Recd 2/22/94

Department of Energy
Albuquerque Field Office
P.O. Box 5400
Albuquerque, New Mexico 87185-5400

FEB 10 1994

Mr. Joseph J. Holonich, Acting Chief
Uranium Recovery Branch
Division of Low-Level Waste
Management and Decommissioning
Office of Nuclear Materials Safety
and Safeguards
Mail Stop 5E-4 OWFN
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Hague

Dear Mr. Holonich:

Please find enclosed three (3) copies each of Project Interface Documents (PID), 09-S-20, and 09-S-21 for the Mexican Hat, Utah, Uranium Mill Tailings disposal cell design. These PID's address design changes relating to erosion protection and bedding gradations respectively.

Should you or your staff have any questions, please call Russel Edge at (505) 845-6130.

Sincerely,

Albert R. Chernoff
Project Manager
Uranium Mill Tailings Remedial Action
Project Office

Enclosures

cc w/out enclosures:
C. Smythe, UMTRA
D. Bierley, TAC

1/2

WM-63
NL04

280083

9403040355 940210
PDR WASTE
WM-63 PDR

delete: LA

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION

UMTRA PROJECT

PROJECT INTERFACE DOCUMENT (PID)

Site HAT/MON	Date 01/18/94	PID No. 09-S-21	Site No. 09	Vic. Prop. No.
Originator and Location R. F. Claire, SF	Phone 415/442-7596	Organization MKES	Answer By:	References: Subcontract: Subcontract No:

Subject Bedding Material Gradation

Description of Problem and Recommended Solution
☐ Clarification ☒ Change

PROBLEM:
A lot of wastage occurs when processing the bedding material at the Bluff gravel source to meet the specified gradations, specifically for the material finer than No. 4 sieve. Placement of bedding material would also be facilitated and a better surface obtained if the material contained more fine sand. ~~(No. 4 sieve)~~ RD There will be less wastage and better production if the gradation limits were modified to increase the amount of fine sand.

SOLUTION:
Ammend the gradation requirements for the bedding material as follows: change percentage passing the No. 4 sieve from "15 - 30" passing to "10 - 30" passing. In addition, change percentage passing the No. 30 sieve from "0 - 5"

[Continued on the following sheet]

Originator: Robert F. Claire (Signature) 1-18-94 (Date)

Disposition ☐ Approved ☐ Disapproved ☒ Approved as Noted

Criteria Change? ☒ Yes ☐ No
(If Yes, DOE approval required)

RAC Site Manager: Robert D'Arezzo 1-21-94
RAC Project Control: William W. Johnson 1-21-94
RAC Engineering/Design: [signature] 1-18-94
RAC Construction Engineer: [signature] Spencer 1-21-94
Review for Quality Requirements: [signature] 01/21/94
Signature / Date

Class I

Russel Edge 2/16/94
DOE Site Manager Approval / Date

Distribution	Name	Location		Name	Location
RAC Site Mgr.			RAC Const. Engr. Mgr.		
DOE Proj. Engr.			RAC Qual. Mgr.		
TAC Site Mgr.			Other		
RAC Site Qual. Engr.					
RAC HS&E Mgr.					

Cost/Time Est.
☐ Attached
☐ Not Required
☐ DOE Approval Req.

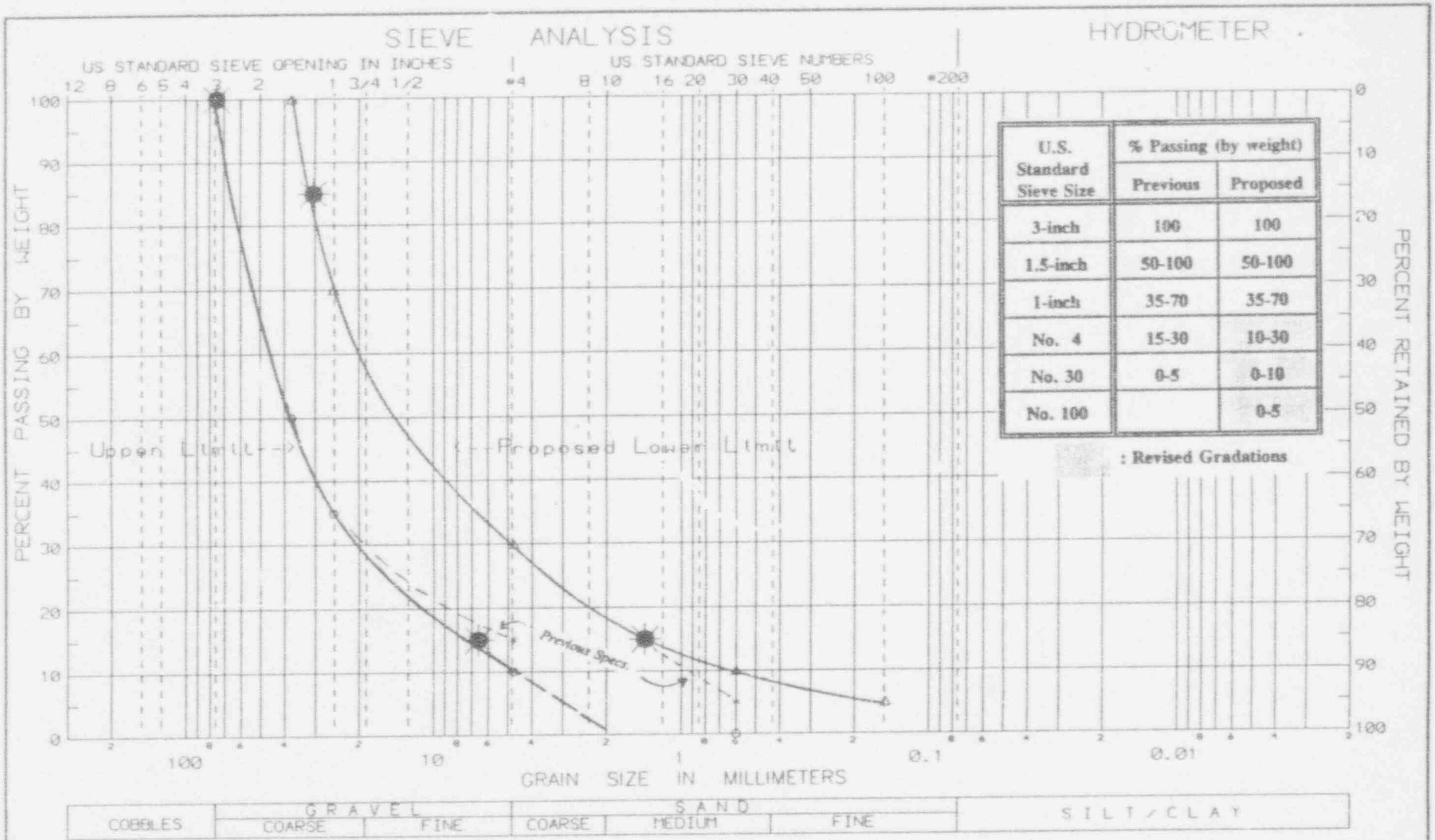
SOLUTION: (Cont'd)

passing to "0 - 10" passing. In addition, a new sieve size, 5% passing the No. 100 sieve, should be added to the requirements to ensure that less than 5% passes the No. 200 sieve.

The proposed changes comply with the calculated gradation limits (see Attached Figure 1).

In Specification Section 02278, Article 2.4.B.2, the gradation specified for the bedding material will be revised to read as follows:

"U.S. Standard Sieve Size (Square Openings)	Percent Passing (by weight)
3-inch	100
1-1/2-inch	50 - 100
1-inch	35 - 70
No. 4	10 - 30
No. 30	0 - 10
No. 100	0 - 5"



U.S. Standard Sieve Size	% Passing (by weight)	
	Previous	Proposed
3-inch	100	100
1.5-inch	50-100	50-100
1-inch	35-70	35-70
No. 4	15-30	10-30
No. 30	0-5	0-10
No. 100		0-5

LEGENDS:

- GRAIN SIZES CRITERIA
- △ Proposed Lower Limit
- ○ Proposed Upper Limit
- + Previous Specs.

NOTES:

FIGURE 1

MK-ENVIRONMENTAL SERVICES

Project: UMTRA-H/M Contract NO. 3885-58
Feature: Bedding Materials Gradation Limits
Item: Revised per PID 21

Designed: JCK Date: 1-13-94

Checked: Date:

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION

UMTRA PROJECT

PROJECT INTERFACE DOCUMENT (PID)

Site HAT/MON	Date 12/10/93	PID No. 09-S-20	Site No. 09	Vic. Prop. No.
Originator and Location R. F. Claire, SF	Phone 415/442-7596	Organization MKES	Answer By:	References: Subcontract: Subcontract No:

Subject Revise Grading and Erosion Protection Plan for the Tailings Embankment Final Configuration and Add Requirements for Test Section and Source for Type B1 Riprap.

Description of Problem and Recommended Solution

☐ Clarification ☒ Change

PROBLEM 1:
Based on the actual quantities of contaminated materials placed to date and the estimated quantities of the remaining contaminated materials to be placed in Mexican Hat tailings embankment, the final topslope elevation of the tailings embankment upon completion is anticipated to be about 10 feet lower than the design elevation. This will require additional regrading and revision of the erosion protection along the south edge of the pile.

SOLUTION 1:
Revise final grading plan of the topslopes and the southwest sideslopes of the tailings embankment as shown on Sketch 1 and corresponding markups of Subcontract Drawings H/M-DS-10-0212 to H/M-DS-10-0214, as attached. The extent

[Continued on the following sheet]

Originator [signature] for RFC — Signature; 12-10-93 — Date

Disposition ☐ Approved ☐ Disapproved ☐ Approved as Noted

Criteria Change? ☒ Yes ☐ No
(If Yes, DOE approval required)

RAC Site Manager [signature] 12-13-93
RAC Project Control [signature] 12-13-93
RAC Engineering/Design [signature] for DRS 12-10-93
RAC Construction Engineer
Review for Quality Requirements [signature] — Signature; 12/13/93 — Date

Class I

[signature] 2/16/94
DOE Site Manager Approval — Date

Distribution	Name	Location		Name	Location
RAC Site Mgr.			RAC Const. Engr. Mgr.		
DOE Proj. Engr.			RAC Qual. Mgr.		
TAC Site Mgr.			Other		
RAC Site Qual. Engr.					
RAC HS&E Mgr.					

Cost/Time Est.

☐ Attached

☐ Not Required

☐ DOE Approval Req.

SOLUTION 1: (Cont'd)

of the Type B1 riprap to be placed and the erosion protection plan and details along the south edge of the tailings embankment shall also be revised as shown on Sketch 2 and corresponding markups of Subcontract Drawings H/M-DS-10-0213, -0215, -0216 and -0219 as attached. The calculation for the proposed erosion protection design is attached (Calculation No. 9-418-14-00).

PROBLEM 2:

The Subcontract Documents, in Specification Section 02278, Article 1.7, require that, for placement control purposes, a test section be constructed for Riprap Types A and B. A test section should also be required for Riprap Type B1.

SOLUTION 2:

In Specification Section 02278, Article 1.7, revise the first sentence to read as follows: "For placement control purposes, one test section for each of Riprap Types A, B1, and B shall be constructed."

PROBLEM 3:

The Subcontract Documents, in Specification Section 02278, Article 2.1.A, require that the Bluff Gravel Quarry is the approved source for Type A and B erosion protection and bedding materials. The Bluff Gravel Quarry should also be the approved source for Riprap Type B1.

SOLUTION 3:

In specification Section 02278, Article 2.1.A, revise the second sentence to read as follows: "The approved source for Type A, B1, and B erosion protection and bedding materials is the Bluff Gravel Quarry near Bluff, Utah, located approximately 30 miles northeast of the tailings site."

MKES Doc. No. 3885-H/M-C-01-02863-00

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES DIVISION

UMTRA PROJECT
CALCULATION COVER SHEET
CALC. NO. 9-418-13-00

Contract No. 3885-58 Discipline CIVIL No. of Sheets 56 (includes cover sheet)

Project

UMTRA - MEXICAN HAT / MONUMENT VALLEY

Feature

EROSION PROTECTION

Item

TAILINGS EMBANKMENT AND SOUTH-EDGE AREAS

Sources of Data

(see references on sheet ii)

Sources of Formulae & References

(see references on sheet ii)

Preliminary Calc. ☐ Final Calc. ☒ Supersedes Calc. No. 9-418-13-00

Checking criteria listed in the MKES UMTRA Project Procedures Manual were used during the checking of all revisions of this calculation.

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
00	-	[illegible]	11/23/93	Tang Hong Wei	12/8/93	[illegible]	12-10-93

Table of Contents

References

1. MKES Cal. No. 09-418-08-00, "UMTRA-HAT/MON, Erosion Protection, Embankment Toe Apron," August 1992.

2. MKES Cal. No. 09-418-05-01, "UMTRA-HAT/MON, Erosion Protection, Oversizing,Gradation and Thickness," Feb. 1992.

3. U.S. Department of Energy (DOE), UMTRA-DOE-AL-050425.0002, "Technical Approach Document," Rev. 11, Dec 1989, Figure 4.1, pp. 71.

4. MKES "RPRP/SFST- A Computer Program for Designing Riprap Protection for Sheet Flow using Factor of Safety or Stephenson's Method," Sept. 1987, MKES Document No. 4005-Gen-0-01-03409-00.

5. M.A. Stevens, D.B. Simons & G.L. Lewis, "Safety Factors for Riprap Protection," ASCE Journal of Hydraulics, Vol. 102, HY5, May 1976, pp. 637-655.

6. D. Stephenson,"Rockfill in Hydraulic Engineering", Elsevier Scientific Publication, N.Y., 1979.

7. MKES UMTRA Design Procedures, Chapter 5, "Erosion Protection," Rev. 7, Jan. 1989.

8. Chow, V. T., "Handbook of Applied Hydrology," McGraw-Hill Book Co. Inc., N.Y., 1964.

9. U.S. Army Corps of Engineers (COE), "Hydraulic Design of Spillways," EM1110-2-1603,March 1965, reprint with change 1.

10. Chow, V.T., "Open Channel Hydraulics," McGraw-Hill Book Co. Inc., N.Y., 1959.

11. NRC,NUREG/CR-4651, "Development of Riprap Design Criteria by Riprap Testing in Flumes, Phase I," May 1987, pp. 60.

12. MKES Cal. No. 09-223-01-02, "UMTRA-HAT/MON, Site Hydrology," May 1988.

13. MKES Cal. No. 09-418-06-00, "UMTRA-HAT/MON, Erosion Protection - Rock Quality, Bluff Source(New Areas)," June 1991.

14. MKES Cal. No. 09-418-04-00, "UMTRA-HAT/MON, Erosion Protection - Rock Quality Evaluation at Sugarloaf and Lime Ridge," May 1991.

15. MKES UMTRA-HAT/MON, "Engineering Geology Report for the Mexican Hat Site," August 1992.

16. U.S. Department of Transportation (DOT), "Hydraulic Design of Energy Dissipitators for Culverts and Channels," Hydraulic Engineering Circular No. 14, Dec. 1975.

17. Davis and Sorensen, "Handbook of Applied Hydraulics," 3rd Ed., McGraw-Hill Book Co., N.Y., 1969

1.0 Introduction and Purpose

Based on the actual quantities of contaminated materials removed at the Monument Valley processing site to date and the estimated remaining quantities, the final disposal embankment (cell) topslope elevation at UMTRA - Mexican Hat site is anticipated to be about 11 feet lower than the current design elevation . Hence the cell configuration has been changed accordingly as shown on sheet 4. This calculation is to perform the erosion protection design for this latest cell configuration. In addition, there is a concern that the approved Bluff borrow source may not have sufficient quantity of material available to meet all the project needs for riprap Type B. Therefore a new Type B1 riprap will be introduced to reduce the wastage and to optimize the volume of raw material to be processed in the Bluff source.

The scope of work in this calculation will include the following:

- Evaluate the stability of Type A (D_{50} = 1.7") riprap to be placed on the 2% cell top slopes.
- Evaluate the stability and the extent of Type B1 (D_{50} = 3.0") and Type B (D_{50} = 4.4") ripraps to be placed on the 20% or flatter embankment side slopes.
- Design the erosion protection along the south edge of the cell. Areas where Type B1, Type B, or Type C (D_{50} = 6.9") ripraps shall be placed will be determined.

The latest cell configuration is anticipated to have no or insignificant adverse effect on the following previously submitted calculations in erosion protection design:

- Calculation No. 9-418-08-00 : erosion protection design along the cell sideslope toe apron (Ref. 1).
- Calculation No. 9-418-05-01 : oversizing, gradation, and thickness for different types of erosion protection materials (Ref. 2).

2.0 Results

- 2 Percent Top Slope

The required min. D_{50} for the top slope is 0.8 inches (see sheet 12) based on the longest critical flow length of 1420 feet. Type A rock, a round river cobble from the Bluff source (Ref. 13), with a min. D_{50} of 1.7 inches (Ref. 2), will be used for the top slope. The average rock quality scores from the Bluff source is greater than 80% and no oversizing is required (Ref. 13).

- Side Slope

Both Type B1 ($D_{50(min)}$ = 3") and Type B ($D_{50(min)}$ = 4.4") rocks will be placed on the side slope. The smaller Type B1 rock with a layer thickness of 12 inches can be placed on the southern portions of the embankment side slopes which have shorter flow lengths (see sheet 4). The gradation requirements were included in Appendix B. The Type B rock should be placed on the northern parts of the embankment side slopes which have longer flow lengths (see sheet 4). Both Type B1 and Type B rocks will also come from the Bluff source, and no oversizing is required.

- South-Edge Upslope Area

1) Type B1 rock will be placed on the slope areas with a slope no steeper than 7(h):1(v) along the western portion of the south-edge upslope area (between points "A" and "B" as shown on sheet 4). A 10-foot wide transition area of about 5.3 % slope with Type B1 rock will be provided between the approximately 7:1 slope area and the 2% top slope. The layer thickness on the upstream apron of the approx. 7:1 slope area should be at least 1 foot deep to protect from local scouring when the existing haul road does not lie on the erosion resistant rock. Otherwise, the upstream portion of the approx. 7:1 rock cover shall tie-in to the erosion resistant rock of the roadway.

2) Type B rock or larger shall be placed along the upstream side of the existing haul road between points "H" and "C" to resist the impact of flow from the short steep upslope ridge (see sheet 4). This area will be graded to drain the runoff across the roadway.

3) A min. 10-foot wide apron consisting of Type B rock connecting the natural ground below the roadway and the 2 % top slope will be placed between points "B" and "C" (see sheet 4). The slope of the apron will be about 5.3 % and the apron will be 12 inches thick at the upstream end.

4) Either Type B rock on a 2.5(h):1(v) slope or Type C rock on a 2(h):1(v) slope should be provided to backfill an existing gully between points "C" and "D" (see sheet 4). The angular Type C rock shall be from the potential borrow source at Sugar Loaf quarry. The $D_{50(min)}$ of the Type C rock is 6.9 inches with a 15% oversizing factor.

5) A min. 10-foot wide apron consisting of Type B rock connecting the short steep south ridge and the 2% top slope will be placed between points "D" and "E" (see sheet 4). The slope of the apron is about 5.3 % and the apron shall be at least 12 inches thick at the upstream end.

6) The erosion protection plan and typical sections revised to incorporate the changes due to a predicted 11-foot lower embankment are shown on sheet 5.

3.0 Methods

All the riprap sizing on the upslope toe/apron area in this calculation are based on sheet flow conditions under PMP storms. Thus, measures shall be provided to assure that sheet flow conditions can be achieved for surface flow onto the embankment top slope.

3.1 Top And Side Slopes

The required min. D_{50} will be determined using the computer program "RPRP/SFST" developed by MKES (Ref. 4).

The Safety Factor method (Ref. 5) is used for the slope less than 10 % (Ref. 7), and Stephenson's Method (Ref. 6) is used for the slope greater than or equal to 10 % (Ref. 7).

- Safety Factor Method (Ref. 5)

On a plane slope, the equation is as follows:

$$D_{50} = \frac{21\tau}{\left[(G_s-1)\ \gamma_w \cos\theta \left\{\frac{1}{S.F.} - \frac{\tan\theta}{\tan\phi}\right\}\right]}$$

where:
S.F. = safety factor = 1.0 for PMP condition
ϕ = angle of repose (in degree) of rock
θ = angle of the plane slope
τ = shear stress (psf)
γ_w = 62.4 pcf
G_s = specific gravity

- Stephenson's Method (Ref. 6)

$$D_{50} = \left[\frac{q\ (\tan\theta)^{\frac{7}{6}}\ (p)^{\frac{1}{6}}}{C\ g^{\frac{1}{2}}[(1-p)\ (G_s-1)\ \cos\theta\ (\tan\phi - \tan\theta)]^{\frac{5}{3}}}\right]^{\frac{2}{3}}$$

where:
p = porosity ≐ 0.33
C = empirical factor
= 0.22 for rounded rock
= 0.27 for angular rock
other parameters are previously defined.

3.2 South-Edge Upslope Area

The critical peak PMP discharge at each different locations along the south-edge area will be estimated from the Rational Formula, Q = C I A (Ref. 8). For a sheet flow condition, the length of the slope will be used to represent the area (i.e. A = length x 1 foot strip.) The longest slope length will be chosen for the design peak discharge.

Stable rock size, D_{50}(min), on the upslope apron will be estimated by the appropriate methods such as the U.S. Army Corps of Engineer's Stilling Basin Method (Ref. 9), Stephenson's Method (Ref. 6), and the Safety Factor Method (Ref. 5). The equations and criteria are described below:

3.2.1 Flow Characteristics (Manning's and other equations)

Based on Manning's Formula and a sheet flow conditions, the flow characteristics (i.e. flow depth, flow velocity, etc ...) are computed with:

$$q = \frac{1.486}{n} y^{\frac{5}{3}} s^{\frac{1}{2}}, \quad \text{or} \quad y = \left[\frac{n\ q}{1.486\ s^{\frac{1}{2}}}\right]^{0.6} \qquad \text{(Ref. 10)}$$

$$v = \frac{q}{y}, \quad Fr = \frac{v}{\sqrt{g\ y\ \cos\theta}}, \quad \tau = \gamma_w\ y\ s \qquad \text{(Ref. 10)}$$

$n = 0.0456\ (D_{50}\ s)^{0.159}$ for slopes > 10% and D_{50} in inches (Ref.11),

or

$n = \dfrac{y^{1/6}}{(23.85 + 21.95\ \log(y/D_{50}))}$ for slopes ≤ 10% and D_{50} in feet (Ref.7)

where, q = flow per unit width (cfs/ft)
y = flow depth (ft)

v = flow velocity (fps)
s = energy slope (approximated as side slope)
n = Manning's roughness coeff.
D_{50} = Median diameter of riprap
Fr = Froude number
$\theta = \tan^{-1}(s)$ = slope angle
g = acceleration of gravity (ft/sec^2)

3.2.2 <u>Riprap Sizing for Erosion Protection</u>

The Safety Factor Method and Stephenson Method are the same as described in Sec. 3.1 above. The U.S. Army Corps of Engineers Stilling Basin Method (Ref. 9) is presented below:

$$D_{50} = \frac{v^2}{\left[E^2\ 2\ g\ (G_s - 1)(\cos\theta - \sin\theta)\right]}$$

where:
v = minimum velocity to move the D_{50} rock
(The velocity on the steeper slope will be used.)
E = Empirical constant
= 0.86 for high turbulence
= 1.20 for low turbulence
θ = slope of the apron
G_s = Specific gravity of the rock

4.0 Calculations

4.1 Top and Side Slopes

The calculations were either performed using the computer program "RPRP/SFST" (Ref. 4) or by hand computation. The various assumptions and input parameters used are presented below:

1) PMP rainfall intensity-duration regression equation (Ref. 12 and see sheet A-1) constants are:

$$I = 10^{G - H(\log T)^Z}$$

$G = 1.797$; $H = 0.307$; and $Z = 1.816$

2) Specific gravities of the rocks are 2.64 for rounded rock from Bluff source (Ref. 13) and 2.70 for angular rock from Sugar Loaf source

3) Coefficient in Stephenson's equation C = 0.22 for rounded rock and 0.27 for angular rock.

4) Factor of Safety = 1.0

5) No flow through the rock pores is considered (a conservative assumption)

6) Porosity of the rock = 0.30 (assumed)

7) Rock friction angle- estimated from sheet A-2 (Ref. 3)

The rock source for Type A, B, and B1 rocks will be from Bluff source. These rocks will consist of rounded river cobbles with rock quality scores greater than 80%. Therefore no oversizing is required (Ref. 3).

4.1.1 Top Slope

The longest/critical flow length was determined to be line T-T (at point c_1) as shown on sheet 4.

L_1 = 150' s_1 = 0.4
L_2 = 1270' s_2 = 0.02

Total $L = L_1 + L_2 = 1420'$

Based on computer output (see sheets 11 and 12) and using the round rocks, the required $D_{50(min)}$ is 0.8 inches.

Hence Type A rock is stable on the 2% top slope.

At point "c_1",

I_{PMP} = 28.3 in/hr, q = 0.92 cfs/ft,
y = 0.18', v = 4.3 fps, n = 0.026 (see sheet 13)

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HATSP8.OUT                  11/12/93                    Page 1

**INPUT FILE PRINTOUT**
              TOP SLOPE
UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP8.OUT)

HAT   FHW    11-12 1993
   1.797  .307 1.816 2.640  .220      1  .002 1.0
    2    0
    0    0
    3   25
  UPS      150.0  40.0   .30  35.0  ST
  TOP      *****   2.0   .30  37.0  FS
   .5000   1.0   .00065
   .0250   1.0   .00065

 * * * * * * * * * * * * END INPUT DATA * * * * * * * * * * * *



UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP8.OUT)

 UMTRA/HAT       RUN I.D.=FHW      DATE=11-12 1993

***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***

* * * * * * * * * * * * INPUT DATA * * * * * * * * * * * * * *

 COEFFICIENTS FOR INTENSITY DURATION CURVE -
         IPMP=10**(G-H*(LOGT)**Z):

           G= 1.797  H= .307  Z=1.816

  RIPRAP STONE SP.GRAVITY= 2.64    C IN STEPHENSONS EQN=  .22

              - - - EMBANKMENT - - -
   AREA
(LOCATION  SEGMENT  LENGTH  SLOPE POROSITY  FRICTION
IN PLAN)             (FT)    (%)            ANGLE
                                            (DEG)
   1        UPS      150.     40.     .30    35.  STEPHENSONS
   1        TOP     1270.      2.     .30    37.  SAFETY FACTOR

 * * * * * * * * * * * * END INPUT DATA * * * * * * * * * * * *
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Note: Input data here on this sheet are for output on sheet 12

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet 11
Feature EROSION PROTECTION	Designed BYW	File No. —
		Date 11-18-93
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-19-93

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HATSP8.OUT                11/12/93                  Page 1

