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TECHNOLOGY CORPORATION

As-Built Report

1996 Final Reclamation Construction

Church Rock Site
Gallup, New Mexico

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Gallup, New Mexico

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AS-BUILT REPORT

1996 FINAL RECLAMATION CONSTRUCTION
UNITED NUCLEAR CORPORATION
CHURCH ROCK FACILITY
GALLUP, NEW MEXICO

1.0 INTRODUCTION

This report describes the construction in 1996 of surface water control structures associated with the final reclamation cover at United Nuclear Corporation's (United Nuclear's) Church Rock facility. The former uranium mill and tailings disposal area is located northeast of Gallup, New Mexico, along State Highway 566, as shown on Sheet 1. United Nuclear is conducting reclamation of the site as scheduled, in accordance with the "Tailings Reclamation Plan as Approved by NRC March 1, 1991, License Number SUA-1475" (Reclamation Plan) [Canonie Environmental Services Corp. (Canonie), 1991].

Construction activities in 1996 focused on completing the surface water control structures around the perimeter of the reclaimed tailings disposal area. These activities included constructing the South Cell Drainage Channel and the lower reach of the North Cell Drainage Channel, armoring 2 portions of the North Diversion Ditch, installing the buried jetty and low flow channel in the Pipeline Arroyo, and completing the Runoff Control Ditch. The locations of these construction activities are shown on Sheets 2 and 3.

Work in 1996 represents the fifth and next to last stage of final reclamation for the tailings disposal area. Other than general cleanup, the only remaining final reclamation activities to be completed at the site are the backfilling of the evaporation ponds and completion of the drainage swales in the immediate vicinity of the ponds. Final reclamation of the North Cell was completed in 1993 as documented in the "As-Built Report, North Cell Final Reclamation" (Canonie, 1994), final reclamation of the Central Cell was completed in 1994 as documented in the "As-Built Report, Central Cell Final

Reclamation" (Canonie, 1995), and final reclamation of the South Cell and Borrow Pit No. 2 was completed in 1995, as documented in the "As-Built Report, South Cell Final Reclamation" [Smith Environmental Technologies Corporation (Smith Environmental), 1996a] and "As-Built Report, Borrow Pit No. 2 Final Reclamation" (Smith Environmental, 1996b).

Interim stabilization of the entire tailings disposal area was 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. (WTI), 1991], South Cell (Canonie, 1992a) and Central Cell Addendum (Canonie, 1992b). Mill decommissioning activities are described in the "Mill Decommissioning Report" (United Nuclear, 1993).

Construction activities during 1996 were performed in accordance with the design drawings and the specifications of the approved Reclamation Plan (Canonie, 1991) as modified by the Technical Support for Amendment Requests dated February 1996 and June 1996 (Smith Environmental, 1996c and 1996d). For reference purposes, Figures 5-1, 5-2, 5-3, 5-3A, 5-4, 5-9, 5-12 and 5-13 and Tables 5.6 and 5.7 from the Reclamation Plan have been included as Appendix A of this report.

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 riprap and bedding material for the surface water control structures were provided by Hamilton Brothers, Inc. (Hamilton). WTI provided geotechnical sampling and testing services. WTI's test methods and 1996 field reports of daily construction activities are included in Appendix B.

The construction activities and quality control procedures performed during 1996 are described in the following sections of this report. The specifications, field modifications, construction methods and materials, and quality control procedures are documented for each surface water control structure in Sections 2 through 7. Section 8, which documents the gradation and durability testing of both bedding material and riprap, is applicable to all of the construction activities performed during 1996. Copies of the geotechnical test results and field measurements are provided in Appendices D through J.

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2.0 SOUTH CELL DRAINAGE CHANNEL

During June 1996, the South Cell Drainage Channel was constructed from Swale I to the Pipeline Arroyo, a distance of approximately 1,600 feet. Sheet 3 shows the as-built configuration of the South Cell Drainage Channel, which provides surface drainage for the South Cell and the southern portion of the Central Cell of the reclaimed tailings disposal area.

2.1 Specifications

Specifications for construction of the South Cell Drainage Channel as stipulated in the Reclamation Plan (Canonie, 1991) include:

1. The South Cell Drainage Channel is to be constructed as shown on Figures 5-1 and 5-4 (see Appendix A).

2. The subgrade is to be compacted to a minimum of 90 percent of the maximum dry density as determined by American Society for Testing and Materials (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 upper 450 feet of the South Cell Drainage Channel (see Table 5.7 in Appendix A).

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 upper 450 feet of the South Cell Drainage Channel (see Table 5.7 in Appendix A).

5. A minimum of 23 inches of riprap consisting of durable rock with a D_{50} of 15 inches is to be placed on top of the bedding layers in the upper 450 feet of the

South Cell Drainage Channel (see Table 5.6 in Appendix A). The lower portion of the channel does not require riprap because it is to be completed in bedrock.

2.2 Field Modifications

Minor field modifications were developed prior to and during construction to accommodate the channel design to the as-built conditions. These modifications, as described below, were developed in a manner consistent with the design methods and objectives of the approved Reclamation Plan.

In 1995, prior to the start of final reclamation of the South Cell, United Nuclear conducted a detailed review of the reclamation plan requirements for construction of the cell's surface water control structures including the South Cell Drainage Channel. The review indicated that the invert elevation where Swale I flows into the South Cell Drainage Channel was at 6,947.85 feet rather than the design elevation of 6,951 feet shown on Figure 5-1. Review of the Reclamation Plan indicated that the design elevation was incorrect, probably the result of a mathematical or typographical error.

This decrease in elevation at the head of the channel resulted in a significant grade reduction from 0.0244 to 0.0174 over the first 450 feet of the channel thereby allowing the use of smaller riprap while still meeting NRC requirements. Smith Environmental evaluated riprap requirements in its June 26, 1995, transmittal to United Nuclear entitled "Field Design Modifications Central and South Cell Reclamation". This evaluation, presented in Appendix C, indicated that 15 inches of riprap with a D_{50} of 10 inches would meet NRC requirements for stability in the modified channel.

The channel design was further modified in 1996 when sandstone bedrock was encountered after the first 200 feet of channel excavation rather than 450 feet as had been projected in the Reclamation Plan (see Figure 5-4). The sandstone was found to be competent thus eliminating the need for riprap from Station 2+00 to 4+50.

2.3 Construction Methods and Materials

The initial portion of the South Cell Drainage Channel, which is located within the South Cell of the tailings disposal area, was previously excavated in 1995 to the required subgrade elevation. This work was performed in 1995 so that any radioactive materials encountered during excavation could be placed under the tailings cap, as required by the reclamation plan, during final reclamation of Borrow Pit No. 2 and the South Cell of the tailings disposal area.

