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Response to Comments and Proposed Reclamation Plan Modifications

Church Rock Site
Gallup, New Mexico

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1.0 INTRODUCTION

This document provides responses to Nuclear Regulatory Commission (NRC) comments regarding United Nuclear Corporation's (United Nuclear) reclamation plan for the Church Rock uranium mill tailings disposal site in Gallup, New Mexico. The comments addressed herein were presented by the NRC in letters of June 29 and August 16, 1990 and in meetings held on July 27 and October 12, 1990. Many of these comments were addressed in the September 17, 1990 response to comments. The comments remaining to be addressed primarily concern erosion protection of the tailings cover and tailings embankment sideslope, the long-term stability of Pipeline Arroyo and the North and South Diversion ditches, and specifications for the soil cover material and riprap materials as presented in the original plan.

This response proposes certain modifications to the original reclamation plan design submitted to the NRC in an effort to alleviate the NRC's concerns. This response also provides substantiation that demonstrates that United Nuclear's original tailings reclamation plan fully complies with the standards set forth in 10 Code of Federal Regulations (CFR) 40, Appendix A.

In addition, this response demonstrates that either of these alternatives achieves the level of stabilization and a level of protection for the public health and safety and the environment equivalent to the extent practicable that would allow the NRC to make a finding in accordance with Section 84(c), 42 United States Code (USC) 2114, of the Atomic Energy Act. Finally, this response requests that such a finding be made by the NRC. This request is based on Canonie Environmental Services Corp.'s (Canonie) and United Nuclear's belief that, the NRC concerns notwithstanding, the reclamation plan as originally submitted and the proposed modifications to the plan submitted in this document adequately protect tailings from release for the minimum 200-year design period. In addition, it provides reasonable assurances that tailings would not be released to the environment for 1,000 years to the extent practicable.

1.1 General Comments

In June 1987, as required by the NRC, United Nuclear submitted a reclamation plan for the Church Rock site. It was subsequently modified in responses to the NRC's comments dated May 23, 1988, August 31, 1988, February 23, 1989, and September 12, 1990. Reclamation activity was initiated in 1988 at the direction of the NRC. United Nuclear reluctantly initiated reclamation only after the NRC threatened to serve an Administrative Order requiring United Nuclear to commence construction of the tailings cover if the company would not agree to such action voluntarily and issued a unilateral license amendment requiring United Nuclear to do so.

Implementation of these interim activities, including construction of the evaporation ponds, regrading of the North and Central cells of the tailings impoundment, and installing the interim soil cover over these cells, were required by the NRC as a license amendment. These activities, performed in 1988, 1989, and 1990, represent the first three years of an eight-year phased program for final reclamation.

As of September 30, 1990, United Nuclear has completed placement of the first foot of soil cover over tailings on the North and Central cells of the impoundment, providing interim stabilization for 73 acres of tailings. United Nuclear has also constructed two lined 5-acre evaporation ponds and an enhanced spray evaporation system and has installed and is currently operating 20 seepage collection wells.

United Nuclear's intent has always been to implement an integrated plan that addresses not only tailings stabilization but also ground water protection. This has been a consistent theme with regard to all of its tailings reclamation and seepage remediation planning. United Nuclear's reluctance to initiate reclamation activities in 1988 was because of the interrelationship of the various components of the plan. United Nuclear expressed significant concern that subsequent changes to the plan could negatively impact the reclamation activities, thereby creating duplicate work, wasted effort, and the waste of money. Only after being threatened with the Administrative Order and being assured by the former director of the NRC and his staff that any future design changes would be in the manner of "fine tuning" and would not significantly impact reclamation did United Nuclear agree to commence reclamation. The NRC viewed the plan presented to it at the time as "over 90 percent approved," as represented by the director and his staff. United Nuclear was told that there remained only technical details to be finalized in review but that only the ground water issue remained unresolved because of the Environmental Protection Agency's ongoing Remedial Investigation and Feasibility Study. At no time did the NRC represent that the surface water issues were of significant concern.

Significantly, the changes proposed by the NRC in its comments are not based on the lack of performance by United Nuclear or the design as implemented to date, but rather the NRC's desire to achieve a more conservative measure of comfort. The NRC's proposed changes, however, are very costly. The total estimated additional cost for the NRC's proposed changes is approximately $11.9 million almost doubling the cost of the original reclamation plan. The concomitant benefits to public health and the environment, however, are clearly not doubled. The risks associated with following the NRC's proposals versus United Nuclear's original plan are very small. In fact, because United Nuclear's reclamation plan addresses interrelated impacts, such as surface water erosion versus ground water impacts, its plan has fewer risks associated with it. The NRC's proposal is more likely to result in larger potential impact to ground water while attempting to address surface water erosion considerations because it does not attempt to balance risks.

The design originally submitted was prepared using prudent engineering judgment and accepted analytical methods and criteria commonly used by the engineering community and many other governmental agencies. The quality control monitoring conducted to date in the field during interim reclamation activities confirms that the original plan does in fact exceed prescribed requirements. There is no reason to believe that the construction yet to be conducted in final reclamation will not also exceed the NRC's requirements.

The original design provides permanent isolation of the tailings pursuant to 10 CFR 40 Appendix A by minimizing disturbance and dispersion by natural forces without ongoing maintenance. It also successfully meets the stated goal of isolating tailings from possible release to the environment for 1,000 years to the extent practicable and for 200 years at a minimum. The design also provides for protection of ground water, another primary objective of 10 CFR 40, by alleviating conditions that lead to excessive seepage from the tailings impoundment. The primary source of such potential seepage following reclamation is the infiltration of precipitation through the tailings impoundment. Minimizing infiltration was and continues to be a primary design goal in the original reclamation plan.

This year, as United Nuclear entered the third season of work at the site, the NRC asked for major amendments to the plan to satisfy the new NRC technical guidance. The requested changes, in many cases, are inconsistent with the previously approved plan, requiring that major new elements be added or that expensive measures already completed or underway be redone.

1.2 NRC Comments

In June 1990 through October 12, 1990, well into the third season of construction, the NRC provided United Nuclear with additional comments on the reclamation plan. Despite the commitment by the NRC not to require major changes, the NRC, citing a new Staff Technical Position (STP), indicated for the first time that major changes in the plan were necessary. The NRC's comments indicate that the original reclamation design would have to be significantly revised to meet the guidelines in the STP. Originally, the NRC enumerated 13 comments concerning these topics. All but four of the comments were addressed in the September 12, 1990 responses to comments.

The remaining comments to be addressed herein include the following points in response to NRC comment Nos. 7 and 8 of the NRC's June 29, 1990 letter and comment Nos. 9b and 9c of the NRC's August 16, 1990 letter:

1. That vegetation could not be taken into account for the control of erosion on tailings covers in arid areas;

2. That the Maximum Permissible Velocity (MPV) of 3 feet per second (fps) is no longer appropriate for erosion protection due to shallow overland flow;

3. That the runoff interception ditches on the embankment sideslopes will not be stable; and

4. That the reconfigured channel design for Pipeline Arroyo will not provide long-term stability.

The four points criticize the original design as it relates to the tailings cover, the tailings embankment, and the reconfigured Pipeline Arroyo. These criticisms result in three significant changes proposed by the NRC to the original plan:

1. Place a 6-inch rock mulch layer on the entire impoundment cover or, alternatively, reconfigure the cover design to much flatter slopes;

2. Place a 6-inch rock mulch on the embankment sideslopes or, alternatively, significantly flatten the sideslopes; and

3. Provide riprap rock armor on the reconfigured excavated Pipeline Arroyo and a 6-inch rock mulch layer over the sacrificial areas between the arroyo and the toe of the embankment.

In preparing the responses to these comments as contained herein, Canonie reaffirms that the original design is appropriate to meet the requirements of 10 CFR 40, Appendix A.

1.3 Proposed Modifications to Reclamation Plan

The NRC proposes changes in the reclamation plan design, prompted in part by the final NRC STP concerning the design of erosion protection covers for stabilization of uranium mill tailings sites (US NRC, 1990) and in part by a significant change in the NRC's position regarding the appropriate plan for Pipeline Arroyo. The NRC's STP incorporates some new methodologies and criteria for surface water control and erosion protection designs and reinterprets others originally endorsed by the NRC and used by United Nuclear and its design engineers for the original design plan.

Extensive changes to the original reclamation plan cover design would be required to rigorously adhere to recent changes in the NRC's prescribed analytical methodologies particularly because it has been three years since submittal and implementation of the plan per license requirement. Such changes will cause the reclamation work completed to date to be wasted at a cost of several million dollars as the STP requires that flat "table-top" slopes (stable slopes) be constructed to reduce tractive forces to acceptable levels. In addition, strict adherence to the NRC's methodologies with regard to grading design to minimize erosion increases the potential for infiltration into the tailings, which could have a detrimental impact on United Nuclear's ground water remediation program.

There are, of course, a number of engineering approaches that can be taken to design a reclamation plan that meets the specified criteria. Each has its attendant costs. Some are very conservative and attempt to eliminate all risk to human health and the environment, while others attempt to balance the relative risks against cost considerations. While United Nuclear and Canonie believe that the original design appropriately balances those factors and provided a plan which meets the criteria, the proposed modifications described above equally succeed in achieving these goals. They also address the recent changes in analytical protocol recommended by the NRC without discounting or otherwise negating the work already performed. In addition, the proposed modifications integrate the need to protect ground water by eliminating infiltration concerns.

While United Nuclear and Canonie believe that the original reclamation plan fully complies with 10 CFR 40, Appendix A, the following proposed modifications to the original reclamation plan are submitted for NRC's consideration to address the NRC concerns. These proposed modifications are designed within the context of reclamation work already performed and are offered without prejudice to United Nuclear's position that they are not necessary. Rather they are offered as an accommodation to the NRC to settle and resolve the NRC's outstanding comments set forth above.

The components of the proposed modified design include the following:

1. Installation of a buried jetty across the Pipeline Arroyo valley to reinforce the nickpoint, but to otherwise leave the present channel configuration unchanged;

2. Addition of a rock mulch protective cover over the tailings embankment slopes in conjunction with construction of a protective bench between the toe of the embankment and the Pipeline Arroyo channel; and

3. Construction of a tailings cover consisting of a 1.5-foot-thick soil cover to control radon emanation to prescribed levels and a six-inch-thick soil/rock matrix (erosion protection layer) over the radon attenuation soil cover on the tailings to provide long-term stability similar to that recently approved by the NRC at another site.

Section 2.0 provides a detailed discussion of the proposed design modification.

The proposed modified design meets the requirements of 10 CFR 40, Appendix A, by using the methods and criteria set forth in the STP and other applicable scientific guidelines. Also, it can be implemented within the framework of reclamation activities already performed on site.

Installation of rock mulch on the tailings embankment and soil/rock material on the tailings soil cover provide long-term stability to these areas without relying on vegetation. By leaving the present Pipeline Arroyo channel unchanged, the potential for future changes to the present geomorphic conditions is minimized. Furthermore, the buried jetty ensures that the stable conditions that currently exist upstream of the nickpoint remain for a 1,000-year period. The result of the proposed modified design is long-term stability with no maintenance requirements.

United Nuclear proposes to reduce the radon attenuation soil cover by incorporating the data gathered during the interim reclamation activities. The reduction in radon cover requirements for the Church Rock site is consistent with the original reclamation plan design submitted to the NRC. The plan recognized that the soil characteristics used in the RADON computer model to design the 3.4-foot radon attenuation soil cover were very conservative. It contemplated that those parameters would be checked by field data as they became available during construction of the interim cover in anticipation of providing justification for the reduction of the cover design by use of actual numbers obtained in the field rather than estimates. These new data confirm that estimates used in the original submittal are excessively conservative. The field data provide justification for the reduced soil cover thickness of 1.5 feet to meet the radon emanation standard.

1.4 Request for NRC Finding

The proposed design modifications described above represent a reasonable approach that will allow the NRC to approve United Nuclear's reclamation plan. Alternatively, the NRC could approve the originally submitted design as being equally protective of human health and the environment. The original design provides a practicable design for protection of the public health and safety and the environment. The cost of implementing the NRC's proposed fixes to meet the technical guidance is inordinately high and provides only minimal additional protection to human health and the environment. The additional cost of meeting the NRC's technical guidance to mitigate the NRC's concerns regarding the potential impacts of surface water erosion by implementing the proposals contained in the NRC's comments would approach $11.9 million as compared to the original implementation cost of $12.4 million. For the reasons discussed in more detail later in this document, the added benefit of implementing the NRC's proposals to meet the technical guidance is minimal when compared to the extraordinary costs that would be incurred and cannot be justified.

United Nuclear requests that the NRC approve either the proposed modified design contained in this document or the reclamation plan design as originally submitted by United Nuclear, pursuant to Section 84(c), 42 USC 2114, of the Atomic Energy Act, wherein the commission may find that the proposed alternatives meet the commission's requirements if the alternatives "achieve the level of stabilization and containment...and a level of protection of public health, safety, and the environment from radiological and nonradiological hazards associated with the [Church Rock] site which is equivalent to the extent practicable to the level which would be achieved by the standards of...[10 CFR 40, Appendix A and the standards promulgated by the Environmental Protection Agency in 40 CFR 192, Subparts D and E]." In particular, criterion 6 of Appendix A requires that the tailings disposal design provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years.

United Nuclear and Canonie believe that the design as originally submitted meets the 1,000-year design criteria to the extent reasonably achievable as defined in the Uranium Mill Tailings Radiation Control Act and the NRC's regulations. It also meets the design criteria of 200 years. It is designed to protect tailings from release to the environment in a manner protective of human health and the environment. It considers the site-specific constraints unique to Church Rock and provides mechanisms to accommodate them. It considers the state of technology by providing feasible solutions that will work as designed. In addition, and importantly, it considers the economics of alternative solutions in relation to benefits to the public health and safety and other societal and socioeconomic considerations.

The NRC should approve either the proposed modified design or the original reclamation plan design because they take into account the risk to the public health and safety and the environment with due consideration to the economic costs involved. These two designs balance all of the competing needs of the criteria contained in 10 CFR 40 Appendix A, in particular the concerns regarding the effects of surface water erosion and the concerns of protecting ground water. United Nuclear and Canonie believe that adequate demonstration has been made that either design is approvable under the authority described in Section 84(c) of the Atomic Energy Act. If the NRC cannot make such a finding, then United Nuclear requests a hearing before the commission to further substantiate its position.

2.0 DETAILED RESPONSE TO COMMENTS AND PROPOSED DESIGN MODIFICATIONS

This section provides details of the proposed design modifications to the tailings cover, tailings embankment, and Pipeline Arroyo. The proposed design modifications described herein have been prepared to address the NRC's concerns as presented in their comments. Submission of these proposals should not be construed by the NRC to mean that United Nuclear and Canonie believe that the original design is inadequate.

Section 2.1 provides the proposed design modifications for the tailings cover, including the technical discussion and basis for the stability of the erosion protection cover and the radon attenuation soil cover. Sections 2.2 and 2.3 provide the proposed design changes for the tailings embankment and Pipeline Arroyo, respectively. Section 2.4 provides responses to other NRC comments regarding the stability of the North and South Diversion ditches.

2.1 Tailings Cover - Comment Number 7 (June 29, 1990)

NRC comments regarding the tailings cover design state that:

1. Vegetative cover over the reclaimed tailings cannot be taken into account for control of erosion in arid areas; and

2. The MPV of 3 FPS is not appropriate for shallow overland flow.

NRC requests that United Nuclear either add an appropriate riprap layer on top of the originally designed soil cover or, alternatively, redesign the tailings soil cover to meet the STP tractive force criteria.

...ssed in Section 3.1, Canonie believes that the original design for ...g erosion on the regraded tailings impoundment remains valid. ... the NRC's STP has changed the criteria for evaluation of the ...l stability of the tailings cover.

In order to meet the STP's requirements, either the entire surface of the regraded tailings cover would have to be covered with riprap or the design would have to be changed to flatten the tailings cover. Placement of riprap over the entire regraded surface of 120 acres would be prohibitively expensive and cannot be justified in relation to the benefits obtained.

Table 2.1 provides a summary of the costs attendant to construction of the various alternatives proposed by the NRC in its comments. The cost of placing a 6-inch rock mulch layer over the entire regraded tailings cover is estimated to be $2.4 million. This estimate is based on placing 96,700 cubic yards (cy) of rock mulch at a unit cost of $25 per cy of placed material. The rock mulch must be transported 42 miles to the site.

Designing the cover to meet the tractive force requirements of the STP will require that the cover be regraded to be nearly as flat as a table top at 0.002 feet per foot (ft/ft). Such a configuration would also be prohibitively expensive. Table 2.1 indicates that the construction of a reconfigured "flat table top" design is estimated to cost $4.0 million. This estimate is based on the movement of approximately 776,500 cy of additional soil material at a unit cost of $3/cy and placement of 31,300 cy of riprap on the downslopes from the table top and in runoff collection ditches at a unit cost of $54/cy of placed material. The riprap is more expensive than the rock mulch described above because it is much larger, making it more difficult to produce, transport, and place. Implementation of such a design would require that all of the previous reclamation work conducted to date be negated at a cost loss of approximately $3.5 million.

In addition, as a practical matter, it would be impossible to construct a cover which meets the 0.002 ft/ft slope criteria to keep tractive forces to below levels of concern. The closest even the best field equipment could manage would be approximately 0.005 ft/ft and would require extraordinary quality control. Therefore, the desire to meet the NRC's STP criteria for tractive forces is confounded by the practical limitations that render the criteria difficult if not useless.

Finally, either of the two approaches described above would increase infiltration into the tailings due to decreased runoff velocities. Therefore, the NRC's STP criteria for regrading which uses tractive forces as a means of surface water erosion protection is in direct conflict with Criterion 5 of the NRC's regulations which requires protection of ground water. It is critical that any approvable reclamation plan integrate and balance these kinds of competing factors. Reduction of infiltration through the tailings is an important component of the ground water remediation program at the site.

Similarly, approvable plans must also balance the cost against the associated benefits. The NRC's proposed methodologies to mitigate its concerns regarding the erosion on the tailings cover design would add from $2.4 to $4.0 million to the present plan even without accounting for the cost losses for work already performed. It is difficult to ascertain that there is any significant associated benefit to the NRC's proposal. Even if the design were to apply the flat table top concept, the resultant construction limitations would be such that the criteria would not be met. As stated earlier, either design would exacerbate the ground water protection criteria. Therefore there appears to be no associated incremental benefit to a proposed cost addition of $2.4 to $4.0 million.

2.1.1 Proposed Design Modification

A balanced alternative proposed approach to design of the tailings cover that incorporates the original grading design and a 6-inch-thick soil/rock matrix erosion protection layer has been developed. This soil/rock matrix will be constructed by placing a 3-inch-thick rock mulch layer over the tailings cover, then placing a 4- to 6-inch layer of random soil material over the rock mulch. The passage of construction equipment over the soil will force it into the rock mulch voids. This modified design meets the NRC's requirements for erosion protection of the tailings cover while maintaining adequate slopes to promote surface water runoff and reduce infiltration into the tailings. A similar soil/rock matrix design was approved by the NRC for use at Anaconda's Bluewater facility in New Mexico.

The proposed soil/rock matrix will be installed over a 1.5 foot radon attenuation soil cover designed to control radon emanation to below 20 picoCuries per meter squared per second (pCi/m^2/sec). This represents a reduction in radon soil cover requirement of 1.9 feet from the original design requirement of 3.4 feet. As described in greater detail herein, the reduction is justified by the use of data collected during the first two years of construction of the first foot of soil cover. Extensive testing demonstrates that the soil characteristics of the material used for construction is such that the reduction in radon attenuation soil cover is warranted. The resulting total thickness of the soil cover over the tailings including the soil/rock matrix is 2.0 feet.

2.1.1.1 Erosional Stability Analysis

Figures 2-2 and 2-3 depict the proposed modified tailings impoundment configuration and grades at final reclamation. This configuration has been changed from that of the original reclamation plan (see Figure 1 of the August 31, 1988 responses to comments and Figure 3 of the September 12, 1990 response to comments) in three aspects. First, the surface contour elevations have been reduced 2 feet to reflect the resulting reduced tailings cover thickness. Second, additional swales have been added to the South Cell to collect surface water runoff. Third, the tailing's 2-foot soil cover will incorporate a 6-inch-thick soil/rock matrix to protect the cover from erosion. These proposed design modifications promote surface water drainage while maintaining the erosional stability of the tailings soil cover.

Hydraulic Analyses

The proposed swales have been located to provide the optimal combination of hydraulic characteristics (overland slope and slope length) that allow the use of a soil/rock matrix cover to protect the soil cover from erosion. The swales would consist of shallow, trapezoidal ditches with 3H:1V sideslopes. The bottom and sideslopes of the swales will be protected with riprap. Table 2.2 provides a summary of the swale bottom widths and depths.

Hydraulic analyses of the flows to be generated within the swales was performed to determine the minimum depth of the swales. The peak discharge of the runoff generated by the PMP event on the impoundments was calculated using the SCS TR-55 method. The depth of these peak discharges in the swales was calculated using Manning's equation. A freeboard of at least one-half foot was added to the depth of flow in the swales to determine the minimum depth of the swales. This design approach follows the guidelines set forth in the NRC STP and provides for erosionally stable water conveyance structures that will promote drainage and reduce infiltration into the tailings. Table 2.2 provides a summary of the hydraulic analyses for the swales. Appendix A provides the detailed calculations used to perform the hydraulic analyses.

Long-term Stability

Swales - The Safety Factors method of the proposed riprap design was used to size the riprap that would be installed in the swales. Table 2.2 provides a summary of the riprap sizes for the swales. In many cases, the same rock proposed for use for the soil/rock matrix is adequate for the swales. Table 2.3 provides filter and riprap material grading requirements. Appendix A provides the detailed calculations used to determine the riprap sizes.

The riprap sizes shown in Table 2.2 are nominal sizes and have not been oversized to account for weathering. Due to economic considerations, the exact source and, thus, quality of the rock is not yet known. However, the rock used as riprap and rock mulch for reclamation will have a minimum rock quality rating of 50 and will be oversized in accordance with the procedures provided in Appendix D of the STP.

Soil/Rock Matrix - The CSU method described in NUREG 4651 (NRC, 1987) was used to size rock protection for the top surface of the tailings soil cover. Based on flow depths and velocities computed by the unit-width method described in NUREG 4620 (NRC, 1986), a D_{50} of 1.5 inches for the riprap has been determined to provide erosion protection. This form of protection was recently approved by the NRC for use under similar conditions at Anaconda's Bluewater tailings disposal facility in New Mexico.

The erosion protection layer would consist of a 3-inch layer of rock overlain by a 3-inch layer of soil compacted into the rock. A 4- to 6-inch-thick soil lift would be placed over the rock to maintain an approximate thickness of 3 inches above the rock layer. This overall 6-inch-thick soil/rock matrix would provide long-term erosional protection. Compaction of the soil would densify the rock layer by tightly wedging the stones. The soil would fill the void spaces, stabilizing the rock from movement, and decrease the effective evaporative zone depth, thereby providing for more stable and higher long-term moisture content of the radon barrier. The use of soil compacted into rock has been shown to increase the stability of rock protection (NUREG 4651). The gradation of the soil/rock matrix is sufficiently fine-grained so as to not require filter material. The soil/rock matrix would also protect the soil cover from wind erosion. A detail of the soil/rock matrix is shown on Figure 2-1. Appendix A provides the detailed calculations used to size the soil/rock matrix.

2.1.1.2 Proposed Radon Attenuation Soil Cover Reduction

United Nuclear's Reclamation Plan as originally submitted contained a proposed tailings soil cover 4 feet thick to be placed over regraded tailings, 3.4 feet of which was for radon attenuation and 0.6 feet of which was for erosion protection. United Nuclear proposes a reduction and redesign of this cover as follows.

The radon attenuation soil cover portion of the tailings soil cover has been reduced to a total thickness of 1.5 feet to be constructed over regraded tailings. This would be then be overlain by the 6-inch-thick soil/rock matrix. This layer would aid in further reducing radon emanation but has not been included in the analyses. Figure 2-1 illustrates the soil cover profile. Based on recent results obtained from the RADON computer model, the reduced radon attenuation soil cover of 1.5 feet will limit radon emissions from the reclaimed tailings impoundment to the required 20 pCi/m^2/sec. A detailed discussion follows.

Radon Attenuation Parameters

The proposed reduced radon attenuation soil cover thickness of 1.5 feet is based on revised physical and radon attenuating properties derived from more extensive evaluation of proposed soil borrow and results from QA/QC testing performed during construction of the interim soil cover. The following sections discuss the soil cover parameters and values that were used in the RADON model. Appendix B provides a summary of the soil borrow geotechnical properties and the RADON model calculations.

Diffusion Coefficient - The soil cover property that has the greatest impact on reducing the cover thickness is the diffusion coefficient. A revised diffusion coefficient was calculated based on higher in-place densities (derived from actual interim cover QA/QC testing as presented in Appendix B) and lower porosities as compared to more conservative parameters that were estimated for the original design. The original estimated in-place density and porosity were 99.0 pounds per cubic foot (pcf) and 0.39, respectively. The revised in-place density and porosity are 108.3 pcf and 0.33, respectively. This translates to a revised lower diffusion coefficient of 0.0029 square centimeters per second (cm^2/sec) as compared to an original diffusion coefficient of 0.0093 cm^2/sec. These values are summarized in Table 2.4. The lower diffusion coefficient reduces the amount of radon that can emanate through the soil, which significantly decreases the thickness of the soil cover needed.

Long-Term Moisture - An additional soil cover property, which has a very important effect on the diffusion coefficient and, thus, the soil cover thickness, is the long-term moisture content of the soil cover materials. The long-term moisture (i.e., the wilting point moisture content) used in this analysis is 13.4 percent, the same as that used in the original design.

The long-term moisture content was derived based on an average of in-situ moistures for site soils (see June 29, 1988 Response to NRC Comments) and long-term moisture laboratory measurements [American Society for Testing and Materials (ASTM) D-3152)]. These two approaches yielded long-term moistures of 13.4 and 13.6 percent, respectively. In addition, the long-term moisture content was calculated in accordance with Regulatory Guide 3.64 (Equation 5). The empirical equation is based on the percent of fines (-200 sieve-size material) and percent of organic material in the soil cover material. It was conservatively assumed that the organic content was zero. The fines content specified for the soil cover ranges from 40 to 85 percent. Incorporating these fines contents into the above-referenced equation yields long-term moisture contents ranging from 22.6 to 45.1 percent. The lowest long-term moisture content value of 13.4 percent was used in the radon calculations to provide the most conservative soil cover thickness. Appendix B presents the results of the long-term moisture determinations.

Soil Cover Materials - The NRC has requested that procedures be presented for determining the acceptability of borrow material used as soil cover should different borrow sources be used other than those identified in the Response to Comments dated September 12, 1990. It is not expected that other sources of borrow material will be required in excess to those identified in the Response to Comments. If other borrow sources are required, then gradation and classification tests will be performed to ensure that these materials meet project specifications. Testing will be performed at the frequency of one gradation and Atterberg limits test per 6,500 cubic yards of proposed imported fill material. Samples will be obtained by means of borehole drilling and sampling or test pit excavation and sampling and analyses for gradation and classification. The on-site quality assurance engineer will review and accept or reject the test results prior to placement of imported fill as soil cover material.

In informal discussions, the NRC has expressed concern that a thinner soil cover design would be more sensitive to material gradation fluctuations and resultant radon attenuating characteristics. To address this concern, the gradation and Atterberg testing frequency will be increased to an average of one test per 1,500 cubic yards of soil cover material placed for the project. Testing on the soil cover to date has been at the lower frequency of one test per 6,500 cy as specified in the original Reclamation Plan. It will be possible to attain the higher testing frequency of one test per

1,500 cy based on an average of all tests taken for the project. This will be accomplished when the interim soil cover is conditioned (i.e., moisture adjusted and compacted) immediately prior to placement of the final soil cover. Additional in-place density tests and gradation/Atterberg tests will be performed at this time to meet required project frequencies. This will provide assurance that the material placed meets the requirements of that modeled in the design.

As described in the September 12, 1990 responses to comments, the acceptable soil types for use in the soil cover construction will classify as clay (Cl), silt (ML), silty sand (SM), or clayey sand (SC) soils in accordance with the Unified Soil Classification System. The gradation limits will be specified as follows:

Sieve Size	Maximum Percent Passing
3/4 inch	95 - 100
No. 4	90 - 100
No. 10	85 - 100
No. 40	65 - 100
No. 100	50 - 100
No. 200	40 - 85

The above gradation limits provide a tabular representation of the graphical grain size envelope presented as Figure 2 in the September 12, 1990 submittal.

Nuclear Densimeter Correlation - The NRC has requested that a method be outlined for establishing a correlation between sand cone and nuclear densimeter methods during in-situ density testing of the soil cover materials. Based on performance to date for interim construction activities, it has been determined that test results obtained by the nuclear densimeter are erratic. The as-built report North Cell Interim Reclamation Activities documents the erratic nature of the nuclear densimeter test. Therefore, only the sand cone method of in-place density determinations was used in the 1990 construction activities and will be used in all future construction.

Long-Term Stability of Radon Attenuating Soil Cover - The radon attenuation soil cover would be protected from wind and water erosion by the proposed soil/rock matrix erosion protection cover. This layer would also provide for a higher and more stable long-term moisture as compared to a vegetated cover. Previous studies of tailings impoundments (Mayer et al., 1981) indicate that rock covers increase the soil moisture content below the rock cover by decreasing the effective evaporative zone and reducing the overland flow velocity of runoff as compared to a cover consisting of compacted soil only. By decreasing evaporation, the soil and rock cover reduces the gradient which would draw moisture from the soil cover to the atmosphere. Thus, through time, annual precipitation at the site will provide for a long-term moisture content closer to the higher field capacity moisture content rather than the wilting point moisture content, due to minimal moisture gradients through the soil cover.

Frost heave and the potential effect of decreasing radon attenuation of the soil cover were also considered. For a material to be frost susceptible, there must be a source of water close to the frost line, close enough to supply capillary water from a saturated soil layer. The potential for capillary action is dependent on the effective pore diameter. The coarse tailings located below the cover classify as poorly graded sands and are considered relatively free draining. These characteristics are indicative of relatively large pore diameters, which indicate that these materials have a low potential for capillary action. Since this material below the cover material will not support capillary action, the ability to transport water to the frost line by capillary action does not exist. Therefore, the susceptibility of the soil cover to frost heave is low.

Shrinkage and its potential effect on radon attenuation is also governed by the presence of capillary action. When a saturated soil dries, a meniscus develops in each void at the soil surface. Tension develops in the soil water and a matching compression develops within the soil. Since the long-term moisture of the soil cover will remain fairly stable and the material below the cover soil will not support capillary action, shrinkage effects on the cover soil will not be significant.

Radon Source Parameters

The radon source parameters used in this evaluation are more conservative than the average values used in the original design. It is still United Nuclear's belief that average radiological source values are valid for determining the soil cover thickness. Regulatory Guide 3.64 states that the radon flux standard is based on average annual radon emission from the entire site; therefore, average radiological source values are appropriate. Using average soil cover attenuation and average radiological source values in the RADON model result in a required radon attenuation soil cover that is 1.2 feet thick. The results of this RADON model evaluation were presented in the September 12, 1990 (Canonie, 1990) submittal.

The NRC has expressed its concern that more conservative radiological source values, such as the upper 95 percent confidence intervals, be used to design the soil cover. Therefore, in response to this concern, the proposed radon attenuation soil cover thickness has been designed using the upper 95 percent confidence interval values for both coarse- and fine-grained tailings source parameters. Table 2.4 summarizes the values used as input into the RADON model. Use of these conservative values indicates that a 1.5-foot-thick soil cover is required to attenuate radon emissions from the regraded tailings impoundment to within the prescribed limits of 20 pCi/m^2/sec. Appendix B presents the data used in the model and the source of the data.

Source Term - The most critical source parameters that influence the thickness of the soil cover are 1) the source term which is calculated from the radium content and 2) the emanation coefficient. These values were measured in the laboratory. Tables 2.5 and 2.6 summarize the test results of measured radon source parameters for both coarse-grained tailings and fine-grained tailings, respectively. These same tables were presented in the original reclamation plan (Canonie, 1987).

As illustrated in these tables, the upper 95 percent confidence interval values represent very conservative RADON model input values. As shown in Table 2.5, there are only two radium content values and one emanation coefficient value that are higher than the upper 95 percent confidence interval value used in the RADON model for the coarse-grained tailings. Likewise, for the fine-grained tailings (see Table 2.6), there is only one radium content value and one emanation coefficient value higher than the upper 95 percent confidence interval value used in the RADON model. Therefore, use of upper 95 percent confidence interval values in the RADON model represents very conservative conditions for estimation of the source term.

Long-Term Moisture and Diffusion Coefficient - The long-term moisture content and diffusion coefficient values used in the RADON model for the coarse-grained tailings also represent very conservative conditions. As shown in Table 2.5, there are two values lower than the moisture content of 10.4 percent used in the RADON model for coarse tailings. The diffusion coefficient was calculated in accordance with Regulatory Guide 3.64, using the average physical properties for dry density and porosity shown in Table 2.5 and the long-term moisture content of 10.4 percent. As shown in Table 2.5, there are no diffusion coefficient values that are lower than the 0.047 cm^2/sec used in the RADON model.

The long-term moisture content and diffusion coefficient values used in the RADON model for the fine-grained tailings represent the 95 percent confidence interval for these parameters. As shown in Table 2.5, there are only two values lower than the moisture content of 29.7 percent used in the RADON model for fine-grained tailings. The value of 29.7 percent is based on in-situ moisture contents measured in the tailings material. This value is typical of laboratory determined and calculated long-term moisture contents for fine-grained tailings at other sites and for fine-grained soils and is substantially lower than the 42.6 percent moisture content calculated using Equation 5 presented in Regulatory Guide 3.64 (assuming 80 percent -200 material). The diffusion coefficient of 0.0053 cm^2/sec is higher than all but two of the measured diffusion coefficients presented in Table 2.6 and represents a conservative value for input into the RADON model.

Additional Design Considerations

It should be noted that the areas within the tailings disposal area with the highest radon source, i.e., the fine-grained tailings areas, will be covered with a minimum of 7 feet of coarse-grained tailings prior to placement of the soil cover. This 7-foot layer essentially attenuates radon emanating from the fine-grained tailings. The soil cover will therefore only be required to attenuate radon emanating for the lower radon source coarse-grained tailings. Placing a minimum 7-foot-thick coarse-grained tailings layer over the fine-grained tailings provides an approach to the design that enables a thinner single radon attenuating soil layer to be designed as opposed to having two thickness of soil cover, i.e., one for attenuating radon from coarse-grained tailings and one for the higher radon source fine-grained tailings.

In addition, the minimum 7-foot-thick layer of coarse-grained tailings placed over the fine-grained tailings will in actuality consist of a combination of coarse-grained tailings overlain by clean borrow soil. This has been the case in regrading of the North and Central cells conducted in the last two years. Typically clean borrow soil has been required in excess of the regraded coarse tailings to attain the specified grades. This provides for additional conservatism in the cover design in that the thickness of clean soils over the regraded tailings is typically thicker than the design thickness of 1.5 feet. This conservatism has not been accounted for in the RADON model.

Therefore, as discussed above, the soil cover has been designed incorporating as-built interim cover and borrow area radon attenuation properties and conservative radon source parameter values. Use of interim soil cover radon attenuation properties, which is more effective at attenuating radon than those conservatively assumed in the original design and conservative upper 95 percent confidence limit radon source values in the RADON model, results in a soil cover design thickness of 1.5 feet, which is 1.9 feet thinner than the original design. This soil cover, along with the soil/rock matrix for erosion protection, will provide a final soil cover that meets the requirements set forth in 10 CFR 40, Appendix A.

2.2 Tailings Embankment - Comment Number 8 (June 29, 1990)

The NRC is concerned that the runoff interception ditches on the embankment sideslopes may not be stable due to the possibility of flows overtopping the ditches, siltation within the ditches, and gullying on the ditch out-slopes. As discussed in more detail in Section 3.2, the original design consisting of runoff interception ditches and an armored central collection channel provides adequate erosion protection for the embankment slopes.

The NRC requests that either an appropriate riprap layer be placed on the sideslopes or, alternatively, that the sideslopes be flattened sufficiently to mitigate NRC concerns regarding surface water erosion.

In order to comply with the requirements of the STP, the embankment side-slopes would have to be flattened or armored. Flattening the sideslopes as suggested by the NRC would require that the embankment toe be extended out into the arroyo and would expose the tailings embankment to the full erosive forces of runoff within the Pipeline Arroyo. As such, flattening the slopes is not considered a practical solution.

Armoring the entire tailings embankment face as proposed by the NRC is estimated to cost approximately $0.25 million. This estimate is based on a volume of 10,400 cy of rock for a 6-inch-thick layer at a unit cost of $25/cy. While this cost is not exorbitant by itself, certain additional proposed design modifications incorporated into the overall design would result in reducing this cost while mitigating the NRC's concern. These proposed design modifications are discussed herein in more detail.

2.2.1 Proposed Design Modifications

A modified design is proposed for the tailings embankment slopes that incorporates rock mulch armor for erosion protection of the upper portion of the embankment and the construction of a protective bench at the toe of the tailings embankment to provide a buffer between probable maximum flood (PMF) flows in Pipeline Arroyo and the toe of the tailings embankment. Figures 2-2 and 2-3 show the configuration of the proposed tailings embankment at final reclamation. The sideslopes would remain at 5H:1V as provided in the original design and would terminate at the runoff control ditch located at the top of the protective bench to collect runoff from the embankment. The embankment sideslopes would be protected from erosion by a 3-inch-thick rock mulch layer, which extends from to the top of the tailings embankment to the runoff control ditch. The rock mulch would be designed to withstand the runoff generated by the probable maximum precipitation (PMP) event as discussed in more detail herein.

The runoff control ditch, located on the protective bench, would also be located between the embankment toe and the Pipeline Arroyo channel. The top of the protective bench would be 40 feet wide and up to 20 feet higher than the Pipeline Arroyo channel bank. Figure 2-4 shows the profiles of the bench toe, bench top, and embankment top. Figures 2-5 and 2-6 provide several cross sections that illustrate the spatial relationship between these features as well as the Pipeline Arroyo channel. Figure 2-6 provides a detail of the runoff control ditch.

2.2.1.1 Stability Analysis

The Corps of Engineers' program HEC-2 was used to simulate the passage of the PMF through Pipeline Arroyo as configured in accordance with the proposed design modifications discussed herein. Appendix C provides the results of the simulations.

Hydraulic Analysis

Figure 2-4 shows that the PMF water surface elevation is less than that of the top of the proposed protective bench. Thus, the bench would protect the embankment toe and would keep the runoff control ditch above the PMF level. The average velocities and depths of the PMF within Pipeline Arroyo along the 5H:1V sideslopes of the protective bench were determined by the HEC-2 program and are summarized below:

Station No.	Average Velocity (fps)	Depth (feet)
82+90	0	0
80+10	0	0
73+80	0	0
63+80	0	0
62+30	0	0
61+40	2.79	1.0
60+40	5.92	3.5
57+75	6.40	4.6
50+00	3.82	4.0
41+95	3.91	3.0
35+00	0.97	0.5

While the sideslope of the protective bench would be contacted by water produced during the passage of the PMF, the low flow velocities along the sideslopes indicate that little scouring would take place during this one-time event. Evaluation of the amount of scour was performed using the methods described in the Bureau of Reclamation's Technical Guideline for Computing Degradation and Local Scour (Pemberton and Lara, 1984). Appendix D provides the detailed scour calculations.

The evaluation indicated that the maximum lateral bank scour to be expected during the passage of the PMF was 4.9 feet. As shown on Figure 2-6 the runoff control ditch would be located 14 feet from the protective bench edge, and the tailings embankment toe is 40 feet from the protective bench. Thus, the PMF would not contact either the runoff control ditch or the tailings embankment toe.

Long-term Stability

The long-term stability of the tailings embankment is dependent on the rock mulch on the embankment sideslope and the runoff control ditch. The following discussion describes the design considerations used to develop and provide long-term stability of these features. Appendix D provides the detailed calculations for the long-term stability evaluations of the tailings embankment.

Rock Mulch Design - The CSU method (NUREG 4651, 1989) was used to size the rock mulch for protection of the embankment sideslopes from the erosional forces of runoff generated by the PMP. The resulting D_{50} of 1.5 inches and thickness of 3.0 inches for this rock mulch match is similar to that of the proposed tailings cover design so that the same rock material could be used for both areas. Table 2.3 provides the gradation for this rock mulch.

Runoff Control Ditch - The runoff control ditch would have a 10-foot bottom width and 3H:1V sideslope on the left bank and the same 5H:1V sideslope as the tailings embankment slope on the right bank. The minimum depth would be 2 feet. The channel slopes would vary from 0.007 to 0.022 ft/ft.

The riprap that would be used to protect the ditch during the PMF event was sized using the Safety Factors method. The resulting D_{50} was 1.5 inches for the upper section and 3.0 inches for the lower section. The riprap layer thickness would be 6 inches. The gradation for this riprap is provided in Table 2.3.

2.3 Pipeline Arroyo Channel - Comment Number 9B and 9C (August 16, 1990)

The NRC comments indicate a concern that the reconfigured channel design for Pipeline Arroyo would not provide long-term stability. This opinion is based on the concept that the nickpoint incision and channel reconfiguration proposed in the original design will lead to a geomorphic imbalance, eventual erosion of the tailings embankment, and unacceptable risk of potential release of tailings.

The NRC requests United Nuclear to install sufficient riprap in the reconfigured Pipeline Arroyo and place an appropriate rock mulch layer in the area between the toe of the embankment and Pipeline Arroyo.

As discussed in Section 3.3, the original design provides for the erosional stability of Pipeline Arroyo to meet the NRC's regulatory criteria. While the NRC's proposal to riprap the reconfigured Pipeline Arroyo may add an additional measure of comfort as to the long-term stability of the Arroyo, the original design submitted contains sufficient conservatism to protect the tailings from the potential for release of tailings to the environment for 1,000 years to the extent practicable.

As indicated in Table 2.1, the NRC's proposal would cost an additional $7.6 million. This estimate is based on the production, transport, and installation of 132,000 cy of riprap in the reconfigured Pipeline Arroyo at a unit cost of $54/cy, as well as placing 18,500 cy of rock mulch to cover the 23 acres of sacrificial area with a 6-inch-thick layer. The rock mulch would be purchased, transported, and placed at a unit cost of $25/cy. This high cost is affected significantly by the fact that very large rock (i.e., D_{50} of 39 inches) is required to meet the STP. Such rock is not locally available and would have to be imported from 42 miles away.

The original plan submitted by United Nuclear took these high costs into consideration. It was concluded that while the use of riprap theoretically is a viable alternative, the costs are simply prohibitive in relation to the benefits received. It was further concluded that a design could be prepared so as to provide reasonable assurances that tailings would not be released to the environment within the 1,000-year design period.

2.3.1 Proposed Modification

In response to the NRC's comments that the original design is not adequate, Canonie has developed an equally protective proposed design modification, which takes into account the NRC's concerns. This proposal utilizes a "buried jetty" in conjunction with the protective bench discussed in Section 2.2 to protect tailings from being released. The buried jetty, constructed about 150 feet upstream from the nickpoint, will serve to maintain the long-term geomorphic stability of Pipeline Arroyo and deflect flows within the arroyo away from the tailings embankment, thus protecting the tailings embankment toe from erosion.

Figures 2-2 and 2-3 provide a plan view of the revised Pipeline Arroyo channel configuration at final reclamation. The channel will be modified only slightly from its present configuration to enhance its flow capacity while maintaining its present shallow channel bottom slopes. The modifications to the present channel configuration will include the following:

1. Enhancing the low-flow capabilities of the present channel by constructing a 30-foot-wide low-flow channel within the reach upstream from the nickpoint from station 0+00 to station 61+40;

2. Filling in the depressions that presently exist in the area between Pipeline Arroyo and the tailings embankment;

3. Constructing a protective bench along the tailings embankment toe to contain the runoff control ditch and protect the tailings embankment toe from the PMF within Pipeline Arroyo;

4. Constructing a buried jetty from the nickpoint east across the Pipeline Arroyo floodplain to the runoff control ditch to augment the geomorphic control provided by nickpoint; and

5. Filling in the areas that previously had been headcut along the eastern side of Pipeline Arroyo within the sacrificial area.

Figure 2-4 provides profiles of the channel bottom, PMF water surface elevation (WSEL), protective bench toe, protective bench top, and tailings embankment top from station 0+00 to station 82+90. The profile shows the shallow slopes of the Pipeline Arroyo channel bottom upstream from the nickpoint and the spatial relationship of these features.

Figures 2-5 and 2-6 provide several cross sections across Pipeline Arroyo to the reclaimed tailings embankment top. These cross sections also illustrate the spatial relationships between the channel, bench, and embankment.

2.3.1.1 Stability Analysis

Hydraulic Analysis

The Corps of Engineers' program HEC-2 was used to simulate the passage of the PMF of 26,300 cfs through the Pipeline Arroyo channel. The simulation for reaches 1 and 2 (station 0+00 to station 61+40) was performed for the subcritical flow conditions that would occur in these reaches, while that for reach 3 (station 61+40 to station 82+90) was performed to simulate the supercritical flow conditions that would occur in this reach. Appendix C provides the input data and results for this simulation.

Figures 2-2 and 2-3 show the extent of the PMF floodplain, while Figure 2-4 shows the profile of the PMF maximum WSEL. The PMF fills most of the wide valley north of the tailings impoundments. The WSEL of the PMF stays below the top of the protective bench from station 35+00 to station 80+10. Downstream of station 63+90, the PMF is contained within the Pipeline Arroyo channel and does not reach the overbank area or the protective bench.

An evaluation of the flow capacity of the low-flow channel, i.e., the portion of the low-flow channel that is protected from erosion by the rock of the nickpoint, was performed. At Station 59+50 the low-flow channel bottom and west bank will be protected by the rock of the nickpoint while the east bank will be protected by the buried jetty. The low-flow channel will have a bottom width of 30 feet, 3H:1V sideslopes, and a depth of 4.0 feet. HEC-2 simulations were used to determine that 2,250 cfs would be contained within this low-flow channel. This flow is slightly greater than the peak discharge of the 100-year flood of 2,100 cfs for Pipeline Arroyo. Thus, the low-flow channel is capable of containing all low flows up to and including the 100-year flood.

Long-term Stability

The long-term stability of the Pipeline Arroyo channel was evaluated in terms of the potential erosion of the channel banks, the potential for meander formation, and the effects of the nickpoint and reinforcement of the nickpoint by the proposed buried jetty.

<u>Channel Erosion</u> - The proposed modified design of the Pipeline Arroyo effects little change to the existing erosional and geomorphic conditions within the valley. The channel slopes would remain extremely flat (0.003 ft/ft) in reaches 1 and 2 (Station 0+00 to Station 61+90). Thus, the erosional capacity of all flows in these reaches would be minimized. The steeply sloped area within the nickpoint would be protected from erosion by the rock of the nickpoint. The jetty will also ensure that flows remain on the nickpoint at a location as far as possible from the tailings embankment. Some erosion is expected to occur in reach 3, below the nickpoint, but the channel slopes in this reach will remain at their existing values (0.0118 to 0.0220 ft/ft) so as to minimize this erosion. In addition, the vast volume of material existing in the sacrificial area between the Pipeline Arroyo and the tailings embankment effectively prevents the release of tailings due to channel erosion within a 1,000-year period.

As a result of the proposed design modifications proposed above, the riprap in the North Diversion Ditch downdrain and in the lower reach of the South Cell Drainage Channel as contained in the original design would be unnecessary. Pipeline Arroyo channel bottom would not be incised in Reach 1 so that the North Diversion Ditch could enter the Pipeline Arroyo with the same channel bottom elevation. Also both the North Diversion Ditch and the South Cell Drainage Channel are separated from the tailings by a reach cut through rock. Erosion in the reaches downstream from the rock cuts would not be able to affect the reaches upstream from the rock cuts. Thus, the rock cuts provide long-term stability for these channels.

<u>Meander Growth</u> - An evaluation of potential meander growth along Pipeline Arroyo was performed to assess the likelihood of the release of tailings due to this geomorphic phenomenon. The evaluation was performed by first characterizing existing meander patterns of the Pipeline Arroyo and a nearby similar arroyo. These characteristics were then applied to the

proposed channel configuration and location and the potential impact identified.

Figure 2-7 shows the channel reaches and watersheds that were characterized in the watershed known as Hard Ground Canyon, which is about 5 miles northwest of Pipeline Arroyo. The two watersheds are similar in size, soil, and vegetation characteristics. The channels that drain these watersheds are also similar in that their lower reaches are deeply incised, probably by headcutting that has migrated from downstream areas. The headcuts have been terminated by sandstone outcrops (nickpoints) that have resulted in the formation of large alluvial-fill valleys upgradient of the nickpoint. The channels upgradient of the nickpoint have shallow slopes.

Table 2.7 provides the meander characteristics for the two channels. As can be seen, a wide range in channel slopes exists. However, the range of meander amplitudes (lateral distance from meander trough to meander peak) is quite small. Thus, channel slope does not have a strong influence on meander amplitude for these channels. The average meander amplitude for the two channels is 155 feet with a maximum amplitude of 570 feet within Pipeline Arroyo and 350 feet in Hard Ground Canyon. These maximum values may have been influenced by rock outcrops or variations in soil characteristics.

Comparison of the distances between the Pipeline Arroyo channel and the tailings with the 155-foot average meander amplitude indicates that meander growth will not cause the release of tailings. As shown on Figures 2-2 and 2-3, the distance between the channel and the tailings ranges from 335 feet at station 36+50 to 680 feet at station 76+00. Figures 2-5 and 2-6 illustrate this relationship at stations 41+95, 60+40, and 73+80. These distances are all greater than the 155-foot average meander amplitude and approach the maximum amplitudes noted for the two channels. Thus, even if all the meander growth were in the direction of tailings, there is little likelihood of meander growth causing the release of tailings.

Nickpoint Reinforcement - Reinforcement of the nickpoint would be accomplished by constructing a buried jetty consisting of a stone-filled trench that would extend across the valley from the nickpoint to the top of the protective bench along the tailings embankment toe at station 59+50. The proposed jetty would ensure that flows continue to pass over the nickpoint and would provide vertical control of the Pipeline Arroyo channel bottom. Vertical control would maintain the shallow slopes for the channel reach upstream from the nickpoint and thus would maintain the long-term geomorphic stability of Pipeline Arroyo. The proposed jetty has been designed to withstand the effects of the PMF passing over it. In addition, the low-flow channel will contain smaller, but more frequent, flood events and direct these flows over the nickpoint.

Figure 2-2 shows the location of the proposed jetty, while Figure 2-8 provides the jetty details. The jetty would be keyed into the nickpoint at its furthest extent to maximize the flow capacity within the nickpoint. The exact configuration of the eastern edge of the nickpoint will be determined in the field at the time of construction. For the present design, the low-flow channel was considered to be 30 feet wide and located at the west terminus of the jetty. The low-flow channel may be wider, depending on the nickpoint configuration.

The sizing of the stone (riprap) to be used in the proposed jetty was calculated using the Safety Factors method. The maximum depth of the PMF at this station (8.0 feet), as determined by the HEC-2 simulation and the actual channel bottom slope, was used in these calculations. Appendix E provides the detailed calculations. The resulting D_{50} rock size of the proposed jetty is 6 inches.

Stability of the Proposed Jetty and Reach 3

Some potential exists for headcuts to form at the Pipeline Arroyo channel banks downstream of the proposed jetty when flows are greater than those that could be contained in the low-flow channel, i.e., flows greater than 2,250 cfs. These flows would pass across areas that are not protected by riprap and into the channel below the nickpoint. The increasing depth from the channel bank to the channel bottom within the nickpoint would capture these flows allowing the potential formation of headcuts that could migrate towards the proposed jetty. The location of the headcuts would depend upon the water surface elevation of the flows.

Flows greater than 2,250 cfs have a recurrence interval greater than approximately 110 years. Therefore, in a 1,000-year period, flood events with peak discharges greater than 2,250 cfs should occur, on the average, only nine times. This relationship indicates that in a given year the probability of occurrence of a flood event greater than 2,250 cfs is less than 1 percent and that flows would remain within the low-flow channel in more than 99 percent of the years.

As shown on Section B-B′ of Figure 2-8, any potential headcuts would have to start at least 150 feet downstream from the proposed jetty at the beginning of Reach 3. The low-flow channel remains stable for this distance at a constant low slope on the rock of the nickpoint. Thus, the propensity for creating headcuts would not exist in the first 150 feet below the jetty because any flows in the overbank area would be traveling parallel to the channel banks.

The channel slope begins to increase at the distance of 150 feet from the jetty. Thus, at this point, the channel would be capable of carrying more flow and would capture any overbank flow. As this overbank flow entered the channel, it could potentially induce the formation of headcuts beginning at this location. Any headcuts formed at this point would be shallow headcuts because the channel depth is shallow.

Headcuts that could affect the toe of the proposed jetty would have to start at least 308 feet downstream from the proposed jetty. As shown on Section C-C′ of Figure 2-8, the toe of the jetty would extend downward to an elevation of 6,923 feet at Station 59+70. Assuming a headcut channel slope of 0.01 ft/ft, a potential headcut would have to form at or below Station 62+78 where the Pipeline Arroyo channel bottom is at elevation 6,920 feet to be able to be below elevation 6,923 feet at the toe of the proposed jetty. The distance this potential headcut would have to migrate is about 308 feet from Station 62+78 to Station 59+70.

Only the large, more infrequent flood events would be capable of remaining in the overbank area 308 feet downstream from the jetty. Thus, their likelihood of occurrence is extremely small. For example, the PMF is fully contained within the Arroyo at a distance 420 feet downstream of the jetty.

Given the unlikely scenario that a potential headcut migrated from below Station 62+78 to the proposed jetty by the occurrence of nine or less flood events, additional flood events with recurrence intervals greater than 110 years would be required to breach the proposed jetty and migrate upstream from the jetty. Thus, the likelihood of a potential headcut breaching the jetty within a 1,000 year period is reduced further still.

Finally, even should the unlikely event occur that a potential headcut were to breach the jetty, the headcut would then migrate directly upstream parallel to Pipeline Arroyo and thus parallel to the protective bench at the toe of the tailings embankment. Therefore, a potential headcut would not intercept the tailings embankment. In addition, the runoff control ditch on the proposed protective bench would intercept runoff from the tailings embankment ensuring that potential tributary headcuts do not form on or towards the embankment.

Therefore, in consideration of the many reasons provided above, headcut formation is extremely unlikely to breach the proposed jetty and create conditions that could cause the release of tailings in a 1,000-year period. It follows logically that such an occurrence in a 200-year period is infinitely smaller.

2.4 North and South Diversion Ditches

This section addresses two additional comments regarding the North and South Diversion ditches in response to concerns raised by NRC personnel during the meeting on October 12, 1990 as summarized below:

1. The stability of the two diversion ditches at the confluences of the tributaries to the ditches; and

2. The potential effects of the bedding planes and unconformities of the Dilco Coal Member in the steep rock cut through which the North Diversion Ditch passes.

2.4.1 Confluence Stability

The stability of the confluences of tributaries to the North and South Diversion ditches was evaluated to determine whether inflow from the tributaries may damage the diversion ditch banks and allow flows to pass over the reclaimed tailing impoundments. Such an occurrence could potentially allow a release of tailings. Damage to the ditch banks could potentially occur when the flows from the tributary are generally perpendicular to the ditch bank and impinge directly on the far bank. Such flows could potentially scour the far bank of the ditch by removing bank material. The tributary flows would have to be relatively large or relatively fast compared to the flows in the diversion ditch to have sufficient energy to damage the ditch bank.

The evaluation of stability was performed by first comparing total head (velocity head plus elevation head) of the PMF in the diversion ditch and in the tributary at three critical confluences. The second part of the evaluation considered the geometry of the confluences with respect to the confluence angle and extent of material that would have to be scoured to allow the flows to pass over the diversion ditch channel bank.

Three critical locations are shown on Figure 2-2. These three confluences (A1, A2, and B) involve tributaries to the North Diversion Ditch that provide a large proportion of the total flow of the diversion ditches at discrete locations. None of the tributaries to the South Diversion Ditch provide a large proportion of flow to the ditch.

Figure 2-9 provides a schematic of the tributaries and related cross sections on the North Diversion Ditch. Table 2.8 provides a summary of PMF flow characteristics for each of these locations. The PMF peak discharges were determined using the SCS TR55 method. Manning's equation was used to determine the flow depth and discharge in the North Diversion Ditch and in the tribut[illegible] Appendix F provides the calculations.

Table 2.8 also provides a comparison of total head at all the locations. The total head for the flows in tributaries A1, A2, and B are all less than those of the North Diversion Ditch cross sections (K, L, and M) located immediately upstream of the confluences. Thus, while the tributary flow will cause turbulence at the confluence, the flow will not be able to impinge directly on the ditch banks.

Confluence Geometry

The geometry of the three confluences was evaluated to identify the confluence angle and the amount of material existing in the far ditch bank. Figure 2-2 shows that Tributaries A2 and B enter the North Diversion Ditch at shallow confluence angles of approximately 45 degrees. Thus, their flows will not impinge directly on the far ditch bank. Tributary A1 enters the North Diversion Ditch at about a 90-degree angle. This angle indicates that tributary flows would cause more turbulence at the confluence than would be caused by a shallower angle.

Figure 2-9 provides cross sections of the North Diversion Ditch at the confluences. The cross sections show the extent of material that would have to be scoured before flows left the diversion ditch and passed across the tailings. These scour distances are 90 feet at confluence A1, 170 feet at confluence A2, and 150 feet at Tributary B. These distances are all sufficiently large such that channel scour would not allow flows to pass over the tailings. In addition, as channel scour removes material from the far bank during a particular flow event, the channel would become wider and thus protect itself from future scour.

Conclusion

At confluence A1, the total head of the tributary flow is considerably less than that of flow in the ditch. Furthermore, channel scour would have to remove 90 feet of material before flows could pass onto the tailings. At confluence A2, the total head of the tributary flow is less than that of the diversion ditch and the confluence angle is about 45 degrees. Thus, the tributary flows will not impinge directly on the ditch bank. Furthermore, about 170 feet of material would have to be scoured before flows could pass over the tailings. At Tributary B, the total head of the tributary flow is also less than that of the ditch and the confluence angle is about 45 degrees; thus the tributary flows would not impinge directly upon the diversion ditch bank. Furthermore, about 150 feet of material would have to be scoured before flows could pass over the tailings.

The above evaluation indicates that while scour and erosion would occur at the confluences, the total head differential, confluence angles, and amount of ditch material to be removed will not allow the release of tailings.

2.4.2 North Diversion Ditch Slope Stability

Based on a review of data contained in "Geology of the Church Rock Area," Science Applications, Inc. and visual observation of the cut face of the North Diversion Ditch in the northeast portion of the site (station 41+00 to station 50+00), the excavation is stable from a geologic point of view.

The channel cut is through the Dilco Coal member of the Crevasse Canyon formation. Typically, the bedding planes of the Dilco member in this area of the channel excavation trend from southeast to northwest and dip to the northeast at relatively small angles of 3 to 5 degrees. Visual observations of the channel excavation verify these conclusions. This low dip angle of 3 to 5 degrees is significantly lower than the ϕ angle of 45 degrees (Perloff and Baron, 1976) for this material. Therefore, there is little probability of slippage along the bedding planes due to shear failure.

Discontinuities and saturation of the formation could potentially lead to a reduction in shear resistance and failure. The only observable discontinuities in the Dilco Coal member typically consist of lower strength materials (i.e., shale and siltstone) interbedded with higher strength materials (sandstone). These discontinuities alone are not likely to lead to instability due to the high cohesion and friction angles between these layers. Saturation of these layers and resultant strength losses are also highly unlikely. The water table is approximately 140 feet below the excavation, which makes saturation from this source unlikely. The low precipitation (12-14 inches/year), small infiltration area uphill of the excavation (4.9 acres), and impermeable nature of the member make infiltration and percolation through the bedding planes unlikely. Therefore, shear strength losses due to saturation of the interbedded layers are essentially nonexistent.

Based on the observed and predicted stability of the Dilco Coal member exposed in the North Diversion channel excavation from stations 41+00 to 50+00, the cut slopes will remain stable throughout the 1,000-year design life of the reclaimed site. No modifications to stabilize the channel cut slopes are necessary or required.

