had a nominal D_{50} of 0.02 inch. The bedding layer thickness was verified in the field by measuring the depth of the bedding layer on the swale bottom and sides every 100 feet. The results of these measurements are presented in Appendix L and show that the bedding layer ranged from 3 to 4 inches thick over the entire length of the ditch.

Four sieve analyses were performed to determine the gradation characteristics of the bedding material used in constructing the branch swales and the upper reach of the Runoff Control Channel from Station 12+00 to Station 22+75. The results of the sieve analyses are presented in Appendix K and confirm that the bedding material met the gradation specifications of 100 percent passing a 3-inch screen, 85 to 100 percent passing a 3/4-inch screen, 65 to 100 percent passing a No. 4 screen, 47 to 94 percent passing a No. 10 screen, 23 to 70 percent passing a No. 40 screen, and 15 to 30 percent passing a No. 200 screen.

4.2.2.4 Riprap Testing

Riprap consisting of a basaltic rock with a D_{50} of 1.5 inches was placed at a minimum thickness of 3 inches on the bottom and sides of the ditch. Riprap thickness was verified by measuring the depth of the riprap every 100 feet. The results of these measurements are presented in Appendix L and show that all measurements were in excess of the 3-inch minimum.

The rock used for the riprap was the same basaltic rock used to construct the rock mulch. As discussed in Section 3.2.1, Rock Mulch Quality, this rock has superior durability characteristics with an average rock quality score of 86. Sieve analyses of this rock were also performed as discussed in Section 3.2.2, Mulch Rock Thickness and Size Gradation, to maintain the size gradation in conformance with the specifications. Rock quality and gradation test results for the riprap are provided in Appendices F and G, respectively.

5.0 CLOSING REMARKS

The Central Cell of the tailings disposal facility has been reclaimed in accordance with the specifications and construction drawings contained in the Reclamation Plan (Canonie, 1991). This reclamation included construction of the radon attenuation layer, erosion protection cover and surface water controls.

Canonie/Smith Environmental Technologies Corporation appreciates this opportunity to provide engineering services in summarizing information regarding work conducted during 1994 in the Central Cell Tailings Disposal Area at the Church Rock Facility. If you have any questions, please contact me at (303) 790-1747.

Respectfully submitted,

Frank J. Filas, P.E.
Project Engineer

FJF/ca

REFERENCES

REFERENCES

REFERENCES

Canonie Environmental Services Corp., 1990, "As-Built Construction Report, North Cell Interim Stabilization", prepared for United Nuclear Corporation, Church Rock Facility, Gallup, New Mexico.

Canonie Environmental Services Corp., 1991, "Tailings Reclamation Plan as Approved by NRC March 1, 1991, License No. SUA-1475", prepared for United Nuclear Corporation, Church Rock Facility, Gallup, New Mexico.

Canonie Environmental Services Corp., 1992a, "As-Built Report, South Cell Interim Stabilization", prepared for United Nuclear Corporation, Church Rock Facility, Gallup, New Mexico.

Canonie Environmental Services Corp., 1992b, "As-Built Report Addendum, Central Cell Interim Stabilization", prepared for United Nuclear Corporation, Church Rock Facility, Gallup, New Mexico.

Canonie Environmental Services Corp., 1994, "As-Built Report, North Cell Final Reclamation", prepared for United Nuclear Corporation, Church Rock Facility, Gallup, New Mexico.

Western Technologies, Inc., 1991, "As-Built Construction Report, Interim Stabilization, Central Cell Tailings Disposal Area", prepared for United Nuclear Corporation, Church Rock Facility, Gallup, New Mexico.

