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Mr. Leo Higginbotham
Low Level Waste and Uranium
Recovery Branch, US NRC
7915 Eastern Avenue, MS-623-SS
Silver Spring, MD 20910

Dear Leo,

On September 6, 1984, and October 4, 1984, your office provided comments on the final Remedial Action Plan (RAP) for the Shiprock inactive uranium mill tailings site. Discussion toward resolution of those comments has been ongoing between your technical staff and our Technical Assistance Contractor staff (TAC) since our receipt of your first set of comments. I understand that agreement has now been reached on all technical comments except size and durability of the erosion control rock cover. The specific resolution of each NRC comment is found in the following enclosures to this letter:

1. Remedial Action Plan and Site Conceptual Design for Stabiliation of the Inactive Uranium Mill Tailings Site at Shiprock, New Mexico, Revised Final, December, 1984.

2. Shiprock Remedial Action Plan and Site Conceptual Design NRC Comments, September 6, 1984, and DOE Responses December 7, 1984.

3. Shiprock Remedial Action Plan and Site Conceptual Design NRC Comments, October 4, 1984, and DOE Responses, December 7, 1984.

As in the case of the Salt Lake City site, I understand that the NRC can now provide conditional concurrence on the Shiprock RAP, and will sign the RAP signature page which you should receive from the Navajo Tribe within the next few days. Final NRC concurrence will be provided upon successful resolution of the rock size and durability questions.

We continue to have reservations regarding NRC's concurrence role with the environmental, health and safety; radiological support; and quality assurance/quality control aspects of the RAPs. Therefore, these remain open items to be resolved on a generic basis during negotiation of the pending DOE-NRC Memorandum of Understanding.

DEC 14 1984

I wish to thank the NRC technical staff for its diligent efforts in working with our TAC staff in resolving the technical concerns about the Shiprock RAP, and I look forward to receiving your conditional concurrence and the signed signature page.

Sincerely,

John G. Themelis

John G. Themelis, Project Manager
Uranium Mill Tailings Project Office

3 Enclosures

cc w/o enclosures:
J. Baublitz, NE-24, HQ
L. Stepp, JEG

SHIPROCK REMEDIAL ACTION PLAN AND SITE CONCEPTUAL DESIGN

NRC COMMENTS, SEPTEMBER 6, 1984

AND

DOE RESPONSES DECEMBER 7, 1984

NRC COMMENTS

SHIPROCK RAP

1. COMMENT:

Slope Stability and Seismic Risk Evaluation (Page 61, Section 10, Attachment A to Appendix E): The Remedial Action Plan (RAP) proposes a slope of five horizontal to one vertical (5H:1V) for the 50-foot-high tailings embankment. Figures 10.1 and 10.2 of Appendix E to the RAP show the existing conditions and the critical cross-section used in the stability analysis. The critical cross-section through the embankment slope shows a layered stratigraphy that includes a soft slime layer. The RAP presents a stability evaluation using a slip circle method of analysis. A major portion of the failure surface of the critical slip circle passes through the slime layer. Only the long-term stability of the slope was investigated. The minimum calculated factor of safety is 2.5 for the static case, and 1.5 for the pseudo-static case (using a seismic coefficient of 0.13).

The slip circle method of slope stability analysis is not appropriate for a cross-section with layered stratigraphy, particularly with a very soft layer. The sliding wedge method of stability analysis with the failure plane through the soft layer (slime) is more applicable in this case, and will yield a factor of safety lower than that determined by the slip circle method. The slope stability analysis presented in the RAP should be revised using the sliding wedge method of analysis.

The physical and strength properties of the slime layer are based on minimal data: four sets of moisture content and in-situ dry density data from four borings, two sets of Atterberg limits, one multi-stage triaxial test on a remolded sample, and one set of direct shear tests on remolded samples (SHP PSCR). The strength parameters ($C=0; \Phi=15°$) were assigned on the basis of engineering judgement because all the strength tests were conducted on samples at dry densities significantly higher than the in-situ dry density of the slime layer. The test data indicate that the in-situ moisture content of the slime is higher than its liquid limits, and the in-situ dry density of the slime ranges between 52 pcf and 73 pcf. Because the slime is the softest material in the tailings embankment, its strength properties control the stability of the embankment slope. The strength parameters for input into a sliding wedge analysis should be established based on results of additional tests on samples at in-situ densities or, as an alternate, it should be shown by a parametric stability analysis that the slope is stable, even for a very conservative assessment of the strength properties of the slime.

The RAP presents results of the long-term analysis only, whereas stability of the embankment slope both at the end-of-construction condition and the long-term condition should be investigated. Appropriate shear strength parameters, particularly for the slime, should be used in the stability analysis for the end-of-construction condition.

The seismic design criteria mentioned in the RAP is a Maximum Credible Earthquake (MCE) of magnitude 5.75 with a peak ground acceleration of 0.13 g. The seismic design criteria mentioned in the PSCR is an MCE magnitude 5.75 with a peak ground acceleration of 0.05 g. This discrepancy in the PSCR should be rectified.

The slope stability analysis presented in the RAP should be revised in accordance with the above comments.

RESPONSE:

The slope was evaluated using a wedge analysis. Three trial wedges were taken, as shown in the attached analysis. The minimum factor of safety was found to be 1.7 for stripping of the cover, which assumes a shallow failure plane in the slimes just below the tailings-cover interface. The safety factor increases with increasing depth into the slope and equals the safety factor (2.5) obtained in the circular arc analysis. The minimum obtained is still above the accepted factor of safety of 1.5. For seismic loading conditions, the factor of safety for the shallow failure plane is reduced to 1.1. This value increases for deeper failure planes.

In order to evaluate the effect of varying slimes material friction angle values upon the safety factor, additional analysis of the wedge was performed. The factor of safety versus friction angle was plotted and is shown in the attached calculations. A factor of safety of 1.5 still is obtained even when the friction angle is reduced to 10 degrees.

Appropriate material properties of the embankment and foundation materials are not available for end-of-construction analysis. The only layer which may be affected by end-of-construction instability would be that of the slimes layer where there may be a potential for excess pore pressures to develop. Analyses were performed which indicate that the required material properties of the slimes of $\Phi = 0$ and C=325 psf are required for a factor of safety of 1.3. Blow counts of the slimes indicate a minimum cohesion of 1000 psf, therefore, the slope will be stable during and immediately following construction.

The PSCR will include wording to document the use of a 0.13 g ground acceleration.

2. COMMENT:

Liquefaction Analysis (Page 63, Section 10, Attachment A to Appendix E): Your response to comment No. 51 stated that the slimes within the tailings embankment have a potential for liquefaction when subjected to seismic loading. The RAP presents factor of safety against liquefaction at two locations for sand only, and does not discuss the liquefaction potential for the slimes. Liquefaction potential of the slime should be addressed in the RAP.

RESPONSE:

As stated in the RAP (Page 64, Section 10, Appendix E), the tailings slimes were analyzed for liquefaction. Only the slimes have a potential for liquefaction because they are the only soils in the embankment that approach saturation. Where slimes are not saturated, they will not liquefy under seismic loading.

Seed and Idriss (1982) present methods of analysis for sands and silty sands. They also discuss the effects of soil gradation upon the analysis (Pages 107 and 108). They conclude that more fines in the analysis result in a more conservative estimate of liquefaction potential due to reduced blow counts in the finer grained soil. Therefore, the analysis using the curves presented by Seed and Idriss will be conservative for the slimes within the tailings pile. The wording within the RAP will be changed to clarify the analysis.

In addition to the conservatisms of the analysis, the slimes appear to exhibit some cohesion and there is no true water table in the embankment. Rather, the slimes are zones which will range from partially-saturated to saturated. If liquefaction were to occur in the slimes, it would be limited to small pockets and would result in differential settlement of the embankment rather than slope failure.

3. COMMENT:

Gully Reconstruction on Escarpment (Page 72, Section 11, Attachment A to Appendix E): DOE's response to the NRC comment on this item (comment No. 52) is very general. The RAP does not provide enough information to enable an assessment of the stability of the gully reconstruction. However, we recognize that the design is intended to protect the escarpment from long-term erosion and does not have a significant effect on the stability of the tailings embankment. The surveillance and maintenance of these reconstructed gullies on the escarpment should be a part of the long-term surveillance plan for the Shiprock site. A specific commitment to this should be included in the RAP.

RESPONSE:

A specific comment will be included in the RAP incorporating long-term surveillance and maintenance of the reconstructed gullies.

4. COMMENT:

Filter Layer (Page 27, Section 4, Attachment A to Appendix E): The RAP commits to using a graded filter between the rock cover and the earth cover beneath it. It should be clearly stated that this graded filter is in addition to the seven feet of earth cover on top of the tailings. If the thickness of the earth cover is reduced so that the total thickness of the earth cover and the filter is seven feet, then the radon barrier thickness calculations should be revised and submitted to NRC for concurrence.

RESPONSE:

The thickness of the radon barrier and the cover is seven feet. The filter material is in addition to the seven-foot thickness of the radon barrier. This will be clearly stated in Page 27, Section 4, Attachment A to Appendix E of the RAP. It is already shown on Figure E.5.5, page E-30 of Appendix E.

5. COMMENT:

Gravel/Cobble Rock Cover (Page E-13, Paragraph 4): The RAP states that gravel and cobble are available from the proposed borrow source and, if necessary, they will be recovered from the alluvium by screening. Since these have to meet the long-term durability criterion, the RAP should provide more data on the selection, placement, and testing for these materials.

RESPONSE:

The rock used for erosion protection will be screened out of the borrow source. Before the material is placed, it will be tested by the Remedial Action Contractor (RAC) for its grain size distribution and durability. Additionally, once construction has started, the RAC will conduct an ongoing testing program which will ensure that the material meets the specifications for material selection, testing and placement. These specifications, to be performed and followed by the RAC, are described in the following paragraphs.

Material selection, testing, and placement

The sources from which the rock will be obtained should be selected well in advance of the time when the stone will be required for placement. The acceptability of the rock should be determined by service and/or by suitable tests. If testing is required, suitable samples of rock should be taken using Standard Practices for Sampling Aggregate (ASTM D75), at least 60 days prior to the start of construction. Additionally, the approval of some rock from a borrow area will not be construed as constituting the approval of all rock taken from the borrow area.

If service records are not available or do not exist, resistance to disintegration from the type of exposure to which the stone will be subjected should be determined by any or all of the following tests, depending on the rock to be used and the site climatic conditions.

1. One of the parameters needed in the design of the size of rock required for erosion protection is the specific gravity. Additionally, the specific gravity and absorption (ASTM C127) can be used to evaluate the durability of a rock. The specific gravity of a rock is an indicator of its strength. The higher the specific gravity, the better the quality of the rock. The specific gravity is also a good indicator of a rock's ability to withstand cycles of freezing and thawing.

Absorption by itself is not a good indicator of a rock's freeze/thaw characteristics. However, a low absorption is a desirable rock property in that it indicates the rock will not disintegrate rapidly due to salt action and mineral hydration.

It is recommended that suitable rock have a specific gravity greater than 2.60 and an absorption less than 1 percent.

2. When riprap must withstand abrasive action from material transported by streams or large flow on or adjacent to the pile, the Los Angeles Abrasion Test should be used. When the abrasion test in the Los Angeles Machine (ASTM C131 or C535) is used, the stone shall not have a percentage loss of more than 40 percent after testing. For ASTM C131, the ratio of the loss after 100 revolutions to the loss after 500 revolutions should not exceed 20 percent for material of uniform hardness. Likewise for ASTM C535, the ratio of loss after 200 revolutions to the loss after 1000 revolutions should not exceed 20 percent.

3. In locations subject to freezing or where the stone is exposed to salt water, the Sulfate Soundness Test (ASTM C88) should be used. After five cycles, stone should not have a loss exceeding 10 percent if sodium sulfate is used, or 15 percent if magnesium sulfate is used.

4. A better guide to weathering which may be used in place of Item 2 above is AASHTO Test 103 for ledge rock, Procedure A. From this test, the stone should not have a loss exceeding 10 percent after 12 cycles of freezing and thawing.

5. Another method which can be used to evaluate durability of a particular rock is the hardness test as determined by the Point Load Test; or the Schmidt Rebound Hammer. If the Point Load Test is used, a value >300 is acceptable. If the Schmidt Hammer is used, a value of <25 is acceptable.

It must be recognized that considerable judgement is required during site evaluation and selection of laboratory testing procedures. The index tests selected are dependent on the availability of laboratory test equipment. There is sufficient similarity among the various tests described to judge the durability of a rock source with a minimum amount of testing. A greater number of tests should be run on rock types that have been judged to be marginal during site investigations.

Should any of the rock being evaluated for use as erosion protection not meet the recommended standards for acceptable rock durability, a new rock source should be sought within a reasonable distance from the site.