**INPUT FILE PRINTOUT**

UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP8.OUT)
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TOP SLOPE

```
HAT   FHW    11-12 1993
  1.797  .307 1.816 2.640  .220        1  .002 1.0
   2    0
   0    0
   3   25
  UPS      150.0  40.0   .30  35.0  ST
  TOP      *****   2.0   .30  37.0  FS
   .5000   1.0   .00065
   .0250   1.0   .00065

 * * * * * * * * * * * END INPUT DATA * * * * * * * * * * *


UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP8.OUT)

 UMTRA/HAT       RUN I.D.=FHW      DATE=11-12 1993

***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***

* * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *

 COEFFICIENTS FOR INTENSITY DURATION CURVE -
         IPMP=10**(G-H*(LOGT)**Z):

         G= 1.797  H= .307  Z=1.816

  RIPRAP STONE SP.GRAVITY= 2.64    C IN STEPHENSONS EQN=  .22

              - - - EMBANKMENT - - -
   AREA
(LOCATION  SEGMENT  LENGTH  SLOPE POROSITY  FRICTION
IN PLAN)             (FT)    (%)            ANGLE
                                            (DEG)
    1        UPS     150.     40.     .30    35.  STEPHENSONS
    1        TOP    1270.      2.     .30    37.  SAFETY FACTOR

 * * * * * * * * * * * END INPUT DATA * * * * * * * * * * *
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Note: Input data here on this sheet are for output on sheet 12

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON
Feature EROSION PROTECTION
Item EMBANKMENT AND SOUTH-EDGE AREAS

Contract No. 3885-58
Designed BYW
Checked EWW

Sheet 12
File No. --
Date 11-18-93
Date 11-19-93

HATSP8.OUT 11/12/93 Page 2

TOP SLOPE DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=TOP LENGTH=1270. FT. SLOPE= 2.%

ASSUMED D50= .0673FT. AT D/S END OF SEGMENT
CORRESPONDING Q= .998CFS/FT AT SEGMENT END BY FS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.035	.000	.035	.62	.06	.203	1.34	1.34
50.	100.	.070	.000	.070	1.05	.07	.137	.79	2.13
100.	150.	.105	.000	.105	1.42	.07	.115	.59	2.72
0.	51.	.141	.000	.141	1.62	.09	.025	.52	3.24
51.	102.	.177	.000	.177	1.80	.10	.025	.47	3.71
102.	152.	.212	.000	.212	1.96	.11	.024	.43	4.14
152.	203.	.248	.000	.248	2.11	.12	.024	.40	4.54
203.	254.	.284	.000	.284	2.24	.13	.024	.38	4.92
254.	305.	.319	.000	.319	2.36	.14	.023	.36	5.28
305.	356.	.355	.000	.355	2.47	.14	.023	.34	5.62
356.	406.	.391	.000	.391	2.58	.15	.023	.33	5.95
406.	457.	.427	.000	.427	2.68	.16	.023	.32	6.26
457.	508.	.462	.000	.462	2.78	.17	.023	.30	6.57
508.	559.	.498	.000	.498	2.87	.17	.023	.29	6.86
559.	610.	.534	.000	.534	2.96	.18	.023	.29	7.15
610.	660.	.569	.000	.569	3.05	.19	.023	.28	7.43
660.	711.	.605	.000	.605	3.13	.19	.022	.27	7.70
711.	762.	.641	.000	.641	3.21	.20	.022	.26	7.96
762.	813.	.676	.000	.676	3.29	.21	.022	.26	8.22
813.	864.	.712	.000	.712	3.37	.21	.022	.25	8.47
864.	914.	.748	.000	.748	3.44	.22	.022	.25	8.72
914.	965.	.783	.000	.783	3.51	.22	.022	.24	8.96
965.	1016.	.819	.000	.819	3.58	.23	.022	.24	9.19
1016.	1067.	.855	.000	.855	3.65	.23	.022	.23	9.43
1067.	1118.	.890	.000	.890	3.71	.24	.022	.23	9.65
1118.	1168.	.926	.000	.926	3.77	.25	.022	.22	9.88
1168.	1219.	.962	.000	.962	3.84	.25	.022	.22	10.10
1219.	1270.	.998	.000	.998	3.90	.26	.022	.22	10.32

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z))
(INCH/HR) 30.60	(INCH/HR) 30.37

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
UPS	150.	40.0	6.0	.235	2.5	6.00	STEPHENSON
TOP	1270.	2.0	.8	.998	10.3	.30	SAFETY FACTOR

← D_{50} (min) required

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	13
Feature	EROSION PROTECTION	Designed	BYW	File No.	--
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	EHW	Date	11-18-93
				Date	11-19-93

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.032	.000	.032	.58	.06	.209	1.43	1.43
50.	100.	.065	.000	.065	1.00	.06	.145	.83	2.26
100.	150.	.097	.000	.097	1.34	.07	.118	.62	2.89
0.	51.	.130	.000	.130	1.38	.09	.032	.61	3.50
51.	102.	.163	.000	.163	1.54	.11	.031	.55	4.05
102.	152.	.196	.000	.196	1.68	.12	.030	.50	4.55
152.	203.	.229	.000	.229	1.80	.13	.030	.47	5.02
203.	254.	.262	.000	.262	1.92	.14	.029	.44	5.46
254.	305.	.295	.000	.295	2.03	.15	.029	.42	5.88
305.	356.	.328	.000	.328	2.13	.15	.028	.40	6.28
356.	406.	.361	.000	.361	2.22	.16	.028	.38	6.66
406.	457.	.394	.000	.394	2.32	.17	.028	.36	7.02
457.	508.	.427	.000	.427	2.41	.18	.028	.35	7.38
508.	559.	.460	.000	.460	2.49	.18	.027	.34	7.72
559.	610.	.493	.000	.493	2.57	.19	.027	.33	8.04
610.	660.	.526	.000	.526	2.65	.20	.027	.32	8.36
660.	711.	.559	.000	.559	2.72	.21	.027	.31	8.67
711.	762.	.592	.000	.592	2.80	.21	.027	.30	8.98
762.	813.	.625	.000	.625	2.86	.22	.027	.30	9.27
813.	864.	.658	.000	.658	2.93	.22	.026	.29	9.56
864.	914.	.691	.000	.691	3.00	.23	.026	.28	9.84
914.	965.	.724	.000	.724	3.06	.24	.026	.28	10.12
965.	1016.	.757	.000	.757	3.12	.24	.026	.27	10.39
1016.	1067.	.790	.000	.790	3.18	.25	.026	.27	10.66
1067.	1118.	.823	.000	.823	3.24	.25	.026	.26	10.92
1118.	1168.	.856	.000	.856	3.30	.26	.026	.26	11.18
1168.	1219.	.889	.000	.889	3.36	.27	.026	.25	11.43
1219.	1270.	(.922)	.000	.922	3.41	.27	.026	.25	11.68
0.	1.	.922	.000	.922	5.07	.18	.042	.00	11.68
1.	1.	.923	.000	.923	5.07	.18	.042	.00	11.68

← Actual flow condition at end of top slope for $D_{50}=1.5''$ for a total length of 150+1270 = 1420 ft

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L

(INCH/HR)
28.29

RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z))

(INCH/HR)
28.27

Note: Input data not included, but similar to input data on sheet 11 except assigning $D_{50}=1.5''$ on top slope input and adding a hypothetical segment.

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
UPS	150.	40.0	6.0	.235	2.5	6.00	STEPHENSON
TOP	1270.	2.0	1.5	2.524 *1	7.0	1.50	SAFETY FACTOR
HYPO *2	1.	20.0	4.2	.923	11.7	.30	STEPHENSON

Remark: *1 This Q is the largest flow that Type A rock $D_{50}=1.5''$ can sustain. Actual flow rate is 0.92 cfs/ft as shown on above table (underlined)

*2 This very short hypothetical segment is added in order to have the actual flow condition computed as shown on above table (underlined)

4.1.2 Side Slope

Required rock sizes on the embankment side slopes at different locations were evaluated to determine the areas where Type B1 rock can be used to sustain the PMP flow condition and to check the stability of Type B rock at the remainder of the side slope areas.

1) Between "a" and "b" (see sheet 4)

There is no flow contribution from the top slope. Flow is only from the 5:1 side slope itself.

The longest flow length is at "b" with L = 350'.

By Kirpich equation (Ref. 8),

T_c (time of concentration) $= 0.0078\ L^{0.77} / s^{0.385} = 1.3$ min, for s=0.20

use minimum $T_c = 2.5$ min., hence $I_{PMP} = 53.5$ in/hr. (see sheet A-1)

$q = C\ I\ L / 43560 = 1.0\ (53.5)\ (350) / 43560 = 0.43$ cfs/ft

By Stephenson Method:

θ = side slope = 11.31°
For rounded rock, use $\phi \doteq 37°$ (see sheet A-2)

Then $D_{50} = (0.22049\ q)^{2/3} = 0.21' = 2.5"$

This required rock size is less than 3 inches, so use Type B1 rock.

The critical q and longest flow length that the type B1 rock can sustain the PMP flow on the 5:1 side slope alone can be determined as follows:

$q_c = D_{50}^{1.5} / 0.22049$

For $D_{50} = 3"$, q_c = 0.57 cfs/ft.

$q_c = C\ I\ L_c / 43560$

Assume $T_c = 2.5$ min., $I_{PMP} = 53.5$ in/hr. (see sheet A-1)

Hence, L_c = 43560 (0.57) / 53.5 = 465 ft.

Check $T_c = 0.0078\ L^{0.77} / s^{0.385}$ = 1.6 min < 2.5 min O.K.

2) Between "b" and "c" (see sheet 4)

This area will have combined flows from 2% top slope and 5:1 side slope. Flow length combination of top and side slopes that will have stable rock size of Type B1 (D_{50} = 3") under PMP sheet flow condition are as follows:

Top Slope	600'	550'	500'	420'	330'	180'	100'
Side Slope	20'	50'	100'	150'	200'	350'	400'
Total Length	620'	600'	600'	570'	530'	530'	500'

Based on these results, the approximate boundary, where Type B1 rock (D_{50} = 3") is stable on the 5:1 side slope between points "b" and "c" under PMP conditions, is shown on sheet 4.

Output for the "RPRP/SFST" computer runs are presented in Appendix C.

3) Between "c", "c_1 " and "d" (see sheet 4)

This is the area where Type B rock is required on the 5:1 side slope. A check is made to see if Type B rock is stable on the 5:1 side slope under PMP conditions. Several combined top slope and side slope flow lengths were tested, and the most critical condition is at point "c_2" (flow line T-T):

L_1 = 150' s = 0.4
L_2 = 1270' s = 0.02
L_3 = 100' s = 0.2
Total length = 1520'

The required rock size (D_{50}) is 4.3". Hence Type B rock, D_{50} = 4.4" is stable. Output from the "RPRP/SFST" computer runs are presented on sheets 16 to 18.

At point "c_2",
I_{PMP} = 27.6 in/hr, q = 0.96 cfs/ft, n=0.043
y = 0.19', v = 5.1 fps (see sheet 18)

For side slope:

```
HATSP7.OUT              11/12/93                 Page 1

 **INPUT FILE PRINTOUT**

 UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP.OUT)

 HAT   FHW    11-12 1993
   1.797  .307 1.816 2.640  .220       1  .002 1.0
    1    0
    0    0    0
    3   25    2
  UPS      150.0  40.0   .30  35.0  ST
  TOP      *****   2.0   .30  37.0  FS
  SIDE     100.0  20.0   .30  37.0  ST
   .5000   1.0   .00065
   .1250   1.0   .00065
   .0250   1.0   .00065

  * * * * * * * * * * * END INPUT DATA * * * * * * * * * * *



  UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP.OUT)

  UMTRA/HAT      RUN I.D.=FHW       DATE=11-12 1993

  ***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***

  * * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *

   COEFFICIENTS FOR INTENSITY DURATION CURVE -
             IPMP=10**(G-H*(LOGT)**Z):

             G= 1.797  H= .307  Z=1.816

    RIPRAP STONE SP.GRAVITY= 2.64   C IN STEPHENSONS EQN=  .22

                 - - - EMBANKMENT - - -
     AREA
  (LOCATION  SEGMENT  LENGTH  SLOPE POROSITY  FRICTION
  IN PLAN)            (FT)    (%)             ANGLE
                                              (DEG)
     1         UPS     150.    40.     .30     35.  STEPHENSONS
     1         TOP    1270.     2.     .30     37.  SAFETY FACTOR
     1         SIDE    100.    20.     .30     37.  STEPHENSONS