TABLES

TABLES

TABLE 1

EARTHMOVING EQUIPMENT

Equipment Type	Number
Caterpillar 633D Scrapers	3
Caterpillar 815B Sheepsfoot Compactor	1
Caterpillar D-8 Dozer	1
Caterpillar D-6 Dozers	2
Caterpillar Road Graders	2
Caterpillar 950B Front-End Loaders	2
Water Wagons	2
Euclid Pneumatic Roller Compactor	1
Caterpillar 825B Drumroller Compactors	2
Rock Haul-Trucks	3

TABLE 2

SWALES A, B, C, D AND H
DESIGN PARAMETERS

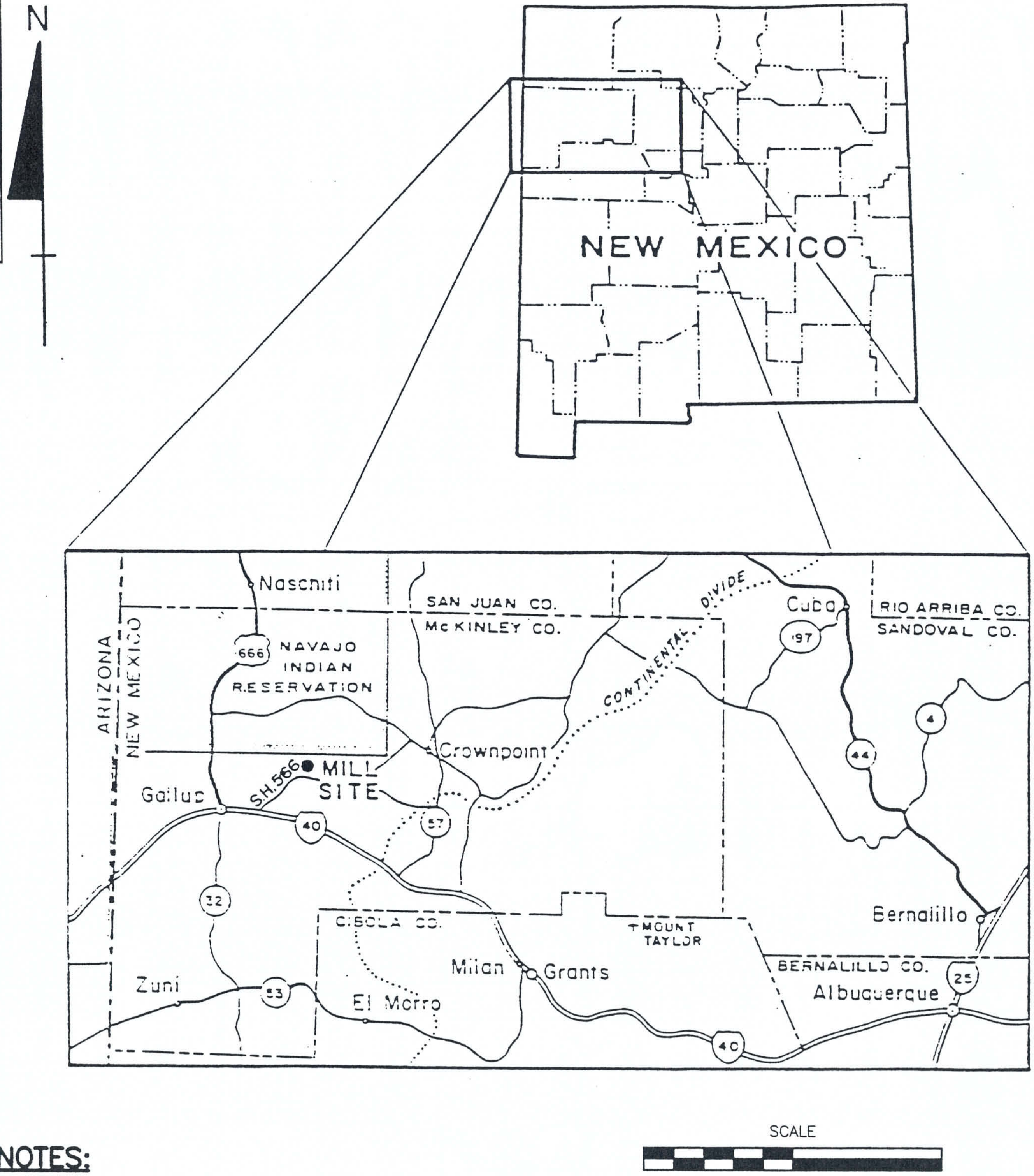
Parameter	Swale A	Swale B	Swale C	Swale D	Swale H
Total Length (ft)	2,600	3,600	3,400	3,200	2,550
Length Completed in 1994 (ft)	900	1,250	1,600	3,200	1,000
Slope (ft/ft)	0.0038	0.0083	0.0050	0.0028	0.0085
Bottom Width (ft)	10	20	10	10	20
Minimum Depth (ft)	2.0	2.0	2.0	2.0	2.5
Bedding Layer D_{50} (in)	0.02	0.02	0.02	0.02	0.02 (Layer 1) 0.35 (Layer 2)
Bedding Layer Thickness (in)	3	3	3	3	3 (Layer 1) 3 (Layer 2)
Riprap D_{50} (in)	1.5	1.5	1.5	1.5	3.0
Riprap Thickness (in)	3	3	3	3	6

