4.2.1 *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 1.5 percent, a sodium sulfate loss of 2.9 percent, and an L.A. Abrasion percentage of 4.9. The rock quality score for the 3 tests, using the scoring criteria provided in the August 1990 STP, ranged from 85 to 93 with an average score of 90.

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 in 1995 a total of 18,479 cy of D_{50} 1.5-inch rock was placed as rock mulch and riprap during final reclamation of the South Cell and Borrow Pit No. 2. No change in rock characteristics was noted by the quality control technician. Therefore, the rock quality testing rate of 1 series of tests per 6,160 cy of rock placed (i.e., 18,479 cy/3 tests) exceeded the test rate required by the specifications.

4.2.2 *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 5 samples were tested at the quarry and 3 at the site prior to spreading. One of the samples collected and tested at the quarry did not meet gradation specifications and this material was not used. The remaining tests at the quarry and at the site 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 100 x 50 foot centers over the entire extent of the Borrow Pit No. 2 area. Areas having a measured thickness of less than 3 inches or greater than 4.5 inches were regraded by Nielson's and then rechecked to verify that the specifications were met. The recorded measurements are presented in Appendix H.

4.2.3 Soil Thickness and Penetration

The soil used to construct the soil/rock matrix was obtained from the South Cell borrow area. Gradation analyses indicate 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 (Appendix B). 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 on the rock mulch was checked on a uniform basis over the entire extent of the soil/rock matrix cover. The measurements were performed on 100 x 50 foot centers. The results of the measurements are presented in Appendix H and show that the soil layer above the rock mulch was a minimum of 3 inches in all areas, and less than 4.5 inches in most areas. In some areas, the soil layer thickness was increased to provide adequate surface drainage. The depth of soil penetration into the rock mulch exceeded 2 inches in all areas.

5.0 SURFACE WATER CONTROL STRUCTURES

Surface water control structures associated with Borrow Pit No. 2 include Branch Swales A, B and C and the North Cell Drainage Channel (NCDC). Branch Swales A, B and C are shallow riprapped ditches located on top of Borrow Pit No. 2 and are designed to convey runoff from the reclaimed tailings area to the NCDC. In conjunction with Borrow Pit No. 2 reclamation activities, the NCDC and the north slope of the North Cell were also riprapped in 1995. Sheets 2 and 3 show the design details for these structures. Sheet 4 shows the as-built conditions for Borrow Pit No. 2 after completion of the 1995 reclamation activities.

5.1 Branch Swales A, B and C

Branch Swales A, B and C were constructed on top of and adjacent to Borrow Pit No. 2 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.

5.1.1 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 types of subgrade material were found:

1. Fill soil which had been placed to backfill Borrow Pit No. 2.

2. Native soils and sedimentary bedrock.

3. Tailings sands located in the area where the borrow pit borders the tailings disposal area. These tailings, when encountered, were overexcavated and replaced with fill soil from the Borrow Pit No. 2 stockpile. The excavated tailings were disposed of in Borrow Pit No. 2 below the interim cover.

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. Exposed soils were also monitored for radon emissions. After completion of the subgrade, a radon attenuation layer was placed over the bottom and sideslopes of the swales. The total thickness of the radon attenuation layer measured a minimum of 18 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.

Sedimentary bedrock and native soils were encountered between Stations 14+00 and 20+00 of combined Swales A and B, Stations 28+00 to 30+00 of Swale B and Stations 30+00 to 33+00 of combined Swales B and C. Soil compaction tests could not be performed in the bedrock. Radon attenuation cover was not placed in these areas.

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 Swales A and B in accordance with the modified design specifications (see Section 5.1.2.1). Bedding layers were placed using a front-end loader and spread to a uniform thickness using hand rakes. A minimum of 3 inches of 1.5-inch riprap was then placed on top of the bedding material in Swale C. A minimum of 6 inches of 3-inch riprap was placed in Swales A and B. The riprap was placed using a front-end loader, hand rakes and a track hoe.

5.1.2 *Specifications and Testing*

Specifications for construction of the branch swales as stipulated in the Reclamation Plan (Canonie, 1991) include:

1. The swales are 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 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 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.

5.1.2.1 *Field Modifications*

Prior to the start of final reclamation of Borrow Pit No. 2, United Nuclear conducted a detailed review of the reclamation plan requirements for construction of the branch swales. This review identified several areas where minor modifications to swales over

Borrow Pit No. 2 were necessary to match the swale design to the as-built topography of the cover and surrounding areas. These minor modifications were developed by Smith Environmental using NRC guidelines and were incorporated into the construction design as a field change.