   * * * * * * * * * * * END INPUT DATA * * * * * * * * * * *
```

Note: Input data on this sheet are for output on sheet 17.

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project: UMTRA - HAT/MON	Contract No. 3885-[illegible]	Sheet	17
Feature: EROSION PROTECTION	Designed: BYW	File No.	–
Item: EMBANKMENT AND SOUTH-EDGE AREAS	Checked: FHW	Date	11-18-93
		Date	11-19-93

For side slope:

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.032	.000	.032	.57	.06	.211	1.46	1.46
50.	100.	.063	.000	.063	.99	.06	.147	.85	2.31
100.	150.	.095	.000	.095	1.32	.07	.119	.63	2.94
0.	51.	.127	.000	.127	1.37	.09	.032	.62	3.56
51.	102.	.160	.000	.160	1.52	.10	.031	.56	4.12
102.	152.	.192	.000	.192	1.67	.12	.030	.51	4.63
152.	203.	.224	.000	.224	1.78	.13	.030	.47	5.10
203.	254.	.256	.000	.256	1.90	.13	.029	.45	5.55
254.	305.	.289	.000	.289	2.01	.14	.029	.42	5.97
305.	356.	.321	.000	.321	2.11	.15	.028	.40	6.37
356.	406.	.353	.000	.353	2.20	.16	.028	.38	6.76
406.	457.	.385	.000	.385	2.30	.17	.028	.37	7.12
457.	[illegible]8.	.418	.000	.418	2.38	.18	.028	.36	7.48
508.	[illegible]	.450	.000	.450	2.47	.18	.027	.34	7.82
559.	610.	.482	.000	.482	2.55	.19	.027	.33	8.15
610.	660.	.514	.000	.514	2.62	.20	.027	.32	8.48
660.	711.	.547	.000	.547	2.70	.20	.027	.31	8.79
711.	762.	.579	.000	.579	2.77	.21	.027	.31	9.10
762.	813.	.611	.000	.611	2.84	.22	.027	.30	9.40
813.	864.	.643	.000	.643	2.90	.22	.027	.29	9.69
864.	914.	.676	.000	.676	2.97	.23	.026	.29	9.97
914.	965.	.708	.000	.708	3.03	.23	.026	.28	10.25
965.	1016.	.740	.000	.740	3.09	.24	.026	.27	10.53
1016.	1067.	.772	.000	.772	3.15	.25	.026	.27	10.80
1067.	1118.	.805	.000	.805	3.21	.25	.026	.26	11.06
1118.	1168.	.837	.000	.837	3.27	.26	.026	.26	11.32
1168.	1219.	.869	.000	.869	3.32	.26	.026	.25	11.57
1219.	1270.	.901	.000	.901	3.38	.27	.026	.25	11.82
0.	50.	.933	.000	.933	5.06	.18	.043	.16	11.99
50.	100.	.965	.000	.965	5.14	.19	.043	.16	12.15

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z))
(INCH/HR)	(INCH/HR)
27.65	27.62

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
UPS	150.	40.0	6.0	.[illegible]5	2.5	6.00	STEPHENSON
TOP	1270.	2.0	1.5 *	2.[illegible]24	7.0	1.50	SAFETY FACTOR
SIDE	100.	20.0	(4.3)	.965	[illegible]2.2	.30	STEPHENSON

*← * D_{50} (min) required*

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet 18	
Feature EROSION PROTECTION	Designed BYW	File No. —	Date 11-18-93
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-19-93	

For side slope:

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.032	.000	.032	.57	.06	.211	1.46	1.46
50.	100.	.063	.000	.063	.98	.06	.147	.85	2.31
100.	150.	.095	.000	.095	1.32	.07	.119	.63	2.94
0.	51.	.127	.000	.127	1.37	.09	.032	.62	3.56
51.	102.	.160	.000	.160	1.52	.10	.031	.56	4.12
102.	152.	.192	.000	.192	1.66	.12	.030	.51	4.63
152.	203.	.224	.000	.224	1.78	.13	.030	.47	5.10
203.	254.	.256	.000	.256	1.90	.13	.029	.45	5.55
254.	305.	.288	.000	.288	2.01	.14	.029	.42	5.97
305.	356.	.321	.000	.321	2.11	.15	.028	.40	6.37
356.	406.	.353	.000	.353	2.20	.16	.028	.38	6.76
406.	457.	.385	.000	.385	2.30	.17	.028	.37	7.13
457.	508.	.417	.000	.417	2.38	.18	.028	.36	7.48
508.	559.	.450	.000	.450	2.47	.18	.027	.34	7.83
559.	610.	.482	.000	.482	2.55	.19	.027	.33	8.16
610.	660.	.514	.000	.514	2.62	.20	.027	.32	8.48
660.	711.	.546	.000	.546	2.69	.20	.027	.31	8.79
711.	762.	.579	.000	.579	2.77	.21	.027	.31	9.10
762.	813.	.611	.000	.611	2.83	.22	.027	.30	9.40
813.	864.	.643	.000	.643	2.90	.22	.027	.29	9.69
864.	914.	.675	.000	.675	2.97	.23	.026	.29	9.98
914.	965.	.707	.000	.707	3.03	.23	.026	.28	10.26
965.	1016.	.740	.000	.740	3.09	.24	.026	.27	10.53
1016.	1067.	.772	.000	.772	3.15	.25	.026	.27	10.80
1067.	1118.	.804	.000	.804	3.21	.25	.026	.26	11.06
1118.	1168.	.836	.000	.836	3.26	.26	.026	.26	11.32
1168.	1219.	.869	.000	.869	3.32	.26	.026	.26	11.58
1219.	1270.	.901	.000	.901	3.37	.27	.026	.25	11.83
0.	50.	.932	.000	.932	5.02	.19	.043	.17	11.99
50.	100.	.964	.000	.964	5.10	.19	.043	.16	12.16 ← *Actual flow condition at end of 5:1 slope (point C_2 on sheet 44). for a total flow length of 1520 ft.*
0.	1.	.965	.000	.965	5.14	.19	.043	.00	12.16

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA=(43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**2)) (INCH/HR)
27.63	27.60

Note: Input data not included, but similar to input data on Sheet 16 except assigning D_{50} = 1.5" & 4.4" on Top + side slope, and also adding a hypothetical segment

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
UPS	150.	40.0	6.0	.235	2.5	6.00	STEPHENSON
TOP	1270.	2.0	1.5	2.524	7.0	1.50	SAFETY FACTOR
SIDE	100.	20.0	4.4	1.007 *1	11.9	4.40	STEPHENSON
HYPO *2	1.	20.0	4.3	.965	12.2	.30	STEPHENSON

*Note: *1 This is the largest Q, D_{50} = 4.4" can sustain. Actual flow rate = 0.964 cfs/ft as shown on above table (underlined)*
**2 hypothetical segment is added in order to have actual flow condition computed as shown on above table.*

MKO

4) Between "d" and "e"

At point "d", where Type B1 rock becomes stable on the side slope, was determined by trial-and-error computation.

At point "d_1",

L_1 = 100 Δh = 4410-4360 = 50 — s_1 = 50/100 = 0.5
L_2 = 50 Δh = 10 — s_2 = 0.1
L_3 = 230 — s_3 = 1/7 = 0.14286
L_4 = 480 — s_4 = 0.02
L_5 = 115(6.2(h):1(v) side slope) — s_5 = 18.5/115 = 1/6.2 = 0.1613

Let part of the length, L_5 of the 6.2(h):1(v) side slope which Type B1 rock can sustain the PMP flow be: L_s = 60'.

Therefore Total length = 100+50+230+480+60 = 930

$$T_c = 0.0078\ (\ 100^{0.77}\ /\ 0.5^{0.385} + 50^{0.77}\ /\ 0.1^{0.385} + 230^{0.77}\ /\ 0.14286^{0.385} + 480^{0.77}\ /\ 0.02^{0.385} + 60^{0.77}\ /\ 0.1613^{0.385}) = 6.3 \text{ min}$$

(note: assumed T_c is approximately the sum of T_c from each flow length segments using Kirpich equation)

Using T_c = 6.3, I_{PMP} = 39.5 in/hr.

q = 1.0 (39.5) (930) / 43560 = 0.84 cfs/ft

By Stephenson Method:
Use $\phi = 37°$, $\theta = \tan^{-1}(1/6.2) = 9.16°$, p = 0.3, C = 0.22, G_s = 2.64

Then $D_{50} = (0.15156\ q)^{2/3}$ = <u>3.0"</u> (Type B1 rock)

At point "d_2",

L_1 = 100 s_1 = 0.5
L_2 = 50 s_2 = 0.1
L_3 = 230 s_3 = 0.14286
L_4 = 460 s_4 = 0.02
L_5 = 125 s_5 = 1:6.5 = 0.15385 (side slope)

Therefore Total length = 100+50+230+460+125 = 965

T_c = 6.3 min, I_{PMP} = 39.5 in/hr.

q = 1.0 (39.5) (965) / 43560 = 0.88 cfs/ft

By Stephenson Method:

Use ϕ = 37°, $\theta = \tan^{-1}(1/6.5)$ = 8.75°, p = 0.3, C = 0.22, G_s = 2.64

Then $D_{50} = (0.1402\ q)^{2/3}$ = 3.0" (use Type B1 rock)

Based on these computations, the approximate boundary of Type B1 rock for side slope on the west side of the embankment is shown on sheet 4.

4.2 South-Edge Upslope Area

4.2.1 Area below haul road between points "A" and "B" with approx.7:1 slope (see sheet 4)

This is the area where 2% top slope will not extend to the existing roadway. A rock cover with slope no steeper than 7(h):1(v) will be provided as transition between the 2% top slope and the roadway.

Based on field investigations and the geology report (Ref. 15), the roadway in this area lies on an erosion resistant rock which can sustain and resist the erosive force of flow from the steep upland area. Thus the roadway can serve as an energy dissipator and disperse the flow downstream; this approximately creates a sheet flow condition downstream of the roadway. Additionally, most of the runoff from the upland in this area will be drained along the upstream side of the roadway and diverted through an open cut area (east of point "H", see sheet 4) toward south-east away from the disposal cell.

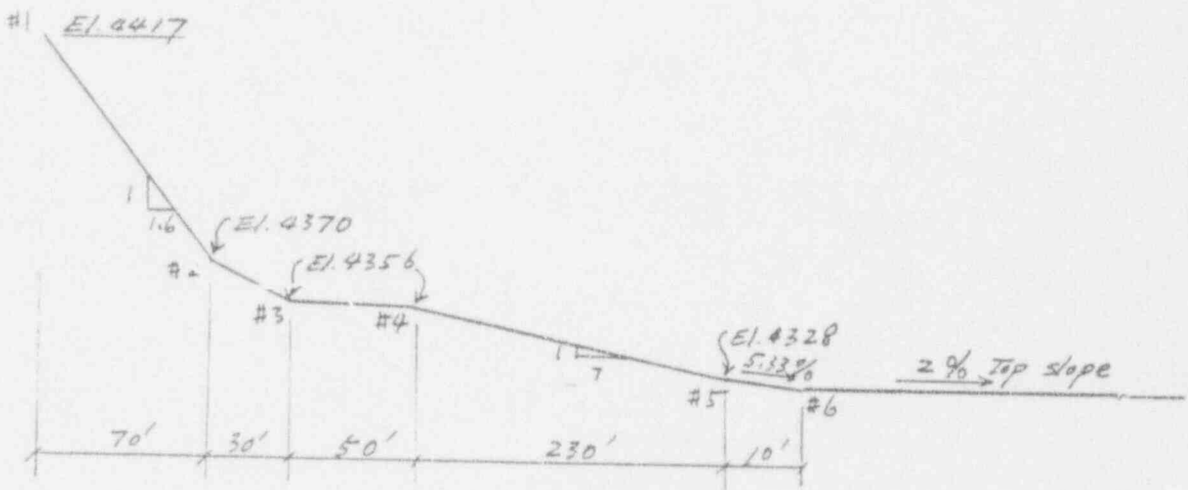
Since gullies currently exist below the roadway, the apron area between the 2% top slope and the roadway will be graded with a maximum slope of about 7:1 and armored with Type B1 riprap (if feasible) to further promote evenly distributed flow.

1) Peak discharge

The longest and most critical flow length is selected as the critical condition for the designed peak discharge. The following is a summary table of the condition along this flow path. A profile is also shown on sheet 21.

location#	Elev.	L	ΔL	ΔH	ΔH/ΔL	slope	T_c (min)	I (in/hr)	q (cfs/ft)
1	4415	0							
2	4370	70	70	45	0.643	1.6:1	0.24		
3	4356	100	30	14	0.47	2.1:1	0.40	53.5**	0.12
4	4356	150	50	0	0		*		
5	4328	380	230	28	0.145+	7:1	1.50	53.5**	0.47
6***	4327.47	390	10	0.53	0.0533	18.75:1	1.70	53.5**	0.48

* To be conservative, neglect the T_c for this section.
** Use a minimum T_c = 2.5 minutes.
*** Slope downstream of location #6 is 2% (embankment top slope).
\+ Actual slope is milder, but use 7:1 slope.
\# See flow-path K-K on sheet 4.



2) Flow characteristics at different slope locations

• At location #3 - upstream side of roadway

q = 0.12 cfs/ft (see table above)
s = 0.47 (approximate upstream slope), θ = 25.2°
let n = 0.05 for jagged and irregular rock cut condition (Ref. 10)

$$y = \left[\frac{n\,q}{1.486\ s^{\frac{1}{2}}}\right]^{0.6} = 0.046'$$

$$v = \frac{q}{y} = 2.6 \text{ fps}, \qquad Fr = \frac{v}{\sqrt{gy\cos\theta}} = 2.3$$

Hydraulic jump occurs at point no. 3

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2}-1\right) = 2.7, \text{ (Ref. 10)} \qquad y_2 = 0.13'$$

$$v_2 = \frac{q}{y_2} = 0.96 \text{ fps}$$

Length of jump $\doteq 5\ y_2 = 0.7'$ (Ref. 10)

Hence, the 25 to 35 feet wide roadway is long enough to spread the flow from the upland slope.

- <u>At location #5 - upstream end of 5.33% transition slope</u>

q = 0.47 cfs/ft (see sheet 21)

<u>On upstream 7:1 slope</u>
$s = 0.1429$ and $\theta = 8.13°$
$n = 0.0456\ (D_{50}\ s)^{0.159} = 0.04$ for $D_{50} = 3.0''$

then, $y_1 = 0.13'$, $v = 3.6$ fps and $Fr = 1.8$
$\tau = \gamma_w\, y\, s = 0.96\ lb/ft^2$

<u>On 5.33% slope</u>
$s = 0.053,\ \theta = 3.05°$; use $n = 0.037$

then, $y_2 = 0.17'$, $v = 2.8$ fps and $Fr = 1.20$
$\tau = \gamma_w\, y\, s = 0.56\ lb/ft^2$

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.037 \qquad \text{O.K.}$$

- At location #6 - upstream end of 2% top slope

$q = 0.48$ cfs/ft (see sheet 21)

On upstream 5.33% slope

$s = 0.0533$ ($\theta = 3.05°$)
use $n = 0.037$

then, $y = 0.17'$, $v = 2.8$ fps, $Fr = 1.2$
$\tau = \gamma_w\, y\, s = 0.57$ psf

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.037 \quad \text{O.K.} \quad (D_{50} = 3.0 \text{ in.})$$

On 2% slope

$s = 0.02$ ($\theta = 1.146°$)
use $n = 0.035$

then, $y = 0.22'$, $v = 2.2$ fps, $Fr = 0.82$
$\tau = \gamma_w\, y\, s = 0.27$ psf

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.035 \quad \text{O.K.}$$

So, hydraulic jump occurs on the 2% slope :

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2}-1\right) = 1.27$$

$y_2 = 1.27\, y_1 = 1.27\,(0.17) = \underline{0.22'}$

Length of jump = $5\, y_2 = 5\,(0.22) = 1$ ft (insignificant).

3) Required riprap sizing

a) At Location #4: upstream of 7:1 slope (see sheet 21).

- Required Rock Size:

l = 150', use T_c = 2.5 min, I_{PMP} = 53.5 in/hr

$q = 1.0\,(53.5)\,(150)\,/\,43560 = 0.184$ cfs/ft

Assume no erosion resistant rock exists at this location.
Assume flow concentration factor (FCF) = 3.0.

Then, $q = 3\,(0.184) = 0.55$ cfs/ft

Using a slope of $s = 0.04$ across the roadway,

$y = [n\,q\,/\,(1.486\,s^{0.5})\,]^{0.6}$, use $n = 0.04$

Then, y = 0.21', v = 2.6 fps, τ = 0.52 lb/ft^2

Required rock size on 7:1 slope (By Stephenson's Method):

using q = 0.55 cfs and slope of 7:1, $\theta = 8.13°$

$G_s = 2.64$, $\phi = 37°$ (see sheet A-2), $C = 0.22$ for round rock

$D_{50} = (0.12443\,q)^{0.667}$ = 2.0" (Type B1 rock is O.K.)

- Estimate of local scour depth at location #4: (Assuming no erosion resistant rock exists at this location):

Depth of apron upstream of 7:1 slope at location #4 will be at least equal to the local scour due to the PMP. Local scour was estimated below:

Using the DOT empirical equation for scour below culvert outlet (Ref 16):

$$D_s = \alpha\, y_e^{\gamma} \left[\frac{Q}{y_e^{2.5}}\right]^{\beta} (t)^{\theta}, \quad \text{where}$$

D_s = depth of scour in feet
y_e = flow depth or equivalent flow depth in feet
Q = peak flow rate in cfs (for sheet flows, Q=q in cfs per unit width)
t = duration in min with peak flow rate, use 30 min.
α, γ, β, and θ are empirical parameters, and the following values are used:
$\alpha = 0.82$, $\beta = 0.375$, $\theta = 0.1$ and $\gamma = 1.0$ (Ref. 10)

Hence for $y_e = 0.21'$, $Q = q = 0.55$ cfs/ft

$$D_s = 0.82\ (0.21)^{1.0} \left[\frac{0.55}{(0.21)^{2.5}}\right]^{0.375} (30)^{0.1} = 0.84\text{ft.}$$

Using Lacey's regime equation (Ref. 17)

$$R = 0.9 \left[\frac{q^2}{f}\right]^{\frac{1}{3}}, \quad q = 0.55 \quad (\text{FCF} = 3), \qquad \text{where}$$

R = hydraulic radius in feet,
q = cfs/ft
f = Lacey's silt factor $= 1.76\sqrt{D_{50}(\text{min})}$

Assume for very fine sand, $D_{50}(\text{min}) \doteq 1.0$ mm, then $f = 1.76$

$$R = 0.9 \left[\frac{0.55^2}{1.76}\right]^{\frac{1}{3}} = 0.5 \text{ ft}$$

Depth of scour below water surface = $\chi R = 2.25\ (0.5) = 1.13$ ft
(χ = 1.75 to 2.25, to be conservative use $\chi = 2.25$)

$\therefore$ Depth of scour below apron = 1.13 - 0.21 = 0.9 ft.

Using the Tractive Force Method (Ref. 10)

It is conservatively assumed that the road surface has the equivalent soil condition as firm loam; thus the critical tractive force is 0.075 lb/ft^2 (Ref. 10). Under the existing slope of 0.04, with n = 0.04, q = 0.55 (FCF = 3) $\tau = 0.52\ lb/ft^2$ (see sheet 24) > 0.075

Thus, local scour will reduce the slope until the shear stress is less than 0.075 lb/ft^2:

at s = 0.002, $y = \left[\frac{0.04 \times 0.55}{1.486\ (0.002)^{0.5}} \right]^{0.6} = 0.52\ \text{ft}$

$\tau = 0.064\ \text{lb/ft}^2 < 0.075$ ok

Therefore, instantaneous local scour = 0.52 - 0.21 = 0.31 ft.

Based on the above estimate, local scour upstream of the 7:1 slope is within 1 foot, and the upstream apron for the 7:1 slope rock cover will be set at 1 foot.

b) At Location #5: downstream of 7:1 slope and upstream of the transition slope (5.33%) where the shear stress is most critical (see sheet 21).

Based on the COE Stilling Basin Equation (Ref. 9):

$$D_{50} = \frac{v^2}{E^2\ 2\ g\ (G_s - 1)\ (\cos\theta - \sin\theta)}$$

use velocity from the 7:1 slope; v = 3.6 fps (see sheet 22)
E = 0.86 (high turbulence) (Ref. 9)
To be conservative, use 7:1 slope, $\theta = \tan^{-1}(1/7) = 8.13°$
G_s = 2.64 for round rock (Ref. 10), then
$D_{50} = 0.015\ v^2 = 0.20' = 2.3''$

Based on Stephenson's equation

$$D_{50} = \left[\frac{q\ (\tan\theta)^{\frac{7}{6}}\ (p)^{\frac{1}{6}}}{C\ g^{\frac{1}{2}}\ [(1-p)\ (G_s-1)\ \cos\theta\ (\tan\phi - \tan\theta)]^{\frac{5}{3}}} \right]^{\frac{2}{3}}$$

use upland slope of 7:1, $\theta = 8.13°$
$p \doteq 0.3$, q = 0.47 cfs (see sheet 21)
$G_s = 2.64$, $\phi = 37°$ (see sheet A-2), C = 0.22
$D_{50} = (0.12443\ q)^{0.667} = 0.15' = 1.8''$

Therefore, Type B1 riprap, D_{50}(min) = 3.0" shall be used for area below the roadway and above the 2% top slope (i.e. between points #4 and #6 as shown on sheet 21)

4) Check stability of Type A rock at upstream end of 2% top slope

- Safety Factor Method on a plan slope

$$D_{50} = \frac{21\tau}{\left[(G_s - 1)\ \gamma_w\ \cos\theta\ \left[\frac{1}{S.F.} - \frac{\tan\theta}{\tan\phi}\right]\right]}$$

use τ = 0.57 psf from the upstream 5.33% slope (see sheet 23)

On the 2% slope, $\theta = \tan^{-1}(0.02) = 1.146°$

$\phi = 35°$ (see sheet A-2)
$G_s = 2.64$ (rounded rock, Ref. 13)
S.F. = 1.0

then $D_{50} = 0.2113\ \tau = 0.12' = 1.5''$ (D_{50} for Type A rock) O.K.

5) Check required rock size between points "H" and "C" on upstream side of Roadway. The most critical location is at point "G" or point 3 (see sheet 4):

Point	Location EL.	ΔL	Σ Δl	Δh / Δl
1	4391.6			
2	4370.0	75	75	0.288
3	4340.0	30	105	1.000

At point 3 (see sheet 4),

Use T_c = 2.5 min, I_{PMP} = 53.5 in/hr, l = 75+30 = 105'

q = (53.5) (105) / 43560 = 0.129 cfs/ft

use FCF = 3.0, q = 0.129 x 3 = 0.39 cfs/ft

use n = 0.05, s = 1.0, and assume Manning Formula can be applied:

$y = [\ n\ q\ /\ (1.486\ s^{0.5})\ ]^{0.6} = 0.074'$

therefore, v = 5.2 fps

Using COE Stilling Basin Method

$$D_{50} = \frac{v^2}{E^2\ 2\ g\ (G_s - 1)\ (\cos\theta - \sin\theta)}$$

where $\theta = 2.29°$ (s = 0.04) , $G_s = 2.64$, and v = 5.2 fps

$D_{50} = 0.01335\ v^2 = 0.37' = 4.4"$

Thus, use at least Type B rock with D_{50} = 4.4" or any larger rock size along this area.

4.2.2 Area between points B & C

In this area, the 2% top slope will intercept the existing ground below the haul road (about 8 % slope) with a 10-foot long, 5.33 % slope transition apron. The stable rock size for erosion protection will be estimated based on the most critical flow length as shown on sheet 4.

Required riprap at the most critical location(i.e. at the upstream end of the 5.33% transition slope) will be sized as below:

1) Peak discharge and flow characteristics

Longest flow length at upstream end of 5.3 % slope is 210 feet.
From Kirpich's equation:

T_c = 1.4 min, use T_c = 2.5 min, and I = 53.5 in/hr.

q = 53.5 (210) / 43560 = 0.26 cfs/ft

use FCF = 3, then q = 3 (.26) = 0.78 cfs/ft,
use n = 0.04, and use upstream slope S = 0.08, then

$y = [\ (0.04 \times 0.78)\ /\ (1.486 \times 0.08^{0.5})\ ]^{0.6} = 0.21'$
v = 3.7 fps, $\tau = \gamma_w\ y\ s = 1.05\ lb/ft^2$

2) Required riprap sizing

Using the Safety Factor Method for a Plane Slope

Use τ = 1.05 lb/ft^2 from the upstream 8 % slope to act on the 5.33% slope.

θ = 3.05° (5.33% slope)
For rounded rock, G_s = 2.64, use ϕ = 38° (see sheet A-2)

D_{50} = 0.221 τ = 0.23′ = 2.8″

Therefore, the use of Type B riprap, D_{50} = 4.4″, will be stable on the 10-foot long transition zone between the natural ground and the upstream end of the 2% top slope.

- Estimate of local scour depth at upstream end of 5.3 % slope:

Using the DOT empirical equation for scour below culvert outlet (Ref 16):

$$D_s = \alpha\, y_e^{\gamma} \left[\frac{Q}{y_e^{2.5}}\right]^{\beta} (t)^{\theta}, \quad \text{where}$$

D_s = depth of scour in feet
y_e = flow depth or equivalent flow depth in feet
Q = peak flow rate in cfs (for sheet flows, Q=q in cfs per unit width)
t = duration in min with peak flow rate, use 30 min.
α, γ, β, and θ are empirical parameters, and the following values are used:
α = 0.82, β = 0.375, θ = 0.1 and γ = 1.0 (Ref. 10)

Hence for y_e = 0.21', Q = q = 0.78 cfs/ft (use FCF = 3)

$$D_s = 0.82\ (0.21)^{1.0} \left[\frac{0.78}{(0.21)^{2.5}}\right]^{0.375} (30)^{0.1} = 0.84\text{ft.}$$

Using Lacey's regime equation (Ref. 17)

$R = 0.9 \left[\frac{q^2}{f}\right]^{\frac{1}{3}}$, $q = 0.78$ (FCF = 3), where

R = hydraulic radius in feet,

q = cfs/ft

f = Lacey's silt factor $= 1.76 \sqrt{D_{50}(\min)}$

Assume for very fine sand, $D_{50}(\min) \doteq 1.0$ mm, then f = 1.76

$$R = 0.9 \left[\frac{0.78^2}{1.76}\right]^{\frac{1}{3}} = 0.63 \text{ ft}$$

Depth of scour below water surface = $\chi R = 2.25\,(0.63) = 1.42$ ft
(χ = 1.75 to 2.25, to be conservative use $\chi = 2.25$)

∴ Depth of scour below apron = 1.42 - 0.21 = 1.2 ft.

Using the Tractive Force Method (Ref. 10)

It is assumed that the natural ground surface has the equivalent soil condition as firm loam; thus the critical tractive force is 0.075 lb/ft² (Ref. 10). Under the existing slope of 0.08, with n = 0.04, q = 0.78 (FCF = 3) $\tau = 1.05$ lb/ft² (see sheet 29) > 0.075

Thus, local scour will reduce the slope until the shear stress is less than 0.075 lb/ft²:

Try s = 0.0015, then y = 0.69', $\tau = 0.065$ lb/ft² < 0.075
Depth of scour = 0.69 - 0.21 = 0.48'

Hence local scour depth upstream of the 5.3 % slope is about 1 foot, and the upstream apron for the 5.3 % transition slope rock cover will be set at 1 foot.

3) Check Stability of Type A rock at Upstream End of 2 % Slope

- Flow characteristics at end of 5.33 % transition zone

  $L = 210 + 10 = 220'$
  $q = C\,I\,L / 43560 = 1.0\,(53.5)\,(220) / 43560 = 0.27$ cfs/ft
  $s = 0.0533$
  use $n = 0.049$

  then, $y = 0.142'$, $v = 1.9$ fps, and $Fr = 0.89$
  $\tau = \gamma_w\, y\, s = 0.47$ psf

  $$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.049 \quad \text{O.K.} \quad (D_{50} = 4.4 \text{ in.})$$

- Rock size required on 2% top slope

  Use Safety Factor Method (see sheet 6 for equation)

  $\tau = 0.47$ psf from the 5.33% transition slope
  $\theta = \tan^{-1}(0.02) = 1.146°$, $G_s = 2.64$ (Ref. 13), $\phi = 35°$ (see sheet A-2)

  then $D_{50} = 0.211\,\tau = 0.099' = 1.2'' <$ Type A rock, $D_{50} = 1.5''$ O.K.

4.2.3 Area between points C & D

The upslope area between C and D (see sheet 5) will be regraded in 2.5:1 slope ($s = 0.4$) or 2:1 ($S=0.5$) slope and backfilled with riprap in order to promote sheet flow. The 2.5:1/2:1 slope will intercept the 2% embankment top slope with a 10-foot long transition apron. The stable rock size for erosion protection will be estimated based on the most critical flow length as shown on sheet 4.

Required riprap at the most critical location (i.e at the downstream end of 2.5:1 slope and at the upstream end of the 5.33% transition slope) will be sized as below:

1) Peak Discharge

Longest flow length on the 2.5/2.0 :1 slopes is 150 feet.
From Kirpich's equation:

$$T_c = \frac{0.0078\ (150)^{0.77}}{(0.4)^{0.385}} = 0.5 \text{ min}$$

Since $T_c < 2.5$ min, use $T_c = 2.5$ min, and I = 53.5 in/hr.

q = 53.5 (150) / 43560 = 0.18 cfs/ft

2) Riprap sizing for 2.5:1 slope

- Flow Characteristics:

For s = 0.4 (θ = 21.8°),
$n = 0.0456\ (D_{50}\ s)^{0.159} = 0.05$ for slopes > 10%
and D_{50} = 4.4" for Type B rock
$y = [\ (0.05 \times 0.18) / (1.486 \times 0.4^{0.5})\ ]^{0.6} = 0.06'$
v = 2.9 fps, and Fr = 2.1
$\tau = \gamma_w\, y\, s = 1.50\ \text{lb/ft}^2$

The hydraulic jump occurs at the 5.33% transition slope apron:

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2}-1\right) = 2.5, \qquad y_2 = 0.15'$$

Therefore, transition length required = 5 y_2 = 1 ft.
Use 10 feet, to be conservative.

- Riprap Sizing:

The critical location is at junction of 2.5:1 slope and 5.33% transition slope

Rounded rock with the following parameters will be used:
G_s = 2.64, c = 0.22, p ≐ 0.3, ϕ = 38°, θ = 21.8° (s = 0.4 or 2.5:1 slope)

Using Stephenson's Method

$D_{50} = (1.009\ q)^{0.667} = 3.8''$ for q = 0.18 cfs/ft

Using the COE Stilling Basin Method

E = 0.86 (high turbulence)
$G_s = 2.64$, $\theta = 21.8°$

$D_{50} = 0.0230\ v^2 = 2.3''$ for v = 2.9 fps

Using the Safety Factor Method for a Plane Slope

Use $\tau = 1.50\ lb/ft^2$ from 2.5:1 slope to act on the 5.33% slope.

$\theta = 3.05°$ (5.33% slope)
For rounded rock, $G_s = 2.64$, use $\phi = 38°$ (see sheet A-2)

$D_{50} = 0.221\ \tau = 0.33' = 4.0''$

Therefore, Type B riprap, $D_{50} = 4.4''$, shall be used on the 2.5:1 slope and on the 10-foot long transition zone at the upstream end of the 2% top slope.

3) Riprap sizing for 2:1 slope

- Flow characteristics:

q = 0.18 cfs/ft (see sheet 32)

For s = 0.5 ($\theta = 26.57°$)
$n = 0.0456\ (D_{50}\ s)^{0.159} = 0.054$ for D_{50} = 6" (Type C rock)

$y = [n\ q\ /\ (1.486\ s^{0.5})\ ]^{0.6} = 0.06'$, v = 3.0 fps
$\tau = \gamma\ y\ s = 1.87\ lb/ft^2$
Fr = 2.3

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_1^2}-1\right) = 2.77, \qquad y_2 = 0.166'$$

Length of the hydraulic jump = 5 y_2 = 1'.

Use a transition length of 10 feet, to be conservative.

- Riprap Sizing:

Critical location is at junction of 2:1 slope and 5.33% transition zone

Using Stephenson Method (for angular rock - Type C)

G_s = 2.7 (Ref. 14), C = 0.27, p = 0.3, ϕ = 40° (see sheet A-2), and θ = 26.57° (2:1 slope)

then, $D_{50} = (1.30\ q)^{0.667} = 4.6"$ for q = 0.18 cfs/ft

$D_{50,required} = 4.6 \times 1.15 =$ 5.2" with 15 % oversizing factor (Ref. 14).

Using the Safety Factor Method

τ = 1.87 lb/ft² from the 2:1 slope to act on the 5.33% transition slope.

θ = 3.05° (5.33% slope)

For angular rock, G_s = 2.7, use ϕ = 40°.

$D_{50} = 0.2117\ \tau = 0.4' = 4.8"$

$D_{50,required} = 4.8 \times 1.15 =$ 5.5" with 15 % oversizing factor.

Using the COE Stilling Basin Method

E = 0.86 (high turbulence), G_s = 2.7, θ = 26.57 (2:1)
v = 3 fps from 2:1 slope

$D_{50} = 0.0276\ v^2 = 0.249' = 3"$

$D_{50,required} = 3.0 \times 1.15 =$ 3.4" with 15 % oversizing factor.

Hence use Type C rock, D_{50} = 6" (before oversizing)
= 6.9" (with 15% oversizing factor).

4) Check stability of Type A rock at upstream end of 2% top slope

Flow characteristics on 5.33% transition zone

L = 150 + 10 = 160′

q = C I L / 43560 = 1.0 (53.5) (160) / 43560 = 0.20 cfs/ft

s = 0.0533

use n = 0.053

then, y = 0.124′, v = 1.6 fps, and Fr = 0.81

$\tau = \gamma_w \, y \, s = 0.41$ psf

assume Type B rock, D_{50} = 4.4 in.

$$\text{check } n = \frac{y^{1/6}}{\left[23.85 + 21.95 * \log\left(\frac{y}{D_{50}}\right)\right]} = 0.053 \qquad \text{O.K.}$$

Rock size required on 2% top slope

Use Safety Factor Method (see sheet 3 for equation)

τ = 0.41 psf from the 5.33% transition slope

$\theta = \tan^{-1}(0.02) = 1.146°$, $G_s = 2.64$ (Ref. 13), $\phi = 35°$ (see sheet A-2)

then $D_{50} = 0.211\,\tau = 0.09' = 1.0'' <$ Type A rock, $D_{50} = 1.5''$ O.K.

4.2.4 Typical transition to 2% slope between points D and E

As shown on sheet 4, the areas near the east part of the upslopes will not be regraded, and the 2% slope will intercept the existing ground with a 10-foot long 5.33% transition apron. Rock size for this transition apron is determined below.

1) Required transition length

The most critical flow length is, L = 50′ at location F (see sheet 4). The existing slope is about 48% ($\Delta H/L = 0.48$, $\theta = 25.6°$).

T_c = 0.21 min < 2.5 min, so use I = 53.5 in/hr

$\therefore$ q = C I L / 43560 = 1.0 (53.5) (50) / 43560 = 0.06 cfs/ft

By Mannings Formula,
n = 0.05 for jagged and irregular rock cut condition (Ref. 10)
y = 0.03′, v = 2.0 fps, Fr = 2.1
$\tau = \gamma\, y\, s = 0.90\ lb/ft^2$

The hydraulic jump occurs on the 5.33% slope:

$$\frac{y_2}{0.03} = \frac{1}{2}\left(\sqrt{1+8(2.1)^2} - 1\right) = 2.56, \qquad y_2 = 0.08'$$

Therefore, transition length required = 5 y_2 = 0.4 ft; and using a transition length of 10 feet is conservative.

2) Riprap sizing at intersection of 48% (existing) and 5.33% slope

- Stephenson's Method

Based on the 48% slope, θ = 25.64°, q = 0.06 cfs/ft
For rounded rock, C = 0.22, G_s = 2.64, and ϕ = 38° (Type B riprap), p ≐ 0.3

then $D_{50} = (1.94\ q)^{0.667} = 0.24' = 2.9''$

Use Type B rock, D_{50} = 4.4″

The critical q for D_{50} = 4.4″ to remain stable would be:

$4.4'' / 12 = (1.94\ q_c)^{0.667}, \quad \therefore q_c = 0.115$ cfs/ft

This is equivalent to a flow concentration factor, FCF, of q_c / q = <u>1.9</u>

- Safety Factor Method

Assume shear stress acting on the 48% slope will act on the 5.33% transition slope.

$\tau = 0.90\ lb/ft^2$, θ = 3.05° (s = 0.0533), ϕ = 38°
G_s = 2.64

Then, $D_{50} = 0.220\ \tau = 0.2' = 2.4''$

For Type B rock, $\tau_c = D_{50} / 0.22 = 1.67$
$y_c = \tau_c / \gamma s = 1.67 / (62.4 \times 0.48) = 0.0556$
$q_c = 1.486 / 0.05 (0.0556)^{5/3} (0.48)^{1/2} = 0.167$ cfs/ft

FCF = q_c / q = 2.8

- COE Stilling Basin Method

$G_s = 2.64$, θ = slope of apron = 3.05° (s = 0.0533)
E = 0.86 (high turbulence)

then, $D_{50} = 0.01354\ v^2$
for q = 0.06 cfs/ft, v = 2.0 fps, D_{50} = 0.7"

For D_{50} = 4.4" (Type B rock),
$v_c = [\ (4.4/12) / 0.01354\ ]^{0.5}$ = 5.2 fps, $v_c = 1.486/n * y^{2/3} * s^{1/2}$,
Hence, $y_c = (n\ v_c / 1.486\ s^{1/2})^{1.5} = 0.127$, $q_c = v_c\ y_c = 0.66$, FCF $= q_c/q = 11$

Hence, the use of Type B rock can sustain a flow concentration factor of 2 to 11.

3) Estimate local scour depth

Assume FCF = 3.0, q = 0.06 x 3 = 0.18 cfs/ft, s = 0.48
use n = 0.05, $y = [n\ q / (1.486\ s^{0.5})\ ]^{0.6}$ = 0.06'
v = 3.1 fps, $\tau = \gamma\ y\ s$ = 1.24 lb/ft²

- Using the DOT empirical equation (Ref. 16)

$$D_s = \alpha\ y_c^{\gamma} \left[\frac{Q}{y_c^{2.5}} \right]^{\beta} (t)^{\theta}, \quad \text{where}$$

For y_c = 0.06', Q = q = 0.18 cfs/ft

$$D_s = 0.82\ (0.06)^{1.0} \left[\frac{0.18}{(0.06)^{2.5}} \right]^{0.375} (30)^{0.1} = 0.51\text{ft.}$$

- Using the Tractive Force Method (Ref. 10)

Use critical shear, $\tau_c = 0.075$ lb/ft^2

$q = 0.18$ cfs/ft (FCF = 3), $n = 0.05$

Try $s = 0.004$, then $y = 0.24$, $\tau = 0.061 < \tau_c = 0.075$ O.K.

$D_s = 0.24 - 0.06 = 0.2'$

- Using the Lacey's Regime Equation

Assume for very fine sand, $D_{50}(\text{min}) \doteq 1.0$ mm, then $f = 1.76$

$$R = 0.9 \left[\frac{0.18^2}{1.76}\right]^{\frac{1}{3}} = 0.24 \text{ ft}$$

$D_s = y\,R - y_o = 2.25\,(0.24) - 0.06 = \underline{0.5'}$

Hence scour depth is approximately 0.5 ft, use a depth of at least 1 ft for the rock cover along the edge of the apron.

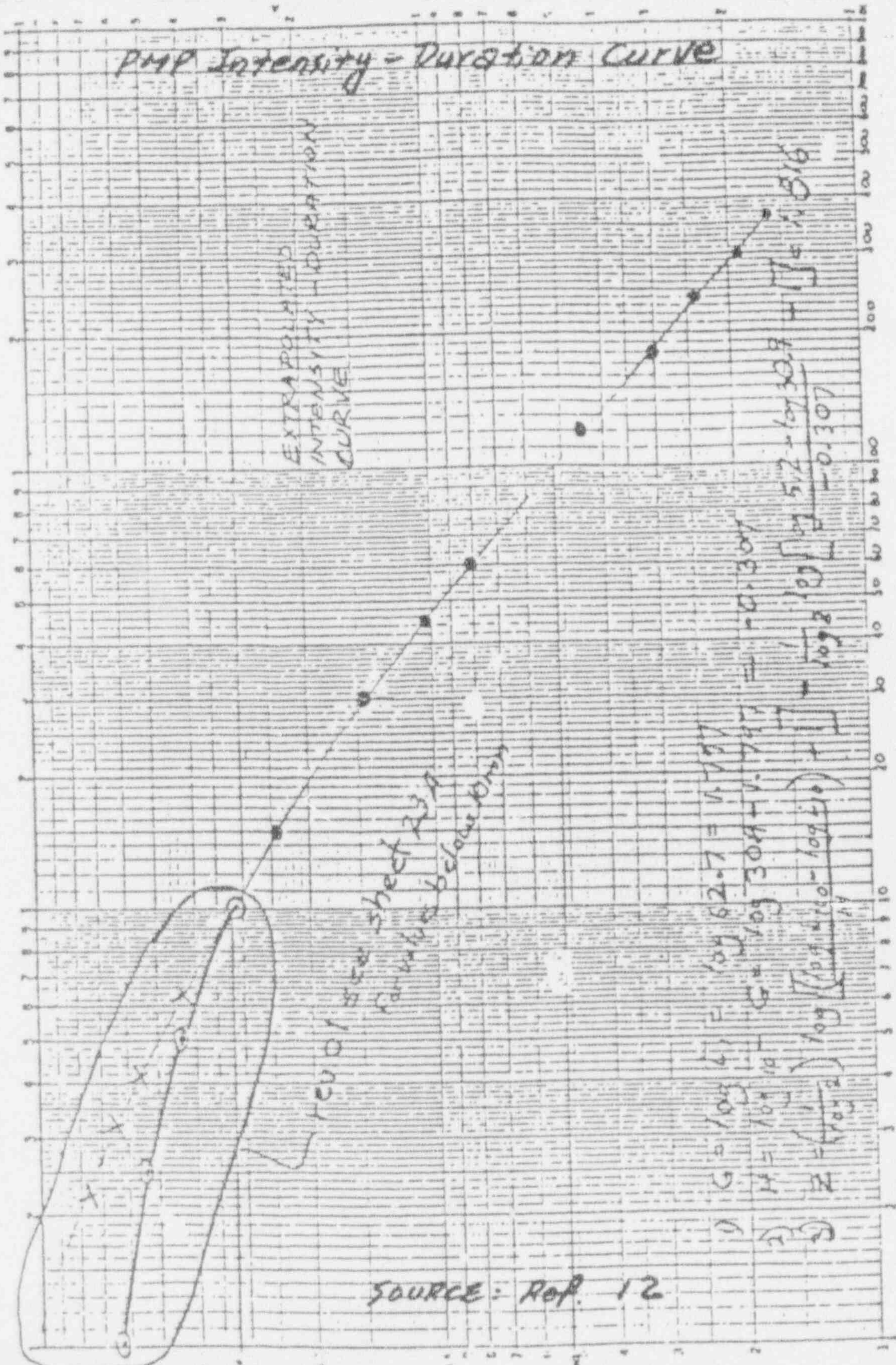
APPENDIX A

REFERENCE CHARTS

MORRISON KNUDSEN CORPORATION

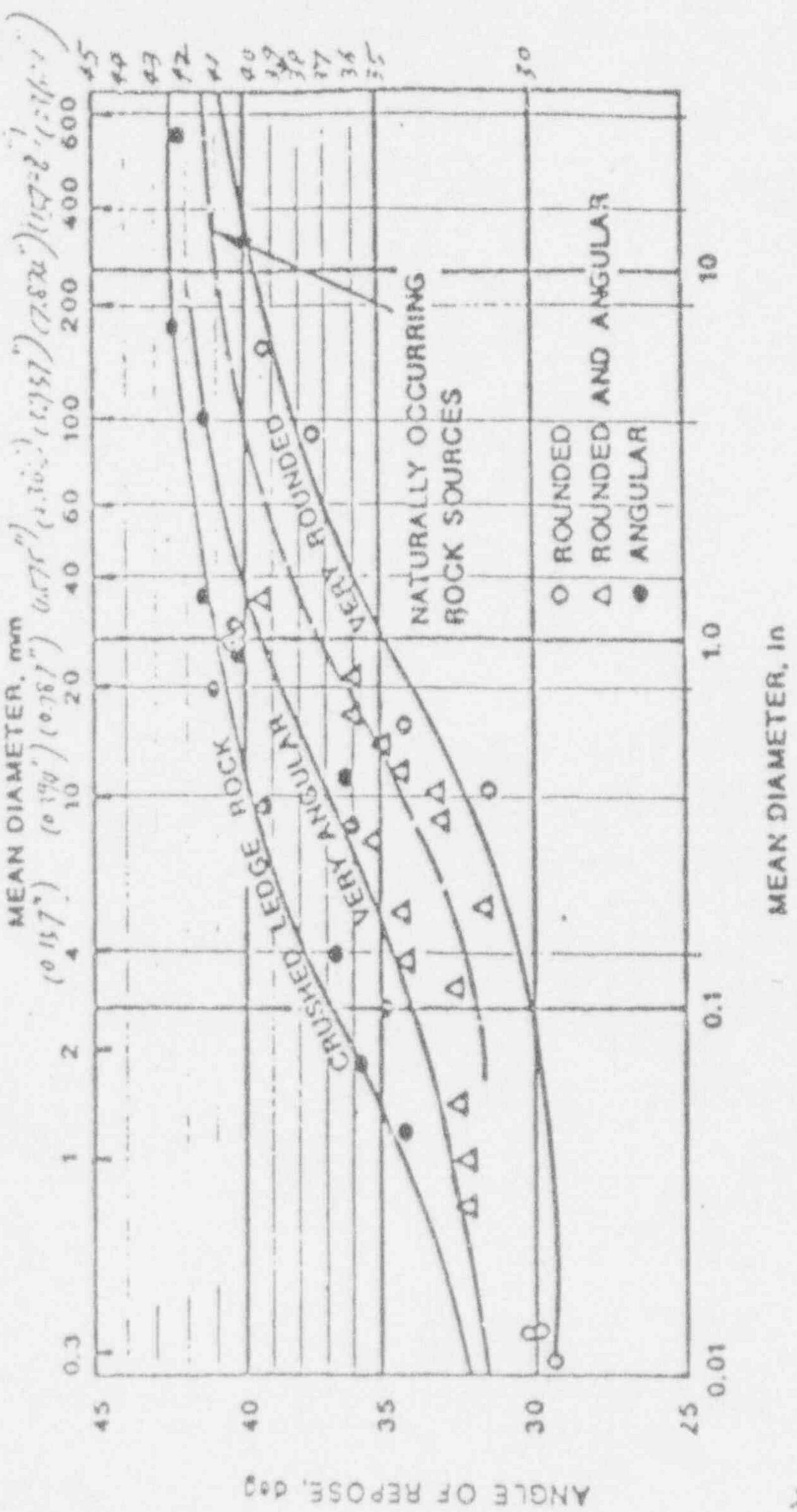
ENVIRONMENTAL SERVICES GROUP

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	A-1
Feature	EROSION PROTECTION	Designed	BYW	File No.	—
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	FHW	Date	11-29-93
				Date	11-30-93



MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	A-2
Feature	EROSION PROTECTION	Designed	BYW	File No.	–
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	FHW	Date	11-29-93
				Date	11-30-93



ANGLE OF REPOSE FOR ROCK OF VARIOUS DIAMETERS

Source: Ref. 3

APPENDIX B

GRADATION OF TYPE B1 ROCK

Appendix B -Type B1 Riprap Gradation

1.0 Gradation Requirements:

$D_{50}(min)$ = 3 " (Bluff source with round rock, and no oversizing required, (Ref.13))

$D_{100}(max) = 1.71 * D_{50}(min)$ = 5.1 " = 5.0 " (Ref. 7)

$D_{100}(min) = 1.26 * D_{50}(min)$ = 3.8 " = 4.0 " (Ref. 7)

$D_{25}(min) = 0.68 * D_{50}(min)$ = 2.0 " (Ref. 7)

Based on above values, the upper and lower bounds of gradation curves for the Type B1 rock are developed as shown on sheet B2.

The gradation limits are given below:

U.S. Standard Sieve Opening	% Passing By Weight
5 "	100
4 "	0 - 100
3 "	0 - 50
2 "	0 - 25
#4	0 - 5

2.0 Layer Thickness:

a. T (min) $\geq 1.9 * D_{50}(min)$ = 5.7 " (Ref. 7)

b. T (min) $\geq 1.5 * D_{50}(max)$ = 1.5*4.5 = 7 " (Ref. 7)

c. T (min) $\geq$ 12 " (Ref. 7)

Thus use the layer thickness = 12 ".

3.0 Bedding Layer:

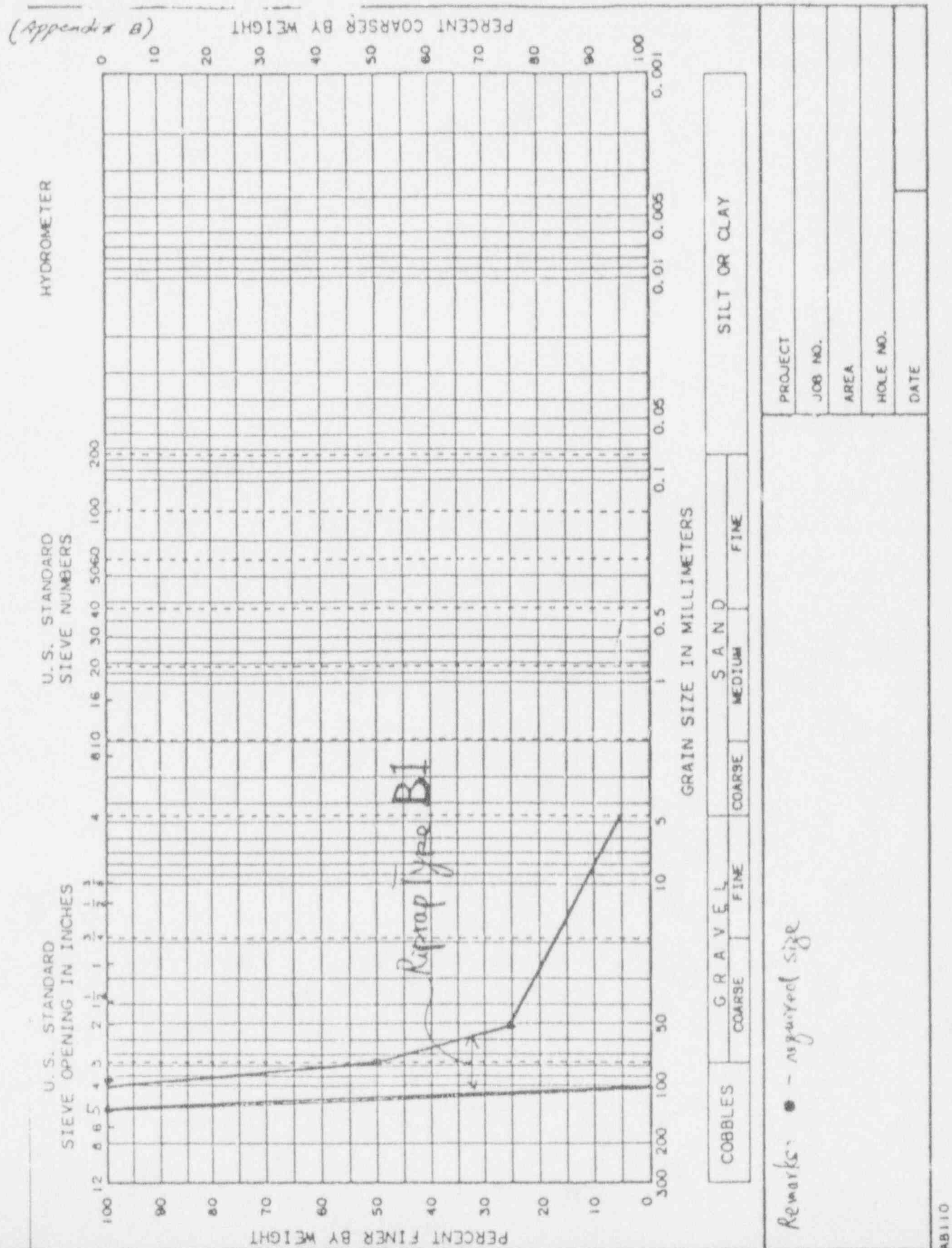
Bedding materials determined in Ref. 2 for all Type A, Type B, Type C rocks can also be used for Type B1 rock since Type B1 rock size is between Type A and Type B rocks.

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet B - 2
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

GRAIN SIZE ANALYSIS

(Appendix B)



AB110

APPENDIX C

COMPUTER OUTPUT FROM RPRP/SFST FOR TYPE B1 ROCK EVALUATION ON THE EAST SIDE OF THE EMBANKMENT

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet C-1
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