Note:
1. The sides of the swales are to be installed at a slope of 3H/1V.

FIGURES

FIGURES

DRAWING NUMBER 86-060-A931



NOTES:

1. AFTER DRAWING No. RM86-060-A24 (FIGURE) 1-1 IN THE 1987 RECLAMATION PLAN (CANONIE, 1987b).

REFERENCE:
URANIUM MILL LICENSE RENEWAL APPLICATION-ENVIRONMENTAL REPORT LICENSE No. NM-UNC-ML. UNC 1981.

SITE VICINITY MAP

PREPARED FOR

UNC MINING AND MILLING
GALLUP, NEW MEXICO

Canonie Environmental

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY			
1	6-30-95	ISSUED FOR AS-BUILT CONSTRUCTION REPORT CENTRAL CELL RECLAMATION	D.S.	[signature]	[signature]	DATE: 4-24-95 / SCALE: AS SHOWN	SHEET 1	DRAWING NUMBER 86-060-A931

NOTES:

1. DESIGN ELEVATION CONTOURS ON THE TAILINGS IMPOUNDMENT ALLOW FOR A 1.5-FOOT RADON BARRIER AND A 6-INCH SOIL/ROCK MATRIX EROSION PROTECTION LAYER OVER REGRADED TAILINGS. SEE SHEET 3 FOR SOIL COVER PROFILE.
2. DETAILS ARE SHOWN ON SHEET 3.
3. BORROW PIT NO. 2 WILL BE RECLAIMED BY BACKFILLING WITH MILL DEMOLITION DEBRIS, ORE PAD MATERIALS, CATCH BASIN MATERIALS AND SOIL EXCAVATION FROM THE SOIL STOCKPILE, IF NECESSARY.
4. THE AREA SURROUNDING THE CATCH BASINS WILL BE RECLAIMED BY STRIPPING THE UPPER SIX INCHES OF SOIL. ALL REMAINING ORE AND TAILINGS MATERIAL WILL BE EXCAVATED TO A MINIMUM DEPTH OF 5 FEET IN THE CATCH BASINS. ALL MATERIALS WILL BE USED AS BACKFILL WITHIN THE BORROW PIT NO. 2. THE ENTIRE CATCH BASIN AREA WILL THEN BE REGRADED TO THE LINES AND GRADES SHOWN.
5. ACCESS ROADS WHICH CURRENTLY EXIST OR WHICH HAVE BEEN ADDED FOR THE CONVENIENCE OF THE CONTRACTOR WILL BE RECLAIMED IN ACCORDANCE WITH THE SPECIFICATIONS.
6. AFTER DRAWING NO. 86-060-E544 (FIGURE 5-1) IN THE AUGUST 1991 RECLAMATION PLAN.