3.0 SUBSTANTIATION OF ORIGINAL DESIGN

This section provides substantiation that the original reclamation plan design submitted to the NRC, and subsequently modified in previous responses to the NRC comments, meets the requirements of 10 CFR 40 Appendix A, particularly as it relates to the recent criticisms as contained in the NRC's comments. The original design provides an integrated approach that appropriately balances all needs of the criteria to meet the requirements as set forth in the regulations at reasonable cost.

The NRC criticizes the original design as not being sufficient to meet the NRC's criteria as it relates to long-term stability via the surface water erosion mechanism. The NRC's concerns are based on the premise that the original design does not meet the NRC's STP and, therefore, does not sufficiently protect against the release of tailings to the environment. Specifically, the NRC is concerned that:

1. The proposed tailings cover is not designed so as to adequately control erosion;

2. The embankment slopes are not adequately protected to control erosion; and

3. The Pipeline Arroyo is not adequately armored to control erosion.

As discussed in this section, United Nuclear will demonstrate that its original design provides erosion control of the tailings soil cover, the embankment slopes, and the Pipeline Arroyo. The design is based on extensive geomorphologic evaluations, surface water hydrology analyses, and numerical engineering calculations.

3.1 Tailings Soil Cover

The present erosion protection design for the tailings soil cover includes regrading of the impoundment to fill in low spots, covering the fine-grained tailings with coarse-grained tailings, and providing gentle top slopes. As more fully described in Section 7.5 of the original Reclamation Plan, the slopes of the cover will average approximately 2 percent. The plan also includes the construction of seven swales to collect surface water runoff and to route the runoff to riprapped drainage channels. The swales were designed to ensure that overland flow velocities and channel flow velocities would not exceed the MPV at which erosion may occur of 3 fps. In addition, the tailings cover will be revegetated.

The soil cover design was prepared on the basis that it had to meet Criterion 4 and Criterion 6 of the 10 CFR 40 Appendix A criteria related to surface water erosion considerations. In addition, the design took into consideration Criterion 5, regarding the need to protect ground water, as well as paragraph 5 of the Introduction to Appendix A that requires that all licensing decisions based on the criteria take public health and safety and the environment in due consideration to the costs involved and other factors as appropriate.

Criterion 4(d)

This criterion requires that a self-sustaining vegetative cover must be established or rock employed to reduce water erosion. It considers that a rock cover must be employed when conditions are such that a vegetative cover is unlikely to be sustained. It also considers that the rock cover requirement will be relaxed for extremely gentle slopes, such as those that may exist on the top of the pile.

Canonie was counseled by the NRC during preparation of the design that the NRC considered gentle slopes to mean those slopes that kept surface water flows to less than 3 fps. This MPV, endorsed by the NRC and the NRC's consultant, is described in a reference by Barfield et al., (1985). The NRC further encouraged United Nuclear to vegetate the soil cover and take credit for same in calculating the MPV.

Criterion 6

This criterion requires that the tailings disposal area be closed in accordance with a design that provides reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable and, in any event, for at least 200 years. Those assurances are to be based, in part, on the adequacy of erosion protection of the soil cover.

The terms "reasonably achievable" and "practicable" are equivalent words as defined in the regulations. Appendix A requires that decisions involving these terms take into account the state of technology and the economics of improvements in relation to benefits to public health and safety and the environment.

Canonie demonstrated in submittals dated May 23, 1988 and August 31, 1988 that constructing gentle slopes, keeping the MPV to less than 3 fps, providing runoff collection swales, and vegetating the soil cover prevented the soil cover from eroding, thus protecting tailings from releases for the prescribed 200 and 1,000 year periods.

Criterion 5

This criterion requires that ground water be protected.

Canonie designed the soil cover to achieve a balance between the need to keep the slopes as gentle as possible to control surface erosion and at the same time contour and swale the cover so that water would be allowed to run off the cover, thus minimizing the opportunity for infiltration of water. This was a critical consideration for United Nuclear because of the EPA's activity at the site relative to CERCLA. During preparation of the design, the NRC concurred that this was an important consideration and endorsed this approach to balancing these potentially conflicting criteria.

Introduction to Appendix A, 10 CFR 40, Paragraph 5

The introduction to Appendix A, 10 CFR 40, requires that licensing decisions made by the commission be based on risks to public health and safety and the environment with due consideration to cost and other factors.

As part of preparing its design, Canonie conducted an assessment of various alternative approaches to tailings stabilization. The alternative of providing a rock cover as well as the alternative of constructing the soil cover using flat "table-top" slopes (stable slopes) were evaluated along with other scenarios. This exercise was conducted in the normal course of decision making to identify cost-effective approaches that provided solutions to regulatory requirements. As such, these evaluations were never formalized into reports. Nonetheless, as a prudent businesslike measure, the costs and benefits of various alternatives were assessed, and it was concluded that the alternative whose cost, as related to the benefit to public health and safety and the environment, was most balanced was the design proposed in June 1987.

In preparing its response to the NRC's most recent comment, as contained herein, Canonie revisited the costs of the NRC's proposed rock mulch and flat, stable slopes alternatives. As discussed in Section 2.1, the costs for these alternatives are $2.4 and $4.0 million, respectively, higher than the proposed design. While these cost estimates are reflective of costs that would be incurred today, not those at the time the design was submitted, they clearly demonstrate the point because the relative costs remain the same. In fact, the earlier cost estimates would have been higher because a potential rock source closer to the site has been identified since 1987 and earth moving estimates today are more accurate.

The fact that no suitable rock of the quality and size required is locally available significantly increases the cost of the rock cover because of the need to import the rock from an off-site source. The significant amount of earth work required to reconfigure the top of the tailings to a more stable slope, together with the requirement for rock to stabilize the ... increased the cost of the flat "table-top" slope design.

Conclusion

The NRC has criticized the original design of the soil cover. It has used as its fundamental argument the fact that the design fails to meet the tractive force criteria contained in its STP, concluding that because the design does not meet the STP, it does not meet the regulatory criteria of Appendix A.

Canonie believes that the NRC's conclusion is in error. The STP is not the controlling document. The regulation is. Staff technical positions can and do change without being subject to the same rule-making process as proposed regulatory changes. As demonstrated by the NRC's most recent comments, in the space of three years the NRC's STP (or its interpretation of its STP) has changed such that it no longer accepts the premise that a vegetative cover can be self-sustaining at the Church Rock site, that an MPV of less than 3 fps is no longer sufficient to protect the cover, as designed, from erosional forces, and the slopes that average 2.0 percent are not sufficiently gentle to protect the cover, as designed, from erosional forces.

Without producing any substantiating technical evidence, the NRC now concludes that the more conservative approach of requiring either a rock mulch addition to the cover design or reconfiguring the design in favor of "flat" slopes is adequate.

Canonie submits that, contrary to the NRC's representation that its proposals should be implemented because they meet the regulatory criteria, the NRC's proposed approach significantly violates its own regulations. The NRC's proposals are in conflict with Criterion 5 of Appendix A, whereby the flat slopes are not protective of ground water impacts. In addition, while "flat slope" designs are theoretically possible, a slope of 0.002 ft/ft must be obtained with the soil available at the site for use as cover material in order to meet the NRC's STP tractive force requirement.

However, it is physically impractical to obtain sufficient field control of construction materials to ensure that slopes at or less than 0.002 ft/ft are in fact being constructed. The very best that might be expected would be 0.005 ft/ft and even accomplishing such a feat in the field is highly unlikely. Additionally, a slope of 0.005 ft/ft will not allow the STP tractive force requirement to be met, creating, as a practical matter, the same concern that the NRC seeks to obviate.

The introduction to Appendix A clearly identifies that alternatives must be technologically and economically practicable. As demonstrated earlier, both of the NRC's proposals are unjustifiable on the basis that no significant incremental benefit to public health, safety, and the environment are realized relative to the increased cost.

For the reasons as stated above, the original cover design as proposed meets the criteria as set forth in 10 CFR 40, Appendix A, and should be approved.

<u>3.2 Tailings Embankment</u>

As described in more detail in the response to comments dated August 31, 1988, the present erosion protection design for the 5H:1V tailings embankment sideslopes includes a series of runoff interception ditches to route runoff to a central collection channel. The interception ditches are spaced at 40-foot intervals to prevent the formation of gullies. The response indicated that this 40-foot spacing was calculated using Horton's method for determining the belt of no erosion. The collection channel is lined with riprap designed for the PMF. The flow velocities in the interception ditches will be below the MPV of 3 fps. The basis used for this design of the tailings embankment protection was the same as that described in Section 3.1 for the tailings cover.

The NRC criticized United Nuclear's design based on the potential for siltation, for the potential for flow to overtop the outer bank, and for potential for progressive erosion of the ditch outbank resulting in gullying.

The NRC's concerns are not well founded with regard to the potential for siltation. An analysis of the potential flow velocities in the interception ditches was made to determine the likelihood of siltation (deposition), transport, or erosion of the soil used in the embankment and ditch design. This soil has an average grain-size diameter of 0.05 millimeters (mm). Figure 6-7 of Ritter (1978) shows that flow velocities above about 0.013 fps will transport sediment of this grainsize while flow velocities below this value will allow siltation of this sediment. This is an extremely low-flow velocity, yet still manages to transport the sediment. Sediment with a diameter of 1 mm (20 times larger than the average) will be transported by a flow velocity of about 0.3 fps. This flow velocity corresponds roughly to a discharge of 0.006 cfs at a depth of 0.08 feet in the interception ditches.

Thus, siltation of even large sediment will not occur in the interception ditches. Appendix G provides the detailed calculations used for this analysis.

With regard for the potential for overtopping, Canonie has overdesigned the ditches so that overtopping would not occur. The design accounts for the total head (velocity head plus elevation head) of incoming flow as compared to the elevation head at the ditch bank crest. Determination of the overland flow down the 5H:1V embankment and 3H:1V interceptor ditch sideslopes was performed by the methods prescribed in NUREG-4620. This method allowed the calculation of the velocity and depth of overland flow at the bottom of the interceptor ditch generated by the PMP. Bernoulli's equation was used to determine the amount of energy, or head, necessary for the overland flow to overtop the interceptor ditch bank. The total head at the bottom of the ditch was found to be 0.25 feet while the total head necessary to overtop the interceptor ditch was 2.5 feet. Therefore, no flow would overtop the ditch bank. Appendix G gives the appropriate calculations for both the overland flow and Bernoulli's equation.

With regard to the potential for progressive erosion of the outbanks, the following evaluation demonstrates that gullying will not cause the interception ditch outbanks to cause the release of tailings. The crest of the ditch outbank provides a watershed divide. The 3H:1V sideslopes of the ditch outbanks intersect the 5H:1V embankment sideslopes approximately 23 feet downhill from this crest. The methods prescribed in the STP were used to estimate the maximum depth of gullying (D_{max}) and the distance from the crest at which the D_{max} would occur. D_{max} was found to be 0.31 feet and would occur 1.1 feet from the intersection of the 3H:1V slopes and the 5H:1V slopes. The gully would not reach the crest of the ditch bank.

The sediment produced by this gullying would be deposited on the 5H:1V sideslopes as the flow velocities decreased. Thus, this minor amount of gullying would not affect the interception ditch, nor cause the release of tailings. Appendix G provides the detailed calculations used for this evaluation.

Therefore, United Nuclear's design for protection of the embankment slopes meets 10 CFR 40 Appendix A criteria and should be approved.

3.3 Pipeline Arroyo

Canonie expended a significant effort in designing and subsequently addressing a large number of NRC comments regarding this design and submitted responses to comments dated August 31, 1988, February 23, 1989, and September 12, 1990 to the NRC specifically on the subject of the stability of the Pipeline Arroyo design. The NRC and its consultants have spent many hours evaluating the proposed design.

The details of the design will not be restated in this document as they are readily available in the above-referenced documents. Briefly, however, the original design for Pipeline Arroyo provides a reconfigured channel to be incised approximately 20 feet into the sandstone outcrop known as the nickpoint. The incision prevents the channel from migrating off of the nickpoint and into the tailings. The reconfigured channel above the nickpoint would have a slope of about 0.008 ft/ft, which is slightly steeper than the existing channel slope of 0.003 ft/ft. Below the nickpoint, the channel slope would vary but would be approximately the same as the existing slope. Riprap would be installed at the nickpoint to protect any channel banks that would be contacted by the PMF.

This design fully contains the PMF within the reconfigured channel; thus, no flow will contact the tailings embankment. Furthermore, the solid rock of the nickpoint provides horizontal and vertical control of the channel, thus ensuring that the channel remains as far as possible from the tailings impoundment.

Analysis of the long-term stability of the reconfigured channel using Yang's unit stream power equation indicated that the channel would not cause the release of tailings in a 1,000-year period. This period includes multiple occurrences of the 2-year through 100-year flood events as well as the PMF. Thus, the reconfigured channel will not cause the release of tailings within a 1,000-year period and permanent isolation of tailings is maintained.

Canonie prepared this design for the Pipeline Arroyo reconfiguration on the basis of meeting Criterion 6 of Appendix A, which requires that the disposal area be closed in accordance with a design that provides reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable and, in any event, at least 200 years.

As was the case with the tailings cover design, Canonie evaluated a number of alternative designs to meet this criterion before concluding that the most appropriate design would require that the nickpoint be incised to allow the PMF to flow as quickly past the site as possible while taking into consideration other factors that could affect meeting the criterion. It was also determined that the design should incorporate an incision in the nickpoint because of the importance this structure plays in the long-term geomorphic stability of the arroyo in the area of the site.

Much careful calculation, each compounded with its own inherent conservatism, was used in the design to account for passage of the PMF and the full range of lesser flood events with the potential for release of tailings during the design period, i.e., 1,000 years. For example, detailed analyses identified above and incorporated herein by reference indicate that, even after the full range of lesser flood events have been factored into the equation, there will still remain over 170 feet of soil that would have to be eroded away from the location closest to the tailings embankment before tailings could possibly be released. Additionally, in calculating the effects of erosion in the arroyo, no credit was taken for the occurrence of vertical (downward) erosion. All erosion was assumed to occur laterally. Also, no credit was taken for the deposition of materials from upgradient as a result of previous storm events. There are many other examples contained in the references. Nonetheless, the NRC is not comfortable with the analysis.

Canonie evaluated the costs attendant to a variety of alternative Pipeline Arroyo designs to determine which offered the best balance of achieving the criteria against the cost. Included in this analysis was the cost of providing riprap sufficient to armor the reconfigured arroyo. A recent reevaluation of the costs indicate that it would cost an additional $7.1 million to riprap the reconfigured arroyo in the original design. This added cost alone would increase the estimated cost of tailings reclamation approximately 55 percent. The cost of placing a 6-inch rock mulch layer between the arroyo and the toe of the embankment would add another $0.5 million.

Canonie also evaluated alternative excavated channel configurations, including shallower and wider channels and steeper sideslopes. This analysis was limited to some extent by physical constraints present at the site, not the least of which is the presence of a liquified natural gas pipeline and a state highway, both running parallel to the Pipeline Arroyo. The analysis indicated that 3H:1V sideslopes were the best configuration to balance the desire to maximize stability, keep the arroyo center line as far away from the tailings as possible, and provide the borrow material needed to construct the tailings cover.

Canonie conducted extensive analyses of the long-term stability of the reconfigured Pipeline Arroyo as designed, as contained in the response to comments dated February 23, 1989. This document clearly demonstrates that there is sufficient conservatism included in the design to accommodate the relatively small risk associated with not riprapping the arroyo channel. The highest risk associated with the possible occurrence of erosion in the reconfigured arroyo is for the arroyo to meander sufficiently towards the tailings, causing release of tailings. Canonie analyzed the potential of such an occurrence by evaluating the meander characteristics of Hard Ground Canyon and Pipeline Arroyo, as described above, and demonstrated that it was unlikely. The average meander amplitude was found to be 155 feet, while the closest distance to the tailings was 355 feet.

Conclusion

The NRC criticizes the original design in its August 16, 1990 comments as not being adequate to meet the criteria of 10 CFR 40, Appendix A, because in its view United Nuclear has not provided sufficient evidence to ensure that the reconfigured channel is stable enough to withstand surface water erosion forces for the long term, i.e., 1,000 years. Additionally, the NRC criticizes the design for not sufficiently protecting the area between the arroyo and the toe of the embankment sideslope.

In a subsequent meeting, the NRC's geomorphic expert revealed that his true concern was that he believed that the nickpoint should never have been proposed to be incised. He further stated that he believed that incising the nickpoint as proposed in the original design was "inherently fatally flawed" because such an action would cause a serious geomorphic imbalance of the arroyo. The NRC's expert offered the observation that in his view Canonie had inappropriately recommended an engineering solution to a geomorphic problem. They had, in his opinion, attempted to solve the problem by focusing entirely on the passage of the PMF through the site as quickly as possible, using engineering techniques that were to the detriment of geomorphic stability. No substantiating technical evidence was offered to support this position.

Canonie believes that the NRC's conclusions are in error. The NRC has presented no technical evidence to support its claim that the original design as originally submitted fails to meet the criteria. A statement of fear that headcuts and meanders "could be created' such that they "would threaten" release of tailings is hardly sufficient justification to require expenditure of $7.1 million.

The NRC's comments notwithstanding, Canonie designed a solution that meets Criterion 6 of providing "reasonable assurances of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable." Canonie evaluated the various alternative technical approaches and appropriately balanced them against the attendant costs and also took into account site-specific constraints to the extent that they affected the design. The incremental benefits of placing riprap in the arroyo when compared to the additional costs clearly cannot be justified. Finally, contrary to the NRC's belief, Canonie thoroughly evaluated and understood both the engineering and geomorphic stability implications of this design and appropriately balanced them in determining the most reasonable technical solution.

Therefore, for the reasons stated above, United Nuclear's Pipeline Arroyo reconfiguration design as proposed meets the criteria as set forth in 10 CFR 40, Appendix A, and should be approved.

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REFERENCES

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TABLES

TABLE 2.1

SUMMARY OF RECLAMATION PLAN ALTERNATIVES AND ADDITIONAL COSTS

	Pipeline Arroyo	Sacrifical Area	Embankment Sideslopes	Tailings Soil Cover	Total Additions Cost
United Nuclear Original Design Submittal	Incise nickpoint, reconfigured arroyo, add riprap at selected locations.	Regrade to eliminate depressions.	Construct and rip-rap runoff control ditch. Install interception ditches.	Regrade tailings to shed water. Install 4-foot soil cover vegetation.	
Additional Cost	$0	$0	$0	$0	$0
NRC Proposed Changes	Install riprap on entire length of reconfigured channel.	Provide a 6-inch-thick rock mulch layer.	Provide a 6-inch-thick Rock mulch layer.	Provide a 6-inch-thick rock mulch layer.	
	$7,100,000	$501,000	$251,000	$2,417,500	$10,269,500
				OR	OR
				Regrade top to stable slopes (benches). Install riprap swales, no vegetation.	
				$4,020,000	$11,872,000
United Nuclear Proposed Design Modifications	Do not incise nick-point; install a low-flow channel, buried jetty.	Regrade to eliminate depressions.	Provide 3-inch-thick rock mulch layer and protective bench.	Provide soil/rock matrix over soil cover, riprap swales, no vegetation.	
Additional Cost	($492,000)	$0	$95,000	$1,380,000	$983,000

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TABLE 2.2

IMPOUNDMENT TOP DRAINAGE SWALE CHARACTERISTICS

Swale Designation	Length (ft)	Slope (ft/ft)	Bottom Width (ft)	Peak Discharge (cfs)	Depth of Flow (ft)	Minimum Swale Depth (ft)	Riprap D_{50} (in)
A	2,600	0.0038	10	40	0.98	2.0	1.5
B	3,600	0.0083	20	97	0.97	2.0	1.5
C	3,400	0.0050	10	75	1.38	2.0	1.5
D	3,200	0.0028	10	68	1.43	2.0	1.5
E	1,350	0.0037	10	85	1.53	2.5	1.5
F	1,600	0.0031	10	126	2.00	2.5	1.5
G	1,400	0.0021	10	99	1.88	2.5	1.5
H	2,550	0.0085	20	284	1.90	2.5	3.0
I	550	0.0040	20	385	2.65	3.5	3.0
J	1,900	0.0047	10	101	1.66	2.5	1.5

Note: See Figures 2-2 and 2-3 for swale locations.

TABLE 2.3

RIPRAP AND FILTER MATERIAL GRADATION REQUIREMENTS (a)

Location	D_{50} (b)	Sieve Size:	30 Inch	25 Inch	20 Inch	15 Inch	10 Inch	5 Inch	4 Inch	3 Inch	1 Inch	No. 4
			Percent Passing by Weight									
Upper Section South Cell Drainage Channel	23 Inches (c)		100		35-45		12-32	5-22		0-17		
Upper Section North Cell Drainage Channel	14 Inches (c)			100		40-70		10-33		0-27		
Lower Section North Cell Drainage Channel	11 Inches (c)					100		17-30		10-24	0-12	
North Diversion Ditch, Buried Jetty	6.0 Inches						100		30-40		7-20	0-3
Swales H and I, Lower Reach of Runoff Control Ditch	3.0 Inches							100		40-47	15-32	0-16
Soil/Rock Matrix, Swales, Upper Reach of Runoff Control Ditch	1.5 Inches									100	25-37	0-17

		Sieve Size:	No. 200	No. 40	No. 10	No. 4	3/4 Inch	3 Inch	+3 Inch
	Filter Layer		0-30	23-70	47-94	65-100	85-100	100	--

(a) The rock quality will be determined in accordance with Appendix D of the NRC's Staff Technical Position (STP) on "Design of Erosion Protection Covers" dated August 1990. Rock used for channels, swales, and the tailings cover soil/rock matrix shall be considered "noncritical" and have a minimum rock quality rating of 50.

(b) Rock sizes shown will be oversized based on their rock quality rating by the methods provided in Appendix D of the NRC's STP.

(c) Rock sizes have been based on Maynord's 1987 method. United Nuclear reserves the right to modify the above gradations using Maynord's 1978 method as an alternative method if justifiable.

TABLE 2.4

SUMMARY OF RADON MODEL INPUT PARAMETERS

General Description	Specific Gravity	Dry Bulk Density (pcf)	Porosity	Moisture Content (percent)	Radium Content (pCi/g)	Diffusion Coefficient (cm2/sec)	Emanation Coefficient
Radon Source Parameters:							
Fine Tailings							
Average	2.78	86	0.53	38.7	547	0.00176	0.26
95 Percent Confidence Interval	2.73 to 2.83 *		0.50 to 0.56 *	29.7 * to 47.7	296 to 798 *	0.00022 to 0.0053 *	0.20 to 0.32 *
Coarse Tailings							
Average	2.81	97.5	0.45	10.4 *	154	0.029	0.26
95 Percent Confidence Interval	2.77 to 2.84 *		0.43 to 0.47 *		125.0 to 183.0 *	0.018 to 0.047 *	0.25 to 0.27 *
Radon Attenuation Parameters:							
Soil Cover	2.6 *	108.3 *	0.33 *	13.4 *	--	0.0029 *	--

Notes:

1. * indicates parameters that were used in the RADON model.

2. Radon attenuation parameters for the soil cover materials were calculated from measured geotechnical parameters.

TABLE 2.5

COARSE TAILINGS LABORATORY TEST DATA

General Description	Boring Number	Depth (feet)	Specific Gravity	Dry Bulk Density (pcf)	Porosity	Moisture Content (percent) (a)	Radium Content (pCi/g)	Diffusion Coefficient (cm2/sec) (b)	Emanation Coefficient
Tailings Sands	658	15	NT	105	0.40	NT	NT	NT	NT
	658	20	2.83	104	0.41	23.5	160	0.0000053	0.32
	658	30	2.81	98	0.44	23.4	141	0.000019	0.27
	658	40	2.89	92	0.49	31.2	212	0.000002	0.25
	659	10	2.84	95	0.46	6.1	125	0.037	0.18
	659	20	2.83	94	0.47	10.5	227	0.023	0.21
	659	30	2.74	97	0.43	13.1	132	0.016	0.29
	659	32.5	NT	106	0.47	8.1	115	0.042	0.27
	662	20	NT	97	0.49	34.1	NT	NT	NT
	662	25	2.78	96	0.36	25.1	108	0.0000025	0.33
	662	30	2.79	94	0.46	29.6	177	0.0000013	0.28
Supplemental (c)							143.1		
Average			2.81	97.5	0.45	20.47	154	NA	0.26
95 Percent Confidence Interval			2.77 to 2.84	NA	0.43 to 0.47	NA	125.0 to 183.0	NA	0.25 to 0.27

NT = Not tested

(a) Moisture contents are not indicative of long-term values, which will typically be lower; therefore, soils test data have been averaged and a value of 10.4 percent obtained.

(b) Diffusion coefficients are typically low due to the high moisture content values; therefore, calculated values will be used.

(c) Value for radium content from Environmental Report on Uranium Mill Tailings Backfill presented in April 8, 1981 letter from United Nuclear to the New Mexico Environmental Improvement Division.

TABLE 2.6

FINE TAILINGS LABORATORY TEST DATA

General Description	Boring Number	Depth (feet)	Specific Gravity	Dry Bulk Density (pcf)	Porosity	Moisture Content (percent)	Radium Content (pCi/g)	Diffusion Coefficient (cm2/sec)	Emanation Coefficient
Fine-Grained	659	37.5	2.72	78	0.54	29.6	602	0.0056	0.16
Tailings	660	8.0	2.81	74	0.58	44.27	341	0.0000011	0.37
Slimes	660	15.0	2.84	94	0.47	60.0	1099	0.0000016	0.31
	660	27.5	2.75	89	0.48	32.2	285	0.0000016	0.26
	660	37.5	2.84	79	0.56	41.4	526	0.0000027	0.28
	662	40.0	2.72	84	0.51	36.4	574	0.0000062	0.21
	662	42.5	NT	89	0.55	43.8	NT	NT	NT
	658	10.0	2.81	88	0.50	17.4	402	0.0067	0.22
	658	32.5	NT	97	0.55	43.6	NT	NT	NT
Average			2.78	86	0.53	38.7	547	0.00076	0.26
95 Percent Confidence Interval			2.73 to 2.83	NA	0.50 to 0.56	29.7 to 47.7	29[illegible] to 793	0.00022 to 0.0053	0.20 to 0.32

NT = Not tested

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TABLE 2.7

SUMMARY OF MEANDER PATTERNS

PIPELINE ARROYO

Elevation Contour	Channel Distance (ft)	Slope (ft/ft)	Valley Distance (ft)	Sinuosity (ft/ft)	Average Meander Amplitude (ft)	Average Meander Wave Length (ft)
6840						
6880	3800	0.011	3375	1.126	200	1150
6920	5200	0.008	5025	1.035	150	1250
6960	7000	0.006	6500	1.077	100	2275
7000	2000	0.020	1675	1.194	100	2000
7040	7200	0.006	6025	1.195	100	1750
7080	3600	0.011	3225	1.116	200	750

Watershed Area = 20.12 square miles
Maximum Amplitude = 570 feet

HARD GROUND CANYON

Elevation Contour	Channel Distance (ft)	Slope (ft/ft)	Valley Distance (ft)	Sinuosity (ft/ft)	Average Meander Amplitude (ft)	Average Meander Wave Length (ft)
6800	0					
6840	5600	0.007	5300	1.057	150	1050
6880	3400	0.012	3300	1.030	150	675
6920	7000	0.006	6800	1.029	200	1800
6960	3300	0.012	2500	1.320	350	1000
7000	7900	0.005	7500	1.053	150	1780
7040	2800	0.014	2600	1.077	100	1400
7080	2300	0.017	2150	1.070	75	2000

Watershed Area = 14.11 square miles
Maximum Amplitude = 350 feet

TABLE 2.8

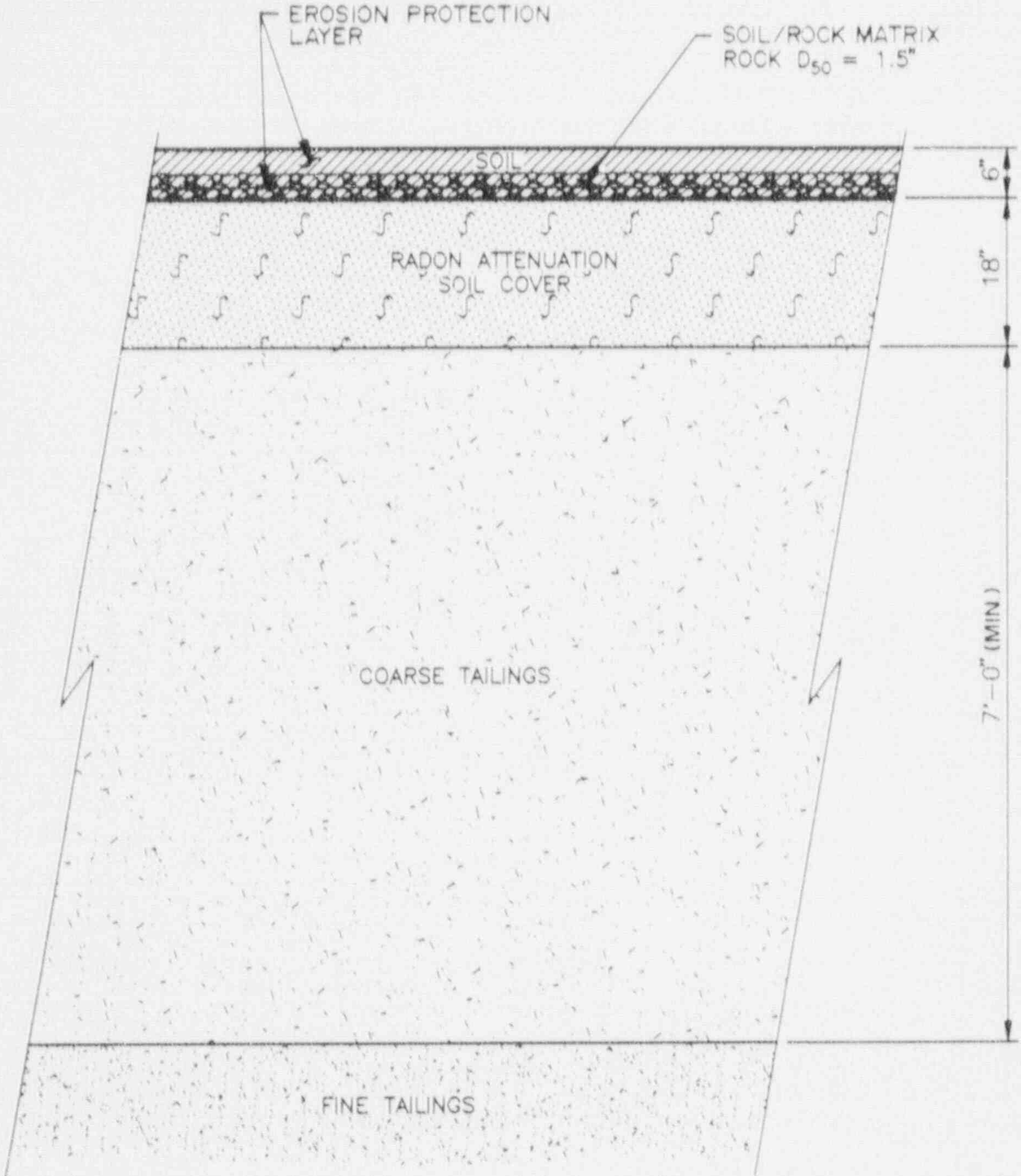
TOTAL HEAD COMPARISONS AT CONFLUENCES

Cross Section Location	Peak Discharge (cfs)	Channel Slope (ft/ft)	Depth of Flow (ft)	Flow Velocity (fps)	Velocity Head (ft)	Total Head (ft)
K	1081	0.0054	4.22	9.0	1.26	5.48
A1	383	0.044	0.88	11.2	1.95	2.93
L	2265	0.0071	5.69	12.5	2.43	8.12
A2	765	0.020	1.81	10.8	1.82	3.63
M	2265	0.0074	4.34	9.8	1.49	5.83
B	2046	0.019	2.48	13.2	2.17	5.19
N	5850	0.0074	8.02	15.1	3.54	11.56

Note: Figure 2-8 provides the cross section locations.

FIGURES

DRAWING NUMBER 86-060-A426



NOTE:

1. THIS DRAWING IS NOT TO SCALE.

SOIL COVER PROFILE

PREPARED FOR

UNC MINING AND MILLING
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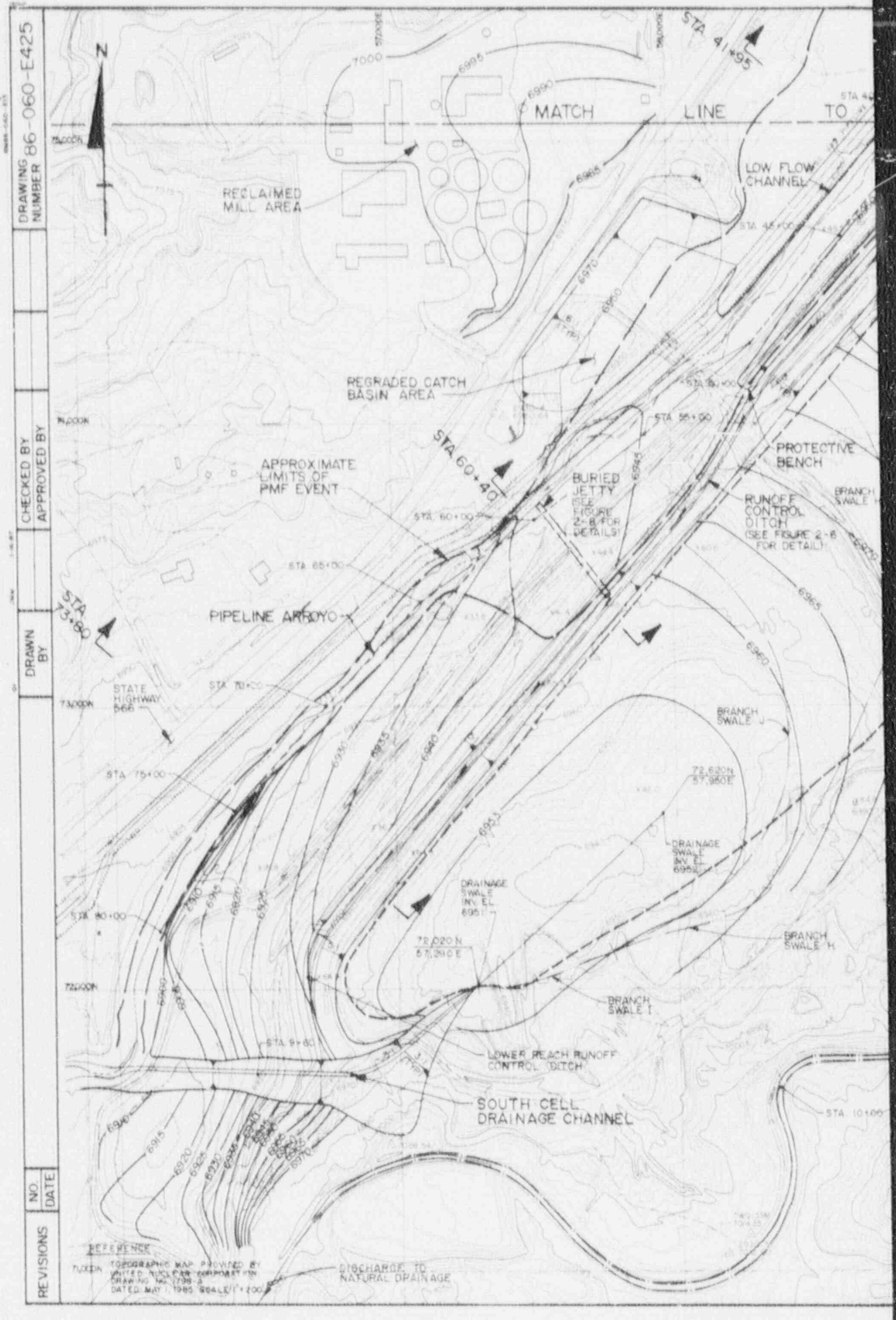
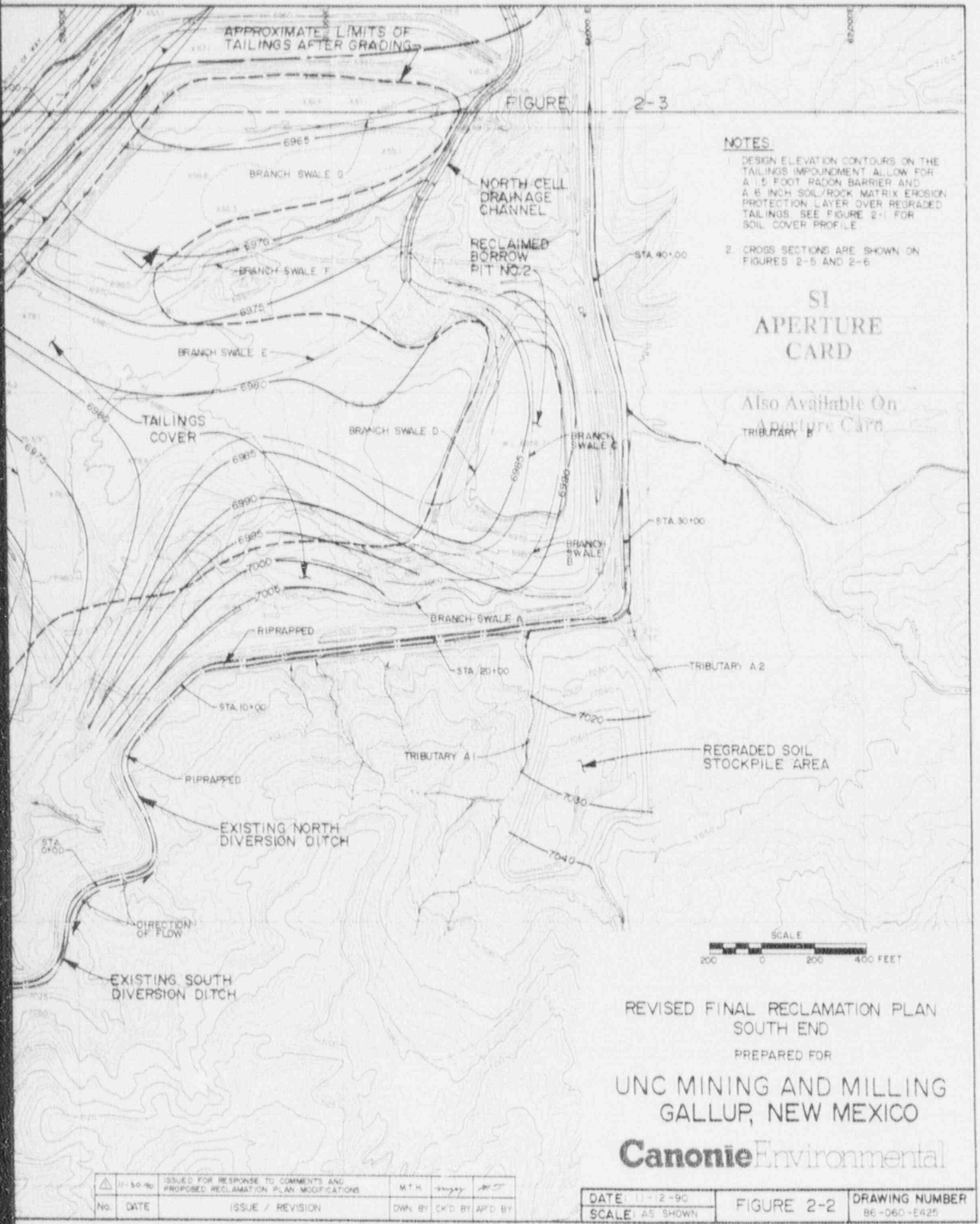
1	12-4-90	ISSUED FOR RESPONSE TO COMMENTS AND PROPOSED RECLAMATION PLAN MODIFICATIONS	P.M.W.	[illegible]	DHG

DATE: 11-12-90	FIGURE 2-1	DRAWING NUMBER 86-060-A426
SCALE: N.T.S.		

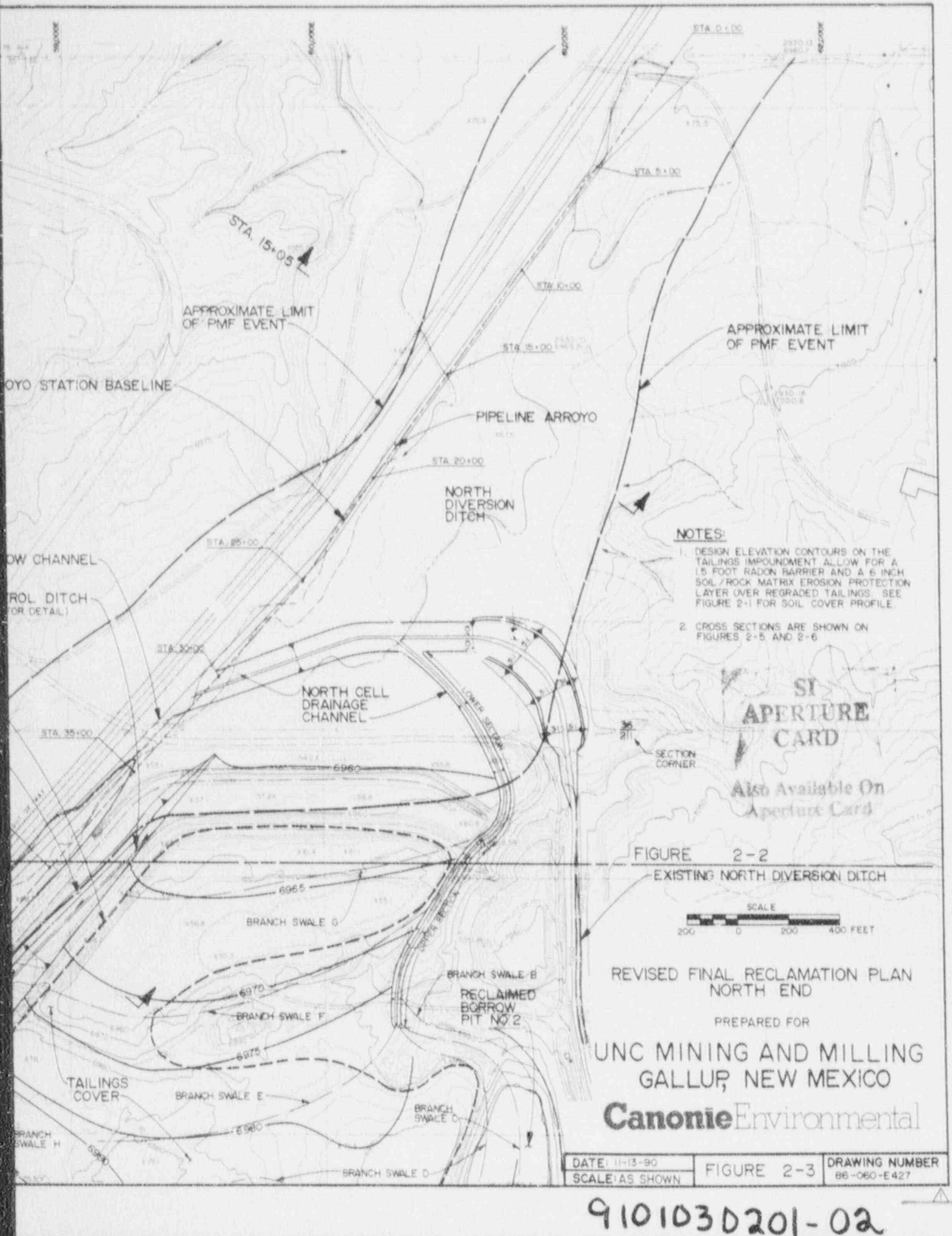
1


DRAWING NUMBER 86-060-E425
CHECKED BY
APPROVED BY
DRAWN BY
REVISIONS
NO.
DATE
N
MATCH LINE TO
STA 41+95
RECLAIMED MILL AREA
LOW FLOW CHANNEL
REGRADED CATCH BASIN AREA
STA 60+40
APPROXIMATE LIMITS OF PMF EVENT
BURIED JETTY (SEE FIGURE 2-6 FOR DETAILS)
PROTECTIVE BENCH
RUNOFF CONTROL DITCH (SEE FIGURE 2-6 FOR DETAIL)
BRANCH SWALE
STA 73+60
PIPELINE ARROYO
STATE HIGHWAY 566
STA 65+00
STA 70+00
STA 75+00
STA 80+00
STA 55+00
STA 45+00
BRANCH SWALE J
72,620N 57,950E
DRAINAGE SWALE INV. EL. 6952
DRAINAGE SWALE INV. EL. 6951
72,020 N 57,210 E
BRANCH SWALE H
BRANCH SWALE I
STA 9+60
LOWER REACH RUNOFF CONTROL DITCH
SOUTH CELL DRAINAGE CHANNEL
STA 10+00
REFERENCE
TOPOGRAPHIC MAP PROVIDED BY UNITED NUCLEAR CORPORATION DRAWING NO. 1798-A DATED MAY 1, 1985 SCALE 1"=200'
DISCHARGE TO NATURAL DRAINAGE
75,000N
74,000N
73,000N
72,000N
71,000N



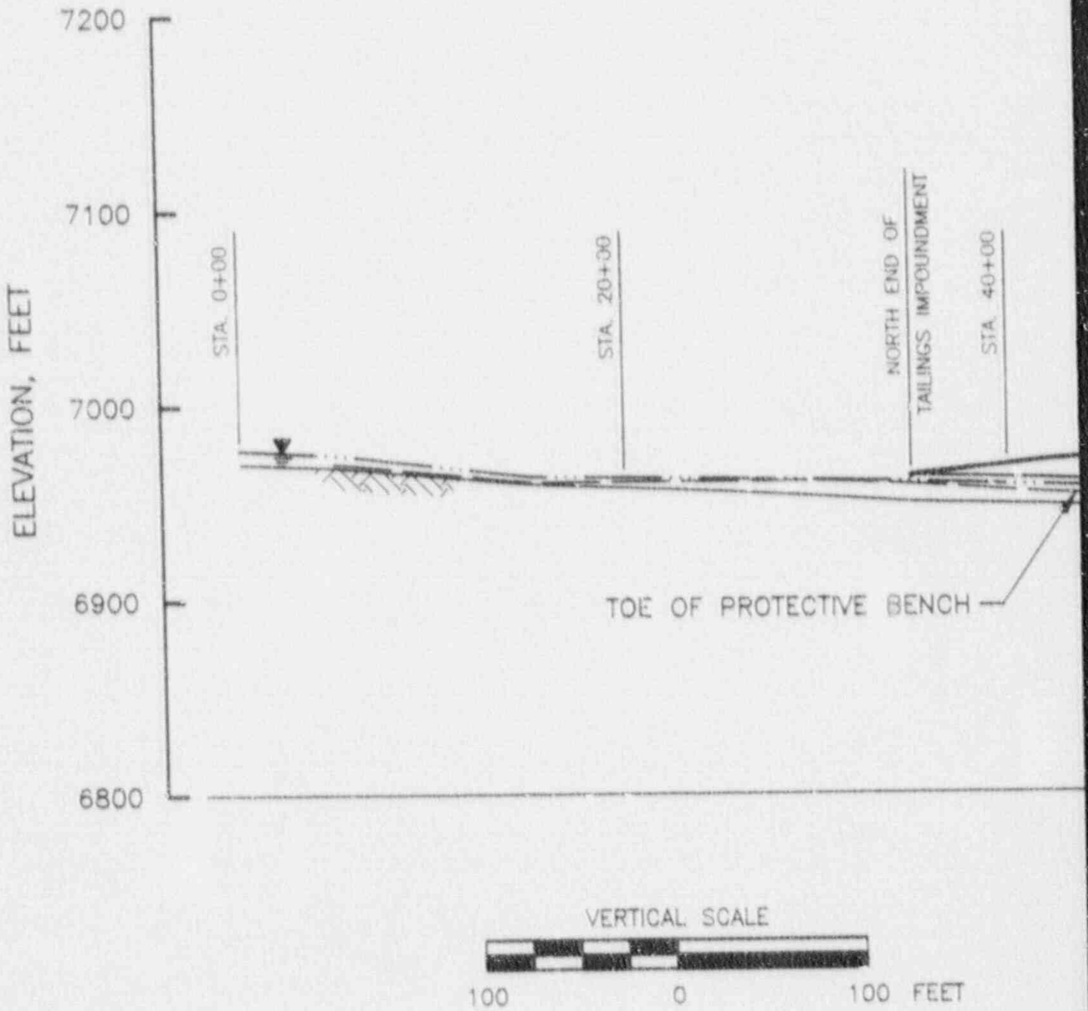
9101030201-01

DRAWING NUMBER 86-060-E427
N
SHAFT
ARR
LOW FL
RUNOFF CONT
(SEE FIGURE 2-6
APPROXIMATE LIMITS OF TAILINGS AFTER GRADING
PROTECTIVE BENCH
RECLAIMED MILL AREA
SECTION CORNER
STA. 41+95
STA 40+00
7000
6995
6990
MATCH LINE TO
REGRADED CATCH BASIN AREA
STA 45+00
6985
6970
6950
6945
REFERENCE
- TOPOGRAPHIC MAP PROVIDED BY UNITED NUCLEAR CORPORATION
ISSUED FOR RESPONSE TO COMMENTS AND PROPOSED RECLAMATION PLAN MODIFICATIONS
P.M.W.
No.
DATE
ISSUE / REVISION
DWN. BY
CK'D BY
AP'D BY



9101030201-02

DRAWING NUMBER 86-060-B420

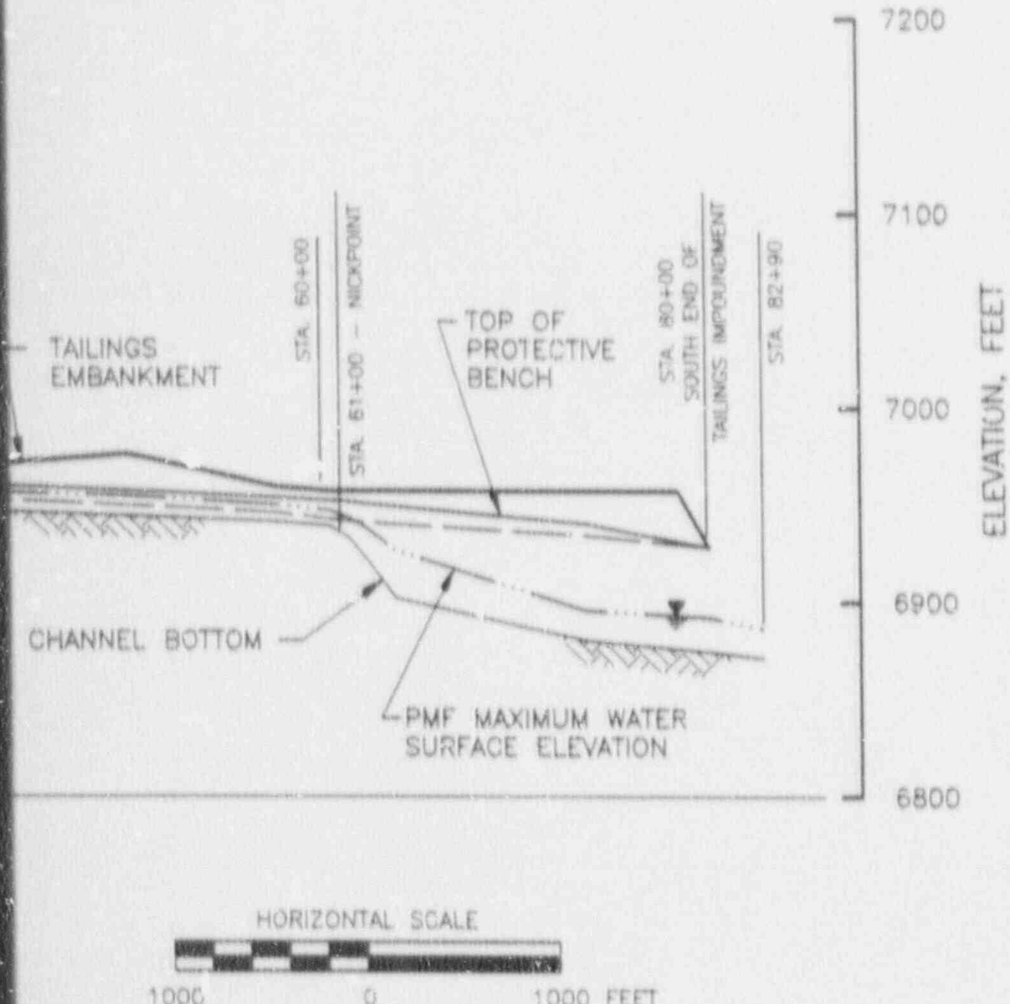


VERTICAL EXAGGER

NOTE:

1. ALIGN
IS SH
AND

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
△	12-4-90	ISSUED FOR RESPONSE TO COMMENTS AND PROPOSED RECLAMATION PLAN MODIFICATIONS	R.H.	mgg	DHG



ATION = 10X

MENT OF PIPELINE ARROYO
OWN ON FIGURES 2-2
2-3.

SI APERTURE CARD

Also Available On Aperture Card

PIPELINE ARROYO PROFILE

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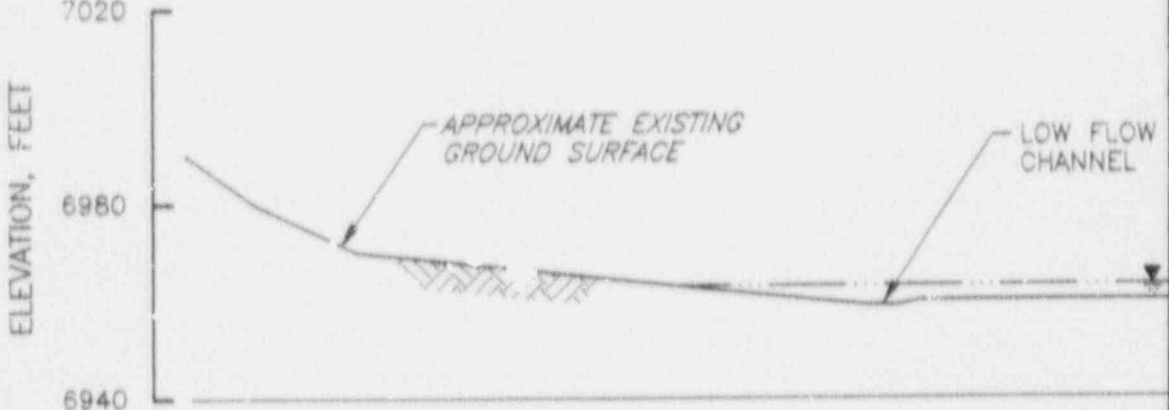
DATE: 11-9-90	FIGURE 2-4	DRAWING NUMBER 86-060-B420
SCALE: AS SHOWN		

9101030201-03

1

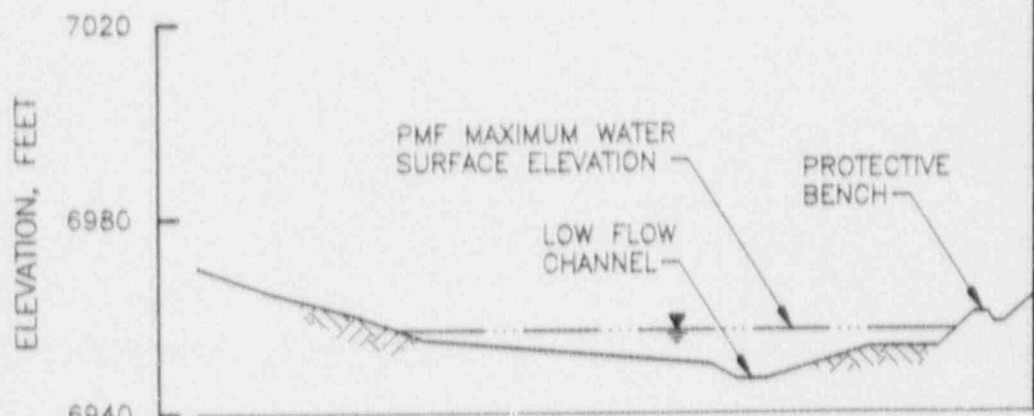
DRAWING NUMBER 86-060-B424



PIPELINE ARROYO CROSS S

STATION 15+05

(LOOKING NORTH)

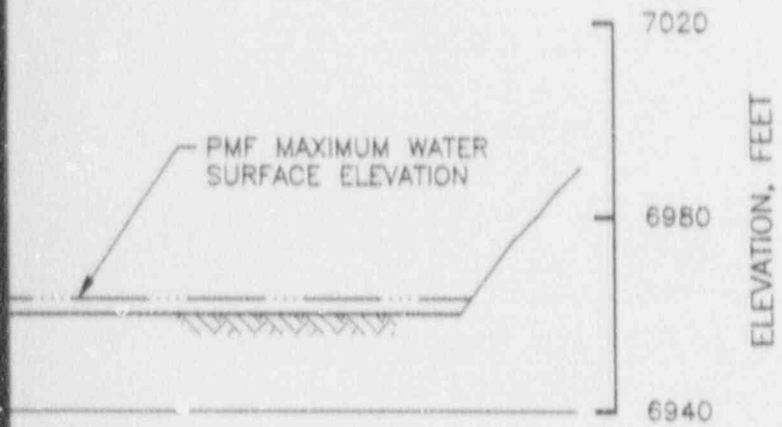


PIPELINE ARROYO CROSS S

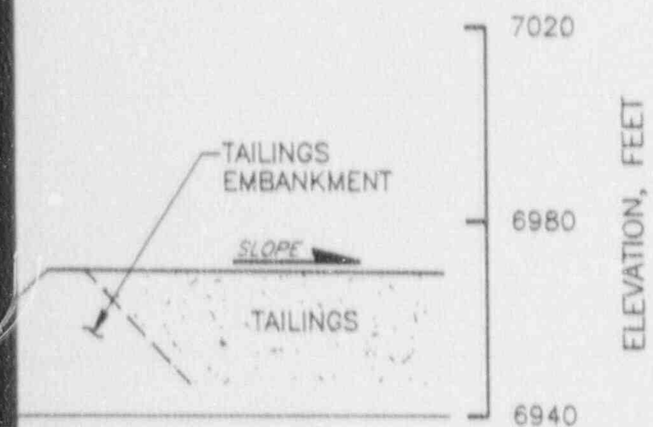
STATION 41+95

(LOOKING NORTH)

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	12-4-90	ISSUED FOR RESPONSE TO COMMENTS AND PROPOSED RECLAMATION PLAN MODIFICATIONS	R..		DHG



ECTION



ECTION

NOTE:

1. CROSS SECTION LOCATIONS ARE SHOWN ON FIGURES 2-2 AND 2-3.

SI
APERTURE
CARD

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VERTICAL SCALE

40 0 40 FEET

HORIZONTAL SCALE

200 0 200 FEET

VERTICAL EXAGGERATION = 5X

PIPELINE ARROYO
CROSS SECTIONS

PREPARED FOR

UNC MINING AND MILLING
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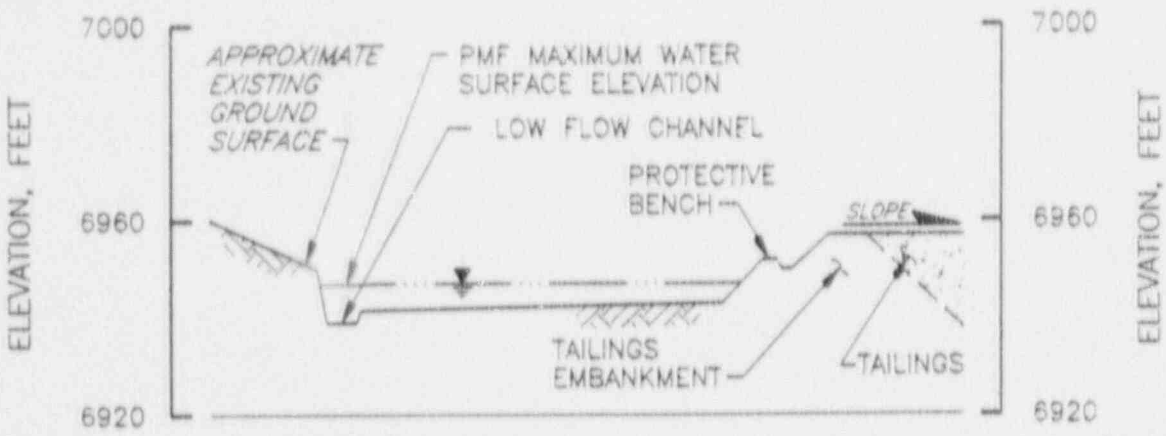
DATE: 11-12-90	FIGURE 2-5	DRAWING NUMBER
SCALE: AS SHOWN		86-060-B424

9101030201-04

1

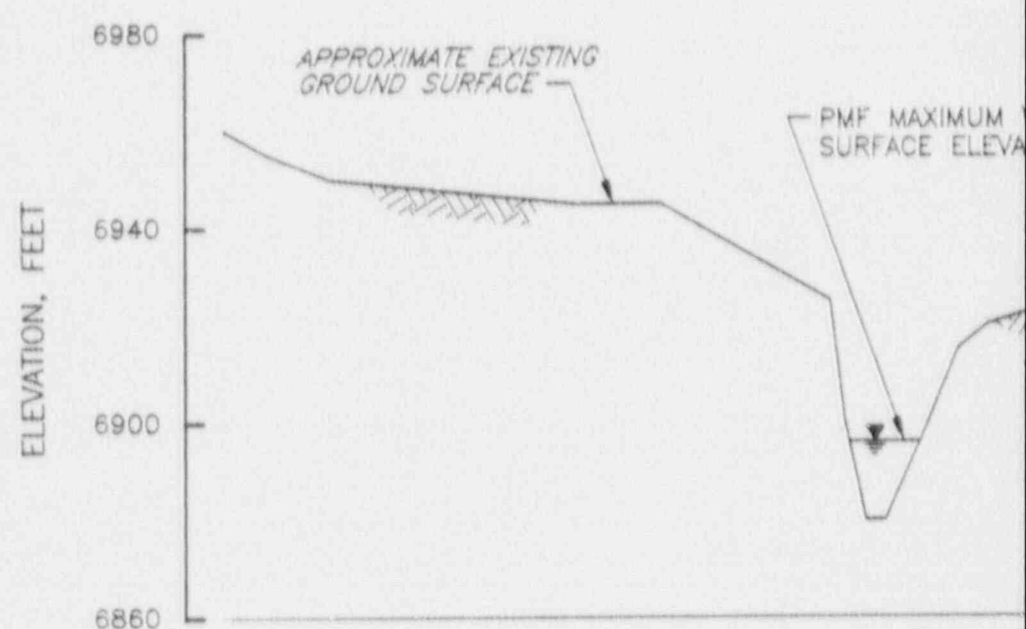
DRAWING NUMBER 86-060-B421



PIPELINE ARROYO CROSS SECTION

STATION 60+40

(LOOKING NORTH)

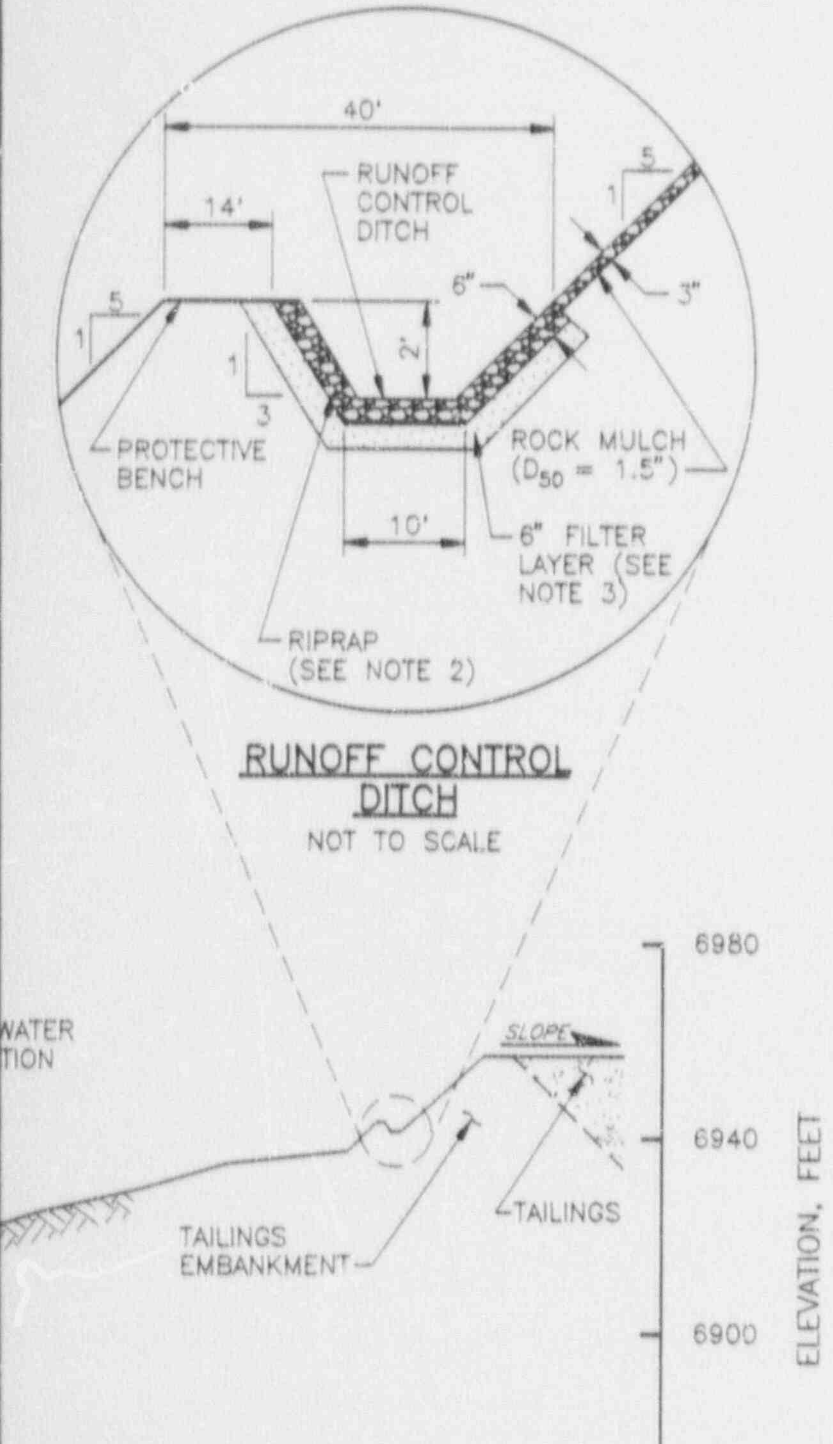


PIPELINE ARROYO CROS

STATION 73+8

(LOOKING NORTH)

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
1	12-4-90	ISSUED FOR RESPONSE TO COMMENTS AND PROPOSED RECLAMATION PLAN MODIFICATIONS	R.H.	mjy	DHG

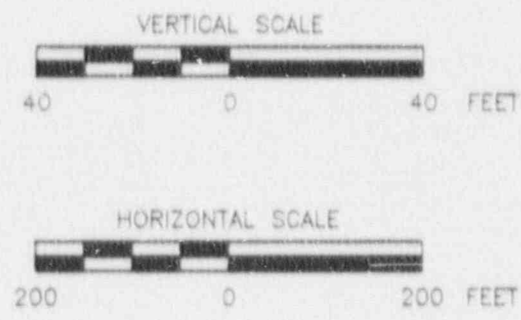


RUNOFF CONTROL DITCH
NOT TO SCALE

SS SECTION

NOTE:

1. CROSS SECTION LOCATIONS ARE SHOWN ON FIGURES 2-2 AND 2-3.
2. RIPRAP D_{50} = 1.5" IN UPPER REACH OF RUNOFF CONTROL DITCH. D_{50} = 3.0" IN LOWER REACH OF RUNOFF CONTROL DITCH.
3. FILTER LAYER REQUIRED ONLY FOR LOWER REACH OF RUNOFF CONTROL DITCH.