```
HATSP1.OUT                11/11/93                    Page 1
UMTRA/H/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP.OUT)
UMTRA/HAT        RUN I.D.=FHW       DATE=11-11 1993

***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***
* * * * * * * * * * * INPUT DATA * * * * * * * * * * * *

COEFFICIENTS FOR INTENSITY DURATION CURVE -
      IPMP=10**(G-H*(LOGT)**Z):
      G= 1.797  H= .307  Z=1.816

RIPRAP STONE SP.GRAVITY= 2.64   C IN STEPHENSONS EQN=  .22
          - - - EMBANKMENT - - -
```

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	600.	2.	.30	35.	SAFETY FACTOR
1	SIDE	20.	20.	.30	37.	STEPHENSONS
1	HYPO	1.	20.	.30	37.	STEPHENSONS

```
* * * * * * * * * * * END INPUT DATA * * * * * * * * * * *

        DETAILED CALC TABLE WITH FINAL ROCK SIZE
  SEGMENT=HYPO    LENGTH=   1. FT.  SLOPE= 20.%

        ASSUMED D50=  .2535FT. AT D/S END OF SEGMENT
CORRESPONDING Q=   .579CFS/FT AT SEGMEN  END-BY STEPHENSONS METHOD
```

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.047	.000	.047	.83	.06	.038	1.00	1.00
50.	100.	.093	.000	.093	1.17	.08	.034	.71	1.71
100.	150.	.140	.000	.140	1.43	.10	.032	.58	2.30
150.	200.	.186	.000	.186	1.64	.11	.030	.51	2.81
200.	250.	.233	.000	.233	1.82	.13	.029	.46	3.27
250.	300.	.280	.000	.280	1.98	.14	29	.42	3.69
300.	350.	.326	.000	.326	2.12	.15	.028	.39	4.08
350.	400.	.373	.000	.373	2.26	.16	.028	.37	4.45
400.	450.	.419	.000	.419	2.39	.18	.028	.35	4.80
450.	500.	.466	.000	.466	2.51	.19	.027	.33	5.13
500.	550.	.513	.000	.513	2.62	.20	.027	.32	5.45
550.	600.	.559	.000	.559	2.72	.21	.027	.31	5.75
0.	20.	.578	.000	.578	4.33	.13	.040	.08	5.83
0.	1.	.579	.000	.579	4.34	.13	.040	.00	5.84

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
40.60	40.53

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	600.	2.0	1.5	2.515	2.9	1.50	SAFETY FACTOR
SIDE	20.	20.0	3.0	.578	5.8	1.50	STEPHENSON
HYPO	1.	20.0	3.0	.579	5.8	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON	Contract No. 3885-58	Sheet C-2
Feature EROSION PROTECTION	Designed BYW	File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS	Checked FHW	Date 11-29-93
		Date 11-30-93

HATR10.OUT 8/4/93 Page 1

Evaluation of Type B rock

MEXICAN HAT - TOP AND SIDE SLOPES, ZERO PORE FLOW, ROUNDED RD *3885-58*

UMTRA/HAT RUN I.D.=FHW DATE=07/28 1993

SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION

* * * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *

COEFFICIENTS FOR INTENSITY DURATION CURVE -

IPMP=10**(G-H*(LOGT)**Z):

G= 1.797 H= .307 Z=1.816

RIPRAP STONE SP.GRAVITY= 2.64 C IN STEPHENSONS EQN= .22

\- - - EMBANKMENT - - -

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	550.	2.	.30	35.	SAFETY FACTOR
1	SIDE	50.	20.	.30	37.	STEPHENSONS
1	SIDE	350.	20.	.30	38.	STEPHENSONS

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=SIDE LENGTH= 350. FT. SLOPE= 20.%

ASSUMED D50= .2978FT. AT D/S END OF SEGMENT

CORRESPONDING Q= .799CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	FLOWS (CFS/FT) ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC (MIN) INT.	TOTAL
0.	50.	.042	.000	.042	.79	.05	.039	1.06	1.06
50.	100.	.084	.000	.084	1.12	.08	.034	.75	1.81
100.	150.	.126	.000	.126	1.36	.09	.032	.61	2.42
150.	200.	.168	.000	.168	1.56	.11	.031	.53	2.95
200.	250.	.210	.000	.210	1.73	.12	.030	.48	3.43
250.	300.	.252	.000	.252	1.88	.13	.029	.44	3.88
300.	350.	.295	.000	.295	2.03	.15	.029	.41	4.29
350.	400.	.337	.000	.337	2.15	.16	.028	.39	4.67
400.	450.	.379	.000	.379	2.28	.17	.028	.37	5.04
450.	500.	.421	.000	.421	2.39	.18	.028	.35	5.39
500.	550.	.463	.000	.463	2.50	.19	.027	.33	5.72
0.	50.	.505	.000	.505	4.06	.12	.041	.21	5.93
0.	50.	.547	.000	.547	4.04	.14	.044	.21	6.13
50.	100.	.589	.000	.589	4.19	.14	.043	.20	6.33
100.	150.	.631	.000	.631	4.34	.15	.043	.19	6.52
150.	200.	.673	.000	.673	4.49	.15	.042	.19	6.71
200.	250.	.715	.000	.715	4.63	.15	.042	.18	6.89
250.	300.	.757	.000	.757	4.77	.16	.041	.17	7.07
300.	350.	.799	.000	.799	4.90	.16	.041	.17	7.24

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA=(43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
36.66	36.63

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	550.	2.0	1.5	2.515	2.6	1.50	SAFETY FACTOR
SIDE	50.	20.0	3.0	.570	5.6	.30	STEPHENSON
SIDE	350.	20.0	3.6	.799	7.2	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

				Sheet	C-3
Project	UMTRA - HAT/MON	Contract No.	3885-56	File No.	–
Feature	EROSION PROTECTION	Designed	BYW	Date	11-29-93
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	FHW	Date	11-30-93

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HAT812.OUT              8/4/93              Page 1   3185-58
MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RO
UMTRA/HAT        RUN I.D.=FHW        DATE=07/28 1993
***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***
```

Evaluation of Type B1 rock

```
* * * * * * * * * * * * INPUT DATA * * * * * * * * * * * *
 COEFFICIENTS FOR INTENSITY DURATION CURVE -
        IPMP=10**(G-H*(LOGT)**Z):
        G= 1.797  H= .307  Z=1.816
  RIPRAP STONE SP.GRAVITY= 2.64   C IN STEPHENSONS EQN=  .22
              - - - EMBANKMENT - - -
```

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE	
1	TOP	500.	2.	.30	35.	SAFETY FACTOR
1	SIDE	100.	20.	.30	37.	STEPHENSONS
1	SIDE	460.	20.	.30	38.	STEPHENSONS

```
         DETAILED CALC TABLE WITH FINAL ROCK SIZE
  SEGMENT=SIDE    LENGTH= 460. FT.  SLOPE= 20.%

         ASSUMED D50=  .3153FT. AT D/S END OF SEGMENT
 CORRESPONDING Q=   .871CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD
```

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	50.	.041	.000	.041	.78	.05	.039	1.07	1.07
50.	100.	.082	.000	.082	1.10	.07	.034	.76	1.83
100.	150.	.123	.000	.123	1.34	.09	.032	.62	2.45
150.	200.	.164	.000	.164	1.54	.11	.031	.54	2.99
200.	250.	.205	.000	.205	1.72	.12	.030	.49	3.47
250.	300.	.247	.000	.247	1.86	.13	.029	.45	3.92
300.	350.	.288	.000	.288	2.00	.14	.029	.42	4.34
350.	400.	.329	.000	.329	2.13	.15	.028	.39	4.73
400.	450.	.370	.000	.370	2.25	.16	.028	.37	5.10
450.	500.	.411	.000	.411	2.37	.17	.028	.35	5.45
0.	50.	.452	.000	.452	3.8[illegible]	.12	.042	.22	5.67
50.	100.	.493	.000	.493	4.00	12	.041	.21	5.88
0.	46.	.531	.000	.531	3.91	.14	.045	.20	6.07
46.	92.	.569	.000	.569	4.05	.14	.045	.19	6.26
92.	138.	.607	.000	.607	4.19	.14	.044	.18	6.44
138.	184.	.644	.000	.644	4.32	.15	.044	.18	6.62
184.	230.	.682	.000	.682	4.45	.15	.043	.17	6.79
230.	276.	.720	.000	.720	4.58	.16	.043	.17	6.96
276.	322.	.758	.000	.758	4.70	.16	.042	.16	7.12
322.	368.	.796	.000	.796	4.81	.17	.042	.16	7.28
368.	414.	.833	.000	.833	4.93	.17	.042	.16	7.44
414.	460.	.871	.000	.871	5.04	.17	.041	.15	7.59

```
      RAINFALL INTENSITY              RAINFALL INTENSITY
      THAT ASSUMED D50             BASED ON CALCULATED
      CAN WITHSTAND BASED             TIME OF CONC.AND USING
      ON THE EQN I=Q/CA=              INTERPOLATING FUNCTION
  (43560*Q)/L                    I=10**(G-H*((LOGT)**Z))
            (INCH/HR)                        (INCH/HR)
             35.81                            35.76
             *******RESULTS SUMMARY******* AREA=1
```

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	500.	2.0	1.5	2.515	2.5	1.50	SAFETY FACTOR
SIDE	100.	20.0	3.0	.577	5.4	.30	STEPHENSON
SIDE	460.	20.0	3.8	.871	7.6	.30	STEPHENSON

HAT814.OUT 8/4/93 Page 1

MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RO

UMTRA/HAT RUN 1.0.=FHW DATE=07/28 1993

SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION

Evaluation of Type B rock

* * * * * * * * * * INPUT DATA * * * * * * * * * * * *

COEFFICIENTS FOR INTENSITY DURATION CURVE -

IPMP=10**(G-H*(LOGT)**Z):

G= 1.797 H= .307 Z=1.816

RIPRAP STONE SP.GRAVITY= 2.64 C IN STEPHENSONS EQN= .22

- - - EMBANKMENT - - -

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	420.	2.	.30	35.	SAFETY FACTOR
1	SIDE	150.	20.	.30	37.	STEPHENSONS
1	SIDE	370.	20.	.30	38.	STEPHENSONS

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=SIDE LENGTH= 370. FT. SLOPE= 20.%

ASSUMED D50= .3010FT. AT D/S END OF SEGMENT

CORRESPONDING Q= .813CFS/FT AT SEGMENT END BY STEPHENSONS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	47.	.040	.000	.040	.77	.05	.039	1.01	1.01
47.	93.	.081	.000	.081	1.09	.07	.034	.71	1.72
93.	140.	.121	.000	.121	1.33	.09	.032	.58	2.31
140.	187.	.161	.000	.161	1.53	.11	.031	.51	2.81
187.	233.	.202	.000	.202	1.70	.12	.030	.46	3.27
233.	280.	.242	.000	.242	1.85	.13	.029	.42	3.69
280.	327.	.282	.000	.282	1.99	.14	.029	.39	4.08
327.	373.	.323	.000	.323	2.11	.15	.028	.37	4.45
373.	420.	.363	.000	.363	2.23	.16	.028	.35	4.80
0.	50.	.406	.000	.406	3.64	.11	.043	.23	5.03
50.	100.	.450	.000	.450	3.83	.12	.042	.22	5.25
100.	150.	.493	.000	.493	4.01	.12	.041	.21	5.46
0.	62.	.546	.000	.546	4.02	.14	.044	.26	5.71
62.	123.	.599	.000	.599	4.22	.14	.043	.24	5.95
123.	185.	.653	.000	.653	4.41	.15	.043	.23	6.19
185.	247.	.706	.000	.706	4.59	.15	.042	.22	6.41
247.	308.	.759	.000	.759	4.76	.16	.041	.22	6.63
308.	370.	.813	.000	.813	4.92	.17	.041	.21	6.84

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
37.66	37.65

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	420.	2.0	1.5	2.515	2.5	1.50	SAFETY FACTOR
SIDE	150.	20.0	3.0	.563	5.1	.30	STEPHENSON
SIDE	370.	20.0	3.6	.813	6.8	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	C-5
Feature	EROSION PROTECTION	Designed	BYW	File No.	--
Item	EMBANKMENT AND SOUTH-EDGE AREAS	Checked	FHW	Date	11-29-93
				Date	11-30-93

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HATR16.OUT                8/4/93            Page 1
MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RO
UMTRA/HAT       RUN I.D.=FHW      DATE=07/28 1993
***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***
```

Evaluation of Type B1 rock

```
* * * * * * * * * * * INPUT DATA * * * * * * * * * * * * * *
COEFFICIENTS FOR INTENSITY DURATION CURVE -
        IPMP=10**(G-H*(LOGT)**2):
        G= 1.797  H= .307  Z=1.816
RIPRAP STONE SP.GRAVITY= 2.64    C IN STEPHENSONS EQN=  .22

              - - - EMBANKMENT - - -
```

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	330.	2.	.30	35.	SAFETY FACTOR
1	SIDE	200.	20.	.30	37.	STEPHENSONS
1	SIDE	300.	20.	.30	38.	STEPHENSONS

```
          DETAILED CALC TABLE WITH FINAL ROCK SIZE
   SEGMENT=SIDE    LENGTH= 300. FT.   SLOPE= 20.%
          ASSUMED D50=  .2900FT. AT D/S END OF SEGMENT
CORRESPONDING Q=   .768CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD
```

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	55.	.051	.000	.051	.87	.06	.037	1.06	1.06
55.	110.	.102	.000	.102	1.23	.08	.033	.75	1.80
110.	165.	.153	.000	.153	1.49	.10	.031	.62	2.42
165.	220.	.204	.000	.204	1.71	.12	.030	.54	2.96
220.	275.	.255	.000	.255	1.89	.13	.029	.48	3.44
275.	330.	.305	.000	.305	2.06	.15	.029	.45	3.89
0.	50.	.352	.000	.352	3.39	.10	.044	.25	4.13
50.	100.	.398	.000	.398	3.61	.11	.043	.23	4.36
100.	150.	.444	.000	.444	3.82	.12	.042	.22	4.58
150.	200.	.491	.000	.491	4.02	.12	.041	.21	4.79
0.	50.	.537	.000	.537	4.03	.13	.043	.21	4.99
50.	100.	.583	.000	.583	4.20	.14	.043	.20	5.19
100.	150.	.629	.000	.629	4.37	.14	.042	.19	5.38
150.	200.	.676	.000	.676	4.53	.15	.042	.18	5.57
200.	250.	.722	.000	.722	4.68	.15	.041	.18	5.75
250.	300.	.768	.000	.768	4.83	.16	.041	.17	5.92

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA= (43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**2)) (INCH/HR)
40.32	40.27