If any alternate rock source of better durability cannot be found, the size of the rock should be increased to take into account the degradation of the rock with time. The increase in size is subjective but it is proposed that the rock size be increased by the percentage that the rock fails a criteria.

When placing the rock, each load of rock should be reasonably well-graded from the smallest to the maximum size specified. Gradation can be controlled by visual inspection or, if the rock size is not greater than three inches, the rock gradation can be physically tested using U.S. standard sieves of the appropriate sizes.

6. COMMENT:

Quality Control/Quality Assurance (Page 41): The RAP presents only general guidelines on the QA program. Specific details such as the type of quality control tests, frequency of such tests, and procedures to address instances of non-compliance should be provided in the RAP or in a separate document for concurrence by NRC.

RESPONSE:

The quality control/quality assurance requirements in regards to type of test, frequency of test, and non-compliance procedures were outlined in the SCD, by the TAC, but based on prior comments received from the NRC these requirements are being transferred to the RAPs for each site. The details for implementation of these requirements will be addressed in a site-specific remedial action inspection plan developed by the RAC and concurred on by the UMTRA Project Office and the TAC.

7. COMMENT:

Health and Safety Plan (Section 6.0 and Appendix D): We will need to review the contractor's implementation plan, Health Physics Monitoring Plan (MK-UMTRA-3), before concurring on the health and safety aspects of the Shiprock Remedial Action Plan. Because the Shiprock Health and Safety Plan has not yet been incorporated into the Health Physics Monitoring Plan, a complete NRC review of the Shiprock health and safety is not possible.

RESPONSE:

The Shiprock Health and Safety Plan prepared by M-K will be available for your review in December 1984.

8. COMMENT:

Radon Barrier (Section 2.0, Attachment A to Appendix E): In your response to NRC comments on the draft RAP, you have provided reasonable answers to NRC questions on radon barrier model methodology. However, because of the complexity of the design assumptions used to model the site, the TAC may have difficulty implementing the design in the field. For example, the model would require construction of 2.5-foot layers of tailings and cover with different parameter values specified for each layer. A simpler model would allow easier design implementation and would be more representative of final site conditions. A three or four layer model is suggested - two layers of tailings (6 to 10 feet of lesser contaminated material on top) and one or two cover layers.

The TAC's job is further complicated because the instructions in the RAP are at times contradictory. For instance, Section 1.0, II.B.2. states that sands will be placed in the top six feet of tailings while Tables 1.2 and 2.4 show sands in the upper ten feet.

RESPONSE:

The modeling of 2.5-foot layers is done to correspond to actual pile data taken at incremental depths of 2.5 feet. These data are then used in the RAECO code to compute the cover thickness. It is not intended to be a construction specification.

We have checked our calculation using the fewer layers as the NRC suggested. The results are essentially identical to that which is presented in the RAP.

As far as the comment regarding 10 feet of sands (based solely on radium content), the low radium content material exists in place so therefore it will remain at that location. Only in fill areas will less than 10 feet of sand be present. However, an overall average of 10 feet of low activity material will result.

The RAECO will be rerun when the final grading and construction sequence has been established for the final design. No specifications of the design parameters are considered appropriate at this time. The RAP has been changed to clarify this matter.

SHIPROCK REMEDIAL ACTION PLAN AND SITE CONCEPTUAL DESIGN

NRC COMMENTS, OCTOBER 4, 1984

AND

DOE RESPONSES, DECEMBER 7, 1984

NRC COMMENTS

SHIPROCK RAP

1. COMMENT:

Attachment A, Section 4.0, p. 25: It is our position that the design method for sizing of long-term erosion protection for the embankment side slopes is not adequate to meet EPA long-term stability criteria. We conclude that the proposed erosion protection could be damaged by rainfall much less intense than the PMP.

Further, we do not agree that the rockfill hydraulics method (Stephenson, 1959) is the best available method for determining the size of erosion protection on embankment slopes to resist long-term sheet flow and gully erosion. This method does not account for future conditions likely to occur over a 1000-year period; we disagree with your conclusion that this method will account for areas of flow concentration which will form due to settlement, turbulence, and random flow spreading. We believe that a conservative analytical method (which assumes that areas of flow concentration will occur) should be used.

An acceptable method of analysis to resolve our concerns would be to assume that areas of flow concentration occur near the downstream toe of the embankment and that the erosion protection provided must resist the PMP sheet flow velocity which occurs in that area. Conservative design assumptions should be used to determine such parameters as drainage areas, Manning's 'n' values, times of concentration, rainfall intensities etc.

Additionally, the method used to compute the rock size for the flatter top slopes of the embankment is not considered adequate. The method outlined above (which accounts for concentration of flow) should also be used to design the rock protection for the top of the pile.

RESPONSE:

Included after Comment 2.

2. COMMENT:

Attachment A, Section 4.0, p. 26: It is our position that the velocity of flow at the toe of the side slopes will be greater than your computed value of 2 feet per second (particularly if flow concentration occurs). It is doubtful that a D50 rock size of less than 7-8 inches will have any practical value other than to reduce wind erosion potential. Therefore, it is our position that the D50 rock size for the side slopes and the ditches be at least 7-8 inches to account for energy dissipation at the toe of the slopes and for flow concentration.

RESPONSE TO 1 AND 2:

As noted previously, the calculation used to size the rock erosion protection for the embankment side slopes is conservative. The method is based on flume studies which accurately represent the design flows and slopes. Random flow spreading and local flow turbulence are accounted for in the design equation. Slope changes resulting from differential settlement after cover placement are calculated to be less than 0.3 percent sloping in any direction, which is within the tolerances for placement of the cover material. Little flow concentration is expected to develop in the 2 percent top slope or 20 percent side slope. The safety factors associated with the time of concentration determination and the flow rate factor of safety of 1.2 associated with the hydraulic design equation provide a conservative design.

We were unable to find any references or published research which discuss the use of flow concentrations in the design of erosion protection; therefore, this office disagrees with NRC position and philosophy stated above.

3. COMMENT:

Page E-13: Based on our visual examination of rock from your proposed borrow area, we believe that some of the rock may be of relatively poor quality. As a result of this potential poor quality, the average riprap sizes and layer thicknesses may need to be increased to provide a rock protection layer that can meet EPA long-term stability criteria.

The two durability tests which you have proposed (p. E-13) are not considered to be adequate to determine if the rock is of acceptable quality. Based on our review, we conclude that you should provide a commitment to perform the tests listed in the table below. The table provides examples of acceptable criteria for rock durability.

Test	Criteria
1. Specific gravity	$\geq$2.60
2. Absorption	$\leq$0.5%
3. Sodium Sulfate weight loss	$\leq$5. %
4. Freeze-Thaw weight loss (250 cycles)	$\leq$0.5%
5. LA Abrasion (100 revolutions)	$\leq$5. %

If the rock does not meet these specifications (USBR Standards for Judging Rock Durability - Depuy and Ensign - 1965) for good quality rock, provide a commitment to increase rock sizes when the rock-selection task is performed by the State. If the rock does not meet the above criteria you should discuss the need to increase average rock sizes to meet the EPA longevity standard. When rock does not meet the above specifications you should also provide a commitment to demonstrate that rock of better quality is not readily available and that the best rock economically available will be used.

RESPONSE:

We agree that four of the tests listed should be run on rock sources that are proposed for erosion protection, however, we do not agree with the criteria listed.

For the absorption test, a criteria of $\leq$1.0 percent is considered reasonable. Although you have not specified the number of cycles involved with meeting the Sulfate Soundness Test Criteria, based upon ASTM standards, we propose that the loss after (5) cycles be $\leq$10.0 percent. Assuming ASTM C535 for large aggregate is the standard used in the LA Abrasion Test, a loss of $\leq$40.0 percent after 1000 revolutions is proposed.

The expense and time involved in Freeze-Thaw Testing should preclude its routine use to determine rock durability unless the other tests indicate the rock to be of marginal adequacy.

We concur that if the rock fails the criteria, rock size should be increased proportionally to the percentage by which the rock fails the criteria.

The rock used for erosion protection will be screened out of the borrow source. Before the material is placed, it will be tested by the Remedial Action Contractor (RAC) for its grain size distribution and durability. Additionally, once construction has started, the RAC will conduct an ongoing testing program which will ensure that the material meets the specifications for material selection, testing, and placement. These specifications, to be performed and followed by the RAC, are described in the following paragraphs.

Material selection, testing, and placement

The sources from which the rock will be obtained should be selected well in advance of the time when the stone will be required for placement. The acceptability of the rock should be determined by service and/or by suitable tests. If testing is required, suitable samples of rock should be taken using Standard Practices for Sampling Aggregate (ASTM D75), at least 60 days prior to the start of construction. Additionally, the approval of some rock from a borrow area will not be construed as constituting the approval of all rock taken from the borrow area.

If service records are not available or do not exist, resistance to disintegration from the type of exposure to which the stone will be subjected should be determined by any or all of the following tests, depending on the rock to be used and the site climatic conditions.

1. One of the parameters needed in the design of the size of rock required for erosion protection is the specific gravity. Additionally, the specific gravity and absorption (ASTM C127) can be used to evaluate the durability of a rock. The specific gravity of a rock is an indicator of its strength. The higher the specific gravity, the better the quality of the rock. The specific gravity is also a good indicator of a rock's ability to withstand cycles of freezing and thawing.

Absorption by itself is not a good indicator of a rock's freeze/thaw characteristics. However, a low absorption is a desirable rock property in that it indicates the rock will not disintegrate rapidly due to salt action and mineral hydration.

It is recommended that suitable rock have a specific gravity greater than 2.60 and an absorption less than 1 percent.

2. When riprap must withstand abrasive action from material transported by streams or large flow on or adjacent to the pile, the Los Angeles Abrasion Test should be used. When the abrasion test in the Los Angeles Machine (ASTM C131 or C535) is used, the stone shall not have a percentage loss of more than 40 percent after testing. For ASTM C131, the ratio of the loss after 100 revolutions to the loss after 500 revolutions should not exceed 20 percent for material of uniform hardness. Likewise for ASTM C535, the ratio of loss after 200 revolutions to the loss after 1000 revolutions, should not exceed 20 percent.

3. In locations subject to freezing or where the stone is exposed to salt water, the Sulfate Soundness Test (ASTM C88) should be used. After five cycles, stone should not have a loss exceeding 10 percent if sodium sulfate is used or 15 percent if magnesium sulfate is used.

4. A better guide to weathering which may be used in place of item 2 above is AASHTO Test 103 for ledge rock, Procedure A. From this test, the stone should not have a loss exceeding 10 percent after 12 cycles of freezing and thawing.

5. Another method which can be used to evaluate durability of a particular rock is the hardness test as determined by the Point Load Test; or the Schmidt Rebound Hammer. If the point load test is used, a value >300 is acceptable. If the Schmidt Hammer is used, a value of <25 is acceptable.

It must be recognized that considerable judgement is required during site evaluation and selection of laboratory testing procedures. The index tests selected are dependent on the availability of laboratory test equipment. There is sufficient similarity among the various tests described to judge the durability of a rock source with a minimum amount of testing. A greater number of tests should be run on rock types that have been judged to be marginal during site investigations.

Should any of the rock being evaluated for use as erosion protection not meet the recommended standards for acceptable rock durability, a new rock source should be sought within a reasonable distance from the site.

If an alternate rock source of better durability cannot be found, the size of the rock should be increased to take into account the degradation of the rock with time. The increase in size is subjective but it is proposed that the rock size be increased by the percentage that the rock fails a criteria.

When placing the rock, each load of rock should be reasonably well-graded from the smallest to the maximum size specified. Gradation can be controlled by visual inspection or, if the rock size is not greater than three inches, the rock gradation can be physically tested using U.S. standard sieves of the appropriate sizes.

4. COMMENT

Section 3.6, p. 14: The Shiprock RAP does not characterize adequately background groundwater quality. As discussed in Section 2.4, pages 7-8, "any degradation of groundwater quality should be evaluated in the context of background groundwater quality and the available quantity of ground water" and "site assessments must include monitoring programs sufficient to establish background groundwater quality and to identify the present movement and extent of contaminant plumes." Consequently, objective evaluation of water quality data collected upgradient hydraulically from the Navajo Mill is required to characterize the extent and movement of contaminated groundwater, in addition to identifying potential beneficial uses of affected groundwater resources.