Initial activities performed in 1996 consisted of excavating and grading the initial 200 feet of the South Cell Drainage Channel to the required bottom width of 10 feet and sideslopes of 3 horizontal to 1 vertical (3H/1V) and then compacting with a sheepsfoot compactor and smooth drum roller. Afterwards, a 3-inch thick bedding layer having a D_{50} of 0.02 inch and a 3-inch thick bedding layer having a D_{50} of 0.35 inch were placed sequentially on the compacted surface. The bedding layers were placed using a front-end loader and spread to a uniform thickness using hand rakes. Riprap with a D_{50} of 10 inches was then placed using the front-end loader and manual labor.

The remaining 1,400 feet of channel was constructed to the specified depths and sideslopes in the sandstone bedrock using a D-9 dozer equipped with a ripper. This portion of the channel was not riprapped because the bedrock was found to be competent.

2.4 Quality Control Procedures

Adherence to the specifications was maintained through survey control, geotechnical testing of rock properties, and measuring the in-place thickness of bedding and riprap. Survey control for construction of the South Cell Drainage Channel consisted of installing grade stakes through the middle of the channel on 50-foot centers with cuts and fills marked to a precision level of plus or minus 0.05 foot. Results of the field testing and measurements are summarized below and in Section 8. Copies of pertinent test results and measurements are provided in Appendices D, I and J.

2.4.1 Subgrade Testing

In-place field density testing of the South Cell Drainage Channel subgrade from Station 0+00 to 2+00 was not conducted because this material consisted of a thin veneer of soil and loose bedrock that could not be tested using sandcone test methods. The remaining portion of the channel also did not require testing as it was completed entirely in competent bedrock.

2.4.2 Bedding Layer Testing

Two layers of bedding material were placed at a minimum thickness of 3 inches per layer (i.e., 6 inches total) on the bottom and sides of the initial 200 feet of the South Cell Drainage Channel. The bottom layer of bedding material consisted of crusher fines with a nominal D_{50} of 0.02 inch. The second layer of bedding material consisted of crushed basaltic aggregate with a nominal D_{50} of 0.35 inch. The bedding layer thicknesses were verified in the field by measuring the depth of each bedding layer on the channel bottom and sides every 50 feet. The results of these measurements are presented in Appendix D and show that both bedding layers ranged in thickness from 3 to 3.5 inches at all locations.

As discussed in Section 8, sieve analyses of both bedding layer materials and durability testing of the D_{50} 0.35-inch bedding material verified that the physical properties of the bedding materials conformed to the Reclamation Plan requirements.

2.4.3 Riprap Testing

In accordance with the field design modifications described in Section 2.2, riprap with a D_{50} of 10 inches was placed at a minimum thickness of 15 inches from Station 0+00 to 2+00. Riprap thickness was verified by measuring the depth of the riprap on the channel bottom and sides every 50 feet. The results of these measurements are presented in Appendix D and show that all measurements met or exceeded the minimum thickness requirements.

As discussed in Section 8, the rock used as riprap in the South Cell Drainage Cell was a dense basaltic rock with durability characteristics superior to the criteria stipulated in the technical specifications and gradation characteristics within the specified gradation envelope.

3.0 NORTH CELL DRAINAGE CHANNEL

The lower reach of the North Cell Drainage Channel was constructed during June and July 1996. The lower reach is a curved channel connecting the previously constructed upper and middle reaches of the North Cell Drainage Channel with an existing natural channel located between the north edge of the tailings pile and an elevated roadway. The as-built location of the lower reach of the North Cell Drainage Channel is shown on Sheet 2. The design of the lower reach is described in "Technical Support for Proposed Modifications to the Church Rock Site Tailings Reclamation Plan" (Smith Environmental, 1996c) which was approved by the NRC in a letter dated May 3, 1996 (NRC, 1996).

As shown on Figures 5-2 and 5-3A in Appendix A, the upper (south) end of the lower reach of the North Cell Drainage Channel is 10 feet wide with 3H/1V sideslopes and is protected on the bottom and sides with riprap. The channel gradually widens, so that at the lower (northwest) end of the curve the armored channel is 30 feet wide. The outer (north) side of the curved channel has 3H/1V sideslopes and is protected from erosion by relatively large riprap. On its inner side, the riprap size decreases and flow is allowed to spread out rather than being confined within a 3H/1V sideslope. Below the curved section, flow continues within a natural, unlined channel.

3.1 Specifications

Specifications for construction of the North Cell Drainage Channel as stipulated in the Reclamation Plan (Canonie, 1991) and the Technical Support for Proposed Modifications to the Church Rock Site Tailings Reclamation Plan (Smith Environmental, 1996c) include:

1. The North Cell Drainage Channel is to be constructed as shown on Figures 5-2, 5-3 and 5-3A (see Appendix A).

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 North Cell Drainage Channel (see Table 5.7 in Appendix A).

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 top of the first bedding layer (see Table 5.7 in Appendix A).

5. A minimum of 10 inches of riprap consisting of durable rock with a D_{50} of 6 inches is to be placed on top of the bedding layer at the south (i.e., upper) end of the lower reach prior to the curve (see Section D-D′ of Figure 5-3A in Appendix A).

6. 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 along the center and outside berm of the curved section, and a minimum of 6 inches of riprap consisting of durable rock with a D_{50} of 3 inches is to be placed on top of the bedding layer along the inside of the curved section (see Section E-E′ of Figure 5-3A in Appendix A).

3.2 Field Modifications

United Nuclear implemented 3 minor field modifications during the construction of the lower reach of the North Cell Drainage Channel. In all 3 cases, the riprap size and/or thickness was increased above that required in the Specifications. These field modifications included:

1. Riprap with a nominal D_{50} of 10 inches was substituted for 9-inch D_{50} riprap at all locations. This allowed United Nuclear to use the same riprap for both the South Cell Drainage Channel and the North Cell Drainage Channel.

2. The south end of the channel was lined with 15 inches of rock having a D_{50} of 10 inches rather than the specified 10 inches of rock having a D_{50} of 6

inches. This change was made so that the riprap size and thickness of the North Cell Drainage Channel remained consistent throughout the length of the channel.

3. A minimum of 10 inches of riprap with a D_{50} of 6 inches was substituted for the 6 inches of riprap with a D_{50} of 3 inches on the inside of the curved section. This substitution was made because the 6-inch rock was readily available and its use eliminated the need for special ordering the small quantity of 3-inch rock specified for this section of the channel.

The increase in riprap size and thickness at these locations improved the structural integrity of the channel above that required by the Reclamation Plan specifications.