```
        *******RESULTS SUMMARY****  * AREA=1
```

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	330.	2.0	1.5	2.515	2.5	1.50	SAFETY FACTOR
SIDE	200.	20.0	2.9	.550	4.5	.30	STEPHENSON
SIDE	300.	20.0	3.5	.768	5.9	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project UMTRA - HAT/MON | Contract No. 3885-58 | Sheet C-6
Feature EROSION PROTECTION | Designed BYW / | File No. –
Item EMBANKMENT AND SOUTH-EDGE AREAS | Checked FHW | Date 11-29-93 | Date 11-30-93

HATR17.OUT 8/4/93 Page 1
MEXICAN HAT - TOP AND SIDE SLOPES,ZERO PORE FLOW, ROUNDED RO
UMTRA/HAT RUN I.D.=FHW DATE=07/28 1993
SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION

Evaluation of Type B1 rock

************ INPUT DATA ************

COEFFICIENTS FOR INTENSITY DURATION CURVE -
IPMP=10**(G-H*(LOGT)**Z):
G= 1.797 H= .307 Z=1.816
RIPRAP STONE SP.GRAVITY= 2.64 C IN STEPHENSONS EQN= .22

- - - EMBANKMENT - - -

AREA (LOCATION IN PLAN)	SEGMENT	LENGTH (FT)	SLOPE (%)	POROSITY	FRICTION ANGLE (DEG)	
1	TOP	180.	2.	.30	35.	SAFETY FACTOR
1	SIDE	350.	20.	.30	37.	STEPHENSONS
1	SIDE	70.	20.	.30	38.	STEPHENSONS

************ END INPUT DATA ************

DETAILED CALC TABLE WITH FINAL ROCK SIZE
SEGMENT=SIDE LENGTH= 70. FT. SLOPE= 20.%

ASSUMED D50= .2529FT. AT D/S END OF SEGMENT
CORRESPONDING Q= .626CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

SLOPED DISTANCE FROM (FT)	TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	45.	.047	.000	.047	.83	.06	.038	.90	.90
45.	90.	.094	.000	.094	1.18	.08	.034	.64	1.54
90.	135.	.141	.000	.141	1.43	.10	.032	.52	2.06
135.	180.	.188	.000	.188	1.64	.11	.030	.46	2.52
0.	50.	.240	.000	.240	2.74	.09	.048	.30	2.82
50.	100.	.292	.000	.292	3.05	.10	.046	.27	3.10
100.	150.	.344	.000	.344	3.33	.10	.044	.25	3.35
150.	200.	.396	.000	.396	3.58	.11	.043	.23	3.58
200.	250.	.448	.000	.448	3.82	.12	.042	.22	3.80
250.	300.	.500	.000	.500	4.04	.12	.041	.21	4.00
300.	350.	.553	.000	.553	4.25	.13	.040	.20	4.20
0.	70.	.626	.000	.626	4.51	.14	.040	.26	4.46

RAINFALL INTENSITY THAT ASSUMED D50 CAN WITHSTAND BASED ON THE EQN I=Q/CA=(43560*Q)/L (INCH/HR)	RAINFALL INTENSITY BASED ON CALCULATED TIME OF CONC.AND USING INTERPOLATING FUNCTION I=10**(G-H*((LOGT)**Z)) (INCH/HR)
45.42	45.39

*******RESULTS SUMMARY******* AREA=1

SEGMENT	LENGTH (FT)	SLOPE (%)	D50 (INCH)	Q AT D/S END (CFS/FT)	TC (MINUTES)	STARTING ROCK D50 (INCH)	METHOD OF CALC.
TOP	180.	2.0	1.5	2.515	2.5	1.50	SAFETY FACTOR
SIDE	350.	20.0	3.0	.570	4.1	.30	STEPHENSON
SIDE	70.	20.0	3.0	.626	4.5	.30	STEPHENSON

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES GROUP

Project	UMTRA - HAT/MON	Contract No.	3885-58	Sheet	C-7
Feature	EROSION PROTECTION	Designed	BYW	File No.	--
Item	EMBANKMENT AND SOUTH-EDGE AREAS			Date	11-29-93
		Checked	FHW	Date	11-30-93

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HATSP.OUT                11/11/93                Page 1
UMTRA/M/H - SIDE SLOPE,ZERO PORE FLOW (FILE:HATSP.OUT)
UMTRA/HAT       RUN I.D.=FHW      DATE=11-11 1993

***SAFETY FACTOR/STEPHENSON METHOD FOR EMBANKMENT EROSION PROTECTION***

* * * * * * * * * * * * INPUT DATA * * * * * * * * * * * * *

COEFFICIENTS FOR INTENSITY DURATION CURVE -
      IPMP=10**(G-H*(LOGT)**Z):

      G= 1.797  H= .307  Z=1.816

RIPRAP STONE SP.GRAVITY= 2.64   C IN STEPHENSONS EQN=  .22

          - - - EMBANKMENT - - -
AREA
(LOCATION  SEGMENT  LENGTH  SLOPE POROSITY  FRICTION
IN PLAN)            (FT)    (%)             ANGLE
                                            (DEG)
   1        TOP     100.     2.     .30     35.  SAFETY FACTOR
   1        SIDE    400.    20.     .30     37.  STEPHENSONS
   1        HYPO      1.    20.     .30     37.  STEPHENSONS
* * * * * * * * * * * * END INPUT DATA * * * * * * * * * * * *

        DETAILED CALC TABLE WITH FINAL ROCK SIZE
  SEGMENT=HYPO    LENGTH=   1. FT.  SLOPE= 20.%

        ASSUMED D50=  .2496FT. AT D/S END OF SEGMENT
CORRESPONDING Q=   .566CFS/FT AT SEGMENT END-BY STEPHENSONS METHOD

SLOPED      *****FLOWS(CFS/FT)**** VEL.  DEPTH  MANNING  TIME OF
DISTANCE    ALLOC.  PORES   ROCK  (FPS)  (FT)    N     CONC(MIN)
FROM  TO                                               INT. TOTAL
(FT)  (FT)
  0.   50.   .056   .000   .056    .91   .06   .037    .91   .91
 50.  100.   .113   .000   .113   1.29   .09   .033    .65  1.56
  0.   50.   .169   .000   .169   2.27   .07   .053    .37  1.93
 50.  100.   .226   .000   .226   2.66   .08   .049    .31  2.24
100.  150.   .282   .000   .282   3.00   .09   .046    .28  2.52
150.  200.   .339   .000   .339   3.30   .10   .044    .25  2.77
200.  250.   .395   .000   .395   3.58   .11   .043    .23  3.00
250.  300.   .452   .000   .452   3.84   .12   .042    .22  3.22
300.  350.   .508   .000   .508   4.08   .12   .041    .20  3.42
350.  400.   .564   .000   .564   4.30   .13   .040    .19  3.62
  0.    1.   .566   .000   .566   4.30   .13   .040    .00  3.62

    RAINFALL INTENSITY           RAINFALL INTENSITY
    THAT ASSUMED D50          BASED ON CALCULATED
    CAN WITHSTAND BASED          TIME OF CONC.AND USING
    ON THE EQN I=Q/CA=           INTERPOLATING FUNCTION
(43560*Q)/L               I=10**(G-H*((LOGT)**Z))

       (INCH/HR)                  (INCH/HR)
         49.17                      49.01

         *******RESULTS SUMMARY******* AREA=1
SEGMENT  LENGTH  SLOPE  D50     Q AT      TC     STARTING  METHOD OF
          (FT)    (%)  (INCH)  D/S END (MINUTES) ROCK D50  CALC.
                               (CFS/FT)           (INCH)
TOP      100.     2.0   1.5    2.515     2.5      1.50  SAFETY FACTOR
SIDE     400.    20.0   3.0     .565     3.6      1.50  STEPHENSON
HYPO       1.    20.0   3.0     .566     3.6       .30  STEPHENSON
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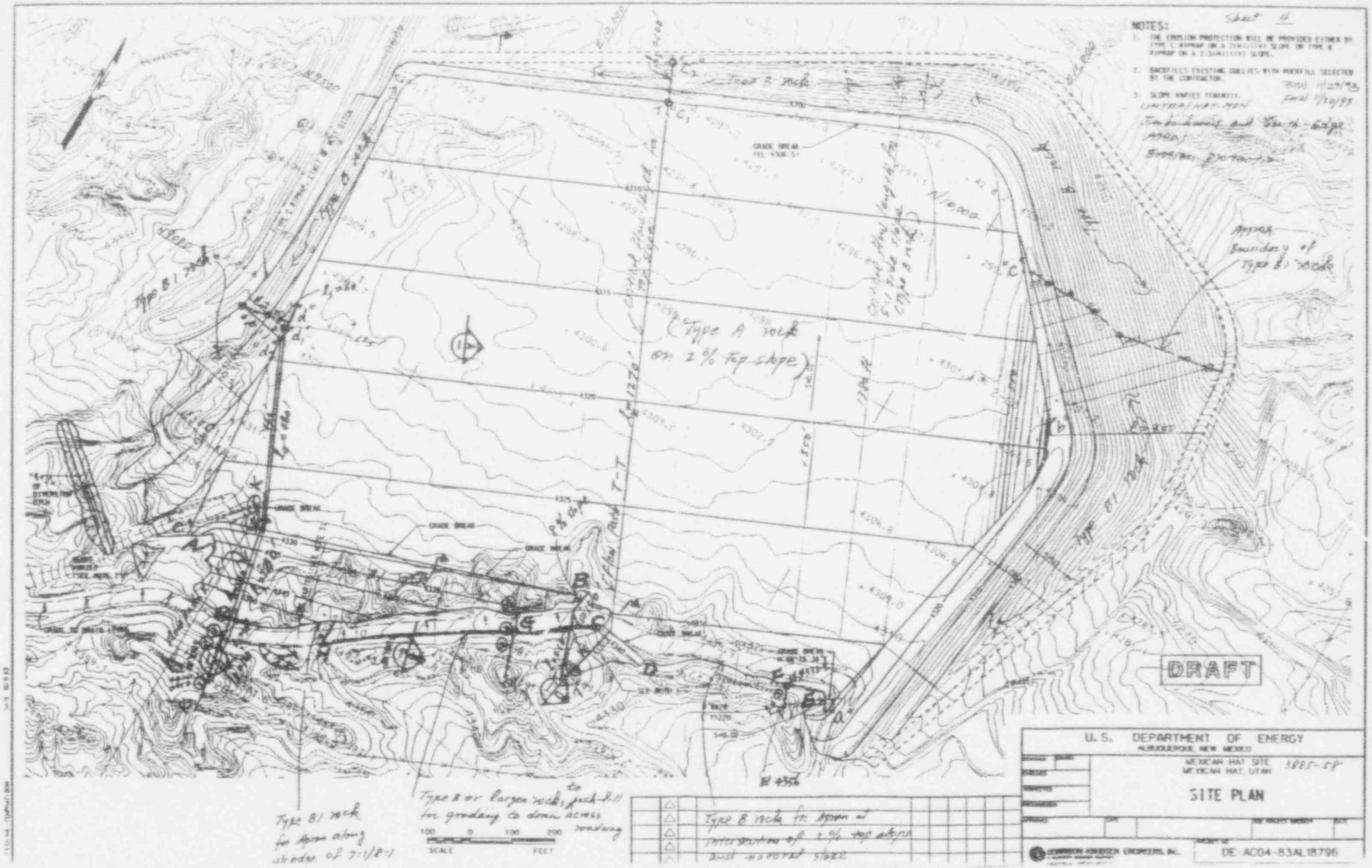
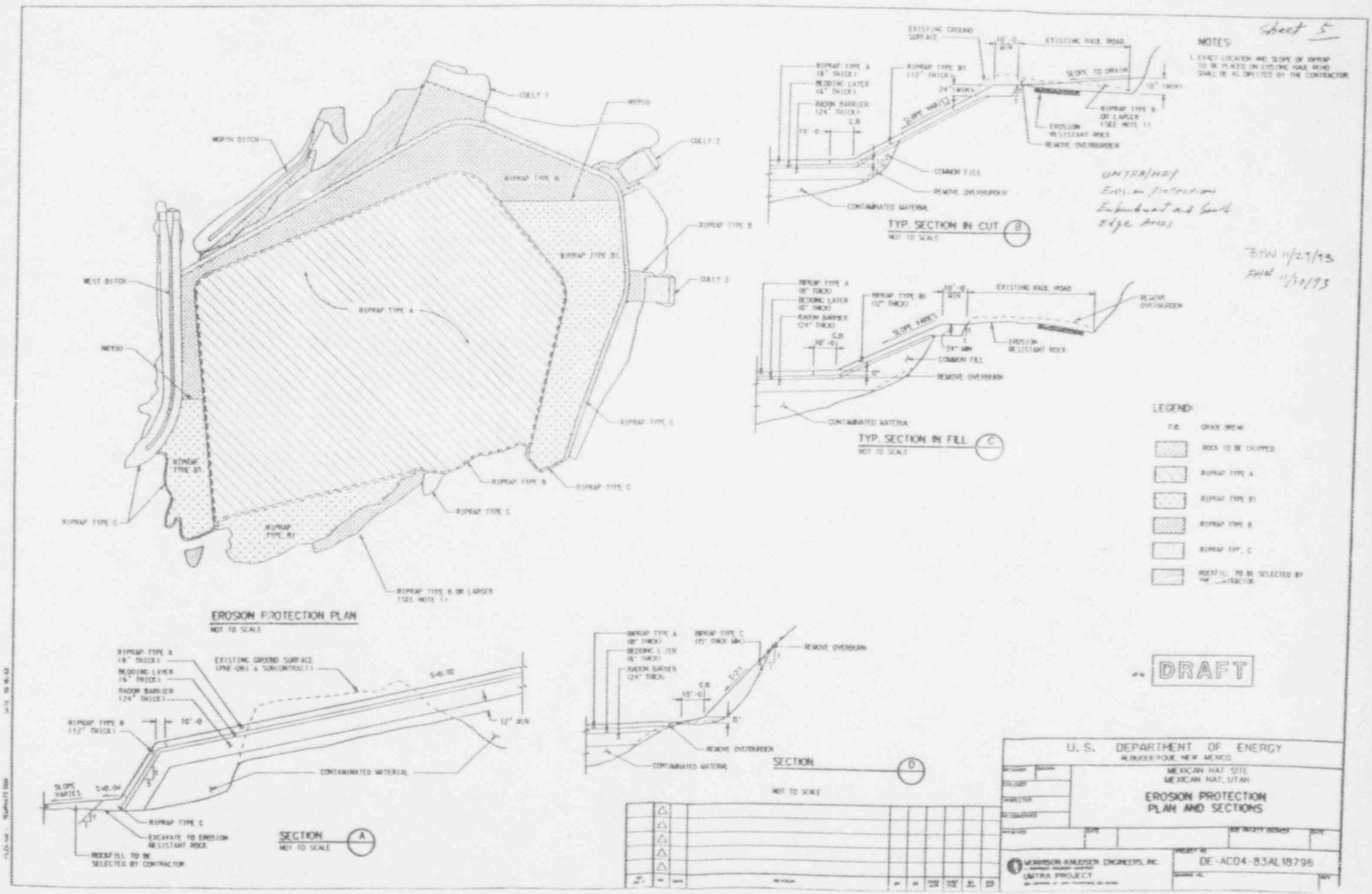
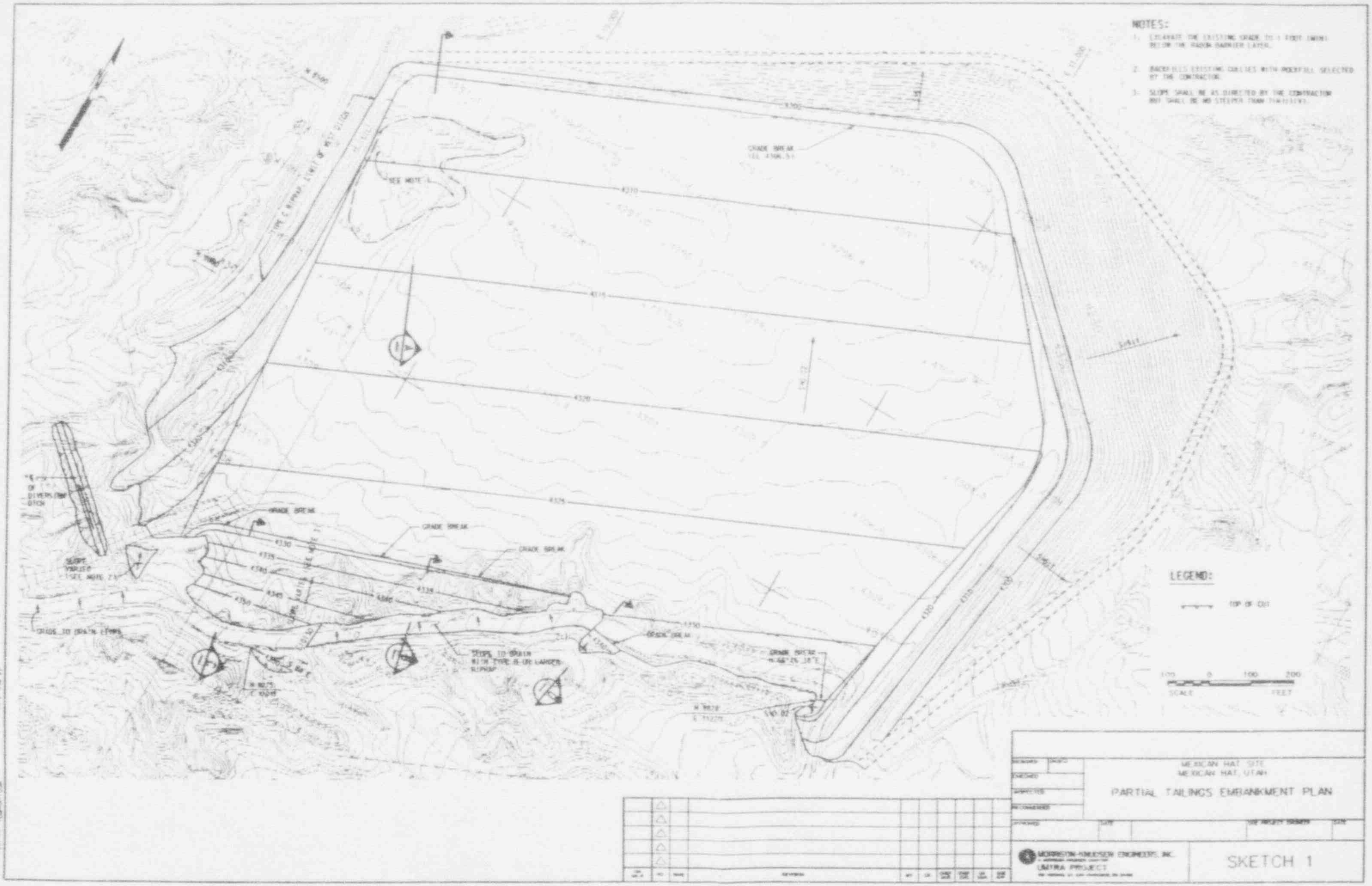
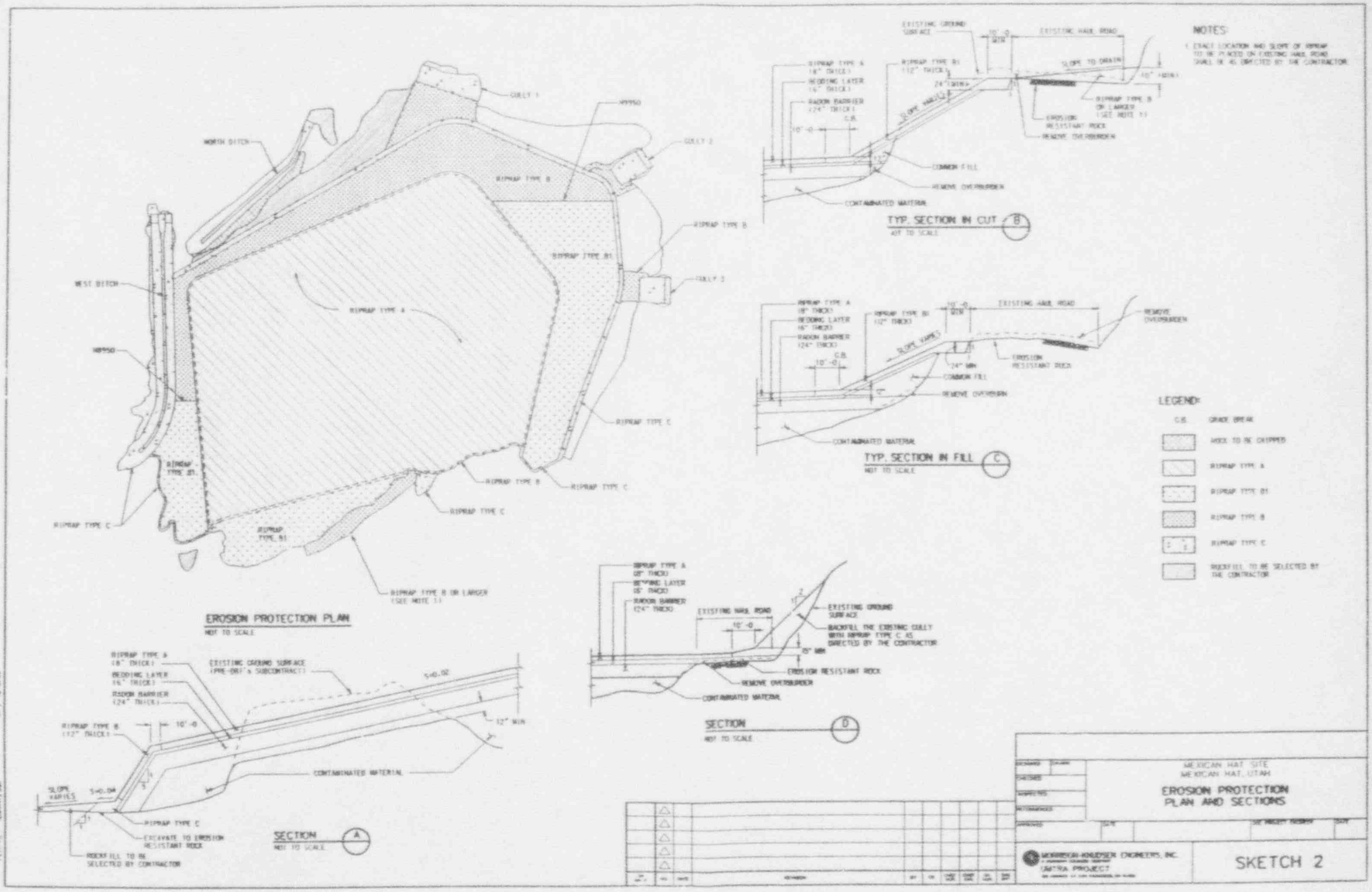
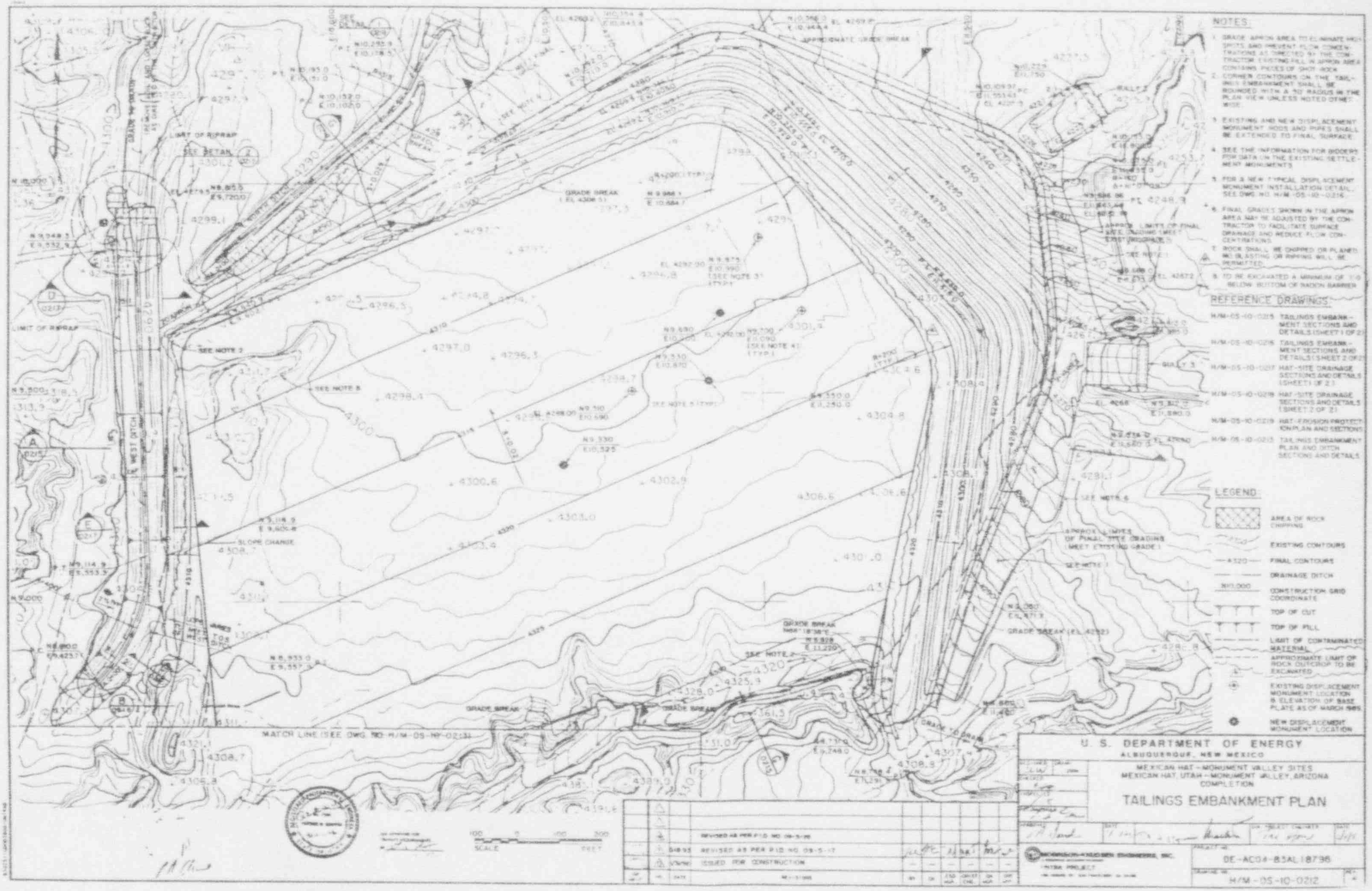
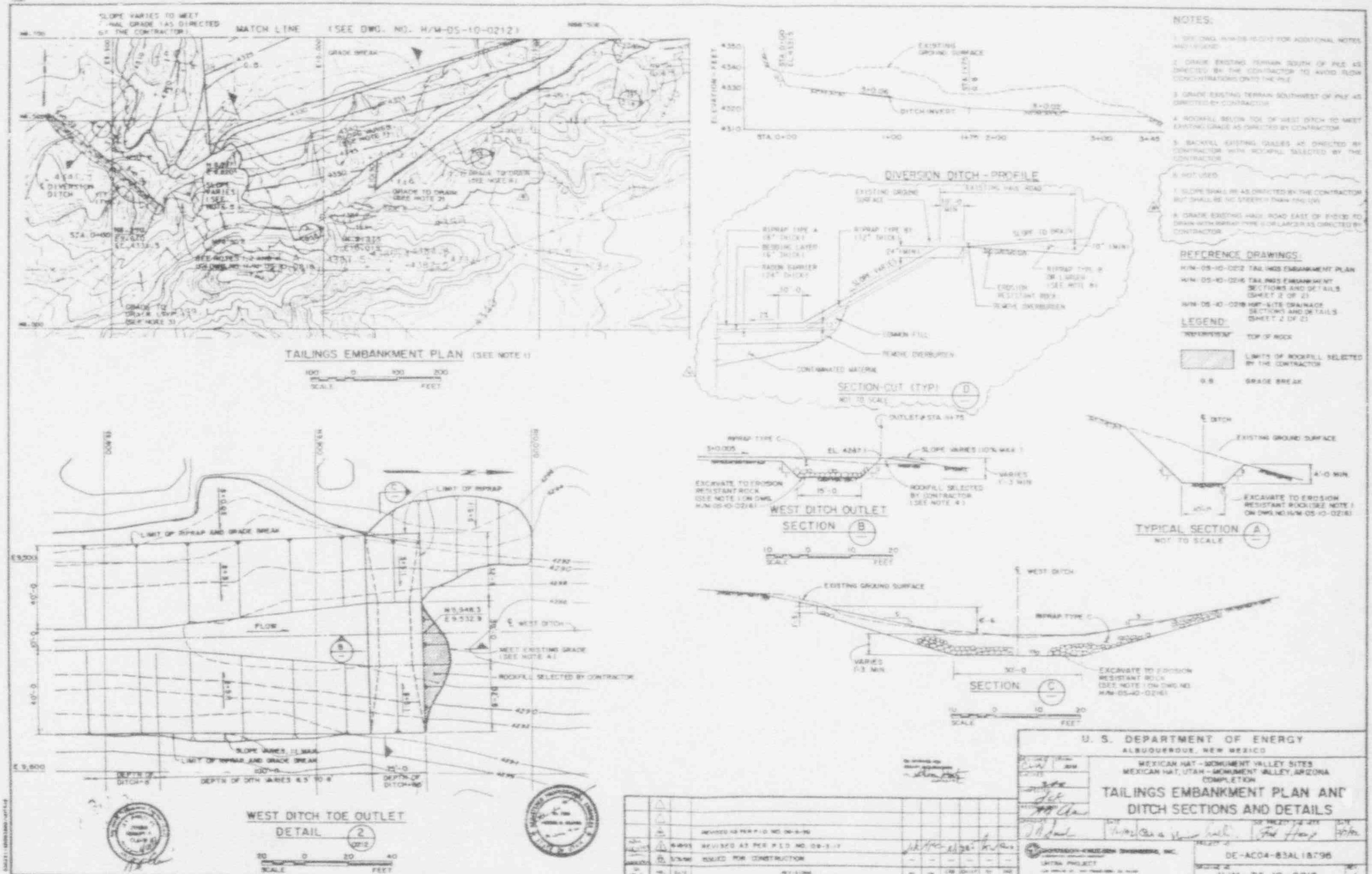

NOTES:
1. THE EROSION PROTECTION WILL BE PROVIDED EITHER BY TYPE C RIPRAP ON A 2H:1V SLOPE OR TYPE B RIPRAP ON A 2.5H:1V SLOPE.
2. BACKFILLS EXISTING GULLIES WITH ROCKFILL SELECTED BY THE CONTRACTOR.
3. SLOPE VARIES TEN:1.
Sheet 4
Type B rock
Type B1 rock
Approx. Boundary of Type B1 rock
(Type A rock on 2% top slope)
GRADE BREAK
Type B1 rock for Apron along ukedge of 7:1/8:1
Type B or larger rocks, pack-fill to for grading to drain across roadway
Type B rock for Apron at intersection of 2% top slope and natural slope
SCALE
FEET
DRAFT
U.S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT SITE
MEXICAN HAT, UTAH
SITE PLAN
DE-AC04-83AL18796


Sheet 5
NOTES:
1. EXACT LOCATION AND SLOPE OF RIPRAP TO BE PLACED ON EXISTING HAUL ROAD SHALL BE AS DIRECTED BY THE CONTRACTOR.
UMTRA/MHA
Erosion Protection
Embankment and South Edge Areas
BTW 11/29/93
EROSION PROTECTION PLAN
NOT TO SCALE
TYP. SECTION IN CUT
NOT TO SCALE
TYP. SECTION IN FILL
NOT TO SCALE
SECTION
NOT TO SCALE
EXISTING HAUL ROAD
CONTAMINATED MATERIAL
REMOVE OVERBURDEN
COMMON FILL
EROSION RESISTANT ROCK
NORTH DITCH
WEST DITCH
GULLY 1
GULLY 2
GULLY 3
RIPRAP TYPE A
RIPRAP TYPE B
RIPRAP TYPE B1
RIPRAP TYPE C
LEGEND:
ROCK TO BE CHIPPED
DRAFT
U.S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT SITE
MEXICAN HAT, UTAH
EROSION PROTECTION
PLAN AND SECTIONS
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
DE-AC04-83AL18796

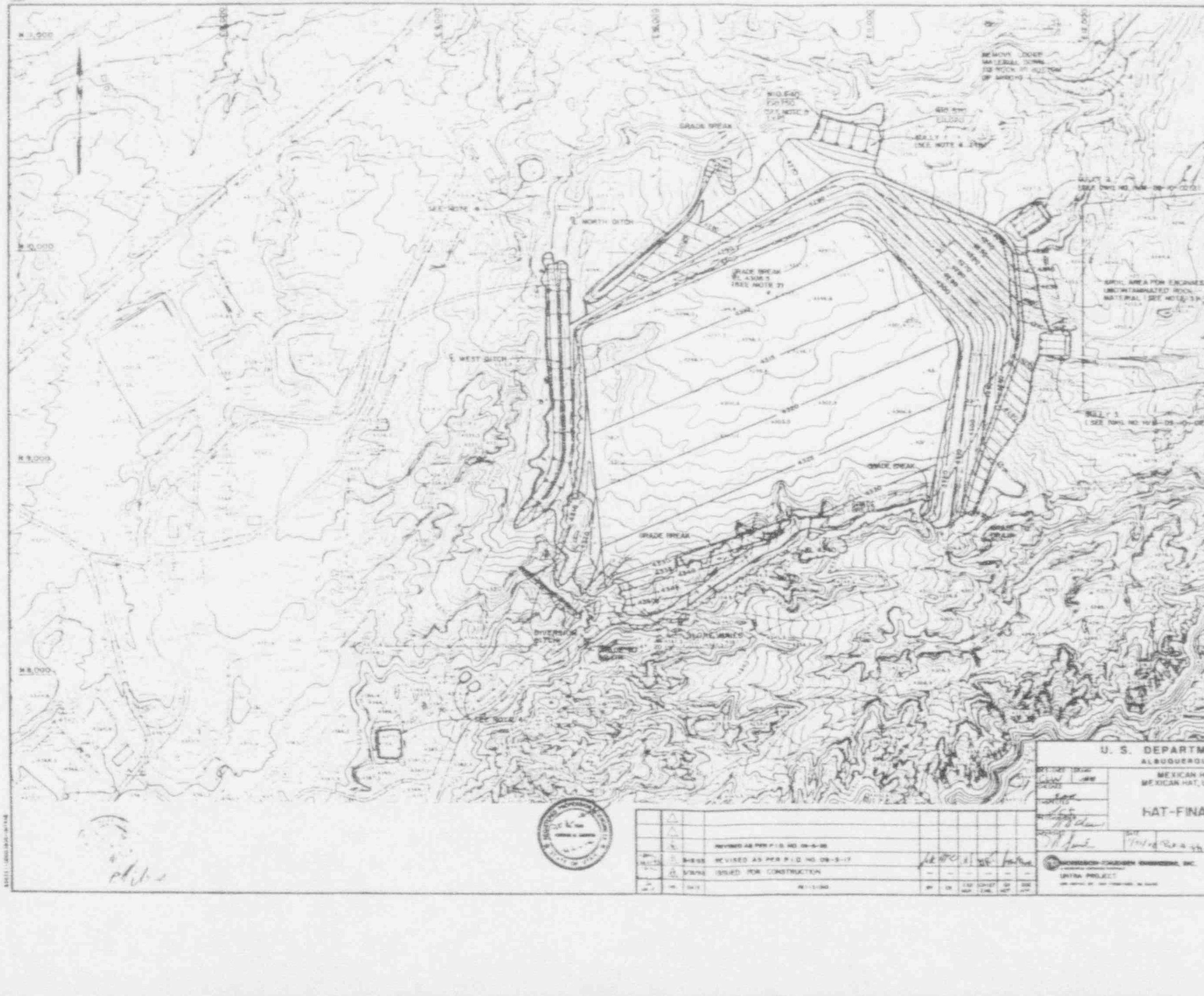

NOTES:
1. EXCAVATE THE EXISTING GRADE TO 1 FOOT (MIN) BELOW THE RADON BARRIER LAYER.
2. BACKFILLS EXISTING GULLIES WITH ROCKFILL SELECTED BY THE CONTRACTOR.
3. SLOPE SHALL BE AS DIRECTED BY THE CONTRACTOR BUT SHALL BE NO STEEPER THAN
GRADE BREAK
SEE NOTE 1
GRADE BREAK
GRADE BREAK
GRADE BREAK
SLOPE TO DRAIN WITH TYPE B OR LARGER RIPRAP
GRADE TO DRAIN EAST
OF DIVERSION DITCH
LEGEND:
TOP OF CUT
SCALE
FEET
100 0 100 200
MEXICAN HAT SITE
MEXICAN HAT, UTAH
PARTIAL TAILINGS EMBANKMENT PLAN
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
SKETCH 1


EROSION PROTECTION PLAN
NOT TO SCALE
RIPRAP TYPE A
RIPRAP TYPE B
RIPRAP TYPE B1
RIPRAP TYPE C
RIPRAP TYPE B OR LARGER (SEE NOTE 1)
GULLY 1
GULLY 2
GULLY 3
NORTH DITCH
WEST DITCH
TYP. SECTION IN CUT B
NOT TO SCALE
TYP. SECTION IN FILL C
NOT TO SCALE