VERTICAL EXAGGERATION = 5X

PIPELINE ARROYO
CROSS SECTIONS
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GALLUP, NEW MEXICO
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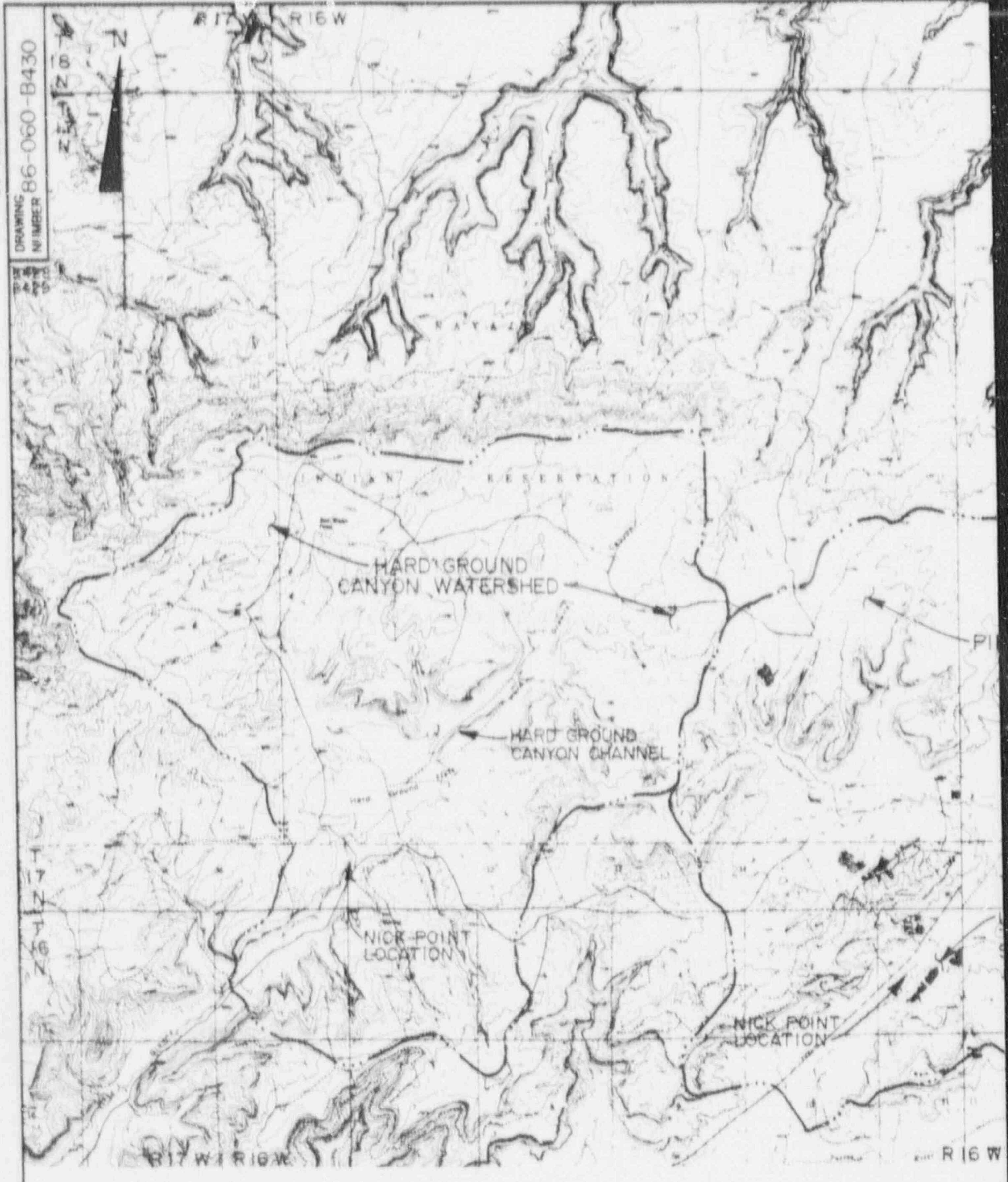
DATE: 11-12-90	FIGURE 2-6	DRAWING NUMBER 86-060-B421
SCALE: AS SHOWN		

9101030201-05

DRAWING NUMBER 86-060-B430

86-060-B429
86-060-B428



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△	12-3-90	ISSUED FOR RESPONCE TO COMMENTS AND PROPOSED RECLAMATION PLAN MODIFICATIONS	M.T.H.		

REFERENCE:

COMPOSITE OF 7.5' USGS TOPOGRAPHIC QUADRANGLE MAPS OF HARD GROUND FLATS AND OAK SPRING, NEW MEXICO.
SCALE: 1" = 2000' DATED: 1963 PHOTOREVISED: 1979.

SCALE

5000 0 5000 FEET

PIPELINE ARROYO AND HARD GROUND CANYON WATERSHEDS

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GALLUP, NEW MEXICO

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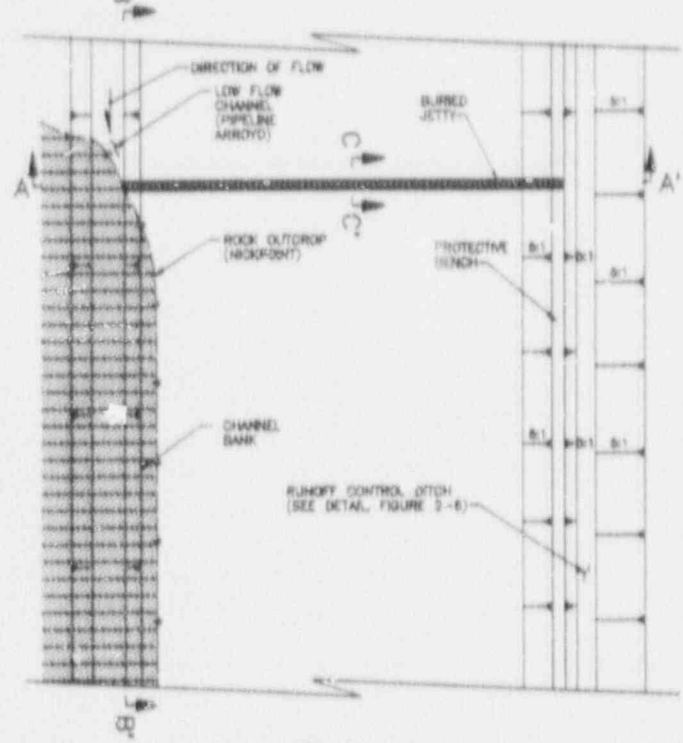
DATE: 11-14-90	FIGURE 2-7	DRAWING NUMBER
SCALE: AS SHOWN		86-060-B430

86-060-B428

86-060-B429

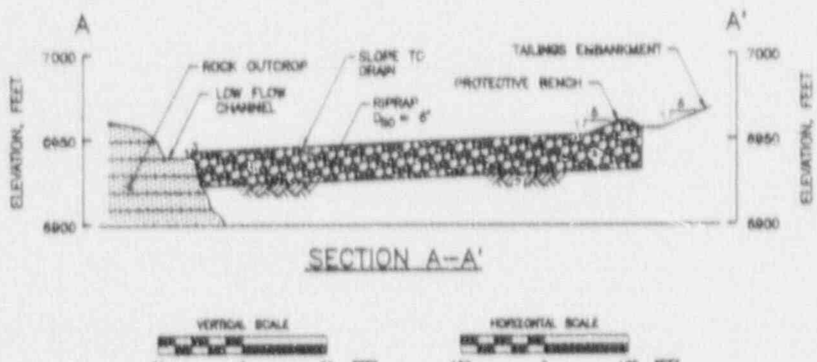
9101030201-06

DRAWING NUMBER 86-060-E419



PLAN

SCALE 100 0 100 FEET



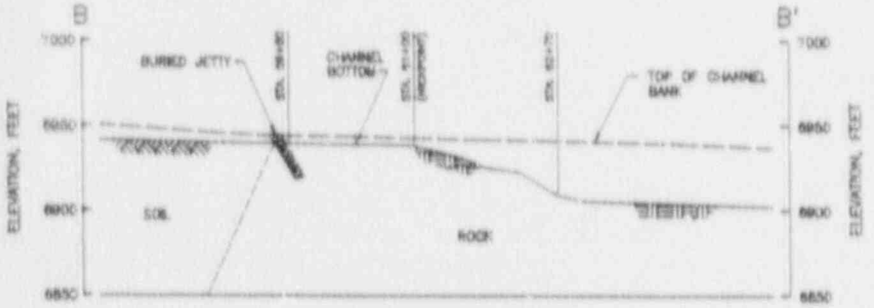
SECTION A-A'

VERTICAL SCALE 50 0 50 FEET

HORIZONTAL SCALE 100 0 100 FEET

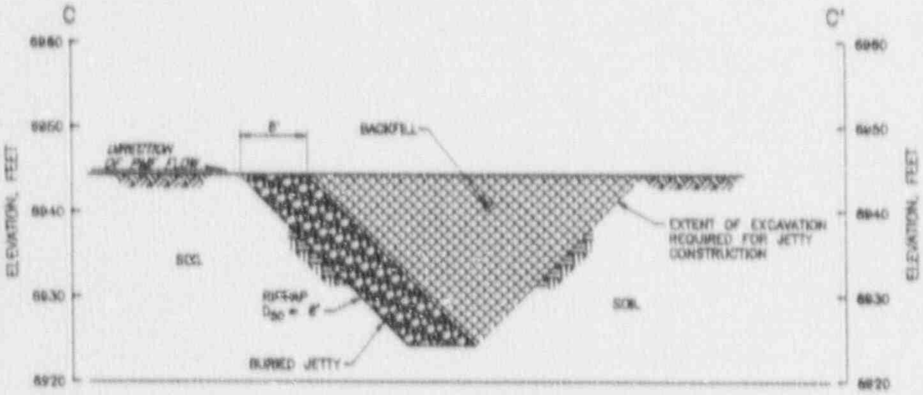
VERTICAL EXAGGERATION = 2X

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	APP'D BY
1	12/21/90	ISSUED FOR RESPONSE TO COMMENTS AND PROPOSED RECLAMATION PLAN MODIFICATIONS	F.N.W.	[illegible]	[illegible]



SECTION B–B'
NICKPOINT REINFORCEMENT

VERTICAL EXAGGERATION = 2X



SECTION C–C'

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BURIED JETTY DETAILS
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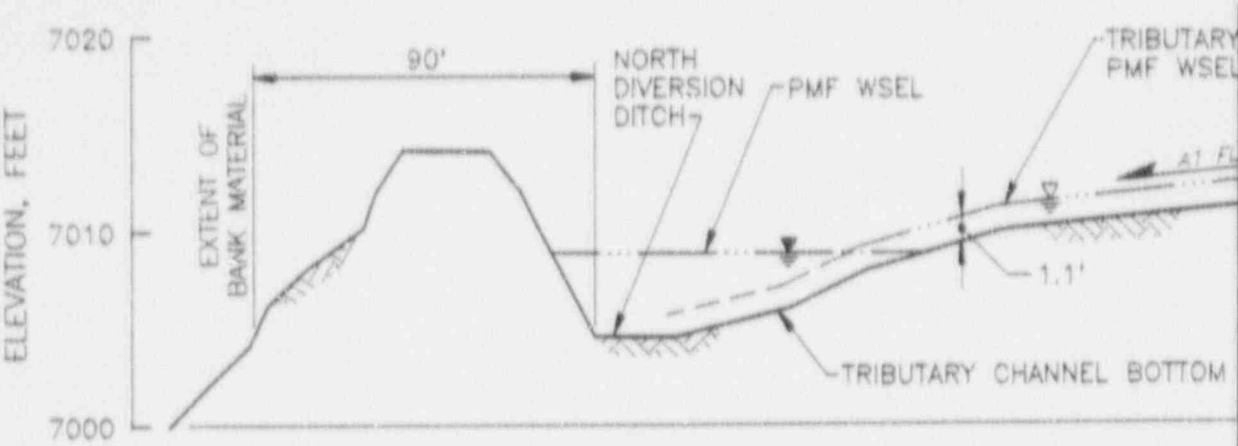
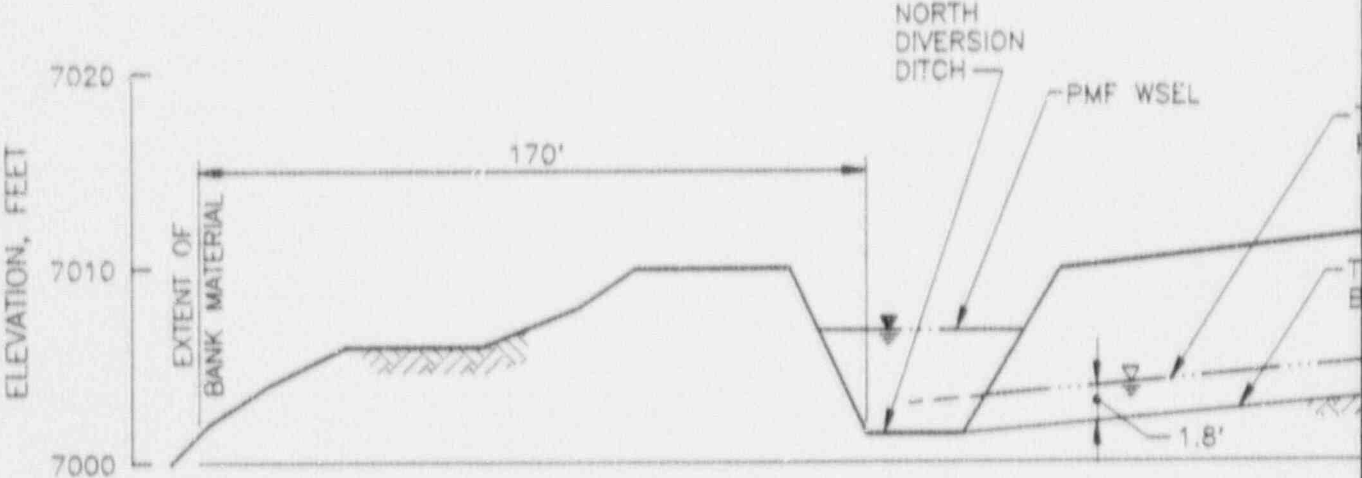
DATE:	11-15-90	FIGURE 2-8	DRAWING NUMBER	
SCALE:	AS SHOWN		88-080-E419	△

9101030201-07

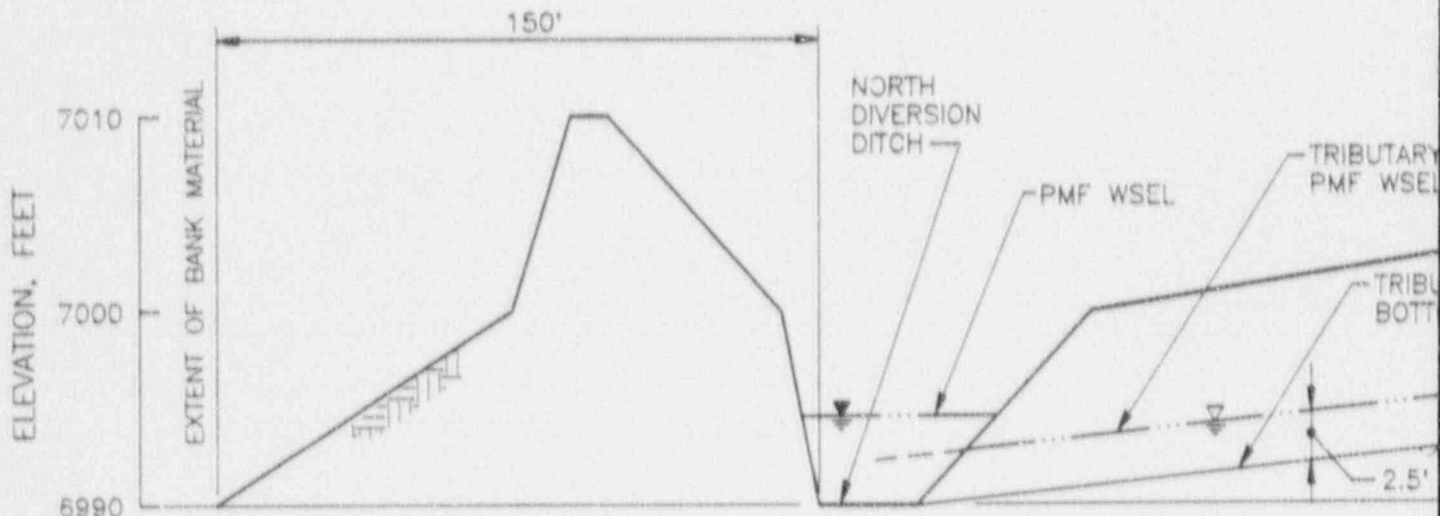
DRAWING NUMBER 86-060-B423



CONFLUENCE A1



CONFLUENCE A2



CONFLUENCE B

No.	DATE	ISSUE / REVISION	DWN. BY	CK'D BY	AP'D BY
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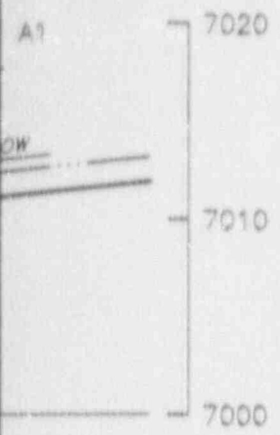
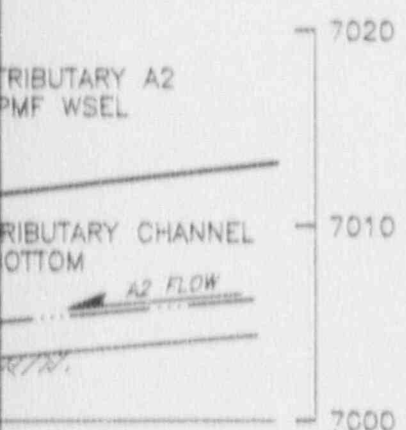
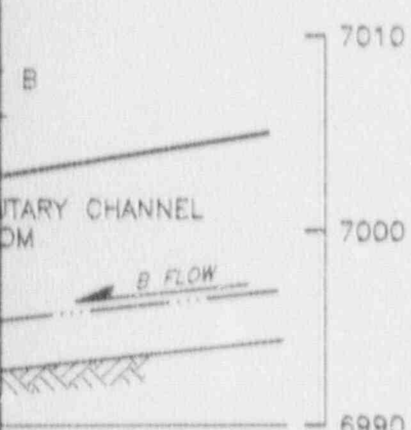
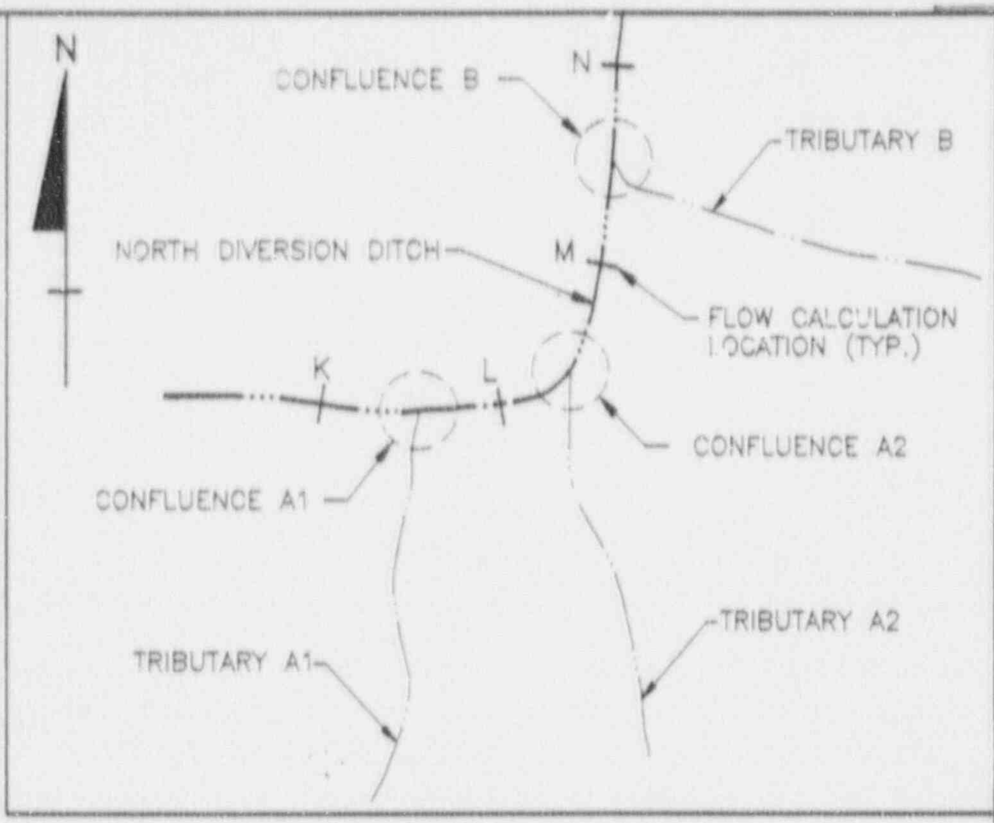








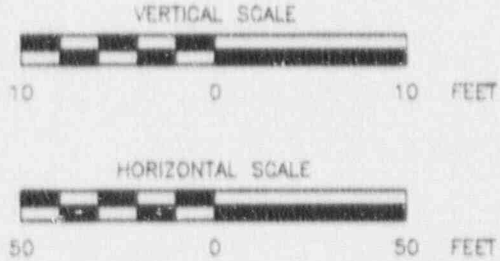
SCHEMATIC OF TRIBUTARY CONFLUENCES
(NOT TO SCALE)

LEGEND:

PMF	PROBABLE MAXIMUM FLOOD
WSEL	WATER SURFACE ELEVATION

NOTE:

1. ACTUAL TRIBUTARY LOCATIONS ARE SHOWN ON FIGURE 2-2.



VERTICAL EXAGGERATION = 5x

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NORTH DIVERSION DITCH
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DATE: 11-12-90 SCALE: AS SHOWN	FIGURE 2-9	DRAWING NUMBER 86-060-B423

9101030201-08

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Vol II of II
40-8907

Project 86-060-24
December 1990

CanonieEnvironmental

Volume II - Appendices

Response to Comments and Proposed Reclamation Plan Modifications

Church Rock Site
Gallup, New Mexico

Prepared For:

United Nuclear Corporation
Gallup, New Mexico

Addl Info
91-0125

40-8907

Volume II - Appendices

Response to Comments and Proposed Reclamation Plan Modifications

w/ltr 12/4/90
91-0125

Canonie Environmental

APPENDIX A

IMPOUNDMENT TOP EROSIONAL STABILITY

HYDRAULIC ANALYSES FOR SWALES

CanonieEnvironmental

By- ______ Date ______ Subject ______ Sheet No. 1 of 23

Chkd. By ______ Date ______ Proj. No. ______

1/4 X 1/4

PURPOSE: TO DETERMINE THE SWALE DESIGN(S) FOR THE RECLAIMED URANIUM TAILINGS IMPOUNDMENT AT THE LYNC SITE

METHODS:

1) DIVIDE IMPOUNDMENT TOP INTO DRAINAGE AREAS BASED ON SWALE LOCATIONS AND DETERMINE FOR EACH AREA:
   - A) AREA
   - B) MAX. FLOW LENGTH
   - C) MAX ELEVATION DIFFERENCE
   - D) TIME OF CONCENTRATION

2) INPUTTING THE PROBABLE MAXIMUM PRECIPITATION EVENT AND CURVE NUMBER PREVIOUSLY DETERMINED FOR THE SITE, DETERMINE THE PMF STORM HYDROGRAPH USING THE SCS TR-55 METHOD FOR A TYPE II STORM DISTRIBUTION

RESULTS: SEE TABLE NEXT PAGE FOR DETAILS

CanonieEnvironmental

By mjz Date 11/14/90 Subject UMC - IMPOUNDMENT TOP Sheet No. 2 of 23
Chkd. By DS Date 12-03-90 SWALE DESIGN Proj. No. 86-060-24
1/4 X 1/4

IMPOUNDMENT TOP DRAINAGE SWALE CHARACTERISTICS
SIDE SLOPES 3H:1V

CHANNEL REACH	LENGTH (ft)	SLOPE (ft/ft)	BOTTOM WIDTH (ft)	Q (cfs)	DEPTH OF FLOW (ft)	RIPRAP D_{50} (in)	
A	2600	0.0038	10	40	0.98	0.7	USE 1.5
B	3600	0.0083	20	97	0.97	1.5	
C	3400	0.0050	10	75	1.38	1.5	
D	3200	0.0028	10	68	1.43	0.7	= USE 1.5"
E	1350	0.0037	10	85	1.53	0.9	USE 1.5"
F	1600	0.0031	10	126	2.00	1.0	USE 1.5"
G	1400	0.0021	10	99	1.88	0.7	USE 1.5"
H	2,550	0.0085	20	284	1.90	3.0	
I	550	0.0040	20	385	2.65	1.8	
J	1900	0.0042	10	101	1.66	1.2	USE 1.5"

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By MJG Date 11/10/90 Subject UNC · Impoundment Top Sheet No. 3 of 23

Chkd. By GS Date 12-03-90 SWALE DESIGN Proj. No. 86-060-?

1/4" X 1/4"

CHANNEL SLOPE DETERMINATIONS

CHANNEL	ΔEL	LENGTH	SLOPE
SWALE A	7005 - 6995 (10)	2600 ✓	0.0038
B	7003 - 6973 (30)	3600 ✓	0.0083
C	6995 - 6978 (17)	3400 ✓	0.0050
D	6989 - 6980 (9)	3200 ✓	0.0028
E	6982 - 6977 (5)	1350 ✓	0.0037
F	6973 - 6968 (5)	1600 ✓	0.0031
G	6966 - 6963 (3)	1400	0.0021
H	6977 - 6955 (22)	2600	0.0085
J	6963 - 6955 (8)	1900 ✓	0.0042
I	6955 - 6953 2ft	500'	0.004

CanonieEnvironmental

By KWJ7? Date 11/10/90 Subject UNC - IMPOUNDMENT TOP Sheet No. 4 of 23
Chkd. By GJ Date 12-03-90 SWALE DESIGN Proj. No. [illegible]
1/4" X 1/4"

CALCULATIONS: MEASURE THE FOLLOWING FROM PLAN TOPO MAP

FOR AREA AND DRAINAGE SWALE A

DRAINAGE AREA: 231880 ft² = 5.3 AC.
MAX OVERLAND FLOW LENGTH 200 ft
MAX CHANNEL FLOW LENGTH 2600 ft
MAX ELEV DIFF (7005 - 6995) 10 ft

DETERMINE 1ST CUT TIME OF CONCENTRATION BY ADDING OVERLAND FLOW TIME AND CHANNEL FLOW TIME. ASSUME $V_{overland} = 1$ ft/sec & $V_{channel} = 5$ ft/sec. (Check this assumption later)

$t_c = 200\text{ ft}/(1\text{ ft/sec}) + 2600\text{ ft}/(5\text{ ft/sec}) = 720\text{ sec}$
$= 0.2$ hrs

FOR AREA AND DRAINAGE SWALE B

DRAINAGE AREA: 562961 = 12.9 AC
MAX OVERLAND FLOW LENGTH: 540 ft
MAX CHANNEL FLOW LENGTH: 3600 ft
MAX ELEV DIFF 7003 - 6936 35 ft

First cut $t_c = 540/1 + 3600/5 = 1,260$ sec
$= 0.35$ hrs $\rightarrow 0.3$ hrs

THE 540' overland flow length is at the downstream end of the swale (near end of swale). Max upstream overland flow length is 120 ft. If 120 ft is used a more conservative $t_c = 0.23 \Rightarrow 0.2$ is obtained.
Use $0.2 = t_c$

CanonieEnvironmental

By [illegible] Date [illegible] Subject [illegible] Sheet No 5 of 23
Chkd. By GS Date 12-03-90 [illegible] Proj. No 86-060-24
1/4 X 1/4

FOR AREA AND DRAINAGE SWALE C

DRAINAGE AREA:	430281 = 9.9 AC
MAX OVERLAND FLOW LENGTH	200 ft
MAX CHANNEL FLOW LENGTH:	3400 ft
MAX ELEV DIFF: 6995 - [illegible]	[illegible] ft

First cut $t_c = 200/1 + 3400/5 = 880$ sec
$= 0.24$ hrs → 0.2 hrs

FOR AREA AND DRAINAGE SWALE D

DRAINAGE AREA:	462521 ft² = 10.6 AC
MAX OVERLAND FLOW LENGTH:	260 ft
MAX CHANNEL FLOW LENGTH	3200 ft
MAX ELEV DIFF 6994 - 6985	9 ft

First cut $t_c = 260/1 + 3200/5 = 900$ sec
$= 0.25$ hrs → 0.3 hrs

FOR AREA AND DRAINAGE SWALE E

DRAINAGE AREA:	580321 ft² = 13.3 AC.
MAX OVERLAND FLOW LENGTH:	750 ft
MAX CHANNEL FLOW LENGTH:	1350 ft
MAX ELEV DIFF: (6982 - 6977)	5 ft

First cut $t_c = 750/1 + 1350/5 = 1020$ sec
$= 0.28$ hrs → 0.3 hrs

CanonieEnvironmental

By mjj Date 11/10/90 Subject UNC - IMPOUNDMENT TOP Sheet No. 6 of 23
Chkd. By GS Date 12.03.90 SWALE DESIGN Proj. No. 86-060-24
1/4 X 1/4

FOR AREA AND DRAINAGE SWALE F

DRAINAGE AREA:	729121 ft²	= 16.7 AC
MAX OVERLAND FLOW LENGTH		500 ft
MAX CHANNEL FLOW LENGTH		1600 ft
MAX ELEV DIFF:	6973 - 6968	5 ft

First cut t_c = 500/1 + 1600/5 = 820 sec
= 0.23 hrs → 0.2 hrs

FOR AREA AND DRAINAGE SWALE G

DRAINAGE AREA	570401 ft² =	13.1 AC
MAX OVERLAND FLOW LENGTH:		500 ft
MAX CHANNEL FLOW LENGTH:		1400 ft
MAX ELEV. DIFF:	6966 - 6963	3 ft

First cut t_c = 500/1 + 1400/5 = 780 sec
= 0.22 hrs → 0.2 hrs

FOR AREA AND DRAINAGE SWALE H & I

DRAINAGE AREA:	2,481,864 ft²	57.0 ac.
MAX OVERLAND FLOW LENGTH:		1300 ft
MAX CHANNEL FLOW LENGTH:		3100 ft
MAX ELEV. DIFF:	(6953 - 6977)	24 ft

First cut t_c = 1300 ft/1 + 3100 ft/5 = 1920 sec
= 0.53 hrs → 0.5 hrs

CanonieEnvironmental

By MJJ Date 11/10/90 Subject UNC - IMPOUNDMENT TOP SWALE DESIGN Sheet No. 7 of 23

Chkd. By GS Date 12-03-90 Proj. No. 86-060-24

1/4 X 1/4

FOR AREA AND DRAINAGE SWALE J

DRAINAGE AREA	689,441 ft²	= 15.8 Ac
MAX OVERLAND FLOW LENGTH		800 ft
MAX CHANNEL FLOW LENGTH		1900 ft
MAX ELEV DIFF. 1963-55		8 ft

First cut $t_c = 800/1 + 1900/5 = 1180$ sec

$= 0.33$ hrs $\rightarrow 0.3$ hrs

CanonieEnvironmental

By MJM Date 11/10/90 Subject UNC - IMPOUNDMENT TOP Sheet No. 8 of 23

Chkd. By GS Date 12-05-90 SWALE DESIGN Proj. No. 86-060-24

1/4 X 1/4

DETERMINE CURVE NO.

A CN OF 79 WAS DETERMINED BY FAITH AND PROVIDERS IN ITS 1981 REPORT TO UNC ENTITLED "DESIGN FLOOD ANALYSIS: NORTH CELL TAILINGS EMBANKMENT." FAITH USED AN AREA-WEIGHTED DETERMINATION USING THE NAMES, COVER TYPES, HYDROLOGIC SOIL GROUPS, CN, AND AREA OF EACH OF FIVE SOIL ASSOCIATIONS FOUND IN PIPELINE ARROYO.

SCIENCE APPLICATION, INC. DETERMINED A CN OF 80 FOR THE AREA DRAINING TO THE N. & S. DIVERSION DITCHES IN ITS JUNE 1981 REPORT ENTITLED "PMF DETERMINATION FOR THE SOUTHEAST DIVERSION CHANNEL AND SECTION 1 WATERSHED USING SCS HYDROLOGICAL TECHNIQUES." (REF: RESPONSE TO NRC COMMENTS, MAY 23, 88E)

USE CN = 80

DETERMINE PMP EVENT

PMP HAS BEEN DETERMINED TO BE 9.4 IN HOWEVER A CORRECTION MUST BE MADE FOR THE HIGH ELEVATION OF THE SITE. (MEAN BASIN ELEVATION CORRECTION)

THE CORRECTION FACTOR IS - 5% FOR EVERY 1000 FT OF ELEVATION IN EXCESS OF 5000 ft. CONSERVATIVELY CHOOSE MEAN BASIN ELEVATION OF 7000 FT.

PMP = 8.43 inches

DETERMINE HYDROGRAPH BY TR-55 METHOD

CanonieEnvironmental

By MJJ Date 11/16/90 Subject UNC - IMPOUNDMENT TOP Sheet No. 9 of 23
Chkd. By GS Date 12-03-90 SWALE DESIGN Proj. No. 86-060-24
1/4 X 1/4

DETERMINE CHANNEL AND RIPRAP DESIGN

USE PEAK FLOWS RESULTING FROM PMF AS DETERMINED BY SCS TR-55 HYDROGRAPH

INPUT PEAK FLOW RATES, (ASSUMED) CHANNEL SLOPES & BOTTOM WIDTHS, AND SIDE SLOPES TO CALCULATE CHANNEL DIMENSIONS AND RIPRAP SIZES BY SAFETY FACTOR METHOD. USE SPREADSHEET "RIPSF.WR1."

TRY TO KEEP ROCK SIZES AS UNIFORM AS POSSIBLE.

Tc = 0.2 RUNOFF HYDROGRAPHS BY THE SCS TR-55 METHOD

TYPE-II STORM DISTRIBUTION

TIME OF CONCENTRATION = 0.2 HOURS
TRAVEL TIME = 0 HOURS

10-Nov-90
02:24 PM

HYDROGRAPH TIME IN HOURS

WATERSHED DESIGNATION	DRAINAGE AREA (AC)	DRAINAGE AREA (SQ MI)	CURVE NUMBER	PPT AMT (IN)	RUNOFF (IN)	(TIME) (CSM/IN)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6
							23	31	47	209	403	739	800	481	250	166	128	102	86	70	61	54	49	44	40	35	33
AREA A UNC	5.3	8.28E-03	80.0	8.43	6.03	(CFS)	1	2	2	10	20	37	40	24	12	8	6	5	4	3	3	3	2	2	2	2	2
AREA B UNC	12.9	2.02E-02	80.0	8.43	6.03	(CFS)	3	4	6	25	49	90	97	58	30	20	16	12	10	9	7	7	6	5	5	4	4
AREA C UNC	9.9	1.55E-02	80.0	8.43	6.03	(CFS)	2	3	4	19	38	69	75	45	23	15	12	10	8	7	6	5	5	4	4	3	3
AREA F UNC	16.7	2.61E-02	80.0	8.43	6.03	(CFS)	4	5	7	33	63	116	126	76	39	26	20	16	14	11	10	8	8	7	6	6	5
AREA G UNC	13.1	2.05E-02	80.0	8.43	6.03	(CFS)	3	4	6	26	50	91	99	59	31	20	16	13	11	9	8	7	6	5	5	4	4

5.133

Tc = 0.5 RUNOFF HYDROGRAPHS BY THE SCS TR-55 METHOD

TYPE-II STORM DISTRIBUTION

TIME OF CONCENTRATION = 0.5 HOURS
TRAVEL TIME = 0 HOURS

10-Nov-90
02:24 PM

HYDROGRAPH TIME IN HOURS

WATERSHED DESIGNATION	DRAINAGE AREA (AC)	DRAINAGE AREA (SQ MI)	CURVE NUMBER	PPT AMT (IN)	RUNOFF (IN)	(TIME) (CSM/IN)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6
							17	23	32	57	94	170	308	467	529	507	402	297	226	140	96	74	61	53	47	41	36
W/ t AREA 0&3 UNC	57.0	8.91E-02	80.0	8.43	6.03	(CFS)	9	12	17	31	50	91	165	251	284	272	236	159	121	75	52	40	33	28	25	22	19

Tc = 0.3 RUNOFF HYDROGRAPHS BY THE SCS TR-55 METHOD

TYPE II STORM DISTRIBUTION

TIME OF CONCENTRATION = 0.3 HOURS
TRAVEL TIME = 0 HOURS

10-Nov-90

10/23
86-060-24

12-07-90

WATERSHED DESIGNATION	DRAINAGE AREA (AC)	DRAINAGE AREA (SQ MI)	CURVE NUMBER	PPT AMT (IN)	RUNOFF (IN)	(TIME)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6
						(CSM/IN)	20	28	41	118	235	447	676	676	459	283	196	146	114	80	65	57	51	46	42	37	33
AREA D UNC	10.6	1.66E-02	80.0	8.43	6.03	(CFS)	2	3	4	12	23	45	[illegible]	68	46	28	20	15	11	8	7	6	5	5	4	4	3
AREA E UNC	13.3	2.08E-02	80.0	8.43	6.03	(CFS)	3	4	5	15	29	56	85	85	56	35	25	18	14	10	8	7	6	6	5	5	4
AREA [illegible] UNC	15.8	2.47E-02	80.0	8.43	6.03	(CFS)	3	4	6	18	35	67	101	101	68	42	29	22	17	12	10	8	8	7	6	6	5
AREA G-3 UNC	13.6	2.12E-02	80.0	8.43	[illegible]	(CFS)	3	4	5	15	30	57	87	87	59	36	25	19	15	10	8	7	7	6	5	5	4

11/23
86-060-21

12/23

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

(init.) 12.03.90

LOCATION: UNC -- DRAINAGE SWALE A

DISCHARGE =	40 CFS			
BOTTOM WIDTH =	10 FT			
Z (SIDE SLOPE)=	3		Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.0038		Theta =	0.22 Degrees
RIPRAP S.G. =	2.5		Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.			

CHANNEL BOTTOM				CHANNEL SIDE SLOPES		
D50 (ASSUM) =	0.06 FT	0.7 inches		D50 (ASSUM) =	0.06 FT	0.7 inches
n =	0.025			n =	0.025	
* TRIAL d =	1.00 ft	******				
DIFFERENCE =	3.49 %					
* calc d =	0.98 ft	******				
DIFFERENCE =	0.28 %					
* calc d =	0.98 ft	******				
DIFFERENCE =	0.03 %					
* calc d =	0.98 ft	******				
DIFFERENCE =	0.00 %					
FINAL d =	0.98 ft					
A =	12.70 sq ft					
R =	0.78 ft			t =	0.17 PSF	
t =	15.89 ft			nb =	0.65	
V =	3.15 fps					
Q(calc) =	40 cfs			Beta =	37.78	
t =	0.23 PSF					
nb =	0.878			n' =	0.53	
SFb =	1.14			SFs =	1.10	

13/23

CAS ✓
12-03-90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology
for Disturbed Areas", pages 185-194

LOCATION: UNC -- DRAINAGE SWALE B

DISCHARGE =	97 CFS		
BOTTOM WIDTH =	20 FT		
Z (SIDE SLOPE)=	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.0083	Theta =	0.48 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM			CHANNEL SIDE SLOPES	
D50 (ASSUM) =	0.13 FT	1.5 inches	D50 (ASSUM) =	0.13 FT 1.5 inches
n =	0.028		n =	0.028
* TRIAL d =	0.97 ft	******		
DIFFERENCE =	-0.33 %			
* calc d =	0.97 ft	******		
DIFFERENCE =	-0.05 %			
* calc d =	0.97 ft	******		
DIFFERENCE =	-0.01 %			
* calc d =	0.97 ft	******		
DIFFERENCE =	-0.00 %			
FINAL d =	0.97 ft			
A =	22.27 sq ft			
R =	0.85 ft		t =	0.38 PSF
t =	25.83 ft		nb =	0.68
V =	4.36 fps			
Q(calc) =	97 cfs		Beta =	30.73
t =	0.50 PSF			
nb =	0.903		n' =	0.55
SFb =	1.09		SFs =	1.00

14/23

(a)
12-03-90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: UNC -- DRAINAGE SWALE C

DISCHARGE =	75 CFS		
BOTTOM WIDTH	10 FT		
Z (SIDE SLOPE)=	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	[redacted] 0.005	Theta =	0.29 Degrees
RIPRAP S.G. =	2.5	Phi =	7.90 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM				CHANNEL SIDE SLOPES		
D50 (ASSUM) =	0.13 FT	1.5 inches		D50 (ASSUM) =	0.13 FT	1.5 inches
n =	0.028			n =	0.028	
* TRIAL d =	1.40 ft	******				
DIFFERENCE =	3.30 %					
* calc d =	1.38 ft	******				
DIFFERENCE =	0.18 %					
* calc d =	1.38 ft	******				
DIFFERENCE =	0.01 %					
* calc d =	1.38 ft	******				
DIFFERENCE =	0.00 %					
FINAL d =	1.38 ft					
A =	19.43 sq ft					
R =	1.04 ft			t =	0.32 PSF	
t =	18.25 ft			nb =	0.58	
V =	3.86 fps					
Q(calc) =	75 cfs			Beta =	34.45	
t =	0.43 PSF					
nb =	0.770			n' =	0.45	
SFb =	1.29			SFs =	1.19	

15/23

GS
12-03-90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: UNC -- DRAINAGE SWALE D

DISCHARGE =	68 CFS		
BOTTOM WIDTH =	10 FT		
Z (SIDE SLOPE) =	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.0023	Theta =	0.16 Degrees
RIPRAP S.G. =	2.6	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM			CHANNEL SIDE SLOPES	
D50 (ASSUM) =	0.06 FT	0.7 inches	D50 (ASSUM) =	0.06 FT 0.7 inches
n =	0.025		n =	0.025
* TRIAL d =	1.50 ft	******		
DIFFERENCE =	9.50 %			
* calc d =	1.43 ft	******		
DIFFERENCE =	0.05 %			
* calc d =	1.43 ft	******		
DIFFERENCE =	0.00 %			
* calc d =	1.43 ft	******		
DIFFERENCE =	0.00 %			
FINAL d =	1.43 ft			
A =	20.40 sq ft			
R =	1.07 ft		t =	0.19 PSF
t =	18.57 ft		nb =	0.70
V =	3.33 fps			
Q(calc) =	68 cfs		Beta =	39.76
t =	0.25 PSF			
nb =	0.933		n' =	0.57
SFb =	1.07		SFs =	1.06

16/23

GJ
12-03-90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: UNC -- DRAINAGE SWALE E

DISCHARGE =	85 CFS		
BOTTOM WIDTH =	10 FT		
Z (SIDE SLOPE)=	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.0037	Theta =	0.21 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM			CHANNEL SIDE SLOPES		
D50 (ASSUM) =	0.08 FT	0.9 inches	D50 (ASSUM) =	0.08 FT	0.9 inches
n =	0.026		n =	0.026	
* TRIAL d =	1.50 ft	******			
DIFFERENCE =	-4.02 %				
* calc d =	1.53 ft	******			
DIFFERENCE =	-0.40 %				
* calc d =	1.53 ft	******			
DIFFERENCE =	-0.03 %				
* calc d =	1.53 ft	******			
DIFFERENCE =	-0.00 %				
FINAL d =	1.53 ft				
A =	22.39 sq ft				
R =	1.14 ft		t =	0.27 PSF	
t =	19.20 ft		nb =	0.74	
V =	3.80 fps				
Q(calc) =	85 cfs		Beta =	41.49	
t =	0.35 PSF				
nb =	0.993		n' =	0.62	
SFb =	1.00		SFs =	1.02	

17/23

GJ
12-03-90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: UMC -- DRAINAGE SWALE F

DISCHARGE =	126 CFS		
BOTTOM WIDTH =	10 FT		
Z (SIDE SLOPE)=	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.0031	Theta =	0.18 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM

D50 (ASSUM) =	0.09 FT	1.0 inches	
n =	0.026		
* TRIAL d =	2.00 ft	******	
DIFFERENCE =	0.06 %		
* calc d =	2.00 ft	******	
DIFFERENCE =	0.00 %		
* calc d =	2.00 ft	******	
DIFFERENCE =	0.00 %		
* calc d =	2.00 ft	******	
DIFFERENCE =	0.00 %		
FINAL d =	2.00 ft		
A =	31.99 sq ft		
R =	1.41 ft		
t =	22.00 ft		
V =	3.94 fps		
Q(calc) =	126 cfs		
t =	0.39 PSF		
nb =	0.964		
SFb =	1.03		

CHANNEL SIDE SLOPES

D50 (ASSUM) =	0.09 FT	1.0 inches
n =	0.026	
t =	0.29 PSF	
nb =	0.72	
Beta =	40.67	
n' =	0.60	
SFs =	1.04	

18/23

GS
12-03-90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: UNC -- DRAINAGE SWALE G

DISCHARGE =	99 CFS		
BOTTOM WIDTH =	10 FT		
Z (SIDE SLOPE)=	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.0021	Theta =	0.12 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM | CHANNEL SIDE SLOPES

	D50 (ASSUM) =	0.06 FT 0.7 inches		D50 (ASSUM) =	0.06 FT 0.7 inches
	n =	0.025		n =	0.025
*	TRIAL d =	1.97 ft	******		
	DIFFERENCE =	8.94 %			
*	calc d =	1.88 ft	******		
	DIFFERENCE =	-0.18 %			
*	calc d =	1.88 ft	******		
	DIFFERENCE =	-0.01 %			
*	calc d =	1.88 ft	******		
	DIFFERENCE =	-0.00 %			
	FINAL d =	1.88 ft			
	A =	29.48 sq ft			
	R =	1.35 ft		t =	0.19 PSF
	t =	21.30 ft		nb =	0.69
	V =	3.36 fps			
	Q(calc) =	99 cfs		Beta =	39.47
	t =	0.25 PSF			
	nb =	0.923		n' =	0.57
	SFb =	1.08		SFs =	1.07

19/23

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

GS
12-03-90

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: UMC -- DRAINAGE SWALE H

DISCHARGE =	284 CFS		
BOTTOM WIDTH =	20 FT		
Z (SIDE SLOPE)=	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.0085	Theta =	0.49 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM			CHANNEL SIDE SLOPES		
D50 (ASSUM) =	0.25 FT	3 inches	D50 (ASSUM) =	0.25 FT	3 inches
n =	0.031		n =	0.031	
* TRIAL d =	2.00 ft	******			
DIFFERENCE =	9.12 %				
* calc d =	1.91 ft	******			
DIFFERENCE =	0.37 %				
* calc d =	1.91 ft	******			
DIFFERENCE =	0.04 %				
* calc d =	1.90 ft	******			
DIFFERENCE =	0.00 %				
FINAL d =	1.90 ft				
A =	48.98 sq ft				
R =	1.53 ft		t =	0.76 PSF	
t =	31.43 ft		nb =	0.68	
V =	5.80 fps				
Q(calc) =	284 cfs		Beta =	38.82	
t =	1.01 PSF				
nb =	0.907		n' =	0.56	
SFb =	1.09		SFs =	1.08	

20/23

GS
12-03-90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: UMC -- DRAINAGE SWALE I

DISCHARGE =	385 CFS		
BOTTOM WIDTH =	20 FT		
Z (SIDE SLOPE)=	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.004	Theta =	0.23 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM			CHANNEL SIDE SLOPES	
D50 (ASSUM) =	0.15 FT 1.8 inches		D50 (ASSUM) =	0.15 FT 1.8 inches
n =	0.029		n =	0.029
* TRIAL d =	2.60 ft	******		
DIFFERENCE =	-3.26 %			
* calc d =	2.64 ft	******		
DIFFERENCE =	-0.35 %			
* calc d =	2.65 ft	******		
DIFFERENCE =	-0.03 %			
* calc d =	2.65 ft	******		
DIFFERENCE =	-0.00 %			
FINAL d =	2.65 ft			
A =	73.97 sq ft			
R =	2.01 ft		t =	0.50 PSF
t =	35.88 ft		nb =	0.74
V =	5.20 fps			
Q(calc) =	385 cfs		Beta =	41.35
t =	0.66 PSF			
nb =	0.988		n' =	0.62
SFb =	1.01		SFs =	1.02

2/23

GS
12-03-90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: UMC -- DRAINAGE SWALE J

DISCHARGE =	101 CFS		
BOTTOM WIDTH =	10 FT		
Z (SIDE SLOPE)=	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.0042	Theta =	0.24 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM			CHANNEL SIDE SLOPES		
D50 (ASSUM) =	0.10 FT	1.2 inches	D50 (ASSUM) =	0.10 FT	1.2 inches
n =	0.027		n =	0.027	
* TRIAL d =	1.65 ft	******			
DIFFERENCE =	-0.91 %				
* calc d =	1.66 ft	******			
DIFFERENCE =	-0.06 %				
* calc d =	1.66 ft	******			
DIFFERENCE =	-0.00 %				
* calc d =	1.66 ft	******			
DIFFERENCE =	-0.00 %				
FINAL d =	1.66 ft				
A =	24.83 sq ft				
R =	1.21 ft		t =	0.33 PSF	
t =	19.95 ft		nb =	0.73	
V =	4.07 fps				
Q(calc) =	101 cfs		Beta =	40.96	
t =	0.43 PSF				
nb =	0.976		n' =	0.61	
SFb =	1.02		SFs =	1.03	

CanonieEnvironmental

By [illegible] Date 11/12/90 Subject UNC - Impoundment Top Swale Design Sheet No. 22 of 23
Chkd. By GS Date 12.03.90 Proj. No. 86-060-24
1/4" X 1/4"

CHECK TIME OF CONCENTRATIONS

AREA A: Design channel velocity = 3.15 fps
Assume overland flow still ≈ 1 ft/sec

$t_c = 200/1 + 2600/3.15 = 1025$ sec = 0.28 hrs
∴ use of t_c = 0.2 hrs is conservative.
(ie will give higher peak flow)

AREA B: Design channel velocity = 4.36 fps

$t_c = 540/1 + 3600/4.36 = 946$ sec = 0.38 hrs
∴ use of t_c = 0.2 hrs is conservative

AREA C: Design channel velocity = 3.86 fps

$t_c = 200/1 + 3400/3.86 = 1081$ sec = 0.30 hrs
∴ use of t_c = 0.2 hrs is conservative

AREA D: Design channel velocity = 3.33 fps

$t_c = 260/1 + 3200/3.33 = 1220$ sec = 34 hrs
∴ use of t_c = 0.3 is conservative

AREA E: Design channel velocity = 3.80 fps

$t_c = 780/1 + 1350/3.80 = 1125$ sec = 0.30 hrs
∴ use of t_c = 0.3 hrs is appropriate

AREA F: Design channel velocity = 3.94 fps

$t_c = 500/1 + 1600/3.94 = 900$ sec = 0.25 hrs
∴ use of t_c = 0.2 hrs is conservative

CanonieEnvironmental

By MJG Date 11/12/90 Subject UNC - Impoundment Top Swale Design Sheet No. 23 of 23
Chkd. By GJ Date 12-03-90 Proj. No. 86-060-24
1/4" X 1/4"

AREA G: Design channel velocity = 3.36 fps

$t_c = 500/1 + 1400/3.36 = 917$ sec = 0.25 hrs
∴ use of t_c = 0.2 hrs is conservative

AREA H&I: Design channel velocity = 5.80 fps in Swale G-H

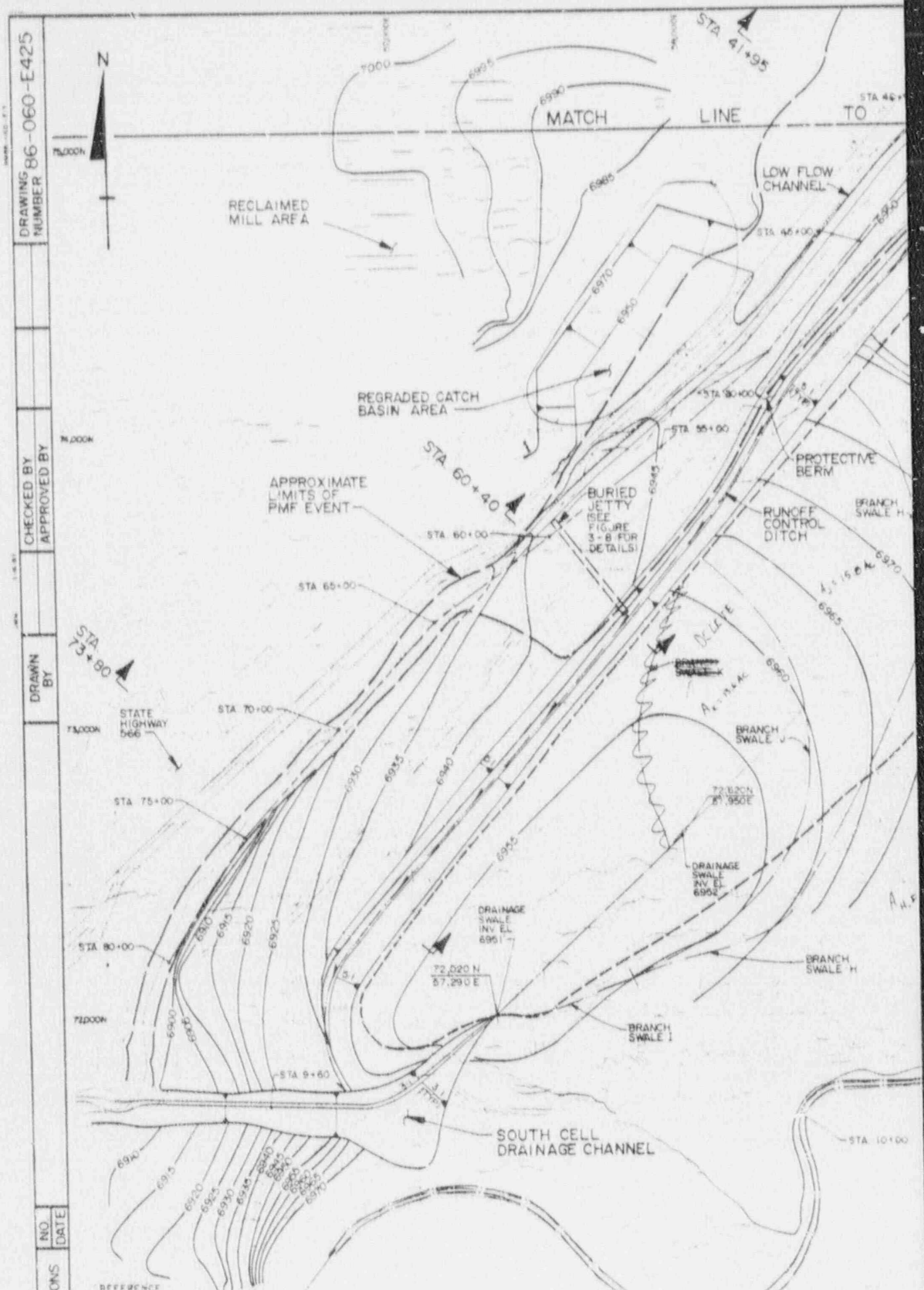
$t_{c_{G-1A}} = 1300/1 + 3100/5.80 = 1834$ sec. = 0.51 hrs
∴ use of t_c = 0.5 hrs is appropriate

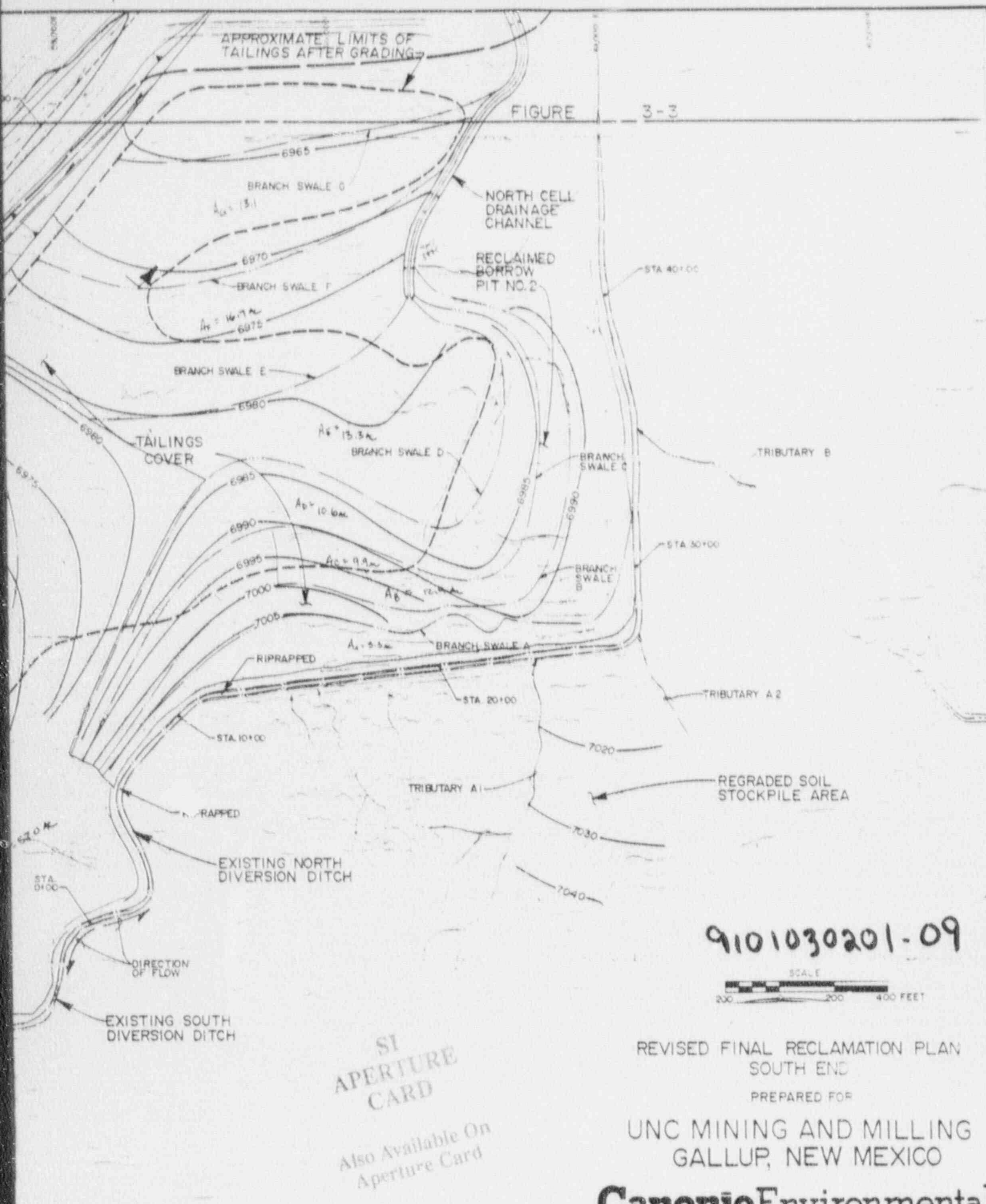
Design channel velocity = 4.17 ft/sec in SWALE G-1B

$t_{c_{G-1B}} = 1300/1 + 3100/4.17 = 2043$ sec = 0.57 hrs
∴ use of t_c = 0.5 hrs is conservative

AREA J: Design channel velocity = 4.02 fps

$t_c = 800/1 + 1900/4.02 = 1261$ sec = 0.35 hrs
∴ use of t_c = 0.3 hrs is conservative


DRAWING NUMBER 86-060-E425
CHECKED BY
APPROVED BY
DRAWN BY
NO. DATE
REVISIONS
N
MATCH LINE TO
STA 41+95
STA 46+
LOW FLOW CHANNEL
RECLAIMED MILL AREA
STA 46+00
REGRADED CATCH BASIN AREA
STA 50+00
STA 55+00
STA 60+40
PROTECTIVE BERM
APPROXIMATE LIMITS OF PMF EVENT
BURIED JETTY (SEE FIGURE 3-8 FOR DETAILS)
RUNOFF CONTROL DITCH
BRANCH SWALE H
STA 60+00
STA 65+00
STA 73+80
STATE HIGHWAY 566
STA 70+00
BRANCH SWALE J
72,820N 87,950E
STA 75+00
DRAINAGE SWALE INV EL 6952
DRAINAGE SWALE INV EL 6951
STA 80+00
72,020 N 87,290 E
BRANCH SWALE H
BRANCH SWALE I
STA 9+60
SOUTH CELL DRAINAGE CHANNEL
STA 10+00
REFERENCE
TOPOGRAPHIC MAP PROVIDED BY UNITED NUCLEAR CORPORATION DRAWING NO. 1799-A DATED MAY 1, 1985. SCALE 1"=200'
DISCHARGE TO NATURAL DRAINAGE



REVISED FINAL RECLAMATION PLAN
SOUTH END

PREPARED FOR

UNC MINING AND MILLING
GALLUP, NEW MEXICO

CanonieEnvironmental

No.	DATE	ISSUE / REVISION	DWN BY	CKD BY	APD BY

DATE: 11-12-90	FIGURE 3-2	DRAWING NUMBER 86-060-E425
SCALE: AS SHOWN		

SOIL/ROCK MATRIX STABILITY CALCULATIONS

Canonie Environmental

By SWM Date 10-29-90 Subject UNC-ROCK MULCH SIZING Sheet No. 1 of 16

Chkd. By GS Date 12-03-90 ON IMPOUNDMENT TOP Proj. No. 86-060-29

1/4 X 1/4

PURPOSE : DETERMINE THE ROCK MULCH SIZE (d_{50}) AND THICKNESS FOR THE IMPOUNDMENT TOPS AT UNC USING THE PROPOSED REVISED GRADING PLAN (2' RADON BARRIER).