The RAP characterizes the quality of groundwater that is upgradient hydraulically from the Shiprock UMTRAP site, but not necessarily representative of background groundwater quality. As characterized in the RAP, upgradient groundwater quality is poor with extremely high concentrations of total dissolved solids, sulfate, magnesium, and sodium, and high concentrations of calcium, chloride, and bicarbonate. Anomalously high concentrations of ammonium, nitrate, and heavy metals in wells 3H, 4H, 12A, 6GT, 5GT, 9GT, and 10GT indicate potential contamination of the shallow groundwater system by uranium recovery operations at the Navajo Mill at Shiprock. The RAP does not evaluate the causes of this contamination and, therefore, cannot conclude whether these high constituent concentrations (e.g., up to 5800 mg/l of NO_3 in well 4H) are associated with uranium recovery operations at Shiprock.

The RAP recognizes tacitly that upgradient groundwater quality may not represent background water quality by stating "the highest of the uranium values reported for some upgradient wells may represent residual contamination due to radial flow away from the pile during active milling" (pg. 14). Monitoring wells most distant from the Shiprock tailings piles (e.g., wells 3H, 4H, 12A) monitor groundwater that contains higher uranium concentrations than groundwater sampled in some wells very near the piles (e.g., wells 8, 1H, and 7). Although the RAP recognizes the potential for groundwater flow radially away from the tailings piles and evaporation pond during and after operation of the Navajo Mill, it does not assess the extent of this flow or integrate water quality data with such a hydraulic assessment.

Comparison of water quality data collected by Dames and Moore (1982) and TAC (1983) indicates significant changes have occurred in the concentrations of constituents in shallow groundwater beneath the Shiprock site during the last couple years. For example, the concentration of nitrate (as No_3-N) in well DM-7 in 1982 was determined to be 0.1 mg/l. In comparison, the concentration of nitrate in groundwater extracted from well DM-7 in 1983 was four orders of magnitude greater (i.e., 1600 mg/l) than the concentration determined in 1982. Based on the considerations listed above, the NRC staff concludes that the hydrogeologic assessments in the Shiprock RAP do not characterize shallow background groundwater quality.

In addition, groundwater quality analyses documented in the Shiprock RAP, EA, and PSCR, do not contain sufficient information to allow detailed external review. These analyses should be accompanied by information such as the date of sample collection, name of the analytical laboratory, analytical methods and procedures, performance of analytical laboratory on quality control samples (i.e., blanks, spikes, standards, and splits), and any specific observations by individuals who collected or analyzed the samples relevant to water quality determination.

This information should also include calculated ion balances (charge balances) based on concentrations of major cations and anions in water samples. Several groundwater quality samples have charge balance errors greater than 5 percent (see for example groundwater quality analysis of a sample from well 6 GT, Table 4.4, Shiprock Processing Site Characterization Report [UMTRA-DOE/AL-0042]). Significant charge balance errors challenge the validity and accuracy of water quality analyses.

RESPONSE:

RAP Section 4.4, "Water Quality," and Attachment A to Appendix E have been modified to indicate that background water quality may not have been determined, and to discuss why background water quality cannot and need not be determined for the limited shallow ground-water system.

5. COMMENT:

Section 4.4, Pg. 19: The RAP states that the shallow groundwater system in the Shiprock region is unusable because of its poor quality, yet it does not cite a reference or provide information necessary to support the conclusion. This conclusion should be supported by citing references and/or supplying appropriate water quality analyses of groundwater from shallow aquifers in the vicinity of the Shiprock site.

RESPONSE:

RAP Section 4.4 has been amended to delete the reference to bad quality water on a regional basis. Section 4.4 and Attachment A to Appendix E have been amended to provide additional discussion of why background quality in the shallow system has not and need not be determined.

6. COMMENT:

Section 4.4, Pg. 19: The RAP does not establish background quality of groundwater within alluvial sediments in the modern flood plain of the San Juan River. The RAP should be revised to include sufficient information to establish defensibly background groundwater quality in the alluvium along the San Juan River northeast of the Shiprock site.

RESPONSE:

RAP Section 4.4 and Attachment A to Appendix E, Section 8, have been amended to indicate that the water quality of the alluvium is assumed to be the same as that of the river. Section 4.4 states that this is "good quality" water.

7. COMMENT:

Appendix D, Section D.3, Page D-22: Please provide "DOE-approved" procedures for groundwater sampling and analysis, which are referenced in Section D.5.3.

RESPONSE:

The referenced DOE-approved procedures for ground-water sampling and analysis are attached.

8. COMMENT:

Section 3.2, Pg. 12: The RAP states that raffinate from the solvent extraction circuit was discharged into separate evaporation ponds, yet it does not include a description or location of these ponds. Contaminant migration from these ponds into shallow groundwater may account for anomalous concentrations of constituents such as NH_4 and NO_3 identified in ground water samples from the Shiprock site. The RAP should be amended to characterize the distribution of contaminant sources and the migration of associated contaminants in shallow groundwater.

RESPONSE:

Attachment A to Appendix E, Section 8, has been amended to include a Figure (8.7) which shows the former raffinate pond area.

9. COMMENT:

Section 3.6, Pg. 14: The RAP identifies the presence of groundwater contamination associated with uranium recovery operations at the Shiprock site. It does not, however, characterize the extent of this contamination, relative concentrations of contaminants in groundwater, and the distribution of contaminant sources. This characterization, as commented previously, is hampered partially because of an inadequate establishment of background groundwater quality and inadequate characterization of the shallow ground water flow system beneath and in the vicinity of the Shiprock site (see comment numbers 6 and 14). Once background groundwater quality is established defensibly and the groundwater flow system is better understood, the RAP should be revised to characterize the extent of groundwater contamination beneath and in the vicinity of the Shiprock site. The NRC staff recognizes that the establishment of background groundwater quality may obviate revisions to the present characterization of the extent of contamination depending on the use potential of the shallow groundwater system.

In addition, the RAP does not characterize adequately the extent of groundwater contamination in the alluvial sediments in the floodplain of the San Juan River. As stated in the letter from Leo Higginbotham to John Baublitz dated June 22, 1984, the characterization of groundwater contamination at the Shiprock Site does not completely satisfy the EPA regulations. The RAP does not justify why contamination is not expected to be present in shallow groundwater in the alluvial sediments along the San Juan River northeast of the Navajo Mill. According to a reference cited in Attachment A to the RAP, the U.S. Public Health Service observed six seeps flowing at rates between 0.5 and 20 gpm in 1960 along the bluff northeast of the Shiprock site. Analyses of samples of the seeping water indicated that the water contained high concentrations of uranium (e.g., 4.8 mg/l; see page 43 of Attachment A to Shiprock RAP). This contaminated water probably recharged the alluvium along the San Juan River northeast of the mill site.

Other evidence that supports indirectly the existence of groundwater contamination in the alluvium along the river includes the deposition of windblown tailings on the flood plain and in the arroyo north of the Shiprock site (see Figure 4.1 in the RAP; note that the north arrow in this figure is incorrect). Leaching of these tailings by infiltrating surface water could be expected to increase concentrations of tailings contaminants (e.g., uranium, arsenic, etc.) in shallow groundwater. During a site visit in December, 1983, NRC staff observed numerous seeps and marshy areas in the arroyo north of the mill site indicating the possibility that the arroyo acts as a conduit for shallow groundwater flow into the alluvium along the river. If the arroyo is a conduit for preferential groundwater flow, it is likely that contaminants migrated in groundwater away from the Shiprock site within the arroyo into flood plain sediments during operation of the Navajo Mill. The Engineering Assessment of the Shiprock site by Ford, Bacon and Davis, (DOE/UMT-0104, 1981) records the presence of a small pond in the flood plain alluvium near the incision point of the arroyo in the bluff northeast of the mill site. Although the purpose of this pond is unknown, the NRC staff assumes in the absence of contrary information that the pond contained effluents from the Navajo Mill.

Section 3.6.2 of the Shiprock EA states that alluvium along the San Juan River near the Shiprock site could yield large quantities of groundwater. Water for the residents of Shiprock is pumped from the San Juan River upstream of the UMTRAP site indicating that water from the river is suitable for domestic use (see Shiprock PSCR, page 89). To characterize the extent of groundwater contamination, DOE should sample groundwater within the alluvium or justify defensibly why shallow groundwater in the alluvium cannot be considered a potential water resource during the next 1000 years.

RESPONSE:

See responses to comments #4 & #6. Section 3.6 has been amended to provide additional discussion of the boundaries and limited extent of the shallow terrace system. The RAP has been amended to note that the San Juan floodplain has been sampled to determine the presence of contamination in the floodplain. Analysis results are expected by December, 1984. Those results will be added to the PSCR as they become available.

10. COMMENT:

Section 4.4, Pg. 19: The RAP states that hydrologic testing indicates that radionuclides in the shallow groundwater system are migrating slowly across the site. This statement needs additional clarification including identification of the migrating radionuclides, the extent of the migration, rates of migration, direction of migration, and the information to support this conclusion.

RESPONSE:

Section 4.4 of the RAP has been amended to state that the radionuclides are primarily uranium. Section 3.6 has been amended to provide further specific discussions of which radionuclides are present in the ground-water. The statement in Section 4.4 is meant to imply that radionuclides move concurrently with the ground water. In a complicated geochemical setting such as Shiprock, with no apparent downgradient area, it is difficult to measure and provide an objective measurement of extent, direction, and rates of movement of contaminants.

11. COMMENT:

Section 4.4, Pg. 19: During the site visit by NRC staff in December, 1983, Leon Stepp, TAC, collected several samples of contaminated sediments in a holding pond northeast of the mill site. The purpose of this sampling was to determine whether these sediments contained organic contaminants from the discharge of steam-cleaning operations that drain into the pond. Seepage from this pond probably flows into the unconsolidated sediments in the arroyo northeast of the mill. The discharge of organic effluents from the Navajo Mill may have caused groundwater contamination by constituents that may not be suspected in uranium mill tailings leachate or raffinate seepage. The results of the sampling and analysis, however, are not provided in the RAP, EA, or PSCR for Shiprock. The RAP should provide the results of these analyses and assess the impact of the discharge of these contaminants on shallow groundwater quality.

RESPONSE:

The purpose of the sampling was not to determine whether the sediments contained organic contaminants but instead to check for toxic metals (EP toxicity). The results of that testing on two samples are as follows (in ppm):

		#1		#2
Silver	----	less than 0.02	----	less than 0.02
Chromium	----	less than 0.05	----	less than 0.05
Cadmium	----	0.029	----	0.041
Lead	----	less than 0.05	----	less than 0.05
Arsenic	----	0.018	----	0.031
Selenium	----	0.019	----	0.015
Mercury	----	less than 0.001	----	less than 0.001
Barium	----	less than 1.0	----	less than 1.0

The four samples measured for radium indicated the following:

26.6 $\pm$ 1.4 pCi/g
5.3 $\pm$ 0.7 pCi/g
1.1 $\pm$ 0.2 pCi/g
28.5 $\pm$ 1.4 pCi/g

The above information will be added to the PSCR.

The water samples recently taken from the floodplain below the arroyo northeast of the mill are being analyzed for total organic carbon. That information will also be added to the PSCR when available.

12. COMMENT:

Section 3.6, Pg. 13: The RAP describes the existence of shallow, discontinuous, perched groundwater lenses beneath the Shiprock site and above the saturated, upper portion of the Mancos Shale. Below the saturated, weathered Mancos Shale, according to the RAP, exists a 400-foot thick sequence of unsaturated, low permeability Upper Mancos Shale. The Gallup Sandstone exists below the Upper Mancos Shale. The first useable aquifer beneath the Shiprock site is reported to be the Dakota Sandstone, which is separated from the tailings by about 2100 feet of nearly impermeable, unsaturated Mancos Shale (see page 14). The information provided in Section 8 of Attachment A, as discussed below, is inadequate to support these conclusions.

As presented in Attachment A, the shallow, perched, discontinuous groundwater lenses in alluvium beneath the site "were identified by a vertical head differential of greater than 10 feet in paired wells." These head differentials are identified in two well pairs: DM-3 and DM-3A/1; and DM-11/1 and DM/11/2. Evaluation of hydraulic heads measured in these well pairs and well construction details indicate that the head differentials in these well pairs do not prove the existence of shallow, discontinuous perched, groundwater lenses beneath the site.

Wells DM-3 and DM-3A/1 are completed at different depths within the alluvium and Mancos Shale beneath the tailings piles. According to Table 8.1 of Attachment A, well DM-3 is completed in both the alluvium and Mancos Shale with a screened interval extending from 25.4 to 29.4 feet below the ground surface. In comparison, well DM-3A/1 is perforated in two discrete intervals from 35 to 45 feet and 52 to 54 feet below the ground surface. Water levels measured in well DM-3A/1 represent a composite head that exists across the entire perforated interval, because the monitoring interval is large compared to that of a piezometer that monitors hydraulic head at a point in a groundwater flow system. Consequently, a well like DM-3A/1 will average hydraulic heads exerted across the interval from 35 to 54 feet below ground surface. The significance of "head-averaging" is greater in flow systems with vertical flow components compared to those where groundwater flow is predominantly horizontal.