Two swale modifications were made in the vicinity of Borrow Pit No. 2. The first modification consisted of combining Swale A with Swale B rather than routing Swale A through the embankment east of Borrow Pit No. 2 as shown on Sheet 2. This modification eliminated the need for substantial excavation through the embankment. To accommodate the modification, the bottom width of the combined Swale A and B was increased to 20 feet and the riprap was increased to a D_{50} of 3 inches. The NCDC was also reevaluated and it was determined that it had sufficient capacity to contain the incremental increase in discharge volume from Swale A. Appendix I provides details of this field modification in the letter dated May 24, 1994, and the memo dated April 8, 1996.

The second modification consisted of combining Swale B with Swale C over the final 367 feet prior to their discharge into the NCDC. This modification was made because the original design routed Swale B through the area where the North Cross-Dike Pump-Back Wells are located. These wells, although currently inactive, have not been approved for decommissioning. Rather than delay reclamation, Swale B was combined with Swale C. Evaluation of the modified design indicated that a 20-foot bottom width and 3-inch riprap would meet NRC guidelines. Appendix I provides additional details of this field modification in the letter dated June 26, 1995.

Sheet 4 shows the final as-built configuration of Swales A, B and C. In this report, the continuous 20-foot-wide channel is referred to as Swale B and the narrower channels are referred to as Swales A and C up to the point where they combine with Swale B.

5.1.2.2 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.

The swales were again surveyed after placement of the radon attenuation layer. This survey served two purposes: it verified that a minimum of 18 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 5.1.2.5 and 5.1.2.6.

5.1.2.3 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 11 locations spaced over the swales were tested, all of which met the required density of 90 percent of the maximum dry density as determined by ASTM D 698 on the initial test.

The Reclamation Plan (Canonie, 1991) 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 4 standard Proctor tests were performed on the subgrade material resulting in a testing frequency of 1 standard Proctor test performed for every 2.75 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.

5.1.2.4 Radon Attenuation Layer Testing

As required in the Reclamation Plan, the radon attenuation layer was placed over Swale C and the central portion of Swale B. Swale A and the upper and lower portions of Swale B did not require a radon attenuation layer because of their location beyond the limits of tailings. Construction of the radon attenuation layer on the swales required the placement and compaction of approximately 2,400 cy of soil from the Borrow Pit No. 2 stockpile area. The volume of soil used in constructing the radon attenuation layer in these swales was estimated by multiplying the area covered by the radon attenuation layer (about 1 acre) by the depth of the compacted soil cover (18 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.

Four gradation tests were performed on the soils, the results 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 600 cy of soil placed exceeded the specified test frequency of 1 test per 1,000 cy of soil placed.

Eleven in-place field moisture-density tests of the radon attenuation cover were performed using the sand cone method (ASTM D 1556). All 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 test frequency of 1 test for every 220 cy of soil (i.e., 2,400 cy/11 tests) exceeded the specified test frequency of 1 test for every 500 cy of soil.

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 5 standard Proctor tests were performed on the radon attenuation material, resulting in a testing frequency of 1 standard Proctor test performed for every 2.2 field density tests. No One-Point Proctor tests were performed because the higher frequency for the standard Proctor tests made such testing redundant.

5.1.2.5 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 swales.

In accordance with the modified swale design presented in Appendix I, a second bedding layer was placed on top of the D_{50} 0.02-inch bedding layer in Swale B and the final 150 feet of Swale A. 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 3 inches of 0.35 inch bedding material was verified by measuring the swales' bottom and sides every 100 feet. The results of these measurements are presented in Appendix J and show that the depth of the bedding layer ranged from 3 to 4 inches thick in Swales A and B.

Three sieve analyses were performed to determine the gradation characteristics of the D_{50} 0.02-inch bedding material used in constructing the branch swales. 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.

Eight sieve analyses were performed to determine the gradation characteristics of the D_{50} 0.35-inch bedding material used in constructing Branch Swales A and B. The results of the sieve analyses are also presented in Appendix K. The first 5 sieve analyses did not meet the gradation requirements, and the tested material was discarded. Results of the last 3 tests 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.