METHOD : FIGURE 1 SHOWS THE SLOPE SEGMENTS FOR WHICH THE OVERLAND FLOW CALCULATIONS WERE PERFORMED. THE CSU METHOD OF RIPRAP SIZING (NUREG/CR-4651 PHASE II) WAS USED TO SIZE THE RIPRAP.

THE SPREADSHEET PROGRAM "OVERCSU" (LOTUS SYMPHONY) WAS DEVELOPED TO ASSIST IN THE CALCULATIONS. THIS PROGRAM DETERMINES THE OVERLAND FLOW RATE PER UNIT WIDTH (q) FOR THE IMPOUNDMENT TOP USING THE RATIONAL FORMULA AS PER NUREG 4620 AND THE NRC'S STP. FROM THIS POINT THE PROGRAM UTILIZES THE q VALUE AND THE SLOPE TO DETERMINE THE RIPRAP d_{50} BY MEANS OF THE FOLLOWING FORMULA (AS PER NUREG/CR-4651 PHASE II):

$$d_{50} = 5.23 \times (\text{slope})^{0.43} \times (q)^{0.56}$$

THIS IS THE CSU METHOD.

CanonieEnvironmental

By SWM Date 11-29-90 Subject UNC - ROCK MULCH SIZING ON IMPOUNDMENT TOP Sheet No 2 of 16

Chkd. By GS Date 12-03-90 Proj. No 86-060-29

1/4 X 1/4

RESULTS : PAGE 3 PROVIDES A SUMMARY TABLE OF THE SLOPE SEGMENTS AND THE RIPRAP SIZES AND THICKNESSES CALCULATED BY THE CSU METHOD.

CanonieEnvironmental

By SWM Date 11-29-90 Subject UNC - SIZING OF ROCK MULCH Sheet No. 3 of 16

Chkd. By GS Date 12-03-90 Proj. No 86-060-24

1/4" X 1/4"

TABLE 1 SUMMARY OF RESULTS

SLOPE SEGMENT	SLOPE LENGTH (ft)	RELIEF (ft)	SLOPE (ft/ft)	q (cfs/ft)	CSU d_{50} (inches)	THICKNESS (inches)
A	240	13.0	0.054	0.92	1.49	3.0
B	120	5.0	0.042	0.46	0.87	↓
C	205	9.0	0.044	0.79	1.20	↓
D	260	7.5	0.029	1.00	1.14	↓
E	205	3.5	0.017	0.79	0.79	↓
F	470	9.0	0.019	1.55	1.22	↓
G	440	6.5	0.015	1.49	1.05	↓
H	500	15.0	0.030	1.71	1.56	↓
J	800	14.5	0.018	2.20	1.44	↓
K	1100	11.0	0.010	2.37	1.71	↓
L	95	5.5	0.058	0.37	0.88	↓
M	155	9.5	0.061	0.60	1.18	↓
N	100	7.0	0.070	0.39	0.98	↓

BY: SWM

p. 4 of 16

BY: SWM
11-30-90

Chkd By: GS
12-03-90

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

PROJECT: UNC: 86-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN,   LOCATION A

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF: 1 RETURN PERIOD: PMP
SLOPE LENGTH: 240 FT 1-HR PPT AMOUNT: 8.47 INCHES
AVE SLOPE: 0.054 FT/FT Tc (calc): 1.632 MIN EQTN 4.44, NUREG4620
MANNING'S n: 0.030 Tc (actual): 2.5 MIN
FLOW CONC: 3 %OF 1-HR PPT: 27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA: 0.005 ACRES PPT AMOUNT: 2.329 INCHES
Mannings n(calc)0.030 PPT INTENSITY: 55.90 IPH

PEAK DISCHARGE: 0.308 CFS Q = CiA
CONC. DISCHARGE:0.924 CFS

DEPTH: 0.220 FT EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.741 PSF
FLOW VELOCITY: 4.20 FPS V = Q/FLOW AREA

CALC. d50: 1.426 INCHES d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	80.833333333
60	100	

BY SWM

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

BY: SWM
11-29-90

PROJECT: UMC: 86-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN, LOCATION 8

Chkd. By: GS
12-03-90

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS
SLOPE LENGTH:	120 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.042 FT/FT	Tc (calc):	1.054 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.027	Tc (actual):	2.5 MIN
FLOW CONC:	3	%OF 1-HR PPT:	27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.002 ACRES	PPT AMOUNT:	2.329 INCHES
Mannings n(calc)	0.027	PPT INTENSITY:	55.90 IPH

PEAK DISCHARGE: 0.154 CFS   Q = CIA
CONC. DISCHARGE: 0.462 CFS

DEPTH: 0.147 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.385 PSF
FLOW VELOCITY: 3.14 FPS   V = Q/FLOW AREA

CALC. d50: 0.868 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	8[illegible].833333333
60	100	

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1   p. 6 of 1

PROJECT: UNC: 86-460-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN,   LOCATION C

BY: SWM
11-29-90

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

Chkd By: GS
12-03-90

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS
SLOPE LENGTH:	205 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.044 FT/FT	Tc (calc):	1.564 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.029	Tc (actual):	2.5 MIN
FLOW CONC:	3	%OF 1-HR PPT:	27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.004 ACRES	PPT AMOUNT:	2.329 INCHES
Mannings n(calc)	0.029	PPT INTENSITY:	55.90 IPH

PEAK DISCHARGE: 0.263 CFS   Q = CIA
CONC. DISCHARGE: 0.789 CFS

DEPTH: 0.208 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.573 PSF
FLOW VELOCITY: 3.78 FPS   V = Q/FLOW AREA

CALC. d50: 1.195 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	80.833333333
60	100	

P- 2[illegible]

BY: JWM
11-29-90

Chkd By: GJ
12-03-90

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

PROJECT: UNC: 86-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN,   LOCATION D

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS
SLOPE LENGTH:	260 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.029 FT/FT	Tc (calc):	2.205 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.027	Tc (actual):	2.5 MIN
FLOW CONC:	3	%OF 1-HR PPT:	27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.005 ACRES	PPT AMOUNT:	2.329 INCHES
Mannings n(calc)	0.027	PPT INTENSITY:	55.90 IPH

PEAK DISCHARGE: 0.3[illegible] CFS   Q = CIA
CONC. DISCHARGE: 1.001 CFS

DEPTH: 0.261 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.472 PSF
FLOW VELOCITY: 3.83 FPS   V = Q/FLOW AREA

CALC. d50: 1.141 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria, Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	80.833333333
60	100	

E- 2-1m

p. 8 of 6
BY: SWM
11-29-90

Chkd. By: GS
12-03-90

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

PROJECT: UNC: 86-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN, LOCATION E

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS
SLOPE LENGTH:	205 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.017 FT/FT	Tc (calc):	2.256 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.025	Tc (actual):	2.5 MIN
FLOW CONC:	3	%OF 1-HR PPT:	27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.004 ACRES	PPT AMOUNT:	2.329 INCHES
Mannings n(calc)	0.025	PPT INTENSITY:	55.90 IPH

PEAK DISCHARGE: 0.263 CFS   Q = CIA
CONC. DISCHARGE: 0.789 CFS

DEPTH: 0.253 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.269 PSF
FLOW VELOCITY: 3.11 FPS   V = Q/FLOW AREA

CALC. d50: 0.794 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	80.833333333
60	100	

BY SWM

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD OVERCSU.WR1

p. 9 of 16

BY SWM
11-29-90

Chkd. By: GS
12-03-90

PROJECT: UNC: 54-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN, LOCATION F

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS
SLOPE LENGTH:	470 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.019 FT/FT	Tc (calc):	4.095 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.027	Tc (actual):	4.1 MIN
FLOW CONC:	3	%OF 1-HR PPT:	38.7 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.010 ACRES	PPT AMOUNT:	3.277 INCHES
Mannings n(calc)	0.027	PPT INTENSITY:	47.96 IPH

PEAK DISCHARGE: 0.517 CFS Q = CiA
CONC. DISCHARGE: 1.552 CFS

DEPTH: 0.386 FT EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.457 PSF
FLOW VELOCITY: 4.02 FPS V = Q/FLOW AREA

CALC. d50: 1.217 INCHES d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	38.7
5	45	41.94
10	62	47.84
15	74	56.56
20	82	70.87
30	89	78.64
45	95	81.366666667
60	100	

BY SWM

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD OVERCSU.WR1

BY: SWM
11-29-90

Chkd. By: GS
12-03-90

PROJECT: UNC: 86-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN, LOCATION 6

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS
SLOPE LENGTH:	440 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.015 FT/FT	Tc (calc):	4.263 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.026	Tc (actual):	4.3 MIN
FLOW CONC:	3	%OF 1-HR PPT:	40.1 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.010 ACRES	PPT AMOUNT:	3.396 INCHES
Mannings n(calc)	0.026	PPT INTENSITY:	47.39 IPH

PEAK DISCHARGE: 0.478 CFS Q = CIA
CONC. DISCHARGE: 1.436 CFS

DEPTH: 0.386 FT EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.361 PSF
FLOW VELOCITY: 3.71 FPS V = Q/FLOW AREA

CALC. d50: 1.052 INCHES d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	40.1
5	45	42.62
10	62	48.32
15	74	56.88
20	82	71.01
30	89	78.72
45	95	81.433333333
60	100	

---

2 + 2 SWM

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

p. 11 of 16

BY: SWM
11-29-90

Ckd By: GS
12-03-90

PROJECT: UMC: 86-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN,   LOCATION H

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP
SLOPE LENGTH:	500 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.03 FT/FT	Tc (calc):	3.602 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.028	Tc (actual):	3.6 MIN
FLOW CONC:	3	%OF 1-HR PPT:	35.2 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.011 ACRES	PPT AMOUNT:	2.981 INCHES
Mannings n(calc)	0.028	PPT INTENSITY:	49.69 IPH

PEAK DISCHARGE: 0.570 CFS   Q = CiA
CONC. DISCHARGE: 1.711 CFS

DEPTH: 0.364 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.682 PSF
FLOW VELOCITY: 4.69 FPS   V = Q/FLOW AREA

CALC. d50: 1.564 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	35.2
5	45	40.24
10	62	46.64
15	74	55.76
20	82	70.52
30	89	78.44
45	95	81.2
60	100	

BY. SWM

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

BY & SWM
11-29-90

PROJECT: UMC: 86-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN.   LOCATION J

Chkd by GS
12-03-90

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF: 1   RETURN PERIOD: PMP YEARS
SLOPE LENGTH: 800 FT   1-HR PPT AMOUNT: 8.47 INCHES
AVE SLOPE: 0.018 FT/FT   Tc (calc): 6.297 MIN   EQTN 4.44, NUREG4620
MANNING'S n: 0.028   Tc (actual): 6.3 MIN
FLOW CONC: 3   %OF 1-HR PPT: 49.42 %   TABLE 2.1, NUREG 4620
DRAINAGE AREA: 0.018 ACRES   PPT AMOUNT: 4.185 INCHES
Mannings n(calc) 0.028   PPT INTENSITY: 39.86 IPH

PEAK DISCHARGE: 0.732 CFS   Q = CIA
CONC. DISCHARGE: 2.196 CFS

DEPTH: 0.493 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.554 PSF
FLOW VELOCITY: 4.45 FPS   V = Q/FLOW AREA

CALC. d50: 1.444 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	54.1
5	45	49.42
10	62	53.12
15	74	60.08
20	82	72.41
30	89	79.52
45	95	82.1
60	100	

B., 2nd

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

p.13 of 16
BY: SWM
11-29-90

PROJECT: UNC: 86-060-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN,   LOCATION K

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

Chkd. By: GS
12-03-90

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS
SLOPE LENGTH:	1100 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.01 FT/FT	Tc (calc):	10.09 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.027	Tc (actual):	10.1 MIN
FLOW CONC:	3	%OF 1-HR PPT:	62.24 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.025 ACRES	PPT AMOUNT:	5.271 INCHES
Mannings n(calc)	0.027	PPT INTENSITY:	31.31 IPH

PEAK DISCHARGE: 0.790 CFS   Q = CiA
CONC. DISCHARGE: 2.372 CFS

DEPTH: 0.603 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.376 PSF
FLOW VELOCITY: 3.93 FPS   V = Q/FLOW AREA

CALC. d50: 1.171 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	80.7
5	45	62.34
10	62	62.24
15	74	66.16
20	82	75.07
30	89	81.04
45	95	83.366666667
60	100	

BY: SWM

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD OVERCSU.WR1

p 14 of 16

BY: SWM
11-29-90

PROJECT: UMC: 86-660-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN, LOCATION L

Chked. By: GS
12-03-90

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS
SLOPE LENGTH:	95 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.058 FT/FT	Tc (calc):	0.770 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.020	Tc (actual):	2.5 MIN
FLOW CONC:	3	%OF 1-HR PPT:	27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.002 ACRES	PPT AMOUNT:	2.329 INCHES
Mannings n(calc)	0.028	PPT INTENSITY:	55.90 IPH

PEAK DISCHARGE: 0.121 CFS Q = CIA
CONC. DISCHARGE: 0.365 CFS

DEPTH: 0.118 FT EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.429 PSF
FLOW VELOCITY: 3.08 FPS V = Q/FLOW AREA

CALC. d50: 0.875 INCHES d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	80.833333333
60	100	

OVERCSUM

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD OVERCSU.WR1

BY: SWM
11-29-90

Chkd. By: GAS
12-03-90

PROJECT: UNC: 86-660-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN. LOCATION N

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP YEARS	
SLOPE LENGTH:	155 FT	1-HR PPT AMOUNT:	8.47 INCHES	
AVE SLOPE:	0.061 FT/FT	Tc (calc):	1.112 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.030	Tc (actual):	2.5 MIN	
FLOW CONC:	3	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.003 ACRES	PPT AMOUNT:	2.329 INCHES	
Mannings n(calc)	0.030	PPT INTENSITY:	55.90 IPH	

PEAK DISCHARGE: 0.198 CFS Q = CIA
CONC. DISCHARGE: 0.596 CFS

DEPTH: 0.163 FT EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.621 PSF
FLOW VELOCITY: 3.65 FPS V = Q/FLOW AREA

CALC. d50: 1.176 INCHES d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	80.833333333
60	100	

BY: SWM

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

BY: SWM
11-29-90

Chkd. By: GS
12-03-90

PROJECT: UNC: 86-460-24
LOCATION: IMPOUNDMENT TOP, ORIGINAL DESIGN,   LOCATION M

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP	
SLOPE LENGTH:	100 FT	1-HR PPT AMOUNT:	8.47 INCHES	
AVE SLOPE:	0.07 FT/FT	Tc (calc):	0.752 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.030	Tc (actual):	2.5 MIN	
FLOW CONC:	3	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.002 ACRES	PPT AMOUNT:	2.329 INCHES	
Mannings n(calc)	0.030	PPT INTENSITY:	55.90 IPH	

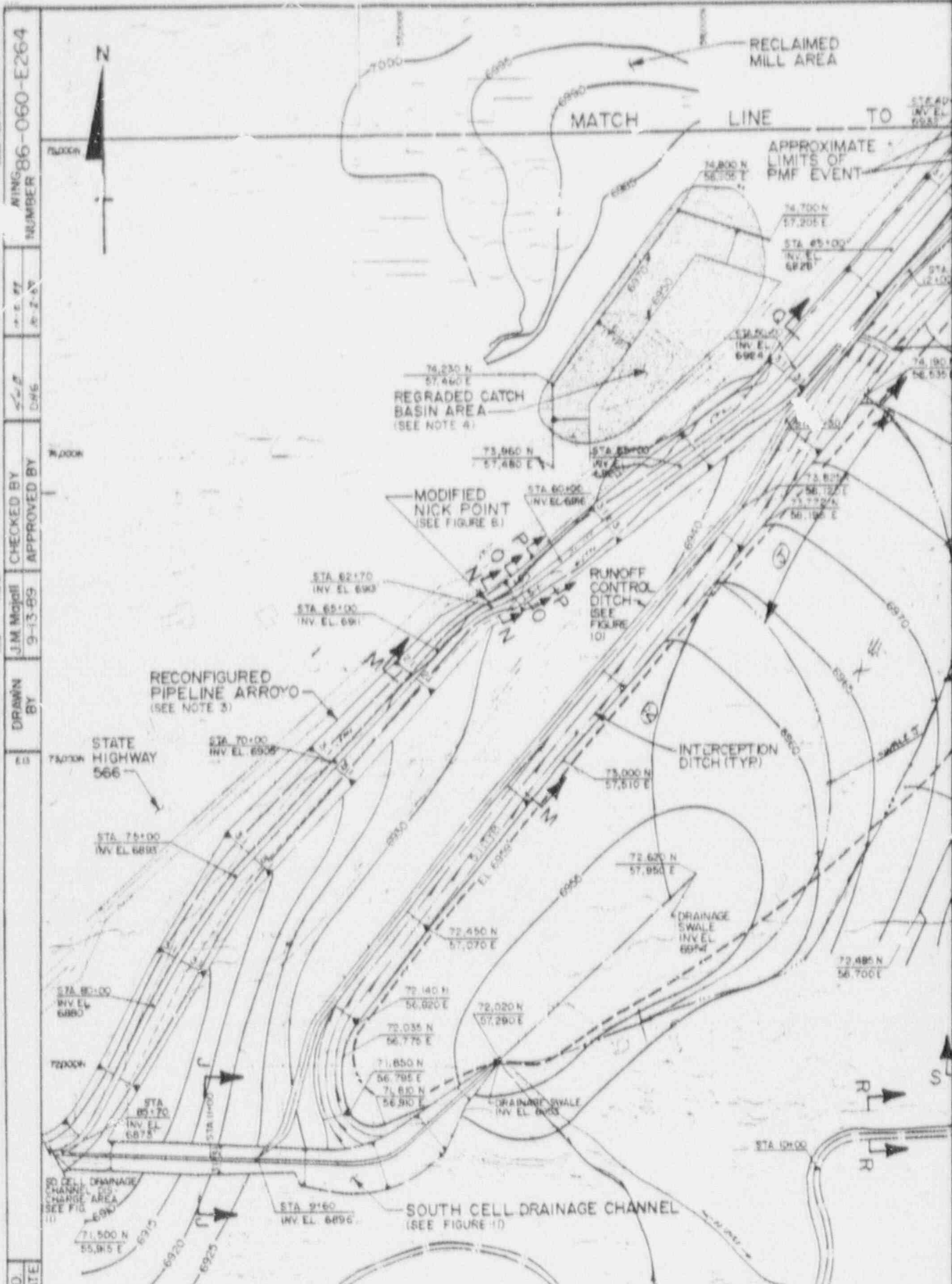
PEAK DISCHARGE: 0.128 CFS   Q = CIA
CONC. DISCHARGE: 0.385 CFS

DEPTH: 0.120 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.526 PSF
FLOW VELOCITY: 3.20 FPS   V = Q/FLOW AREA

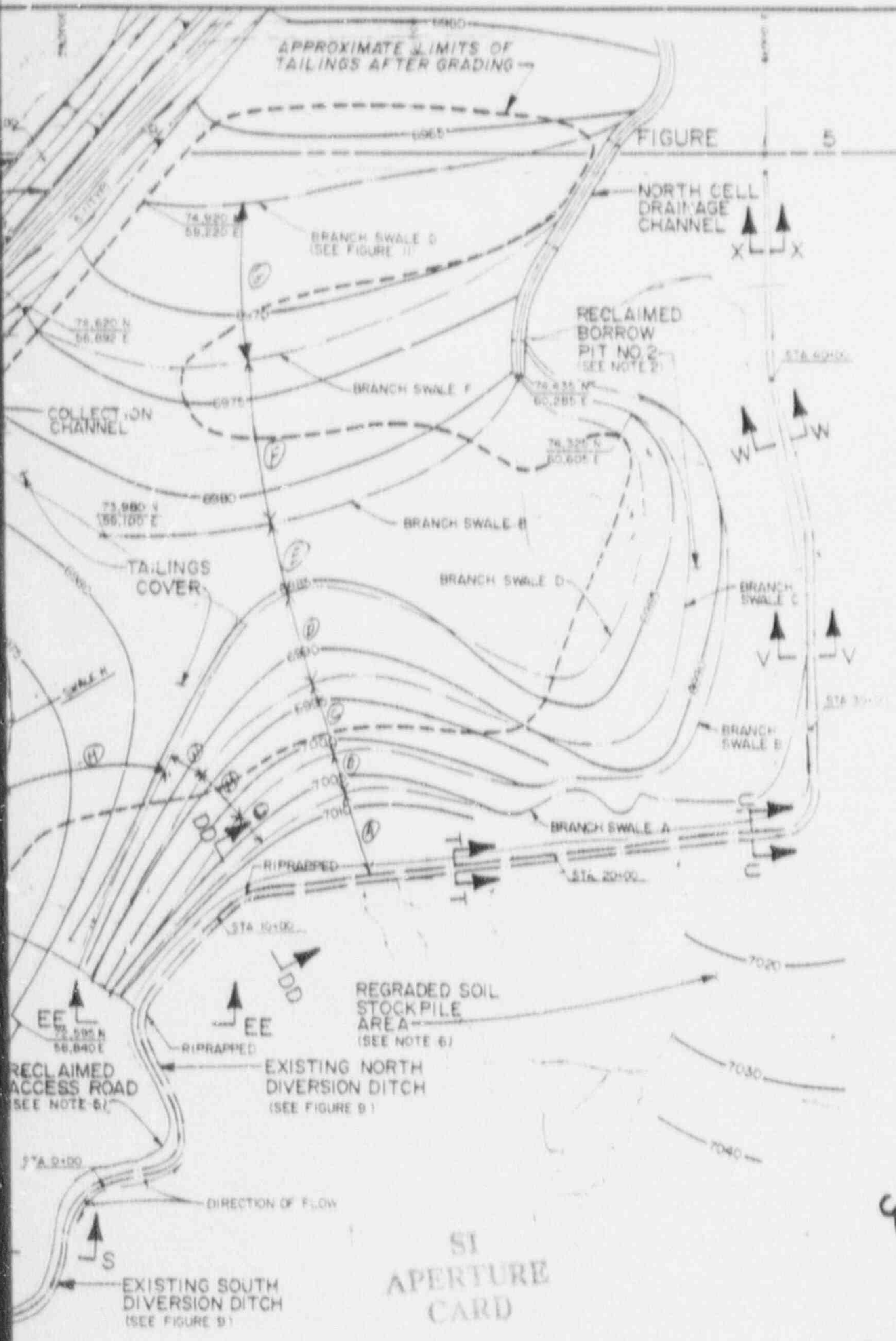
CALC. d50: 0.976 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria, Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O 1-HR PPT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	80.833333333
60	100	



86-060-E264
DRAWING NUMBER
DRAWN BY
J.M. Majell
9-13-89
CHECKED BY
APPROVED BY
REVISIONS
NO.
DATE
N
RECLAIMED MILL AREA
MATCH LINE TO
APPROXIMATE LIMITS OF PMF EVENT
REGRADED CATCH BASIN AREA
(SEE NOTE 4)
MODIFIED NICK POINT
(SEE FIGURE 6)
RUNOFF CONTROL DITCH
(SEE FIGURE 10)
RECONFIGURED PIPELINE ARROYO
(SEE NOTE 3)
STATE HIGHWAY 566
INTERCEPTION DITCH (TYP.)
DRAINAGE SWALE
SO. CELL DRAINAGE CHANNEL DISCHARGE AREA
SEE FIG. 11
SOUTH CELL DRAINAGE CHANNEL
(SEE FIGURE 11)
DISCHARGE TO NATURAL DRAINAGE
STA. 62+70
STA. 65+00
STA. 70+00
STA. 75+00
STA. 80+00
STA. 85+70
STA. 9+60
INV. EL. 6896
STA. 10+00
74,800 N
74,700 N
57,205 E
74,230 N
57,460 E
73,960 N
57,480 E
73,000 N
57,510 E
72,620 N
57,950 E
72,650 N
57,070 E
72,140 N
56,820 E
72,020 N
57,290 E
72,035 N
56,775 E
71,850 N
56,795 E
71,610 N
56,910 E
71,500 N
55,915 E
73,485 N
56,700 E
REFERENCE
TOPOGRAPHIC MAP PROVIDED BY UNITED NUCLEAR CORPORATION
DATED MAY 1, 1985. SCALE 1" = 200'



NOTES:

1. FINAL CONTOURS SHOWN ALLOW FOR A 4-FOOT COMPACTED SOIL COVER OVER THE REGRADED TAILINGS. THE INTERIM SOIL COVER SURFACE WILL BE CLEARED AND GRUBBED PRIOR TO PLACEMENT OF THE FINAL SOIL COVER IN ACCORDANCE WITH THE SPECIFICATIONS.
2. BORROW PIT NO. 2 WILL BE RECLAIMED BY BACKFILLING WITH MILL DEMOLITION DEBRIS, ORE PAD MATERIALS, CATCH BASIN MATERIALS AND SOIL EXCAVATED FROM THE SOIL STOCKPILE.
3. THE PIPELINE ARROYO WILL BE RECONFIGURED TO ALLOW PASSAGE OF THE PROBABLE MAXIMUM FLOOD (PMF). DETAILS OF THE RECONFIGURED SECTIONS AND KICKPOINT MODIFICATION ARE SHOWN ON FIGURES 6 AND 7.
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 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 AND REVEGETATED IN ACCORDANCE WITH THE SPECIFICATIONS.
6. THE EXISTING SOIL STOCKPILE WILL BE USED AS A SOURCE OF BACKFILL FOR BORROW PIT NO. 2. SUBSEQUENT TO BACKFILLING, THE STOCKPILE AREA WILL BE REGRADED TO MEET THE CONTOURS SHOWN.
7. SECTIONS AND DETAILS ARE SHOWN ON FIGURES 8 TO 12.

9101030201-10

SCALE
200 0 200 400 FEET

LEGEND:

- 6985 — ELEVATION OF FINAL SOIL COVER, FT. (SEE NOTE 1)
- APPROXIMATE LIMITS OF CATCH BASINS I AND II AREAS REQUIRING STRIPPING (SEE NOTE 4)
- DIRECTION OF FLOW

FINAL RECLAMATION PLAN
SOUTH END

PREPARED FOR

UNC MINING AND MILLING
GALLUP, NEW MEXICO

CanonieEnvironmental

DATE: 9-13-89	FIGURE 1	DRAWING NUMBER 86-060-E264
SCALE: AS SHOWN		

APPENDIX B

RADON MODEL CALCULATIONS

CanonieEnvironmental

By MJM Date 11/19/90 Subject UNC RECLAMATION Sheet No. 1 of ___
Chkd. By SWM Date 11/24/90 Radon Attenuation Calcs Proj No 86-060-24
1/4 X 1/4

PURPOSE: TO DETERMINE THE REQUIRED SOIL COVER THICKNESS, USING AVAILABLE INTERIM RECLAMATION CONSTRUCTION DATA, TO LIMIT RADON EMISSIONS FROM THE UNC TAILINGS IMPOUNDMENT TO THE REGULATORY LIMIT OF 20 pCi/m²/sec.

METHOD: - DETERMINE THE GEOTECHNICAL AND RADIOLOGIC PROPERTIES OF THE COVER SOILS AND TAILINGS. USE DATA OF IN-SITU SOIL COVER PARAMETERS FROM INTERIM RECLAMATION ACTIVITIES

- USING GEOTECHNICAL AND RADIOLOGIC PARAMETERS, DETERMINE THE REQUIRED SOIL COVER THICKNESS USING THE RADON COMPUTER CODE AND METHODS OF NRC REGULATORY GUIDE 3.64.

RESULTS:

USING ACTUAL FIELD DATA FROM THE CONSTRUCTION OF INTERIM SOIL COVER OVER THE NORTH AND CENTRAL TAILINGS CELLS AND CONSERVATIVE RADIOLOGIC PROPERTIES FOR THE TAILINGS, THE REQUIRED SOIL COVER THICKNESS TO LIMIT RADON GAS EMISSIONS TO 20 pCi/m²/sec is 1.5 feet.

REFERENCES:

1) Sergent, Hauskins, and Beckwith, 1979, "STABILITY AND INTEGRITY ASSESSMENT, CHURCH ROCK TAILINGS DAM, VOL. 3 - BREACH INVESTIGATION"
2) UNITED NUCLEAR CORP., 1987, "RECLAMATION PLAN LICENSE NO SUA-1475"
3) LINSLEY AND FRANZINI, "WATER RESOURCES ENGINEERING"
4) Canonie, Sept. 1990, "Responses to NRC Geotechnical Comments"
5) US Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Regulatory Guide 3.64, "Calculation of Radon Flux Attenuation By Earthen Uranium Mill Tailings Covers"

CanonieEnvironmental

By mjz Date 11/19/90 Subject UNC RECLAMATION Sheet No. 2 of ____

Chkd. By SWM Date 11/29/90 RADON ATTENUATION CALCS Proj. No. 86-060-24

1/4 X 1/4

CALCULATIONS.

DETERMINE RADIOLOGIC PARAMETERS OF TAILINGS USING VALUES DETERMINED IN THE LABORATORY FROM SAMPLES TAKEN ON SITE.

THE FOLLOWING TABLES PRESENT AVAILABLE DATA FOR FINE-GRAINED TAILINGS AND COARSE-GRAINED TAILINGS SAMPLED AT UNC

Coarse Tailings Laboratory Test Data

General Description	Boring Number	Depth	Specific Gravity	Dry Bulk Density (pcf)	Porosity	Moisture Content (%)	Radium Content (pCi/g)	Diffusion Coefficir (cm²/	
Tailings Sands	658	15'		105	.40				
	658	20'	2.83	104	.41	23.5	160	0.0	
	658	30'	2.81	98	.44	23.4	141	0.0[illegible]	
	658	40'	2.89	92	.49	31.2	212	0.000002	
	659	10'	2.84	95	.46	6.1	125	0.037 *	
	659	20'	2.83	94	.47	10.5	227	0.023 *	[illegible]
	659	30'	2.74	97	.43	13.1	132	0.016 *	0.20
	659	32.5'		106	.47	8.1	115	0.042 *	0.27
	662	20'		97	.49	34.1			
	662	25'	2.78	96	.36	25.1	108	0.0000025	0.33
	662	30'	2.79	94	.46	29.6	177	0.0000013	0.28
Supplemental							143.1		
Averages			2.81	97.5	0.45	21.5	154	~~N.A.~~ 0.029 (a)	0.26
95 percent Confidence Interval			2.77 to 2.84	N.A.	0.43 to 0.47	N.A.	125.0 to 183.0	~~N.A.~~ 0.018 to (a) 0.047	0.25 to 0.27

Fine-Grained Tailings Laboratory Test Data (a) USES ONLY DATA WITH *

General Description	Boring Number	Depth	Specific Gravity	Dry Bulk Density (pcf)	Porosity	Moisture Content (%)	Radium Content (pCi/g)	Diffusion Coefficient (cm²/sec)	Emanation Coefficient
Fine-Grained Tailings Slimes	659	37.5'	2.72	78	.54	29.6	602	0.0056	0.16
	660	8.0'	2.81	74	.58	44.27	341	0.0000011	0.37
	660	15.0'	2.84	94	.47	60.0	1099	0.0000016	0.31
	660	27.5'	2.75	89	.48	32.2	285	0.0000016	0.26
	660	37.5'	2.84	79	.56	41.4	526	0.0000027	0.28
	662	40.0'	2.72	84	.51	36.4	574	0.0000062	0.21
	662	42.5'		89	.55	43.8			
	658	10.0'	2.81	88	.50	17.4	402	0.0067	0.22
	658	32.5'		97	.55	43.6			
Averages			2.78	86	.53	38.7	547	1.76×10^{-3}	.26
95 Percent Confidence Interval			2.73 to 2.83	N.A.	0.50 to 0.56	29.7 to 47.7	296 to 798	0.00022 to 0.0053	0.20 to 0.32

(REF: RECLAMATION PLAN, LICENSE NO SUA-1475, JUNE 1987)

USE OF AVERAGE RADIOLOGIC PROPERTIES IS APPROPRIATE BUT FOR CONSERVATISM, IN THIS CASE, OUTER BOUND 95% CONFIDENCE INTERVAL (TWO-TAILED) VALUES WILL BE USED. THE FOLLOWING TABLE LISTS THE RADIOLOGIC PARAMETERS TO BE USED IN THE SOIL COVER THICKNESS CALCULATIONS (RADON MODEL)

COARSE TAILINGS

PARAMETER	AVG VALUE	OUTER-BOUND 95% C.I. VALUE
SPECIFIC GRAVITY	2.81	2.84
BULK DRY DENSITY	97.5 pcf	—
POROSITY	0.45	0.47
RADIUM CONTENT	154 pCi/g	183 pCi/g
EMANATION COEF.	0.26	0.27
DIFFUSION COEF.	0.029 cm²/sec	0.047 cm²/sec

COARSE TAILING DIFF. COEF. AVERAGE AND C.I. TAKEN ONLY FROM THE 4 LABORATORY TEST RESULTS WITH THE LOWEST MOISTURES (6.1% – 13.1%).

FINE-GRAINED TAILINGS

PARAMETER	AVG VALUE	OUTER-BOUND 95% C.I. VALUE
SPECIFIC GRAVITY	2.78	2.83
BULK DRY DENSITY	56 pcf	—
POROSITY	0.53	0.56
RADIUM CONTENT	547 pCi/g	798 pCi/g
EMANATION COEF.	0.26	0.32
DIFFUSION COEF.	0.00176 cm²/sec	0.0053 cm²/sec

USE OUTER BOUND 95% C.I. VALUES EXCEPT BULK DRY DENSITY. SEE PAGES 8-12 FOR LONG-TERM MOISTURE CONTENT DISCUSSION

CHECK COARSE TAILINGS DIFFUSION COEFFICIENT WITH EMPIRICALLY CALCULATED VALUE AT DEFAULT MOISTURE CONTENT OF 6%

USE OUTER-BOUND C.I. POROSITY TO CALCULATE MOISTURE SATURATION FRACTION

$$m = \frac{10^{-2} \rho_T \omega_T}{\eta_T \rho_w} \quad \text{(REG GUIDE 3.64)}$$

$$= \frac{10^{-2} (97.5)(6)}{0.47 (62.4)}$$

$$= 0.20$$

CALCULATE DIFFUSION COEFFICIENT

$$D = 0.07\, e^{-4(m - mn^2 + m^5)} \quad \text{(REG GUIDE 3.64)}$$

$$= 0.07\, e^{-4(0.20 - 0.20(0.47)^2 + 0.20^5)}$$

$$= 0.0375 \text{ cm}^2/\text{sec}$$

THIS IS LOWER THAN THE 0.047 cm²/sec OUTER BOUND C.I. VALUE TO BE USED - THEREFORE USE OF 0.047 cm²/sec IS CONSERVATIVE FOR THE DIFFUSION COEFFICIENT FOR COARSE TAILINGS

CanonieEnvironmental

By mjg Date 11/19/90 Subject UNC RECLAMATION Sheet No. 5 of ____

Chkd. By SWM Date 11/29/90 RADON ATTENUATION CALCS Proj. No 86-060-24

1/4 X 1/4

DETERMINE GEOTECHNICAL AND RADIOLOGIC PROPERTIES OF COVER SOILS. USE DATA FROM NORTH AND CENTRAL CELL INTERIM RECLAMATION AND FROM SAMPLES FROM BORINGS AND TEST PITS DUG WITHIN BORROW AREAS.

TYPICAL IN-PLACE DENSITIES OF INTERIM SOIL COVER FOR EACH SOIL TYPE:

FOR LOW PLASTICITY CLAYS (CL):

LOCATION	γ (pcf)	m_c (%)	
NORTH CELL	109.2	16.0	
↓	113.2	13.3	
	113.7	14.0	
	110.1	15.5	
	109.0	16.1	
CENTRAL CELL	114.6	14.6	
↓	113.0	14.2	
	112.3	15.2	
AVG =	111.9	14.9	n=8

FOR LOW PLASTICITY SILTS (ML)

LOCATION	γ (pcf)	m_c (%)	
NORTH CELL	116.9	12.8	
CENTRAL CELL	111.3	14.6	
AVG =	114.1	13.7	n=2

FOR SILTY AND CLAYEY SANDS (SM-SC)

LOCATION	γ(pcf)	m(%)
NORTH CELL	119.1	11.8
↓	115.5	13.4
	121.0	12.0
	114.7	10.1
	112.2	12.8
	118.3	11.2
CENTRAL CELL	114.7	13.2
↓	118.0	11.0
AVG. =	116.7	11.9

n = 8

(REF: Canonie, 1990) Table 1 presents a summary of geotechnical data from interim reclamation

DETERMINE REPRESENTATIVE SOIL PROPERTIES FOR REMAINING SOIL COVER BY WEIGHTED AVERAGE. USE BORING AND TEST PIT SAMPLE RESULTS FROM THE FOLLOWING BORROW AREAS:

1) PIPELINE ARROYO – MATERIAL FROM PIPELINE ARROYO WILL BE USED FOR SOIL COVER. SAMPLES FROM BORINGS AND TEST PITS ON TABLE 2 ARE REPRESENTATIVE. (NOTE: THIS INCLUDES SOILS FROM THE TAILINGS EMBANKMENT.);

2.) EXISTING BORROW PIT NO 2 STOCKPILE – MATERIAL FROM THE STOCKPILE WILL BE USED AS SOIL COVER. SURFACE SAMPLES AND BORINGS (FROM TABLE 3) ARE REPRESENTATIVE OF SOILS IN THE STOCKPILE, AND

3) MATERIAL ALREADY PLACED AS INTERIM COVER — TABLE 1 PRESENTS REPRESENTATIVE DATA FOR INTERIM COVER ALREADY PLACED OVER THE NORTH AND CENTRAL CELLS.

FROM SAMPLES LISTED ON TABLES 1 THROUGH 3, AND ASSUMING THESE SAMPLES ARE REPRESENTATIVE OF [illegible] SOILS, CALCULATE THE WEIGHTED AVERAGE MAX DRY DENSITY OF THE COMPACTED SOIL COVER (FOR LEVEL OF COMPACTION EFFORT EQUAL TO STANDARD PROCTOR LEVEL). THERE ARE:

24 CL SAMPLES @ $\gamma_d = 111.9$ pcf, mc = 14.9%

19 SM-SC SAMPLES @ $\gamma_d = 116.7$ pcf, mc = 11.9%

7 ML SAMPLES @ $\gamma_d = 114.1$ pcf, mc = 13.7%

$$\gamma_{d\,max} = \frac{24(111.9) + 19(116.7) + 7(114.1)}{50}$$

$$= 114.0 \text{ pcf}$$

ALL COVER SOILS MUST BE COMPACTED TO A MINIMUM OF 95% OF $\gamma_{d\,max}$, THEREFORE AVG. IN-PLACE DENSITY OF SOIL COVER

$$\gamma_{d\,soil\,cover} = 0.95(\gamma_{d\,max}) = 108.3 \text{ pcf} \quad [\rho = 1.74]$$

DETERMINE VOID RATIO AND POROSITY

$$\rho_d = \frac{G_s}{1+e}\rho_w \quad \text{(Ref: R.F. CRAIG, \underline{SOIL MECHANICS})}$$

$$e = G_s \frac{\rho_w}{\rho_d} - 1, \quad \text{ASSUME } G_s = 2.6$$

$$e = 2.6\,(1/1.74) - 1 = 0.49$$

$$\eta = e/1+e = \frac{0.49}{1.49} = 0.328$$

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By mjg Date 11/19/90 Subject UNC RECLAMATION Sheet No. 8 of
Chkd. By JWM Date 11/29/90 RADON ATTENUATION CALCS Proj. No. 86-060-24
1/4 X 1/4

DETERMINE LONG-TERM MOISTURE CONTENTS

FINE-GRAINED TAILINGS

THE LOWER 95% CONFIDENCE INTERVAL VALUE FOR MEASURED IN-SITU DATA IS 29.7% AS PRESENTED ON PAGE 2 OF TI · BRIEF

THE AVERAGE MEASURED IN-SITU MOISTURE CONTENT IS 38.7%

ASSUMING AN 60% -200 FRACTION FOR THE FINE-GRAINED TAILINGS AND USING EQ 5 FROM NRC REGULATORY GUIDE 3.64. THE LONG-TERM MOISTURE CONTENT MAY BE CALCULATED AS FOLLOWS

$$\Theta = 0.026 + 0.005 Z + 0.0158 Y \quad \text{WHERE}$$

Θ = LONG-TERM MOISTURE CONTENT
Z = -200 FRACTION (%)
Y = ORGANIC MATTER CONTENT (%)
(REF REG. GUIDE 3.64)

ASSUME Y = 0

$$\Theta = 0.026 + 0.005(60) + 0$$
$$= 0.326$$
$$= 32.6\%$$

USE THE LOWEST (MOST CONSERVATIVE VALUE) OF THESE MOISTURES. USE THE LOWER 95% CONFIDENCE INTERVAL FOR IN-SITU MOISTURES OF 29.7%. ONLY 2 SAMPLES WERE FOUND WITH LOWER MOISTURE CONTENTS. THEREFORE IT IS APPROPRIATE TO USE 29.7%

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By MJZ Date 11/19/90 Subject UNC RECLAMATION Sheet No. 9 of

Chkd. By SHM Date 11/29/90 RADON ATTENUATION CALCS Proj. No. 86-060-24

1/4 X 1/4

COARSE - GRAINED TAILINGS

THE AVERAGE MEASURED IN-SITU MOISTURE CONTENT FOR THE COARSE-GRAINED TAILINGS IS 21.5% AS PRESENTED ON PAGE 2 OF THIS CALC BRIEF.

THIS VALUE IS NOT REPRESENTATIVE OF LONG-TERM CONDITIONS, HOWEVER, AS THE COARSE TAILINGS ARE EXPECTED TO DRY FURTHER WITH TIME. LONG-TERM MOISTURE OF THE COARSE TAILINGS CAN BE EXPECTED TO APPROACH THAT OF NATURAL NEAR-SURFACE SOILS HAVING A SIMILAR PARTICLE SIZE GRADATION. A REVIEW OF PREVIOUS GEOTECHNICAL REPORTS (SHB, 1979) IDENTIFIED THE MOISTURE CONTENTS OF SIMILAR NON-TAILINGS SANDS FOUND ON-SITE. 79 SAMPLES WERE SELECTED BASED ON A SIMILAR GRADATION TO THAT OF THE COARSE TAILINGS AND THEIR MOISTURE CONTENTS WERE ANALYZED TO ESTIMATE THE LONG-TERM MOISTURE OF THE COARSE TAILINGS. THE AVERAGE MOISTURE CONTENT OF THE REPRESENTATIVE SOIL SAMPLES WAS FOUND TO BE 10.1% — ½ OF THE AVERAGE IN-SITU

LONG-TERM MOISTURE CONTENTS ARE USED TO DETERMINE DIFFUSION COEFFICIENTS. AS STATED ON PAGE 4 OF THIS BRIEF, THE DIFFUSION COEF. USED FOR COARSE TAILINGS IS MORE CONSERVATIVE THAN EVEN THAT DETERMINED BY NRC'S EMPIRICAL EQUATION USING THE DEFAULT VALUE OF 6% FOR LONG-TERM MOISTURE CONTENT.

SOIL COVER MATERIAL

LONG TERM MOISTURE FOR SOIL COVER MATERIAL WAS DETERMINED BY 4 METHODS

1) EMPIRICAL – EQ. 5, NRC REGULATORY GUIDE 3.64.

REQUIRES MINUS 200 SEIVE SIZE CONTENT OF THE SOIL. THREE TEST PITS AND 19 SOIL BORINGS HAVE BEEN PREVIOUSLY LOCATED IN SOIL COVER BORROW AREAS REPRESENTATIVE OF SOIL TO BE USED AS A RADON BARRIER INCLUDING IN PIPELINE ARROYO, ALONG THE TAILINGS EMBANKMENT, AND IN BORROW PIT #2 STOCKPILE. 50 SAMPLES FROM THESE LOCATIONS HAD GRAIN SIZE ANALYSES. ADDITIONALLY, GRAIN SIZE ANALYSES WERE PERFORMED ON SAMPLES OF SOIL COVER PLACED DURING NORTH AND CENTRAL CELL INTERIM RECLAMATION. RESULTS OF THESE ANALYSES ARE PRESENTED IN TABLES 1 THROUGH 3.

THESE GRADATIONS WERE USED TO DEVELOP AN AVERAGE GRADATION FOR THE SOIL COVER AS WELL AS AN ENVELOPE OF ACCEPTABLE GRADATIONS. THIS GRADATION ENVELOPE IS PRESENTED IN FIGURE 1. (Ref. Canonie, 1990)

FIGURE 1 SHOWS THAT THE AVERAGE SOIL COVER -200 FRACTION IS 57%.

USING EQ. 5 FROM REG GUIDE 3.64 AS PREVIOUSLY DISCUSSED

$\theta = 0.026 + 0.005(57) + 0$
$\theta = 0.31 = 31\%$

2) LABORATORY DETERMINED 15 BAR MOISTURE CONTENT

THE EQUILIBRIUM MOISTURE CONTENT AT A VACUUM OF 15 BARS IS DEFINED AS THE LONG-TERM MOISTURE. A SOIL SAMPLE WITH APPROXIMATELY THE SAME -#200 FRACTION AS THE AVERAGE SOIL WAS TESTED FOR LONG-TERM MOISTURE IN ACCORDANCE WITH ASTM-D-3152. THAT SAMPLE HAD A -#200 FRACTION OF 65%. THE LONG-TERM MOISTURE CONTENT, AS SHOWN IN ATTACHMENT A, WAS DETERMINED TO BE 13.6%.

3) LITERATURE-BASED VALUE

LINSLEY & FRANZINI REPORT THAT THE LONG-TERM MOISTURE CONTENT OF A SILTY LOAM SOIL IS APPROXIMATELY 13%. THE AVERAGE GRADATION OF THE SOIL COVER WOULD CLASSIFY AS A SILTY LOAM.

(REF LINSLEY & FRANZINI, WATER RESOURCES ENGINEERING, McGRAW HILL BOOK CO)

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By mjg Date 11/20/90 Subject UNC RECLAMATION Sheet No. 12 of

Chkd. By SWM Date 11/29/90 RADON ATTENUATION CALCS Proj. No. 86-060-24

1/4 X 1/4

4) IN-SITU MOISTURE CONTENTS

11A SAMPLES OF REPRESENTATIVE SOIL COVER BORROW MATERIALS WERE ANALYZED FOR IN-SITU MOISTURE CONTENTS. THE AVERAGE IN-SITU MOISTURE CONTENT WAS DETERMINED TO BE 13.4%

(REF: JUNE 1988 RESPONSE TO NRC COMMENTS)

USE THE CONSERVATIVE VALUE OF 13.4% FROM IN-SITU TESTS. THIS IS LOWER THAN BOTH THE RESULT OBTAINED USING NRC'S EMPIRICAL EQUATION (57%) AND ASTM-D-3152 AT -15 BARS (13.6%).

DETERMINE RADON ATTENUATION PARAMETERS OF THE SOIL COVER.

ASSUME THE RADIUM CONTENT OF THE COVER SOIL IS 0 pCi/g per NRC REG GUIDE 3.64 GUIDANCE (page 10, REG GUIDE 3.64).

THEN THE SOURCE TERM IS 0. INPUT 0 pCi/cm² sec FOR SOIL COVER SOURCE TERM IN RADON MODEL.

DETERMINE DIFFUSION COEFFICIENT

$$D = 0.07\,e^{-4(m - mn^2 + m^5)} \quad \text{(REG GUIDE 3.64)}$$

CALCULATE MOISTURE SATURATION FRACTION

$$m = \frac{10^{-2}\,\rho_c\,w_c}{n_c\,\rho_w}$$

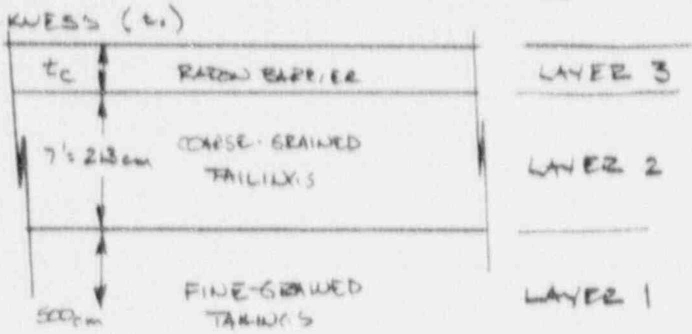
$$= \frac{10^{-2}\,(108.3)(13.4)}{(0.328)(62.4)}$$

$$= 0.709$$

$$D = 0.07\,e^{-4(0.709 - 0.709(0.328)^2 + 0.709^5)}$$

$$= 0.0027 \text{ cm}^2/\text{sec}$$

INPUT APPROPRIATE VALUES INTO RADON MODEL FOR THE FOLLOWING SOIL COVER PROFILE TO CALCULATE COVER THICKNESS (t_c)



THE COMPUTER RUN FOR THE RADON MODEL - SHOWING INPUT & OUTPUT - FOLLOWS:

✓ Swm 11/20/90

-----*****| RADON |*****-----

Version 1.2 - MAY 22, 1989 - G.F. Birchard tel.# (301)492-7000
U.S. Nuclear Regulatory Commission Office of Research

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

UNC RECLAMATION SOIL COVER DESIGN - [illegible]

CONSTANTS

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

GENERAL INPUT PARAMETERS

LAYERS OF COVER AND TAILINGS	[illegible]	
DESIRED RADON FLUX LIMIT	20	pCi m^-2 s^-1
NO. OF THE LAYER TO BE OPTIMIZED	[illegible]	
DEFAULT SURFACE RADON CONCENTRATION	0	pCi l^-1
SURFACE FLUX PRECISION	.01	pCi m^-2 s^-1

LAYER INPUT PARAMETERS

LAYER 1 FINE-GRAINED TAILINGS

THICKNESS	500	cm
POROSITY	.56	
MEASURED MASS DENSITY	1.38	g cm^-3
MEASURED RADIUM ACTIVITY	798	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.32	
CALCULATED SOURCE TERM CONCENTRATION	1.321D-03	pCi cm^-3 s^-1
WEIGHT % MOISTURE	29.7	%
MOISTURE SATURATION FRACTION	.732	
MEASURED DIFFUSION COEFFICIENT	.0053	cm^2 s^-1

LAYER 2 COARSE-GRAINED TAILINGS

THICKNESS	213	cm
POROSITY	.47	
MEASURED MASS DENSITY	1.56	g cm^-3
MEASURED RADIUM ACTIVITY	183	pCi/g^-1
MEASURED EMANATION COEFFICIENT	.27	
CALCULATED SOURCE TERM CONCENTRATION	3.444D-04	pCi cm^-3 s^-1
WEIGHT % MOISTURE	10.1	%
MOISTURE SATURATION FRACTION	.335	
MEASURED DIFFUSION COEFFICIENT	.047	cm^2 s^-1

✓ SWM 11/24/90

LAYER 3   SOIL COVER

THICKNESS	50	cm
POROSITY	.328	
MEASURED MASS DENSITY	1.74	g cm^-3
MEASURED RADIUM-226 CONCENTRATION	0	pCi g^-1
WEIGHT % MOISTURE	13.4	%
MOISTURE SATURATION FRACTION	.711	
MEASURED DIFFUSION COEFFICIENT	.0027	cm^2 s^-1

BARE SOURCE FLUX FROM LAYER 1: [illegible] pCi m^-2 s^-1

RESULTS OF THE RADON DIFFUSION CALCULATIONS

LAYER	THICKNESS (cm)	EXIT FLUX (pCi m^-2 s^-1)	EXIT CONC. (pCi l^-1)
1	5.000D+02	2.493D+02	2.027D+05
2	2.130D+02	3.962D+01	2.202D+05
3	4.710D+01	1.987D+01	0.000D+00

47.1 cm = 1.5 ft

TABLES

TABLE #1

SUMMARY OF GEOTECHNICAL PROPERTIES
NORTH AND CENTRAL CELL INTERIM COVER SOILS

Estimated Borrow Volume: 45,000 cubic yards

Sample Identification	Depth of Sample	Liquid Limit	Plasticity Index	Unified Soil Classification	Percent Passing (U.S. Standard Sieve Size Numbers) 200	100	40	10	4	3/8	3/4
North Cell:											
89 NC-1	0-5	26	10	CL	61	80	94	96	96		100
89 NC-2	0-5	--	NP	SM	47	70	92	98	99	100	
89 NC-3	0-5	27	10	CL	61	84	95	98	100		
89 NC-4	0-4	33	16	CL	70	89	97	99	100		
89 NC-5	0-1	--	NP	SM	45	69	99	100			
89 NC-6	0-1	25	8	CL	56	76	87	92	97	100	
89 NC-7	0-2	27	8	SC - SM	48	63	70	74	79	86	93
89 NC-8	0-1	31	13	CL	63	80	96	97	98	99	100
89 NC-9	0-1	34	17	CL	60	85	98	99	100		
89 NC-10	0-1	--	NP	SM	20	25	43	48	56	63	73
89 NC-11	0-1	22	7	SC - SM	43	63	90	98	99	99	100
89 NC-12	0-1	43	21	CL	63	82	100				
Central Cell:											
90 CC-1	SURFACE	27	9	CL	60	83	94	96	97	99	100
9[illegible] CC-2	SURFACE	32	16	CL	61	84	96	99	100		
90 CC-3	SURFACE	35	15	CL	65	86	96	98	99	100	
90 CC-4	SURFACE	30	15	CL	68	86	96	98	99	100	
90 CC-5	SURFACC	31	11	CL	66	87	96	98	99	100	
90 CC-6	SURFACE	26	12	SC	48	56	90	93	94	96	98
90 CC-7	SURFACE	26	8	CL	59	85	95	97	98	99	100
				Average:	56.0	75.4	90.7	93.6	95.3	96.9	98.1
				Standard Deviation:	11.9	15.5	13.3	12.4	10.6	8.82	6.30
				95 Percent Confidence Level (+/-):	5.33	6.96	5.97	5.59	4.78	3.97	2.03

Notes:

1. NP = Non-plastic.
2. All results listed above are laboratory test results obtained from the "North Cell Interim Stabilization As-Built Report" dated January 1990 and preliminary field data from the Central Cell Interim Stabilization.