3.3 Construction Methods and Materials

The initial step in constructing the lower reach of the North Cell Drainage Channel was to excavate the existing natural channel to create a continuous channel slope. Excess soil was used to fill low spots and to construct a berm along the outside curve of the lower reach of the channel. Excavation was performed using scrapers and dozers. A motor grader, sheepsfoot compactor, and smooth drum roller were used to achieve the required final subgrade elevations and compaction levels.

After contouring and compaction of the channel were 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 lower reach of the channel. The bedding layers were placed using a front-end loader and spread to a uniform thickness using hand rakes. The 10-inch and 6-inch riprap was then placed over the bedding layers using the front-end loader and manual labor.

3.4 Quality Control Procedures

Adherence to the specifications was maintained through survey control, geotechnical testing of soil and rock properties, and measuring of in-place soil densities and depths of bedding material and riprap. Survey control for construction of the South Cell Drainage Channel consisted of installing grade stakes through the middle of the channel on 50-foot centers. Surveying was performed within a precision level of plus or minus 0.05 foot. Results of the field testing and measurements are summarized below and in Section 8. Copies of pertinent test results and measurements are provided in Appendices E, I and J.

3.4.1 Subgrade Testing

In-place field density testing of the subgrade was conducted using the sand cone method (ASTM D 1556). A total of 3 locations in the channel and on the berm 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.

Gradation tests were also performed for the unlined portion of the channel. The 6 tests performed indicated that the soil was predominantly fine-grained consisting of silty clayey sands, sandy silts and sandy lean clays. These results are consistent with the design assumptions made in the "Technical Support for Proposed Modifications to the Church Rock Site Tailings Reclamation Plan" (Smith Environmental, 1996c).

The results of the standard Proctor, field density, and gradation tests for the subgrade material are presented in Appendix E.

3.4.2 Bedding Layer Testing

Two layers of bedding material were placed at a minimum thickness of 3 inches per layer on the bottom and sides of the lower reach. 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 channel bottom and berm every 50 feet. The results of these measurements, presented in Appendix E, show that the bedding layer ranged from 3.25 to 3.5 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 by measuring its depth on the channel bottom and berm every 50 feet. The results of these measurements, presented in Appendix E, show that the depth of the second bedding layer ranged from 3.0 to 3.75 inches thick in all locations.

As discussed in Section 8, sieve analyses of both bedding layer materials and durability testing of the D_{50} 0.35-inch bedding material verified that the physical properties of the bedding materials conformed to the Reclamation Plan requirements.

3.4.3 Riprap Testing

In accordance with the field modifications described above in Section 3.2, the upper portion of the channel and the outer part of the curved channel were lined with riprap consisting of a basaltic rock with a D_{50} of 10 inches, placed at a minimum thickness of 15 inches. The inner part of the curve was lined with riprap having a D_{50} of 6 inches, placed at a minimum thickness of 10 inches. Riprap thickness was verified by measuring the depth of the riprap on the channel bottom and berm every 50 feet. The results of these measurements are presented in Appendix E and show that all measurements met or exceeded the minimum thickness requirements.

As discussed in Section 8, the 6-inch and 10-inch rock used as riprap in the North Cell Drainage Cell was a dense basaltic rock with durability characteristics superior to the criteria stipulated in the technical specifications and gradation characteristics within the specified gradation envelope.

4.0 NORTH DIVERSION DITCH

In accordance with the reclamation plan, bedding material and riprap were placed in the existing North Diversion Ditch at 2 locations where the NRC had expressed concern regarding the long-term potential for erosion. As shown on Sheet 3, the riprap was placed within the 2 sharp curves in the North Diversion Ditch immediately south of the reclaimed Central Cell.

4.1 Specifications

Specifications for placement of the riprap in the North Diversion Ditch as stipulated in the Reclamation Plan (Canonie, 1991) include:

1. The riprap is to be placed in the curves marked as Section AA-AA' and BB-BB' on Figures 5-1 and 5-3 (see Appendix A).

2. 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 curves (see Table 5.7 in Appendix A).

3. A second bedding layer consisting of a minimum 3-inch-thick layer of well-graded crushed rock with a D_{50} of 0.35 inch is to be placed on the bottom and sideslopes of the curves (see Table 5.7 in Appendix A).

4. A minimum of 10 inches of riprap consisting of durable rock with a D_{50} of 6 inches is to be placed on top of the bedding layers (see Table 5.6 in Appendix A).

Because the ditch is preexisting, no compaction requirements were included in the specifications.

4.2 Construction Methods and Materials

A 3-inch-thick bedding layer having a D_{50} of 0.02 inch and an additional 3-inch-thick bedding layer having a D_{50} of 0.35 inch were placed over a distance of 300 feet at Section AA-AA′ and 225 feet at Section BB-BB′. The bedding layers were placed using a front-end loader and spread to a uniform thickness using hand rakes. Riprap with a D_{50} of 6 inches was then placed over the bedding layers using the front-end loader and manual labor.

4.3 Quality Control Procedures

Adherence to the specifications was maintained through testing of rock properties and measuring of in-place depths of bedding layers and riprap. Results of the testing and measurements are summarized below and in Section 8. Copies of pertinent test results and measurements are provided in Appendices F, I and J.

4.3.1 Bedding Layer Testing

Two layers of bedding material were placed at a minimum thickness of 3 inches per layer on the bottom and sides of the 2 curves. The bottom layer of bedding material consisted of crusher fines with a nominal D_{50} of 0.02 inch. The second layer of bedding material consisted of crushed basaltic aggregate with a nominal D_{50} of 0.35 inch. The bedding layer thicknesses were verified in the field by measuring the depth of each bedding layer on the ditch bottom and sides every 50 feet. The results of these measurements are presented in Appendix F and show that the bedding layers ranged in thickness from 3 to 4 inches thick at all locations.

As discussed in Section 8, sieve analyses of both bedding layer materials and durability testing of the D_{50} 0.35-inch bedding material verified that the physical properties of the bedding materials conformed to the Reclamation Plan requirements.

4.3.2 *Riprap Testing*

In accordance with the specifications, the 2 curved sections of the North Diversion Ditch were lined with riprap consisting of a basaltic rock with a D_{50} of 6 inches, placed at a minimum thickness of 10 inches. Riprap thickness was verified by measuring the depth of the riprap on the swale bottom and sides every 50 feet. The results of these measurements, presented in Appendix F, show that all measurements met or exceeded the minimum thickness requirements.

As discussed in Section 8, the 6-inch rock used as riprap in the North Diversion Ditch was a dense basaltic rock with durability characteristics superior to the criteria stipulated in the technical specifications and gradation characteristics within the specified gradation envelope.