The D_{50} 0.35-inch bedding material exceeded the durability specifications for aggregate with rock quality characteristics similar to the 1.5-inch rock aggregate (see Section 4.2.1). The average test values for the rock included a specific gravity of 2.74, an absorption of 1.9 percent, a sodium soundness loss of 4.1 percent, and an L.A. Abrasion percentage of 3.6. The rock quality scores for the test, using the scoring criteria provided in the August 1990 STP (NRC, 1990), ranged from 80 to 90, with an average score of 84.7. The 3 rock quality tests for the D_{50} 0.35-inch aggregate are presented in Appendix F.

5.1.2.6 Riprap Testing

Two sizes of riprap were used during construction of the branch swales associated with Borrow Pit No. 2. In accordance with the field design modifications, riprap with a D_{50} of 1.5 inches was used in Branch Swale C, and a riprap with a D_{50} of 3 inches was used in Branch Swale B and the final 150 feet of Swale A.

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 Swale C. 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 4.2.1, this rock has superior durability characteristics with an average rock quality score of 90. Sieve analyses of this rock were also performed as discussed in Section 4.2.2, 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 Swales A and B. 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 Swales A and B 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 4.2. Three 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 2.74, an absorption of 1.71 percent, a sodium soundness loss of 2.6 percent, and an L.A. Abrasion percentage of 3.9. The rock quality scores for the test, using the scoring criteria provided in the August 1990 STP, ranged from 83 to 90, with an average score of 87.3.

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's records show that a total of 2,554 cy of D_{50} 3-inch rock was placed as riprap during 1995. No change in rock characteristics was noted by the quality control technician. Three rock quality tests were conducted, or 1 for each 850 cy of rock used. Therefore, the rock quality testing rate exceeds the test rate required by the specifications.

The basaltic rock with a D_{50} of 3 inches that was used to riprap Swales A and B was also subjected to 8 sieve analyses to ensure that gradation requirements were being met. The following size gradations were required for the D_{50} 3-inch rock: 100 percent passing a 6-inch screen; 45-80 percent passing a 4-inch screen; and 0-22 percent passing a 1-inch screen. Four of the samples did not meet these requirements, and the sampled material was rejected. The remaining tests showed that the material was within specifications. The results of the sieve analysis testing are presented in Appendix G.

5.2 North Cell Drainage Channel

The NCDC was constructed along the perimeter of the North Cell and Borrow Pit No. 2 at the locations shown on Sheets 2 and 4. This channel is designed to collect surface water runoff from the drainage swales. As shown on Sheet 3, the NCDC is similar to the swales in that it is 10 feet wide with 3H/1V sideslopes. However, to accommodate larger flow volumes, the NCDC is deeper than the swales and is armored with larger riprap.

Sheet 4 presents the extent of NCDC completion at the end of 1995 construction activities. The southern part of the NCDC was excavated in 1993, and the northern part was excavated in 1995. Riprap was installed in 1995.

5.2.1 Construction Methods and Materials

The initial step in NCDC construction was to excavate down to the required subgrade elevation. Excavation was performed using scrapers and dozers and included removal of the underlying material along the length of the channel. The NCDC was excavated to a designed bottom width of 10 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 types of subgrade material were found:

1. Weathered claystone-siltstone bedrock. This represented the majority of the material encountered.

2. Native soils.

Compaction tests were not performed on the bedrock subgrade, but were performed on underlying soils.

After contouring of the channel was completed, a 3-inch-thick bedding layer having a D_{50} of 0.02 inch and an additional 3-inch bedding layer having a D_{50} of 0.35 inch were placed in the NCDC. These bedding layers are designed to prevent undercutting and piping beneath the riprap during surface runoff events. All bedding layers were placed using a front-end loader and spread to a uniform thickness using hand rakes. A minimum of 15 inches of riprap having a D_{50} of 9 inches was then placed on top of the bedding material.

5.2.2 Specifications and Testing

Specifications for construction of the NCDC as stipulated in the Reclamation Plan (Canonie, 1991) include:

1. The NCDC 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 of the NCDC.

4. 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 the NCDC.

5. A minimum of 15 inches of riprap consisting of durable rock with a D_{50} of 9 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.

5.2.2.1 Survey Control

Survey control for construction of the NCDC consisted of installing grade stakes through the middle of the channel and at 10-foot offsets on each side of the channel. 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.

5.2.2.2 Subgrade Density Testing

In-place field density testing of the NCDC subgrade was conducted using the sand cone method (ASTM D 1556). The subgrade consisted primarily of weathered claystone-siltstone bedrock, with native soils in the area from Station 8+00 to Station 9+00. A total of 3 locations in the area underlain by native soils 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 for every 5 field density tests. One standard Proctor test was performed on the subgrade material, resulting in a testing frequency of 1 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.