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TABLE 2

SUMMARY OF GEOTECHNICAL PROPERTIES
PIPELINE ARROYO BORROW MATERIAL

Estimated Borrow Volume: 300,000 cubic yards

Sample Identification	Depth of Sample	Liquid Limit	Plasticity Index	Unified Soil Classification	Grain-Size Analysis (U.S. Standard Sieve Size Numbers) Percent Passing 200	100	40	10	4	3/8	3/4
74 SHB-2	10	38	20	CL	92	98	99	99	100		
78 SHB-7	2.5-4.5	26	5	ML-CL	57	84	99				
	6.0-7.7	--	NP	SM	31	67	99				
78 SHB-8	9.5-10.5	31	14	CL	63	84	96	98	100		
78 SHB-13	0-1.5	22	1	SM	49	81	99				
78 SHB-14	0-1.5	28	12	CL	57	80	91	94	95	99	100
78 SHB-30	9.5-11	--	NP	SM	23	74	100				
78 SHB-31	4.5-6	29	14	CL	55	79	90	95	98	100	
78 SHB-42	4.5-6	28	14	CL	65	74	82	87	92	96	100
86-RP-P2	10.5-11	NT	NT	CL	100						
86-RP-P3	10.5-11	NT	NT	SM	66	96	100				
86-RP-P4	5.5-6	NT	NT	SM-ML	32	56	84	97	98	100	
86-RP-P5	0-3	NT	NT	ML	65	86	98	99	100		
86-RP-P5	3-6	NT	NT	ML	68	87	98	99	99	100	
86-RP-P5	6-6.5	NT	NT	SM	48	83	95	97	98	100	
86-RP-P6	0-3	NT	NT	CL	70	89	98	99	100		
86-RP-P6	3-6	NT	NT	SM	51	80	97	98	99	99	100
86-RP-P8	11-11.5	NT	NT	ML	93	99	100				
86-RP-TP1	5-6	NT	NT	SM	18	32	87	97	98	100	
86-RP-TP2	6-7	NT	NT	SM-ML	40	67	95	97	98	100	
86-RP-TP3	0-10	NT	NT	CL-ML	85	97	99	100			
				Average:	58.5	80.6	95.5	97.9	98.8	99.7	100.0
				Standard Deviation:	22.5	16.0	5.48	3.05	2.02	0.90	0.0
				95 Percent Confidence Level (+/-):	9.61	6.84	2.34	1.30	0.86	0.39	0.0

Notes:

1. NT = Not tested.
2. NP = Non-plastic.
3. Data also include the South Diversion Ditch and the Runoff Control Ditch material.

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TABLE 3

SUMMARY OF GEOTECHNICAL PROPERTIES
EXISTING SOIL STOCKPILE

Estimated Borrow Volume: 100,000 cubic yards

Boring Identification	Depth of Sample	Liquid Limit	Plasticity Index	Unified Soil Classification	Grain-Size Analysis (U.S. Standard Sieve Size Numbers) Percent Passing 200	100	40	10	4	3/8	3/4
78 SHB-18	4.5	26	11	CL	52	79	90	95	99		100
	14.5	32	11	CL	92	98	99	100			
78 SHB-19	4.5	22	NP	SM	41	64	82	88	94	98	100
78 SHB-31	9.5	26	11	CL	52	83	98	99	100		
78 SHB-33	4.5	27	9	CL	51	77	98	100			
	14.5	21	NP	SM	47	86	99	100			
78 SHB-32	4.5	--	NP	SM	29	70	96	100			
89 SS-1	SURFACE	--	NP	ML	55	80	97	99	100		
90 SS-1	SURFACE	23	3	SC-SM	50	79	92	94	96	98	100
90 SS-2	10.5-12.5	26	7	ML-CL	54	84	94	97	98	100	
				Average:	52.3	80.0	94.5	97.2	98.7	99.6	100.0
				Standard Deviation:	16.0	9.1	5.34	3.91	2.11	0.84	0.0
				95 Percent Confidence Level (+/-):	9.92	5.64	3.31	2.42	1.31	0.52	0.0

Note: NP = Non-plastic.

✓ Swm 11/29/90

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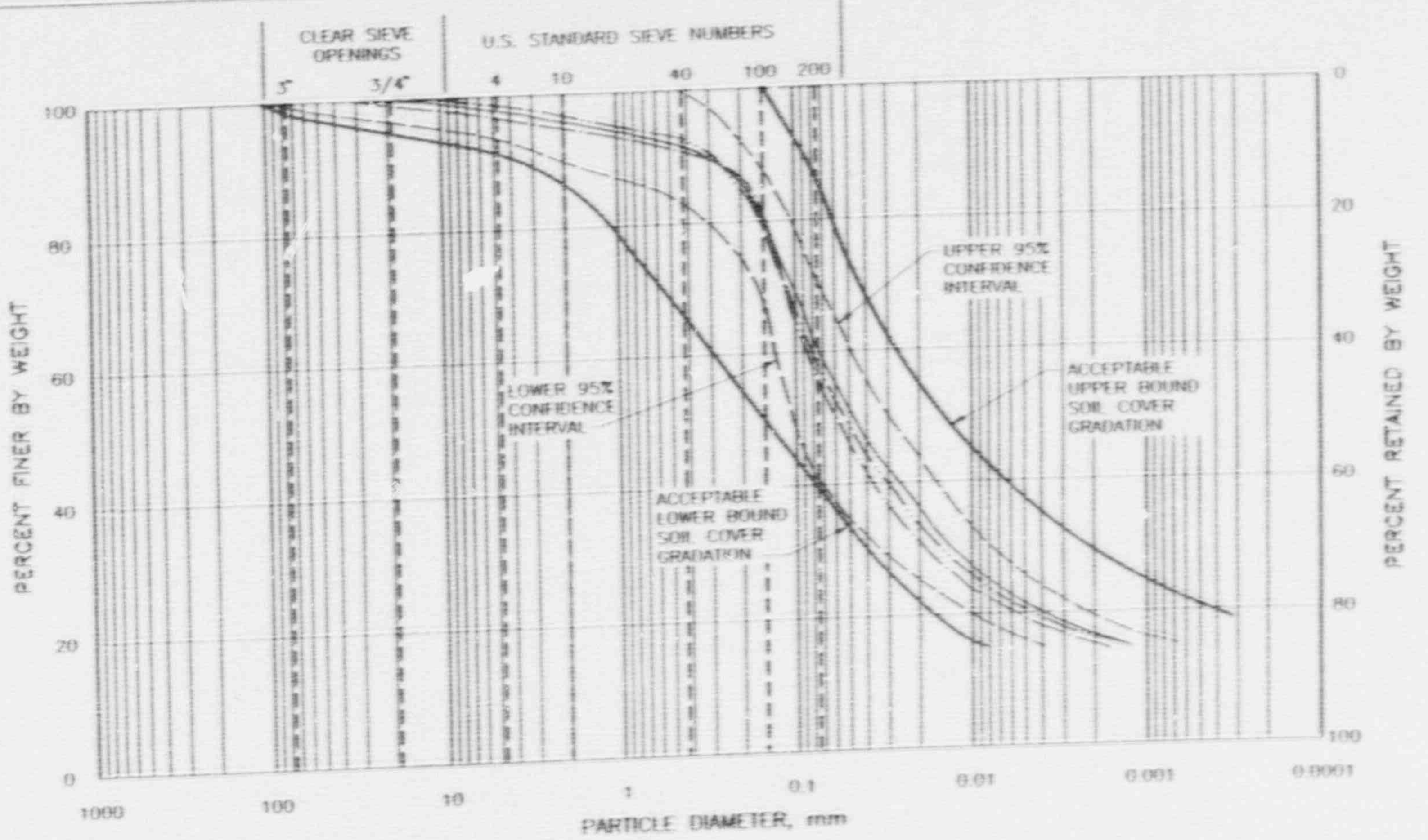
By mjz Date 11/26/90 Subject UNC RECLAMATION Sheet No. ___ of ___
Chkd. By SWM Date 11/29/90 Radon Attenuation Calcs Proj. No. 86-060-24
1/4 X 1/4

FIGURES

✓ SWM 11/29/90

DRAWING NUMBER 86-080-B393



NOTE:

1. AVERAGES DERIVED FROM AVAILABLE FIELD AND LABORATORY TEST DATA TO DATE IN DESIGNATED BURROW AREAS.

LEGEND:

- AVERAGE PIPELINE ARROYO BORROW SOILS
- AVERAGE NORTH AND CENTRAL CELLS INTERIM COVER SOILS
- AVERAGE EXISTING SOIL STOCKPILE SOILS

ACCEPTABLE SOIL COVER GRAIN SIZE ENVELOPE

PREPARED FOR

UNC MINING AND MILLING
GALLUP, NEW MEXICO

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FIGURE 1

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By MJM Date 11/26/90 Subject UNC RECLAMATION Sheet No. ___ of ___
Chkd. By SWM Date 11/29/90 Radon Attenuation Calcs Proj. No. 86-060-21
1/4 X 1/4

ATTACHMENT A

Chen & Associates
Consulting Engineers and Scientists

96 South Zuni
Denver Colorado 80223
303/744-7105

Casper
Cheyenne
Colorado Springs
Fort Collins
Glenwood Springs
Rock Springs
Salt Lake City
San Antonio

August 31, 1988

Subject: Laboratory Testing, Canonie Project No. 86-060-04

Job No. 1 719 88

Mr. Matthew J. Yovich
Canonie Environmental Services Corporation
94 Inverness Terrace East, Suite 10,
Englewood, Colorado 80112

Dear Mr. Yovich:

As requested, we have performed gradation analyses on four soil samples received July 27, 1988, at our Denver laboratory. These results are presented on Figs. 1 and 2. In addition, we have performed a Harvard miniature compaction test (Fig. 3) and a capillary-moisture relationship test (Table I and Fig. 4) on Sample No. 88-RP-P-5 at 0 to 3 feet. All testing assigned to date has been completed.

If you have any questions or need further assistance, please feel free to call.

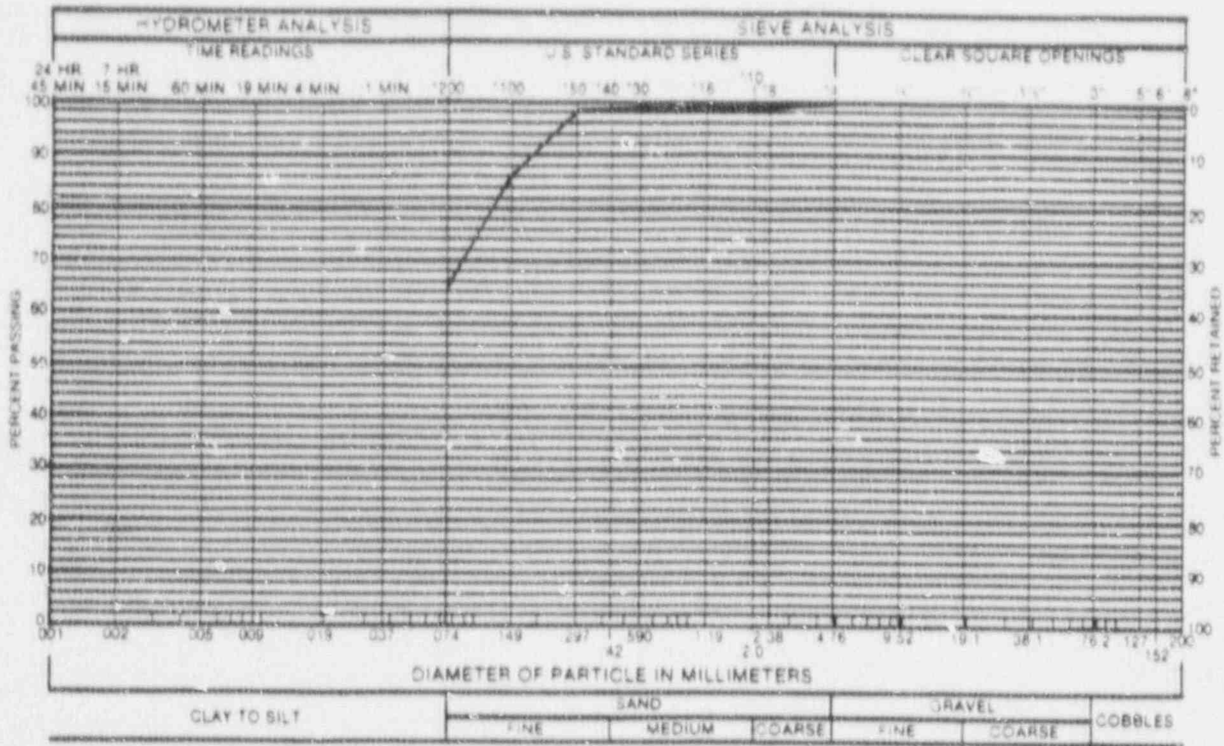
Sincerely,

CHEN & ASSOCIATES, INC.

By Sally K. Miller
Sally K. Miller, A.E.T.
Soils Laboratory Supervisor

SKM/djb
Rev. By: KRC

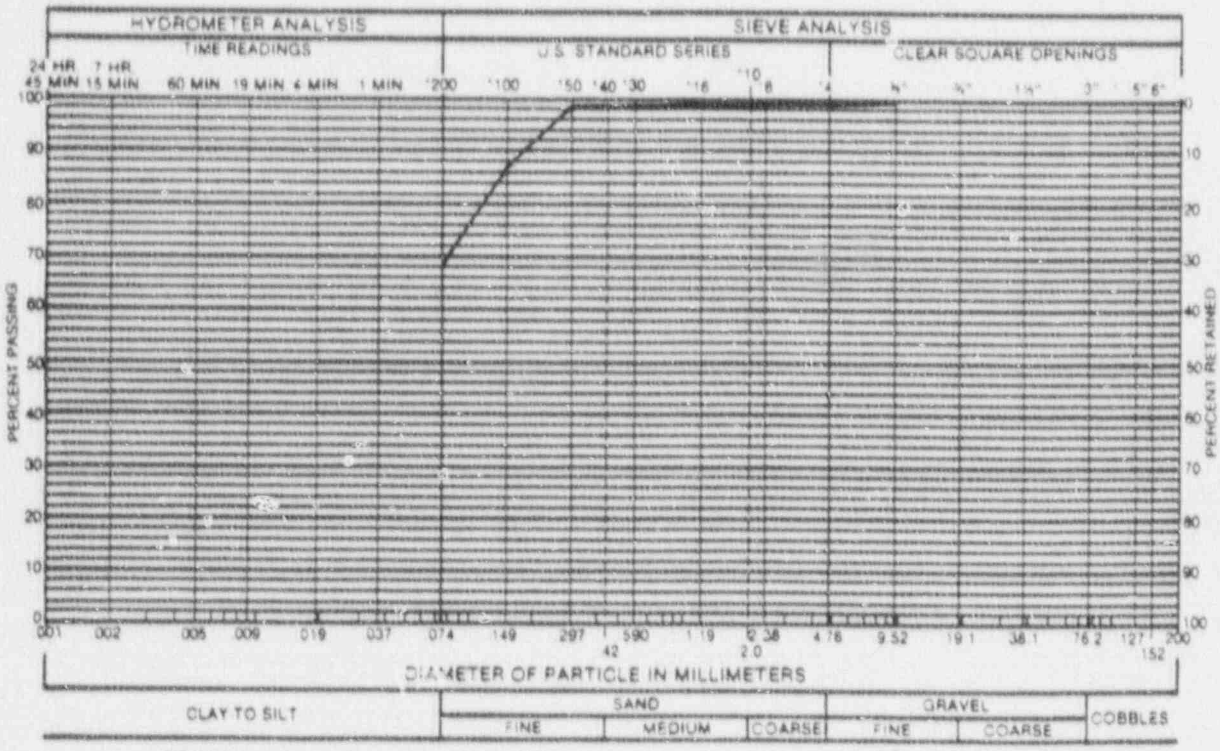
chen and associates, inc.



GRAVEL 0 % SAND 35 % SILT AND CLAY 65 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM Hole 88-RP-P-5 at depth 0' to 3'



GRAVEL 1 % SAND 31 % SILT AND CLAY 68 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM Hole 88-RP-P-5 at depth 3' to 6'

1 719 88

GRADATION TEST RESULTS

Fig. 1

CA-2-79

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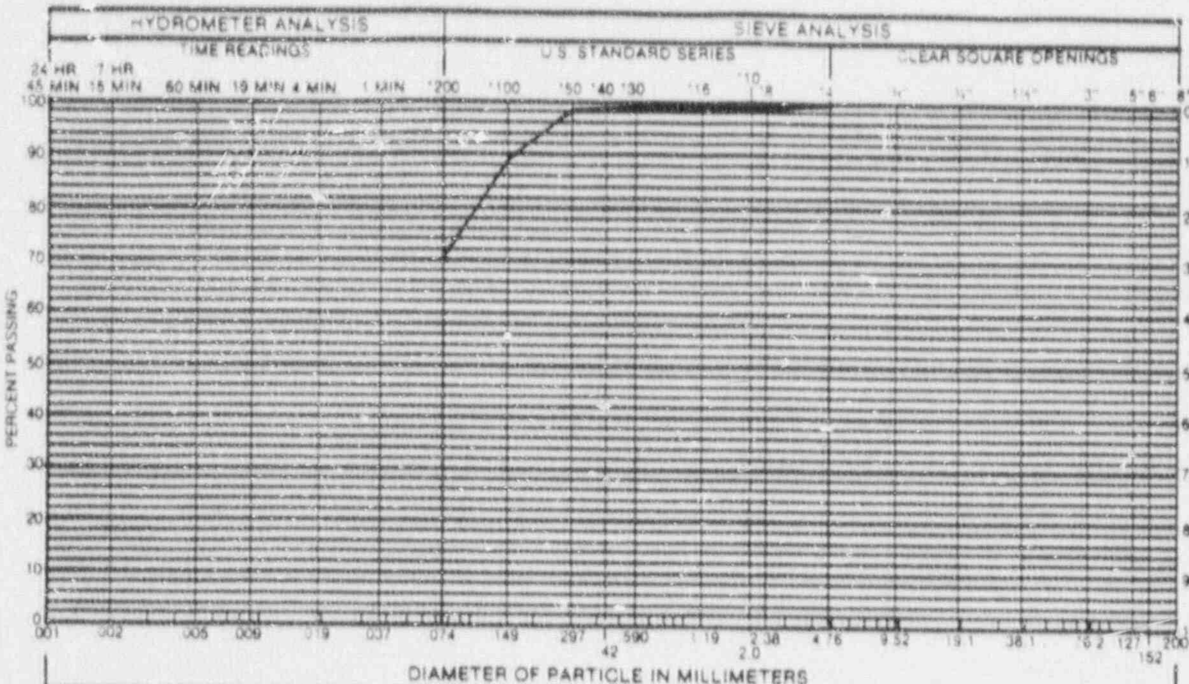
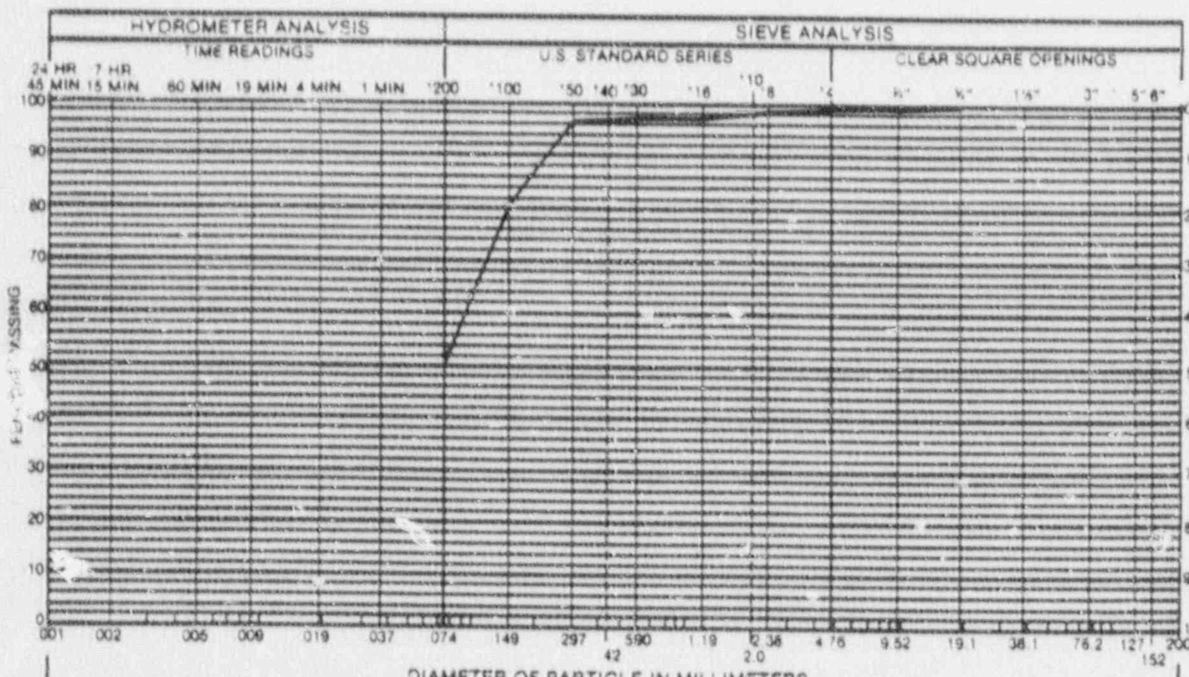


CLAY TO SILT	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

GRAVEL 0 % SAND 30 % SILT AND CLAY 70 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM Hole 88-RP-P-6 at depth 0' to 3'



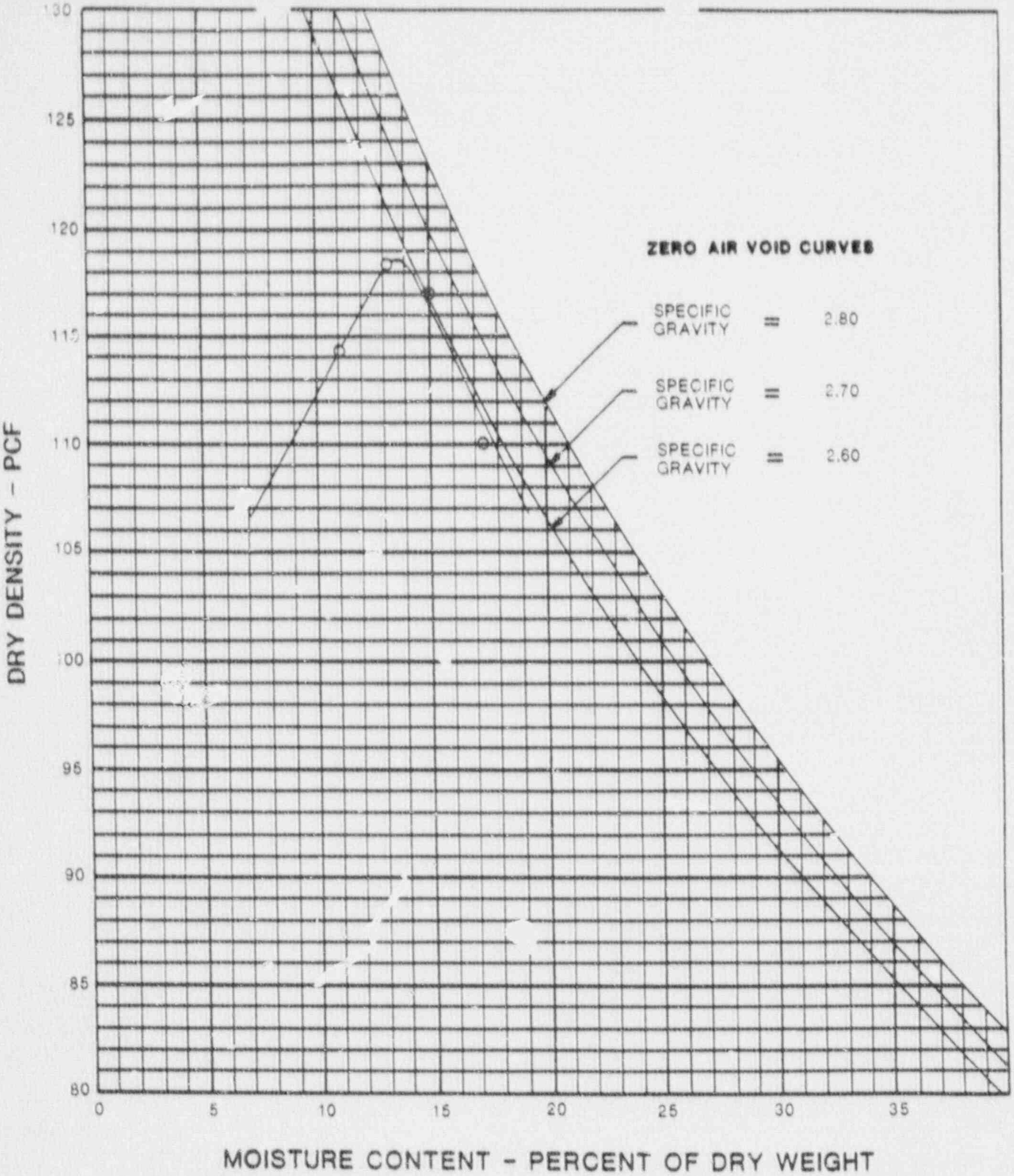
CLAY TO SILT	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

GRAVEL 1 % SAND 48 % SILT AND CLAY 51 %

LIQUID LIMIT % PLASTICITY INDEX %

SAMPLE OF FROM Hole 88-RP-P-6 at depth 3' to 6'

1 ?1? 88 GRADATION TEST RESULTS Fig. 2



LOCATION :	MOISTURE-DENSITY RELATIONSHIPS
HOLE NO. : 88-RP-P-5 DEPTH : 0'-3' SAMPLE NO. :	
SOIL DESCRIPTION :	Chen & Associates
MAX. DRY DENSITY : 118.5 PCF OPT. MOIST. CONTENT : 13.6 %	PROCEDURE : HARVARD MINIATURE
LIQUID LIMIT : PLASTICITY INDEX :	JOB NO. : 1 719 88 / FIG. NO.
GRAVEL : 0 % SAND : 35 % SILT AND CLAY (-200) : 65 %	DATE : August 3, 1988 / 3

August 31, 1988
#86-060-04
Job No. 1 719 88

CHEN AND ASSOCIATES, INC.

TABLE I

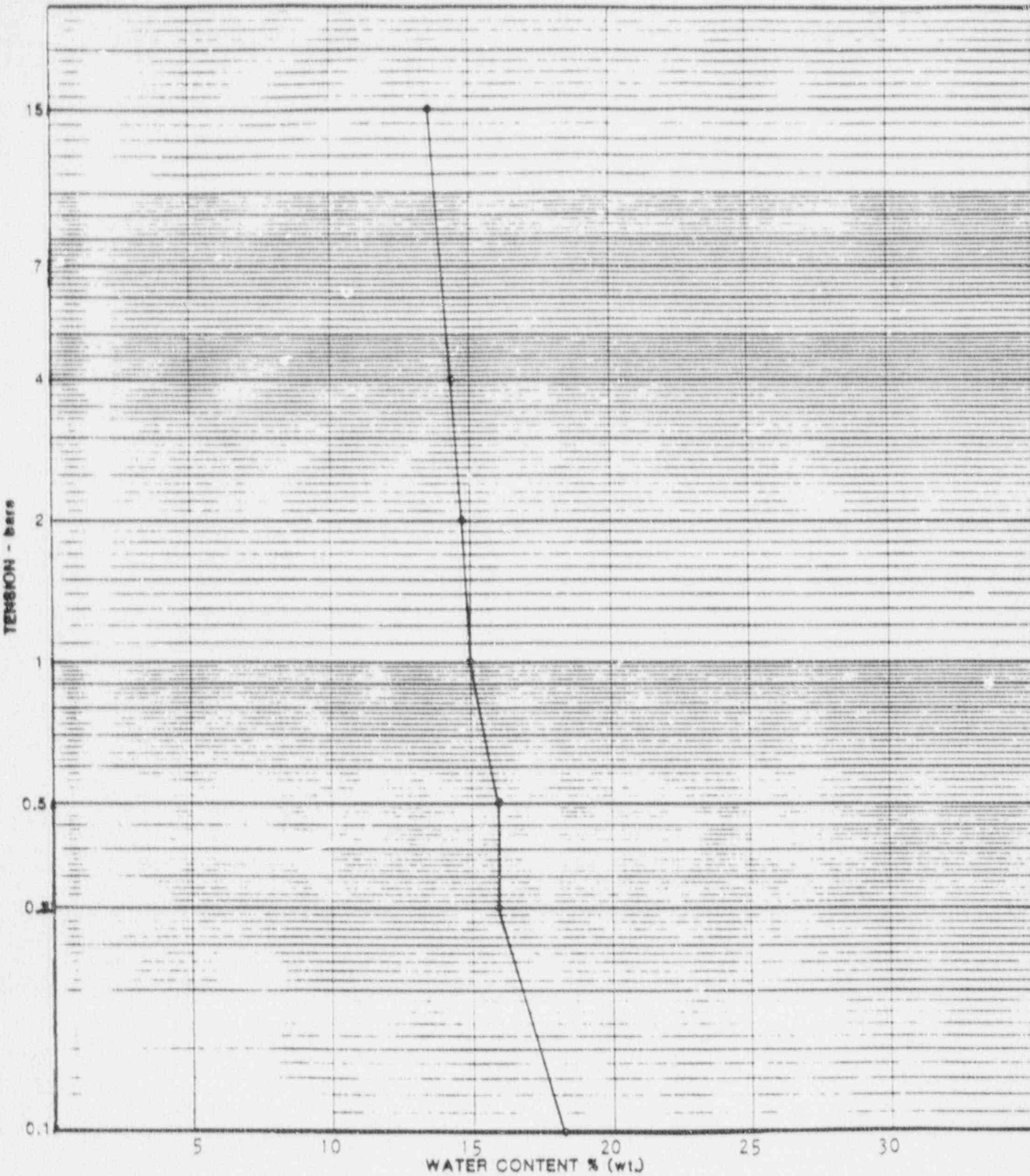
Summary of Capillary-Moisture Relationship Test Results

Sample No. 88-RP-P-5 @ 0-3'

Average Initial Moisture
Content, % = 14.6

Average Initial Dry Density, pcf = 112.6

Tension, bars	Moisture Content, %
0.1	18.29
0.3	15.89
0.5	16.00
1.0	14.96
2.0	14.88
4.0	14.43
15.0	13.63



LOCATION: ______

HOLE: P-5 DEPTH: 0-3' SAMPLE NO: ______

DESCRIPTION: Sandy Clay Average DRY DENSITY pcf: 112.6 Average WATER CONTENT %: 14.6

LIQUID LIMIT: - PLASTIC LIMIT: - PLASTIC INDEX: - -200: 65

1 719 88	**Chen & Associates**	CAPILLARY-MOISTURE RELATIONSHIPS	Fig. 4

APPENDIX C

PIPELINE ARROYO HYDROLOGY

HEC-2 ANALYSIS FOR PMF

CANONIE ENVIRONMENTAL

By: SWM | Date: 11-29-90 | Subject: UNC Gallup, New Mexico Pipeline Arroyo Redesign

Checked By: GS/12-03-90 | Project #: 86-060-24 |

Purpose:

This calculation brief presents a description and HEC-2 analysis of Alternative #7 (recommended redesign alternative for Pipeline Arroyo). More specifically, the design assumptions, summary, and HEC-2 input/output for Alterative #7 are included.

The HEC-2 analysis for Alternative #7 involved two separate runs of the HEC-2 program. The first HEC-2 run represents subcritical flow in Reaches #1 &#2 (flatter slopes) of the reconfigured channel. The second HEC-2 run represents supercritical flow in Reach #3 (steeper slopes) of the reconfigured channel.

The cross sections used in the HEC-2 analysis are shown on the enclosed maps (Figures #1A &#1B).

Method:

The U.S. Army Corps of Engineers' HEC-2 computer model for open channel flow was utilized to analyze the reconfigured channel.

Results:

- See the HEC-2 output that is included at the end of this calculation brief.

- See Figure #2 on page #4 for relationship (profile view) between the following elevations:

  1) Bench Top

  2) Embankment Top

  3) Bench Toe

  4) Channel Bottom

  5) PMF Maximum Water Surface Elevation

Assumptions: The following assumptions were made in the design process:

- the reference line used in all alternatives is the centerline for the present channel design under the existing reclamation plan. All station numbers refer to stations along this line, which is plotted on the enclosed maps.
- The sandstone outcrop located at @Sta 62+70 is known as the Nickpoint.
- Reach #1 is defined as that part of the channel that is located between Sta 0+00 to Sta 40+00.
- Reach #2 is defined as that part of the channel that is located between Sta 40+00 to Nickpoint.
- Reach #3 is defined as that part of the channel that is located between the Nickpoint and Sta 85+70 (end of channel).

Summary of Alternative #7:

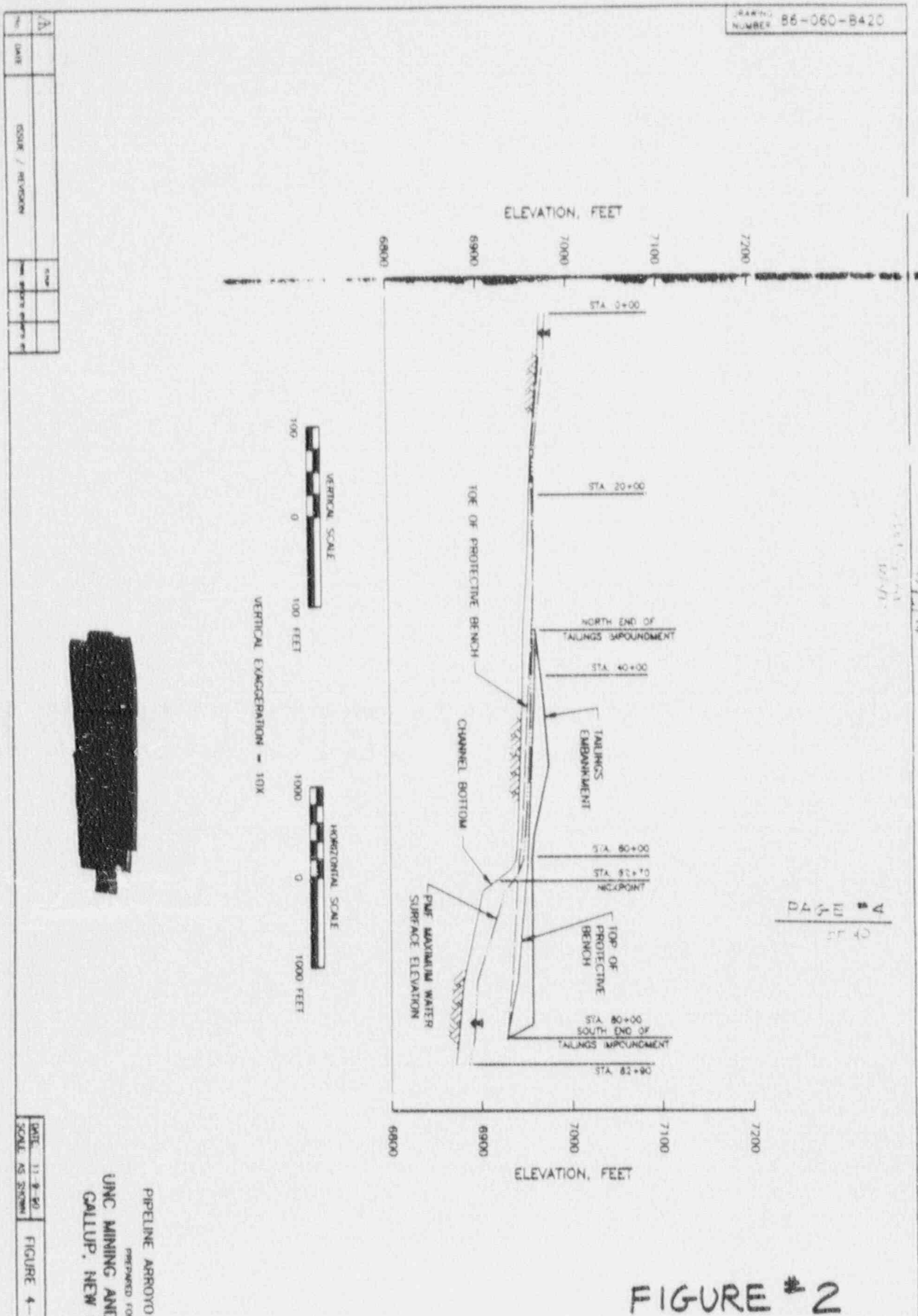
In Alternative #7, the channel is modified only slightly from the existing configuration as follows:

- ensure a 30' wide, 2' deep channel bottom from Sta 5+00 to Sta 61+70 (i.e. low-flow channel)

- Fill existing depressions and headcuts

- a stone filled trench (jetty) will be installed at Sta 59+50 to reinforce the Nickpoint and maintain shallow upstream slopes.

- a 40' wide protective bench will be constructed at the tailings embankment toe which would protect the embankment and tailings during the PMF.



PAGE #4

FIGURE #2

ALTERNATIVE #7

[illegible]
REACHES #1 + #2
CORRECTED

```
*****************************************************         ****************************************
* WATER SURFACE PROFILES                              *         * U.S. ARMY CORPS OF ENGINEERS         *
* VERSION OF SEPTEMBER 1988                           *         * THE HYDROLOGIC ENGINEERING CENTER    *
* ERROR: 01,02,03,04                                  *         * 609 SECOND STREET, SUITE D           *
* UPDATED:  JUNE 1990                                 *         * DAVIS, CALIFORNIA 95616-4687         *
* RUN DATE    11/23/90       TIME   23:03:22          *         *                                      *
*****************************************************         ****************************************
```

BY SNM
12/2/90
Chkd By: GS
12/3/90

p. 5 of 40

```
X     X  XXXXXXX   XXXXX             XXXXX
X     X  X        X     X           X     X
X     X  X        X                       X
XXXXXXX  XXXX     X          XXXXX   XXXXX
X     X  X        X                 X
X     X  X        X     X           X
X     X  XXXXXXX   XXXXX            XXXXXXX
```

```
:::::::::::::::::::::::::::::::::::::::::::::::::::
:::::::::::::::::::::::::::::::::::::::::::::::::::
:::                                             :::
:::    FULL MICRO-COMPUTER IMPLEMENTATION       :::
:::                                             :::
:::::::::::::::::::::::::::::::::::::::::::::::::::
:::::::::::::::::::::::::::::::::::::::::::::::::::
```

REACHES #1 + #2

```
******************************
H A E S T A D   M E T H O D S
******************************
```

37 Brookside Road * Waterbury, Connecticut 06708 * (203) 755-1666

END OF BANNER

Chkd. By: GS
12/03/90

THIS RUN EXECUTED 11/26/90   18:20:33

****

HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

ERROR CORR - 01,02,03,04
MODIFICATION -

****

p. 6 of 40

T1 ALTERNATIVE #7--REACH 1&2--Q=26300 CFS
T2 UNC PROJECT NO. 86-060-24 RESP. TO NRC COMMENTS 11/7/90
T3 PIPELINE ARROYO SUBCRITICAL FLOW

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	0	0	0	0.04	0	0	26300	6950	0

NC	0.036	0.036	0.03							
X1	61.40	17	250	676	0	0	0			
GR	6960	0	6956	56	6950	127	6945	250	6940	260
GR	6935	270	6933	275	6933	300	6937	310	6937	480
GR	6942	600	6942	650	6942	660	6942	676	6951.5	727.5
GR	6951.5	767.5	6957	792						
X1	60.40	10	110	515	160	130	100			
GR	6960	0	6950	110	6939	115	6939	140	6941.5	145
GR	6943	515	6943	530	6952	572.5	6952	612.5	6957	632
X1	57.75	16	145	543	270	295	262			
GR	6960	0	6955	35	6950	90	6945.5	145	6941	155
GR	6941	185	6945	195	6945	230	6945	270	6945	295
GR	6945	330	6945	375	6945	543	6953.5	587.5	6953.5	627.5
GR	6960	660								
X1	50.00	14	456	712	750	850	775			
GR	6975	0	6970	10	6965	30	6960	100	6950	140
GR	6950	320	6950	456	6944	532	6944	562	6950	650
GR	6950	712	6957	746	6957	785	6976	880		
X1	41.95	12	535	772	820	800	805			
GR	6970	0	6965	70	6960	165	6955	235	6950	535
GR	6947	567	6947	587	6953.5	700	6953.5	772	6960.5	810
GR	6960.5	850	6970	905						
X1	35.00	9	215	780	700	700	705			
GR	6970	0	6960	145	6956	215	6948.7	583	6948.7	613
GR	6958	710	6958.5	780	6962.5	800	6962.5	840		
X1	30.10	21	135	980	495	1140	490			
GR	6970	0	6960	135	6965	565	6952	575	6952	605
GR	6955	615	6955	660	6955	765	6956	800	6955	850
GR	6955	880	6956	980	6958	990	6960	1000	6960	1070
GR	6962	1422	6962.4	1510	6964.5	1680	6966.5	1795	6968	1900
GR	6970	1910								

EY GNM
12/3/90
Chkd By: GS

p. 7/40

X1	24.95	26	795	1800	560	540	520			
GR	7000	0	6990	45	6980	140	6970	275	6960	545
GR	6960	615	6960	795	6955	865	6953	865	6953	895
GR	6955	895	6955	1175	6955	1295	6955	1385	6955	1715
GR	6958	1770	6960	1800	6960	1970	6962	2060	6964	2070
GR	6966	2080	6968	2090	6970	2100	6980	2150	6990	2165
GR	7000	2230								
X1	15.05	15	690	795	910	1180	990			
GR	7000	0	6990	35	6980	105	6970	210	6960	690
GR	6959	710	6959	740	6960	795	6960	1520	6975	1575
GR	6980	1600	6985	1620	6990	1645	6995	1660	7000	1690
X1	4.85	14	820	1155	1035	1070	1022			
GR	6980	0	6970	820	6970	890	6968	890	6968	920
GR	6970	920	6970	930	6970	950	6970	1000	6970	1030
GR	6970	1060	6970	1105	6970	1155	6980	1540		

p. 8/40

```
SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

*PROF 1

*SECNO 61.400
3720 CRITICAL DEPTH ASSUMED
    61.400     10.32   6943.32   6943.32   6950.00   6945.77      2.45       .00       .00   6945.00
   26300.0        .0   26286.8      13.2        .0    2090.3       4.7        .0        .0   6942.00
       .00       .00     12.58      2.80      .000      .030      .035      .000   6933.00    253.36
   .007727        0.        0.        0.         0        18         0       .00    429.80    683.16

*SECNO 60.400
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    60.400      7.99   6946.99   6946.99       .00   6949.47      2.48       .79       .00   6950.00
   26300.0        .0   25507.0     793.0        .0    2000.7      97.3       4.8       1.0   6943.00
       .00       .00     12.75      8.15      .000      .030      .035      .000   6939.00    111.37
   .007987      160.      100.      130.        20        15         0       .00    437.46    548.83

*SECNO 57.750
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    57.750      8.64   6949.64   6949.64       .00   6952.05      2.41      2.05       .00   6945.50
   26300.0     626.4   25313.3     360.3     104.5    2002.5      56.3      17.7       3.8   6945.00
       .01      5.99     12.64      6.40      .035      .030      .035      .000   6941.00     94.45
   .007597      270.      262.      295.        20         8         0       .00    472.82    567.27

*SECNO 50.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.60

    50.000     10.33   6954.33       .00       .00   6955.52      1.20      3.48       .00   6950.00
   26300.0    8537.4   17593.8     168.8    1401.0    1787.5      44.2      65.4      13.3   6950.00
       .03      6.09      9.84      3.82      .035      .030      .035      .000   6944.00    122.69
   .002981      750.      775.      850.         3         0         0       .00    609.72    732.41
```

p. 9/40

```
 SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
 Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
 TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
 SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


*SECNO 41.950
   41.950      9.92   6956.92       .00       .00   6958.39      1.47      2.86       .00   6950.00
  26300.0    9943.8   16232.2     123.9    1350.5    1481.8      31.7     122.2      24.5   6953.50
      .06      7.36     10.95      3.91      .035      .030      .035      .000   6947.00    208.18
  .004254      820.      805.      800.         3         0         0       .00    582.37    790.54


*SECNO 35.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.62

   35.000     10.68   6959.38       .00       .00   6960.13       .75      1.74       .00   6955.00
  26300.0     386.5   25911.6       1.9     134.4    3709.7       1.9     176.4      34.3   6958.50
      .08      2.88      6.98       .98      .035      .030      .035      .000   6948.70    153.66
  .001619      700.      705.      700.         2         0         0       .00    630.75    784.41


*SECNO 30.100
   30.100      8.40   6960.40       .00       .00   6961.22       .82      1.09       .00   6960.00
  26300.0        .9   26026.9     272.2       1.1    3557.5      90.0     219.2      44.7   6956.00
      .10       .82      7.32      3.02      .035      .030      .035      .000   6952.00    129.61
  .003213      495.      490.     1140.         3         0         0       .00   1010.69   1140.30


*SECNO 24.950

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.36

   24.950      8.57   6961.57       .00       .00   6961.81       .24       .59       .00   6960.00
  26300.0     570.0   25313.9     416.1     426.0    6286.2     322.6     203.3      60.2   6960.00
      .14      1.34      4.03      1.29      .035      .030      .035      .000   6953.00    502.59
  .000577      560.      520.      540.         2         0         0       .00   1538.10   2040.69


*SECNO 15.050
```

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3301 HV CHANGED MORE THAN HVINS

0.10/40

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

15.050	4.03	6963.03	6963.03	.00	6964.48	1.45	1.61	.00	6960.00
26300.0	1277.3	4707.3	20315.4	220.3	385.6	2213.4	400.2	90.6	6960.00
.17	5.80	12.21	9.18	.035	.030	.035	.000	6959.00	544.57
.010721	910.	990.	1180.	20	14	0	.00	986.54	1531.11

*SECNO 4.850
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

4.850	6.56	6974.56	6974.56	.00	6976.23	1.67	9.03	.00	6970.00
26300.0	5277.9	18544.5	2477.6	851.3	1586.5	399.7	468.2	113.1	6970.00
.20	6.20	11.69	6.20	.035	.030	.035	.000	6968.00	446.36
.007113	1035.	1022.	1070.	3	14	0	.00	884.08	1330.43

p.___/40

```
PROFILE FOR STREAM  INE ARROYO SUBCRITICAL F


PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,*-LOWER END STA


ELEVATION  6933.     6938.     6943.     6948.     6953.     6958.     6963.     6968.     6973.     6978.
    SECNO   CUMDIS

    61.40     0.   I         .       R.W   L E   .         .       * .         .         .         .         .         .
    60.40   100.   .         . I       R       W . EL      .       * .         .         .         .         .         .
           200.   .         .   I     .R       WL    E    .         *         .         .         .         .         .
           300.   .         .    I    .  R   L  .W    E   .         .  *      .         .         .         .         .
    57.75   400.   .         .     I   .   RL    . W     E .         .   *     .         .         .         .         .
           500.   C         .      I  .    RL   .   W    E.         .       * .         .         .         .         .
           600.   C         .       I .      L  .     W   E         .         .*        .         .         .         .
           700.   C         .       I .       L .      W  .E        .         .     *   .         .         .         .
           800.   C         .        I.        RL       W . E       .         .        *.         .         .         .
           900.   C         .         I         RL       W.  E      .         .         .  *      .         .         .
          1000.   C         .         .I        . L       .W E      .         .         .      *  .         .         .
          1100.   C         .         .I        .  L      . W E     .         .         .         .*        .         .
    50.00  1200.   C         .         . I       .   L     .  W E    .         .         .         .   *     .         .
          1300.   C         .         .  I      .   LR    .  W  E   .         .         .         .  *      .         .
          1400.   C         .         .  I      .   L R   .   W E   .         .         .         . *       .         .
          1500.   C         .         .   I     .   L  R  .    W E  .         .         .         *         .         .
          1600.   C         .         .    I    .   L  R  .    W  E .         .         .        *.         .         .
          1700.   C         .         .     I   .   L   R .     W  E.         .         .       * .         .         .
          1800.   C         .         .     I   .   L    R.      W E.         .         .      *  .         .         .
          1900.   C         .         .      I  .   L     R      W  E         .         .    *    .         .         .
    41.95  2000.   C         .         .       I .   L     .R      W .E        .         .   *     .         .         .
          2100.   C         .         .       I .    L    . R      W.E        .         . *       .         .         .
          2200.   C         .         .        I.      L  .   R    W. E       .         *         .         .         .
          2300.   C         .         .        I.       L .    R    W E       .       * .         .         .         .
          2400.   C         .         .         I         L      R .W  E      .    *    .         .         .         .
          2500.   C         .         .         I         .L      R.W  E      .  *      .         .         .         .
          2600.   C         .         .         .I        .  L      R W E     .*        .         .         .         .
    35.00  2700.   C         .         .         .I        .   L     .R WE    *.         .         .         .         .
          2800.   C         .         .         .  I      .     L   R  W E    . *       .         .         .         .
          2900.   C         .         .         .   I     .       LR.   WE    .    *    .         .         .         .
          3000.   C         .         .         .    I    .       R L   W E   .       * .         .         .         .
          3100.   C         .         .         .      I  .      R .. L W E   .         .*        .         .         .
    30.10  3200.   C         .         .         .       I .      R  .    LWE  .         .   *     .         .         .
          3300.   C         .         .         .       I .       R .   LW E  .         .         .     *   .         .
          3400.             .         .         .        I.        R.   L WE  .         .         .         .      *  .
          3500.   C         .         .         .        I.         .R  L WE  .         .         .         .         *
          3600.   C         .         .         .         I         . R L  E  .         .         .         .         *
    24.95  3700.   C         .         .         .         I         .   L  WE .         .         .         .         *
          3800.   C         .         .         .         .I        .   L  WE .         .         .         .         *
          3900.   C         .         .         .         . I       .   L   WE.         .         .         .         *
          4000.   C         .         .         .         .   I     .   L   WE.         .         .         .         *
          4100.   C         .         .         .         .    I    .   L   W E         .         .         .         *
          4200.   C         .         .         .         .     I   .   L    WE         .         .         .         *
          4300.   C         .         .         .         .      I  .   L    W.E        .         .         .         *
          4400.   C         .         .         .         .       I .   L    W.E        .         .         .         *
          4500.   C         .         .         .         .         I   L    W. E       .         .         .         *
          4600.   C         .         .         .         .         .I  L     W E       .         .         .         *
    15.05  4700.   .         .         .         .         .         . I L     W  E      .         .         .         *
          4800.   .         .         .         .         .         .   I L   . W  E    .         .         .         *
```

```
        5000                                                   I  .      *  .                           *
        5100.  .                                      .        I .          E                           *
        5200.  .     .     .     .     .     .     .   .I  L      .W  E                         .       *
        5300.  .     .     .     .     .     .     .   .  I  L  .    W  E .                    .       *
        5400.  .     .     .     .     .     .     .   .    I  L .      W  E.                  .       *
        5500.  .     .     .     .     .     .     .   .      I  L        W .E                 .       *
        5600.  .     .     .     .     .     .     .   .        I . L       W    E             .      *.
   4.05 5700.  .     .     .     .     .     .     .   .          I   L   .   W  E     .    *         .
```

p.12/40

THIS RUN EXECUTED 11/23/90 23: 3:31

****

HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

p. 13/40

ERROR CORR - 01,02,03,04
MODIFICATION -

****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

IME ARROYO SUBCRITICAL F

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	61.400	.00	.00	.00	6933.00	26300.00	6943.32	6943.32	6945.77	77.27	12.58	2095.00	2992.01
*	60.400	100.00	.00	.00	6939.00	26300.00	6946.99	6946.99	6949.47	79.87	12.75	2098.02	2942.85
*	57.750	262.00	.00	.00	6941.00	26300.00	6949.64	6949.64	6952.05	75.97	12.64	2163.31	3017.47
*	50.000	775.00	.00	.00	6944.00	26300.00	6954.33	.00	6955.52	29.81	9.84	3232.61	4817.25
	41.950	805.00	.00	.00	6947.00	26300.00	6956.92	.00	6958.39	42.54	10.95	2864.02	4032.10
*	35.000	705.00	.00	.00	6948.70	26300.00	6959.38	.00	6960.13	16.19	6.98	3845.98	6536.47
	30.100	490.00	.00	.00	6952.00	26300.00	6960.40	.00	6961.22	32.13	7.32	3648.57	4639.55
*	24.950	520.00	.00	.00	6953.00	26300.00	6961.57	.00	6961.81	5.77	4.03	7034.72	10951.51
*	15.050	990.00	.00	.00	6959.00	26300.00	6963.03	6963.03	6964.48	107.21	12.21	2819.36	2539.98
*	4.850	1022.00	.00	.00	6968.00	26300.00	6974.56	6974.56	6976.23	71.13	11.69	2837.44	3118.29

INE ARROYO SUBCRITICAL F

SUMMARY PRINTOUT TABLE 150

p. 14/40

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	61.400	26300.00	6943.32	.00	.00	-6.68	429.80	.00
*	60.400	26300.00	6946.99	.00	3.67	.00	437.46	100.00
*	57.750	26300.00	6949.64	.00	2.65	.00	472.82	262.00
*	50.000	26300.00	6954.33	.00	4.69	.00	609.72	775.00
	41.950	26300.00	6956.92	.00	2.59	.00	582.37	805.00
*	35.000	26300.00	6959.38	.00	2.46	.00	630.75	705.00
	30.100	26300.00	6960.40	.00	1.02	.00	1010.69	490.00
*	24.950	26300.00	6961.57	.00	1.17	.00	1538.10	520.00
*	15.050	26300.00	6963.03	.00	1.46	.00	986.54	990.00
*	4.050	26300.00	6974.56	.00	11.53	.00	834.00	1022.00

ALTERNATIVE #7
REACH #3
CORRECTED

```
*********************************************      ********************************
* WATER SURFACE PROFILES                    *      * U.S. ARMY CORPS OF ENGINEERS     *
* VERSION OF SEPTEMBER 1988                 *      * THE HYDROLOGIC ENGINEERING CENTER *
* ERROR: 01,02,03,04                        *      * 609 SECOND STREET, SUITE D       *
* UPDATED:  JUNE 1990                       *      * DAVIS, CALIFORNIA 95616-4687     *
* RUN DATE    11/26/90      TIME   15:58:57 *      *                                  *
*********************************************      ********************************
```

[handwritten: Smith 12-3-90; Chkd. By: GS. 12.03.90; 10.15/40]

```
X     X XXXXXXX  XXXXX           XXXXX
X     X X       X     X         X     X
X     X X       X                     X
XXXXXXX XXXX    X         XXXXX   XXXXX
X     X X       X               X
X     X X       X     X         X
X     X XXXXXXX  XXXXX          XXXXXXX
```

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::::::::::::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::::::::::::
:::                                                :::
:::      FULL MICRO-COMPUTER IMPLEMENTATION        :::
:::                                                :::
::::::::::::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::::::::::::
```

REACH #3

```
*****************************
H A E S T A D   M E T H O D S
*****************************
```

37 Brookside Road * Waterbury, Connecticut 06708 * (203) 755-1666

END OF BANNER

THIS RUN EXECUTED 11/26/90 18:30:52

****

HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

ERROR CORR - 01,02,03,04

MODIFICATION -

****

Ch'k'd By: G.
12-03-90

p. 16/40

T1 ALTERNATIVE #7-RECONFIGURED REACH #3 Q(PMF)=26300 CFS

T2 UNC PROJECT NO. 86-060-24 RESP. TO NRC COMMENTS 10/17/90

T3 REACH 3 - SUPERCRITICAL FLOW

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	0	0	1	0.015	0	0	26300	6956	

NC	0.035	0.035	0.03							
X1	57.75	16	145	543	275	285	262			
GR	6960	0	6955	35	6950	90	6945.5	145	6941	155
GR	6941	185	6945	195	6945	230	6945	270	6945	295
GR	6945	330	6945	375	6945	543	6953.5	587.5	6953.5	627.5
GR	6960	660								
X1	60.40	10	110	515	160	130	100			
GR	6960	0	6950	110	6939	115	6939	140	6941.5	145
GR	6943	515	6943	530	6952	572.5	6952	612.5	6957	632
X1	61.40	17	250	660	60	165	95			
GR	6960	0	6955	55	6950	127	6945	250	6940	260
GR	6935	270	6933	275	6933	300	6937	310	6937	480
GR	6942	600	6942	650	6942	660	6942	676	6951.9	727.5
GR	6951.5	767.5	6957	792						
X1	62.30	22	250	330	265	75	150			
GR	6960	0	6955	35	6950	85	6945	155	6945	175
GR	6940	250	6935	260	6930	265	6922	280	6922	300
GR	6930	320	6935	330	6935	395	6935	435	6939	476
GR	6939	595	6940	620	6940	655	6940.7	717	6950.5	769.9
GR	6950.5	809.9	6957	845						
X1	63.80	20	300	335	1060	945	1005			
GR	6960	0	6955	80	6950	90	6945	105	6940	180
GR	6935	245	6925	250	6920	270	6925	300	6902	305
GR	6902	325	6925	330	6930	335	6935	375	6939	575
GR	6940	655	6940.7	728.5	6950.5	777.5	6950.5	817.5	6957	850
X1	73.80	20	650	735	850	520	630			
GR	6960	0	6955	40	6950	105	6945	240	6945	340
GR	6945	350	6940	450	6930	605	6925	625	6900	650
GR	6880	670	6880	690	6900	735	6925	757	6925	995
GR	6934	1075	6934	1180	6940	1210	6940	1250	6957	1335

Chkd. By: GNS
12.03.90

X1	80.10	15	325	440	290	330	280			
GR	6925	0	6920	140	6920	270	6915	280	6910	290
GR	6905	310	6900	325	6874.3	380	6874.3	400	6900	440
GR	6912	480	6925	790	6928	900	6928	1072	6957	1275
X1	82.90	19	480	645	0	0	0			
GR	6925	0	6920	115	6915	200	6910	460	6905	470
GR	6900	480	6871	510	6871	530	6900	645	6905	655
GR	6905	705	6905	860	6899	900	6899	935	6926	1100
GR	6930	1180	6940	1195	6950	1205	6960	1215		

P.17/40

Chkd. By: GS 12-03-90

X1	80.10	15	325	440	290	330	280			
GR	6925	0	6920	140	6920	270	6915	280	6910	290
GR	6905	310	6900	325	6874.3	380	6874.3	400	6900	440
GR	6912	480	6925	790	6928	900	6928	1072	6957	1275
X1	82.90	19	480	645	0	0	0			
GR	6925	0	6920	115	6915	200	6910	460	6905	470
GR	6900	480	6871	510	6871	530	6900	645	6905	655
GR	6905	705	6905	860	6899	900	6899	935	6926	1100
GR	6930	1180	69[illegible]0	1195	6950	1205	6960	1215		

P. 17/40