5.0 BURIED JETTY

To ensure the geomorphic stability of the Pipeline Arroyo, a stone-filled trench, referred to as the buried jetty, was constructed across the arroyo approximately 150 feet north of the nickpoint outcrop as shown on Sheet 3. The nickpoint consists of Gallup Sandstone outcropping within the arroyo. The jetty is designed to provide vertical control of the Pipeline Arroyo channel bottom and ensure that the arroyo maintains its current configuration in this area (i.e., surface flow passing directly over the nickpoint).

5.1 Specifications

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

1. The buried jetty is to be constructed at the location shown on Figure 5-1 and in accordance with the cross sections shown on Figure 5-9 (see Appendix A). The jetty is to be 8 feet wide by 20 feet deep and extend from the Gallup Sandstone subcrop in the arroyo's west bank to the top of the protective bench along the tailings embankment toe.

2. The jetty is to consist of durable rock with a D_{50} of 6 inches as shown in Table 5.6 (see Appendix A).

3. After rock placement is complete, soil shall be placed in horizontal lifts with a maximum loose lift thickness of 12 inches and compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D 698.

5.2 Construction Methods and Materials

A trench extending from the subcrop in the west bank of the arroyo to the protective bench was excavated using a dozer and a large backhoe. The trench was 45 feet wide and varied in depth from 9 feet at the west bank of the arroyo to 28 feet at the protective bench. The final excavated depth of the trench was determined by the depth to the Gallup Sandstone subcrop. Equipment access to the trench was provided through a ramp constructed at the east end of the trench. Construction of this ramp required excavating a section of the runoff control ditch which was reconstructed after completion of the buried jetty, as discussed in Section 7.

After the trench was excavated, crushed rock having a D_{50} of 6 inches was placed in a series of 3-foot lifts across a width of 8 feet over the entire length of the trench. Loose soil in 12 inch lifts was backfilled and compacted in the remaining portion of the trench after each lift of crushed rock was placed. The rock and soil lifts were constructed to the elevation of the existing channel.

5.3 Quality Control Procedures

Adherence to the specifications was maintained through survey control, testing of rock properties, and measuring of in-place soil densities. As discussed in Section 8, the 6-inch rock was a dense basaltic rock with durability characteristics superior to the criteria stipulated in the technical specifications and gradation characteristics within the specified gradation envelope. In-place field density testing of the native soil backfill was conducted using the sand cone method (ASTM D 1556). A total of 17 locations were tested, 16 of which met the required density of 95 percent of the maximum dry density as determined by ASTM D 698 on the initial test. The remaining location was reworked and compacted, then tested a second time. The retest showed that the required compaction had been achieved.

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. Two standard Proctor tests were performed on the backfill material, resulting in a testing frequency of 1 standard Proctor test performed for every 8.5 field density tests. No 1-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 backfill material are presented in Appendix G.

6.0 PIPELINE ARROYO

A low-flow channel, as shown on Sheets 2 and 3, was constructed within the Pipeline Arroyo from the buried jetty upstream (i.e. to the northeast) for approximately 6,000 feet. This channel is 30 feet wide by 2 to 4 feet deep and is designed to enhance the flow capabilities of the present channel. South of the buried jetty, the existing drainage channels were cleaned out and obstructions removed.

6.1 Specifications

Specifications for construction of the low-flow channel as stipulated in the Reclamation Plan (Canonie, 1991) include:

1. The low-flow channel is to be constructed from the buried jetty upstream to Station 0+00 as shown on Figures 5-1 and 5-2 (see Appendix A).

2. The low-flow channel is to be configured as shown on Figures 5-12 and 5-13 (see Appendix A).

South of the buried jetty, the Pipeline Arroyo and the area between the South Cell and the Pipeline Arroyo are to remain in place as described in the "Technical Support for Proposed Modifications to the Church Rock Site Tailings Reclamation Plan, Revision 1" dated June 1996 (Smith Environmental, 1996d). This modification did, however, require that the existing small surface drainages in this area be cleaned out and regraded as necessary to ensure positive drainage parallel to the face of the tailings pile until the channels discharge into the Pipeline Arroyo.

6.2 Field Modifications

Minor changes in the alignment of the low flow channel were made to avoid the natural gas lines buried in the immediate area. Cuts were also adjusted in some areas to produce a uniform bottom slope for the low-flow channel. These field modifications were minor in scope and consistent with the reclamation plan.

6.3 Construction Methods and Materials

The construction of the low-flow channel above the buried jetty and cleaning below the buried jetty were performed using dozers, scrapers and a front-end loader. Compaction of the channel and drainages was obtained through the compactive force of the equipments' tracks/tires. Excavated material was used to fill in low spots in adjacent areas.

6.4 Quality Control Procedures

Adherence to the specifications was maintained through survey control and visual observations. Survey control for construction of the low-flow channel consisted of installing grade stakes through the middle of the channel on 100-foot centers. Cuts and fills were made to a precision level of 0.05 foot. The channels adjacent to the buried jetty were regraded using visual observations so as to maintain a gradual slope from the top of the buried jetty to the bottom of the channels. No subgrade testing or riprap placement was required for any part of the Pipeline Arroyo.

7.0 RUNOFF CONTROL DITCH

The Runoff Control Ditch, located immediately west of the reclaimed tailings area, was constructed during previous stages of final reclamation. Work in 1996 was limited to extending the south end of the ditch approximately 100 feet to intersect the South Cell Drainage Channel and reconstruction of a 90-foot section of the ditch that was removed during construction of the buried jetty.

7.1 Specifications

Specifications for construction of the south end (i.e., exit section) and buried jetty portion (i.e., reconstructed section) of the Runoff Control Ditch as stipulated in the Reclamation Plan include:

1. The ditch is to be constructed to the lines, grades and configuration shown on Figures 5-1 and 5-4 (see Appendix A).

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 reconstructed section and exit section (see Upper and Lower Runoff Control Ditch, Table 5.7 in Appendix A).

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 exit section (see Lower Runoff Control Ditch, Table 5.7 in Appendix A).

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 in the reconstructed section (see Upper Runoff Control ditch, Table 5.6 in Appendix A).

6. A minimum of 6 inches of riprap consisting of durable rock with a D_{50} of 3 inches is to be placed on top of the bedding layers in the exit section (see Lower Runoff Control Ditch, Table 5.6 in Appendix A).

7.2 Field Modifications

A minimum of 8 inches of riprap with a D_{50} of 6 inches was substituted for the 6 inches of riprap with a D_{50} of 3 inches in the exit section of the runoff control ditch. This substitution was made to avoid having to manufacture a small quantity of the smaller-sized riprap.