SECTION A
NOT TO SCALE
SECTION D
NOT TO SCALE
EXISTING GROUND SURFACE
EXISTING HAUL ROAD
SLOPE TO DRAIN
EROSION RESISTANT ROCK
REMOVE OVERBURDEN
COMMON FILL
CONTAMINATED MATERIAL
BEDDING LAYER
RADON BARRIER
BACKFILL THE EXISTING GULLY WITH RIPRAP TYPE C AS DIRECTED BY THE CONTRACTOR
EXCAVATE TO EROSION RESISTANT ROCK
ROCKFILL TO BE SELECTED BY CONTRACTOR
NOTES:
1. EXACT LOCATION AND SLOPE OF RIPRAP TO BE PLACED ON EXISTING HAUL ROAD SHALL BE AS DIRECTED BY THE CONTRACTOR.
LEGEND:
C.B. GRADE BREAK
ROCK TO BE CHIPPED
RIPRAP TYPE A
RIPRAP TYPE B1
RIPRAP TYPE B
RIPRAP TYPE C
ROCKFILL TO BE SELECTED BY THE CONTRACTOR
MEXICAN HAT SITE
MEXICAN HAT, UTAH
EROSION PROTECTION PLAN AND SECTIONS
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
SKETCH 2


NOTES:
1. GRADE APRON AREA TO ELIMINATE HIGH SPOTS AND PREVENT FLOW CONCENTRATIONS AS DIRECTED BY THE CONTRACTOR. EXISTING FILL IN APRON AREA CONTAINS PIECES OF SHOT ROCK.
2. CORNER CONTOURS ON THE TAILINGS EMBANKMENT SHALL BE ROUNDED WITH A 50' RADIUS IN THE PLAN VIEW UNLESS NOTED OTHERWISE.
3. EXISTING AND NEW DISPLACEMENT MONUMENT RODS AND PIPES SHALL BE EXTENDED TO FINAL SURFACE.
4. SEE THE INFORMATION FOR BIDDERS FOR DATA ON THE EXISTING SETTLEMENT MONUMENTS.
5. FOR A NEW TYPICAL DISPLACEMENT MONUMENT INSTALLATION DETAIL, SEE DWG NO. H/M-05-10-0216.
6. FINAL GRADES SHOWN IN THE APRON AREA MAY BE ADJUSTED BY THE CONTRACTOR TO FACILITATE SURFACE DRAINAGE AND REDUCE FLOW CONCENTRATIONS.
7. ROCK SHALL BE CHIPPED OR PLANED. NO BLASTING OR RIPPING WILL BE PERMITTED.
8. TO BE EXCAVATED A MINIMUM OF 1.0' BELOW BOTTOM OF RADON BARRIER.
REFERENCE DRAWINGS:
H/M-05-10-0215 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-05-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-05-10-0217 HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-05-10-0218 HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-05-10-0219 HAT-EROSION PROTECTION PLAN AND SECTIONS
H/M-05-10-0213 TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS
LEGEND:
AREA OF ROCK CHIPPING
EXISTING CONTOURS
4320 FINAL CONTOURS
DRAINAGE DITCH
N10,000 CONSTRUCTION GRID COORDINATE
TOP OF CUT
TOP OF FILL
LIMIT OF CONTAMINATED MATERIAL
APPROXIMATE LIMIT OF ROCK OUTCROP TO BE EXCAVATED
EXISTING DISPLACEMENT MONUMENT LOCATION & ELEVATION OF BASE PLATE AS OF MARCH 1985
NEW DISPLACEMENT MONUMENT LOCATION
MATCH LINE (SEE DWG. NO. H/M-05-10-0213)
SCALE 100 0 100 200 FEET
REVISED AS PER P.I.D. NO. 05-5-26
REVISED AS PER P.I.D. NO. 05-5-17
ISSUED FOR CONSTRUCTION
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION
TAILINGS EMBANKMENT PLAN
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
DE-AC04-83AL18796
H/M-05-10-0212



NOTES:
1. SEE DWG. H/M-05-10-0212 FOR ADDITIONAL NOTES AND LEGEND.
2. GRADE EXISTING TERRAIN SOUTH OF PILE AS DIRECTED BY THE CONTRACTOR TO AVOID FLOW CONCENTRATIONS ONTO THE PILE.
3. GRADE EXISTING TERRAIN SOUTHWEST OF PILE AS DIRECTED BY CONTRACTOR.
4. ROCKFILL BELOW TOE OF WEST DITCH TO MEET EXISTING GRADE AS DIRECTED BY CONTRACTOR.
5. BACKFILL EXISTING GULLIES AS DIRECTED BY CONTRACTOR WITH ROCKFILL SELECTED BY THE CONTRACTOR.
6. NOT USED.
7. SLOPE SHALL BE AS DIRECTED BY THE CONTRACTOR BUT SHALL BE NO STEEPER THAN 1H:1.5V.
8. GRADE EXISTING HAUL ROAD EAST OF E10130 TO DRAIN WITH RIPRAP TYPE C OR LARGER AS DIRECTED BY CONTRACTOR.
REFERENCE DRAWINGS:
H/M-05-10-0212 TAILINGS EMBANKMENT PLAN
H/M-05-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-05-10-0218 HMT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 2 OF 2)
LEGEND:
TOP OF ROCK
LIMITS OF ROCKFILL SELECTED BY THE CONTRACTOR
G.B. GRADE BREAK
MATCH LINE (SEE DWG. NO. H/M-05-10-0212)
SLOPE VARIES TO MEET FINAL GRADE (AS DIRECTED BY THE CONTRACTOR)
GRADE BREAK
DIVERSION DITCH
GRADE TO DRAIN (SEE NOTE 2)
GRADE TO DRAIN (SEE NOTE 3)
TAILINGS EMBANKMENT PLAN (SEE NOTE 1)
SCALE FEET
EXISTING GROUND SURFACE
DITCH INVERT
STA. 0+00
DIVERSION DITCH - PROFILE
EXISTING HAUL ROAD
RIPRAP TYPE A (18" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER (24" THICK)
RIPRAP TYPE B (12" THICK)
SLOPE TO DRAIN
EROSION RESISTANT ROCK
REMOVE OVERBURDEN
COMMON FILL
CONTAMINATED MATERIAL
SECTION-CUT (TYP) D
NOT TO SCALE
OUTLET @ STA. 1+75
RIPRAP TYPE C
EL. 4247
SLOPE VARIES (10% MAX.)
EXCAVATE TO EROSION RESISTANT ROCK (SEE NOTE 1 ON DWG. H/M-05-10-0216)
ROCKFILL SELECTED BY CONTRACTOR (SEE NOTE 4)
WEST DITCH OUTLET
SECTION B
TYPICAL SECTION A
NOT TO SCALE
EXISTING GROUND SURFACE
4'-0 MIN.
WEST DITCH
SECTION C
LIMIT OF RIPRAP
LIMIT OF RIPRAP AND GRADE BREAK
FLOW
MEET EXISTING GRADE (SEE NOTE 4)
ROCKFILL SELECTED BY CONTRACTOR
SLOPE VARIES, 1% MAX.
DEPTH OF DITCH VARIES 6.5' TO 8'
WEST DITCH TOE OUTLET
DETAIL 2
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION
TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS
REVISED AS PER F.I.D. NO. 08-3-17
ISSUED FOR CONSTRUCTION
UMTRA PROJECT
DE-AC04-83AL18796
H/M-05-10-0213



NOTES:

1. SEE DWG NO. H/M-DS-10-0212 AND H/M-DS-10-0213 FOR FINAL SITE GRADING REQUIREMENTS AROUND DISPOSAL CELL.
2. THE ACTUAL LOCATION OF THE GRADE BREAK BETWEEN THE EMBANKMENT TOP AND THE 5:1 SIDESLOPES WILL VARY BASED ON THE VOLUME OF CONTAMINATED MATERIAL PLACED IN THE EMBANKMENT.
3. ALTERNATIVE SPOIL AREA MAY BE SELECTED BY CONTRACTOR.
4. ALL DEPRESSIONS AND LOW SPOTS INCLUDING WATER PONDS SHALL BE BACKFILLED WITH COMMON FILL AND SLOPED TO DRAIN AS DIRECTED BY THE CONTRACTOR.
5. FOR LEGEND, SEE DWG NO. H/M-DS-10-0202.
6. FOR GULLY DETAILS, SEE DWG NO. H/M-DS-10-0220.
7. REMOVE TEMPORARY ACCESS ROADS AND [illegible] AREAS AS DIRECTED BY THE CONTRACTOR.
8. FINAL GRADES MAY BE ADJUSTED BY THE CONTRACTOR TO MEET THE FIELD CONDITIONS.

REFERENCE DRAWINGS:

H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN
H/M-DS-10-0213 TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS
H/M-DS-10-0220 HAT - GULLY DETAILS

LEGEND:

TOP OF CUT
TOP OF FILL
FLOWPATH

200 0 200 400
SCALE FEET

		REVISED AS PER P.I.D. NO. 09-6-[illegible]
	8-9-95	REVISED AS PER P.I.D. NO. 09-5-17
	5/9/94	ISSUED FOR CONSTRUCTION

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

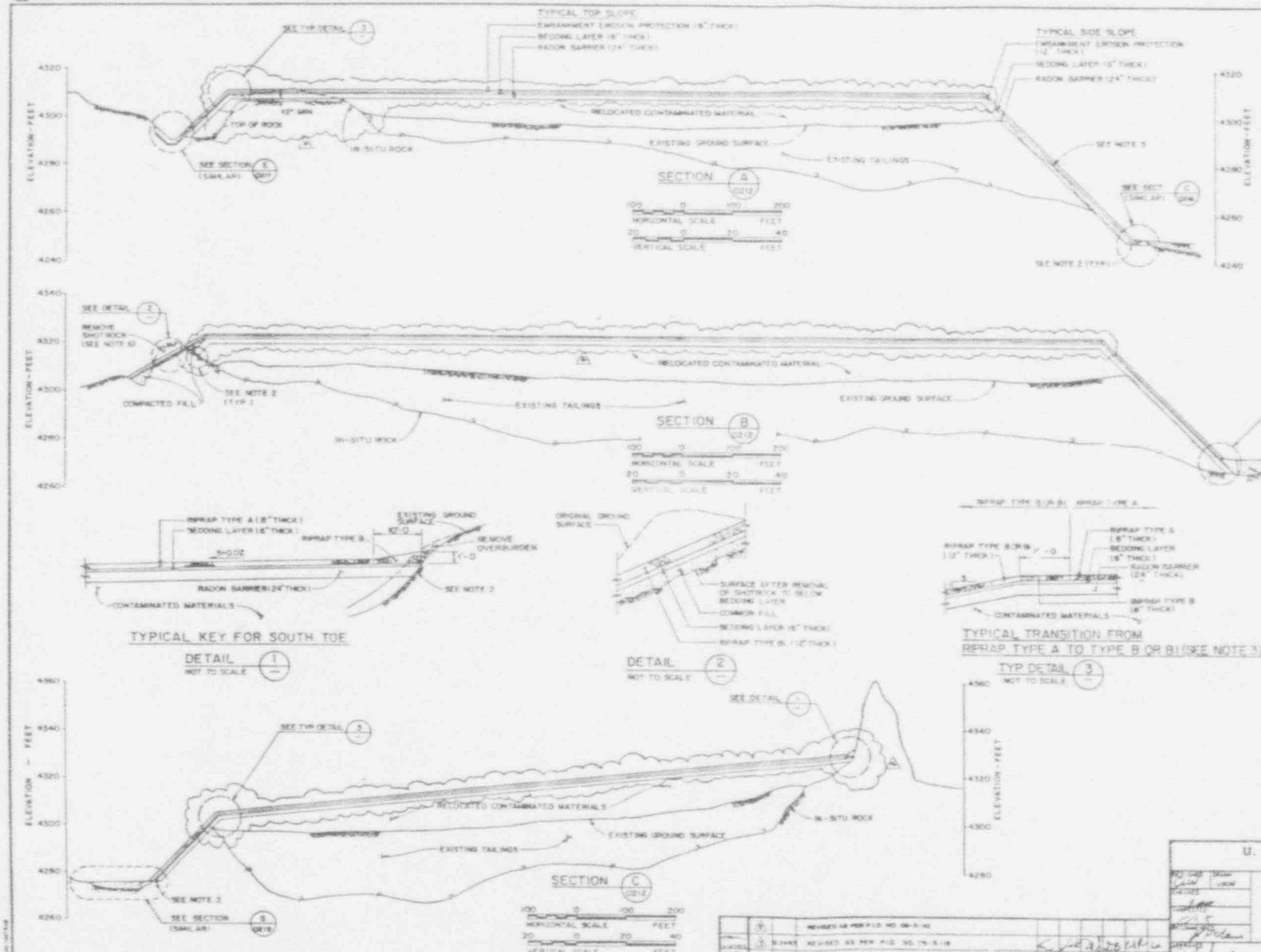
MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA
COMPLETION

HAT-FINAL SITE GRADING PLAN

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. H/M-DS-10-0214



NOTES:

1. THICKNESS OF THE RADON BARRIER MAY BE REVISED BY THE CONTRACTOR BASED ON RADIOLOGICAL MEASUREMENT OF CONTAMINATED FILL MATERIALS PLACED ON THE EMBANKMENT.
2. EXTEND RADON BARRIER AND EROSION PROTECTION TO TIE INTO UNCONTAMINATED COMPETENT IN-SITU ROCK. ALL OVERBURDEN AND LOOSE ROCK SHALL BE REMOVED PRIOR TO PLACING RADON BARRIER AND EROSION PROTECTION.
3. SEE EROSION PROTECTION PLAN ON DWG. NO. H/M-05-10-[illegible] FOR LOCATION OF RIPRAP TYPE B AND TYPE B1.
4. NOT USED.
5. REGRADE EXISTING SLOPE TO MATCH FINAL GRADE OF CONTAMINATED MATERIALS.
6. SHOTROCK IS ROCK PREVIOUSLY BLASTED BY OTHERS BUT NOT EXCAVATED.

REFERENCE DRAWINGS:

- H/M-05-10-0212 TAILINGS EMBANKMENT PLAN
- H/M-05-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
- H/M-05-10-0217 HAT SITE DRAINAGE SECTIONS AND DETAILS (SHEET 1 OF 2)
- H/M-05-10-0219 HAT-EROSION PROTECTION PLAN AND SECTIONS

LEGEND:

TOP OF ROCK

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

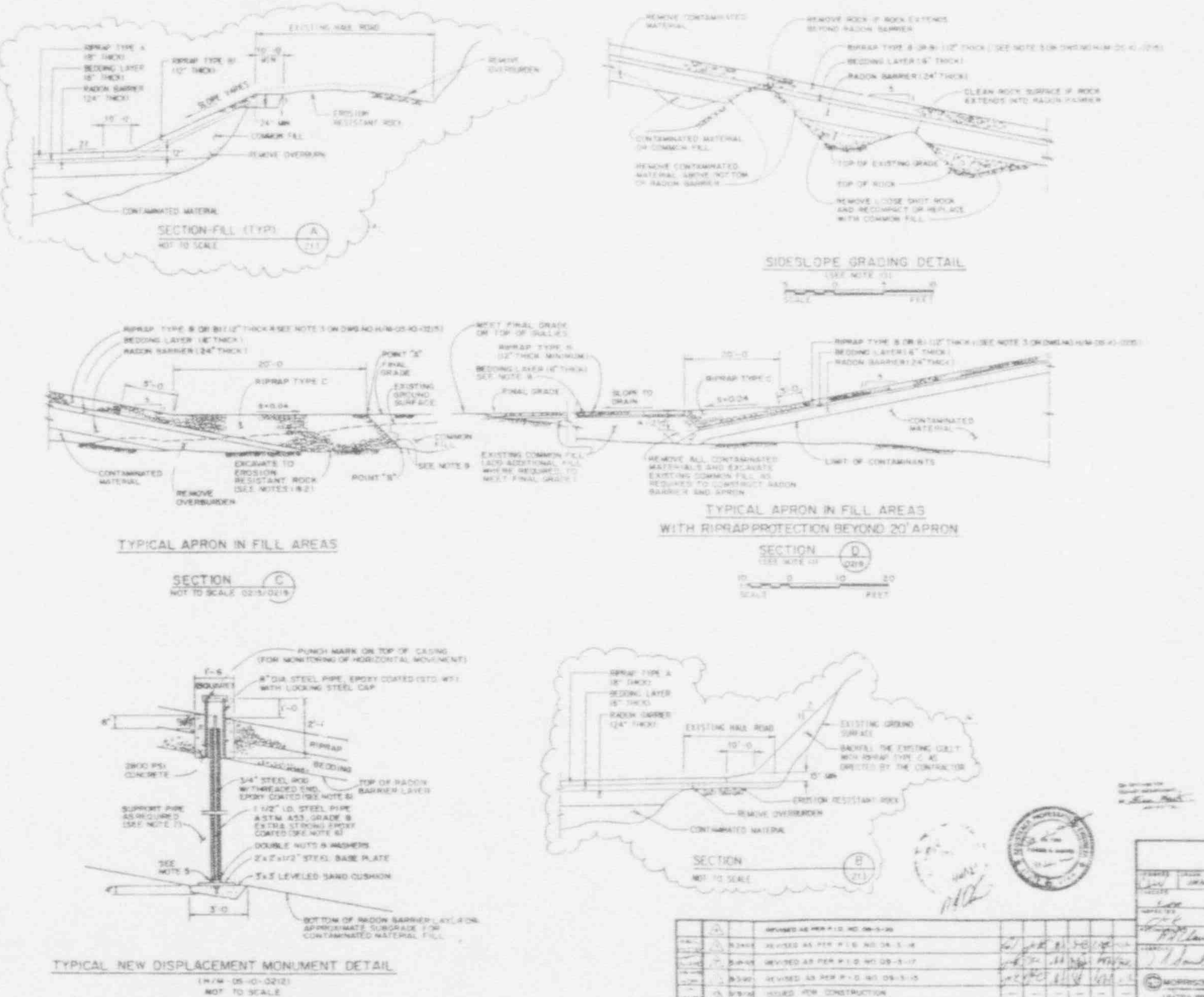
TAILINGS EMBANKMENT SECTIONS AND DETAILS

(SHEET 1 OF 2)

UMTRA PROJECT

DE-AC04-83AL18796

H/M-05-10-0215



NOTES:

1. EROSION RESISTANT ROCK IS DETERMINED BY REFUSAL OF A POWER AUGER DRILLING VERTICALLY USING AN AUGER BIT. TRENCH BOTTOMS WILL BE TESTED ON MAXIMUM OF 20 FOOT CENTERS. GENERALLY EROSION RESISTANT ROCK IS NATURAL, UNDISTURBED, INTACT ROCK WHICH CANNOT BE READILY RIPPED OR LOOSENED OR BROKEN BY A BACKHOE DURING NORMAL EXCAVATION AND RINGS WHEN STRUCK WITH A GEOLOGIST'S ROCK HAMMER.
2. WHERE EXCAVATIONS ARE TO GO TO EROSION RESISTANT ROCK, THE SUBCONTRACTOR SHALL EXPOSE THE EROSION RESISTANT ROCK FOR INSPECTION AND LOGGING BY THE CONTRACTOR'S GEOLOGIST. ALL LOOSE MATERIAL SHALL BE REMOVED AND THE ROCK SURFACE CLEANED TO THE ACCEPTABLE ROCK CLEANUP SURFACE. BACKFILL SHALL NOT BE PLACED UNTIL CONTRACTOR APPROVES THE ROCK SURFACE AT THE BOTTOM OF THE EXCAVATION.