FINAL RECLAMATION PLAN
SOUTH END
PREPARED FOR

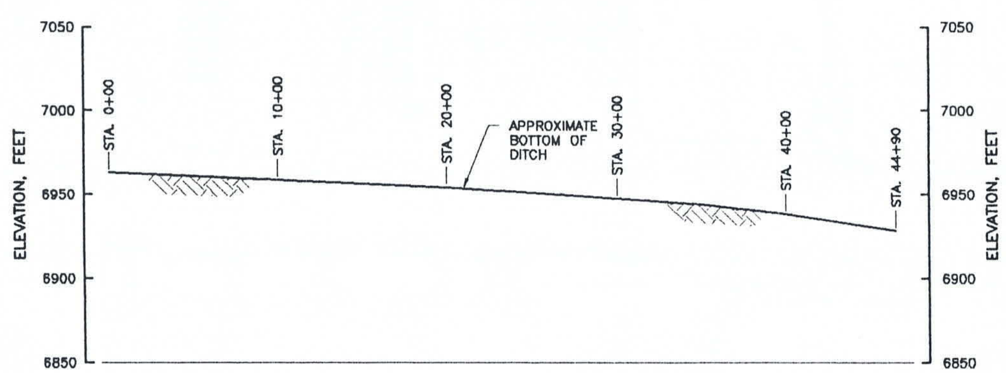
UNC MINING AND MILLING
GALLUP, NEW MEXICO

Canonie Environmental

DATE: 4-27-95	SHEET 2	DRAWING NUMBER
SCALE: AS SHOWN		86-060-E933

86-060-E639

DRAWING NUMBER 86-060-E930

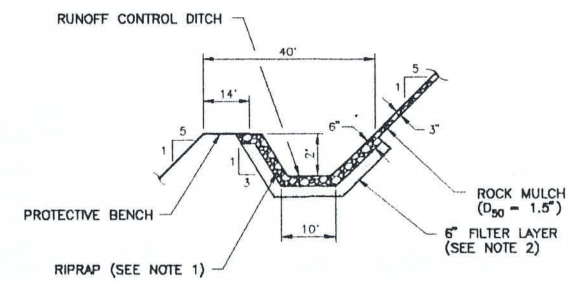


PROFILE RUNOFF CONTROL DITCH

VERTICAL SCALE 50 0 50 FEET

HORIZONTAL SCALE 500 0 500 FEET

VERTICAL EXAGGERATION = 10X



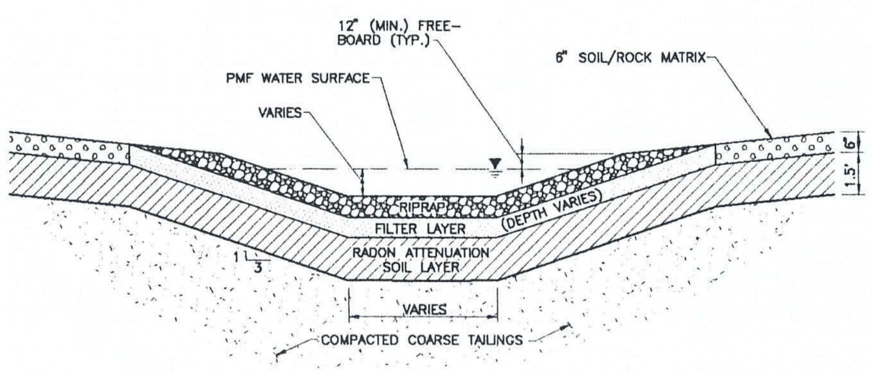
NOTES:

1. RIPRAP D_{50} = 1.5" IN UPPER REACH OF RUNOFF CONTROL DITCH. D_{50} = 3.0" IN LOWER REACH OF RUNOFF CONTROL DITCH.
2. RIPRAP LAYER 3" AND FILTER LAYER 3" IN UPPER REACH OF RUNOFF CONTROL DITCH.