7.3 Construction Methods and Materials

The Runoff Control Ditch was excavated down to the required subgrade elevation using a dozer. The native soils at the bottom and sides of the ditch were then compacted with a sheepsfoot compactor and smooth drum roller to achieve the required density. The lower portion of the exit section was completed in bedrock and did not require compaction.

After the subgrade met the in-place density specifications, a front-end loader and hand rakes were used to place the bedding layers. A minimum of 3 inches of bedding material having a D_{50} of 0.02 inch was placed in the reconstructed ditch section near the buried jetty. This same 0.02 inch bedding layer plus a second 3-inch thick bedding layer of rock aggregate with a D_{50} of 0.35 inch was placed in the exit section of the Runoff Control Ditch. Riprap was then placed using the front-end loader and hand labor. Riprap consisted of 3 inches of rock with a D_{50} of 1.5 inches in the reconstructed section and 8 to 9 inches of rock with a D_{50} of 6 inches in the exit section.

7.4 Quality Control Procedures

Adherence to the specifications was maintained through survey control, geotechnical testing of soil and rock properties, and measuring of in-place soil densities and depths of bedding and riprap. Survey control for the Runoff Control Ditch consisted of installing grade stakes through the middle of the channel on 50-foot centers with cuts and fills marked to a precision level of plus or minus 0.05 foot. Results of the field testing and measurements are summarized below and in Section 8. Copies of pertinent test results and measurements are provided in Appendices H, I and J.

7.4.1 Subgrade Testing

In-place field density testing of the reconstructed ditch subgrade at Station 24+00 and the exit section subgrade at Station 43+00 was conducted using the sand cone method (ASTM D 1556). A total of 5 locations in the reconstructed channel and 3 locations in the exit section 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. Density tests for the reconstructed section were compared to the standard Proctor tests performed on the soil fill used to construct the buried jetty. This approach was valid because the ditch was excavated through this same fill. One standard Proctor test was performed on the subgrade material at the exit section. The overall test frequency of 1 standard Proctor test performed for every 8 field density tests was consistent with the specifications.

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

7.4.2 Bedding Layer Testing

Bedding material was placed at a minimum thickness of 3 inches on the bottom and sides of the reconstructed portion of the ditch prior to the installation of riprap. The bedding material consisted of crusher fines with 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 ditch bottom and sides on 50-foot intervals. The results of these measurements are presented in Appendix H and show that the bedding layer was 3.5 inches thick at all locations.

At the exit section of the Runoff Control Ditch, 2 bedding layers were placed: an initial layer of crusher fines with a D_{50} of 0.02 inch and a second layer consisting of crushed basaltic aggregate with a D_{50} of 0.35 inch. Both bedding layers were placed at a minimum thickness of 3 inches. The thickness of each bedding layer was verified by measuring the depth of the layers on the ditch bottom and sides on 50-foot intervals. The results of these measurements are presented in Appendix H and show that the bedding layers ranged in thickness from 3 to 4.5 inches.

As discussed in Section 8, sieve analyses of both bedding layer materials and durability testing of the D_{50} 0.35-inch bedding material verified that the physical properties of the bedding materials conformed to the Reclamation Plan requirements.

7.4.3 Riprap Testing

The reconstructed section of the Runoff Control Ditch was lined with riprap consisting of a basaltic rock with a D_{50} of 1.5 inches, placed at a minimum thickness of 3 inches. Riprap thickness was verified by measuring the depth of the riprap on the ditch bottom and sides every 50 feet. The results of these measurements are presented in Appendix H and show that all measurements exceeded the minimum thickness requirement.

In accordance with the field design modifications described in Section 7.2, riprap with a D_{50} of 6 inches was placed at a minimum thickness of 8 inches from Stations 43+00 to 44+00 of the Runoff Control Ditch (i.e., exit section). Riprap thickness was verified by measuring the depth of the riprap on the ditch bottom and sides every 50 feet. The results of these measurements are presented in Appendix H and show that the riprap thickness was between 8 and 9 inches at all locations.

As discussed in Section 8, the rock used as riprap in the Runoff Control Ditch was a dense basaltic rock with durability characteristics superior to the criteria stipulated in the technical specifications and gradation characteristics within the specified gradation envelope.

8.0 TESTING OF RIPRAP AND BEDDING MATERIALS

The specifications require the riprap and bedding materials used in constructing the surface water control structures to be well graded and durable. Gradation requirements for the riprap and bedding materials are listed in Tables 5.6 and 5.7, respectively (see Appendix A). With regard to durability the specifications require that:

1. The rock 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, or

2. 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" [Nuclear Regulatory Commission (NRC), 1990] or equivalent, and shall be oversized, if needed, in accordance with the procedures provided in Appendix D of the August 1990 STP.

The specifications require that a series of rock durability tests be performed initially and for each additional 10,000 cubic yards (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 performed 3 durability tests for each size rock. Given that the materials were relatively uniform in composition and quantities used for each size rock were less than 10,000 cy, the durability testing frequency exceeded the requirements. United Nuclear also required a minimum of 3 passing gradation tests for each type of bedding material and riprap.

The size and quantity of bedding material and riprap used for each of the surface water control structures constructed in 1996 are summarized in Table 2. As discussed below, gradation and durability tests performed for each of the bedding materials and riprap sizes demonstrate that these materials conformed to the gradation requirements and had durability characteristics superior to the criteria stipulated above.

8.1 Bedding Layer 1

Bedding Layer 1 consisted of well-graded crusher fines with a D_{50} of 0.02 inch from the Hamilton Brothers quarry. Bedding Layer 1 is designed to prevent undercutting and piping beneath the riprap with a D_{50} of 1.5 inches and Bedding Layer 2. As shown in Table 2, a total of 1,355 cy of this material were used in constructing the surface water control structures during 1996.

Three sieve analyses were performed to determine the gradation characteristics of the D_{50} 0.02-inch bedding material. The results of the sieve analyses are presented in Appendix I 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. The small size of this material did not allow for durability testing.

8.2 Bedding Layer 2

Bedding Layer 2 consisted of a basaltic aggregate with a nominal D_{50} of 0.35-inch. This bedding material is placed over Bedding Layer 1 and is designed to prevent undercutting and piping beneath the riprap having a D_{50} of 3 inches or larger. As shown in Table 2, a total of 1,150 cy of this material were used in constructing the surface water control structures during 1996.

Five 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 I. Two of the tests did not meet 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. This material was subsequently rejected. Of the remaining 3 tests, one passed all of the gradation specifications while 2 tests passed all of the gradation specifications except for the #40 screen size which was 1 to 2 percent high. Given the relatively small variance from the specification, this material was determined to be acceptable.