```
 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


*PROF 1

*SECNO 57.750
   57.750      7.76   6948.76   6949.66   6956.00   6952.43      3.67       .00       .00   6945.50
  26300.0     465.8   25545.1     289.1      64.9    1642.2      37.0        .0        .0   6945.00
      .00      7.18     15.55      7.82      .035      .030      .035      .000   6941.00    105.17
  .014971        0.        0.        0.         0        14         6       .00    457.51    562.68


*SECNO 60.400

3301 HV CHANGED MORE THAN HVINS

   60.400      7.85   6946.85   6946.99       .00   6949.47      2.63      2.96       .00   6950.00
  26300.0        .0   25523.5     776.5        .0    1944.7      92.7      11.4       2.7   6943.00
      .01       .00     13.12      8.38      .000      .030      .035      .000   6939.00    111.43
  .008786      275.      262.      285.         2         8         0       .00    436.74    548.17


*SECNO 61.400

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.84

   61.400      8.15   6941.15   6943.30       .00   6947.99      6.84      1.48       .00   6945.00
  26300.0        .0   26300.0        .0        .0    1253.2        .0      15.2       3.6   6942.00
      .01       .00     20.99       .00      .000      .030      .000      .000   6933.00    257.69
  .029659      160.      100.      130.         7        11         0       .00    322.08    579.76


*SECNO 62.300

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .58

   62.300     16.91   6938.91   6941.60       .00   6946.37      7.46      1.62       .00   6940.00
  26300.0        .0   21460.3    4839.7        .0     901.3     488.6      18.5       4.3   6935.00
      .01       .00     23.81      9.91      .000      .030      .035      .005   6922.00    252.18
  .010000       60.       95.      165.         8        17         0       .00    222.87    475.05
```

```
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


*SECNO 63.800

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.64

    63.800      24.85   6926.85    6932.13        .00   6944.03      17.18       2.34        .00    6925.00
   26300.0     3988.3   22311.7         .0      218.7     632.4         .0       22.2        4.8    6930.00
       .01      18.24     35.28        .00       .035      .030       .000       .000    6902.00     249.07
   .026800       265.      150.        75.          7        14          0        .00      82.79     331.86


*SECNO 73.800

3301 HV CHANGED MORE THAN HVINS

    73.800      15.92   6895.92    6901.95        .00   6916.08      20.16      27.95        .00    6900.00
   26300.0         .0   26300.0         .0         .0     729.8         .0       40.7        6.6    6900.00
       .02        .00     36.04        .00       .000      .030       .000       .000    6880.00     654.09
   .028546      1080.     1005.       945.          6        15          0        .00      71.72     725.81


*SECNO 80.100

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .70

    80.100      18.08   6892.38    6895.78        .00   6903.90      11.52      12.18        .00    6900.00
   26300.0         .0   26300.0         .0         .0     965.5         .0       52.9        7.7    6900.00
       .02        .00     27.24        .00       .000      .030       .000       .000    6874.30     341.31
   .013957       850.      630.       520.          6        11          0        .00      86.82     428.13


*SECNO 82.900

3301 HV CHANGED MORE THAN HVINS

    82.900      15.55   6886.55    6890.63        .00   6899.37      12.82       4.53        .00    6900.00
   26300.0         .0   26300.0         .0         .0     915.2         .0       59.0        8.3    6900.00
       .03        .00     28.74        .00       .000      .030       .000       .000    6871.00     493.92
   .018988       290.      280.       330.          7         8          0        .00      97.73     591.65
```

PROFILE FOR STREAM 3 - SUPERCRITICAL FLOW

PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

```
ELEVATION  6871.     6881.     6891.     6901.     6911.     6921.     6931.     6941.     6951.     6961.
   SECNO   CUMDIS

   57.75      0. .         .         .         .         .         .         .         I   RL  WC.E        M.        .
             50. .         .         .         .         .         .         .         I   RL  WC .E      M .        .
            100. .         .         .         .         .         .         .        I.  R  LWC E       M .        .
            150. .         .         .         .         .         .         .        I.  R   W  E      M  .        .
            200. .         .         .         .         .         .         .       I . R   WCLE.     M  .        .
            250. .         .         .         .         .         .         .       I . R   W  E.    M   .        .
   60.40    300. .         .         .         .         .         .         .       I . R   W CL.    M   .        .
            350. .         .         .         .         .         .         .    I    . RWC  LE .    M   .        .
   61.40    400. .         .         .         .         .         .       . I      WRC L  E        M   .        .
            450. .         .         .         .         .         .     I   .    R W.C   E   .     M   .        .
   62.30    500. .         .         .         .         .         .I         .  R  WL.C   E  .     M   .        .
            550. .         .         .         .         .   I     .         .R W  C  .   E  .     M   .        .
            600. .         .         .         .         .I        .        LWR  C    .  E  .     M   .        .
   63.80    650. .         .         .         .I        .         .    L W  R.C       . E  .     M   .        .
            700. .         .         .         I         .         .  LW   R C        . E   .     M   .        .
            750. .         .         .        I.         .         . LW  R C .        E     .     M   .        .
            800. .         .         .       I .         .         LW   R C .       E.     .     M   .        .
            850. .         .         .      I  .         .        LW  R C   .     E  .     .     M   .        .
            900. .         .         .     I   .         .      W . R C     .    E   .     .     M   .        .
            950. .         .         .   I     .         .     W  R C       .   E    .     .     M   .        .
           1000. .         .         . I       .         .   W   R.C        . E      .     .     M   .        .
           1050. .         .         .I        .         .  W  R C.         .E       .     .     M   .        .
           1100. .         .         .I        .         .WL  R C .         E        .     .     M   .        .
           1150. .         .         I         .        W L R C   .        E.        .     .     M   .        .
           1200. .         .        I.         .       WL  R C    .       E .        .     .     M   .        .
           1250. .         .       I .         .     W L.R C      .     E   .        .     .     M   .        .
           1300. .         .      I  .         .    W L R C       .    E    .        .     .     M   .        .
           1350. .         .     I   .         .  W  LR C         .   E     .        .     .     M   .        .
           1400. .         .    I    .         .W L R C.         .E         .        .     .     M   .        .
           1450. .         .  I      .        .W  LR C  .        .E         .        .     .     M   .        .
           1500. .         . I       .        W  LR C   .       E.          .        .     .     M   .        .
           1550. .         .I        .      W . L C     .      E .          .        .     .     M   .        .
           1600. .         I         .     W  LR C      .     E  .          .        .     .     M   .        .
   73.80   1650. .        I.         .   W    L.C       .   E    .          .        .     .     M   .        .
           1700. .        I.         .   W    LC        .  E     .          .        .     .  M      .        .
           1750. .       I .         .  W    LC         . E      .          .        .    .M        .        .
           1800. .       I .         .  W    C.         .E       .          .        .  M .         .        .
           1850. .      I  .         .  W    C.         E        .          .        . M  .         .        .
           1900. .      I  .         .  W    C.        E         .          .       M     .         .        .
           1950. .     I   .         . W    CL.        E.        .          .     .M      .         .        .
           2000. .     I   .         . W    CL.       E .        .          .    M .      .         .        .
           2050. .    I    .         . W   C L.      E  .        .          .  M   .      .         .        .
           2100. .    I    .         .W    C L.     E   .        .         .M    .      .         .        .
           2150. .   I     .         .W   C  L.    E    .        .        .M     .      .         .        .
           2200. .   I     .         .W   C  L.   E     .        .      M .      .      .         .        .
   80.10   2250. .  I      .         .W  C   L.  E      .        .   M    .      .      .         .        .
           2300. .  I      .         W   C   L. E       .        .   M    .      .      .         .        .
           2350. . I       .        W.  C    L.E        .        .   M    .      .      .         .        .
           2400. . I       .       W . C     LE         .        .   M    .      .      .         .        .
```

p.20/41

```
         2500.  I              *          E                            *
 82.90   2550.  I              *          E.                           *
```

Run Date: 11/26/90   Run Time: 15:58:57   HMVersion: 5.30   Data File: reach3.hc2   ~~Page 6~~

THIS RUN EXECUTED 11/26/90   15:59: 5

0.21/46

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**********************************************
 HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

 ERROR CORR -  01,02,03,04
 MODIFICATION -
**********************************************
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

3 - SUPERCRITICAL FLOW

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	57.750	.00	.00	.00	6941.00	26300.00	6948.76	6949.66	6952.43	149.71	15.55	1744.13	2149.50
	60.400	262.00	.00	.00	6939.00	26300.00	6946.85	6946.99	6949.47	87.86	13.12	2037.41	2805.80
*	61.400	100.00	.00	.00	6933.00	26300.00	6941.15	6943.30	6947.99	296.59	20.99	1253.16	1527.14
*	62.300	95.00	.00	.00	6922.00	26300.00	6930.91	6941.60	6946.37	100.00	23.81	1389.08	2630.05
*	63.800	150.00	.00	.00	6902.00	26300.00	6926.85	6932.13	6944.03	268.00	35.28	851.14	1606.52
	73.800	1005.00	.00	.00	6880.00	26300.00	6895.92	6901.95	6916.08	285.46	36.04	729.82	1556.62
*	80.100	630.00	.00	.00	6874.30	26300.00	6892.38	6895.78	6903.90	159.57	27.24	965.47	2226.16
	82.900	280.00	.00	.00	6871.00	26300.00	6886.55	6890.63	6899.37	189.88	28.74	915.20	1900.63

* = SUPERCRITICAL FLOW

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	57.750	26300.00	6948.76	.00	.00	-7.24	457.51	.00
	60.400	26300.00	6946.85	.00	-1.91	.06	436.74	262.00
*	61.400	26300.00	6941.15	.00	-5.69	.00	[illegible]	100.00
*	62.300	26300.00	6938.91	.00	-2.25	.00	222.87	95.00
*	63.800	26300.00	6926.85	.00	-12.06	.00	82.79	150.00
	73.800	26300.00	6895.92	.00	-30.93	.00	71.72	1005.00
*	[illegible]0.100	26300.00	6892.38	.00	-3.54	.00	86.82	630.00
	82.900	26300.00	6886.55	.00	-5.83	.00	97.73	280.00

REACHES # 1 & # 2

p.23/90

```
***********************************************************          ****************************************
* WATER SURFACE PROFILES                                  *          * U.S. ARMY CORPS OF ENGINEERS         *
* VERSION OF SEPTEMBER 1988                               *          * THE HYDROLOGIC ENGINEERING CENTER    *
* ERROR: 01.02.03.04                                      *          * 609 SECOND STREET, SUITE D           *
* UPDATED: JUNE 1990                                      *          * DAVIS, CALIFORNIA 95616-4687         *
* RUN DATE   11/12/90      TIME   17:45:06                *          *                                      *
***********************************************************          ****************************************
```

```
X     X XXXXXXX  XXXXX          XXXXX
X     X X        X     X        X     X
X     X X        X                    X
XXXXXXX XXXX     X        XXXXX   XXXXX
X     X X        X                X
X     X X        X     X          X
X     X XXXXXXX  XXXXX            XXXXXXX
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::::::::::::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::::::::::::
:::                                                :::
:::      FULL MICRO-COMPUTER IMPLEMENTATION        :::
:::                                                :::
::::::::::::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::::::::::::
```

```
*****************************
 H A E S T A D   M E T H O D S
*****************************
```

37 Brookside Road * Waterbury, Connecticut 06708 * (203) 755-1666

END OF BANNER

THIS RUN EXECUTED 11/12/90   17:45: 6

```
**************************************************
 HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

 ERROR CORR - 01,02,03,04
 MODIFICATION -
**************************************************
```

p.24/40

```
T1 ALTERNATIVE #7--REACH 1&2--Q=26300 CFS
T2 UNC PROJECT NO. 86-060-24 RESP. TO NRC COMMENTS 11/7/90
T3 PIPELINE ARR.-3 SUBCRITICAL FLOW

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ

         0        0        0        0     0.04        0        0    26300     6950        0

NC   0.035    0.035     0.03
X1   61.40       17      250      376        0        0        0
GR    6960        0     6955       56     6950      127     6945      250     6940      260
GR    6935      270     6933      270     6933      300     6937      310     6937      490
GR    6942      600     6942      650     6942      660     6942      672   6951.5    727.5
GR  6951.5    767.5     6957      792

X1   60.40       10      110      515      160      130      100
GR    6960        0     6950      110     6939      115     6939      145   6941.5      145
GR    6943      515     6943      530     6952    572.5     6952    612.5     6957      632

X1   57.75       16      145      543      270      295      262
GR    6960        0     6955       35     6950       90   6945.5      145     6941      155
GR    6941      185     6945      195     6945      230     6945      270     6945      295
GR    6945      330     6945      375     6945      543   6953.5    587.5   6953.5    627.5
GR    6960      660

X1   50.00       14      456      712      750  [illegible]    775
GR    6975        0     6970       10     6965  [illegible]   6960      100     6950      140
GR    6950      320     6950      456     6944      532     6944      562     6950      650
GR    6950      712     6957      745     6957      785     6976      880

X1   41.95       12      535      772      820      800      605
GR    6970        0     6965       70     696'      165     6955      235     6950      535
GR    6947      557     6947      587   6953.5      700   6953.5      772   6960.5      810
GR  6960.5      850     6970      905

X1   35.00        9      215      790      700      700      705
GR    6970        0     6960      145     6955      215   6948.7      583   6948.7      603
GR    6958      710   6958.5      780   6962.5      900   6962.5      840

X1   30.10       21      135      980      495     1140      490
GR    6970        0     6960      135     6955      565     6952      575     6952      605
GR    6955      615     6955      660     6955      765     6955      900     6955      950
GR    6955      880     6956      980     6958      990     6960     1000     6960     1070
GR    6960     1422     6962     1510     6964     1580     6966     1795     6968     1900
GR    6970     1910
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p. 25/40

X1	24.38	26	795	1800	560	540	520			
GR	5900	0	6990	45	6980	140	6970	275	6950	505
GR	6960	615	6960	705	6955	865	6952	965	6943	795
GR	6955	996	6955	1125	6965	1295	6965	1435	6956	1715
GR	6950	1770	6960	1800	6960	1970	6962	2060	6964	2070
GR	6966	2080	6968	2090	6970	2100	6990	2110	6990	2165
GR	7000	2230								
X1	15.05	15	690	795	710	1190	750			
GR	7000	0	6990	35	6980	105	6970	210	6960	590
GR	6960	735	6960	705	6960	795	6960	1520	6975	1575
GR	6980	1600	6985	1620	6990	1645	6995	1660	7000	1690
X1	4.05	10	820	1155	1035	1070	1022			
GR	6980	0	6970	820	6970	890	6968	890	6968	920
GR	6970	920	6970	950	6970	960	6970	1000	6970	1030
GR	6970	1060	6970	1105	6970	1155	6980	1540		

```
Run Date: 11/12/90   Run Time: 17:C5: 6   HMVersion: 5.30   Data File:  ALT7.HC2

  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

*PROF 1

*SECNO 61.400
3720 CRITICAL DEPTH ASSUMED
    61.400     10.31   6943.31   6943.31   6960.00   6945.79      2.46       .00       .00   6945.00
   26300.0        .0   26287.0      13.0        .0    2091.8       4.7        .0        .0   6941.00
       .00       .00     12.57      2.79      .000      .030      .035      .000   6933.00    253.3?
   .007747        0.        0.        0.         0        18         0       .00    429.74    683.11

*SECNO 60.400
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    60.400      7.98   6946.98   6946.98       .00   6949.45      2.48       .79       .00   6960.00
   26300.0        .0   25509.9     790.1        .0    2002.4      97.0       4.9       1.0   6943.00
       .00       .00     12.74      8.15      .000      .030      .035      .000   6939.00    111.37
   .008015      160.      100.      130.        20        19         0       .00    437.40    548.78

*SECNO 57.750
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    57.750      8.64   6949.64   6949.64       .00   6952.05      2.41      2.05       .00   6945.50
   26300.0     626.7   25312.9     360.4     104.8    2003.1      56.3      17.7       3.8   6945.00
       .01      5.99     12.64      6.40      .035      .030      .035      .000   6941.00     94.43
   .007589      270.      262.      295.        20         8         0       .00    472.84    567.28

*SECNO 50.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE.  KRATIO =  1.60

    50.000     10.33   6954.33       .00       .00   6955.52      1.20      3.48       .00   6950.00
   26300.0    8537.0   17594.2     168.8    1400.8    1787.3      44.2      65.4      13.3   6950.00
       .03      6.09      9.84      3.82      .035      .030      .035      .000   6944.00    122.69
   .002982      750.      775.      850.         3         0         0       .00    609.72    732.40
```

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P.27/40

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 41.050

41.050	9.52	6956.92	.00	.00	6958.39	1.47	2.06	.00	6960.00
26900.0	6941.8	18032.2	173.9	1350.5	1481.8	31.7	122.2	24.5	6953.50
.06	7.36	10.95	3.91	.035	.030	.035	.000	6947.00	208.15
.004254	828.	805.	800.	1	0	0	.00	582.37	790.54

*SECNO 35.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.62

35.000	10.68	6959.38	.00	.00	6960.13	.75	1.74	.00	6955.00
26900.0	386.5	25911.6	1.9	134.3	3709.4	1.9	176.4	34.3	6952.50
.08	2.88	6.99	.98	.035	.030	.035	.000	6948.70	153.67
.001619	700.	705.	700.	2	0	0	.00	630.74	784.40

*SECNO 30.100

30.100	8.42	6960.42	.00	.00	6961.21	.80	1.09	.00	6960.00
26900.0	1.0	25839.4	459.7	1.2	3572.4	228.1	221.1	48.6	6956.00
.10	.83	7.23	2.01	.035	.030	.035	.000	6952.00	129.37
.003124	495.	490.	1140.	3	0	0	.00	1310.98	1440.35

*SECNO 24.950

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 2.32

24.950	8.56	6961.56	.00	.00	6961.81	.24	.59	.00	6960.00
26900.0	565.3	25322.2	412.5	423.0	6275.8	320.1	286.1	65.9	6960.00
.14	1.34	4.03	1.29	.035	.030	.035	.000	6953.00	502.37
.000580	560.	520.	540.	2	0	0	.00	[illegible]	2040.22

*SECNO 15.050

Run Date: 11/12/90 Run Time: 17:45: 5 HMVersion: 4.90 Data File: ALT7.HC2

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

.28/40

3301 HV CHANGED MORE THAN HVINS

3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

15.050	4.03	6963.03	6963.03	.00	6964.08	1.05	1.03	.00	6960.00
26300.0	1278.6	4706.1	20315.3	220.7	395.9	2215.8	403.1	96.5	6960.00
.17	5.79	12.19	9.17	.035	.030	.035	.000	6959.00	544.43
.010687	910.	990.	1190.	20	14	0	.00	986.69	1531.12

*SECNO 4.050
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

4.050	6.56	6974.56	6974.56	.00	6976.23	1.67	9.01	.00	6970.00
26300.0	5277.9	18544.5	2477.6	851.3	1586.5	399.7	471.1	119.0	6970.00
.20	6.20	11.69	6.20	.035	.030	.035	.000	6968.00	446.36
.007113	1035.	1022.	1070.	3	14	0	.00	884.08	1330.43

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```
PROFILE FOR STREAM  INE ARROYO SUBCRITICAL F

PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

ELEVATION 6933.    6938.    6943.    6948.    6953.    6958.    6963.    6968.    6973.    6978.
   SECNO  CUMDIS

   61.40     0. I                R .W L E  .         .    M         .         .         .
   90.40   100. .         . I      R      W .  EL    .    M .       .         .         .
           200. .         .   I    . R     WL   E    .      M       .         .         .
           300. .         .    I   .  R   L  . W   E .          . M .         .         .
   57.75   400. .         .     I  .    RL   .  W   E .          . M          .         .
           500. C         .      I .    RL   .   W   E.          .    M .     .         .
           600. C         .       I.      L  .     W  E          .      . M   .         .
           700. C         .       I.       L .      W .E         .          M .         .
           800. C         .        I.       RL       W . E       .           M.         .
           900. C         .        I        RL        W.  E      .          .  M        .
          1000. C         .        .I       . L       .W E       .          .      M    .
          1100. C         .        .I        . L       . W E     .          .        .M .
   50.00  1200. C         .        . I       .  L      .  W E    .          .          . M
          1300. C         .        .  I      .  LR     .  W  E   .          .          .M
          1400. C         .        .  I      .  L R    .   W E   .          .         .M
          1500. C         .        .   I     .  L  R   .   W E   .          .         M
          1600. C         .        .    I    .  L  R   .   W  E  .          .        M.
          1700. C         .        .     I   .  L   R  .    W  E.           .       M .
          1800. C         .        .     I   .  L    R.     W E.            .      M  .
          1900. C         .        .      I  .  L    R      W  E            .     M   .
   41.95  2000. C         .        .       I .  L    .R      W .E           .    M    .
          2100. C         .        .       I .    L  . R     W.F            .  .M     .
          2200. C         .        .        I.     L .   R   W. E           . M       .
          2300. C         .        .        I.      L.   R    W E           M .       .
          2400. C         .        .        I        L     R .W E       .  M  .       .
          2500. C         .        .        I       .L     R .W E       . M   .       .
          2600. C         .        .        .I      .  L    R W E       .M    .       .
   35.00  2700. C         .        .        .I      .   L   .R WE     M.      .       .
          2800. C         .        .        . I     .    L   R  W E    .M     .       .
          2900. C         .        .        .  I    .      LR.  WE     .   M  .       .
          3000. C         .        .        .   I   .      R L  W E    .      M.      .
          3100. C         .        .        .     I .     R  . L W E   .        .M    .
   30.10  3200. C         .        .        .      I.    R   .  LWE    .        .   M .
          3300. C         .        .        .      I.      R .  LW E   .        .     .     M    .
          3400. C         .        .        .       I.      R.  L WE   .        .     .         M .
          3500. C         .        .        .       I.       .R L WE   .        .     .          M
          3600. C         .        .        .        I       . R L E   .        .     .          M
   24.95  3700. C         .        .        .        I       .  L  WE  .        .     .          M
          3800. C         .        .        .        .I      .  L  WE  .        .     .          M
          3900. C         .        .        .        . I     .  L   WE.         .     .          M
          4000. C         .        .        .        .   I   .  L   WE.         .     .          M
          4100. C         .        .        .        .    I  .  L   W E         .     .          M
          4200. C         .        .        .        .     I .  L    WE         .     .          M
          4300. C         .        .        .        .      I.  L    W.E        .     .          M
          4400. C         .        .        .        .       I. L    W.E        .     .          M
          4500. C         .        .        .        .        I L    W. E       .     .          M
          4600. C         .        .        .        .       .I L     W E       .     .          M
   15.05  4700. .         .        .        .        .       . I L    W  E      .     .          M
          4800. .         .        .        .        .       .  I L  . W  E     .     .          M
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      5200.  .                                                              *
      5300.  .                                        I    *  I              *
      5400.  .                                     I  L     * I.       .     *
      5500.  .    .    .    .    .    .    .    .   I  L      * .E      .     *
      5600.  .    .    .    .    .    .    .    .    I , L     *  E     .    *.
4.86  5700.  .    .    .    .    .    .    .    .     I  L   . *  E  .  *    .
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Run Date: 11/12/90 Run Time: 17:45: 6 HMVersion: 5.90 Data File: ALT7.HC2

THIS RUN EXECUTED 11/12/90 17:45:16

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HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

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ERROR CORR - 01.02.03.04
MODIFICATION -

****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

INE ARROYO SUBCRITICAL F

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	61.400	.00	.00	.00	6933.00	26300.00	6943.31	6943.31	6945.76	77.47	12.57	2096.43	2988.09
*	60.400	100.00	.00	.00	6939.00	26300.00	6946.98	6946.98	6949.45	80.15	12.74	[illegible]	[illegible]
*	57.750	262.00	.00	.00	6941.00	26300.00	6949.64	6949.64	6952.05	75.89	12.64	2164.00	[illegible]
*	50.000	775.00	.00	.00	6944.00	26300.00	6954.33	.00	6955.52	29.82	9.84	[illegible]	[illegible]
	41.950	805.00	.00	.00	6947.00	26300.00	6956.92	.00	6958.39	42.54	10.96	2864.02	[illegible]
*	35.000	705.00	.00	.00	6948.70	26300.00	6959.38	.00	6960.13	16.19	6.99	3845.67	[illegible]
	30.100	490.00	.00	.00	6952.00	26300.00	6960.42	.00	6961.21	31.24	7.23	3801.67	4706.40
*	24.950	520.00	.00	.00	6953.00	26300.00	6961.56	.00	6961.81	5.80	4.03	7018.96	[illegible]
*	15.050	990.00	.00	.00	6959.00	26300.00	6963.03	6963.03	6964.48	106.87	12.19	2922.25	3544.09
*	4.850	1022.00	.00	.00	6968.00	26300.00	6974.56	6974.56	6976.23	71.13	11.69	2257.44	3115.29

INC ARROYO SUBCRITICAL F

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	61.400	26300.00	6943.31	.00	.00	-6.69	429.74	.00
*	60.400	26300.00	6946.06	.00	3.66	.00	437.93	100.00
*	57.750	26300.00	6949.64	.00	2.66	.00	472.84	262.50
	50.000	26300.00	6954.33	.00	4.69	.00	509.72	775.00
	41.950	26300.00	6956.92	.00	2.59	.00	592.37	805.00
*	35.000	26300.00	6959.38	.00	2.46	.00	630.74	705.00
	30.100	26300.00	6960.42	.00	1.03	.00	1310.98	490.00
*	24.950	26300.00	6961.56	.00	1.15	.00	1537.36	520.00
*	15.050	26300.00	6963.03	.00	1.47	.00	986.69	990.00
*	4.850	26300.00	6974.56	.00	11.52	.00	884.08	1022.00

ALTERNATE #7
REACH #2
UNCORRECTED

```
*************************************************
*  WATER SURFACE PROFILES                       *
*  VERSION OF SEPTEMBER 1988                    *
*  ERROR: 01,02,03,04                           *
*  UPDATED:  JUNE 1990                          *
*  RUN DATE    11/26/90      TIME   15:16:43    *
*************************************************
```

```
*****************************************
*  U.S. ARMY CORPS OF ENGINEERS         *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*  609 SECOND STREET, SUITE D           *
*  DAVIS, CALIFORNIA 95616-4687         *
*                                       *
*****************************************
```

p.33/40

```
I     I  IIIIIII   IIIII             IIIII
I     I  I        I     I           I     I
I     I  I        I                       I
IIIIIII  IIII     I         IIIII    IIIII
I     I  I        I                 I
I     I  I        I     I           I
I     I  IIIIIII   IIIII            IIIIIII
```

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::::::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::::::
:::                                          :::
:::   FULL MICRO-COMPUTER IMPLEMENTATION     :::
:::                                          :::
::::::::::::::::::::::::::::::::::::::::::::::::
::::::::::::::::::::::::::::::::::::::::::::::::
```

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****************************
H A E S T A D   M E T H O D S
****************************
```

37 Brookside Road * Waterbury, Connecticut 06708 * (203) 755-1666

END OF BANNER

Run Date: 11/26/90   Run Time: 15:16:43   HHVersion: 5.30   Data File: re3old.hc2

p.34/40

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                                                      THIS RUN EXECUTED 11/26/90   15:16:43
**********************************************
 HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

 ERROR CORR -  01,02,03,04
 MODIFICATION -
**********************************************

T1 ALTERNATIVE 00D-PRESENT REACH 3--Q=26300 CFS
T2 UNC PROJECT NO. 86-060-24 RESP. TO NRC COMMENTS 10/17/90
T3 REACH 3 - SUPERCRITICAL FLOW

J1  ICHECK    INQ     NINV    IDIR    STRT    METRIC   HVINS    Q       WSEL    FQ

         0      0        0       1   0.015       0        0  26300     6956

NC   0.036  0.035     0.03
X1   57.75     17      145     540     270     285     262
GR    6960      0     6955      35    6950      90  6945.5     145    6941     160
GR    6941    180     6945     195    6945     230    6945     270    6945     295
GR    6945    330     6945     275    6946     540  6953.5     580  6953.5     620
GR    6960    655     6960     755

X1   60.40      9      110     520     160     130     100
GR    6960      0     6950     110    6939     120    6939     140  6941.5     145
GR    6943    520     6952     560    6952     600    6962     640

X1   61.40     16      250     660      60     260      95
GR    6960      0     6955      55    6950     127    6945     250    6940     260
GR    6935    270     6933     275    6933     295    6937     297    6937     480
GR    6942    600     6942     650    6942     660  6951.9     710  6951.9     750
GR    6960    795

X1   62.30     23      250     330     265     110     150
GR    6960      0     6955      35    6950      85    6945     155    6945     175
GR    6940    250     6935     260    6930     265    6922     280    6922     300
GR    6930    320     6935     330    6935     395  6933.8     420    6935     435
GR    6939    476     6939     595    6940     620    6940     655  6940.7     717
GR  6950.5  769.9   6950.5   809.9    6957     845

X1   63.80     20      300     335    1000    1015    1005
GR    6960      0     6955      60    6950      90    6945     105    6940     180
GR    6935    245     6925     250    6920     270    6925     300    6902     305
GR    6902    325     6925     330    6930     335    6935     375    6939     575
GR    6940    655   6940.7   720.5  6950.5   777.5  6950.5   817.5    6957     850

X1   73.80     20      650     735     850     595     630
GR    6960      0     6955      40    6950     105    6945     240    6945     340
GR    6945    350     6940     450    6930     605    6925     625    6900     650
GR    6880    670     6880     690    6900     735    6920     757    6925     960
GR    6935   1075     6934    1180    6940    1210    6940    1250    6957    1335
```

X1	80.10	15	325	440	290	330	275			
GR	6925	0	6920	140	6920	270	6915	280	6910	295
GR	6905	310	6900	325	6874.3	380	6874.3	400	6900	440
GR	6912	480	6925	790	[illegible]	900	6928	1072	6957	1275
X1	82.90	19	480	645	0	0	0			
GR	6925	0	6920	115	6915	200	6910	460	6905	470
GR	6900	480	6871	510	6871	530	6900	645	6905	655
GR	6905	705	6905	860	6899	900	6899	935	6926	1100
GR	6930	1100	6940	1195	6950	1205	6960	1215		

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SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

*PROF 1

*SECNO 57.750
   57.750      8.01   6949.01   6949.95   6956.00   6952.71      3.70       .00       .00   6945.50
  26300.0     567.8   25569.2     162.9      75.3    1637.6      24.2        .0        .0   6946.00
      .00      7.54     15.61      6.75      .035      .030      .035      .000   6941.00    102.10
  .014977        0.        0.        0.         0        14         6       .00    453.95    556.05

*SECNO 60.400

3301 HV CHANGED MORE THAN HVINS

   60.400      7.83   6946.83   6947.12       .00   6949.64      2.81      3.07       .00   6950.00
  26300.0        .0   26096.7     203.3        .0    193[illegible].6      32.5      11.2       2.7   6943.00
      .01       .00     23.50      6.25      .000      .030      .035      .000   6939.00    112.88
  .009423      270.      262.      285.         3         5         0       .00    424.12    537.01

*SECNO 61.400

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.79

   61.400      8.27   6941.27   6943.38       .00   6948.09      6.82      1.55       .00   6945.00
  26300.0        .0   26300.0        .0        .0    1255.1        .0      14.9       3.5   6942.00
      .01       .00     20.95       .00      .000      .030      .000      .000   6933.00    257.45
  .030088      160.      100.      130.         7        11         0       .00    325.12    582.57

*SECNO 62.300

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .59

   62.300     16.70   6938.70   6941.51       .00   6946.35      7.65      1.73       .00   6940.00
  26300.0        .0   21369.2    4931.0        .0     885.4     483.1      18.3       4.3   6935.00
      .01       .00     24.13     10.21      .000      .030      .035      .000   6922.00    252.[illegible]9
  .010444       60.       95.      200.         8        17         0       .00    220.36    472.96
```

p.37/40

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 63.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.59

63.000	24.89	6926.89	6931.90	.00	6943.91	17.01	2.45	.00	6925.00
26300.0	4035.3	22264.7	.0	221.0	633.8	.0	22.2	4.8	6930.00
.01	18.26	35.13	.00	.035	.030	.000	.000	6902.00	249.05
.026521	265.	150.	110.	7	14	0	.00	82.85	331.90

*SECNO 73.000

3301 HV CHANGED MORE THAN HVINS

73.000	15.91	6895.91	6901.95	.00	6916.09	20.18	27.82	.00	6900.00
26300.0	.0	26300.0	.0	.0	729.5	.0	40.7	6.6	6900.00
.02	.00	36.05	.00	.000	.030	.000	.000	6880.00	654.09
.028576	1000.	1005.	1015.	6	15	0	.00	71.71	725.80

*SECNO 80.100

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO =   .70

80.100	18.09	6892.38	6895.70	.00	6903.90	11.53	12.19	.00	6900.00
26300.0	.0	26300.0	.0	.0	965.3	.0	52.9	7.8	6900.00
.02	.00	27.25	.00	.000	.030	.000	.000	6874.30	341.32
.013964	850.	630.	595.	6	11	0	.00	86.81	428.13

*SECNO 82.900

3301 HV CHANGED MORE THAN HVINS

82.900	15.51	6886.51	6890.63	.00	6899.43	12.92	4.47	.00	6900.00
26300.0	.0	26300.0	.0	.0	911.8	.0	58.9	8.4	6900.00
.03	.00	28.84	.00	.000	.030	.000	.000	6871.00	493.95
.019177	290.	275.	330.	7	9	0	.00	97.56	591.51

PROFILE FOR STREAM   3 - SUPERCRITICAL FLOW

PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

p. 38/40

```
ELEVATION  6871.     6 -       891.     6901.     6911.     6921.     6931.     6941.     6951.     6961.
   SECNO   CUMDIS

    57.75     0.   .         .         .         .         .         .         .         I    L WC. E       M.         .
             50.   .         .         .         .         .         .         .         I  RL  W .E        M.         .
            100.   .         .         .         .         .         .         .        I.  R LWC .E        M.         .
            150.   .         .         .         .         .         .         .        I. R   W  E         M.         .
            200.   .         .         .         .         .         .         .       I .  R  WCLE.        M.         .
            250.   .         .         .         .         .         .         .       I . R   W  E         M.         .
    60.40   300.   .         .         .         .         .         .         .       I . R   W  E.        M.         .
            350.   .         .         .         .         .         .         .    I    . RWC  LE .        M.         .
    61.40   400.   .         .         .         .         .         .         . I      WRC L   E  .        M.         .
            450.   .         .         .         .         .         .     I   .      R W.C    E   .      M .          .
    62.30   500.   .         .         .         .         .I        .   R  WL.C    E    .     M   .         .
            550.   .         .         .         .   I     .         . R W  C  .    E    .     M   .         .
            600.   .         .         .       I .         .        LWR  C     .   E     .     M   .         .
    63.80   650.   .         .         .I        .         .   L W  R.C           E      .     M   .         .
            700.   .         .         I         .         .  LW   RC.           E       .     M   .         .
            750.   .         .        I.         .         .LW   R C .         E         .     M   .         .
            800.   .         .       I .         .         LW   RC   .        E.         .     M   .         .
            850.   .         .      I  .         .        LW  R C    .      E  .         .     M   .         .
            900.   .         .     I   .         .       W.  R C     .     E   .         .     M   .         .
            950.   .         .   I     .         .      W  R C       .    E    .         .     M   .         .
           1000.   .         .  I      .         .    W   R.C        .  E      .         .     M   .         .
           1050.   .         . I       .         .   W  R C.         . E       .         .     M   .         .
           1100.   .         .I        .         .WL  R C  .         E         .         .     M   .         .
           1150.   .         I         .          W L R C  .         E.        .         .     M   .         .
           1200.   .         .        I.         .        WL  R C    .       E.          .         .     M   .         .
           1250.   .         .       I .         .      W L.R C      .     E   .         .         .     M   .         .
           1300.   .         .      I  .         .     W L R C       .    E    .         .         .     M   .         .
           1350.   .         .     I   .         .   W  LR C         .   E     .         .         .     M   .         .
           1400.   .         .    I    .         .  W L R C.         . E       .         .         .     M   .         .
           1450.   .         .  I      .         .W  LR  C .         .E        .         .         .     M   .         .
           1500.   .         . I       .         W  LR  C  .        E.         .         .         .     M   .         .
           1550.   .         .I        .       W . L C     .       E .         .         .         .     M   .         .
           1600.   .         I         .      W  LR C      .      E  .         .         .         .     M   .         .
    73.00  1650.   .        I.         .     W  L.C        .     E   .         .         .         .     M   .         .
           1700.   .        I.         .    W   LC         .    E    .         .         .         .   M               .
           1750.   .       I .         .    W   LC         .  E      .         .         .         .M                  .
           1800.   .       I .         .    W   C.         . E       .         .       M .                   .
           1850.   .      I  .         .    W   C.         .E        .         .      M   .                   .
           1900.   .      I  .         .    W   C.         E         .         .  M      .                   .
           1950.   .     I   .         .   W   CL.        E.         .         .M        .                   .
           2000.   .     I   .         .   W   CL.       E .         .       M .         .                   .
           2050.   .    I    .         .   W  C L.      E  .         .         .     M   .         .                   .
           2100.   .    I    .         .W     C L.     E   .         .         .   M     .         .                   .
           2150.   .   I     .         .W    C  L.    E    .         .         .M        .         .                   .
           2200.   .   I     .         .W    C  L.   E     .         .        M.         .         .                   .
    80.10  2250.   .  I      .         .W    C  L.  E      .         .    M    .         .         .                   .
           2300.   .  I      .          W   C   L.E        .         .    M    .         .         .                   .
           2350.   . I       .         W.  C    L.E        .         .    M    .         .         .                   .
           2400.   .I        .        W . C     LE         .         .    M    .         .         .                   .
```

```
        2450.  I              W  C     EC                    *
        2500.  I              W  C     E                     *
82.90   2550.  I              W        EL                    *
```


THIS RUN EXECUTED 11/26/90   15:16:50

****

HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

p. 39/40

ERROR CORR - 01,02,03,04
MODIFICATION -

****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

3 - SUPERCRITICAL FLOW

SUMMARY PRINTOUT TABLE 150

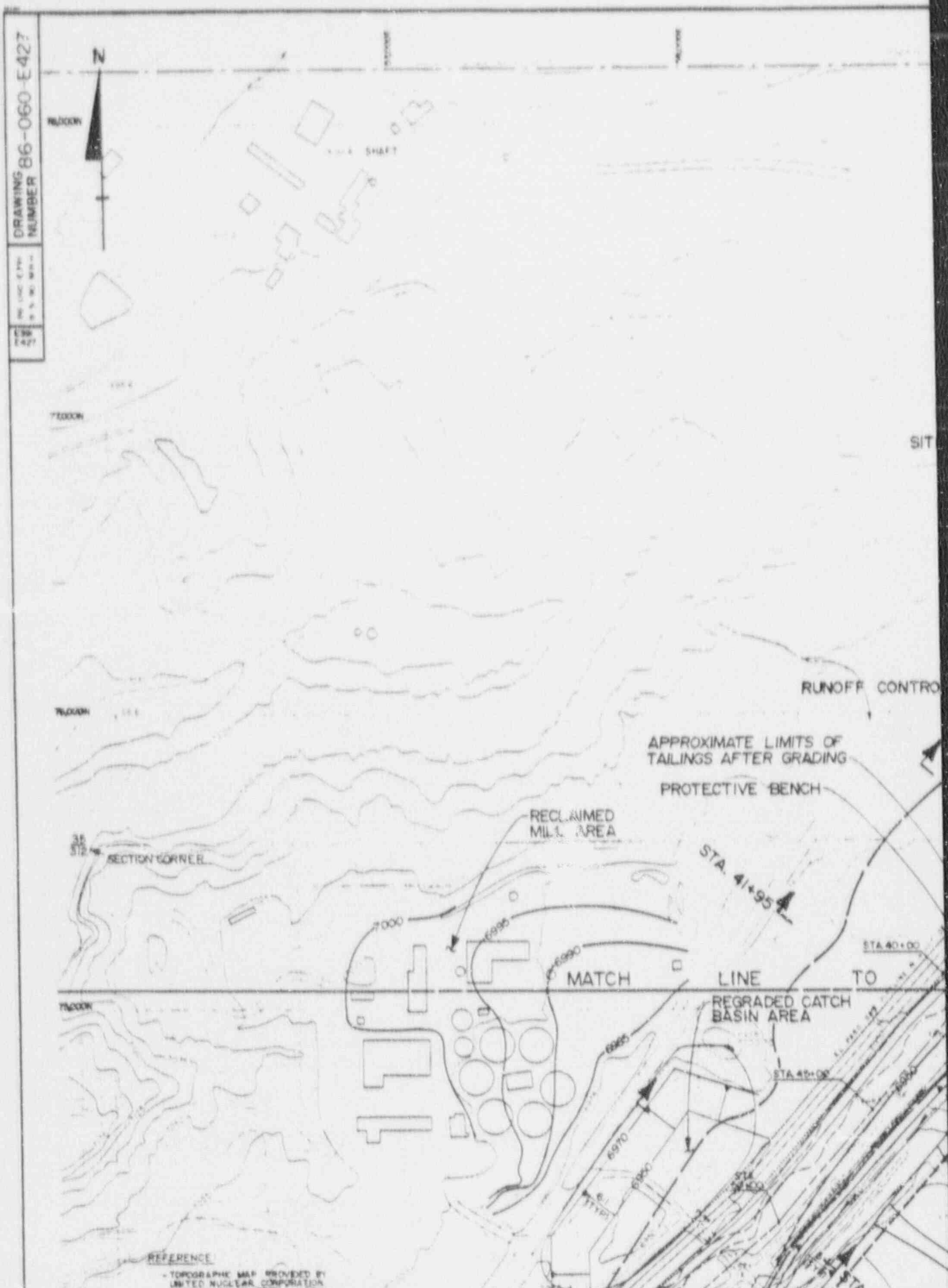
	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	57.750	.00	.00	.00	6941.00	26300.00	6949.01	6949.95	6952.71	149.77	15.61	1737.04	2149.01
	60.400	262.00	.00	.00	6939.00	26300.00	6946.83	6947.12	6949.64	94.23	13.50	1966.05	2709.27
*	61.400	100.00	.00	.00	6933.00	26300.00	6941.27	6943.38	6948.09	300.88	20.95	1255.08	1516.20
*	62.300	95.00	.00	.00	6922.00	26300.00	6938.70	6941.51	6946.35	104.44	24.13	1368.54	2573.47
*	63.800	150.00	.00	.00	6902.00	26300.00	6926.89	6931.98	6943.91	265.21	35.10	854.82	1614.95
	73.800	1005.00	.00	.00	6880.00	26300.00	6895.91	6901.95	6916.09	285.76	36.05	729.54	1555.81
*	80.100	630.00	.00	.00	6874.30	26300.00	6892.38	6895.78	6903.90	139.64	27.25	965.30	2225.64
	82.900	275.00	.00	.00	6871.00	26300.00	6886.51	6890.63	6899.43	191.77	28.84	911.82	1899.17

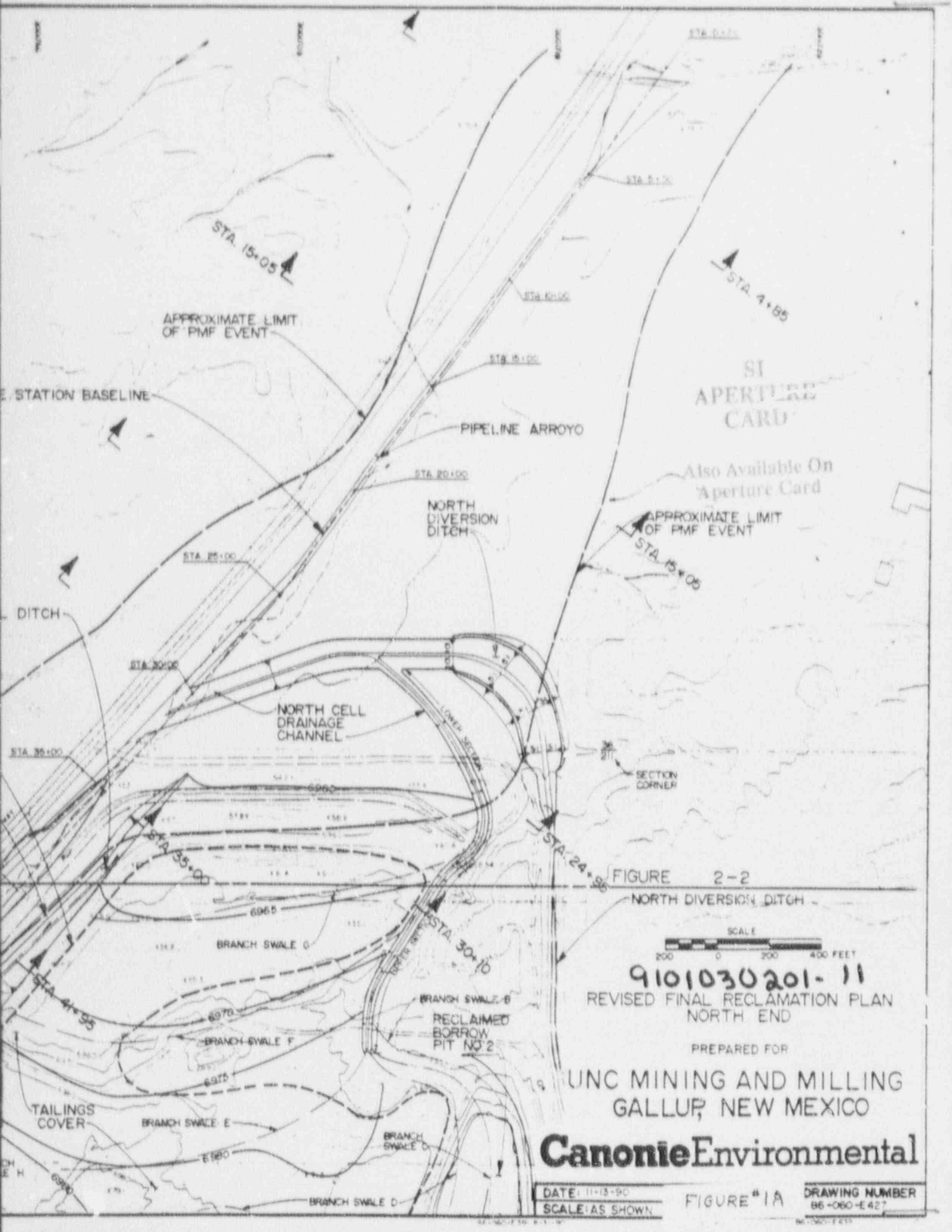
Run Date: 11/26/90 Run Time: 15:16:43 HRVersion: 5.30 Data File: re3old.hc2

3 - SUPERCRITICAL FLOW

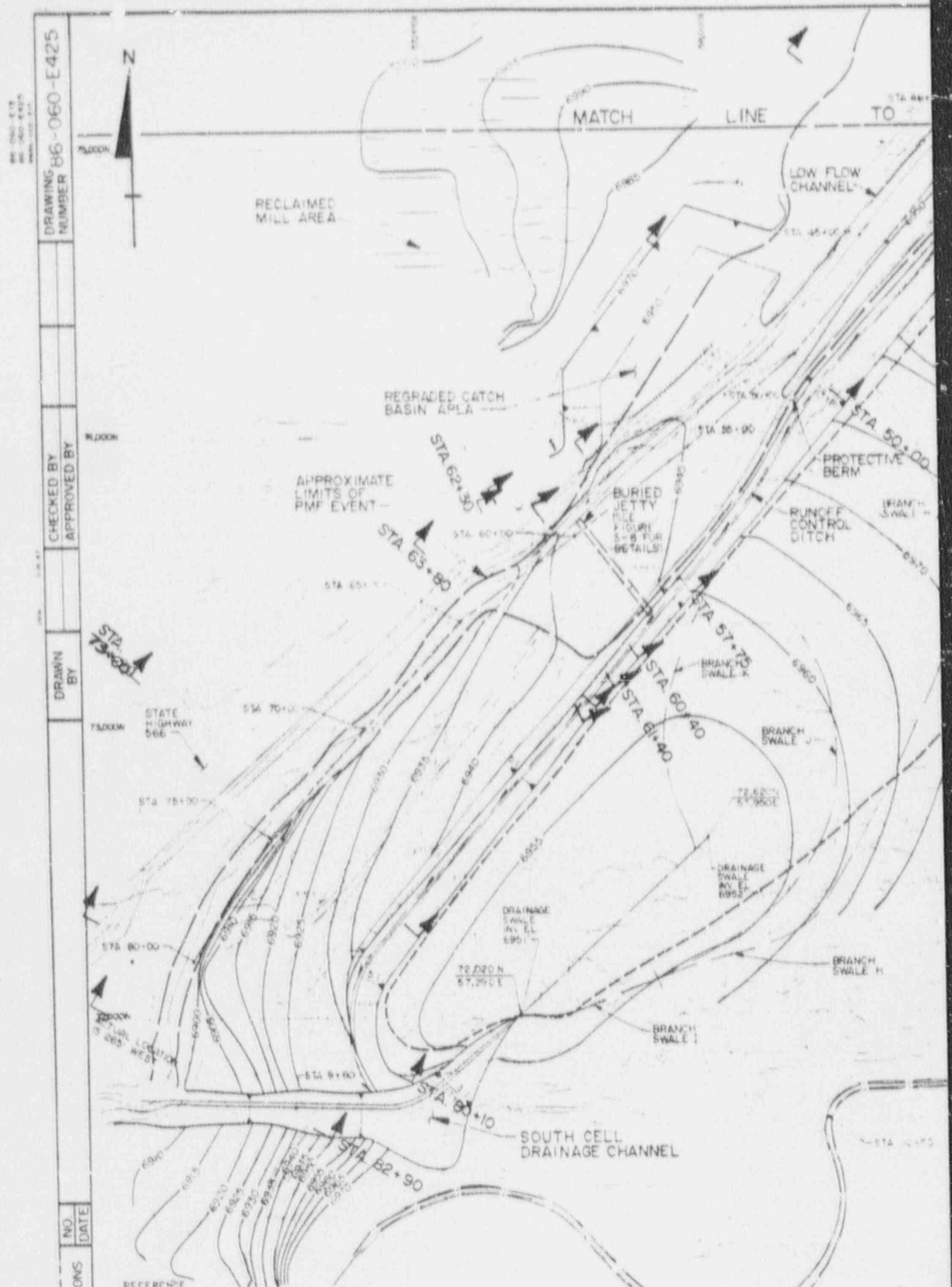
SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	57.750	26300.00	6949.01	.00	.00	-6.99	453.95	.00
	60.400	26300.00	6946.83	.00	-2.18	.00	424.12	262.00
*	61.400	26300.00	6941.27	.00	-5.56	.00	325.12	100.00
*	62.300	26300.00	6938.70	.00	-2.57	.00	220.36	95.00
*	63.800	26300.00	6926.89	.00	-11.81	.00	82.85	150.00
	73.800	26300.00	6895.91	.00	-30.98	.00	71.71	1005.00
*	80.100	26300.00	6892.38	.00	-3.54	.00	86.81	630.00
	82.900	26300.00	6886.51	.00	-5.86	.00	97.56	275.00

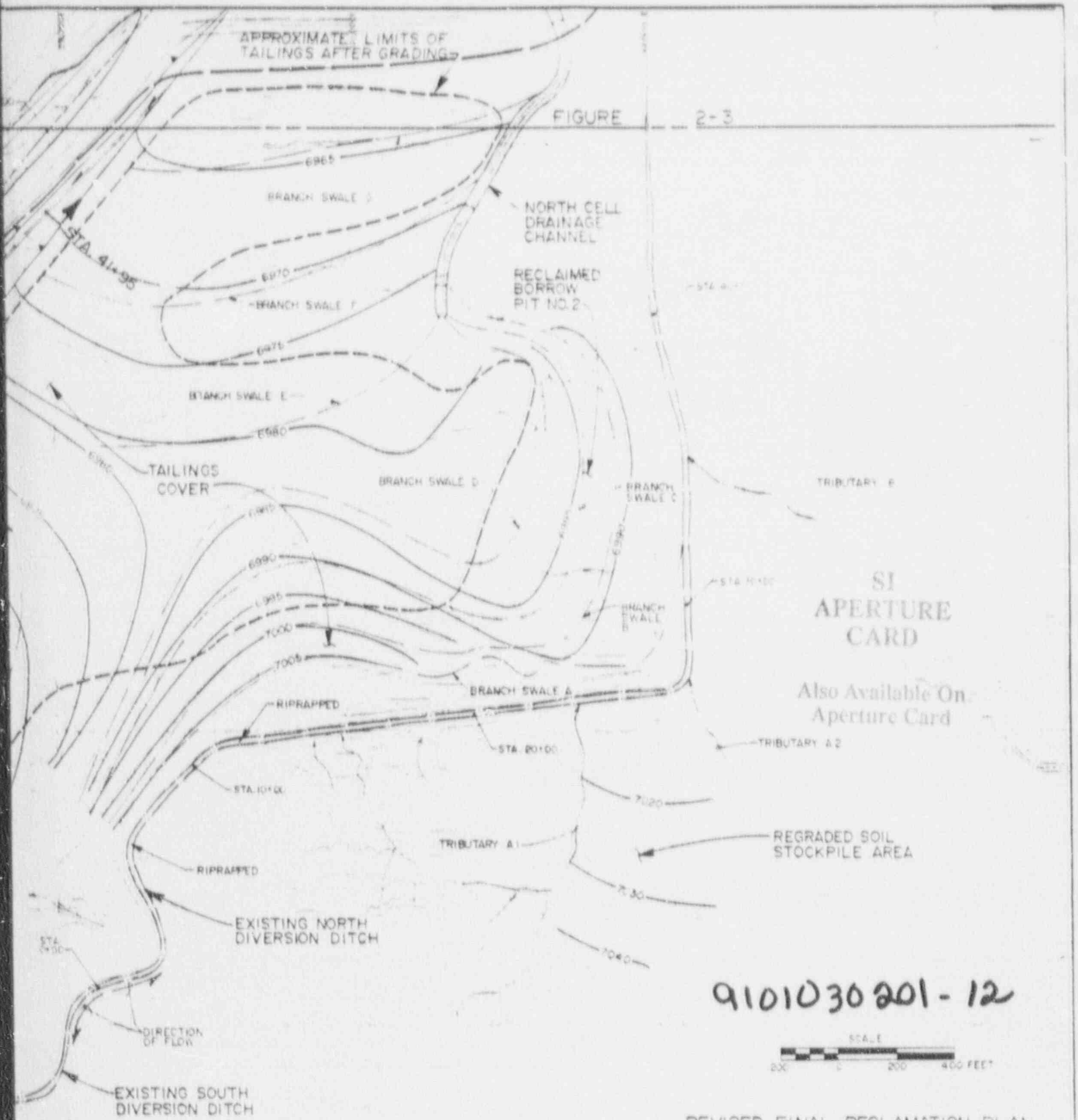

DRAWING NUMBER 86-060-E427
N
SHAFT
SIT
RUNOFF CONTRO
APPROXIMATE LIMITS OF TAILINGS AFTER GRADING
PROTECTIVE BENCH
RECLAIMED MILL AREA
SECTION CORNER
STA. 41+95
7000
6995
6990
MATCH LINE TO
STA 40+00
REGRADED CATCH BASIN AREA
6985
STA 45+00
6970
6960
STA 50+00
REFERENCE:
- TOPOGRAPHIC MAP PROVIDED BY UNITED NUCLEAR CORPORATION
No.
DATE
ISSUE / REVISION
DWN. BY
CK'D BY
APP'D BY



STA. 15+05
STA. 4+85
APPROXIMATE LIMIT OF PMF EVENT
STATION BASELINE
PIPELINE ARROYO
SI APERTURE CARD
Also Available On Aperture Card
NORTH DIVERSION DITCH
APPROXIMATE LIMIT OF PMF EVENT
STA. 15+05
DITCH
NORTH CELL DRAINAGE CHANNEL
SECTION CORNER
STA. 35+00
STA. 24+95
FIGURE 2-2
NORTH DIVERSION DITCH
6965
BRANCH SWALE G
STA. 30+10
STA. 41+95
BRANCH SWALE B
6970
RECLAIMED BORROW PIT NO.2
BRANCH SWALE F
6975
TAILINGS COVER
BRANCH SWALE E
BRANCH SWALE C
6980
BRANCH SWALE D
SCALE
200 0 200 400 FEET
9101030201- 11
REVISED FINAL RECLAMATION PLAN
NORTH END
PREPARED FOR
UNC MINING AND MILLING
GALLUP, NEW MEXICO
Canonie Environmental
DATE: 11-13-90
SCALE: AS SHOWN
FIGURE #1A
DRAWING NUMBER
86-060-E427



DRAWING NUMBER 86-060-E425
CHECKED BY
APPROVED BY
DRAWN BY
REVISIONS
NO.
DATE
N
MATCH LINE TO
RECLAIMED MILL AREA
LOW FLOW CHANNEL
REGRADED CATCH BASIN AREA
APPROXIMATE LIMITS OF PMF EVENT
BURIED JETTY (SEE FIGURE 5-8 FOR DETAILS)
PROTECTIVE BERM
RUNOFF CONTROL DITCH
BRANCH SWALE K
BRANCH SWALE J
BRANCH SWALE H
BRANCH SWALE I
STATE HIGHWAY 566
DRAINAGE SWALE INV. EL. 6952
DRAINAGE SWALE INV. EL. 6951
SOUTH CELL DRAINAGE CHANNEL
DISCHARGE TO NATURAL DRAINAGE
STA. 50+00
STA. 57+75
STA. 60+40
STA. 61+40
STA. 62+30
STA. 63+80
STA. 73+00
STA. 80+10
STA. 82+90
REFERENCE
TOPOGRAPHIC MAP PROVIDED BY UNITED NUCLEAR CORPORATION DRAWING NO. 7195-3 DATED MAY 1, 1985. SCALE: 1" = 200'



SI APERTURE CARD

Also Available On Aperture Card

9101030201 - 12

REVISED FINAL RECLAMATION PLAN
SOUTH END
PREPARED FOR
UNC MINING AND MILLING
GALLUP, NEW MEXICO

Canonie Environmental

No.	DATE	ISSUE / REVISION	DWN BY	CHK BY	APP BY

DATE:	FIGURE #1B	DRAWING NUMBER
SCALE: AS SHOWN		

HEC-2 ANALYSIS FOR LOW FLOW CHANNEL

CanonieEnvironmental

By SWM Date 11-8-90 Subject UNC Sheet No 1 of

Chkd By mg Date 12/3/90 PIPELINE ARROYO HEC-2 ANALYSIS OF LOW FLOW CHANNEL AT BURIED JETTY Proj. No 86-060-24

1/4 X 1/4

PURPOSE: TO COMPUTE THE DISCHARGE (Q) AT WHICH THE STORMWATER WILL OVERTOP THE LOW-FLOW CHANNEL AND CONTACT THE BURIED JETTY (SEE FIGURE #1). THIS ANALYSIS WILL BE PERFORMED FOR THE RECOMMENDED REDESIGN ALTERNATIVE (i.e. HEC-2 ALTERNATIVE #7).

METHOD: PERFORM A TRIAL AND ERROR ANALYSIS USING THE HEC-2 DATA FILE THAT DESCRIBES THE ALTERNATIVE #7 CHANNEL CONFIGURATION (SEE PAGE 5 FOR SUMMARY OF ALTERNATIVE #7). THE INPUT DISCHARGE WILL BE VARIED TO PRODUCE A DISCHARGE VS. WATER SURFACE ELEVATION CURVE (SEE FIGURE 2)

NOTE: THE PROPOSED JETTY WILL BE LOCATED AT STATION 59+50. THIS IS IN CLOSE PROXIMITY TO THE HEC-2 CROSS-SECTION AT STATION 60+40. THEREFORE IT IS ASSUMED THAT THE WATER SURFACE ELEVATIONS AT THESE STATIONS ARE EQUIVALENT (i.e. THE HEC-2 DATA FOR STATION 60+40 IS REPRESENTATIVE OF STATION 59+50)

CanonieEnvironmental

By SWM Date 11-8-90 Subject UNC Sheet No. ___ of 2

Chkd. By mm Date 12/5/96 Proj. No 86-060-27

1/4" X 1/4"

RESULTS:

THE CHANNEL IS OVERTOPPED AT ELEVATION 6993', WHICH OCCURS AT A DISCHARGE Q = 2250 CFS.