TYPICAL SECTION RUNOFF CONTROL DITCH

(LOOKING NORTHEAST)

NOT TO SCALE

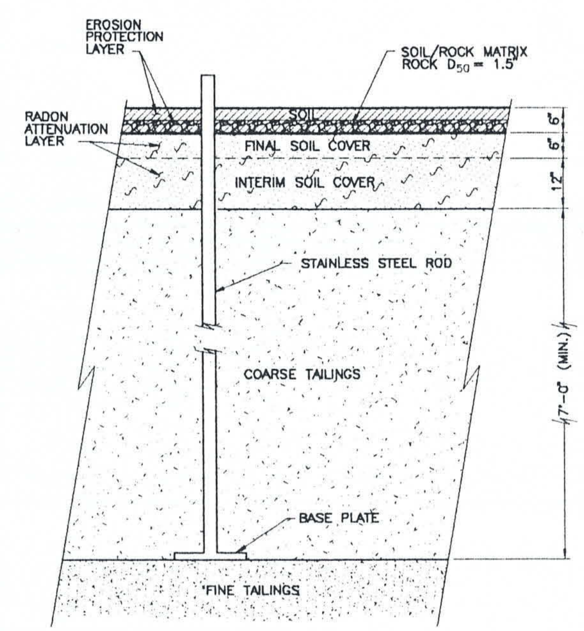


TYPICAL BRANCH SWALE

NOT TO SCALE

NOTE:

1. BRANCH SWALE DIMENSIONS AND RIPRAP SIZES PROVIDED IN TABLE 2.



SOIL COVER PROFILE

NOT TO SCALE

NOTES:

1. AFTER DRAWINGS 86-060-E569 (FIGURE 5-3) AND 86-060-E565 (FIGURE 5-4) IN THE AUGUST, 1991 RECLAMATION PLAN.
2. THE FINAL SOIL COVER WAS INCREASED FROM 6 INCHES TO 9 INCHES OVER THE CENTRAL CELL. THIS MINOR MODIFICATION TO THE PLAN WAS IMPLEMENTED AS A FIELD CHANGE.