The D_{50} 0.35-inch bedding material exceeded the durability specifications for rock aggregate. As shown in Table 3, the average test values for the 0.35-inch aggregate included a specific gravity of 2.80, an absorption of 1.3 percent, a sodium soundness loss of 4.0 percent, and an L.A. Abrasion percentage of 3.45. The rock quality scores for the test, using the scoring criteria provided in the August 1990 STP (NRC, 1990), ranged from 84 to 91, with an average score of 88.3. The 3 rock quality tests for the D_{50} 0.35-inch aggregate are presented in Appendix J.

8.3 1.5-Inch Riprap

A total of 105 cy of basaltic riprap with a D_{50} of 1.5 inches were used to reconstruct the runoff control ditch by the buried jetty. This riprap was placed on top of Bedding Layer 1. A small quantity of 1.5-inch rock was also used to armor a portion of the South Cell embankment.

The 3 sieve analyses conducted on this rock showed that material was within the gradation specifications of 100 percent passing a 2-inch screen; 20-37 percent passing a 1-inch screen; and 0-8 percent passing a #4 screen. The results of the sieve analysis testing are presented in Appendix I.

As shown in Table 3, the D_{50} 1.5-inch riprap exceeded the durability specifications. The average test values for this rock included a specific gravity of 2.77, an absorption of 1.2 percent, a sodium soundness loss of 4.1 percent, and an L.A. Abrasion percentage of 4.0. The rock quality scores for the test, using the scoring criteria provided in the August 1990 STP, ranged from 83 to 91, with an average score of 86.0. The 3 rock quality tests for the D_{50} 1.5-inch riprap are presented in Appendix J.

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8.4 6-Inch Riprap

As shown in Table 2, 3,437 cy of basaltic rock with a D_{50} of 6 inches were used to construct the buried jetty and an additional 1,274 cy were used as riprap in the lower reach of the North Cell Drainage Channel, the North Diversion Ditch and the exit section of the Runoff Control Ditch. When used as riprap, this rock was placed over a minimum of 3 inches of Bedding Layer 1 and 3 inches of Bedding Layer 2.

The 6-inch rock aggregate was subjected to 5 sieve analyses to ensure that gradation requirements were being met. The following size gradations were required for the D_{50} 6-inch rock: 100 percent passing a 10-inch screen; 38-50 percent passing a 6-inch screen; 20-36 percent passing a 4-inch screen; and 0-9 percent passing a 1-inch screen. The first 2 samples 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 I.

Rock quality testing indicated that the rock had durability characteristics superior to the criteria stipulated in the technical specifications. As shown in Table 3, the average test values for the 6-inch rock included a specific gravity of 2.76, an absorption of 1.7 percent, a sodium soundness loss of 2.8 percent, and an L.A. Abrasion percentage of 4.7. The rock quality scores for the test, using the scoring criteria provided in the August 1990 STP, ranged from 82 to 95, with an average score of 88.3. The 3 rock quality tests for the D_{50} 6-inch rock are presented in Appendix J.

8.5 10-Inch Riprap

A total of 1,073 cy of D_{50} 10-inch rock were used as riprap in the South Cell Drainage Channel and the lower reach of the North Cell Drainage Channel. The 10-inch riprap, like the 6-inch riprap, was placed over a minimum of 3 inches of Bedding Layer 1 and 3 inches of Bedding Layer 2.

Consistent with methods used in the Reclamation Plan, the following gradation specification was established for the D_{50} 10-inch rock: 100 percent passing a 15-inch screen; 42-55 percent passing a 10-inch screen; 7-30 percent passing a 5-inch screen; and 0-20 percent passing a 3-inch screen. The gradation test results, presented in Appendix I, showed that all of the 10-inch rock met these specifications.

Rock quality testing indicated that the rock had durability characteristics superior to the criteria stipulated in the technical specifications. As shown in Table 3, the average rock quality test values for the 10-inch rock included a specific gravity of 2.82, an absorption of 1.2 percent, a sodium soundness loss of 3.6 percent, and an L.A. Abrasion percentage of 4.0. The rock quality scores ranged from 88 to 90, with an average score of 88.7. The 3 rock quality tests for the D_{50} 10-inch riprap are presented in Appendix J.

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9.0 CLOSING REMARKS

Reclamation construction activities conducted in 1996 were carried out in accordance with the specifications and construction drawings contained in the Reclamation Plan (Canonie, 1991). This reclamation included constructing the South Cell Drainage Channel and the lower reach of the North Cell Drainage Channel, armoring 2 portions of the North Diversion Ditch, installing the buried jetty and low flow channel in the Pipeline Arroyo, and completing the Runoff Control Ditch.

Smith Technology appreciates this opportunity to provide engineering services in summarizing information regarding work conducted during 1996 at the Church Rock Facility. If you have any questions, please contact me at (303) 790-1747.

Respectfully submitted,

Frank Filas, P.E.
Project Supervisor

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TABLES

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TABLE 1

CONSTRUCTION EQUIPMENT

Equipment Type	Number
Caterpillar D9H Dozer	1
Caterpillar EL 300B Backhoe	1
Caterpillar D6H Dozer	1
Caterpillar 825B Sheepsfoot Compactor	1
Caterpillar 769B Dump Truck	3
Caterpillar 633D Scraper	2
Belly Dump Truck	1
Caterpillar 631B Water Wagon	1
Caterpillar 14G Grader	1
Caterpillar 950B Front-End Loader	1
Ford 9000 Water Truck	1
Caterpillar 980G Front-End Loader	1

TABLE 2

SUMMARY OF 1996 ROCK SIZES AND QUANTITIES

Rock Aggregate D_{50} (inches)	Quantity of Rock Used (Cubic Yards)							
	South Cell Drainage Channel	North Cell Drainage Channel	North Diversion Ditch	Buried Jetty	Runoff Control Ditch (Reconstruction)	Runoff Control Ditch (Exit Section)	South Cell Slope	Total
0.02	575	300	260	---	140	80	---	1,355
0.35	532	284	254	---	---	80	---	1,150
1.5	---	---	---	---	105	---	133	238
6.0	---	418	755	3,437	---	61	---	4,671
10.0	670	403	---	---	---	---	---	1,073

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TABLE 3
SUMMARY OF 1996 ROCK QUALITY TESTING

0.35-inch Aggregate	6/7/96	7/12/96	7/12/96	Average
Specific Gravity	2.802	2.814	2.798	2.805
Absorption, %	0.99	1.233	1.608	1.277
LA Abrasion, 100 Rev, %	5.0	3.0	4.0	4.0
Sodium Soundness Loss, %	3.11	2.42	4.82	3.45
Rock Quality Score	90	91	84	88.3