For lack of more precise information, the NRC staff assumes that monitoring wells like DM-3A/1 measure the hydraulic head that exists at the center point of the perforated interval. The elevation distance between the centerpoints of the perforated intervals in wells DM-3 and -3A/1 is 17.7 feet. A maximum water level difference of 11.4 feet was recorded between these wells on December 14, 1983. Assuming plausible vertical hydraulic gradients less than 1 ft/ft, the water level differences measured in these wells may be explained without reliance on a conceptual model that involves multiple perched, discontinuous groundwater lenses. Consequently, water level differences greater than 10 feet do not prove the existence of these discontinuous lenses, contrary to conclusions in the RAP.

The existence of a large vertical gradient in shallow groundwater beneath the Shiprock site is consistent with a conceptual model where groundwater flows vertically beneath the site towards discharge locations along the San Juan River bluff, depending on the vertical hydraulic conductivity of alluvium and the Mancos Shale beneath the site. Consistent with this model, the elevated water levels in wells DM-3 and DM-11/2 (evaluated similarly to the assessment for DM-3 and -3A/1 noted above) represent hydraulic heads in the upper portion of the shallow groundwater system beneath the Shiprock site. Evaluation of the water levels recorded in wells DM-3, DM-3A/1, DM-11/1, and DM-11/2 may indicate the existence of a large hydraulic gradient (0.64 ft/ft in wells DM-3 and -3A/1; 0.69 ft/ft wells DM-11/1 and -11/2) vertically downward beneath the Shiprock site. Evaluation of these data, however, are complicated by well construction details (e.g. filterpack interval, casing perforations, etc.) and natural heterogeneities of the hydrogeologic units in which the monitoring wells are completed. In the absence of additional characterization of the hydrogeologic system at Shiprock, it should be assumed that the "shallow, discontinuous, perched" groundwater lenses are not discontinuous, but rather represent the upper portion of the shallow groundwater system beneath the Shiprock site.

The Gallup Sandstone is identified in the RAP as the uppermost bedrock aquifer 400 feet beneath the Shiprock site. Based on information contained in Callahan and Harshbarger (1955), the NRC staff agrees with DOE that present use of this aquifer is not likely because water sources of higher quantity and quality are available currently in deeper aquifers, alluvial aquifers, and the San Juan River. Callahan and Harshbarger report that the Gallup Sandstone is a flowing artesian aquifer in the Shiprock area and contains concentrations of total dissolved solids from 1240 ppm to 2440 ppm (based on 2 analyses). The NRC staff notes, however, that increasing water demands in the western San Juan Basin during the next thousand years may motivate groundwater extraction from the Gallup Sandstone near Shiprock. Consequently, the potential for contaminant migration from the shallow groundwater system to the Gallup Sandstone should be assessed to support remedial action decisions at Shiprock.

The thickness estimate of the Mancos Shale, an established confining unit in the Colorado Plateau, beneath the Shiprock site is not supported by geological reasoning in the RAP. The RAP should be revised to include information that supports the thickness estimate of the Mancos Shale above the Gallup Sandstone at the Shiprock site. The RAP should also be revised to include information about the use of groundwater from the Gallup Sandstone in the San Juan Basin, where such use exists.

The Lower Mancos Shale is underlain by the Dakota Sandstone, the uppermost useable bedrock aquifer in the Shiprock Area (Callahan and Harshbarger, 1955). Callahan and Harshbarger (1955) report the total thickness of the Upper and Lower Mancos Shale and Gallup Sandstone at the Shiprock School two miles north of the Shiprock site is about 1135 feet. In comparison, the RAP states that the Dakota Sandstone is separated from the Shiprock tailings by about 2100 feet of nearly impermeable, unsaturated Mancos Shale. These two conclusions are inconsistent; the RAP should be revised to explain or remove this inconsistency. In addition, the NRC staff considers it unlikely that the Mancos Shale is unsaturated down to the Dakota Sandstone because the Mancos Shale confines two artesian aquifers: the Gallup Sandstone and Dakota Sandstone. The staff does not consider the packer permeability test and moisture content data included in Dames and Moore (1982) adequate to conclude that the Mancos Shale is unsaturated beneath the shallow groundwater system and above the Dakota Sandstone at the Shiprock site. Consequently, it should be assumed that the entire sequence below the weathered Mancos Shale to the Dakota Sandstone is saturated, unless hydrogeologic data and assessments are developed that prove defensibly that the sequence is not saturated.

RESPONSE:

Attachment A to Appendix E, Section 8, has been modified to provide references for visual identification of the perched layer. The description of the thickness of the Mancos Shale and the depth to the Gallup Sandstone has been modified to reflect information from 2 wells within about 1/4 and 1/2 mile of the tailings, respectively (Attachment A to Appendix E, Section 8). The RAP does not rely solely on the low saturation of the shale, but rather its low permeability as a barrier.

13. COMMENT:

Section 3.6, Pg. 14: The RAP states that the flow direction within the shallow groundwater system in alluvium and weathered Mancos Shale is toward the northeast. Evaluation of water levels recorded at Shiprock, however, indicates that shallow groundwater is also flowing to the northwest and west (see water levels in wells completed in both the alluvium and Mancos Shale). The assessment of flow direction is complicated, as noted earlier, by details of monitoring well construction and heterogeneities of the hydrogeologic system. Dames and Moore (1982; see Plate 8) report that shallow groundwater flows to the northwest, north, and northeast from beneath the Shiprock mill site. Groundwater flow directions and rates in the mill site area may be particularly important in assessing the migration of seepage from evaporation ponds away from the site. The RAP should be revised to characterize the rates and directions of contaminated groundwater migration away from the Shiprock site.

RESPONSE:

The RAP has been revised throughout to state that ground-water flow directions vary, and to emphasize that the net ground-water flow is to the northeast. An alternate potentiometric map has been added (Figure 8.8, Appendix E, Attachment A) and explained which shows that ground-water flow is generally to the northeast.

14. COMMENT:

Appendix E, Section 2.2.2, Pg. E-5: This section (paragraph 2) does not mention the existence of the Gallup Sandstone beneath the Shiprock site. This omission should be corrected. On page E-6, the word "relatively" should be inserted before the phrase "impermeable shale" in paragraph 1.

RESPONSE:

The RAP has been amended to include the suggested changes.

15. COMMENT:

Appendix E, Section 2.2.2, Pg. E-6: Water quality samples from monitoring wells reported to be nearest the recharge area of the shallow groundwater system at Shiprock are probably not representative of background groundwater quality as indicated by anomalously high concentrations of constituents such as NH_4, NO_3, Se, and Mn. The statement to the contrary in the RAP should be revised.

RESPONSE:

The RAP statement about background water quality has been revised. An expanded discussion of water quality in the shallow system has been added.

16. COMMENT:

Appendix E, Section 2.2.2, Pg. E-6: Calculations of net infiltration at Shiprock in the RAP are not necessarily conservative and are complicated by invalidity of several assumptions that affect the calculations. The NRC staff agrees with DOE that a conservative approach to calculate net infiltration at Shiprock is to assume that groundwater flow beneath the site is recharged only by infiltration (i.e., through-flow from the area southwest of the site upgradient hydraulically is negligible). The staff concludes, however, that several of the other assumptions are non-conservative and invalid. These assumptions include the following:

a) Vertical groundwater flow is assumed to be negligible; as previously stated, the vertical hydraulic gradient measured in wells DM-3, -3A/1, -11/1, and -11/2 is large (0.65 ft/ft) indicating that vertical flow may be significant beneath the Shiprock site.

b) Groundwater flow is assumed to be from south to north-northeast; as commented previously, the directions of shallow groundwater flow have not been fully characterized; based on available information, groundwater flows away from the site toward the northwest, north, northeast, and may also flow to the west and southeast.

c) The hydraulic gradient is averaged across the site along a transect that is oblique to the direction of the maximum hydraulic gradient; because this direction does not parallel the direction of the maximum hydraulic gradient and aquifer anisotropy is not considered, the groundwater flow rate is underestimated.

d) The cross-sectional area of flow is assumed to be constant beneath the pile; this assumption is inconsistent with available information and underestimates the groundwater flow rate.

e) Geometric mean of hydraulic conductivity (K) based on 26 slug tests is assumed to represent the average hydraulic conductivity of the hydrogeologic units beneath the Shiprock site; geometric means of hydraulic conductivity may overemphasize the low values of K and underemphasize high K values, depending on the distribution of K in space. Without knowledge of this distribution, the NRC staff prefers a more conservative approach such as assuming that the highest measured value of K represents the K of the hydrogeologic units beneath the site. In addition, vertical hydraulic conductivities, which are required to estimate migration of contaminants, have not been characterized at the Shiprock site.

f) Infiltration calculations do not account for irrigation of the piles, seepage from raffinate evaporation ponds, or the transient behavior of the shallow groundwater system probably induced by the elimination of these recharge sources.

g) Seepage along the San Juan River bluff is assumed to occur evenly along the bluff; this assumption is inconsistent with observations of the site (e.g., U.S. Public Health Service Report, 1962; observations of TAC; observations of NRC staff) and is nonconservative. Seepage occurs at isolated seeps along the bluff, so the exposed surface area and surface evaporation are reduced compared to evenly distributed seepage along the bluff. Observations by the Public Health Service record flow rates of these seeps between 0.5 and 20 gpm.

These invalid and non-conservative assumptions preclude objective evaluation of the infiltration estimate at the Shiprock site. Although the NRC staff agrees with DOE that infiltration rates are probably low at Shiprock, the staff concludes that the infiltration rates estimated in the RAP are not necessarily conservative and that additional characterization and/or evaluation of the hydrogeologic system at Shiprock would be necessary to support conservative infiltration estimates.

RESPONSE

The low flow of the shallow system has been further substantiated by reference to visual observations below grade and to how easily flow is intercepted (Attachment A to Appendix E, Section 8). One of the assumptions has been substantiated by visual observations. Additional discussions of flow in the shallow system have been added. It is felt that observations of the shallow system fully substantiate the conclusion that volumetric flow is low and infiltration must therefore be low.

17. COMMENT:

Appendix E, Attachment A, Section 8, Pg. 41: The RAP supports the conclusion that infiltration to the water table at Shiprock is negligible by citing unpublished data collected at the Riverton UMTRAP site in Riverton, Wyoming. The validity of this support cannot be assessed until these data are provided; the RAP should not support conclusions by referencing unavailable information. In addition, the validity of conclusions about the behavior of moisture migration at one site must be carefully assessed in light of the differences and similarities between these sites. The RAP does not provide a detailed comparison. The RAP should provide the Riverton data, analyses, and conclusions along with a comparison of the characteristics of the two sites to support the conclusion that infiltration to the water table at Shiprock is negligible.

RESPONSE:

Attachment A to Appendix E, Section 8, has been amended to provide a published reference for the Riverton data. It has been stated that there are differences between the two sites. The passage in question is not meant as a major portion of the analysis, but to provide a useful comparison in lieu of other data.

18. COMMENT:

Section 3.6: The RAP does not provide any information about the attenuative capacity of unsaturated and saturated hydrogeologic units at Shiprock to determine contaminant transport. Depending on the conclusions of characterization of background groundwater quality, groundwater flow rates and directions, and the extent of contamination, the RAP may require revision to evaluate the attenuative capacity of hydrogeologic units in the unsaturated and saturated zones necessary to evaluate contaminant transport away from the Shiprock site.

RESPONSE:

The RAP has been revised (Section 3.6, Attachment A to Appendix E, Section 8) to provide a further discussion of background water quality and extent of the ground-water system. It is felt that these discussions preclude the need to evaluate the attenuative capacity of the hydrogeologic units.

19. COMMENT:

Section 3.6: Pending completion of additional hydrogeologic characterization (e.g., background groundwater quality, extent of groundwater contamination, groundwater flow rates and directions), the RAP may require revision to address the considerations listed in 40 CFR Part 264.94 (b) and compliance with relevant water quality standards.

RESPONSE:

The amended discussion of the hydrogeologic system should obviate further consideration of 40 CFR Part 264.94.

20. COMMENT:

Appendix A, Section 3, Pg. A-8: The RAP does not provide relevant Federal, State, and Tribal surface water and/or groundwater quality criteria that will not be exceeded during remedial actions at Shiprock. The RAP should provide all relevant water quality criteria (e.g., New Mexico Human Health Standards for Groundwater, New Mexico Surface Water Quality Criteria, etc.).

RESPONSE:

The remedial action is subject to applicable Federal, state, and Navajo Tribal regulations. These applicable regulations, including water quality related regulations, have been identified in consultation with the Navajo Tribe, State of New Mexico, and identified Federal agencies and are described in Appendix A of the RAP. The determination of criteria (or, more likely, effluent standards) that must be met during the remedial action will be made by the appropriate agency(ies) in response to permit applications submitted by the RAC. Inclusion of this information in the RAP is not considered appropriate.