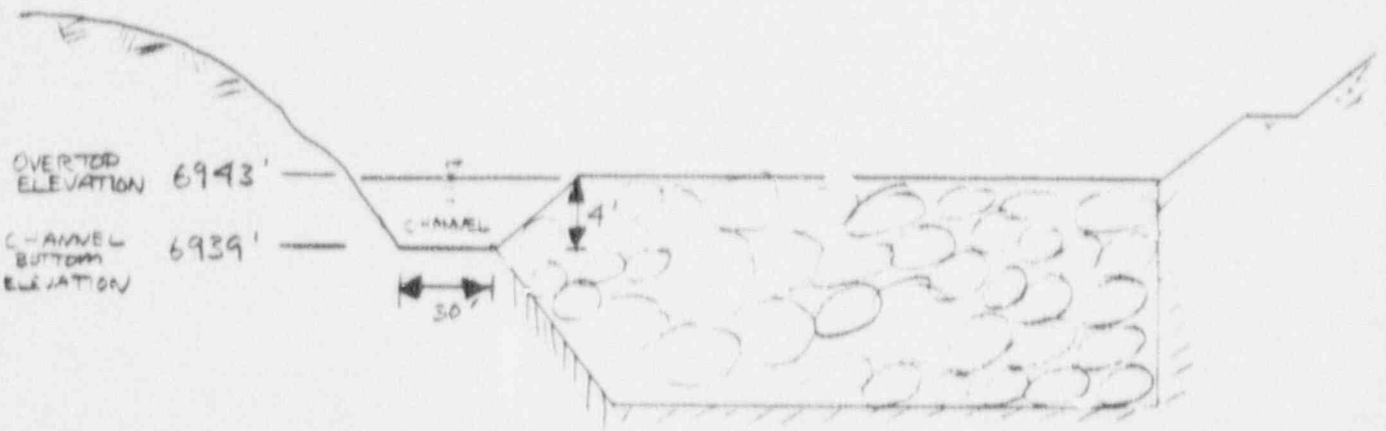
THE HEC-2 OUTPUT FOR Q_{INPUT} = 2250 CFS IS INCLUDED IN THIS CALC BRIEF.

CanonieEnvironmental

By SWM Date 11-8-90 Subject UNC Sheet No 5 of ____

Chkd. By [signature] Date 12/5/90 FIGURE # 1 Proj. No 86-060-24

1/4 X 1/4



STATION 5950'

FIGURE 1

CanonieEnvironmental

By SWM Date 11-8-90 Subject UNC Sheet No. 4 of

Chkd. By ___ Date 12/3/90 FIGURE 2 Proj. No 86-060-29

1/4 X 1/4

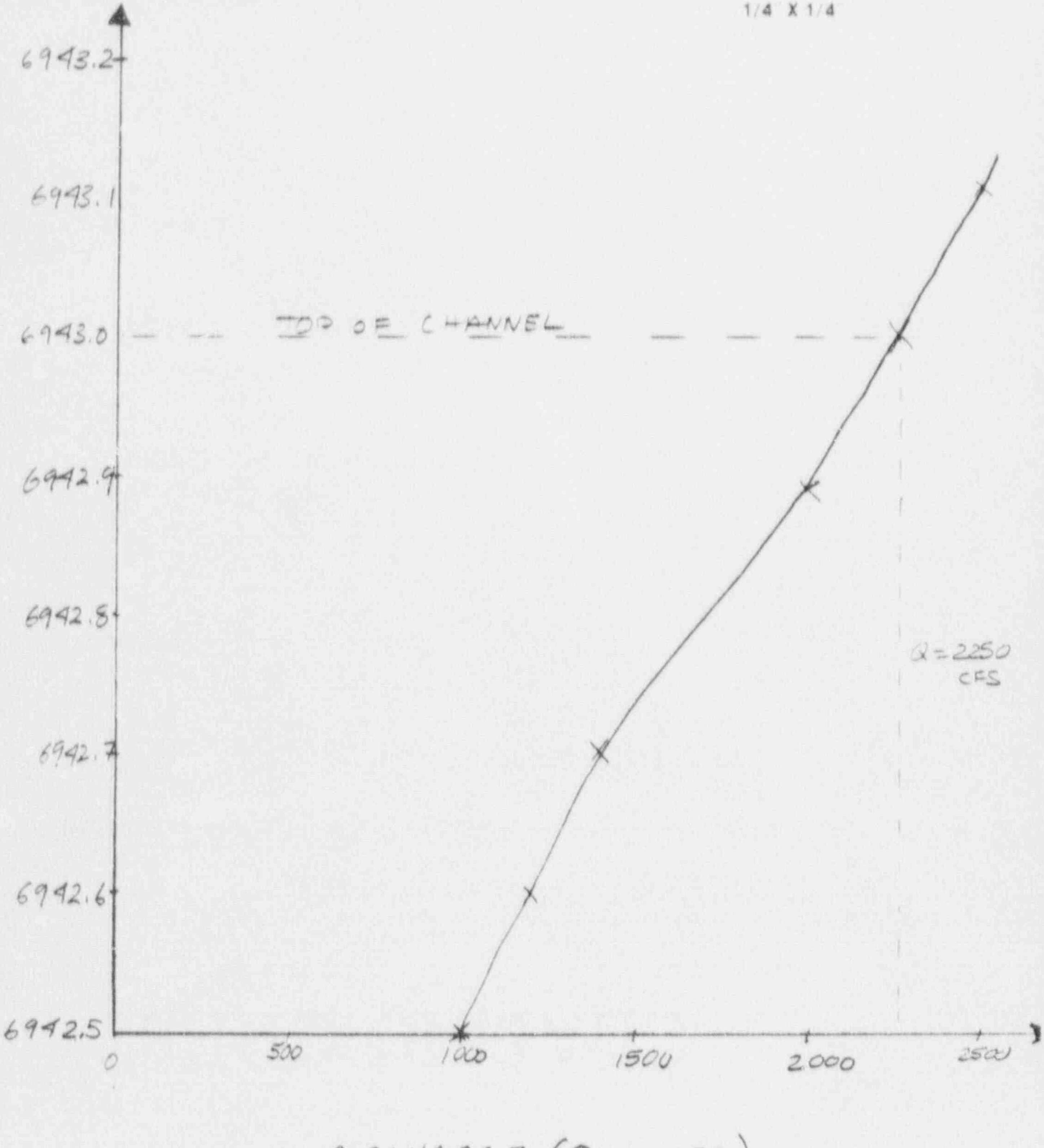


FIGURE 2

Summary of Alternative #7:

In Alternative #7, the channel is modified only slightly from the existing configuration as follows:

- o ensure a 30' wide, 2' deep channel bottom from Sta 5+00 to Sta 61+70 (i.e. low-flow channel)
- o Fill existing depressions and headcuts
- o a stone filled trench (jetty) will be installed at Sta 59+50 to reinforce the Nickpoint and maintain shallow upstream slopes.
- o a 40' wide protective bench will be constructed at the tailings embankment toe which would protect the embankment and tailings during the PMF.

U-~~ 2/3/9~

```
*************************************************      ***********************************
* WATER SURFACE PROFILES                        *      * U.S. ARMY CORPS OF ENGINEERS    *
* VERSION OF SEPTEMBER 1988                     *      * THE HYDROLOGIC ENGINEERING CENTER *
* ERROR: 01,02,03,04                            *      * 609 SECOND STREET, SUITE D      *
* UPDATED: JUNE 1990                            *      * DAVIS, CALIFORNIA 95616-4687    *
* RUN DATE    11/26/90      TIME          19    *      *                                 *
*************************************************      ***********************************
```

```
X     X XXXXXXX  XXXXX           XXXXX
X     X X       X     X         X     X
X     X X       X                     X
XXXXXXX XXXX    X        XXXXX   XXXXX
X     X X       X               X
X     X X       X     X         X
X     X XXXXXXX  XXXXX          XXXXXXX
```

B. SWM
1-8-90

P 6

```
:::::::::::::::::::::::::::::::::::::::::::::::
:::::::::::::::::::::::::::::::::::::::::::::::
:::                                         :::
:::   FULL MICRO-COMPUTER IMPLEMENTATION    :::
:::                                         :::
:::::::::::::::::::::::::::::::::::::::::::::::
:::::::::::::::::::::::::::::::::::::::::::::::
```

```
===============================
H A E S T A D   M E T H O D S
===============================
```

37 Brookside Road * Waterbury, Connecticut 06708 * (203) 756-1666

END OF BANNER

ALTERNATIVE # 7
RUN FOR
Q = 2250 cfs

✓ [handwritten initials] 12/3/90

THIS RUN EXECUTED 11/26/90 17:12:29

****

HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

ERROR CORR - 01,02,03,04
MODIFICATION -

****

Alt 7

T1 ALTERNATIVE #7--REACH 1&2-[redacted]
T2 UNC PROJECT NO. 86-060-24 RESP. TO NRC COMMENTS 11/7/90
T3 PIPELINE ARROYO SUBCRITICAL FLOW

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	0	0	0	0.04	0	0	2250	6950	0

NC	0.036	0.035	0.03							
X1	61.40	17	250	676	0	0	0			
GR	6960	0	6955	56	6950	127	6945	250	6940	260
GR	6935	270	6933	275	6933	300	6937	310	6937	490
GR	6942	600	6942	650	6942	660	6942	676	6951.5	727.5
GR	6951.5	767.5	6957	792						
X1	60.40	10	110	515	160	130	100			
GR	6960	0	6950	110	6939	115	6939	140	6941.5	145
GR	6943	515	6943	530	6952	572.5	6952	612.5	6957	632
X1	57.75	16	145	543	270	295	262			
GR	[illegible]	0	6955	35	6950	90	6945.5	145	6941	155
GR	6941	185	6945	195	6945	230	6945	270	6945	295
GR	6945	330	6945	375	6946	543	6953.5	587.5	6953.5	627.5
GR	6960	669								
X1	50.60	14	455	712	750	850	775			
GR	6975	0	6970	10	6965	30	6960	100	6950	140
GR	6960	320	6960	455	6944	532	6944	562	6950	650
GR	6950	712	6957	745	6967	785	6976	880		
X1	41.95	12	535	772	820	800	805			
GR	6970	0	6965	70	6960	165	6955	235	6950	535
GR	6947	567	6947	587	6953.5	700	6953.5	772	6960.5	810
GR	6960.5	850	6970	905						
X1	35.00	9	215	780	700	700	705			
GR	6970	[illegible]	6950	145	6965	215	6948.7	583	6948.7	603
GR	6958	710	6958.5	780	6962.5	800	6962.5	840		
X1	30.10	21	[illegible]	980	495	1140	490			
GR	6970	0	6960	135	6955	565	6952	575	6952	585
GR	6955	615	6955	660	6956	765	6955	800	6955	850
GR	6955	880	6956	980	6968	990	6960	1000	6960	1070
GR	[illegible]	1422	6962.4	1510	6964.5	1680	6966.5	1795	6968	[illegible]
GR	6970	1910								

✓ [illegible] 12/3/90

12.8

X1	24.95	26	795	1800	560	540	520			
GR	7000	0	6990	45	6980	140	6970	275	6960	545
GR	6960	615	6950	795	6955	865	6953	865	6953	895
GR	6956	895	6956	1175	6956	1295	6955	1385	6955	1715
GR	6958	1770	6960	1800	6960	1970	6962	2060	6964	2070
GR	6966	2080	[illegible]	2090	6970	2100	6980	2150	6996	2165
GR	7000	2230								
X1	15.05	15	690	795	910	1180	990			
GR	7000	0	6990	35	6980	105	6970	210	6960	690
GR	6959	710	6959	740	6960	795	6960	1520	6975	1575
GR	6980	1600	6985	1620	6990	1645	6995	1660	7000	1690
X1	4.85	14	820	1155	1035	1070	1022			
GR	6980	0	6970	820	6970	890	6965	890	6968	920
GR	6970	920	6970	930	6970	950	[illegible]	1000	6970	103[illegible]
GR	6970	1050	6970	1105	6970	1155	6980	1540		

12/3/90

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SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*PROF 1

*SECNO 61.400
3720 CRITICAL DEPTH ASSUMED

61.400	4.79	6937.79	6937.79	6950.00	6938.58	.78	.00	.00	6945.00
2250.0	.0	2250.0	.0	.0	317.2	.0	.0	.0	6942.00
.00	.00	7.09	.00	.000	.030	.000	.000	6933.00	264.41
.013861	0.	0.	0.	0	17	0	.00	234.66	499.07

*SECNO 60.400
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

60.400	4.02	6943.02	6943.02	.00	6943.50	.49	1.34	.00	6950.00
2250.0	.0	2249.9	.1	.0	401.8	.3	.8	.8	6943.00
.00	.00	5.60	.32	.000	.030	.035	.000	6939.00	113.17
.012921	160.	100.	130.	20	10	0	.00	416.91	530.08

*SECNO 57.750

57.750	4.76	6945.76	.00	.00	6946.13	.37	2.63	.00	6945.50
2250.0	.4	2246.6	3.0	.4	461.1	1.5	3.4	3.2	6945.00
.02	.98	4.87	1.97	.035	.030	.035	.000	6941.00	141.79
.008000	270.	262.	295.	5	0	0	.00	405.20	546.99

*SECNO 50.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.85

50.000	4.83	6948.83	.00	.00	6949.19	.36	3.06	.00	6950.00
2250.0	.0	2250.0	.0	.0	465.8	.0	11.7	8.3	6950.00
.06	.00	4.83	.00	.000	.030	.000	.000	6944.00	470.01
.002349	750.	775.	850.	5	0	0	.00	162.84	632.85

*SECNO 41.950

41.950	4.15	6951.15	.00	.00	6951.79	.64	2.60	.00	6950.00
2250.0	79.4	2170.6	.0	39.5	332.2	.0	19.4	11.6	6953.50
.10	2.01	6.53	.00	.035	.030	.000	.000	6947.00	466.15
.004698	820.	805.	800.	3	0	0	.00	192.95	659.10

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 35.000

3301 HV CHANGED MORE THAN HVINS

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 2.02

35.000	4.40	6953.10	.00	.00	6953.24	.14	1.45	.00	6955.00
2250.0	.0	2250.0	.0	.0	763.0	.0	26.6	15.8	6958.50
.17	.00	2.95	.00	.000	.030	.000	.000	6948.70	326.30
.001147	700.	705.	700.	2	0	0	.00	327.27	653.56

*SECNO 30.100
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

30.100	3.74	6956.74	6956.74	.00	6956.22	.48	1.38	.00	6960.00
2250.0	.0	2250.0	.0	.0	403.5	.0	35.2	20.2	6966.00
.19	.00	5.58	.00	.000	.030	.000	.000	6952.00	501.47
.014004	495.	490.	1140.	20	9	0	.00	452.41	953.88

*SECNO 24.950

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 6.30

24.950	3.77	6956.77	.00	.00	6956.80	.03	.58	.00	6960.00
2250.0	.0	2250.0	.0	.0	1609.9	.0	47.2	28.3	6960.00
.29	.00	1.40	.00	.000	.030	.000	.000	6953.00	840.30
.000373	560.	520.	540.	5	0	0	.00	907.04	1747.34

*SECNO 15.050
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED

15.050	1.61	6960.61	6960.61	.00	6960.92	.31	1.12	.00	6960.00
2250.0	18.2	799.9	1431.8	9.0	131.7	444.3	73.1	50.0	69[illegible].00
.36	2.03	6.07	3.22	.035	.030	.035	.000	6959.00	660.53
.011109	910.	990.	1180.	20	12	0	.00	861.61	1522.24

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 4.850

4.850	3.00	6971.00	.00	.00	6971.41	.41	10.49	.00	6970.00
2250.0	106.5	2093.5	50.0	41.3	396.3	19.4	86.6	65.8	6970.00
.42	2.58	5.28	2.58	.035	.030	.035	.000	6968.00	737.68
.009235	1035.	1022.	1070.	5	0	0	.00	455.97	1193.65

/ mpo 93.90

PROFILE FOR STREAM INE ARROYO SUBCRITICAL F

PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

P.12

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ELEVATION 6933.    6938.    6943.    6948.    6953.    6958.    6963.    6968.    6973.    6978.
   SECNO   CUMDIS

   61.40     0.  I         WE      R .   L     .       .     M .       .       .       .       .       .
   60.40   100.  .       . I        WE       .    L    .     M .       .       .       .       .       .
           200.  C       .   I     . WE     .L     .       M       .       .       .       .       .
           300.  C       .    I     .  RWE L  .     .       . M     .       .       .       .       .
   57.75   400.  C       .     I    .   RLE   .     .       .  M    .       .       .       .       .
           500.  C       .      I    .    RWE .     .       .      M .       .       .       .       .
           600.  C       .       I   .      WE .     .       .       . M     .       .       .       .
           700.  C       .       I   .      WE.      .       .       .      M .       .       .       .
           800.  C       .        I.         EL      .       .       .       .   M.      .       .       .
           900.  C       .         I         WEL     .       .       .       .       . M     .       .
          1000.  C       .        .I         WEL     .       .       .       .       .      M .       .
          1100.  C       .        .I        .WEL     .       .       .       .       .       .M      .
   50.00  1200.  C       .        . I       . E L    .       .       .       .       .       . M     .
          1300.  C       .        .  I      . WELR   .       .       .       .       .       .M      .
          1400.  C       .        .  I      .  WE R  .       .       .       .       .       .M      .
          1500.  C       .        .   I     .  WE  R .       .       .       .       .       M       .
          1600.  C       .        .    I    .   WE R .       .       .       .       .      M.       .
          1700.  C       .        .     I   .   LWE R .      .       .       .       .     M .       .
          1800.  C       .        .     I   .   LWE  R.      .       .       .       .    M  .       .
          1900.  C       .        .      I  .   L WE  R      .       .       .       .   M   .       .
   41.95  2000.  C       .        .       I .   L W E .R     .       .       .       .  M    .       .
          2100.  C       .        .       I .    L WE . R    .       .       .       .M      .       .
          2200.  C       .        .        I.      WE .  R   .       .       .      M.       .       .
          2300.  C       .        .        I.       WE.   R  .       .       .    M  .       .       .
          2400.  C       .        .         I        EL     R.       .       . M     .       .       .
          2500.  C       .        .         I        WEL     R.      .      .M       .       .       .
          2600.  C       .        .        .I        E L      R      .    .M         .       .       .
   35.00  2700.  C       .        .        .I        E  L    .R      .   M.          .       .       .
          2800.  C       .        .        . I      .WE  L    R      . M     .       .       .       .
          2900.  C       .        .        .  I     . WE   LR.       .    M  .       .       .       .
          3000.  C       .        .        .   I    .  WE  R L       .       M.      .       .       .
          3100.  C       .        .        .     I  .   E R  . L     .       .M      .       .       .
   30.10  3200.  .       .        .        .      I .   WE   .  L    .       .   M   .       .       .
          3300.  C       .        .        .      I .    WER .  L    .       .       .     M .       .
          3400.  C       .        .        .       I.    WE R.  L    .       .       .       .      M.
          3500.  C       .        .        .       I.      E .R L    .       .       .       .       M
          3600.  C       .        .        .        I      E  .R L   .       .       .       .       M
   24.95  3700.  C       .        .        .        I      F  . L    .       .       .       .       M
          3800.  C       .        .        .       .I      E. L      .       .       .       .       M
          3900.  C       .        .        .       . I      E. L     .       .       .       .       M
          4000.  C       .        .        .        .  I     E  L    .       .       .       .       M
          4100.  C       .        .        .        .   I   .E L     .       .       .       .       M
          4200.  C       .        .        .        .    I  .WE L    .       .       .       .       M
          4300.  C       .        .        .        .     I . WEL    .       .       .       .       M
          4400.  C       .        .        .        .      I .  EL   .       .       .       .       M
          4500.  C       .        .        .        .       I   E    .       .       .       .       M
          4600.  C       .        .        .        .       .I  LE   .       .       .       .       M
   15.05  4700.  .       .        .        .        .        . I LWE  .      .       .       .       M
          4800.  C       .        .        .        .        .   I LWE .     .       .       .       M
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```
      4900.  C         .         .         .         .         .      I LWE        .         .         .         M
      5000.  C         .         .         .         .         .       I LWE       .         .         .         M
      5100.  C         .         .         .         .         .        I. LWE     .         .         .         M
      5200.  C         .         .         .         .         .         .I LWE    .         .         .         M
      5300.  C         .         .         .         .         .         . I LWE   .         .         .         M
      5400.  C         .         .         .         .         .         .   I   LWE         .         .         M
      5500.  C         .         .         .         .         .         .     I   LWE       .         .         M
      5600.  C         .         .         .         .         .         .       I.L E       .         .        M.
4.85  5700.  C         .         .         .         .         .         .         I   L WE  .         .   M     .
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✓ mjp 12/3/90

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/ mjg 12/3/90

THIS RUN EXECUTED 11/26/90 17:12:37

**************************** **********************

HEC2 RELEASE DATED SEP 88 UPDATED JUN 1990

ERROR CORR - 01,02,03,04
MODIFICATION -

****

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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

INE ARROYO SUBCRITICAL F

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	61.400	.00	.00	.00	6933.00	2250.00	6937.79	6937.79	6938.58	138.61	7.09	317.21	191.11
*	[redacted]	100.00	.00	.00	6939.00	[redacted]		6943.02	6943.50	129.21	5.60	402.01	197.94
	57.750	262.00	.60	.00	6941.00	2250.00	6945.76	.00	6946.13	80.00	4.87	463.00	251.55
*	50.000	775.00	.00	.00	6944.00	2250.00	6948.83	.00	6949.19	23.09	4.83	465.76	464.22
	41.950	805.00	.00	.00	6947.06	2250.00	6951.15	.00	69C1.79	46.98	6.53	371.69	328.25
*	35.000	705.00	.00	.00	6948.70	2250.00	6953.10	.00	6953.24	11.47	2.95	763.04	664.20
*	30.100	490.00	.00	.00	6952.00	2250.00	6956.74	6956.74	6956.22	148.04	5.58	403.47	184.92
*	24.950	520.00	.00	.00	6963.00	2250.00	6966.77	.60	6966.80	3.73	1.40	1609.85	1165.44
*	15.050	990.00	.00	.00	6959.00	2250.00	6960.61	6960.61	6960.92	111.09	6.07	584.98	213.48
	4.850	1022.00	.00	.00	6968.00	2250.00	6971.00	.00	6971.41	92.35	5.28	457.03	234.13

✓ mjm 12/3/90

INE ARROYO SUBCRITICAL F

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	61.400	2250.00	6937.79	.00	.00	-12.21	234.66	.00
*	60.400	2250.00	6943.02	.00	5.22	.00	416.91	100.00
	57.750	2250.00	6945.76	.00	2.74	.00	405.20	262.00
*	50.000	2250.00	6948.83	.00	3.07	.00	162.84	775.00
	41.950	2250.00	6951.15	.00	2.32	.00	192.95	805.00
*	35.000	2250.00	6953.10	.00	1.96	.00	327.27	705.00
*	30.100	2250.00	6955.74	.00	2.63	.00	452.41	490.00
*	24.950	2250.00	6956.77	.00	1.03	.00	907.04	520.00
*	15.050	2250.00	6960.61	.00	3.84	.00	861.61	990.00
	4.850	2250.00	6971.00	.00	10.39	.00	455.97	1022.00

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APPENDIX D

TAILINGS EMBANKMENT STABILITY

Canonie Environmental

ROCK MULCH DESIGN

CanonieEnvironmental

By mjz Date 10/29/90 Subject UNC - ROCK MULCH SIZING Sheet No. 1 of ___
Chkd. By SWM Date 12/2/90 FOR 5:1 EMBANKMENT SLOPES Proj. No 86-060-24

1/4 X 1/4

PURPOSE: TO DETERMINE THE SIZE (D_{50}) OF ROCK MULCH REQUIRED TO PROTECT THE 5H:1V EMBANKMENT SIDESLOPES AT UNC

METHOD: USE THE CSU METHOD (NUREG 4651) FOR OVERLAND FLOW CALCULATIONS TO DETERMINE ROCK MULCH SIZE REQUIRED.

THE SPREADSHEET PROGRAM OVERCSU.WR1 WAS DEVELOPED TO AID IN CALCULATION OF ROCK MULCH SIZE.

RESULTS: FOR THE PMF, A ROCK MULCH WITH A D_{50} = 1.5" IS REQUIRED

CALCULATIONS:

THE EMBANKMENT SLOPE IS 100 FT WIDE AND HAS A 5H:1V SLOPE (WORST CASE, MAX)

AT 5H:1V
THE SLOPE IS 20% OR 0.20

~~FOR THE~~
THE PMP CORRECTED FOR ALTITUDE = 8.47 INCHES

THE SPREADSHEET OUTPUT, INCLUDING INPUT VALUES FOLLOWS.

BY [illegible] 10/24/90

2/2
86-060-24

√ SWM 12/2/90

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE CSU METHOD   OVERCSU.WR1

PROJECT: UNC: 86-060-24
LOCATION: EMBANKMENT SIDESLOPES

OVERLAND FLOW CALLULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

RUNOFF COEF:	1	RETURN PERIOD:	PMP	
SLOPE LENGTH:	100 FT	1-HR PPT AMOUNT:	8.47 INCHES	
AVE SLOPE:	0.2 FT/FT	Tc (calc):	0.502 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.038	Tc (actual):	2.5 MIN	
FLOW CONC:	3	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.002 ACRES	PPT AMOUNT:	2.329 INCHES	
Mannings n(calc)	0.038	PPT INTENSITY:	55.90 IPH	

PEAK DISCHARGE: 0.128 CFS   Q = CIA
CONC. DISCHARGE: 0.385 CFS

DEPTH: 0.101 FT   EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 1.264 PSF
FLOW VELOCITY: 3.80 FPS   V = Q/FLOW AREA

CALC. d50: 1.533 INCHES   d50 = 5.23 x Slope^0.43 x Conc. Discharge^0.56
Development of Riprap Design Criteria,
Phase II, CSU Method

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT O ... PT	INTERPOLATED PERCENT
2.5	27.5	27.5
5	45	36.5
10	62	44
15	74	54
20	82	69.75
30	89	78
45	95	80.833333333
60	100	

RUNOFF CONTROL DITCH DESIGN

CanonieEnvironmental

By GS Date 11/12/90 Subject UNC - Run-off Control Ditch Design Sheet No. 1 of 10

Chkd. By [illegible] Date 11/30/90 Proj. No. [illegible]

1/4" X 1/4"

PURPOSE: To determine the right design for the run-off control ditch for the reclaimed uranium tailings impoundment embankment at the UNC site.

METHODS: 1) Determine:

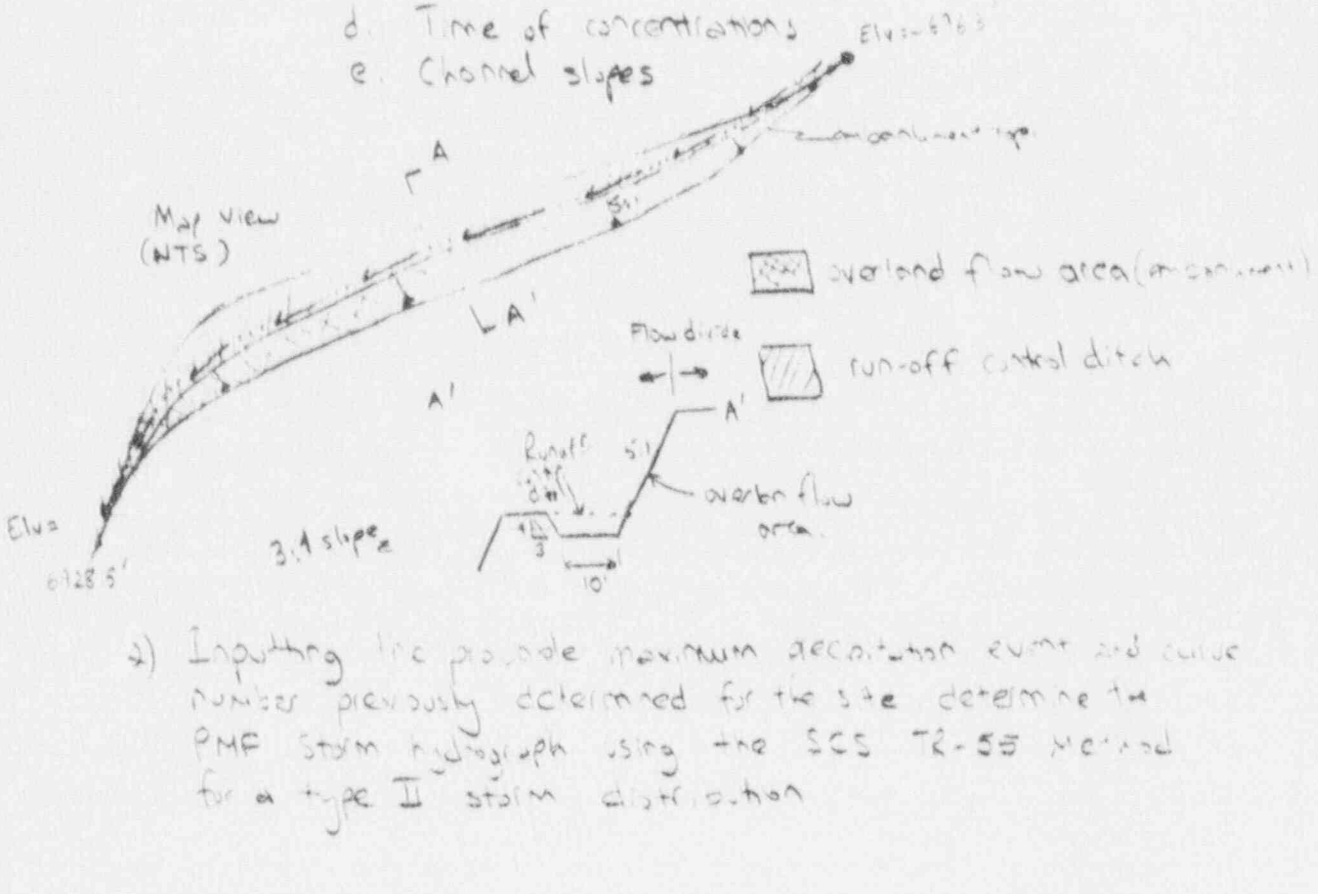
a. Drainage Area

b. Maximum flow length

c. Maximum elevation difference

d. Time of concentrations

e. Channel slopes



2) Inputting the probable maximum precipitation event and curve number previously determined for the site determine the PMF storm hydrograph using the SCS TR-55 Method for a type II storm distribution

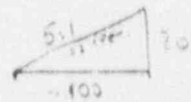
CanonieEnvironmental

By GS Date 10-12-90 Subject UNC - Run-off [illegible]
Chkd. By [illegible] Date 11/3/90 [illegible] Sheet No. 2 of 10
Proj. No. [illegible]
1/4 X 1/4

CALCULATIONS Measure the following from plan topo map

Drainage area (embankment area + run-off control ditch area) = 402,587.46 ft² = 9.24 acres

Max overland flow length = 102 feet



Max channel flow length = 4,400 feet

Max. elev. diff (6963 - 6928.5) = 34.5 feet

Determine 1st cut time of concentration by adding overland flow time and channel flow time. Assume $V_{overland}$ = 1 ft/sec & V_{chc} = 3 ft/sec

t_c = 102 ft / (1 ft/sec) + 4,400 ft / (3 ft/sec) = 1569 sec.

t_c = 26.15 min. / 60 = 2.43 hrs

DETERMINE CURVE NO. (CN)

A CN of 79 was determined by Faith & provided in its 1981 Report to UNC entitled "Design Flood Analysis: North Cell Tailings Embankment". Faith used an area-weighted determination using the names, cover types, hydrologic soil groups, CN.

Science Application, Inc. determined a CN of 80 for the area draining to the N & S diversion ditches in its June 1981 report entitled "PMF Determination for the Southeast Diversion Channel & Section 1 Watershed Using SCS Hydrologic Techniques" (REF: Response to NRC Comments, May 23, 1988)

USE CN = 80

CanonieEnvironmental

By GS Date [illegible] Subject UNC - Runoff Control Sheet No. 3 of 10

Chkd. By [illegible] Date 11/3/86 Ditch Design Proj. No. 86-066-01

1/4 X 1/4

DETERMINE PMP EVENT

PMP has been determined to be 9.4 inch. However a collection must be made for the high elevation of the site (Mean basin elevation collection)

The correction factor is -5%. For every 1000 ft of elevation in excess of 5000 ft conservatively choose mean basin elevation of 7000 ft.

PMP = 8.43 inches

DETERMINE HYDROGRAPH BY TR-55 METHOD.

(see p. 4)

Tc = 0.4

RUNOFF HYDROGRAPHS BY THE SCS TR-55 METHOD

TYPE-II STORM DISTRIBUTION

27-Nov-90
02:40 PM

TIME OF CONCENTRATION = 0.4 HOURS
TRAVEL TIME = 0 HOURS

HYDROGRAPH TIME IN HOURS

WATERSHED DESIGNATION	DRAINAGE AREA (AC)	DRAINAGE AREA (SQ MI)	CURVE NUMBER	PPT AMT (IN)	RUNOFF (IN)	(TIME)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0
						(CSL/IN)	10	25	36	77	141	271	460	592	574	431	298	216	163	104	77	63	55	49	44
RUNOFF CONTROL DIT.N	9.24	1.44E-02	80.0	8.43	6.03	(CFS)	1.57	2.10	3.13	6.70	12.27	23.59	40.74	51.53	49.97	37.52	25.94	19.00	14.19	9.05	6.70	5.48	4.79	4.27	3.83

14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0	26.0
38	34	31	28	25	22	21	20	18	16	14	12	0
3.31	2.96	2.70	2.44	2.18	1.92	1.83	1.74	1.57	1.39	1.22	1.04	0.00

CanonieEnvironmental

By GS Date 11-12-90 Subject UMC - Run-off Control Sheet No. 5 of 10
Chkd. By [illegible] Date 11/30/90 Ditch Design Proj. No. 86-0.0-24
1/4 X 1/4

Determine channel & riprap design
Use peak flows resulting from PMF as determined by SCS TR-55 Hydrograph
Peak flow = 51.5 cfs at time 12.3 hrs

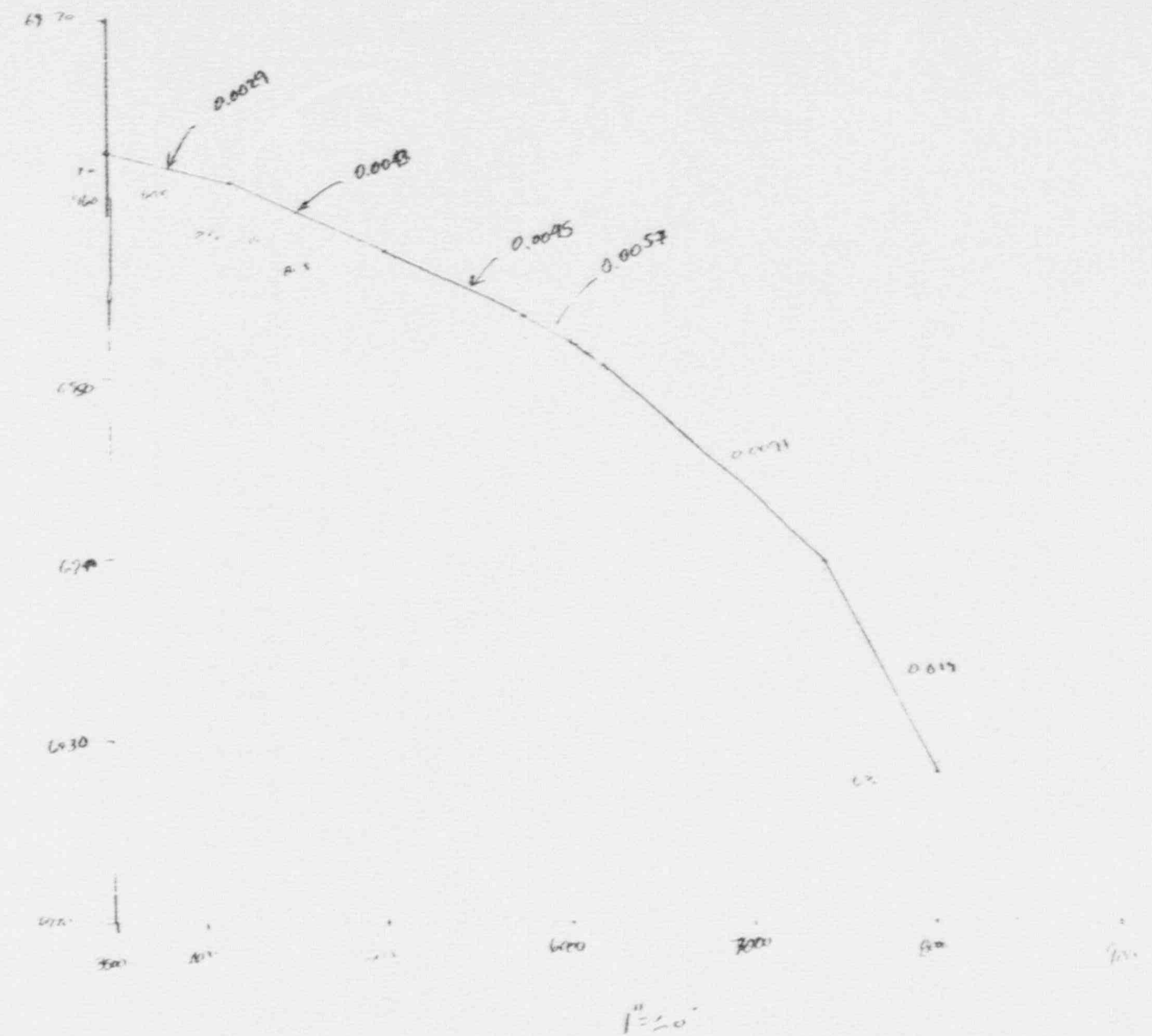
Input peak flow rates assumed channel slopes & bottom widths and side slopes to calculate channel dimensions & riprap sizes by Safety Factor Method. Use spreadsheet "RIPSF. WR1".
(results in pages 7, 8 & 9).

DITCH SLOPE

ΔElv	Length	Slope
6963 - 6928.5 = 34.5	4,400 feet	0.0078 Avg.
	for 3" rock ←	0.019 Max
	for 1.5" rock	0.0029 Min
		0.0091 Max

→ see profile in next page for slope variation.

8610,6928
7300,6939
6730,6950.5
6140,6951.6
6000,6952
5775,6953.5
5000,6957
4195,6960.5
3500,6962.5



11/30/90

0000 ✓ mjg 11/30/90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: RUNOFF CONTROL DITCH

Using avg. slope (0.0078)

DISCHARGE =	51.6 CFS		
BOTTOM WIDTH =	10 FT		
Z (SIDE SLOPE)=	4	Alpha =	14.04 Degrees
CHANNEL SLOPE =	0.0078	Theta =	0.45 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM		CHANNEL SIDE SLOPES	
D50 (ASSUM) =	0.13 FT 1.5 inches	D50 (ASSUM) =	0.13 FT 1.5 inches
n =	0.028	n =	0.028
TRIAL d =	1.00 ft ******		
DIFFERENCE =	7.06 %		
calc d =	0.96 ft ******		
DIFFERENCE =	0.22 %		
calc d =	0.96 ft ******		
DIFFERENCE =	0.02 %		
calc d =	0.96 ft ******		
DIFFERENCE =	0.00 %		
FINAL d =	0.96 ft		
A =	13.35 sq ft		
R =	0.74 ft	t =	0.35 PSF
t =	17.71 ft	nb =	0.63
V =	3.86 fps		
Q(calc) =	52 cfs	Beta =	44.23
t =	0.47 PSF		
nb =	0.842	n' =	0.54
SFb =	1.17 ✓OK	SFs =	1.26 ✓OK

d = 0.96'

✓ 11/30/90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: RUNOFF CONTROL DITCH

Using max. slope (0.019)

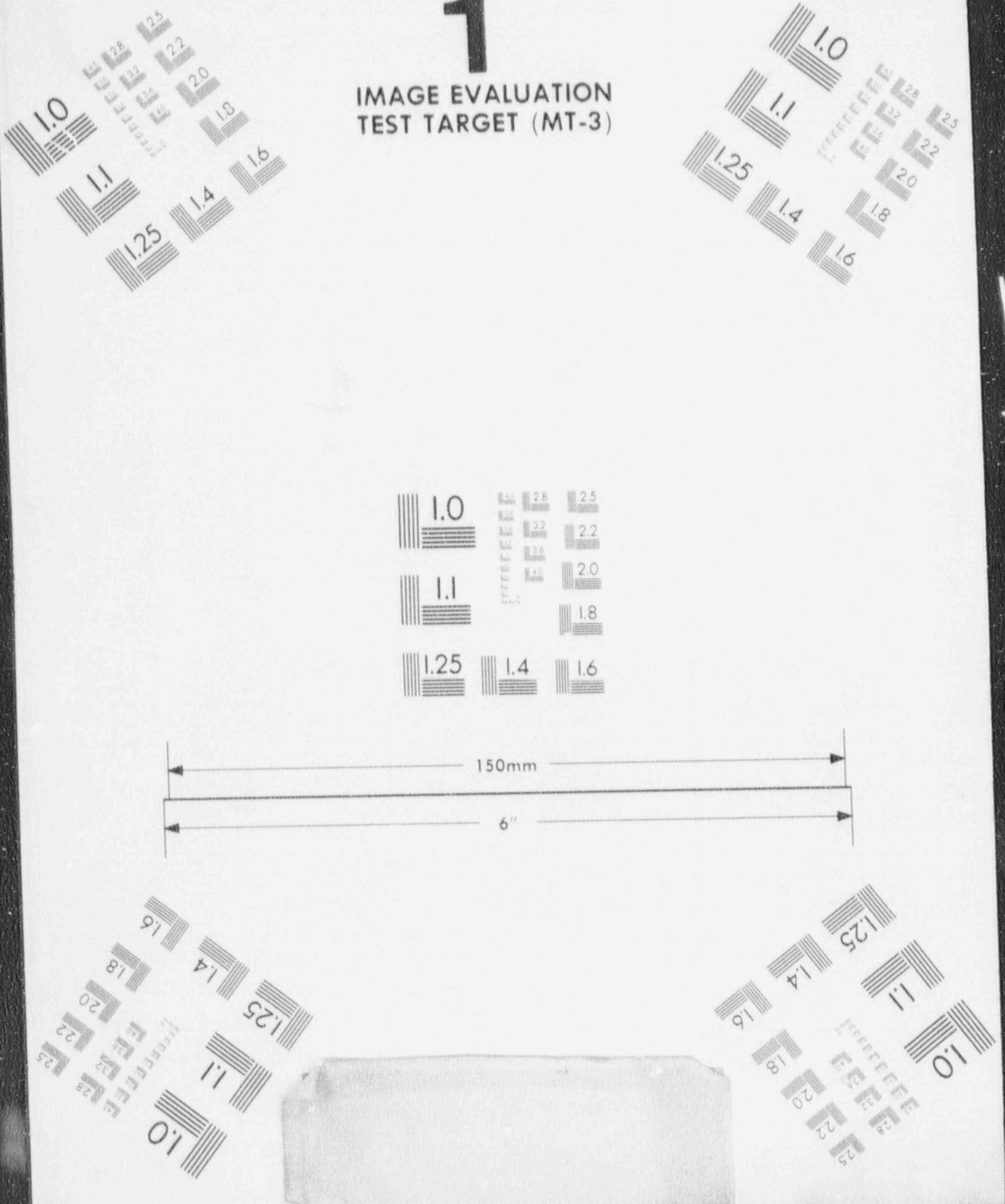
DISCHARGE =	51.5 CFS		
BOTTOM WIDTH =	10 FT		
Z (SIDE SLOPE) =	4	Alpha =	14.04 Degrees
CHANNEL SLOPE =	0.019	Theta =	1.09 Degrees
RIPRAP S.G. =	2.5	Phi =	37.00 Degrees
COEF FOR t =	0.80 see Fig 3.16, ref.		

CHANNEL BOTTOM			CHANNEL SIDE SLOPES		
D50 (ASSUM) =	0.22 FT	2.6 inches	D50 (ASSUM) =	0.22 FT	2.6 inches
n =	0.031		n =	0.031	
TRIAL d =	0.80 ft	******			
DIFFERENCE =	1.24 %				
calc d =	0.80 ft	******			
DIFFERENCE =	0.11 %				
calc d =	0.79 ft	******			
DIFFERENCE =	0.01 %				
calc d =	0.79 ft	******			
DIFFERENCE =	0.00 %				
FINAL d =	0.79 ft				
A =	10.47 sq ft				
R =	0.63 ft		t =	0.75 PSF	
t =	16.36 ft		nb =	0.77	
V =	4.92 fps				
Q(calc) =	52 cfs		Beta =	49.41	
t =	0.94 PSF				
nb =	0.961		n' =	0.68	
SFb =	(1.01) ok		SFs =	(1.09) ok	

d = 0.79'

1

IMAGE EVALUATION
TEST TARGET (MT-3)



1

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

mjg 1/30/90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 185-194

LOCATION: RUNOFF CONTROL DITCH

Using min. slope (0.0029)

DISCHARGE =	51.5 CFS		
BOTTOM WIDTH =	10 FT		
(SIDE SLOPE)=	4	Alpha =	14.04 Degrees
CHANNEL SLOPE =	0.0029	Theta =	0.17 Degrees
RIPRAP S.G. =	2.6	Phi =	37.00 Degrees
COEF FOR t =	0.80 see Fig 3.16, ref.		

CHANNEL BOTTOM

D50 (ASSUM) =	0.13 FT	1.5 inches	
n =	0.028		
TRIAL d =	1.25 ft	******	
DIFFERENCE =	-1.09 %		
calc d =	1.26 ft	******	
DIFFERENCE =	-0.07 %		
calc d =	1.26 ft	******	
DIFFERENCE =	-0.00 %		
calc d =	1.26 ft	******	
DIFFERENCE =	-0.00 %		

CHANNEL SIDE SLOPES

D50 (ASSUM) =	0.13 FT	1.5 inches
n =	0.028	

FINAL d =	1.26 ft
A =	18.90 sq ft
R =	0.93 ft
T =	20.06 ft
V =	2.73 fps
Q(calc) =	51 cfs
t =	0.23 PSF
nb =	0.408
SFb =	2.43 ok

t =	0.18 PSF
nb =	0.33
Beta =	26.87
n' =	0.24
SFs =	1.85 ok

d = 1.26 ft

12/3/90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD FOR CHANNEL BOTTOM AND SIDE SLOPES

RIPSF.WR1 REF: "Applied Hydrology and Sedimentology for Disturbed Areas", pages 18.-194

LOCATION: RUNOFF CONTROL DITCH

DISCHARGE =	51.5 CFS		
BOTTOM WIDTH =	10 FT		
Z (SIDE SLOPE)=	4	Alpha =	14.04 Degrees
CHANNEL SLOPE =	0.0091	Theta =	0.52 Degrees
RIPRAP S.G. =	2.6	Phi =	37.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM			CHANNEL SIDE SLOPES	
D50 (ASSUM) =	0.13 FT	1.5 inches	D50 (ASSUM) =	0.13 FT 1.5 inches
n =	0.028		n =	0.028
TRIAL d =	0.92 ft	******		
DIFFERENCE =	-0.77 %			
calc d =	0.92 ft	******		
DIFFERENCE =	-0.07 %			
calc d =	0.92 ft	******		
DIFFERENCE =	-0.01 %			
calc d =	0.92 ft	******		
DIFFERENCE =	-0.00 %			
FINAL d =	0.92 ft			
A =	12.65 sq ft			
R =	0.72 ft		t =	0.39 PSF
t =	17.39 ft		nb =	0.71
V =	4.07 fps			
Q(calc) =	51 cfs		Beta =	47.37
t =	0.52 PSF			
nb =	0.942		n' =	0.62
SFb =	1.05		SFs =	1.16

VERIFICATION OF THE TIME OF CONCENTRATION ASSUMPTION FOR THE RUNOFF CONTROL DITCH.

Water velocity of 3 ft/sec was assumed in calculating the time of concentration in page 2. This velocity revealed 0.4 hrs for the time of concentration. This number was checked by using the average slope (0.0078) of the runoff control ditch (see the spread sheet in page 7).

As shown in the spread sheet, water velocity in the ditch was calculated to be 3.8 ft/sec.

Using the velocity of 3.8 ft/sec

$$t_c = \underbrace{102\ (1\ ft/s)}_{\text{For the overland flow}} + \underbrace{4{,}400\ (3.8\ ft/s)}_{\text{For the runoff control ditch}} = 0.35\ hrs = \sim \underline{\underline{0.4\ hrs}}$$

RESULTS

The runoff control ditch for the reclaimed uranium tailings impoundment embankment at the UNC site will be armored with 6' thick 1.5" diameter rock except the last 630' in the profile. This part requires 6' thick 3" diameter rock.

SCOUR CALCULATION ALONG PROTECTIVE BENCH

CanonieEnvironmental

By MT Date 26 Nov 90 Subject UNC Sheet No. 1 of 4

Chkd. By MKM Date 12/3/90 Beach Scour Proj. No. 86-060-24

1/4 X 1/4

Purpose The purpose of this calc brief is to estimate the potential scour of the protective beach during passage of the PMF

Methods The empirical methods found in the US Bureau of Reclamations Technical Guideline "Computing Degradation and Local Scour" by Pemberton and Lara (1984) were used. Specifically equations 25 through 30, were used. These equations were derived primarily for wide alluvial channels. The width of the PMF (> 450') indicates that these equations are valid for determining the depth of scour.

The extent of lateral bank scour on the protective beach was considered as one half of the depth of scour, because the tractive forces are less on the beach sideslopes than on the channel bottom and the beach is located approximately 350 feet from the channel. Most of the scour will occur in or near the channel

Results The extent of scour as determined by three methods are summarized below

Method	Extent of beach scour
Neill	2.45 ft
Lacey	1.91 ft
Blench	4.85 ft

Thus for the worst case the beach will be scoured 4.85 ft.

Calculations

Neill Method (Equations 25 and 28)

$$d_f = d_i \left(\frac{q_f}{q_i}\right)^m \qquad (25)$$

where d_f = Scoured depth below design flood water level
d_i = Average depth of bankfull discharge in incised reach - assumed to be 8 feet
q_f = Design flood discharge per unit width
= 26300 cfs / 430 ft = 61.2 cfs/ft
q_i = Bankfull discharge in incised reach per unit width
= 2250 cfs / 50' = 45 cfs/ft
m = 0.67 for sand

$$d_f = 8\left(\frac{61.2}{45}\right)^{0.67} = 9.83'$$

$d_s = 0.5\, d_f$ for Straight reach (28)
where d_s = depth of Scour

$d_s = 0.5 \cdot 9.83 = 4.92'$

Extent of scour = $0.5 \cdot 4.92 = 2.45'$

Lacey Method

$$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3} \qquad (26)$$

where d_m : Mean depth at design discharge
Q : Design discharge = 26300 cfs
$f = 1.76 (D_m)^{1/2}$ where D_m = average grain size of bed material
assume that bed material = fine sand
so D_m = 0.2 mm
$= 1.76 (0.2)^{1/2} = 0.79$

$$d_m = 0.47 \left(\frac{26300}{0.79}\right)^{1/3} = 15.1'$$

$$d_s = 0.25\, d_m = 3.78' \qquad (29)$$

Extent of scour = 0.5 · 3.78 = 1.9'

CanonieEnvironmental

By MT Date 26 Nov 90 Subject UAC Sheet No. 4 of 4

Chkd. By [illegible] Date 12/3/90 Bleach Scour Proj. No. 86-060-24

1/4 X 1/4

Blench Equation

$$d_{f0} = \frac{q_f^{2/3}}{F_{b0}^{1/3}} \qquad (27)$$

where d_{f0} = Depth for zero bed transport

q_f = Design flood discharge for unit width

= 26200 cfs/430 ft = 61.2 cfs/ft

F_{b0} = Blench's zero bed factor from Figure 9 (attached)

= 0.9 for D_m = 0.2 mm

$$d_{f0} = \frac{61.2^{2/3}}{0.9^{1/3}} = 16.1'$$

$$d_s = 0.6 \cdot 16.1' = 9.7' \qquad (30)$$

Extent of scour = 0.5 · 9.7' = 4.85'

The use of equation 24 except as a check on other methods would be limited to channels similar to those observed on relatively steep slopes ranging from 0.004 to 0.008 ft/ft (m/m). Because of shallow depths of flow and medium to coarse sand size bed material the bedload transport should also be very high.

Regime equations supported by field measurements method. - This approach as suggested by Neill (1973) on recommendations by Blench (1969) involves obtaining field measurements in an incised reach of river from which the bankfull discharge and hydraluics can be determined. From the bankfull hydraulics in the incised reach of river, the flood depths can be computed by:

$$d_f = d_i \left(\frac{q_f}{q_i}\right)^m \qquad (25)$$

where:

d_f = Scoured depth below design floodwater level
d_i = Average depth at bankfull discharge in incised reach
q_f = Design flood discharge per unit width
q_i = Bankfull discharge in incised reach per unit width
m = Exponent varying from 0.67 for sand to 0.85 for coarse gravel

This method has been expanded for Reclamation use to include the empirical regime equation by Lacey (1930) and the method of zero bed-sediment transport by Blench (1969) in the form of the Lacey equation:

$$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3} \qquad (26)$$

where:

d_m = Mean depth at design discharge, ft (m)
Q = Design discharge, ft^3/s (m^3/s)
f = Lacey's silt factor equa[illegible] [illegible].76 $(D_m)^{1/2}$ where D_m equal mean grain size of bed mate[illegible] in millimeters

and the Blench equation for "z[illegible]o bed factor":

$$d_{fo} = \frac{q_f^{\,2/3}}{F_{bo}^{\,1/3}} \qquad (27)$$

where:

d_{fo} = Depth for zero bed sediment transport, ft (m)
q_f = Design flood discharge per unit wigth, ft^3/s per ft (m^3/s per m)
F_{bo} = Blench's "zero bed factor" in ft/s^2 (m/s^2) from figure 9

The maximum natural channel scour depth for design of any structure placed below the streambed (i.e., siphon) or along the bank of a channel must

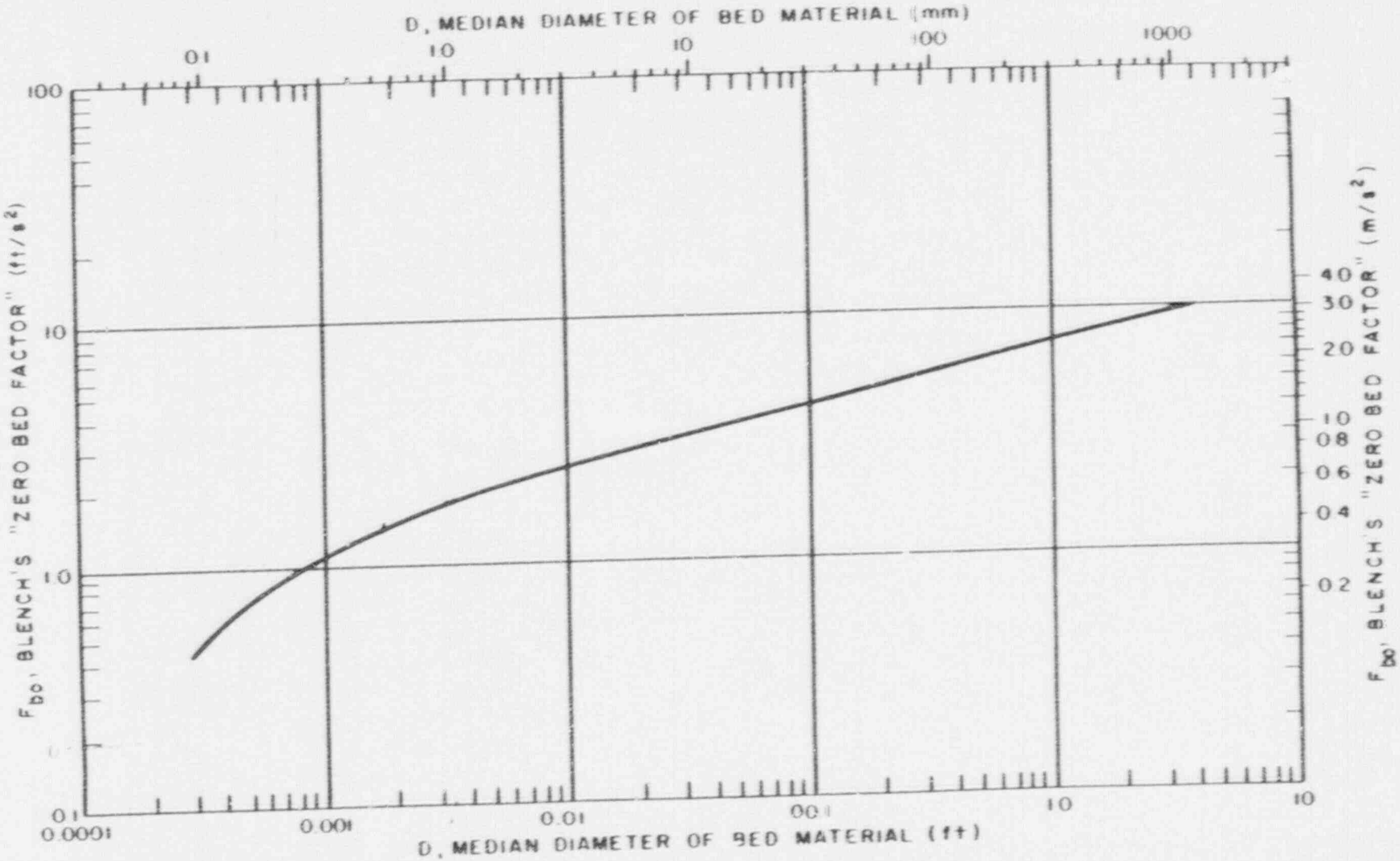


CHART FOR ESTIMATING F_{bo} (AFTER BLENCH)

Figure 9. - Chart for estimating F_{bo} (after Blench, 1969).

consider the probable concentration of floodflows in some portion of the natural channel. Equations 25, 26, or 27 for predicting this maximum depth are to be adjusted by the empirical multiplying factors, Z, shown for formula Types A and B (table 6), in table 7. An illustration of maximum scour depth associated with a flood discharge is shown in a sketch of a natural channel, figure 10. As shown in table 7 and on figure 10, the d_s equals depth of scour below streambed.

$$d_s = Z\, d_f \tag{28}$$

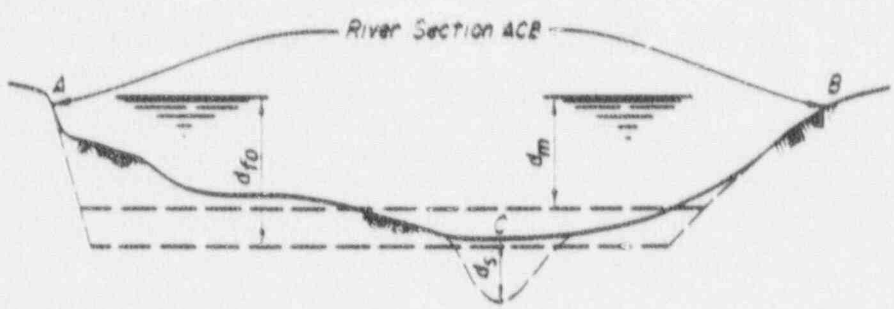
$$d_s = Z\, d_m \tag{29}$$

$$d_s = Z\, d_{fo} \tag{30}$$

Table 7. - Multiplying factors, Z, for use in scour depths by regime equations

Condition	Value of Z		
	Neill $d_s = Z\, d_f$	Lacey $d_s = Z\, d_m$	Blench $d_s = Z\, d_{fo}$
<u>Equation Types A and B</u>			
Straight reach	0.5 [redacted]	0.25 [redacted]	1/ 0.6 [redacted]
Moderate bend	0.6	0.5	
Severe bend	0.7	0.75	
Right angle bends		1.0	1.25
Vertical rock bank or wall		1.25	
<u>Equation Types C and D</u>			
Nose of piers	1.0		0.5 to 1.0
Nose of guide banks	0.4 to 0.7	1.50 to 1.75	1.0 to 1.75
Small dam or control across river		1.5	0.75 to 1.25

1/ Z value selected by USBR for use on bends in river.