1.5-inch Aggregate	4/9/96	4/23/96	7/12/96	Average
Specific Gravity	2.71	2.798	2.815	2.774
Absorption, %	1.3	1.1	1.083	1.161
LA Abrasion, 100 Rev, %	4.0	4.0	4.0	4.0
Sodium Soundness Loss, %	3.83	2.37	6.12	4.11
Rock Quality Score	84	91	83	86.0

6.0-inch Aggregate	4/1/96	4/27/96	5/21/96	Average
Specific Gravity	2.715	2.751	2.827	2.764
Absorption, %	2	2.2	0.9	1.700
LA Abrasion, 100 Rev, %	5.0	5.0	4.2	4.7
Sodium Soundness Loss, %	4.15	2.95	1.25	2.78
Rock Quality Score	82	88	95	88.3

10-inch Aggregate	6/7/96	6/17/96	7/12/96	Average
Specific Gravity	2.807	2.818	2.829	2.818
Absorption, %	1.3	1.2	1.006	1.169
LA Abrasion, 100 Rev, %	4.0	4.0	4.0	4.0
Sodium Soundness Loss, %	3.06	4.03	3.76	3.62
Rock Quality Score	90	88	88	88.7

FIGURES

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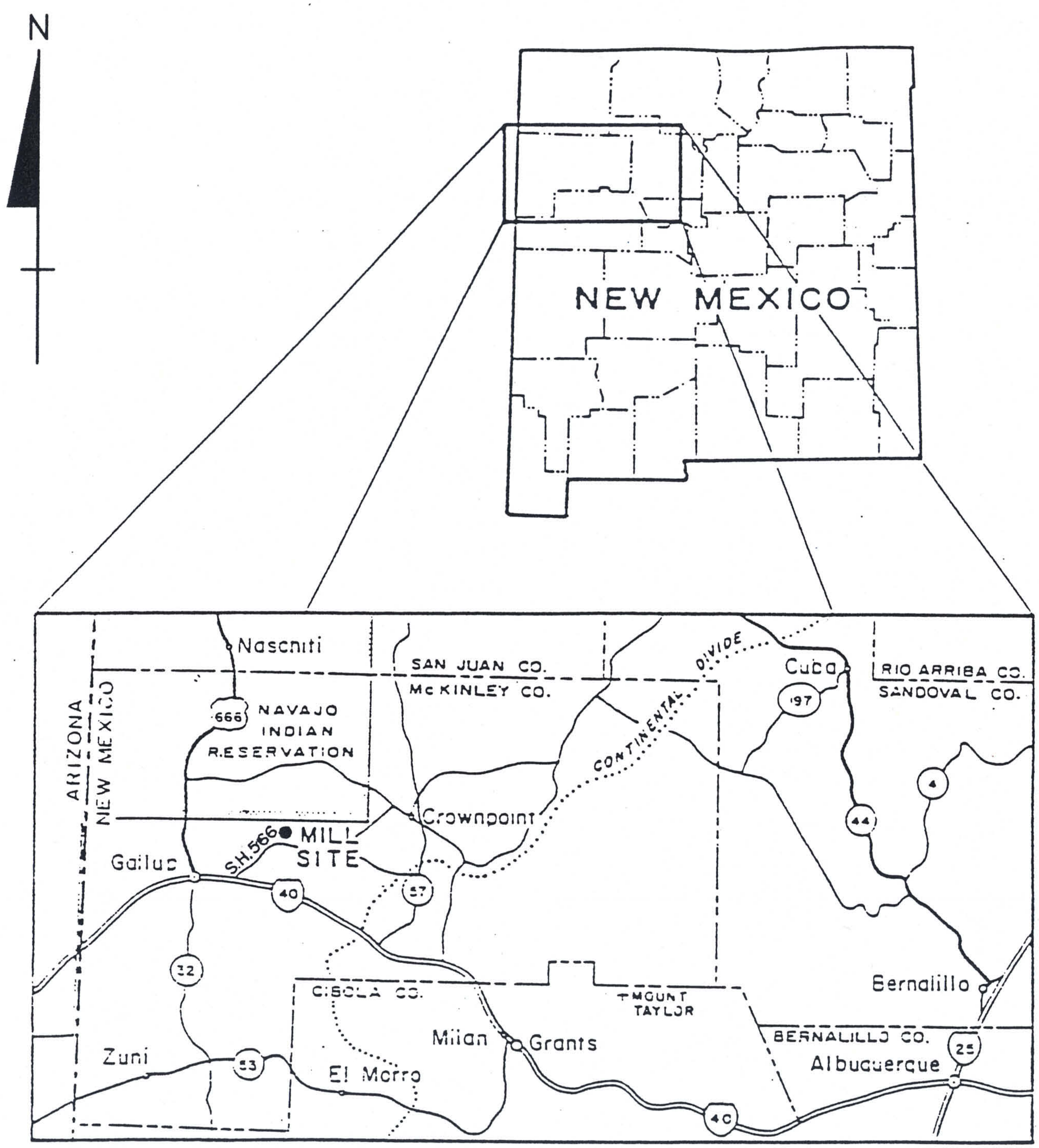
FIGURES