21. COMMENT:

Appendix E, Attachment A, Section 5.0, Pg. 30: The RAP implies that a waste water retention basin will be designed without a low-permeability liner because seepage from the basin is considered to be insignificant, yet this section does not predict the approximate quality of water to be collected in the waste-water retention basin from runoff, dewatering, decontamination, and other sources of waste water. Section 4.1 of the Shiprock PSCR (see page 56) reports that the hydraulic conductivities of shallow, unconsolidated alluvium and weathered Mancos Shale beneath the Shiprock site range from 1E-3 cm/s to 1E-5 cm/s. The combination of these moderately high hydraulic conductivities and poor quality waste water retained in the basin may degrade shallow groundwater quality beneath the site, depending on background quality of this groundwater. The RAP should be revised to consider potential degradation of shallow groundwater quality and justify the design of the waste water retention basin.

RESPONSE:

The RAP has been revised to note that the waste-water retention basin will be designed with a low-permeability liner. Consultation with the RAC has disclosed that preliminary design of the retention basin includes the following features:

a) One foot of recompacted Mancos Shale on the pond bottom and two feet on the sides which will result in permeability of less than 10^{-7} cm/sec.

b) Average 1½-foot water depth from the top of the overflow weir to the pond bottom.

22. COMMENT:

Section 5.0: Pending completion of additional hydrogeological characterization at the Shiprock site (e.g., background groundwater quality, extent of contamination, groundwater flow rates and direction), the RAP may require revision to address the factors listed for consideration in 40 CFR Part 192.20 (3) in deciding whether to implement remedial actions for protection and restoration of affected aquifers.

RESPONSE:

The RAP has been amended (Section 3.6; Section 8, Attachment A to Appendix E) to further discuss the ground-water system. This should obviate the need to further discuss factors in 40 CFR Part 192.30.

23. COMMENT:

Appendix D, Section D.5.4., Pg. D-22: The RAP states that additional waste water treatment will be required when monitoring indicates discharge standards are exceeded and discusses discharge of potentially-contaminated water from the site. In contrast, Section 6.0 of Attachment A states that all waste water will be retained and evaporated, so waste water treatment is unnecessary. These sections should be revised to remove the apparent inconsistency. If waste water discharge from the site during remedial actions is unlikely, but may occur, a contingency treatment plan should be prepared to achieve compliance with discharge standards. As noted earlier, prediction of expected waste water quality may be required to prepare contingency plans for waste water treatment.

RESPONSE:

Since the waste-water retention basin has been designed for evaporation of runoff from at least the 10-year 24-hour storm, no discharge is expected during the remedial action. Appendix D of the RAP will be modified to delete the requirement for sampling the water in the waste-water retention basin.

24. COMMENT:

Appendix E, Attachment A, Pg. 44: The RAP states that cover installation on the stabilized tailings pile will not affect significantly water infiltration to the water table beneath the site. As stated in Section 9 of Attachment A of the RAP, however, cover installation is expected to reduce infiltration. This reduction in infiltration may affect the shallow groundwater system. The RAP should be revised to evaluate potential impacts of cover installation; this evaluation should be consistent with the background quality of shallow groundwater and its potential resource value.

In addition, the third paragraph of part II of Section 9 should be revised to read ". . . support an increasing amount of vegetation, and net infiltration to the water table will likely decrease as plant transpiration increases."

RESPONSE:

Appendix E, Pgs. E-5, E-6, E-14, and E-15 along with Attachment A, Section 8, describe the present infiltration as negligible in terms of ground-water recharge. The poor quality of the near surface aquifer is documented and the change in infiltration rate is demonstrated to be so small as to have an unmeasurable impact, positive or negative, on ground-water usability . The suggested wording change in Part II, Section 9.0, is not considered critical to understanding the sentence which is considered correct as printed.

25. COMMENT:

Appendix E, Section E.3.2.4., Pg. E-12: The RAP does not provide estimates of the hydraulic properties of the cover materials. Estimated properties are required to estimate post-remedial action infiltration into the cover and the moisture content of the cover materials, an important parameter in determining radon diffusion in earthen covers. This section states that the design moisture contents for the cover are consistent with moisture contents measured in local undisturbed soil samples. The NRC staff concludes, however, that in-situ moisture contents of surrounding soils may not be representative of moisture contents in disturbed, compacted earthen covers during the term of stabilization. This information is, therefore, inadequate to predict moisture infiltration into the cover and tailings, and moisture contents of the embankment cover. The RAP should provide the hydraulic characteristics of design covers along with calculations demonstrating that moisture contents will be maintained at or above 5 to 7.5 percent.

RESPONSE:

Test pits were dug in the proposed borrow material and samples tested for their grain size, specific gravity, permeability and compaction properties. The results of these tests show that the average properties of the borrow material are a sandy silt with an average of 68 percent minus a 200 mesh sieve and 13 percent clay. The specific gravity will be 2.64 and will be compacted to 95 percent of standard Proctor. This corresponds to a density of 111.0 pcf and a moisture content of 15 percent.

Using these average properties and correlations developed by Rawls et al. (1982) and Gupta and Larson (1979) for predicting the moisture content versus bar suction (computer printout attached), the 15 bar moisture varied from 5.4 percent to 10.7 percent and the 2 bar moisture content varied from 7.6 percent to 12.3 percent. We have checked these correlations against actual data and we have found that for soils with similar properties, the Gupta and Larson correlation more closely predicts the moisture content at various bar suctions. Using this correlation, we would have predicted a long-term moisture content in excess of 10 percent. However, since we did not have any actual data, we chose the more conservative number of 5 percent in the top foot and 7.5 percent in the remaining depth of the layer.

We also feel these numbers are conservative based on the fact that the sandy silt will be placed at a moisture content of 13 percent to 15 percent and that the cover material will have a rock layer placed over it which will help the soil return moisture over the long term (PNL, Beedlow, 1984).

26. COMMENT:

Section 4.4, P. 19: The RAP states that there is no evidence of water quality degradation of the San Juan River. Sediment sampling for toxic metals and radionuclides associated with the Shiprock UMTRAP site, however, has not been performed recently because of the "limited value" of additional sampling and analysis (see Shiprock PSCR, Page 90). The data cited in the PSCR to support this conclusion were collected in November of 1960, only six years after the Navajo Mill was constructed. These sediment analyses, therefore, may have been performed before substantial degradation of river sediment had occurred. Without additional sediment composition data and analyses of these data, conclusions about contamination of river sediments at Shiprock cannot be supported.

RESPONSE:

The SHP EA, pages 101 to 112, provides water quality data for the period 1962 to 1977. These data and the work of others (USGS, GECR, EPA) show that there is no evidence of water quality degradation. Further sampling of river water or sediments would not contribute to the conclusions reached in the RAP.

27. COMMENT:

Glossary: Definitions of the terms "groundwater," "hydraulic gradient," "vadose," and "potentiometric surface" are not consistent with standard definitions. Appropriate definitions of these terms may be found in standard references such as U.S.G.S. Water Supply Paper 1988 (1972) and ASTM Special Technical Publication 746 (1981).

RESPONSE:

These definitions have been revised.

28. COMMENT:

Attachment A, Pg. 54: The perforated interval for monitoring well DM-3A/2 should extend from 25.5 feet to 29.5 feet below the ground surface. The description of this well in Table 8.1 is incorrect.

RESPONSE:

The table has been corrected.

29. COMMENT:

Bibliography, Pg. 51: The reference listing of USGS Professional Paper 521-A is incorrect. This listing should be "Cooley, M.E., Harshbarger, T.W., Akers, J. P., Hardt, W. F., and Hicks, O. N., 1969. Regional Hydrogeology of the Navajo and Hopi Indian Reservations Arizona, New Mexico, and Utah, United States Geological Survey, Professional Paper 521-A."

RESPONSE:

The reference has been corrected.

1.0 PURPOSE

To ensure that field programs for the collection of ground water quality data are conducted properly.

2.0 PROCEDURE

Field programs consist of three parts: pre-field procedures, field procedures, post-field procedures.

2.1 Pre-Field Procedures

The following steps will be taken no less than 10 days before leaving for the field.

Sample locations will be determined by the Site Hydrogeologist and approved by the Project Hydrogeologist, Site Manager, Manager of Engineering, and Contracts Manager.

The analytical laboratory will be told:

o Approximately how many samples it will be receiving.

o Approximately when it will receive them.

o The set of analytes.

o The type of bottles and preservatives it will provide (See EPA-GOO/U-79-020, Methods for Chemical Analysis of Water and Wastes, 1983), and where to send them.

Also, all equipment will be checked to ensure that it is working properly. Supplies of reagents, solutions, filters, etc., will be checked to ensure there is enough on hand.

These steps will be documented on the pre-field checklist (Attachment 1).

2.2 Field Procedures

This section consists of two parts: field measurements and sample collection.

2.2.1 Field measurements

General

All field measurements and comments will be recorded on the water quality field form (Attachment 2). All lines on the field form will be completed. If some steps were not taken or not applicable, so indicate in the appropriate space. The forms are to be completed with non-water soluble black ink, not felt tip type pens or pencils. If any procedures are not performed as prescribed, the reason must be stated on the field form.

Final field measurements are to be taken after at least three bore volumes have been pumped from the well and as close to the time of sampling as is practicable.

pH

1. Connect the probe to the meter and immerse it in a flow through cell soon after pumping has begun. This will reduce or eliminate drift.

2. Bring the standard solutions to the temperature of the water in a flow through bath. If the meter has a temperature adjustment, set it to the temperature of the water.

3. Calibrate the meter immediately before taking the measurement. The calibrating solutions must bracket the sample: either pH = 2.0 and pH = 4.0, or pH = 7.0 and pH = 4.0, or pH = 7.0 and pH = 10.0.

4. Adjust the slope as follows.

2.2.1 Field Measurements (Continued)

- Put the probe in the pH = 7.0, or the pH = 4.0 solution if the pH is less than 4.0, and adjust the reading to 7.0 or 4.0.

- o Put the probe in the other solution and adjust the reading to 2.00, 4.00, or 10.00 as appropriate.
- o Repeat the above steps until adjustment is no longer required.

5. Clean the probe and that portion of cable which will be downhole with distilled water and clean tissues.

6. Put the probe downhole or in a flow through cell. Downhole measurements are preferred. Record measurement within 5 minutes or after drift has ceased, whichever is sooner.

7. Immediately rinse and dry the probe and put it in each calibrating solution for about 30 seconds. Records the readings.

Notes:

- o During storage and between measurements, keep the probe immersed in pH = 4.0 solution.
- o Rinse the probe in distilled water and pat dry with a clean tissue completely before putting it in a calibrating solution. Rubbing the probe may cause a static charge which will disrupt measurements.
- o Keep hoses leading to the flow through bath or cell out of direct sunlight as the water can heat up quickly at low discharge rates.

Temperature

Measure temperature downhole or in a small flow through cell. Downhole measurements are preferred. Record measurements periodically throughout the time of pumping.

Notes:

- o The field thermometer must be calibrated against a lab grade thermometer. Do this before going to the field.

o If a flow through cell is used, place it close to the well head. Keep the cell and discharge hose out of direct sunlight.

Electrical Conductivity

The conductivity meter will be calibrated with at least three standard solutions, the extremes of which bracket the samples. This will be done at least three times during the field program: before sampling, after the first day of sampling, after sampling is completed. If there are significant differences between the first two calibrations, the meter must be calibrated each sampling day. A record of each calibration will be kept and the temperature of each calibrating solution will be recorded.

1. Clean probe and cable with distilled water and clean tissues.

2. Measure conductivity downhole or in a flow through cell. Downhole measurements are preferred. Record conductivity periodically throughout the time of pumping. Record the position of each setting on the meter.

Notes:

o Rinse the probe in distilled water and dry it completely before putting it in a calibration solution.

o Most conductivity probes produce an electrical field which may be disturbed if the probe is near a solid object. Therefore, keep the probe at least 2 inches away from cell walls when making measurements in flow through cells. Keep lead weights at least 6 inches above the probe. This does not apply to the martek x probe.

Alkalinity

Digital Titration

1. Eject a few drops of titrant from the tip of the titrator and wipe the tip with a clean tissue. Re-set the counter to 0000.

2. Bring the temperature of the pH = 4.0 standard solution to the temperature of the sample in a flow through bath. Calibrate the meter just before taking the measurement.

3. Rinse the titration flask and graduated cylinder in sample water. Remove droplets of water from the flask by shaking it vigorously.

4. Measure 100 ml of unfiltered sample in the graduated cylinder and pour it into the flask.

5. Rinse and dry the pH probe and put it into the flask. Titrate the sample until the pH reaches 4.5. Record the alkalinity and the lot number of the titrant.