5.2.2.3 *Bedding Layer Testing*

Two layers of bedding material were placed at a minimum thickness of 6 inches on the bottom and sides of the NCDC. The bottom layer of 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 5 inches thick in all locations.

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. Its thickness was also 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 L and show that the depth of the second bedding layer ranged from 3 to 4 inches thick in all locations.

Three sieve analyses were performed to determine the gradation characteristics of the D_{50} 0.02-inch bedding material used in constructing the NCDC, the branch swales and the upper reach of the Runoff Control Ditch. 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.

Eight sieve analyses were performed to determine the gradation characteristics of the D_{50} 0.35-inch bedding material. The results of the sieve analyses are presented in Appendix K. The first 5 sieve analyses did not meet the gradation requirements, and the tested material was discarded. Results of the last 3 tests 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.

The D_{50} 0.35-inch bedding material exceeded the durability specifications for aggregate with rock quality characteristics similar to the 1.5-inch rock aggregate (see Section 4.2.1). The average test values for the rock included a specific gravity of 2.74, an absorption of 1.9 percent, a sodium soundness loss of 4.1 percent, and an L.A. Abrasion percentage of 3.6. The rock quality scores for the test, using the scoring criteria provided in the August 1990 STP (NRC, 1990), ranged from 80 to 90, with an average score of 84.7. The 3 rock quality tests for the D_{50} 0.35-inch aggregate are presented in Appendix F.

5.2.2.4 Riprap Testing

In accordance with the specifications of the reclamation plan, riprap consisting of a basaltic rock with a D_{50} of 9 inches was placed at a minimum thickness of 15 inches on the bottom and sides of the NCDC. 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 L and show that all measurements met or exceeded the 15-inch minimum.

The rock used as riprap in the NCDC was a dense basaltic rock with durability characteristics superior to the criteria stipulated in the technical specifications. Three tests were performed to verify the rock's quality. The test results are presented in Appendix L. The average test values for the rock included a specific gravity of 2.74, an absorption of 1.4 percent, a sodium soundness loss of 0.5 percent, and an L.A. Abrasion percentage of 8.0. The rock quality scores for the test, using the scoring criteria provided in the August 1990 STP, ranged from 91 to 92, with an average score of 91.7.

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's records show that a total of 1,437 cy of D_{50} 9-inch rock was placed as riprap during 1995. No change in rock characteristics was noted by the quality control technician. Three rock quality tests were conducted, or 1 for each 479 cy of rock used. Therefore, the rock quality testing rate exceeds the test rate required by the specifications.

The basaltic rock with a D_{50} of 9 inches that was used to riprap the NCDC was also subjected to 3 sieve analyses to ensure that gradation requirements were being met. The following size gradations were required for the D_{50} 9-inch rock: 100 percent passing a 15-inch screen; 45-58 percent passing a 10-inch screen; 10-33 percent passing a 5-inch screen; and 0-23 percent passing a 3-inch screen. The first sample did not meet these requirements, and the material was rejected. The remaining tests showed that the material was within specifications. The results of the sieve analysis testing are presented in Appendix L.

5.3 North Slope of North Cell

The non-tailings area north of the North Cell was covered with D_{50} 1.5-inch riprap during 1995 as shown on Sheet 4. The aggregate consisted of basaltic rock having the same rock quality characteristics and gradation as the 1.5-inch riprap previously described in Sections 4.2.1 and 4.2.2. The aggregate was placed using a motor grader and spread to a thickness ranging from 3 inches to 4.75 inches. Aggregate thickness was verified by measuring the thickness at surveyed points located on approximately 100-foot centers. The results of these measurements are presented in Appendix M and show that all measurements met or exceeded the 3-inch minimum.

6.0 CLOSING REMARKS

Borrow Pit No. 2 has been reclaimed in accordance with the specifications and construction drawings contained in the Reclamation Plan (Canonie, 1991). This reclamation included backfilling the borrow pit with decommissioned mill materials and fill soil, and construction of the radon attenuation layer, erosion protection cover and surface water controls.

Smith Environmental appreciates this opportunity to provide engineering services in summarizing information regarding work conducted from 1991 to 1995 in the Borrow Pit No. 2 Area at the Church Rock Facility. If you have any questions, please contact me at (303) 790-1747.

Respectfully submitted,

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Project Manager

BWH/ajw

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