DRAWING NUMBER 86-060-A1089



SCALE

25 0 25 MILES

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

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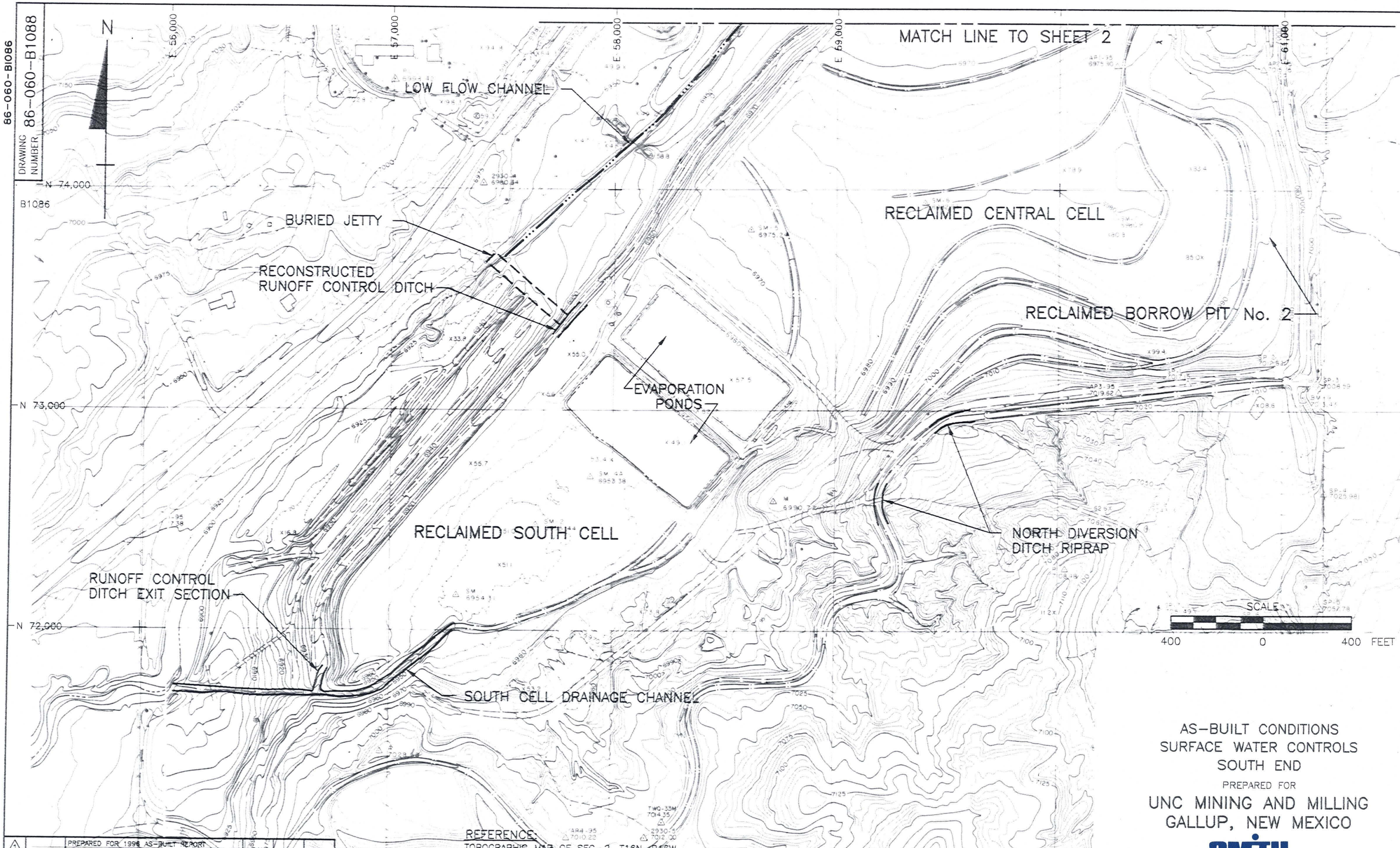

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86-060-B1086

REFERENCE:
TOPOGRAPHIC MAP OF SEC. 2, T16N, R16W
N.M.P.M. & VICINITY PROVIDED BY UNITED
NUCLEAR CORPORATION, GALLUP, N.M.
DATED: 8-1-96. SCALE: 1" = 400'.

AS-BUILT CONDITIONS
SURFACE WATER CONTROLS
SOUTH END

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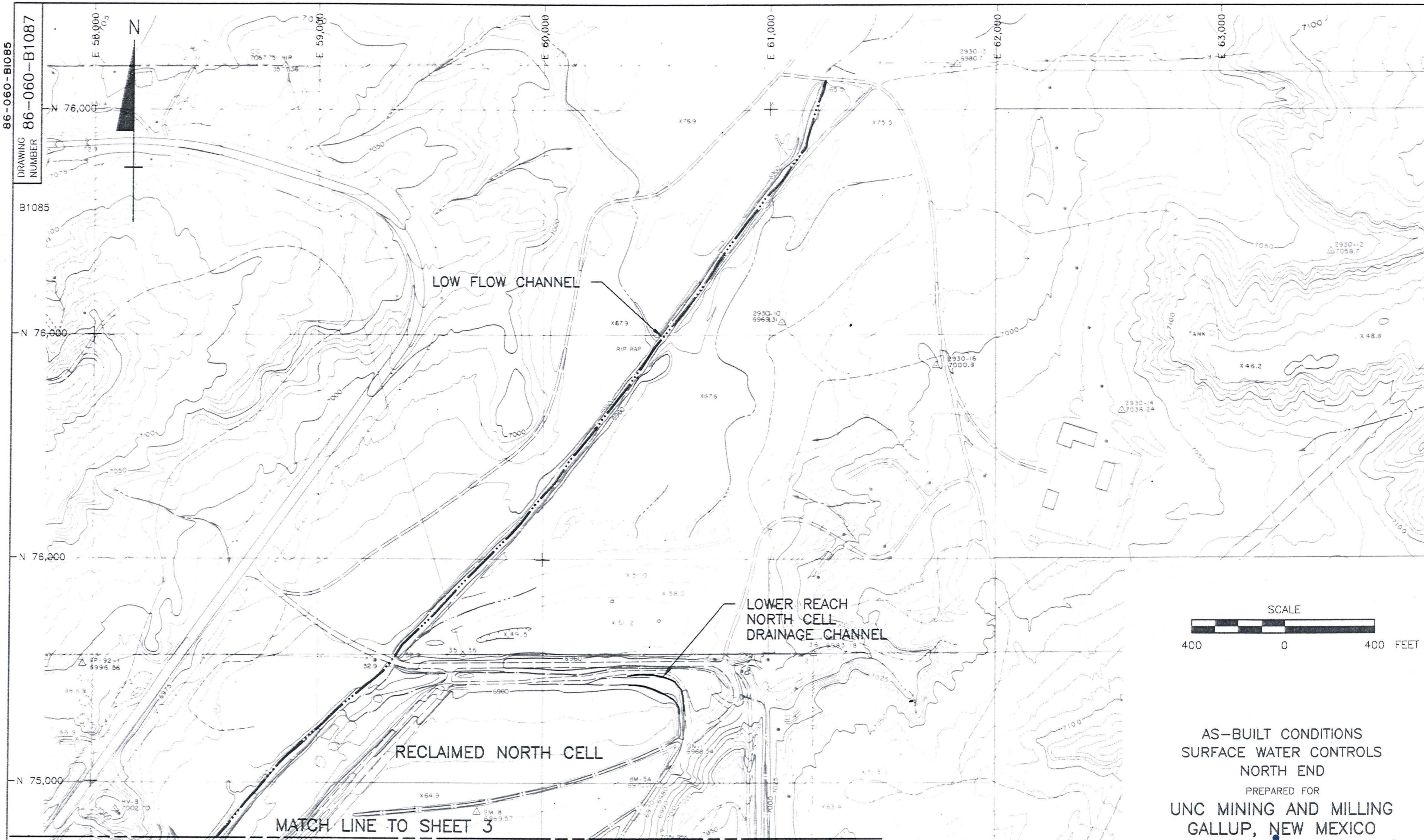

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AS-BUILT CONDITIONS
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NORTH END

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