Notes:

- o The sample alkalinity may begin changing once it is brought into contact with the atmosphere. Therefore, do not allow the sample to stand before taking the measurement.
- o Swirl the flask while titrating and keep the tip of the titrator immersed in the sample.
- o Watch the pH meter closely, as the drop in pH to 4.5 or below is usually sudden.
- o Titrate with the 1.6 N sulfuric acid first. If the alkalinity is less than 30 mg/l as $CaCO_3$, measure alkalinity using 0.16 N sulfuric acid.

Buret Titration

To be added.

Eh

To be added.

2.2.2 Sample Collection

General

To prevent cross-contamination, sample wells which are unlikely to be contaminated before

2.2.2 Sample Collection (Continued)

those which may be contaminated. When sampling domestic wells, ask for information regarding depth, completion interval, use, diameter, etc. Take water from domestic wells as close to the well head as is practicable and downhole if possible. Do not take samples downstream of any device which alters water quality, such as water softeners. Put location of domestic wells on a map.

Samples are to be taken after at least three bore volumes have been pumped from the well. Make a note of any odors, colors, etc., that are noticed during pumping.

1. Drain pump hoses to ensure all old sample water is expelled.

2. Pump approximately 2 L of distilled water through the hoses. Continue pumping until all distilled water is expelled.

3. Clean outside of hoses with distilled water and tissues before putting them down the hole. Set the intakes approximately 1 foot above the top of the screened interval.

4. Disassemble the filter apparatus and discard the old filter. Thoroughly rinse all surfaces which come in contact with the sample in distilled water.

5. With clean hands, install a new filter, touching it only along its perimeter. Allow no dirt or dust to blow onto the cleaned apparatus or filter. Re-assemble the apparatus.

6. Before taking any samples, run a few hundred ml of sample water through the filter.

7. Fill the sample bottles. Allow no dirt or dust to blow into bottles or bottle caps.

8. Add appropriate preservatives immediately after filling bottles. Note the amount and type.

2.2.2 Sample Collection (Continued)

9. Rinse inside of bottle caps with filtered water and screw onto bottle. Shake the bottle to mix the preservative.

10. Pour a few drops of acidified samples onto litmus paper to check the pH. If the pH is too high, add acid as appropriate and note the amount added.

10. Rinse inside of bottle caps with filtered sample and screw caps on tightly. Seal bottles with electrical tape or parafilm.

Notes:

- While filling, and once the sample is in the bottle, do not allow it to touch anything but the bottle walls. Never stick anything into the sample.
- Do not smoke near open sample bottles.
- Keep samples out of direct sunlight.
- If the filter becomes clogged, replace it as above, repeating steps 4 through 6. Do not clean it, back flush it, etc.

Labeling and Transport

1. If bottles are unlabeled, label them with masking tape, wrapping the tape completely around the bottle. Include the following information: sample I.D., sample type, type and amount of preservative added, date and time sample taken, approximate electrical conductivity.

2. Immediately put the samples into an insulated container with ice or "blue ice."

3. Put the address and telephone number of the UMTRA Project Office and the name of a contact in the insulated container.

4. Tape the container with strapping tape for shipping. Ship the samples so they arrive at the lab no later than 36 hours after they were taken. Tell the lab when they will be arriving.

2.2.2 Sample Collection (Continued)

5. Schedule sampling so that samples do not arrive at the lab after 4 p.m. on a Friday or on a Saturday or Sunday.

Split Samples

1. Thoroughly rinse the split jug with about 1 gallon of distilled water. Drain through both the inlet and outlet tubes.

2. Pump approximately 10 L of filtered sample water into the split jug. Rinse thoroughly and drain through both the inlet and outlet tubes.

3. Pump more than enough filtered water into the split jug to fill both sample sets. Swirl the jug to thoroughly mix the water.

4. Dispense sample types consecutively. That is, fill one lab's anion bottle immediately after the other's, one lab's metals bottle immediately after the other's, etc.

2.3 Post Field

1. Clean field equipment.

2. Replace expended items, filters, reagents, etc.

3. Report and repair broken equipment.

4. Examine electrical conductivity and temperature calibrations. Adjust data as indicated and note on field forms.

5. Make copies of field forms and give the originals to Document Control. Give final field values to data base administrator for inclusion in technical data base.

Prepared By: George Rice

Approved By: D K Lewis

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

GROUND WATER SAMPLING RECORD

SITE ID: ______________________

LOCATION ID: ______________________

SAMPLE ID: ______________________

STATIC WATER LEVEL (FT) ________

SAMPLE DEPTH (FT) ______________

SAMPLING DATE ______________

SAMPLING TIME:

START ______________

COMPLETE ______________

FINAL FIELD VALUES:

	SURFACE	DOWN HOLE
pH (S.U.):		
Ec (μmhos/cm)		
Eh (millivolts)		
TEMP. (°C):		
ALKALINITY (mg/l $CaCO_3$):		

LOCATION DESCRIPTION ______________________

DATE	TIME	TOTAL VOLUME WITHDRAWN (Gals)	TOTAL VOLUME WITHDRAWN (Bore Volumes)	pH (S.U.)	Ec (μmhos/cm)	TEMP. (°C)	COMMENTS
		0.0	0.0	–	–	–	START PUMPING

	CONTAINER SIZE	NONACIDIFIED (no.)	ACIDIFIED (no.)	VOL. ACID (ml)
NUMBER OF CONTAINERS COLLECTED:	ONE-LITER			
	150 ml			
	50 ml			
SPECIFY OTHERS:				

COMMENTS: ______________________

FIELD REP (S): ______________________

GROUNDWATER SAMPLING RECORD

BORE VOL CALCULATION $(d/2)^2\pi(h_1-h_2)$	SAMPLING INFORMATION

DEPTH TO WATER (h_2) (FT.) ________ WITHDRAWAL METHOD ________

DEPTH OF WELL (h_1) (FT.) ________ SAMPLING METHOD ________

WELL DIA (FT.) ________ FILTER SIZE ________

BORE VOL. $(FT.)^3$ ________ THERMOMETER ID ________

DEPTH TO SCREEN (FT.) ________ Ec/pH/Eh METER ID's ________

CALIBRATION INFORMATION

DATE/TIME OF LAST Ec CALIBRATION ________

TIME OF pH CALIBRATION ________

pH AFTER MEASUREMENT ________ FOR STANDARD pH ________

pH AFTER MEASUREMENT ________ FOR STANDARD SOLUTION pH ________

Eh OF CALIBRATING SOLUTION ________

Eh READING IN CALIBRATING SOLN. AFTER MEASUREMENT ________

TEMP. OF CALIBRATION SOLN. (°C) ________

SHIPPING INFORMATION

LAB(S) SHIPPED TO: ________ ________ ________

DATE(S) SHIPPED: ________ ________ ________

METHOD OF SHIPMENT: ________ ________ ________

NOTES:

EQUIPMENT CHECKLIST

(Fill out all blanks prior to leaving for field)

pH BUFFER	Yes	No	Comments
sufficient volume 4	______	______	
sufficient volume 7	______	______	
sufficient volume 10	______	______	
vials for buffers	______	______	

REAGENTS & BOTTLES

Litmus paper	______	______	
Nitric acid (pres.)	______	______	
Sulfuric acid (pres.)	______	______	
not required ______*			
Other reagents*	______	______	
not required ______			

Required sample bottles:

No. of samples ____

× 1 TDS samples (sm) ______
× 1 anion sample (sm/lg) ______
× 1 metal sample (sm/lg) ______
× ___ radio. samples (lg) ______
× extras*: small ____ large ____
contingency: small ____ large ____
TOTAL: small _____ large _____

	Yes	No	Comments
Sufficient bottles	______	______	
ck pipette (for TDS)			
intact ____ broken ____			
rubber bulb present	______	______	
Alkalinity kit			
ck reagent volumes	______		
ck glass for breakage	______		

pH METER(s)	Mertek	Ecologic	Comments
ck electrode:			
full of fluid	______	______	
glass intact	______	______	
ck by immersing in tap water	______	______	

*if required, must explain under Comments

EQUIPMENT CHECKLIST (Continued)
(Fill out all blanks prior to leaving for field)

---

pH METER (cont'd)	Martek	Ecologic	Comments
ck calibrate it	______	______	
rinse, fill, replace cap	______	______	
Temp probe: ck in			
tap water	______°C	______°C	
hot water	______°C	______°C	

Ec METER — Comments

ck battery — ok ______ dead ______

ck in tap water — ok ______ faulty ___

ck against calibration solution

calibration solution	______	______
solution temp	______	______
conductivity of solution	______	______

Eh meter ______
Zobell solution ______
calibrate ______

HAND-HELD THERMOMETER

temp ice water ______
temp versus lab thermometer ______

OTHER EQUIPMENT — Comments

squeeze bottle ______

acid dispensette ______

deionized H_2O
quantity _____ gallons

distilled H_2O _____ gallons

sampling container ______

water level sounder ______ battery check _____
hand tape ______
steel tape ______
blue chalk ______
cloth towels or wipes ______________

EQUIPMENT CHECKLIST (Continued)
(Fill out all blanks prior to leaving for field)

FIELD FORMS AND MISCELLANEOUS EQUIPMENT:

Expected no. of samples ____ No. of forms ____

Clipboard with cover ____ Sample ticket book ____

Maps ____ marked with well locations ____

well information (completion, depth, etc.) ____

Field instruction book ____

Key(s) to well(s) ____ To be picked up at ____________________

Large clean bottles (3-5 gal.) _____

Large clean pails (3-5 gal.) _____

WD-40 (for locks) ________ transparent tape ________

Marking pen ________ Strapping tape (nylon) ________

Coolers ________ Blue ice ________

Shipping address of lab(s):

______________________ ______________________

______________________ ______________________

______________________ ______________________

______________________ ______________________

Phone numbers and contact:

______________________ ______________________

______________________ ______________________

PUMPS AND FILTERS

Gas Pump

Pump:

last date used ________ Battery check ________

unit working ok ________ Power cord ________

EQUIPMENT CHECKLIST (Concluded)
(Fill out all blanks prior to leaving for field)

PUMPS AND FILTERS (continued)

logic unit ________ logic unit cord ________
regulator ________ wrenches ________

Hoses

condition ________ air hose ________
length ________

Peristaltic Pump

battery cable ________ Rechargeable battery ________

2 pump heads ________ Battery charges ________

clean? yes _____ no _____

tubing ________ length ________

Filter system:

pump nipple ________ Filter unit legs ________

Inspect filter housing for cracks ________

Number of filters ________ Filter size ________

EPA-600 4-79-020

METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES

March 1983
Second Printing June 1982

ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

INPUT INFORMATION:

SITE ID =SHIPROCK
SAMPLE ID =BORROW MATERIAL

% SAND = 31.5
% SILT = 65.3
% CLAY = 13.2
% ORGANICS = 0

DRY DENSITY = 111
SPECIFIC GRAVITY = 2.64

PRECIPITATION = 7 INCHES
LAKE EVAPORATION = 60 INCHES

OUTPUT INFORMATION:

15. BAR MOISTURE CONTENT BY RAWLS ET AL. = 5.44 %

10. BAR MOISTURE CONTENT BY RAWLS ET AL. = 5.90 %

7. BAR MOISTURE CONTENT BY RAWLS ET AL. = 6.26 %

4. BAR MOISTURE CONTENT BY RAWLS ET AL. = 6.76 %

2. BAR MOISTURE CONTENT BY RAWLS ET AL. = 7.62 %

1. BAR MOISTURE CONTENT BY RAWLS ET AL. = 8.67 %

---

15. BAR MOISTURE CONTENT BY GUPTA & LARSON = 10.66 %

10. BAR MOISTURE CONTENT BY GUPTA & LARSON = 10.95 %

7. BAR MOISTURE CONTENT BY GUPTA & LARSON = 11.25 %

4. BAR MOISTURE CONTENT BY GUPTA & LARSON = 11.22 %

2. BAR MOISTURE CONTENT BY GUPTA & LARSON = 12.30 %

1. BAR MOISTURE CONTENT BY GUPTA & LARSON = 12.82 %

---

15 BAR MOISTURE CONTENT BY BAUMER & BRASHER

FOR KAOLIN DOMINATED = 4.64 %
FOR MONTMORILONITE DOMINATED = 4.65 %

LONG TERM MOISTURE CONTENT BY ROGERS = 8.07 %

WESTON
DESIGNERS CONSULTANTS

BY AH DATE 11-1-84 DIV ______ SHEET ______ OF ______
CHKD BY ______ DATE ______ DEPT ______ W.O. NO. ______
PROJECT Shiprock
SUBJECT Borrow material properties