SOIL COVER AND SURFACE WATER CONTROL DETAILS

PREPARED FOR

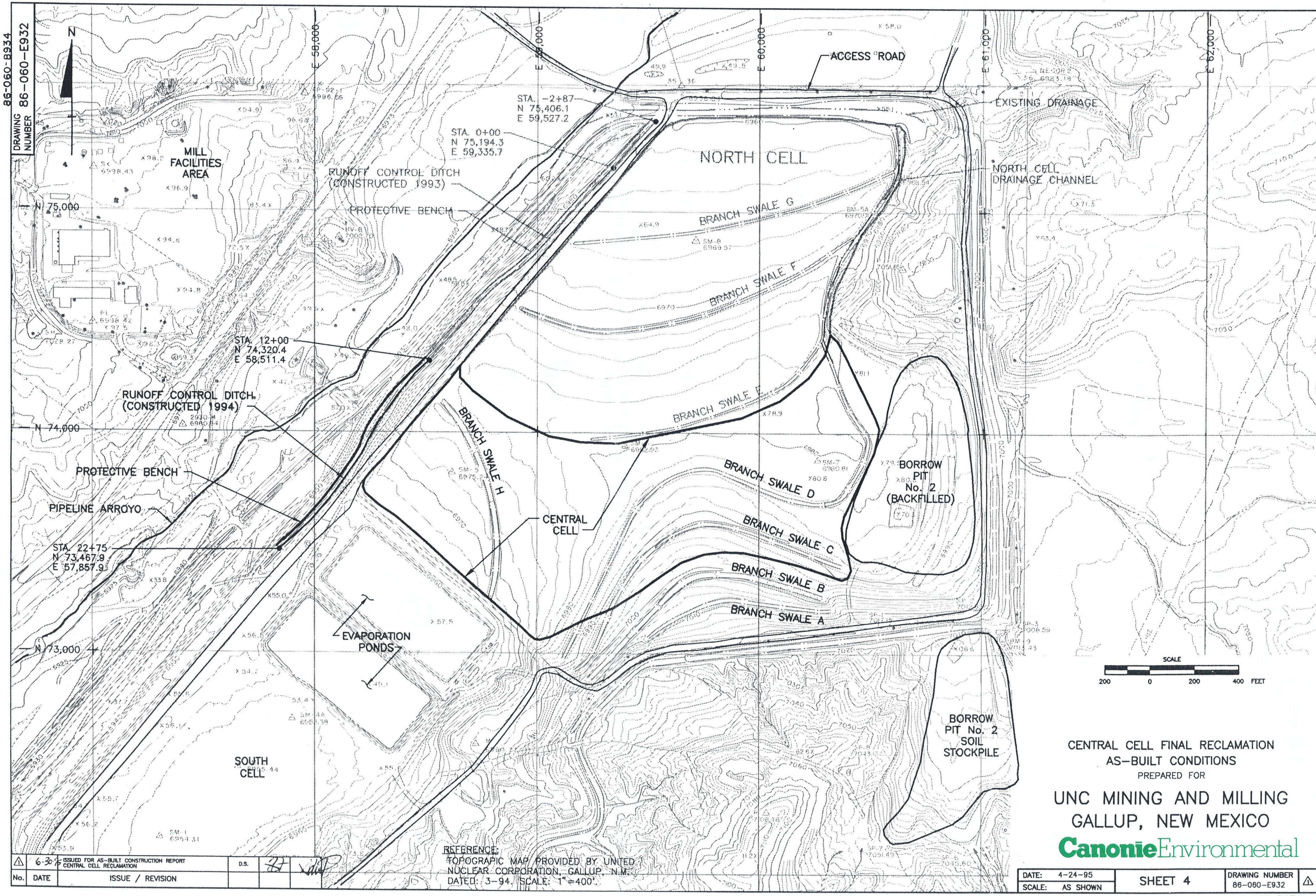
UNC MINING AND MILLING

GALLUP, NEW MEXICO

Canonie Environmental

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
⚠	6-30-95	ISSUED FOR AS-BUILT CONSTRUCTION REPORT CENTRAL CELL FINAL RECLAMATION	D.S.	[signature]	[signature]

DATE: 4-24-95	SHEET 3	DRAWING NUMBER 86-060-E930	⚠
SCALE: AS SHOWN			


DRAWING NUMBER 86-060-E932
86-060-B934
N
MILL FACILITIES AREA
ACCESS ROAD
EXISTING DRAINAGE
NORTH CELL
NORTH CELL DRAINAGE CHANNEL
STA. -2+87
N 75,406.1
E 59,527.2
STA. 0+00
N 75,194.3
E 59,335.7
RUNOFF CONTROL DITCH (CONSTRUCTED 1993)
PROTECTIVE BENCH
BRANCH SWALE G
BRANCH SWALE F
BRANCH SWALE E
BRANCH SWALE D
BRANCH SWALE C
BRANCH SWALE B
BRANCH SWALE A
BRANCH SWALE H
STA. 12+00
N 74,320.4
E 58,511.4
RUNOFF CONTROL DITCH (CONSTRUCTED 1994)
PROTECTIVE BENCH
PIPELINE ARROYO
STA. 22+75
N 73,467.9
E 57,857.9
CENTRAL CELL
BORROW PIT No. 2 (BACKFILLED)
EVAPORATION PONDS
SOUTH CELL
BORROW PIT No. 2 SOIL STOCKPILE
N 75,000
N 74,000
N 73,000
E 58,000
E 59,000
E 60,000
E 61,000
E 62,000
SCALE
200 0 200 400 FEET
REFERENCE:
TOPOGRAPHIC MAP PROVIDED BY UNITED NUCLEAR CORPORATION, GALLUP, N.M. DATED: 3-94. SCALE: 1"=400'.
CENTRAL CELL FINAL RECLAMATION
AS-BUILT CONDITIONS
PREPARED FOR
UNC MINING AND MILLING
GALLUP, NEW MEXICO
Canonie Environmental
DATE: 4-24-95
SCALE: AS SHOWN
SHEET 4
DRAWING NUMBER 86-060-E932
6-30-95 ISSUED FOR AS-BUILT CONSTRUCTION REPORT CENTRAL CELL RECLAMATION
No. DATE ISSUE / REVISION D.S.
86-060-B934