NOTE: $d_{fo} > d_f > d_m$. Point C is low point of natural section.

Figure 10. - Sketch of natural channel scour by regime method.

APPENDIX E

NICKPOINT STABILITY - RIPRAP DESIGN FOR JETTY

CanonieEnvironmental

By SWM Date 12-3-90 Subject UNC Sheet No. 1 of 3

Chkd. By mjp Date 12/3/90 Proj. No 86-060-24

1/4 X 1/4

PURPOSE: TO DETERMINE THE RIPRAP d_{50} FOR THE BURIED JETTY AT STA 59+50 OF THE RECOMMENDED PIPELINE ARROYO REDESIGN ALTERNATIVE (HEC-2 ALTERNATIVE #7).

METHOD: USE RIPSFHEC.WRI (LOTUS SYMPHONY SPREADSHEET) TO DETERMINE RIPRAP d_{50} BY MEANS OF THE SAFETY FACTOR METHOD. HEC-2 RESULTS FROM ALTERNATIVE #7 ARE USED AS INPUT FOR RIPSFHEC.WRI.

REFERENCES: "APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS", PAGES 185-194.

86-060-24 CALC. BRIEF - HEC-2 ANALYSIS OF THE RECOMMENDED REDESIGN ALTERNATIVE FOR PIPELINE ARROYO.

RESULTS: A RIPRAP d_{50} OF 6.4 INCHES WAS CALCULATED FOR THE BURIED JETTY. (SEE ATTACHED RIPSFHEC.WRI PRINTOUT)

CanonieEnvironmental

By SVM Date 12-3-90 Subject UNC Sheet No. 2 of 3

Chkd. By mzg Date 12/3/90 Proj. No 86-060-29

1/4" X 1/4

CALCULATIONS :

- SLOPE BETWEEN STA 59+50 AND STA 57+75 (ELEVATIONS WERE DERIVED FROM JIM FLETCHER'S SURVEY DATA OF PIPELINE ARROYO) :

$$m = \frac{\Delta elev}{\Delta dist} = \frac{6941.4 - 6940.5}{|5775 - 5950|} = \underline{\underline{0.005}}$$

- ASSUME A SPECIFIC GRAVITY OF 2.6 FOR RIPRAP.

BY: SWM
12-3-90

✓ [initials] 12/3/90

RIPRAP DETERMINATION BY SAFETY FACTOR METHOD USING HEC2 RESULTS RIPSFHEC.WR1
REF: "Applied Hydrology and Sedimentology
for Disturbed Areas", pages 185-194

LOCATION: CROSS-SECTION @ STA 60.40

Z (SIDE SLOPE)	3	Alpha =	18.43 Degrees
CHANNEL SLOPE =	0.005	Theta =	0.29 Degrees
RIPRAP S.G. =	2.6	Phi =	41.00 Degrees
COEF FOR t =	0.75 see Fig 3.16, ref.		

CHANNEL BOTTOM

D50 (ASSUM) = 0.53 FT 6.4 INCHES
n = 0.036
DEPTH= 8 FT
t = 2.50 PSF
nb = 0.991

SFb = 1.00

CHANNEL SIDE SLOPES

D50 (ASSUM) = 0.53 FT 6.4 INCHES
n = 0.036
DEPTH= 8 FT
t = 1.87 PSF
nb = 0.74

Beta = 45.45

n' = 0.64

SFs = 1.06

EMBANKMENT SIDESLOPES

D50 (ASSUM) = NA FT NA INCHES
n = NA
DEPTH= NA FT
t = NA PSF
nb = NA

Beta = NA

n' = NA

SFs = NA

UNC MINING AND MILLING

UNC

Division of United Nuclear Corporation
A UNC RESOURCES Company

Church Rock Operations
P.O. Drawer QQ

Gallup, New Mexico 87301
Telephone 505/722-6651

Memorandum

To: C. Johnson

Date: April 9, 1990

From: J. Fletcher

Subject: Pipeline Arroyo Profile

Station	Latitude	Departure	Elevation
0	73847.56	57678.51	6941.37
1+3	73788.83	57593.20	6939.73
1+14	73782.34	57585.59	6940.43
1+32	73770.67	57571.88	6940.69
1+69	73746.03	57542.96	6940.58
2+13	73717.63	57509.62	6938.44
2+37	73700.25	57493.06	6940.34
2+64	73679.98	57473.74	6939.48
3+13	73645.23	57440.63	6939.88
3+54	73615.19	57412.00	6939.61
3+62	73608.83	57405.74	6939.23
3+68	73604.24	57401.22	6938.53
3+78	73601.07	57398.09	6936.70
3+88	73594.01	57391.13	6936.23
3+99	73585.54	57382.79	6933.55
4+13	73575.65	57373.05	6932.73
4+33	73561.89	57359.49	6931.37
4+53.5	73547.41	57345.24	6930.16
4+54	73547.06	57344.89	6925.53
4+60	73542.36	57340.25	6925.30
4+84	73558.56	57323.21	6924.63
5+01	73548.52	57309.52	6922.26
5+47	73538.35	57263.91	6909.56
5+70	73525.86	57245.39	6908.77
5+85	73512.16	57239.49	6905.77
6+40	73477.88	57196.88	6901.02

Station	Latitude	Departure	Elevation
7+09	73431.33	57146.01	6902.68
7+92	73358.79	57105.69	6901.95
8+10	73342.24	57098.60	6900.57
9+11	73272.66	57025.03	6901.04
9+35	73254.66	57009.14	6901.54
10+33	73182.37	56942.97	6899.94
10+72	73160.12	56911.23	6899.92
10+81	73155.60	56903.00	6897.37
10+99	73143.01	56890.13	6897.03
11+07	73137.35	56884.46	6894.58
11+32	73113.96	56877.09	6897.84
11+75	73082.95	56846.17	6896.85
11+83	73075.49	56843.27	6889.91
12+36	73041.90	56802.52	6889.84
12+93	73019.42	56749.93	6886.93
13+25	72989.53	56738.58	6887.17
14+05	72957.42	56665.82	6884.52
14+82	72893.62	56620.82	6881.92
15+67	72837.58	56558.59	6880.91
16+54	72766.46	56508.04	6879.85
17+39	72707.64	56446.60	6879.84
18+30	72628.77	56399.89	6879.80
19+22	72553.61	56348.16	6878.01
19+97	72498.07	56297.93	6877.51
20+76	72429.84	56257.85	6876.75
21+32	72383.18	56226.09	6875.84
22+19	72307.06	56184.12	6875.[illegible]
23+04	72233.58	56141.40	687[illegible].31
23+98	72146.88	56106.32	6874.29
24+94	72057.86	56069.97	6873.95
25+86	71968.17	56049.39	6872.66
27+41	71813.21	56041.22	6868.74
27+80	71776.55	56052.79	6871.27
28+86	71691.52	55988.75	6869.76
29+85	71721.69	55894.24	6869.07
29+99	71729.18	55882.32	6868.76

APPENDIX F

CONFLUENCE STABILITY

Canonie Environmental

By MT Date 12 Nov 90 Subject UMC Sheet No. 1 of 9

Chkd. By MJR Date 12/3/90 Confluence Stability Proj. No. 86-060-24

1/4 X 1/4

Purpose: To compare the total head of the PMF peak discharge in three tributaries to the North Diversion Ditch with the total head of the PMF peak discharge in the North Diversion Ditch at their confluences.

Figure 1 provides the tributary location and designations

Methods: 1. The PMF peak discharges in the North Diversion Ditch at the locations shown on Figure 2 were estimated by the SCS triangular unit hydrograph method as discussed in Appendix C of the original reclamation plan.

2. The PMF peak discharges of the tributaries at the confluence was determined by the SCS TR-55 graphical method.

3. The depth and velocity of the PMF peak discharges was determined with Manning's equation

4. The total head (velocity head + elevation head) was determined using Bernoulli's equation.

Results: Table 1 on Page 2 provide the results of the calculations

Table 1
Results of Calculations

Location (1)	Peak Discharge (cfs)	Channel Slope (ft/ft)	Depth of Flow (ft)	Velocity (fps)	Velocity head (ft)	Total Head (2)
K	1081	0.0054	4.22	9.0	1.26	5.48
A_1	383	0.044	0.98	11.2	1.95	2.93
L	2265	0.00714	5.69	12.5	2.43	8.12
A_2	765	0.02	1.81	10.8	1.82	3.63
M	2265	0.00746	4.34	9.8	1.49	5.83
B	2046	0.019	2.48	13.2	2.76	5.19
N	5850	0.00746	8.02	15.1	3.54	11.56

(1) See Figure 2 for schematic of locations

(2) Total head = Depth of flow + Velocity head.
This assumes that the channel bottom for the North Diversion Ditch and the tributary are at the same datum at each confluence

Canonie Environmental

By MT Date 12 Nov 90 Subject Confluence Stability Sheet No. 2 of 10
Chkd. By mjn Date 12/3/92 Proj. No. 85-064-0
1/4 X 1/4

Methods

1. The peak discharges and velocities at cross-sections 1, 2, 3, and 4 are provided in Appendix C to the original reclamation plan. They are summarized in Table 1 of this calc brief.

2. The peak discharges at cross sections A_1, A_2 and B were determined with the SCS-TR55 method. The input data for the watersheds contributing runoff to these locations are summarized below. Figure 1 delineates the watersheds.

		A_1	A_2	B
Mean Basin El	(ft)	7080	7080	7100
Longest Flow Path	(mi)	0.62	0.62	1.23
Maximum Relief	(ft)	360	200	440
Watershed Area	(mi^2)	0.08	0.16	0.58
Curve Number		80	80	80
PMP Amount	(inches)	9.4	9.4	9.4
Corrected PMP	(inches)	8.42	8.42	8.41
t_c	(hours)	0.2	0.2	0.4

The curve number is that used in previous calculations as shown in Appendix C of the reclamation plan. The PMP amount of 9.4 inches was determined from HMR-49. It is corrected by the formula

$$PMP \times [1 - ((\text{Mean Basin Elevation} - 5000\,ft)/1000 \times 0.05)]$$

The t_c values (times of concentration) were determined by the methods provided in TR-55.

The output from the SCS TR-55 calculations are provided on page 6.

CanonieEnvironmental

By MT Date 12 Nov 90 Subject UAC Sheet No. 4 of 9

Chkd. By mm Date 12/3/90 Confluence Stability Proj. No. 86-052-24

1/4 X 1/4

3. Mannings equation, as utilized by the Haestad Methods Inc Program Flow Master, were used to calculate flow depth and velocity for the peak discharges calculated above. The channel characteristics for the tributaries are summarized below:

		A_1	A_2	B
Bottom Width	(ft)	30	30	50
Side slope, Z		5	5	5
Mannings n		0.025	0.025	0.025
Channel Slope	(ft/ft)	0.044	0.020	0.019
Peak Discharge	(cfs)	383	765	2046

The resulting depths and velocities are summarized below (See pgs 7, 8, 9)

Depth	(ft)	0.98	1.81	2.48
Velocity	(fps)	11.2	10.8	13.2

4. The velocity head was calculated with the formula $H_v = V^2/2g$ where H_v = velocity head, V = flow velocity and g = gravitational acceleration (32.2 fps²). Total head was calculated as the velocity head plus the depth as follows:

		A_1	A_2	B
Velocity head	(ft)	1.95	1.82	2.71
Depth	(ft)	0.98	1.81	2.48
Total head	(ft)	2.93	3.63	5.19

Table 1 provides the velocity and total heads ~~that~~ at the cross sections on the North Diversion Ditch

CanonieEnvironmental

By MI Date 12 Nov 90 Subject UMC Sheet No. 5 of 9

Chkd. By [illegible] Date 12/3/90 Confluence Stability Proj. No. 86-060-[illegible]

1/4 X 1/4

Discussion

Table 1 shows that the total head for flows in tributaries A1 and A2 are considerably less than those of the North Diversion cross sections (1 & 2) located immediately upstream of the confluence. Thus, while the tributary flow will cause turbulence at the confluence, the tributary flow will not be able to impinge directly on the far bank of the ditch. The total head of tributary [illegible] flow is greater than that of cross section 3 of the North Diversion Ditch. Thus this tributary has the potential for more direct impingement on the far bank of the ditch. However, the tributary B confluence angle is about 45° thus lessening the effect of impingement. Also about 150' of bank material exists on the far bank ~~which~~ that would have to be scoured away before flow could pass over the tailings.

Tc = 0.2 RUNOFF HYDROGRAPHS BY THE SCS TR 55 METHOD

TYPE II STORM DISTRIBUTION

01-Dec-90
05:21 PM

TIME OF CONCENTRATION - 0.2 HOURS
TRAVEL TIME - 0 HOURS

HYDROGRAPH TIME IN HOURS

WATERSHED DESIGNATION	DRAINAGE AREA (AC)	DRAINAGE AREA (SQ MI)	CURVE NUMBER	PPT AMT (IN)	RUNOFF (IN)	(TIME)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6
						(CSM/IN)	23	31	47	209	403	739	800	481	250	166	128	102	86	70	61	54	49	44	40	35	33
TRIBUTARY A1	51.00	7.97E-02	98.0	8.4	6.00	(CFS)	10.999	14.824	22.475	99.944	192.715	353.391	382.561	230.015	119.550	79.381	61.210	40.777	41.125	33.474	29.170	25.823	23.432	21.041	19.128	16.737	15.781
TRIBUTARY A2	102.00	1.59E-01	98.0	8.4	6.00	(CFS)	21.997	29.649	44.951	199.880	385.431	706.782	765.123	460.030	239.101	158.763	122.420	97.563	82.251	66.948	58.391	51.646	46.464	42.082	38.256	33.474	31.561

Tc 0.4 RUNOFF HYDROGRAPHS BY THE SCS TR-55 METHOD

TYPE II STORM DISTRIBUTION

01-Dec-90
05:23 PM

TIME OF CONCENTRATION - 0.4 HOURS
TRAVEL TIME - 0 HOURS

HYDROGRAPH TIME IN HOURS

WATERSHED DESIGNATION	DRAINAGE AREA (AC)	DRAINAGE AREA (SQ MI)	CURVE NUMBER	PPT AMT (IN)	RUNOFF (IN)	(TIME)	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6
						(CSM/IN)	18	25	36	77	141	271	468	592	574	431	298	216	163	104	77	63	55	[illegible]	44	38	34
TRIBUTARY B	360	5.75E-01	98.0	8.41	6.01	(CFS)	62	[illegible]	124	266	487	937	1617	2046	1944	1490	1030	746	563	359	266	218	190	169	152	131	118

Page 6 of 9
86-060-24
MT
[signature] 12/3/96

Page 7 of 9
#6-060-24
MC
[illegible] 12/3/92

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UNC

Comment: CONFLUENCE A1

Solve For Depth

Given Input Data:

Bottom Width.....	30.00 ft
Left Side Slope..	5.00:1 (H:V)
Right Side Slope.	5.00:1 (H:V)
Manning's n......	0.025
Channel Slope....	0.0440 ft/ft
Discharge........	383.00 cfs

Computed Results:

Depth............	0.98 ft
Velocity.........	11.22 fps
Flow Area........	34.13 sf
Flow Top Width...	39.78 ft
Wetted Perimeter.	39.98 ft
Critical Depth...	1.57 ft
Critical Slope...	0.0084 ft/ft
Froude Number....	2.13 (flow is Supercritical)

Page 8 of 9
86-060-24
MZ
✓ [illegible] 12/3/90

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UNC

Comment: CONFLUENCE A2

Solve For Depth

Given Input Data:

Bottom Width.....	30.00 ft
Left Side Slope..	5.00:1 (H:V)
Right Side Slope.	5.00:1 (H:V)
Manning's n......	0.025
Channel Slope....	0.0290 ft/ft
Discharge........	765.00 cfs

Computed Results:

Depth............	1.81 ft
Velocity.........	10.82 fps
Flow Area........	70.73 sf
Flow Top Width...	48.11 ft
Wetted Perimeter.	48.47 ft
Critical Depth...	2.57 ft
Critical Slope...	0.0075 ft/ft
Froude Number....	1.57 (flow is Supercritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UNC

Comment: CONFLUENCE B

Solve For Depth

Given Input Data:

Bottom Width......	50.00 ft
Left Side Slope..	5.00:1 (H:V)
Right Side Slope.	5.00:1 (H:V)
Manning's n......	0.025
Channel Slope....	0.0190 ft/ft
Discharge........	2046.00 cfs

Computed Results:

Depth............	2.48 ft
Velocity.........	13.24 fps
Flow Area........	154.56 sf
Flow Top Width...	74.77 ft
Wetted Perimeter.	75.27 ft
Critical Depth...	3.32 ft
Critical Slope...	0.0066 ft/ft
Froude Number....	1.62 (flow is Supercritical)

North Diversion Ditch
B
A1
A2
Puerco
River
PIPELINE
Figure 1

CanonieEnvironmental

By ________ Date ________ Subject ____________________ Sheet No. ____ of ____

Chkd. By ____ Date ________ ____________________ Proj. No. ________

1/4" X 1/4"

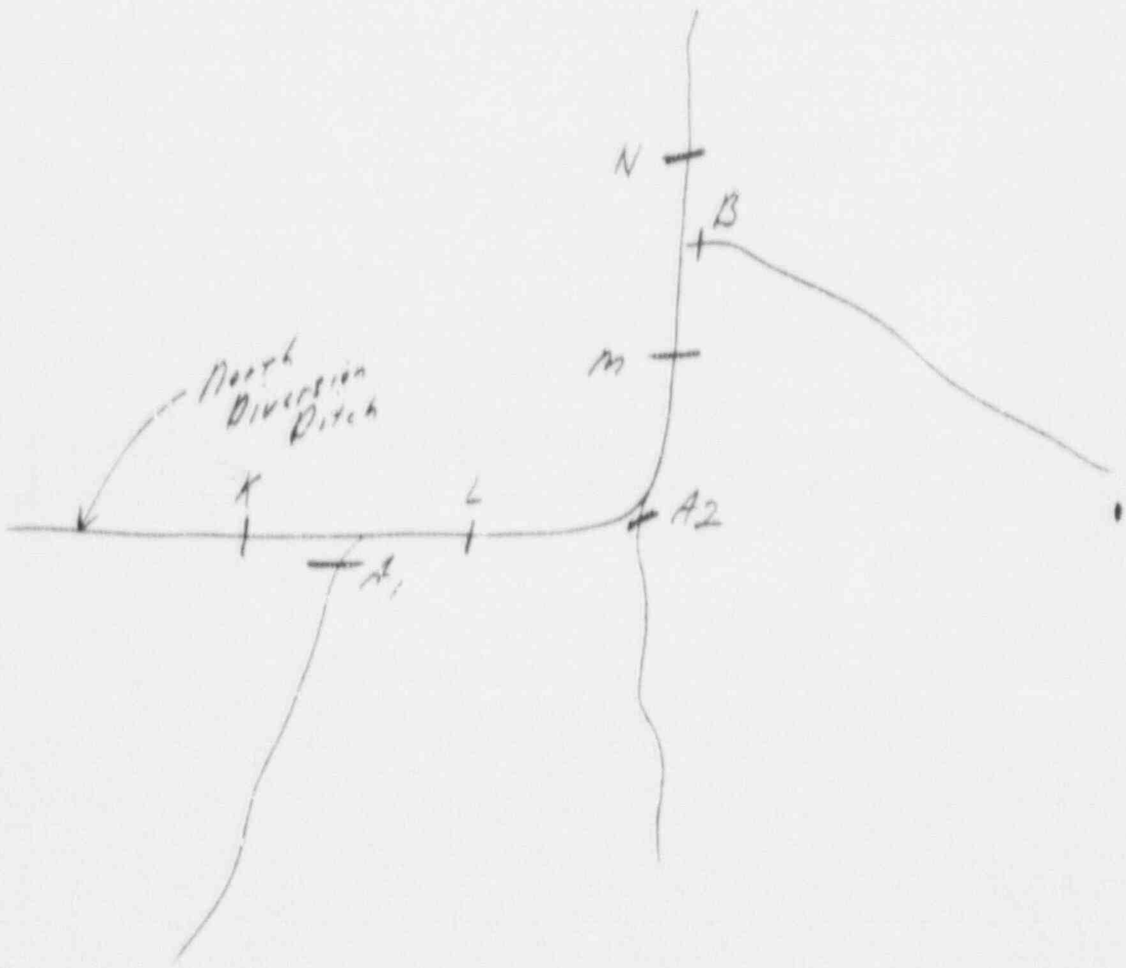


Figure 2

Schematic of Cross-Section Locations

APPENDIX G

INTERCEPTION DITCH STABILITY

Canonie Environmental

By PMW Date 10/2/90 Subject INTERCEPTION DITCH Sheet No. 1 of 20
Chkd. By [illegible] Date [illegible] EROSION ETC. 5:1 EMBANKMENT Proj. No 86-060-24

1/4 X 1/4

PURPOSE: THE PURPOSE OF THIS CALCULATION BRIEF IS TO ANSWER THE QUESTIONS POSED BY COMMENT 8 OF THE COMMENTS PRESENTED BY

THIS CALC. BRIEF IS BROKEN DOWN INTO 3 SECTIONS. EACH SECTION WILL ANSWER A SPECIFIC PORTION OF COMMENT 8.

SECTION: I. WILL SILTATION OCCUR IN THE INTERCEPTION DITCHES ON THE 5H:1V' EMBANKMENT SLOPES

II WILL FLOW OVERTOP OR FLOW OVER THE OUTER BANK OF THE INTERCEPTION DITCHES

III WILL EROSION OF THE OUTER BANK OF THE INTERCEPTION DITCH CAUSE GULLYING.

RESULTS:

SECTION I: BOTH SILTATION AND EROSION WILL NOT OCCUR IN THE INTERCEPTION DITCHES

SECTION II: FLOW COMING OFF THE EMBANKMENT WILL NOT CONTINUE THRU THE DITCH AND OVER THE TOP. FLOW WILL BE CONTAINED WITHIN THE INTERCEPTION DITCH

SECTION III: GULLYING WILL OCCUR TO THE INTERCEPTION DITCH OUTER BANK, YET IS WELL WITHIN ACCEPTABLE LIMITS SET FORTH BY THE NRC STAFF TECHNICAL POSITION ON EROSION PROTECTION.

Canonie Environmental

By FMW Date 10/2/90 Subject SILTATION OF INTERCEPTION DITCHES Sheet No. 2 of 20

Chkd. By ___ Date ___ Proj. No 86 066 2A

1/4 X 1/4

I. SILTATION OF THE INTERCEPTION DITCHES ON THE 5H:1V EMBANKMENT SLOPE

A. WILL SILTATION OCCUR?

USING INFORMATION PREVIOUSLY DETERMINED IN THE CALCULATION BRIEF "INTERCEPTION DITCH AND COLLECTION CHANNEL DESIGN, 5H:1V EMBANKMENT," DATED 10/1/90, INTERCEPTION DITCH FLOW VELOCITIES WERE FOUND TO BE 2.24 feet per second AT A 1.6 FOOT DEPTH OF FLOW.

FROM CHOW, V.T., OPEN-CHANNEL HYDRAULICS, 1959, the MAXIMUM PERMISSIBLE VELOCITY FOR A LEAN CLAYEY SOIL, COMPACT, WITH A VOID RATIO OF 0.45 IS 3.5 fps, AND CHOW'S CORRECTION FACTOR (MULTIPLIER) FOR A FLOW DEPTH OF 1.6 FEET IS 0.86.

(SEE PAGE 4 FOR VELOCITY & MULTIPLIER TABLES)

THEREFORE, WITH A FLOW DEPTH OF 1.6 FEET, THE MAXIMUM PERMISSIBLE VELOCITY IS:

$$3.5\ \text{fps} \times 0.86 = 3.01 \text{ or } \underline{3\ \text{fps}}$$

THE CALCULATED VELOCITY OF FLOW IN THE CHANNELS IS 2.24 fps, WHICH IS LESS THAN 3 fps.

EROSION OF THE CHANNELS WILL NOT OCCUR.

CanonieEnvironmental

By PMW Date 10/2/90 Subject SILTATION Sheet No. 3 of 20

Chkd. By KLK Date Proj. No 86 06C 24

1/4 X 1/4

(A. cont)

IN ADDITION, FROM RITTER, D.F, "PROCESS GEOMORPHOLOGY" 1978, A GRAPH IS PRESENTED REFERING TO SILTATION, TRANSPORTATION AND EROSION OF SOILS FROM VARIOUS MEAN VELOCITIES.

SEE PAGE 5 FOR THE GRAPH.

THE GRAPH SHOWS THAT THE SOILS USED FOR THE INTERCEPTOR DITCHES FALL WITHIN THE EROSION/TRANSPORTATION ZONE. Find d_{50} OF SITE SOILS ON PAGE 17. $d_{50} = 0.05mm$. A RANGE OF VELOCITIES WITHIN THE TRANSPORTATION ZONE IS:

FROM 35 cm/s TO 0.4 cm/s (1.14 fps to 0.013 fps)

$$2.24\,fps \times \frac{12\,in}{ft} \times \frac{2.54\,cm}{in} = 68\,cm/sec$$

ACCORDINGLY, THE GRAPH SHOWS THAT THE 2.24 fps FLOW RATE IS EROSIVE, YET THE PREVIOUS INVESTIGATION USING CHOWS METHOD AND THE WIDE RANGE OF UNCERTAINTY ON THE GRAPH BETWEEN EROSIVE AND TRANSPORTIVE VELOCITIES INDICATES NO EROSION WILL TAKE PLACE.

ALSO, THE RANGE OF FLOW VELOCITIES WITHIN THE TRANSPORTIVE ZONE, FROM 1.14 fps to 0.013 fps, INDICATES THAT EVEN VERY LOW FLOWS WILL CARRY OFF EXCESS SILT.

 4/20

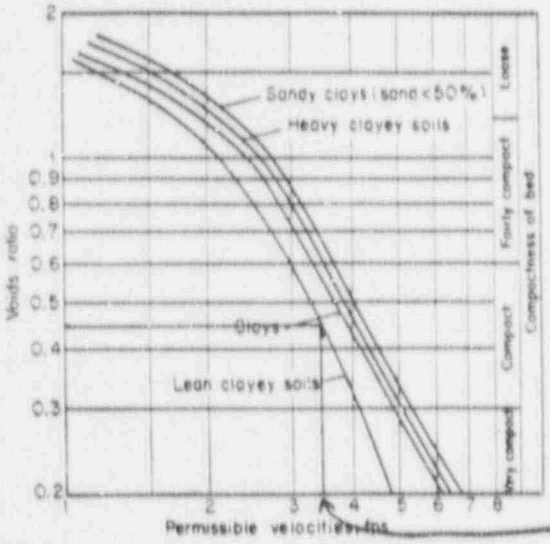


FIG. 7-4. Curves showing U.S.S.R. data on permissible velocities for cohesive soils.

suitable n values for various materials and the converted values for the corresponding permissible tractive force, which will be discussed later (Art. 7-13). In 1936, a Russian magazine [28] published values of maximum permissible velocities (Figs. 7-3 and 7-4) above which scour would be produced in noncohesive material of a wide range of particle sizes and various kinds of cohesive soil. It also gave the variation of these velocities with channel depth (Fig. 7-5).

The maximum permissible velocities mentioned above are with reference to straight channels. For sinuous channels, the velocities should be lowered in order to reduce scour. Percentages of reduction suggested by Lane [29] are 5% for slightly sinuous canals, 13% for moderately sinuous canals, and 22% for very sinuous canals. These percentage values, however, are very approximate, since no accurate data are available at the present time.

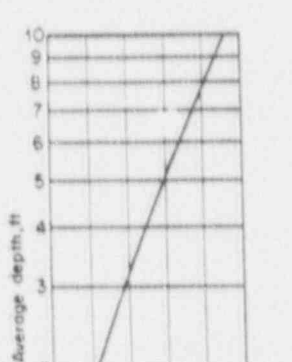


FIG. 7-5. Curves showing U.S.S.R. corrections of permissible velocity for depth for both cohesive and noncohesive materials.

7-10. Method of Permissible Velocity. Using the maximum permissible velocity as a criterion, the design procedure for a channel section, assumed to be trapezoidal, consists of the following steps:

t completely
in the size
nore impor-
smaller sizes
lependent of
d only for
nt requires
uld predict.
udy of the

Hjulstrom
le size, and
he trend of

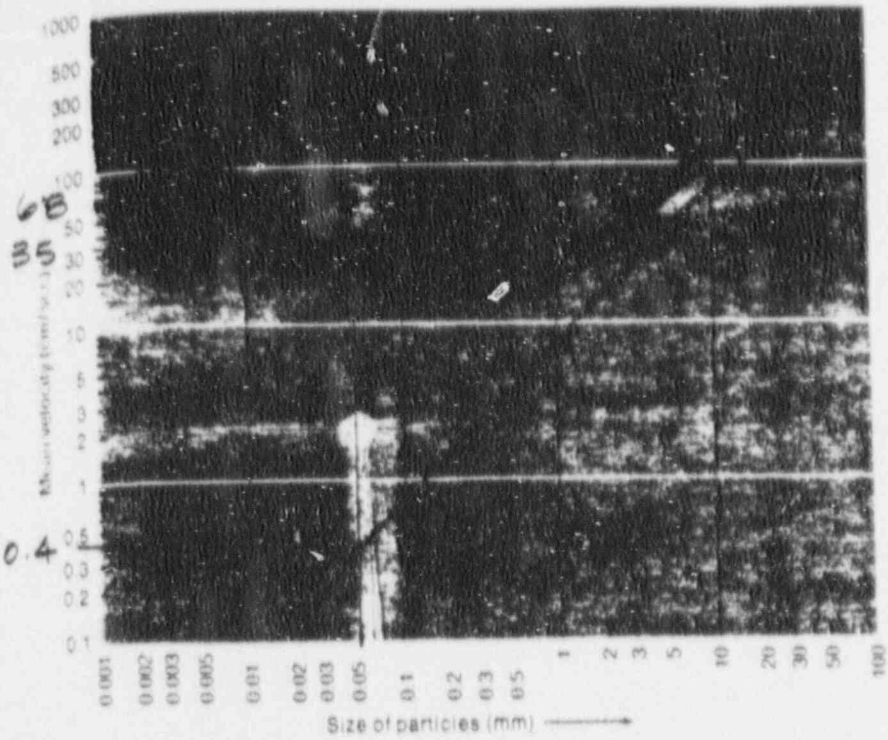


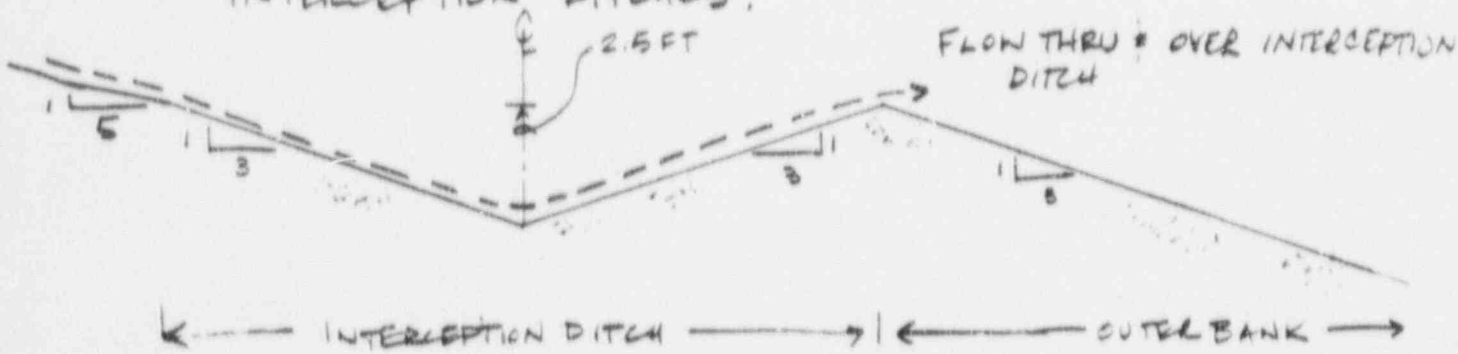
Figure 6.7. Mean velocity at which uniformly sorted particles of various size are eroded, transported, and deposited. (From Hjulstrom 1939. Used with permission of American Association of Petroleum Geologists)

the boundary between erosion and transportation, that is, the velocity needed to initiate motion. The velocity that produces erosion of clay-sized particles is in some cases as great as that needed to entrain larger material. This explains the commonly observed phenomenon of coarse particles being transported across stationary material of a smaller size.

Unfortunately, flumes are not useful in the study of competence when particles are larger than pebble size. Most competence investigations of coarser sediment have therefore been made in natural rivers or canals and, for reasons explained earlier, employ shear stress as the diagnostic hydraulic variable (L?ne 1955; Fahnestock, 1963; Kellerhals 1967; Scott and Gravlee 1968; Church 1972). The shear stress criterion was justified mathematically by Shields (1936), but his equation also is of questionable value when particle size exceeds 7 mm, and it may be too sensitive for use in uncontrolled situations. The Shields equation has been adapted for use with larger sediment (Komar 1970); when assumptions are made about particle and water densities (Baker 1973b, 1974) it simplifies to

$$\frac{DS}{1.65d} = 0.06$$

II. FLOW OVERTOPPING THE OUTER BANK OF THE INTERCEPTION DITCHES.



▷ IN ORDER TO PROVE OR DISPROVE THAT FLOW WILL NOT OVERTOP THE OUTER BANK, A 2 STEP APPROACH WAS TAKEN.

STEP 1: DETERMINE THE VELOCITY AND DEPTH OF FLOW AT THE BOTTOM OF THE INTERCEPTOR DITCH.

① USING THE SPREADSHEET OVERLAND.WR1 (HORTONS METHOD OF OVERLAND FLOW) FIND THE VELOCITY & DEPTH OF FLOW @ THE ENTRANCE TO THE INTERCEPTION DITCH (WHERE 5:1 SLOPE MEETS 3:1 SLOPE) SEE PAGE 9.

② DETERMINE THE VELOCITY & DEPTH OF FLOW FOR JUST THE 3:1 SLOPE OF THE INTERCEPTION DITCH USING OVERLAND.WR1 SEE PAGE 10.

③ COMBINE THE TWO OVERLAND.WR1 SPREADSHEETS: COMBINE TIME OF CONCENTRATIONS AND SLOPE LENGTH. USE THE STEEPER OF THE TWO SLOPES TO BE MORE CONSERVATIVE.

CanonieEnvironmental

By PMW Date 10/1/90 Subject BERNOULIS EQN. Sheet No. 7 of 20

Chkd. By ___ Date ___ Proj. No 86-060-2A

1/4 X 1/4

(3 cont.)

THIS END RESULT WILL GIVE THE VELOCITY & DEPTH OF FLOW IN THE BOTTOM OF THE INTERCEPTION DITCH. SEE PAGE 11.

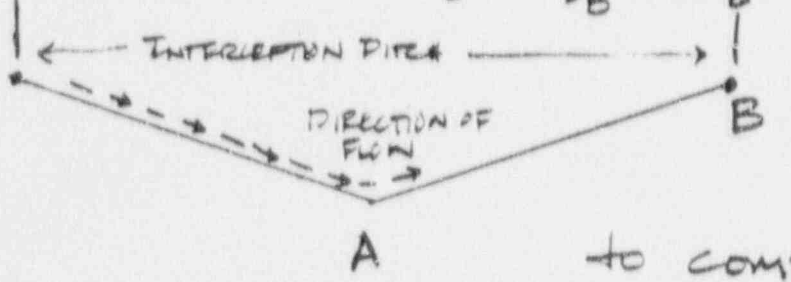
RESULTS:

5:1 SLOPE, V = 3.04 fps depth = 0.05 FT
3:1 SLOPE, V = 1.81 fps depth = 0.015 FT
COMBINED, V = 3.78 fps depth = 0.05 FT

STEP 2: USING BERNOULIS EQUATION;

$$H_1 = H_2, \quad H_A = h_{zA} + he_A + \frac{V_A^2}{2g}$$

$$H_B = h_{zB} + he_B + \frac{V_B^2}{2g} + h_L$$

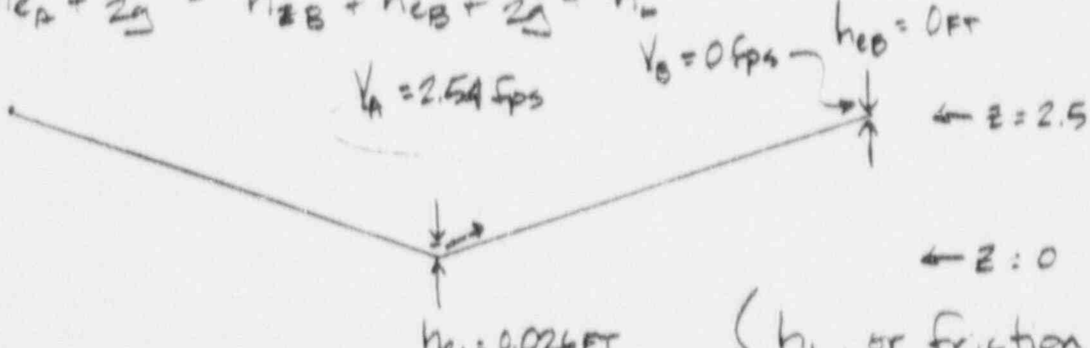


to COMPARE THE ENERGY AT POINT A to POINT B

FOR EXAMPLE, IF THE ENERGY IS GREATER AT POINT A THAN POINT B, FLOW WILL GO OVER THE BANK. IF THE ENERGY AT PT. A IS LESS THAN POINT B, FLOW WILL NOT OVERTOP DITCH.

(STEP 2 CONT.)

$$h_{z_A} + h_{e_A} + \frac{V_A^2}{2g} = h_{z_B} + h_{e_B} + \frac{V_B^2}{2g} - h_L$$



(h_L, or friction loss, will be considered zero, to be CONSERVATIVE.)

$$0 + 0.026\text{FT} + \frac{(3.78\text{fps})^2}{2(32.2\text{f/s}^2)} = 2.5\text{FT} + 0\text{FT} + \frac{(0\text{fps})^2}{2(32.2)} + 0$$

$$0.25\text{ FT} \neq 2.5\text{FT}$$

0.25 < 2.5FT, FLOW WILL NOT OVERTOP THE INTERCEPTION DITCH BANK.

9/20

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE UNIT WIDTH METHOD   OVER.WR1

PROJECT: UMC 86-060-24
LOCATION: 5H:1V SLOPE BEFORE INTERCEPTION DITCHES

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

```
   RUNOFF COEF:     1           RETURN PERIOD:   100 YRS
  SLOPE LENGTH:    40 FT       1-HR PPT AMOUNT: 8.47 INCHES
     AVE SLOPE:   0.2 FT/FT          Tc (calc): 0.248 MIN   EQ 4.44, NUREG 4620
   MANNING'S n: 0.030              Tc (actual):   2.5 MIN
    FLOW CONC:      3              %OF 1-HR PPT:  27.5 %     TABLE 2.1, NUREG 4620
 DRAINAGE AREA: 0.000 ACRES          PPT AMOUNT: 2.329 INCHES
Mannings n(calc)0.039             PPT INTENSITY: 55.90 IPH

PEAK DISCHARGE: 0.051 CFS      Q = CIA                 -36.5
CONC. DISCHARGE:0.154 CFS

         DEPTH: 0.050 FT       EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.633 PSF
 FLOW VELOCITY:  3.04 FPS      V = Q/FLOW AREA
-----------------------------------------------
```

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT	
2.5	27.5	27.5
5	45	36.5
10	62	
15	74	
20	82	
30	89	
45	95	
60	100	

10/20

OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE UNIT WIDTH METHOD   OVER.WR1

PROJECT: UNC 86-060-24
LOCATION: 3H:1V SLOPE, INTERCEPTION DITCHES

OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments)

```
   RUNOFF COEF:     1           RETURN PERIOD:   100 YRS
 SLOPE LENGTH:   7.5 FT        1-HR PPT AMOUNT: 8.47 INCHES
    AVE SLOPE:  0.33 FT/FT          Tc (calc): 0.056 MIN   EQ 4.44, NUREG 4620
  MANNING'S n: 0.030               Tc (actual):   2.5 MIN
    FLOW CONC:     3             %OF 1-HR PPT:  27.5 %     TABLE 2.1, NUREG 4620
DRAINAGE AREA: 0.000 ACRES          PPT AMOUNT: 2.329 INCHES
Mannings n(calc)0.039            PPT INTENSITY: 55.90 IPH

PEAK DISCHARGE: 0.009 CFS      Q = CIA                  =36.5
CONC. DISCHARGE:0.028 CFS

         DEPTH: 0.015 FT       EQTN 4.46, NUREG 4620
TRACTIVE FORCE: 0.329 PSF
 FLOW VELOCITY:  1.81 FPS      V = Q/FLOW AREA
--------------------------------------------
```

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT	
2.5	77.5	27.5
5	45	36.5
10	62	
15	74	
20	82	
30	89	
45	95	
60	100	

```
OVERLAND FLOW AND RIPRAP CALCULATIONS USING THE UNIT WIDTH METHOD   OVER.WR1

        PROJECT: UNC  86-060-24
       LOCATION: 5H:1V AND 3H:1V SLOPES COMBINED, INTERCEPTION DITCHES

 OVERLAND FLOW CALCULATIONS (NUREG-4620, Methodologies for Evaluating Long-Term
                            Stabilization Designs of Uranium Mill Tailings
                            Impoundments)

    RUNOFF COEF:      1          RETURN PERIOD:    100 YRS
   SLOPE LENGTH:  47.5 FT      1-HR PPT AMOUNT: 8.47 INCHES
      AVE SLOPE:  0.53 FT/FT         Tc (calc): 0.233 MIN   EQ 4.44, NUREG 4620
   MANNING'S n: 0.030              Tc (actual):   2.5 MIN
      FLOW CONC:      3           %OF 1-HR PPT:  27.5 %     TABLE 2.1, NUREG 4620
  DRAINAGE AREA: 0.001 ACRES        PPT AMOUNT: 2.329 INCHES
 Mannings n(calc)0.048           PPT INTENSITY: 55.90 IPH

 PEAK DISCHARGE: 0.060 CFS      Q = CIA                -36.5
 CONC. DISCHARGE:0.182 CFS

          DEPTH: 0.048 FT       EQTN 4.46, NUREG 4620
 TRACTIVE FORCE: 0.996 PSF
  FLOW VELOCITY:  3.78 FPS      V = Q/FLOW AREA
 ---------------------------------------------
       TABLE 2.1 OF NUREG 4620
        RAINFALL       PERCENT OF
        DURATION       1-HR PPT
           (MIN)
             2.5             27.5           27.5
               5               45           36.5
              10               62
              15               74
              20               82
              30               89
              45               95
              60              100
 ---------------------------------------------
```

III. EROSION OF INTERCEPTION DITCH OUTERBANK THAT MAY RESULT IN GULLYING.

USING METHODS DESCRIBED IN STAFF TECHNICAL POSITION, DESIGN OF EROSION PROTECTION COVERS FOR STABILIZATION OF URANIUM MILL TAILINGS SITES, US NUCLEAR REGULATORY COMMISSION, MAY 1990, TO DETERMINE SLOPE GULLYING:

STEP 1: ASSUME FOLLOWING VALUES:

SLOPE LENGTH : L_1 = 22.5 FT
TAILINGS SETBACK = x = 0 FT
ELEVATION DIFFERENCE = H = 7.5 FT
INITIAL SLOPE : S_i = 0.33

SEE PAGE 15 FOR FIGURES 1 & 2.

STEP 2: CALCULATE STABLE SLOPE, S_s.

$$S_s^{7/6} = \frac{65\, t_a^{5/3}}{PLF n}$$

where: t_a = allowable shear stress = 0.035 psf (FROM CALC. BRIEF CALC OF ACTUAL & MAXIMUM PERMISSIBLE TRACTIVE FORCE..., DATED 9/21/90 by JWB)

P = rainfall intensity = 55.9 in/hr. SEE PAGE 16.

L = TOTAL SLOPE LENGTH = $L_1 + X$ = 22.5 FT

F : RUNOFF CONCENTRATION # = 3.0 (ASSUMED)

n = MANNINGS # (ASSUMED) = 0.03

$$S_s^{7/6} = \frac{65(0.035)^{5/3}}{55.9 * 22.5 * 3 * 0.03} = 2.15 \times 10^{-3}$$

$$\therefore (2.15 \times 10^{-3})^{6/7} = S_s = 5.2 \times 10^{-3}$$

$$S_s = 0.0052$$

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STEP 3: CALCULATE TRANSITIONAL SLOPE, S_t (FROM NUREG-4620, 1986)

$S_t = S_i * e^{-(G S_s t)}$ where: S_i = initial slope = 0.33
G = Slope constant = 1.7
SEE PAGE 18.
S_s = Stable Slope = 0.0052
t = time period = 200 years

$S_t = 0.33 * e^{-(1.7 * 0.0052 * 200)}$

$S_t = 0.056$ (≈ 17.8:1 SLOPE)

STEP 4: CALCULATE L_D & D_{MAX}

FIRST, CALCULATE $S_t * C_u$ where:
S_t = stable slope = 0.056
C_u = COEFFICIENT OF UNIFORMITY = $= d_{60}/d_{10} = 0.08/0.0005 = 160$
(SEE PAGE 17.)

$S_t * C_u = 0.056 * 160 = 8.96$

FROM FIG. 4A OF NUREG-4620 (PAGE 19.) L_D/L (OCCURANCE OF D_{MAX} FROM TOE) IS CLOSE TO ZERO; FOR THE PURPOSE OF THIS CALCULATION, ASSUME $L_D/L = 0.05$

$\therefore L_D = 0.05 * L = 0.05 * 22.5 = 1.13 \text{ FT} = L_D$

$D_{MAX} = L_D/L (H - L * S_t)$

$D_{MAX} = 0.05 (7.5 - 22.5 * 0.056) = 0.31 \text{ FEET} = D_{MAX}$

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STEP 5: CALCULATE DISTANCE FROM POINT B TO POINT G, y. (SEE FIGURE 2, PAGE 15.)

$$y = H - (S_E * L_D)$$

$$y = 7.5 - (0.056 * 1.13\,FT)$$

$$\underline{y = 7.4\,FT}$$

STEP 6: CALCULATE LENGTH OF REPOSE SLOPE, L_R.

$$L_R = \frac{y}{\tan R}$$ where R = angle of repose = 30° (assumed)

$$L_R = \frac{7.4}{\tan 30} = \underline{12.8\,FT = L_R}$$

STEP 7: CALCULATE TOTAL SLOPE LENGTH, L_T.

$$L_T = L_D + L_R = 1.13\,FT + 12.8\,FT = \underline{13.9\,FT = L_T}$$

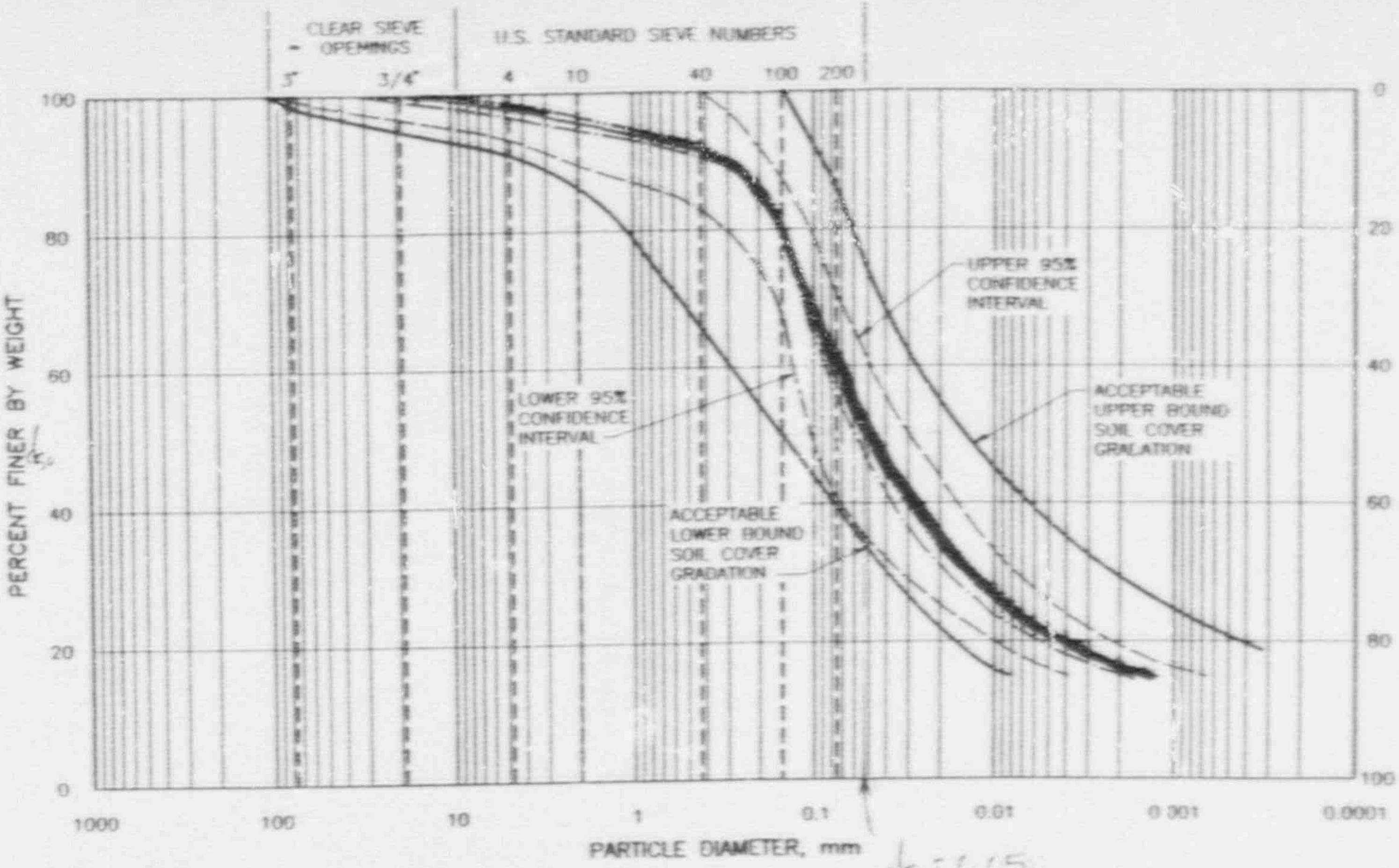
COMPARE L_T TO L

$$13.9\text{ FEET} \neq 225$$
$$L_T < L$$

SINCE L_T IS LESS THAN L, THE ASSUMED SACRIFICIAL SLOPES ARE ACCEPTABLE.
THE EXTENT OF GULLYING IS SHOWN ON FIGURE 2, PAGE 15.

(THE SPREADSHEET SACSLOP.WR1, PAGE 20., CALCULATES THESE VALUES)

DRAWING NUMBER 83-060-B393



NOTE:

1. AVERAGES DERIVED FROM AVAILABLE FIELD AND LABORATORY TEST DATA TO DATE IN DESIGNATED BORROW AREAS.

LEGEND:

AVERAGE PIPELINE ARROYO BORROW SOILS*

AVERAGE NORTH AND CENTRAL CELLS INTERIM COVER SOILS

AVERAGE EXISTING SOIL STOCKPILE SOILS

ACCEPTABLE SOIL COVER GRAIN SIZE ENVELOPE

PREPARED FOR

UNC MINING AND MILLING
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FIGURE 2

No.	DATE	ISSUE / REVISION	
1	9-13-90	ISSUED FOR RESPONSE TO COMMENTS	

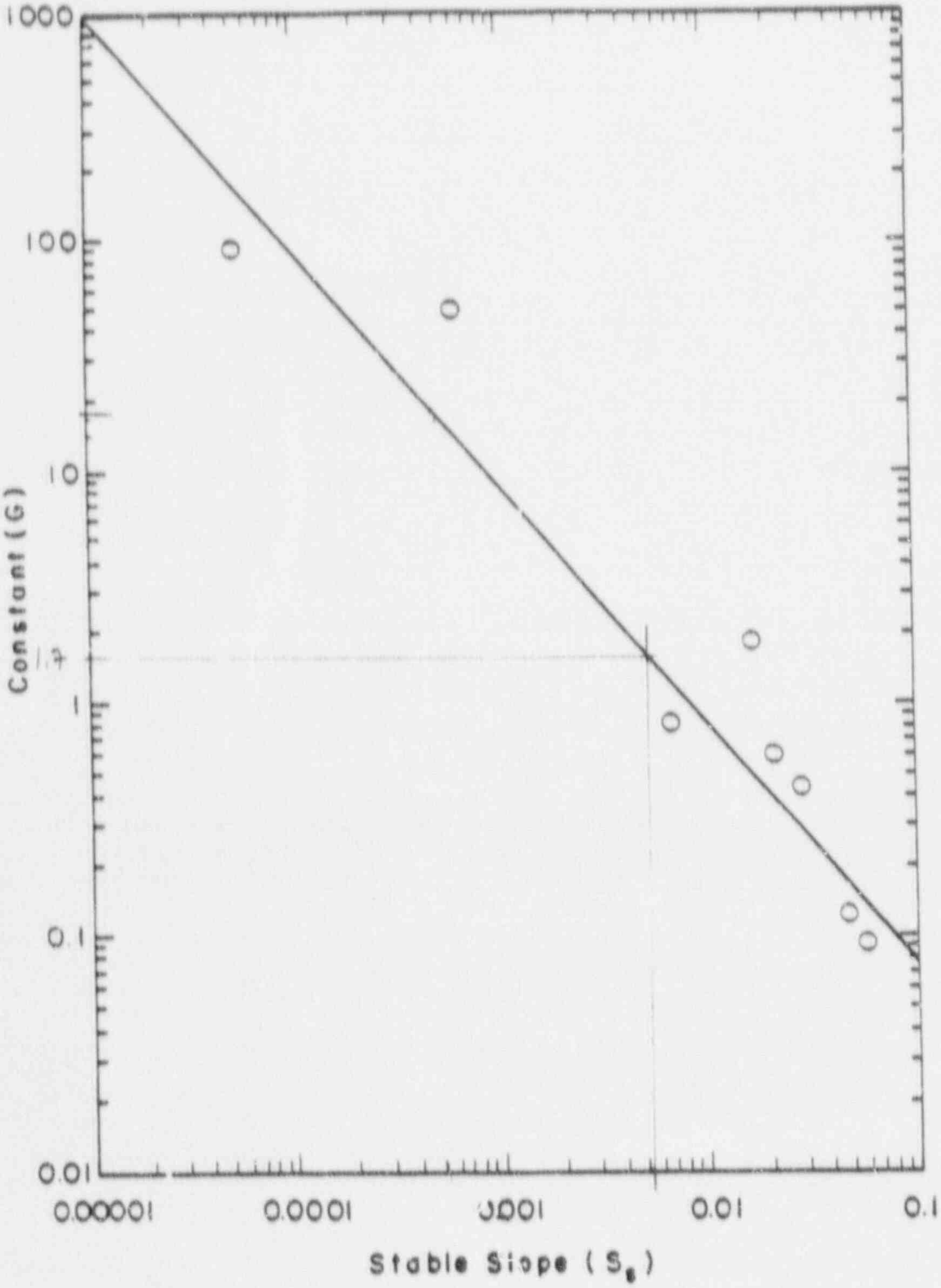

Fig. 4.3. Relation of stable slope to the calibration constant, G.

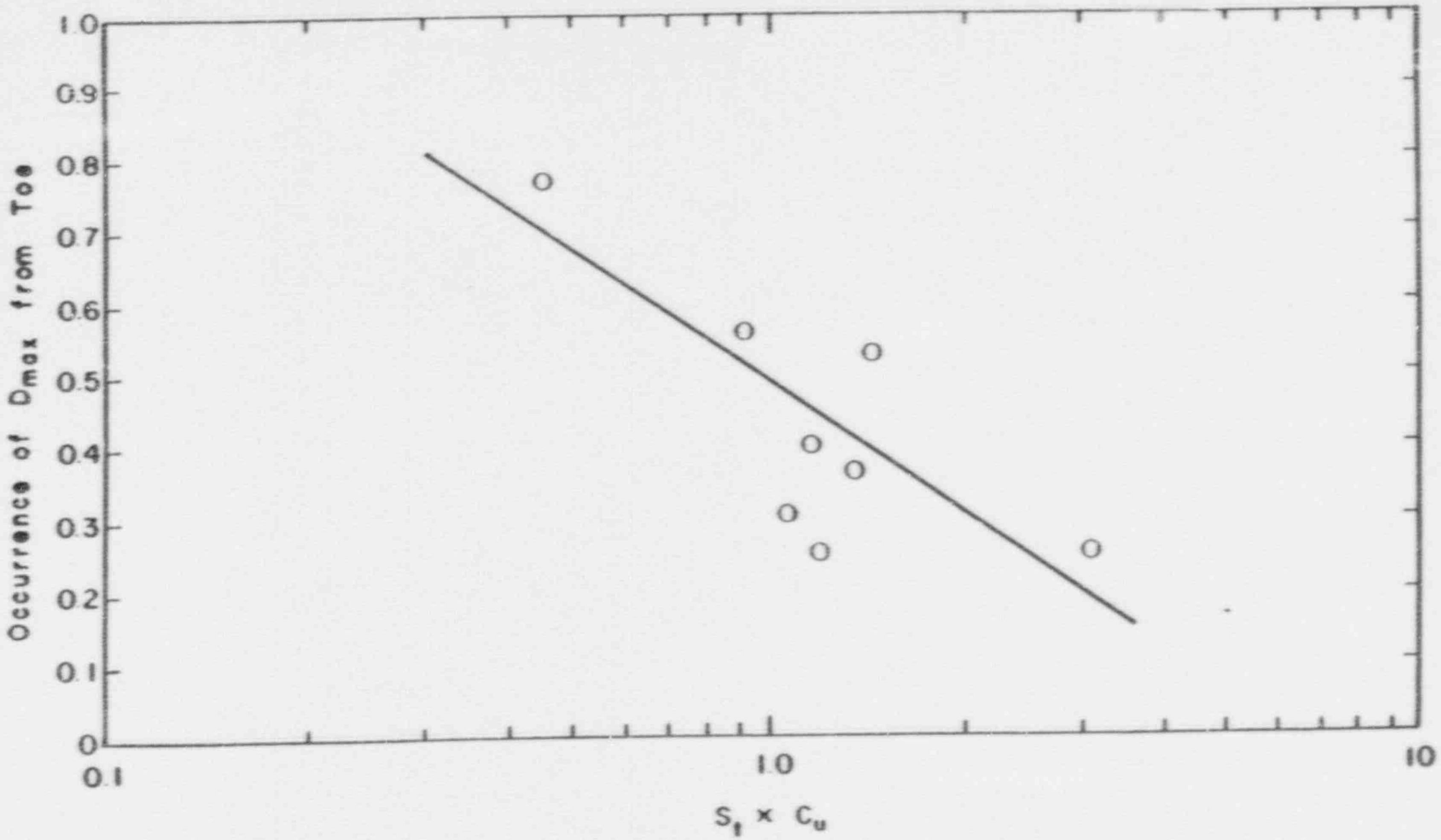

Fig. 4.4. Relation of time-dependent slope and uniformity coefficient vs occurrence of maximum gully depth from toe-of-slope.

SACSLOP.WR1

PROJECT: UNC 86-060-24
LOCATION: INTERCEPTOR DITCH OUTER SLOPES, 5:1 EMBANKMENTS

INPUT PARAMETERS			CALCULATED PARAMETERS		
Slope Length	L1	22.5 ft			
Tailings setback	X	0 ft			
Elevation Difference	H	7.5 ft			
Length plus Setback	L	22.5 ft			
Max Shear Stress	ta	0.035 lbs/sq ft			
Rainfall Intensity	P	55.9 iph			
Runoff Conc. Factor	F	3			
Roughness Coef	n	0.03			
			Stable Slope	Ss	0.0052 ft/ft
Slope Constant	G	1.7 (1)			
Time Period	t	200 yrs			
			Transition Slope	St	0.0575 ft/ft
Uniformity Coef	Cu	160 (2)			
St * Cu		9.19			
Location of Gully	Ld/L	0.05 (3)			
			Distance to Gully	Ld	1.13 ft
			Max Depth of Gully	Dmax	0.31 ft
Distance-Top to Gully	Y	7.44 ft			
Angle of Repose	R	30 degrees			
			Repose Slope Length	Lr	12.88 ft
			Total Slope Length	Lt	14.0 ft
			Length plus Setback	L	22.5 ft

(1) From Figure 4.3 of NUREG 4620
(2) Cu = D60/D10, From Soil Mechanics and Foundations
(3) From Figure 4.4 of NUREG 4620