Kradon	Hole	Depth	PI	% -200	% -2μ	γ_d max	w_{opt} %	G_s	$w_{as\ rec.}$ %
	1	0-2½	NP	24	7			2.50	5.6
	1	7-12	NP	5	3			2.72	—
2.5x10⁻⁸ (Tuff)	2	2-7½	2	73	9	114.6	13.6	2.65	5.5
	2	9½-11.0	NP	29	9			2.71	2.3
2x10⁻⁷ (contact wash)	3	7-11	NP	40	10	118.8	12.7	2.80	3.0
	3	11-15	2	75	15	117.7	12.1	2.48	5.3
	4	1-10	2	86	19	116.0	13.7	2.62	5.4
	5	5-13	NP	15	3			2.68	—
2x10⁻⁹	8	0-4 (mancos)	11	23	5	121.3	12.8	2.82	4.1

63.5 Avg 13.2
Excluding mancos 116.8 12.9

Avg Properties of Fill to be used for Radon Barrier

% sand 31.5
% silt 55.3
% clay 13.2
G_s 2.64
γ_d 111.0

Moisture Content during Placement ≥ 15%

RFW 338-5-81

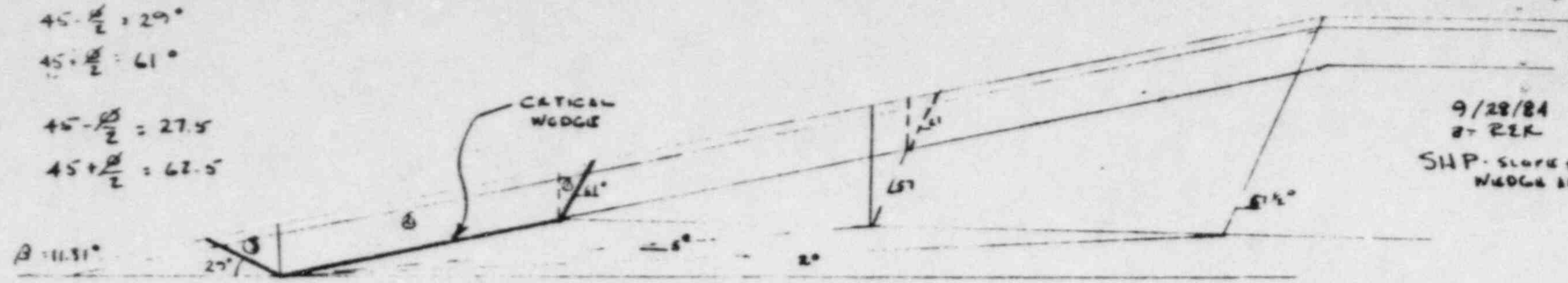
COVER $\phi = 32°$ $45 - \frac{\phi}{2} = 29°$

$45 + \frac{\phi}{2} = 61°$

ARMOR $\phi\ 35°$ $45 - \frac{\phi}{2} = 27.5$

$45 + \frac{\phi}{2} = 62.5$

9/28/84
BY RZK
SHP - SLOPE STABIL WEDGE ANAL.



Case I

Wedge 1

$W = 6 \times 2 \times 120 + 7 \times 5 \times \frac{1}{2} \times 127 = 3662.5^{\#}$

$$P_a = 3662.5 \left[\frac{\tan 61° - \frac{\tan 32}{F_s}}{1 + \frac{\tan 61°}{F_s} \cdot \tan 32} \right] = \frac{6607.3 - \frac{2288.6}{F_s}}{1 + \frac{1.127}{F_s}} = \frac{6607.3 F_s - 2288.6}{F_s + 1.127}$$

Wedge 2

$W = 2 \times 52 \times 120 + 7 \times 52 \times 127 = 58,708^{\#}$

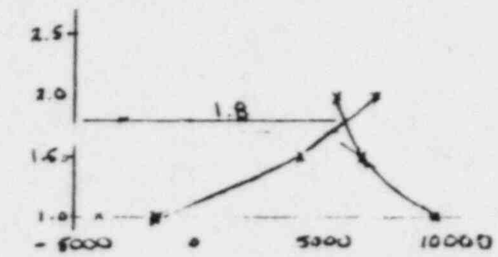
$$P_a = 58,708 \left[\frac{\tan 11.31 - \frac{\tan 15}{F_s}}{1 + \frac{\tan 15}{F_s} \tan 11.31} \right] = \frac{11,741.7 F_s - 15730.8}{F_s + .054}$$

Wedge 3

$W = 120 \times 2 \times 4.2 + 12 \times 6.5 \left(\frac{1}{2}\right) 127 = 5433$

$$P_B = 5433 \left[\frac{\tan 29 + \frac{\tan 32}{F_s}}{1 - \tan 29 \left(\frac{\tan 32}{F_s}\right)} \right] = \frac{3011.6 F_s + 3394.7}{F_s - .3464}$$

F_s	P_{a_1}	P_{a_2}	ΣP_a	P_B
1.0	2036.2	-3784.8	-1748.6	9856.2
2.0	3510.6	3774.6	7285.2	6708
3.0	[illegible]	[illegible]	[illegible]	[illegible]
4.0	[illegible]	7318.3	11497.4	4226.3
1.5	2908.2	1210.9	4119.1	6880.2



JE JACOBS ENGINEERING

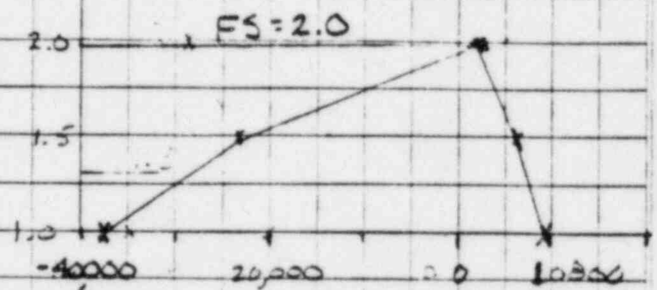
DATE 9/28/84 SUBJECT SHP Slope Stability SHEET NO. 20=5

BY ZEL CHKD. ______ Wedge Anal JOB NO. ______

Case II

Wedge 1

$$P_a = \frac{6607.3\,F_s - 2288.6}{F_s + 1.1821}$$



Wedge 2

$$W = 2 \times 6 \times 120 + 6 \times 7 \times 127 + 13 \times 6 \times \tfrac{1}{2} \times 113 = 11{,}181.0$$

$$P_a = 11{,}181 \; \frac{\tan 57.5 - \frac{\tan 25}{F_s}}{1 + \frac{\tan 57.5 (\tan 25)}{F_s}} = \frac{17550.6 F_s - 5213.8}{F_s + 0.73}$$

Wedge 3

$$W = 109 \times 2 \times 120 + 109 \times 7 \times 127 + 116.5 \times 22 \times \tfrac{1}{2} \times 113$$
$$= 267{,}870.5$$

$$P_a = 267{,}870.5 \left[\frac{\tan 15^\circ - \frac{\tan 15}{F_s}}{1 + \frac{\tan 5 \,\tan 15}{F_s}} \right] = \frac{23{,}435.6\,F_s - 71{,}775.7}{F_s + .023}$$

Wedge 4

$$P_\beta = \frac{3011.6 F_s + 3394.9}{F_s - .3464}$$

F_s	P_{a_1}	P_{a_2}	P_{a_3}	ΣP_a	P_β
1.0	2036	7131	-47253	-38086	9856
2.0	3502	10948	-12310.7	-2139.3	1590
1.5	2909	9467.3	-35799	-23423	6880

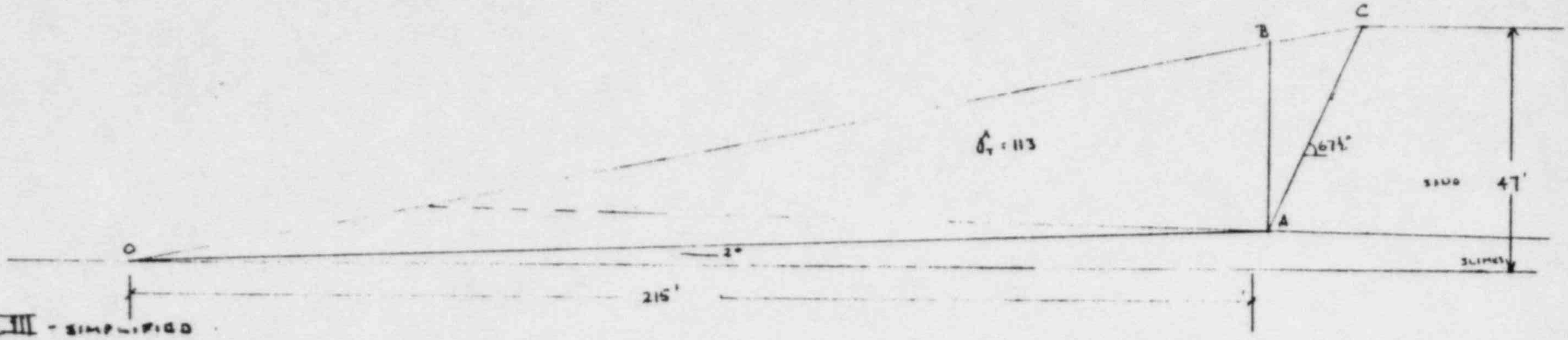
FORM 91-005-1 (4/81)

9/28/84
by ZEL
SHP Slope Stability
Wedge Anal
3 of 5

$45 + \phi/2 = 45 + \frac{23}{2} = 67\frac{1}{2}°$

INFINITE SLOPE FAILURE IN SLIMES $FS = \frac{\tan \phi}{\tan \beta} = \frac{\tan 15°}{\tan 11°} = 1.34$

HOWEVER, UNREALISTIC



Case III - simplified

Weights of wedges:

$W_{OBA} = 113(\frac{1}{2})215(47) = 570{,}932.5^{\#}$

$W_{ABC} = 113(\frac{1}{2})18(40) = 40{,}680^{\#}$

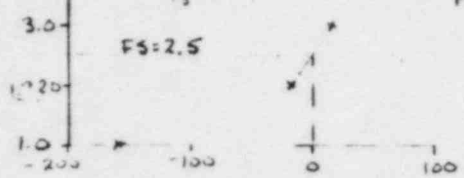
$P_a = (40{,}680)\left[\frac{\tan 67.5 - \frac{\tan 25}{F_s}}{1 + \tan 67.5\left(\frac{\tan 25}{F_s}\right)}\right] = 40680\left[\frac{1.57 - \frac{0.47}{F_s}}{1 + 1.57\left(\frac{0.47}{F_s}\right)}\right] = 40680\,\frac{1.57 - \frac{.47}{F_s}}{1 + \frac{.7378}{F_s}} = \frac{63{,}855 - \frac{19{,}119.6}{F_s}}{1 + \frac{.7378}{F_s}}$

$= \frac{63{,}855 F_s - 19{,}119.6}{F_s + .7378}$

46124
$-30{,}062$

$P_p = 570{,}932\left[\frac{\tan 2° - \frac{\tan 15}{F_s}}{1 + \tan 2°\left(\frac{\tan 15}{F_s}\right)}\right] = 570932\left[\frac{.0349 - \frac{.2679}{F_s}}{1 + .0349\left(\frac{.2679}{F_s}\right)}\right] = \frac{19925.5 - \frac{152{,}952.7}{F_s}}{1 + \frac{.0093}{F_s}} = \frac{19{,}925.5 F_s - 152{,}952.7}{F_s + .0093}$

F_s	ΣP_a
1.0	-157,544
2.0	-16,626
3.0	+151617



VARY PARAMETERS OF SLIMES FOR THE CRITICAL FAILURE SURFACE (CASE I)

WEDGE 1 ... UNCHANGED

WEDGE 3 ... UNCHANGED

WEDGE 2 ... FOR $\phi = 10°$

$$P_a = \frac{11{,}741.7F_s - (.66)15730.8}{F_s + (.66).054}$$

F_s	P_{a_1}	P_{a_2}	ΣP_a	F_β
1.0	2036.2	1313	3448.8	9856.2
1.2	2431.1	3000.6	5431.7	8245.7
1.4	2762.6	4218.4	6981.0	7248.7

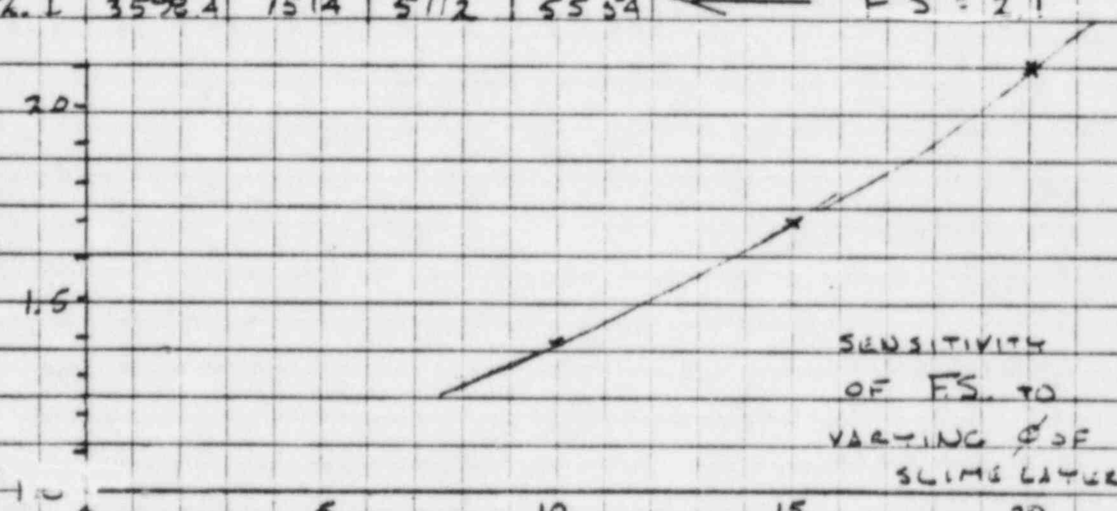
⟸ FS = 1.4

WEDGE 2 FOR $\phi = 20°$ MULT BY 1.36

F_s	P_{a_1}	P_{a_2}	ΣP_a	F_β
2.0	3510.8	-1039.1	4550	5708
1.8	3289.2	-124.3	3165	6080
2.1	3598.4	1514	5112	5554

⟸ FS = 2.1

F.S



ϕ OF SLIMES

BY IGNORING THE ACTIVE AND PASSIVE WEDGES THE FAILURE OF THE WEDGE BECOMES AN INFINITE SLOPE FAILURE WITH A F.S. = 1.3. USING THIS CONSERVATIVE APPROACH THE DYNAMIC STABILITY OF THE SLOPE CAN BE CHECKED USING A SLIDING BLOCK APPROACH (LAMBE AND WHITMAN, 1969). THIS APPROACH COMPARES ACCELERATIONS OF THE SEISMIC EVENT TO THAT REQUIRED TO MAKE THE BLOCK SLIDE AS FOLLOWS:

$A' = \cos\theta \tan\phi + \sin\theta$ WHERE $\theta = \tan^{-1}\frac{1}{2} = 11.3°$

$\phi = 15°$

$A' = .46$

$A = .13 < .46$ ∴ NO DISPLACEMENT WILL OCCUR

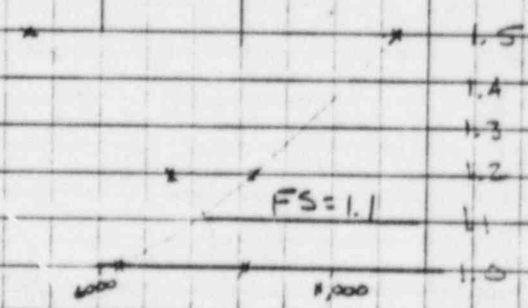
TRY A MORE DETAILED APPROACH - USE NAVFAC DM7 METHOD & APPLY A HORIZONTAL FORCE DOWN SLOPE DIRECTION EQUAL TO $W \times .13(g)$. IE $P_\alpha + W \times .13$ & $P_\beta + W \times .13$

FOR CASE 1 $W_1 \times .13 = 3662.5(.13) = 476^\#$

$W_2 \times .13 = 58708(.13) = 7632^\#$

$W_3 \times .13 = 5433(.13) = 706^\#$

FS	P_α	P_{α_2}	ΣP_α	P_β
1.0	2512	3847	6359	9150
1.5	3384	8842	12,226	3520
1.2	2928	6319	9247	7540



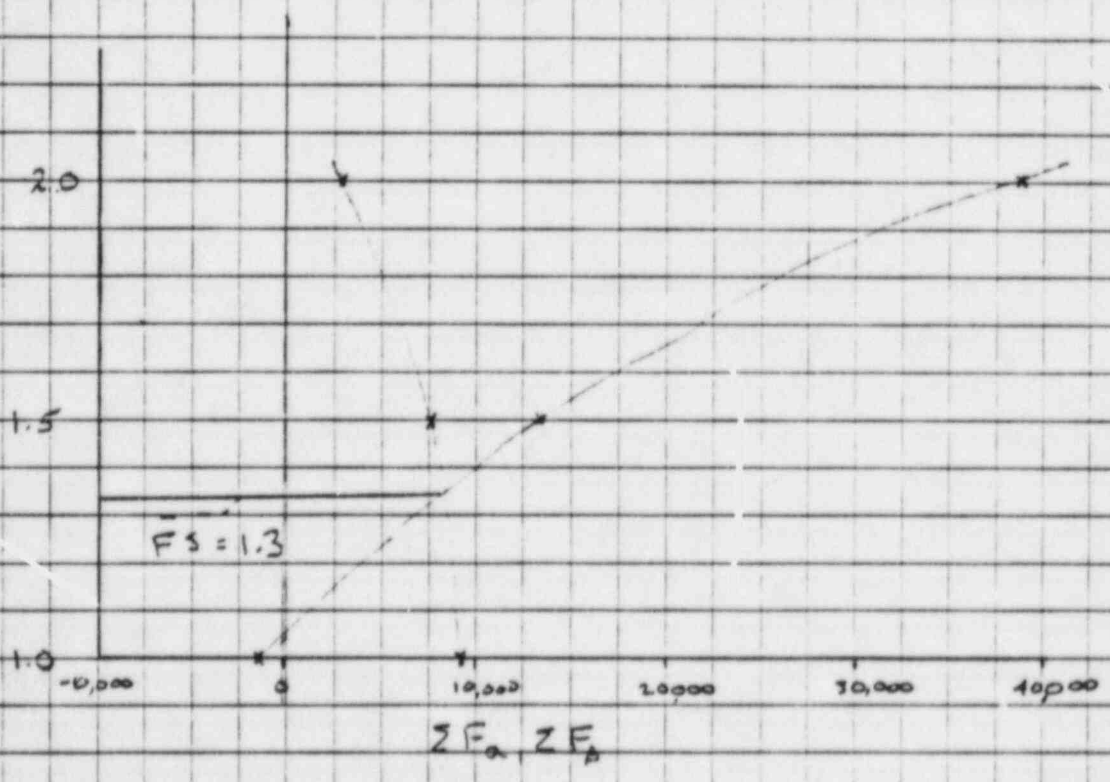
JE JACOBS ENGINEERING

DATE 9/28/84 SUBJECT SHP Slope Stability Wedge Anal SHEET NO. 5 of 5
BY RSL CHKD. JOB NO.

CASE II

$W_1 \times .13 = 476$
$W_2 \times .13 = 1454$
$W_3 \times .13 = 34,823$
$W_4 \times .13 = 706$

F.S.	F_a	Pa_2	P_{a_3}	ΣF_a	F_p
1.0	2512	8585	-12430	-1333	9150
1.5	3384	10,921	+976	13,329	7586
2.0	3978	12,402	22,512	38,892	2296



∴ MIN FS = 1.1 INCREASING WITH DEPTH OF ASSUMED FAILURE PLANE.

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JACOBS ENGINEERING

DATE 10/2/84 SUBJECT SWP Slope Stability EOC. SHEET NO. 1 of 3

BY JER CHKD. JOB NO. [illegible]

Case I with slimes using $\phi = 0$ concept

Wedge 1 . . . same as c = 0 & ϕ case

Wedge 2 . . .

$$P_a = W \tan \alpha - \frac{cL}{\cos \alpha}$$

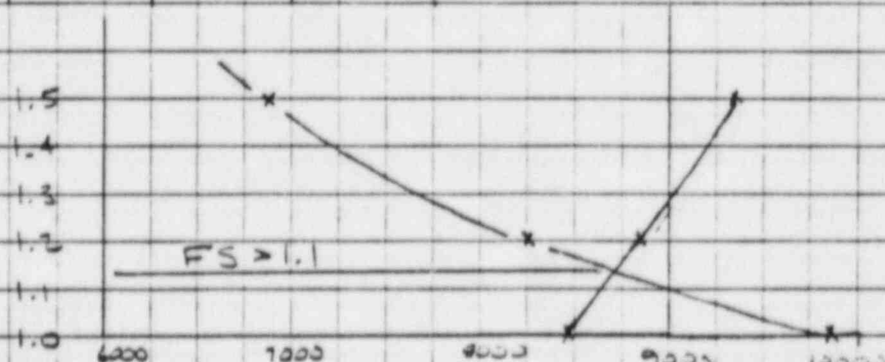
$$58{,}708 \tan 11.31 - \frac{(c)\,52}{\cos 11.31\,(F_s)}$$

$$P_a = 11{,}742 - 53(c)$$

Wedge 3 . . . same as c = 0 & ϕ case

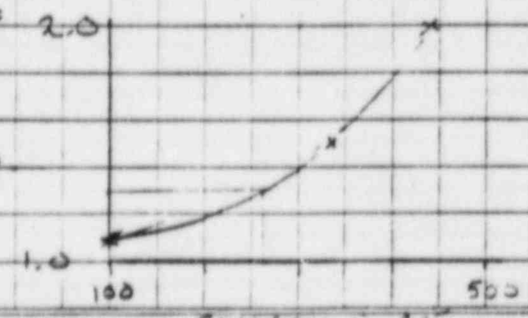
Try c = 100 psf

F_s	P_{a_1}	P_{a_2}	ΣP_a	P_B
1.0	2036	6420	8456	9356
1.5	2908	6420	9328	6930
1.2	2452	6420	8872	8246



For FS = 1.5 c = 332 psf

For FS = 2.0 c = 443 psf



Cohesion, psf

JE JACOBS ENGINEERING

DATE 10/2/94 SUBJECT SHP Slope Stability SHEET NO. 2 of 3
BY TSY CHKD. ______ E.O.C. JOB NO. 74-2703

Case II w/o cover

9233 Fs = 2743

Fs = .73

Wedge 2 ... same as c=0, ϕ concept reduced by ratio of weights

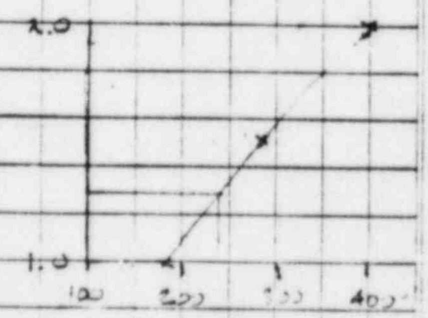
Wedge 3 ...

$$P_a = 176,311 \tan 5° - \frac{c(106)}{\cos 5° \, F_s}$$

$$= 15,425 - \frac{106(c)}{F_s}$$

Setting $P_{a_2} + P_{a_3} = 0$

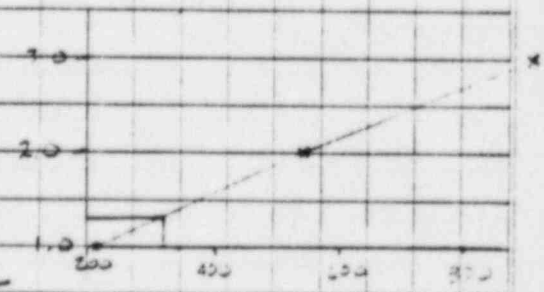
FS	P_{a_2}	c
1.0	3750	181
1.5	4979	288
2.0	5,757	400



Note: Values conservative: ignores strength of cover but includes weight of cover in analysis.

Case III $P_a = 570,933 \tan 2° - \frac{c(217)}{\cos 2° \, F_s} = 19,937 - \frac{217c}{F_s}$

F_s	P_a	c
1.0	25,710	210
2.0	39,651	549
3.0	46,108	913



For FS = 1.3

Case	c
I	260
II	240
III	325 ⇐ Maximum

∴ The analysis indicates that strength values in the slimes of $\phi = 0$ c = 325 are required for end of construction factor of safety equal to 1.3

FORM 91-006-1 (4/81)

JE JACOBS ENGINEERING

DATE 10/2/84 SUBJECT SHP SLOPE STABILITY E.O.C. SHEET NO. 3 of 3

BY TEK CHKD. JOB NO. 34-6703

COMPARING THE REQUIRED COHESION TO BLOW COUNTS:

THE MINIMUM BLOW COUNT IN THE SLIMES LAYERS IS 4 WHICH CORRESPONDS TO 1000 PSF UNCONFINED COMPRESSIVE STRENGTH (TERZAGHI AND PECK, 1967)

1000 > 325 ∴ THERE IS NO PROBLEM FOR THE END OF CONSTRUCTION CONDITIONS.

FORM 91-008-1 (4/81)