3. FOR APRON AREAS REQUIRING RIPRAP PROTECTION SEE DWG NO. H/M-05-10-0219.
4. LENGTH OF PIPE AND ROD OF EXISTING DISPLACEMENT MONUMENT VARY ACCORDING TO ELEVATION OF BASE PLATE AS SHOWN ON DWG NO. H/M-05-10-0212.
5. WHERE THE BASE PLATE IS LOCATED AT THE TOP OF THE RELOCATED TAILINGS (UNDERNEATH THE RADON BARRIER) THE PIPE SHALL BE PLACED DIRECTLY ON THE PLATE. PIPES SHALL NOT BE ATTACHED TO PLATES OR RODS.
6. PIPES AND RODS WITH TOTAL LENGTH GREATER THAN FOUR FEET SHALL BE INSTALLED IN 4-FOOT SECTIONS AS FILL CONSTRUCTION PROGRESSES. RODS SHALL BE SECURELY FLUSH-COUPLED AS REQUIRED. PIPES SHALL BE SECURELY COUPLED SUCH THAT INSIDE DIAMETER IS NOT LESS THAN 1 1/2" AT ANY POINT. SUBCONTRACTOR SHALL MAKE ELEVATION MEASUREMENTS OF TOP OF ROD IMMEDIATELY BEFORE AND AFTER ADDITION OF EACH ROD SECTION. PIPES SHALL BE CAPPED AT ALL TIMES TO PREVENT ENTRANCE OF FOREIGN MATTER.
7. PIPES SHALL BE SUPPORTED BY FILL COMPACTED BY LIGHT WEIGHT TAMPERS WITHIN FIVE FEET OF PIPES TO MEET SAME COMPACTION REQUIREMENTS AS FOR ADJACENT FILL. CARE SHALL BE TAKEN TO ENSURE THAT PIPES REMAIN NOMINALLY CENTERED AROUND RODS.
8. BEYOND THE EMBANKMENT APRON, BEDDING LAYER IS NOT REQUIRED IF RIPRAP IS IN CONTACT WITH IN SITU BEDROCK.
9. THE DEPTH TO EROSION RESISTANT ROCK BELOW POINT "A" WILL VARY. THE MINIMUM DEPTH IS 15 INCHES BELOW FINAL GRADE. THE LOCATION OF POINT "A" IS FIXED. THE 1:1 SLOPE OF RIPRAP TYPE C EXTENDS TO TOP OF THE EROSION RESISTANT ROCK. LOCATION OF POINT "B" WILL VARY.
10. SIDE SLOPE DETAIL APPLIES TO AREAS OF EXISTING SIDE SLOPE WHERE ROCK IS AT OR NEAR THE SURFACE.
11. SECTION D - APPLIES BETWEEN THE GULLIES AND THE EMBANKMENT AND OTHER AREAS WHERE DEPTH TO COMPETENT ROCK BELOW FINAL GRADE IS GREATER THAN 4'-2 1/2".

REFERENCE DRAWINGS:

H/M-05-10-0212 TAILINGS EMBANKMENT PLAN
H/M-05-10-0213 TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS
H/M-05-10-0215 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-05-10-0219 HAT-EROSION PROTECTION PLAN AND SECTIONS

		REVISED AS PER P.I.O. NO. 05-5-20
	8/3/86	REVISED AS PER P.I.O. NO. 05-5-16
	5/4/86	REVISED AS PER P.I.O. NO. 05-5-17
	8/3/86	REVISED AS PER P.I.O. NO. 05-5-15
	5/5/86	ISSUED FOR CONSTRUCTION
NO.	DATE	REVISIONS

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

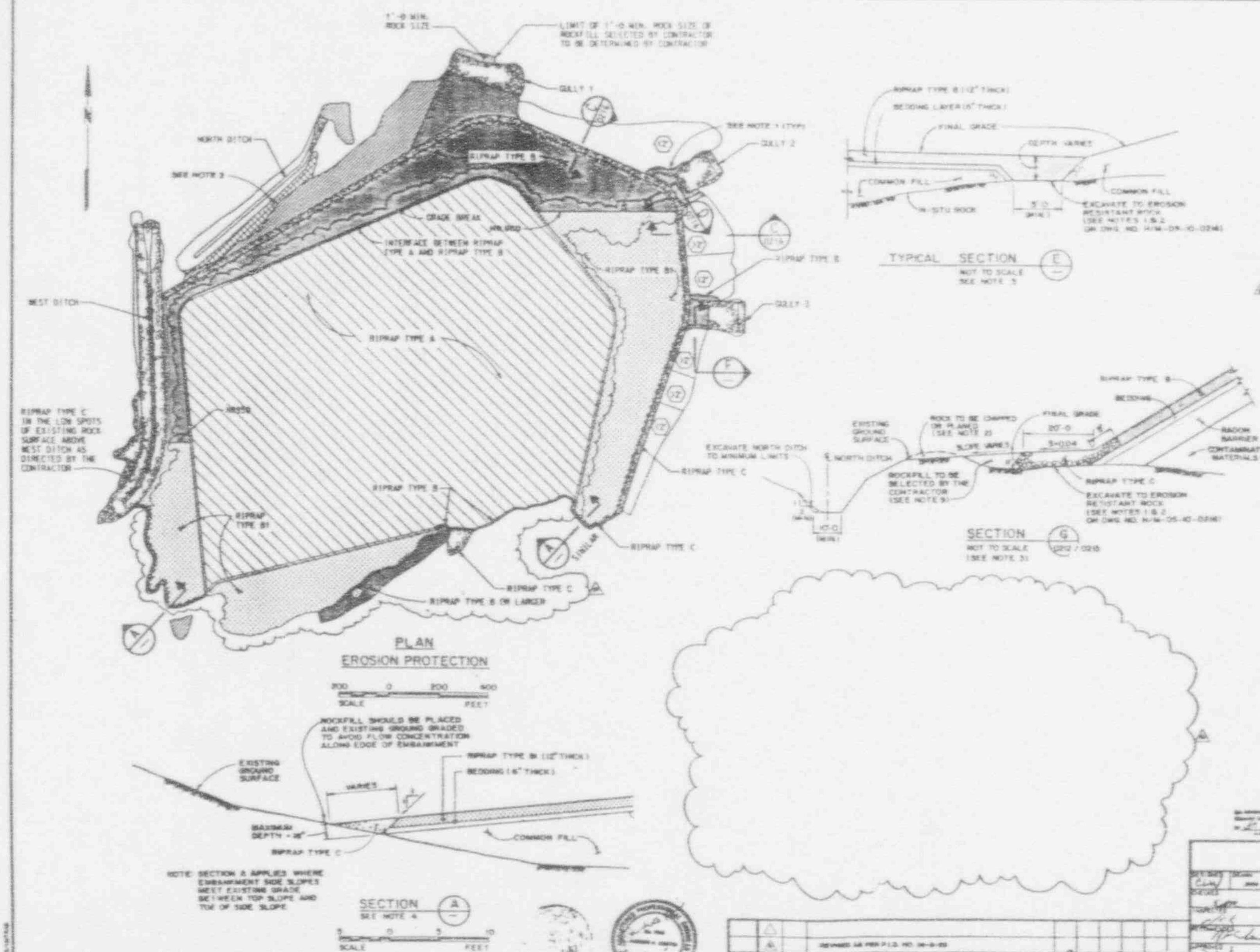
MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA
COMPLETION

TAILINGS EMBANKMENT
SECTIONS AND DETAILS
(SHEET 2 OF 2)

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

DE-AC04-83AL18796

H/M-05-10-0216



NOTES:

1. THE OUTER LIMIT OF RIPRAP COVER SHOWN IS APPROXIMATE. FINAL LIMIT SHALL BE DETERMINED IN THE FIELD DURING CONSTRUCTION.
2. ROCK TO BE CHIPPED OR PLANED SHALL NOT BE RIPPED OR BLASTED.
3. SECTION G APPLIES WHERE DEPTH TO ROCK BELOW FINAL GRADE IS 3 FEET OR LESS OR AS DIRECTED BY THE CONTRACTOR.
4. SECTION A APPLIES WHERE THE EMBANKMENT SIDE SLOPE COMES IN CONTACT WITH GROUND SURFACE. DETAIL 1 ON DWG. H/M-DS-10-0215 APPLIES WHERE THE EMBANKMENT TOP SLOPE COMES IN CONTACT WITH GROUND SURFACE.
5. SECTION E APPLIES WHEREVER THERE IS A TRANSITION BETWEEN EROSION PROTECTION AND COMMON FILL BETWEEN THE EMBANKMENT APRON AND THE GULLIES.
6. TOP OF RIPRAP TYPE C SHALL BE GRADED TO PROVIDE SMOOTH TRANSITION TO TOP OF RIPRAP TYPE A.
7. WIDTH IS 13.5' MINIMUM. ACTUAL WIDTH WILL BE DETERMINED BY THE CONTRACTOR DEPENDING ON LOCAL TOPOGRAPHY.
8. NOT USED.
9. ROCKFILL TO BE PLACED IN 1-FOOT LIFTS AND COMPACTED BY TRACK WALKING.

REFERENCE DRAWINGS:

- H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN
- H/M-DS-10-0215 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
- H/M-DS-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)

LEGEND:

- TOP OF CUT
- TOP OF FILL
- TOP OF ROCK
- ROCK TO BE CHIPPED
- RIPRAP TYPE A
- RIPRAP TYPE B1
- RIPRAP TYPE B
- RIPRAP TYPE C
- ROCKFILL (TO BE SELECTED BY CONTRACTOR)
- APPROXIMATE DEPTH OF EXISTING FILL IN APRON IS LESS THAN 4' BUT GREATER THAN 2'
- APPROXIMATE DEPTH OF EXISTING FILL IN APRON IS LESS THAN 2'

4		REVISED AS PER P.I.D. NO. 06-8-89
3		REVISED AS PER P.I.S. NO. 05-5-18
2		REVISED AS PER P.I.S. NO. 05-2-17
1		ISSUED FOR CONSTRUCTION

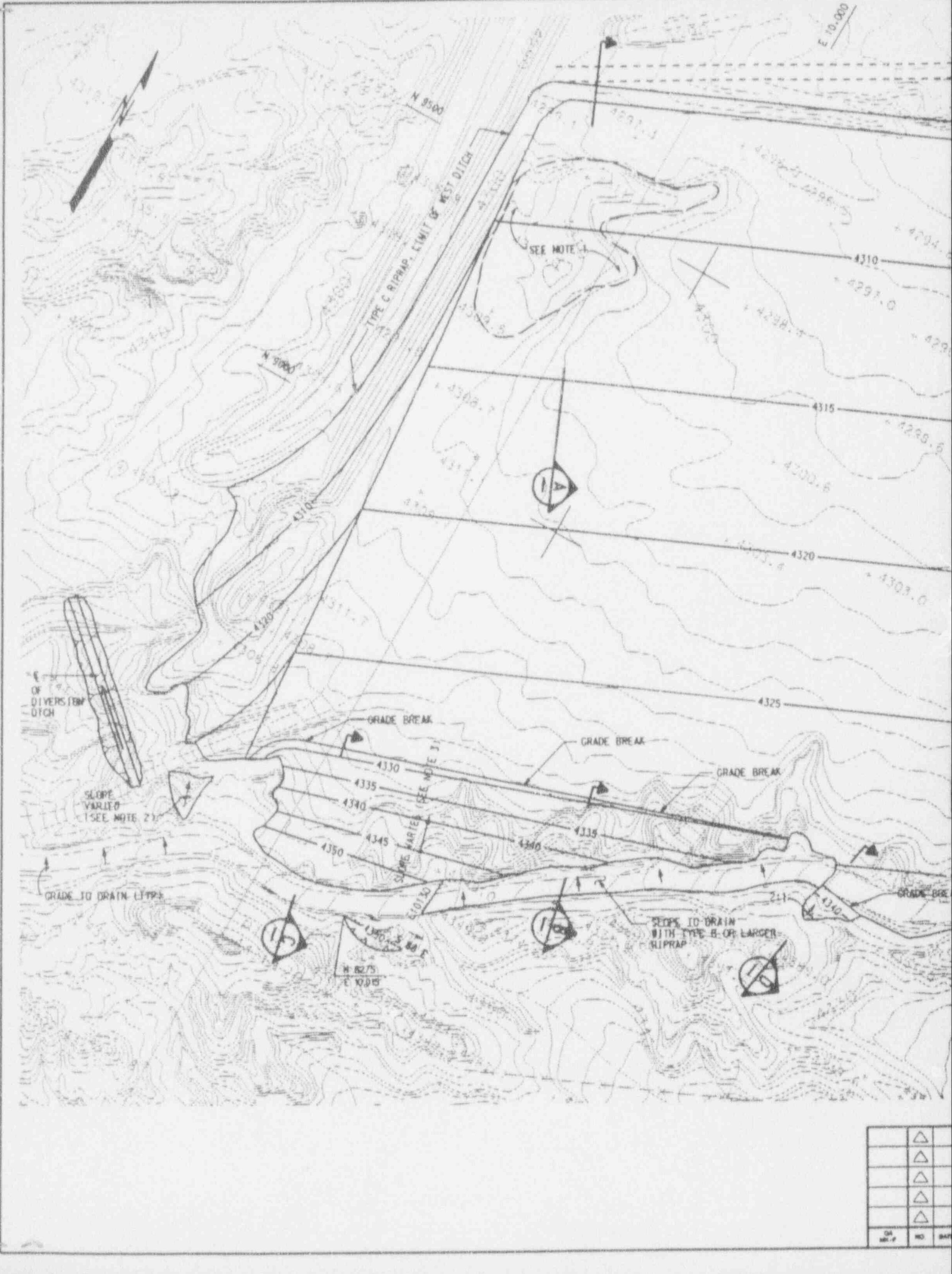
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA
COMPLETION

HAT-EROSION PROTECTION
PLAN AND SECTIONS

DE-AC04-83AL18796

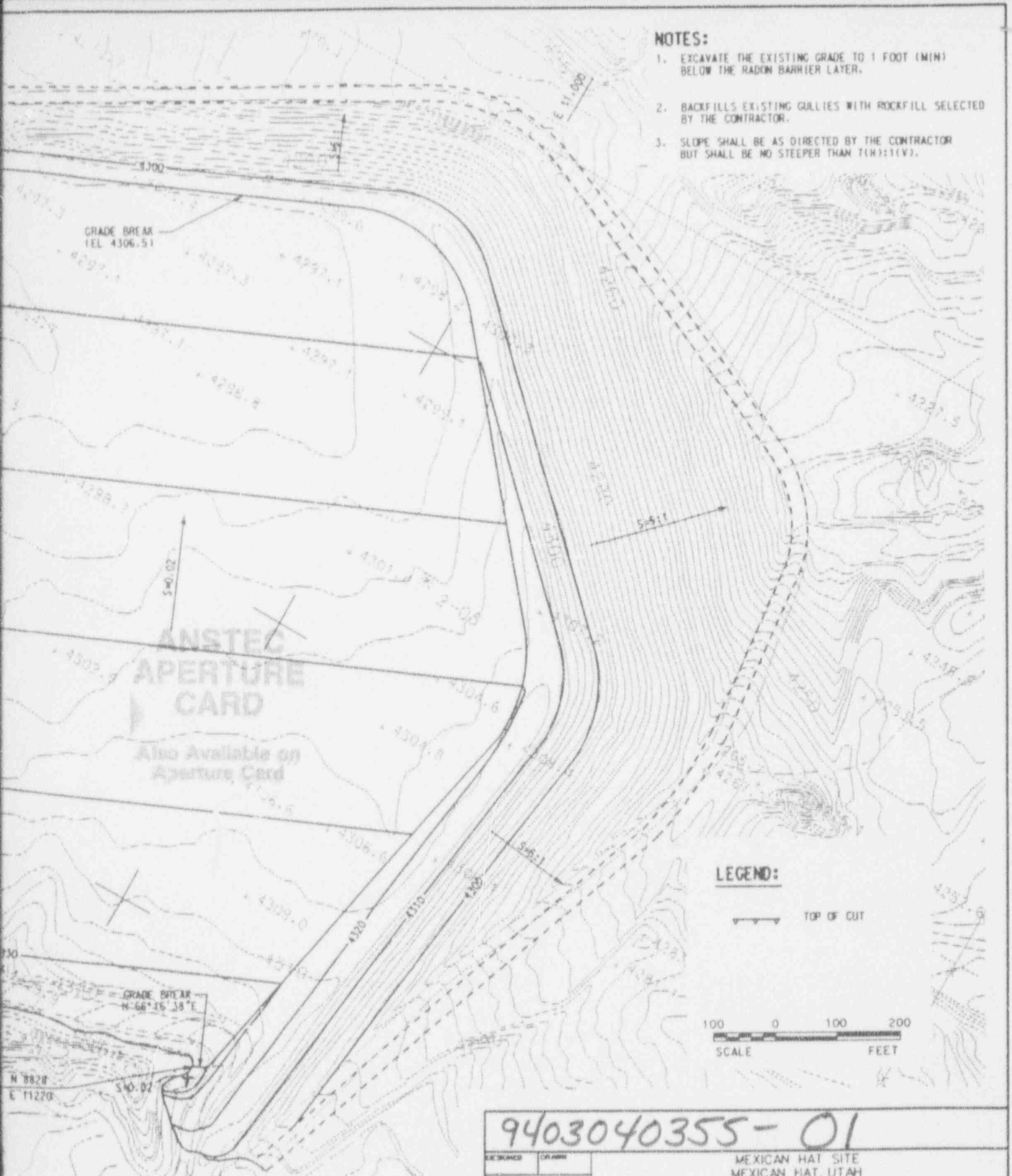
H/M-DS-10-0219



E 10,000
N 9500
N 9000
TYPE C RIPRAP, LIMIT OF WEST DITCH
SEE NOTE 1
4310
4315
4320
4325
4330
4335
4340
4345
4350
GRADE BREAK
GRADE BREAK
GRADE BREAK
SLOPE VARIES (SEE NOTE 3)
OF DIVERSION DITCH
SLOPE VARIED (SEE NOTE 2)
GRADE TO DRAIN
SLOPE TO DRAIN WITH TYPE B OR LARGER RIPRAP
N 8275
E 10,015
2:1

NOTES:

1. EXCAVATE THE EXISTING GRADE TO 1 FOOT (MIN) BELOW THE RADON BARRIER LAYER.
2. BACKFILLS EXISTING GULLIES WITH ROCKFILL SELECTED BY THE CONTRACTOR.
3. SLOPE SHALL BE AS DIRECTED BY THE CONTRACTOR BUT SHALL BE NO STEEPER THAN 7(H):1(V).



LEGEND:

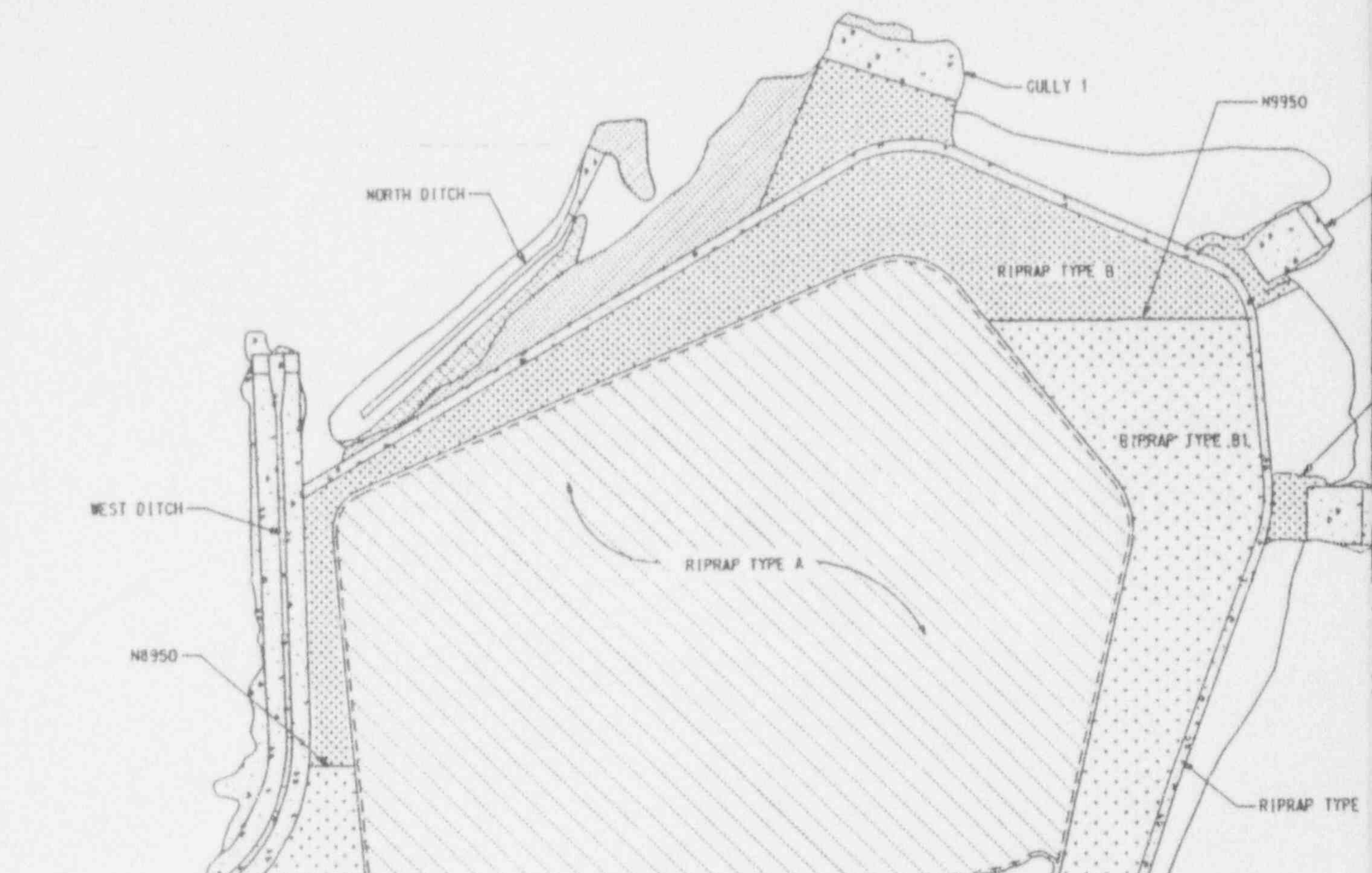
TOP OF CUT

100 0 100 200
SCALE FEET

9403040355-01

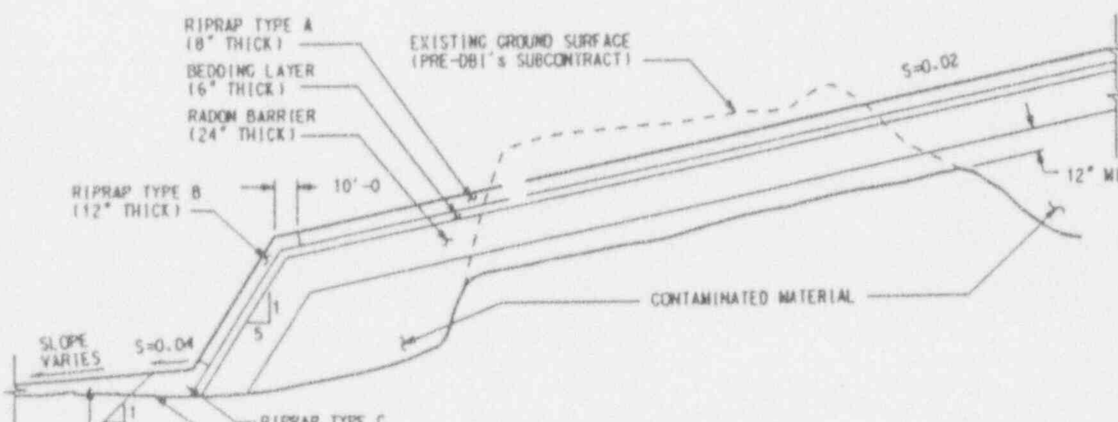
DESIGNED / DRAWN / CHECKED / INSPECTED / RECOMMENDED	MEXICAN HAT SITE MEXICAN HAT, UTAH PARTIAL TAILINGS EMBANKMENT PLAN
APPROVED / DATE	DOE PROJECT ENGINEER / DATE
MORRISON-KNUDSEN ENGINEERS, INC. A MORRISON KNUDSEN COMPANY UMTRA PROJECT 180 HOWARD ST SAN FRANCISCO, CA 94105	SKETCH 1

REVISION	BY	CK	CHKD MOE	CHKD ENG	QA MGR	DOE APP



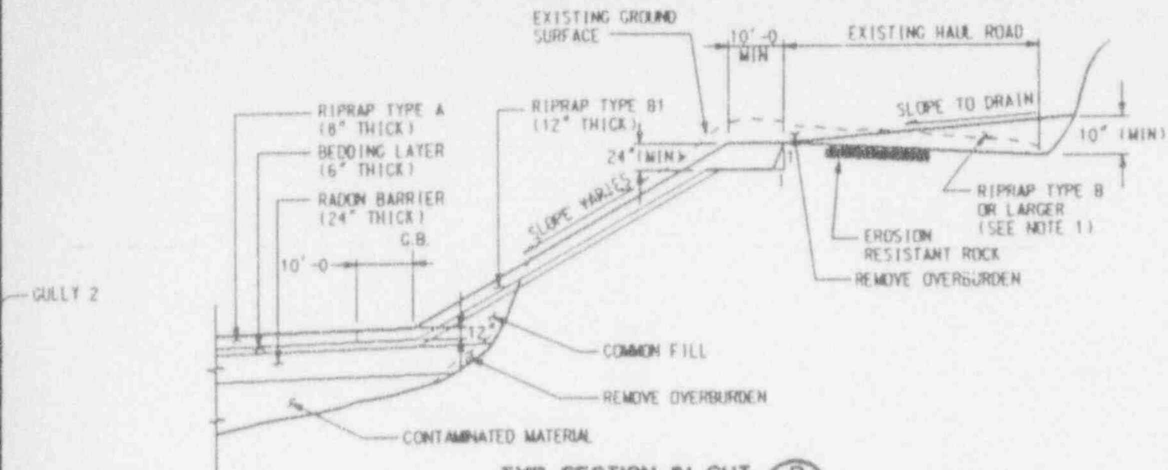
EROSION PROTECTION PLAN

NOT TO SCALE



SECTION (A)

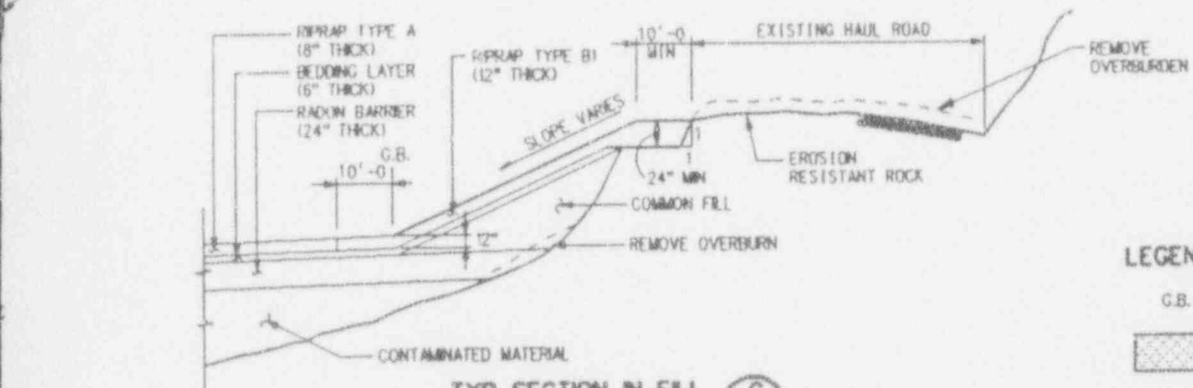
NOT TO SCALE



TYP. SECTION IN CUT (B)
NOT TO SCALE

NOTES:

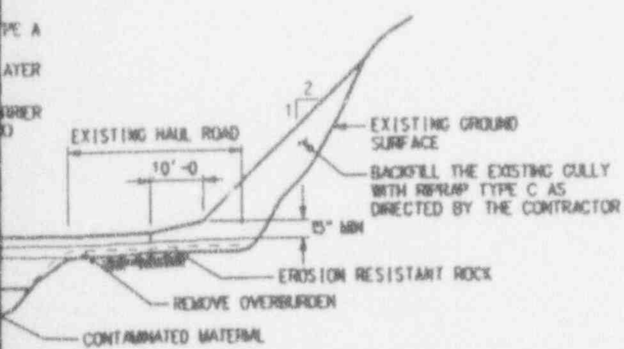
1. EXACT LOCATION AND SLOPE OF RIPRAP TO BE PLACED ON EXISTING HAUL ROAD SHALL BE AS DIRECTED BY THE CONTRACTOR.



TYP. SECTION IN FILL (C)
NOT TO SCALE

LEGEND:

G.B.	GRADE BREAK
	ROCK TO BE CHIPPED
	RIPRAP TYPE A
	RIPRAP TYPE B1
	RIPRAP TYPE B
	RIPRAP TYPE C
	ROCKFILL TO BE SELECTED BY THE CONTRACTOR



SECTION (D)
NOT TO SCALE

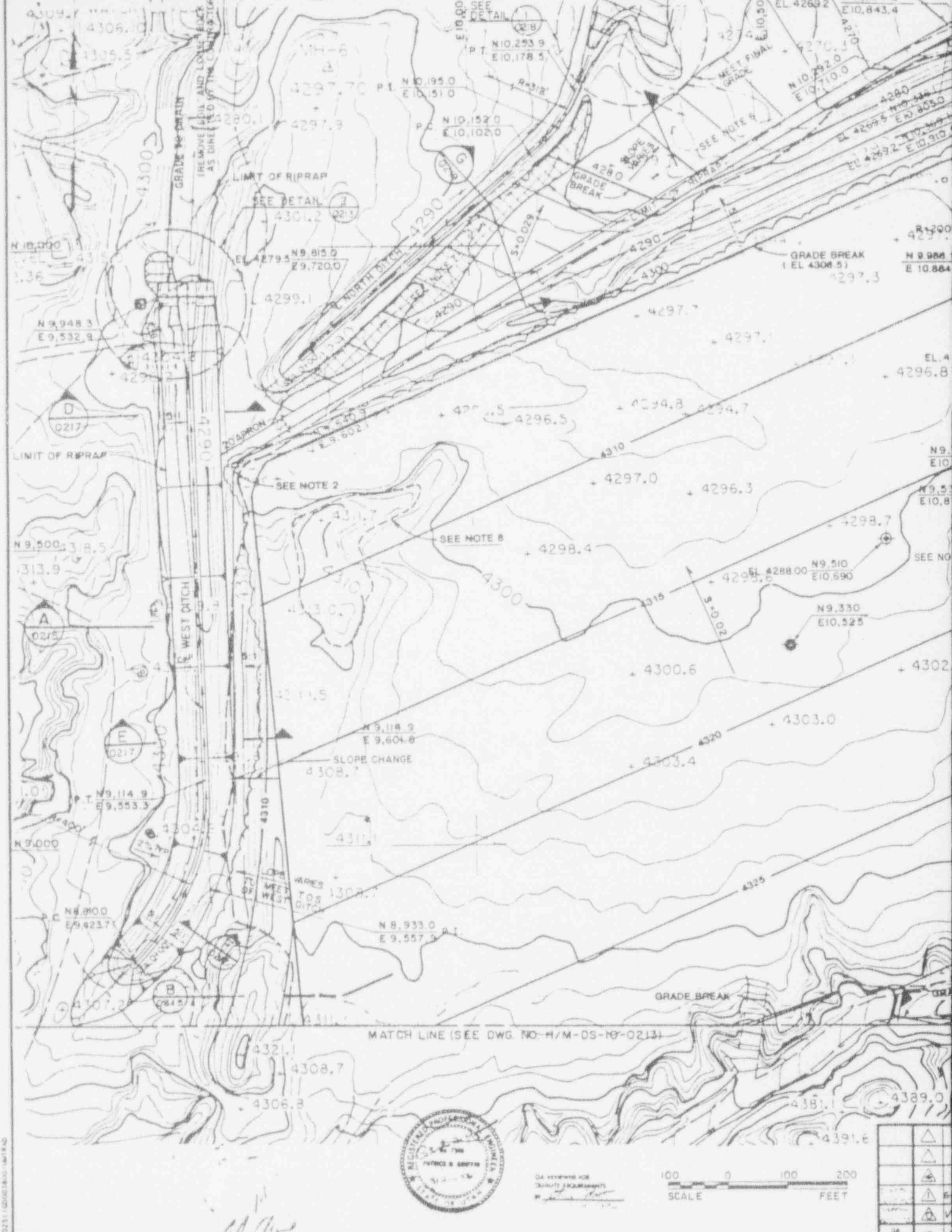
9403040355-02

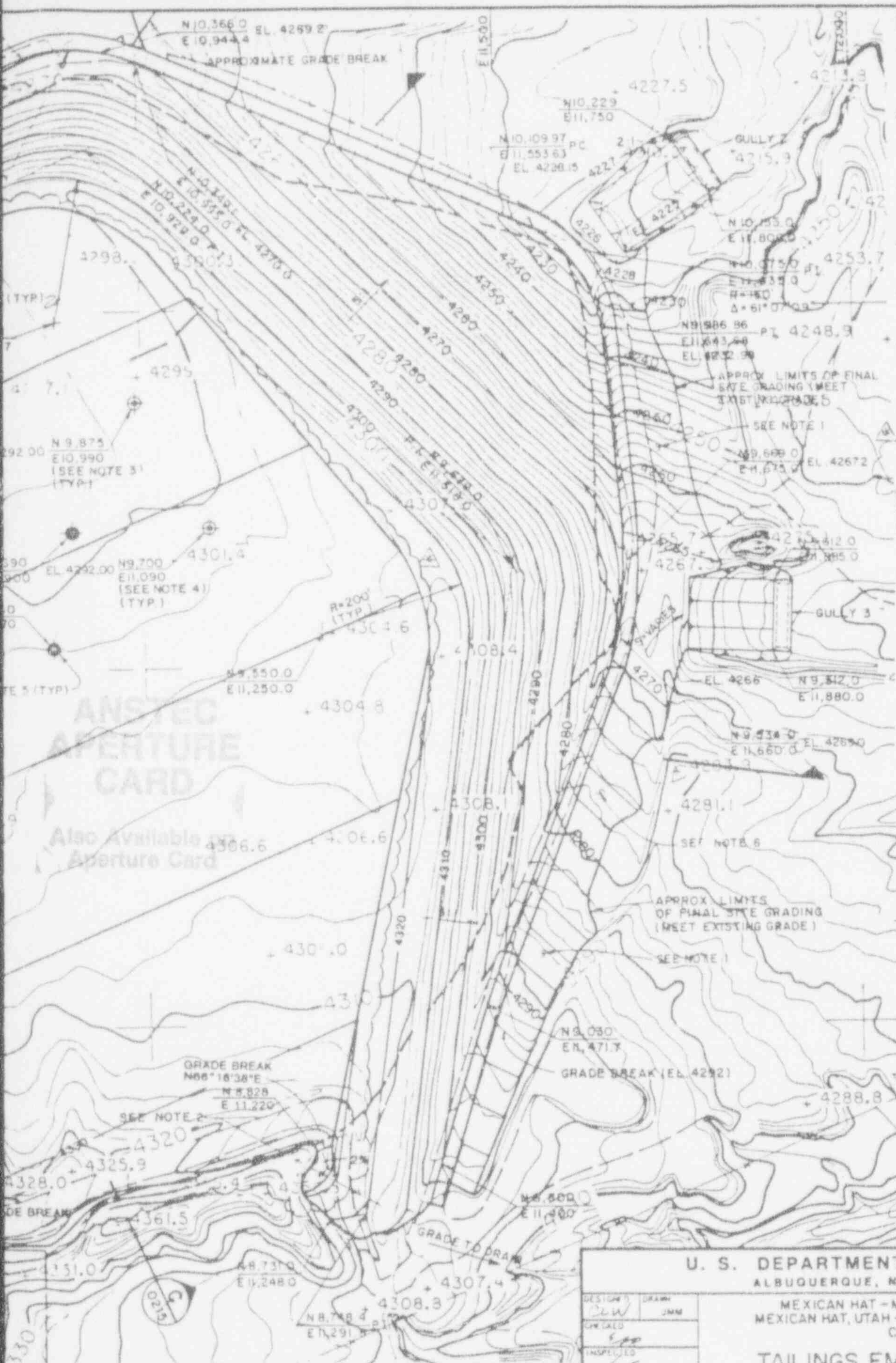
DESIGNED	DRAWN	MEXICAN HAT SITE MEXICAN HAT, UTAH EROSION PROTECTION PLAN AND SECTIONS
CHECKED		
INSPECTED		
RECOMMENDED		
APPROVED	DATE	DOE PROJECT ENGINEER / DATE

NO.	DATE	REVISION	BY	CK	CHIEF MGR.	CHIEF ENG.	QA MGR.	DOE APP.

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

SKETCH 2


SEE DETAIL
GRADE TO DRAIN
REMOVE SOIL AND LOOSE ROCK AS DIRECTED BY THE CONTRACTOR
LIMIT OF RIPRAP
SEE DETAIL
NORTH DITCH
WEST DITCH
WEST FINAL GRADE
SEE NOTE 9
SLOPE VARIES
GRADE BREAK
GRADE BREAK (EL 4308.5)
20' APRON
SEE NOTE 2
SEE NOTE 8
SLOPE CHANGE
N 9,118.9
E 9,604.8
N 8,933.0
E 9,557.5
N 9,510
E10,690
N9,330
E10,525
N 10,195.0
E 10,151.0
N 10,152.0
E 10,102.0
N10,253.9
E10,178.5
N9,815.0
E9,720.0
N 9,948.3
E 9,532.9
N8,810.0
E9,423.7
N9,114.9
E9,553.3
N 9,986
E 10,884
N10,354.8
E10,843.4
N 10,292.0
E10,710.0
EL. 4269.2
EL 4279.5
EL 4288.00
N 10,000
N 9,500
N 9,000
4290
4300
4310
4315
4320
4325
4297.0
4296.3
4298.4
4298.7
4300.6
4303.0
4303.4
4296.5
4296.8
4299.1
4301.2
4297.70
4297.9
4308.7
4321.1
4306.8
4389.0
4381.1
4391.6
GRADE BREAK
MATCH LINE (SEE DWG. NO. H/M-DS-10-0213)
SCALE
FEET
100 0 100 200
STATE OF UTAH
PATRICK B. GRIFFIN
QA REVIEWED FOR QUALITY REQUIREMENTS



NOTES:

1. GRADE APRON AREA TO ELIMINATE HIGH SPOTS AND PREVENT FLOW CONCENTRATIONS AS DIRECTED BY THE CONTRACTOR. EXISTING FILL IN APRON AREA CONTAINS PIECES OF SHOT ROCK.
2. CORNER CONTOURS ON THE TAILINGS EMBANKMENT SHALL BE ROUNDED WITH A 50' RADIUS IN THE PLAN VIEW UNLESS NOTED OTHERWISE.
3. EXISTING AND NEW DISPLACEMENT MONUMENT RODS AND PIPES SHALL BE EXTENDED TO FINAL SURFACE.
4. SEE THE INFORMATION FOR BIDDERS FOR DATA ON THE EXISTING SETTLEMENT MONUMENTS.
5. FOR A NEW TYPICAL DISPLACEMENT MONUMENT INSTALLATION DETAIL, SEE DWG. NO. H/M-DS-10-0216.
6. FINAL GRADES SHOWN IN THE APRON AREA MAY BE ADJUSTED BY THE CONTRACTOR TO FACILITATE SURFACE DRAINAGE AND REDUCE FLOW CONCENTRATIONS.
7. ROCK SHALL BE CHIPPED OR PLANED. NO BLASTING OR RIPPING WILL BE PERMITTED.
8. TO BE EXCAVATED A MINIMUM OF 1'-0 BELOW BOTTOM OF RADON BARRIER.

REFERENCE DRAWINGS:

H/M-DS-10-0215	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0216	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-DS-10-0217	HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0218	HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-DS-10-0219	HAT-EROSION PROTECTION PLAN AND SECTIONS
H/M-DS-10-0213	TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS

LEGEND:

- AREA OF ROCK CHIPPING
- 4320 — EXISTING CONTOURS
- — 4320 — FINAL CONTOURS
- DRAINAGE DITCH
- N10,000 — CONSTRUCTION GRID COORDINATE
- TOP OF CUT
- TOP OF FILL
- LIMIT OF CONTAMINATED MATERIAL
- APPROXIMATE LIMIT OF ROCK OUTCROP TO BE EXCAVATED
- EXISTING DISPLACEMENT MONUMENT LOCATION & ELEVATION OF BASE PLATE AS OF MARCH 1989
- NEW DISPLACEMENT MONUMENT LOCATION

9403040355-03

DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	REVISED AS PER P.I.D. NO. 09-5-20						
[illegible]8.93	REVISED AS PER P.I.D. NO. 09-5-17	[signature]	[signature]	[signature]	[signature]	[signature]	
[illegible]/92	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

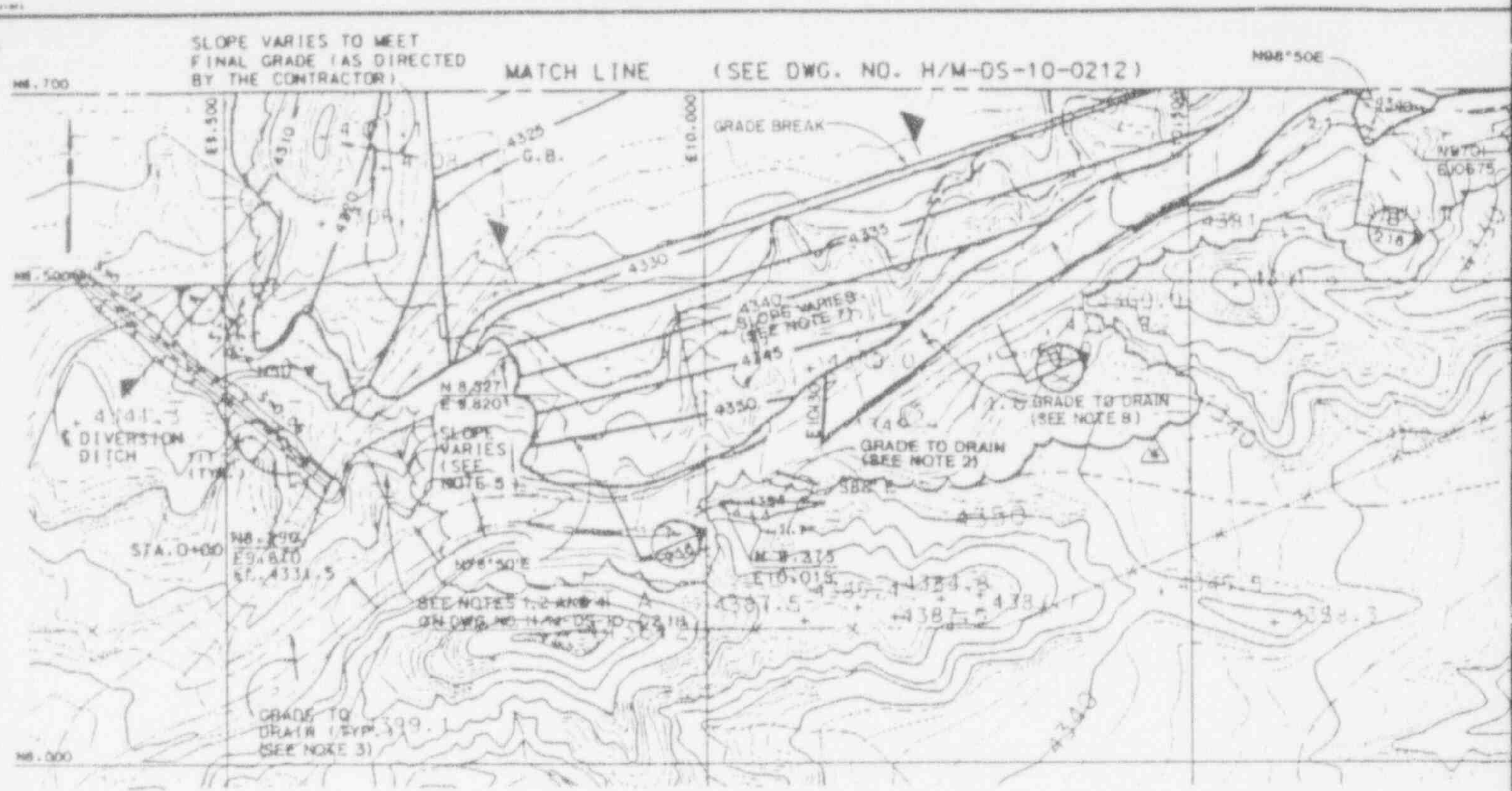
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

TAILINGS EMBANKMENT PLAN

DESIGNED: CLW | DRAWN: JMM | CHECKED: [signature] | INSPECTED: [signature] | RECOMMENDED: [signature] | APPROVED: [signature] | DATE: [illegible] | DOE PROJECT ENGINEER: [signature] | DATE: [illegible]

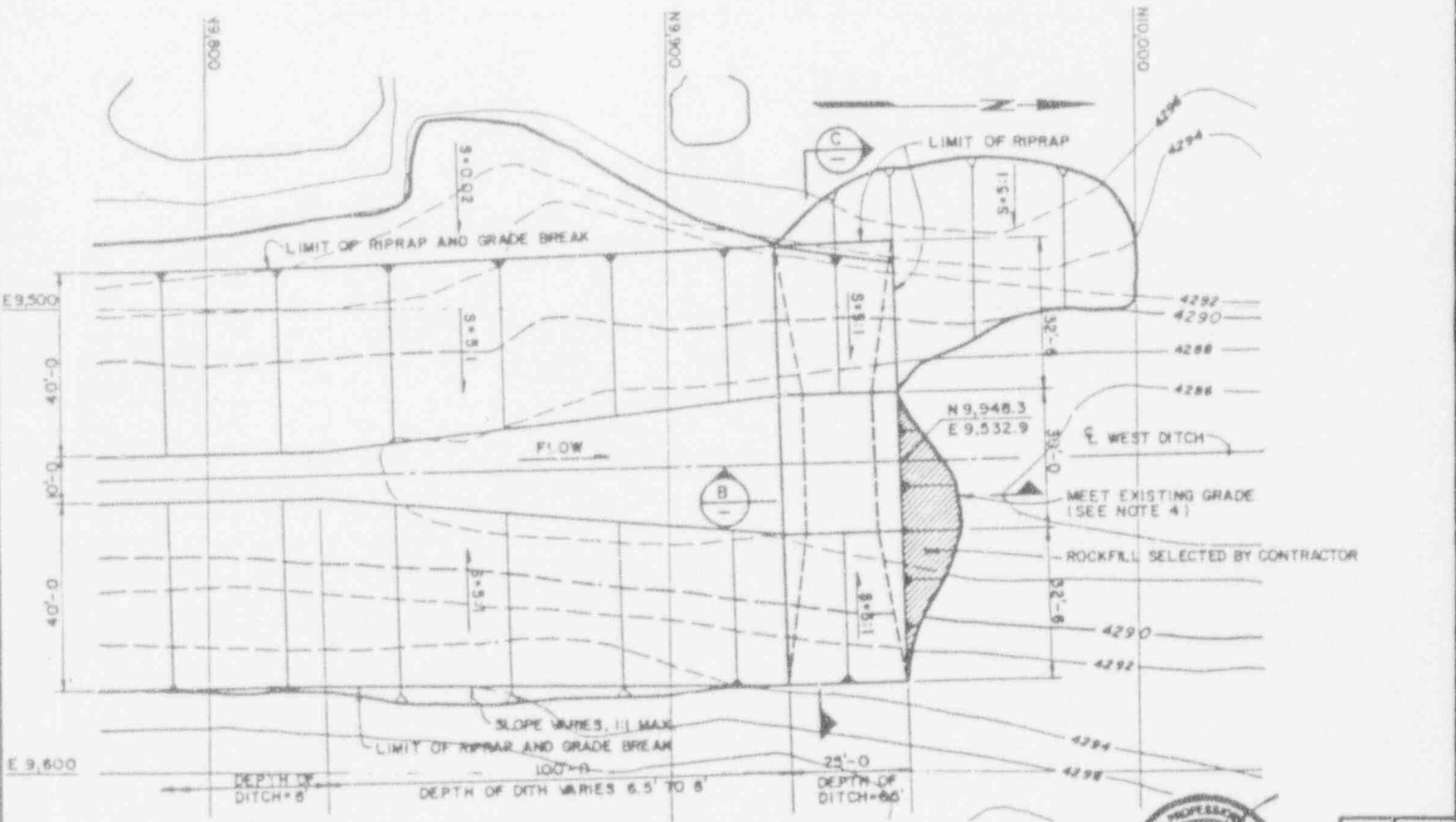
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO.: DE-AC04-83AL18796
DRAWING NO.: H/M-DS-10-0212
REV.: [illegible]



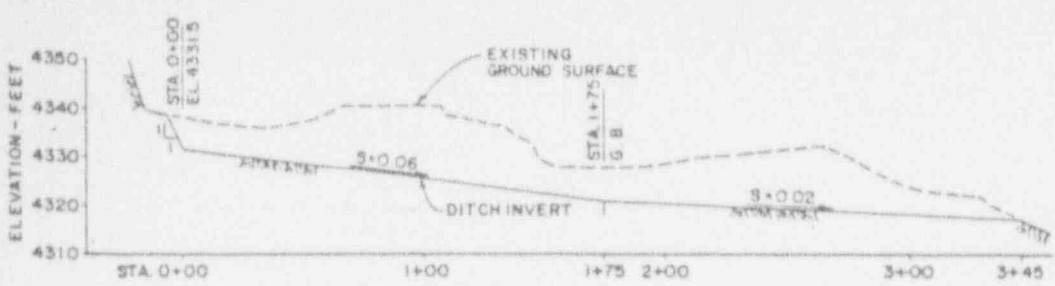
TAILINGS EMBANKMENT PLAN (SEE NOTE 1)

SCALE 100 0 100 200 FEET

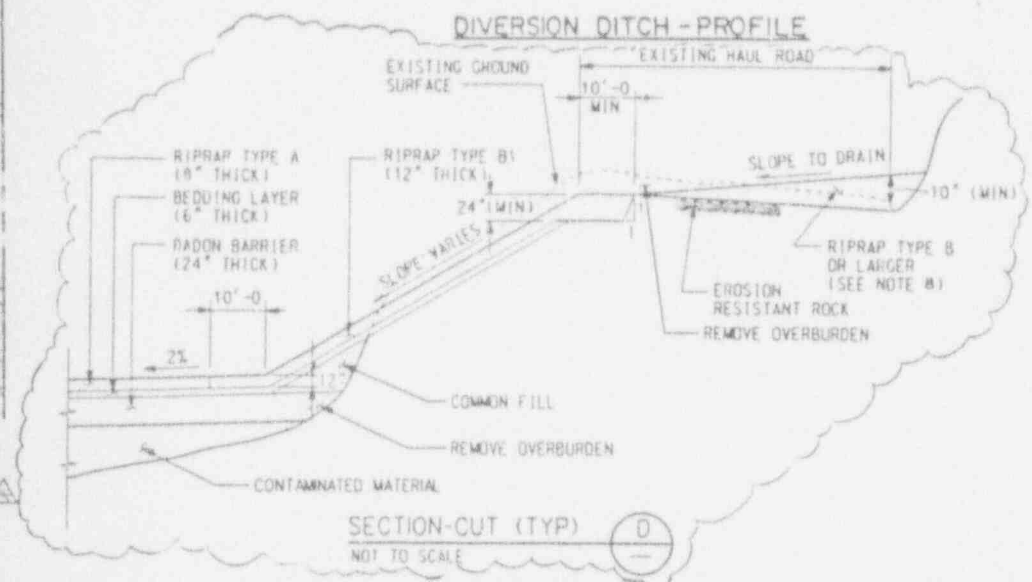


WEST DITCH TOE OUTLET
DETAIL 2 (0212)

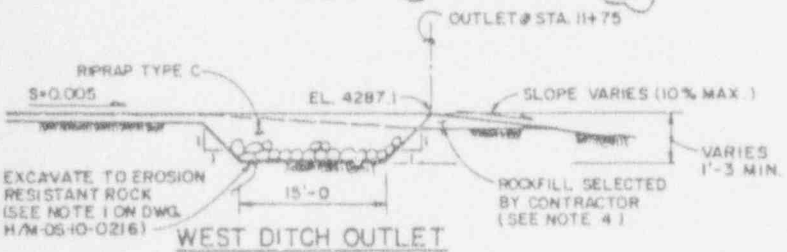
SCALE 20 0 20 40 FEET



DIVERSION DITCH - PROFILE

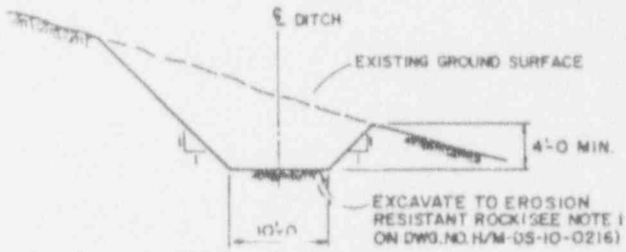


SECTION-CUT (TYP) (D)
NOT TO SCALE

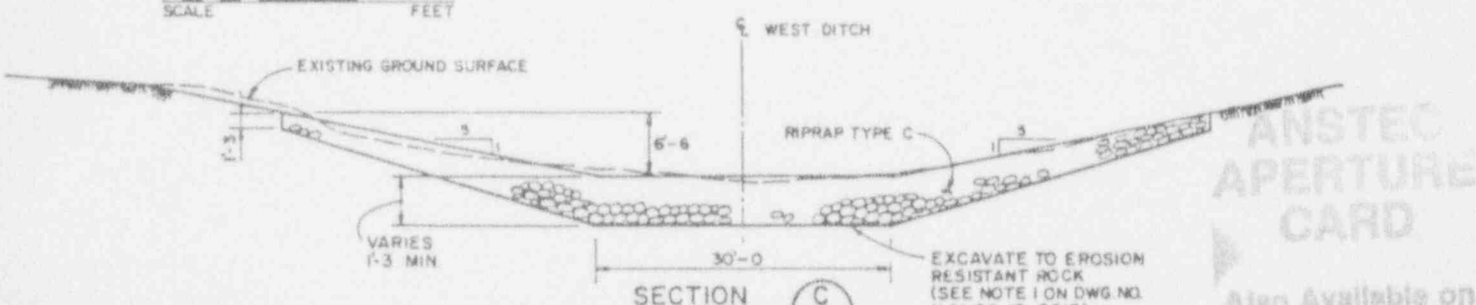


WEST DITCH OUTLET
SECTION (B)

10 0 10 20
SCALE FEET



TYPICAL SECTION (A)
NOT TO SCALE



SECTION (C)

10 0 10 20
SCALE FEET

NOTES:

1. SEE DWG. H/M-DS-10-0212 FOR ADDITIONAL NOTES AND LEGEND.
2. GRADE EXISTING TERRAIN SOUTH OF PILE AS DIRECTED BY THE CONTRACTOR TO AVOID FLOW CONCENTRATIONS ONTO THE PILE.
3. GRADE EXISTING TERRAIN SOUTHWEST OF PILE AS DIRECTED BY CONTRACTOR.
4. ROCKFILL BELOW TOE OF WEST DITCH TO MEET EXISTING GRADE AS DIRECTED BY CONTRACTOR.
5. BACKFILL EXISTING GULLIES AS DIRECTED BY CONTRACTOR WITH ROCKFILL SELECTED BY THE CONTRACTOR.
6. NOT USED.
7. SLOPE SHALL BE AS DIRECTED BY THE CONTRACTOR BUT SHALL BE NO STEEPER THAN 7(H):1(V).
8. GRADE EXISTING HAUL ROAD EAST OF E10130 TO DRAIN WITH RIPRAP TYPE B OR LARGER AS DIRECTED BY CONTRACTOR.

REFERENCE DRAWINGS:

H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN
H/M-DS-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-DS-10-0218 HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 2 OF 2)

LEGEND:

(symbol)	TOP OF ROCK
(hatched box)	LIMITS OF ROCKFILL SELECTED BY THE CONTRACTOR
G.B.	GRADE BREAK

9403040355-04

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS

DESIGNED CLW DRAWN JMM
CHECKED
INSPECTED JCK
RECOMMENDED
APPROVED
DATE 1/21/92
DOE PROJECT ENGINEER
DATE 2/7/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. H/M-DS-10-0213

DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	REVISED AS PER P.I.D. NO. 09-3-20						
	REVISED AS PER P.I.D. NO. 09-3-17	JCK					
	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

N 11,000
N 10,000
N 9,000
N 8,000
E 8,000
E 9,000
E 10,000
SEE NOTE 4
℄ NORTH DITCH
℄ WEST DITCH
GRADE BREAK
DIVERSION DITCH
SEE NOTE 4
STATE OF UTAH

NOTES:

1. SEE DWG. NO. H/M-DS-10-0212 AND H/M-DS-10-0213 FOR FINAL SITE GRADING REQUIREMENTS AROUND DISPOSAL CELL.
2. THE ACTUAL LOCATION OF THE GRADE BREAK BETWEEN THE EMBANKMENT TOP AND THE 5:1 SIDESLOPES WILL VARY BASED ON THE VOLUME OF CONTAMINATED MATERIAL PLACED IN THE EMBANKMENT.
3. ALTERNATIVE SPOIL AREA MAY BE SELECTED BY CONTRACTOR.
4. ALL DEPRESSIONS AND LOW SPOTS INCLUDING WATER PONDS SHALL BE BACKFILLED WITH COMMON FILL AND SLOPED TO DRAIN AS DIRECTED BY THE CONTRACTOR.
5. FOR LEGEND, SEE DWG. NO. H/M-DS-10-0212.
6. FOR GULLY DETAILS, SEE DWG. NO. H/M-DS-10-0220.
7. REMOVE TEMPORARY ACCESS ROADS AND PARKING AREAS AS DIRECTED BY THE CONTRACTOR.
8. FINAL GRADES MAY BE ADJUSTED BY THE CONTRACTOR TO MEET THE FIELD CONDITIONS.

REFERENCE DRAWINGS:

H/M-DS-10-0212	TAILINGS EMBANKMENT PLAN
H/M-DS-10-0213	TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS
H/M-DS-10-0220	HAT - GULLY DETAILS

LEGEND:

TOP OF CUT

TOP OF FILL

FLOWPATH

200 0 200 400
SCALE FEET

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA
COMPLETION

HAT-FINAL SITE GRADING PLAN

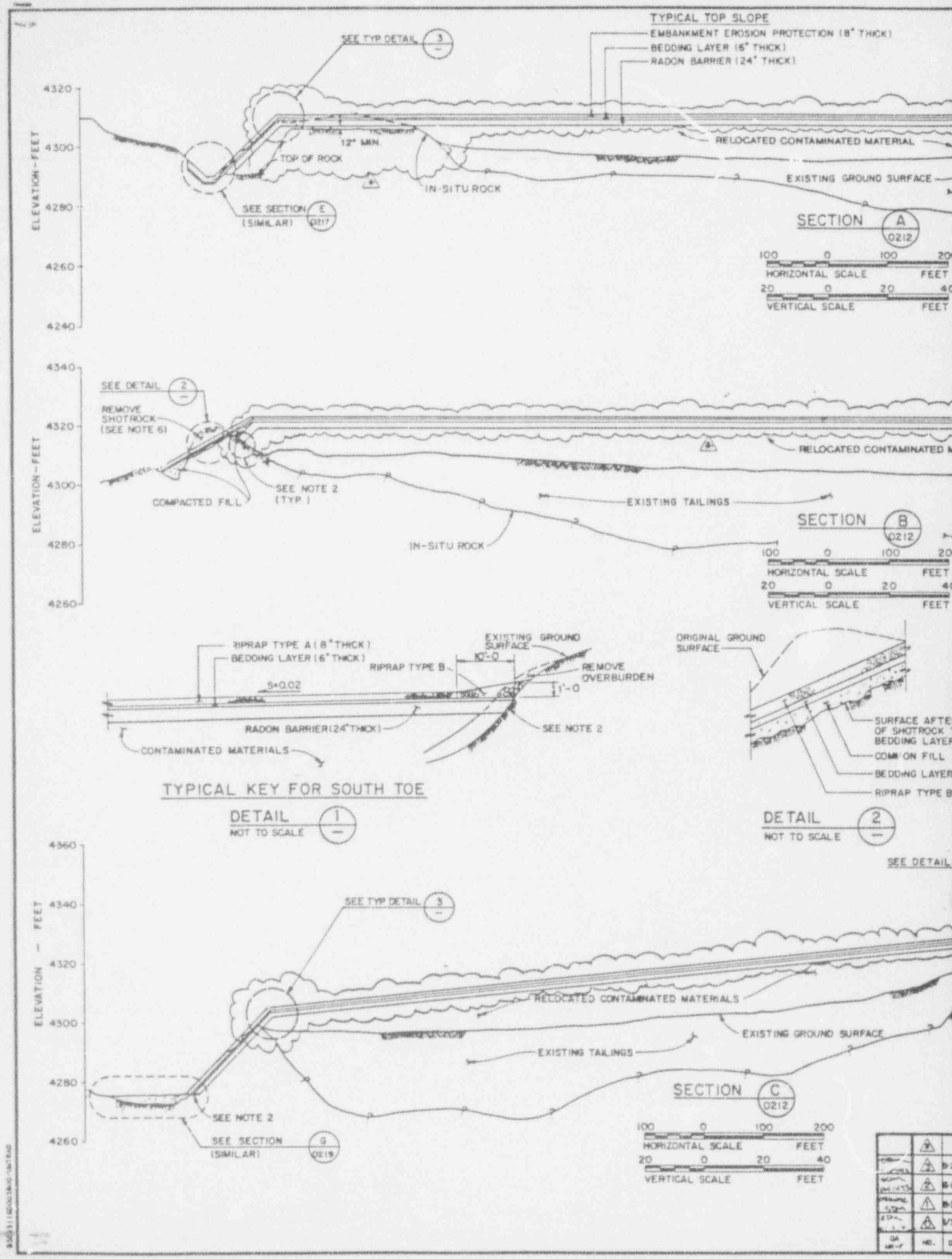
9403040355-05

REV.	REVISIONS	BY	CK	CED MGR	CHIEF ENG.	QA MGR	DOE APP
	REVISED AS PER P.I.D. NO. 09-5-20						
	REVISED AS PER P.I.D. NO. 09-3-17						
	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

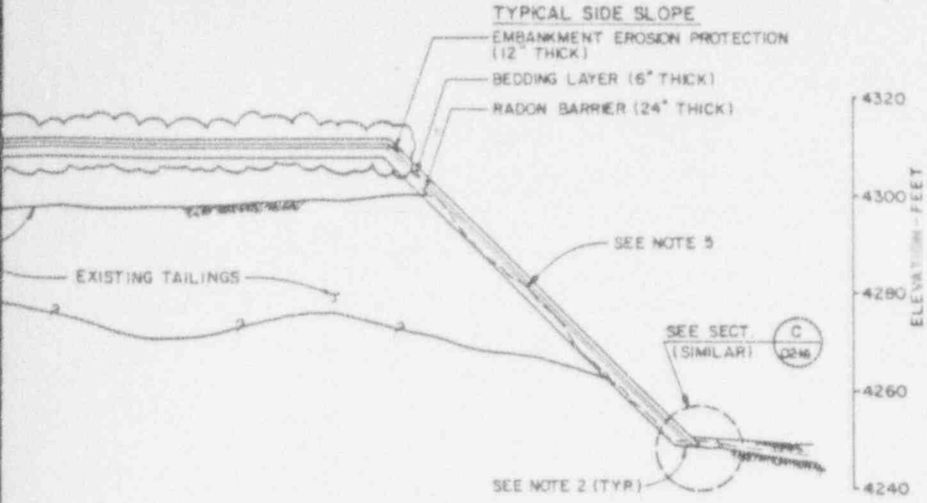
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO.: DE-AC04-83AL18796

DRAWING NO.: H/M-DS-10-0214



TYPICAL TOP SLOPE
EMBANKMENT EROSION PROTECTION (8" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER (24" THICK)
SEE TYP DETAIL 3
12" MIN.
TOP OF ROCK
IN-SITU ROCK
RELOCATED CONTAMINATED MATERIAL
EXISTING GROUND SURFACE
SEE SECTION E 0217 (SIMILAR)
ELEVATION-FEET
4320
4300
4280
4260
4240
SECTION A 0212
100 0 100 200
HORIZONTAL SCALE FEET
20 0 20 40
VERTICAL SCALE FEET
4340
SEE DETAIL 2
REMOVE SHOTROCK (SEE NOTE 6)
COMPACTED FILL
SEE NOTE 2 (TYP.)
RELOCATED CONTAMINATED M
EXISTING TAILINGS
IN-SITU ROCK
SECTION B 0212
RIPRAP TYPE A (8" THICK)
BEDDING LAYER (6" THICK)
S=0.02
RIPRAP TYPE B
10'-0
EXISTING GROUND SURFACE
REMOVE OVERBURDEN
1'-0
RADON BARRIER (24" THICK)
SEE NOTE 2
CONTAMINATED MATERIALS
TYPICAL KEY FOR SOUTH TOE
DETAIL 1
NOT TO SCALE
ORIGINAL GROUND SURFACE
SURFACE AFTER OF SHOTROCK T BEDDING LAYER
COMPON FILL
BEDDING LAYER
RIPRAP TYPE B
DETAIL 2
NOT TO SCALE
SEE DETAIL
4360
ELEVATION — FEET
SEE TYP DETAIL 3
RELOCATED CONTAMINATED MATERIALS
EXISTING GROUND SURFACE
EXISTING TAILINGS
SEE NOTE 2
SEE SECTION G 0219 (SIMILAR)
SECTION C 0212
NO.

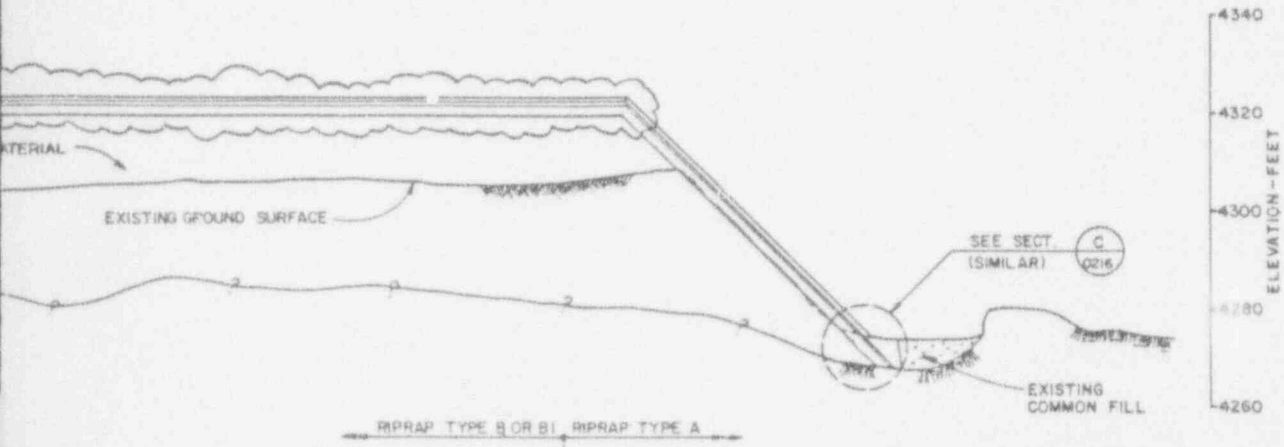


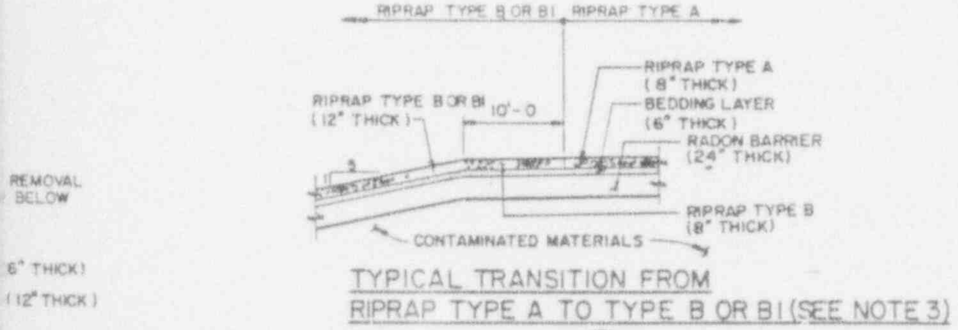
NOTES:

1. THICKNESS OF THE RADON BARRIER MAY BE REVISED BY THE CONTRACTOR BASED ON RADIOLOGICAL MEASUREMENT OF CONTAMINATED FILL MATERIALS PLACED ON THE EMBANKMENT.
2. EXTEND RADON BARRIER AND EROSION PROTECTION TO TIE INTO UNCONTAMINATED COMPETENT IN-SITU ROCK. ALL OVERBURDEN AND LOOSE ROCK SHALL BE REMOVED PRIOR TO PLACING RADON BARRIER AND EROSION PROTECTION.
3. SEE EROSION PROTECTION PLAN ON DWG. NO. H/M-DS-10-0219 FOR LOCATION OF RIPRAP TYPE B AND TYPE B1.
4. NOT USED.
5. REGRADE EXISTING SLOPE TO MATCH FINAL GRADE OF CONTAMINATED MATERIALS.
6. SHOTROCK IS ROCK PREVIOUSLY BLASTED BY OTHERS BUT NOT EXCAVATED.

REFERENCE DRAWINGS:

H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN
H/M-DS-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)
H/M-DS-10-0217 HAT-SITE DRAINAGE SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0219 HAT-EROSION PROTECTION PLAN AND SECTIONS



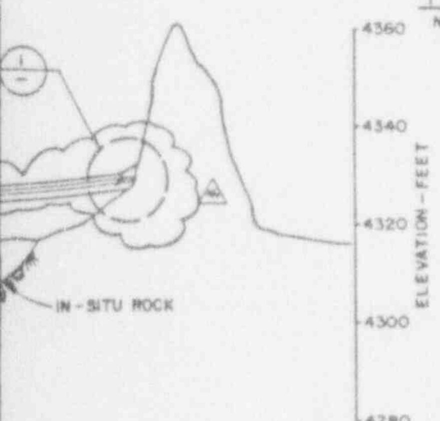


TYPICAL TRANSITION FROM RIPRAP TYPE A TO TYPE B OR B1 (SEE NOTE 3)

TYP DETAIL 3
NOT TO SCALE

LEGEND:

TOP OF ROCK



9403040355-06

QA REVIEWED FOR QUALITY REQUIREMENTS

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT-MONUMENT VALLEY SITES
MEXICAN HAT, UTAH-MONUMENT VALLEY, ARIZONA
COMPLETION

TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)

DESIGNED CLW · DRAWN UMM · CHECKED · INSPECTED · RECOMMENDED · APPROVED

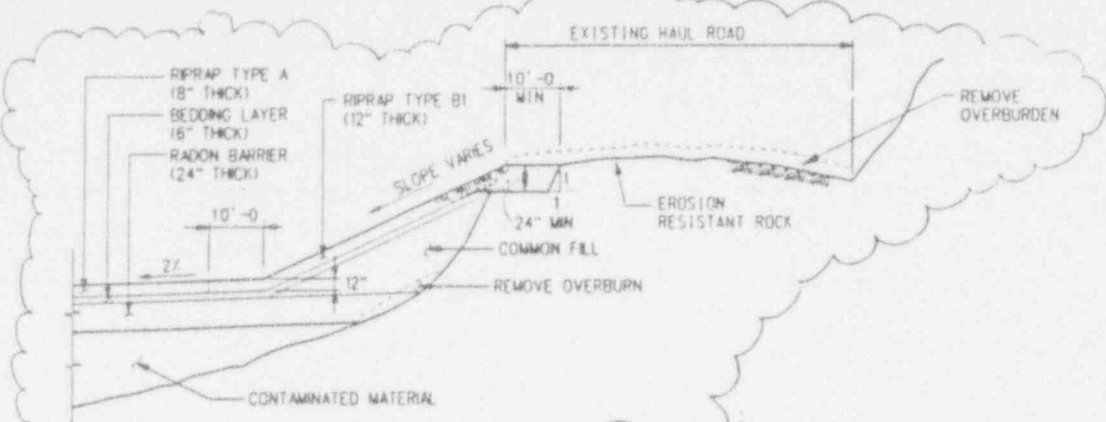
DATE 1/31/92 · DATE 2/3/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

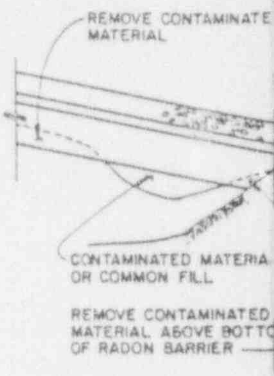
PROJECT NO.: DE-AC04-83AL18796

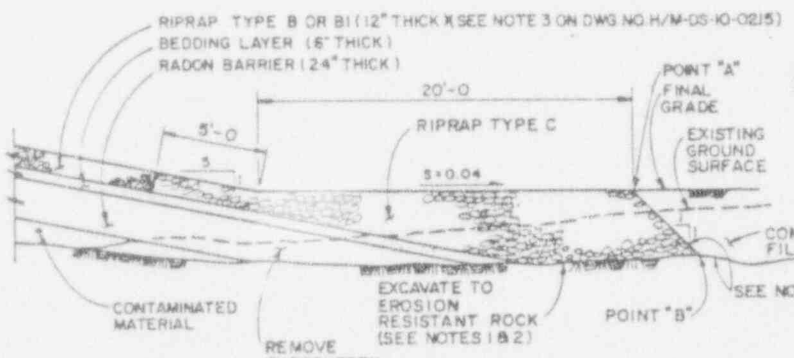
DRAWING NO.: H/M-DS-10-0215

	REVISIONS	BY	CK	ESD MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	REVISED AS PER P.I.D. NO. 09-5-20						
	REVISED AS PER P.I.D. NO. 09-5-18						
	REVISED AS PER P.I.D. NO. 09-5-17						
	REVISED AS PER P.I.D. NO. 09-5-15						
	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—



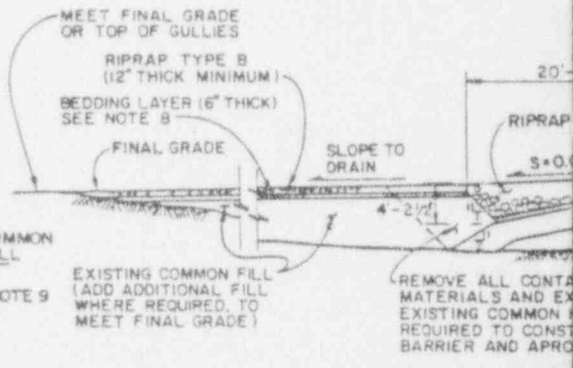
SECTION-FILL (TYP) A/213
NOT TO SCALE

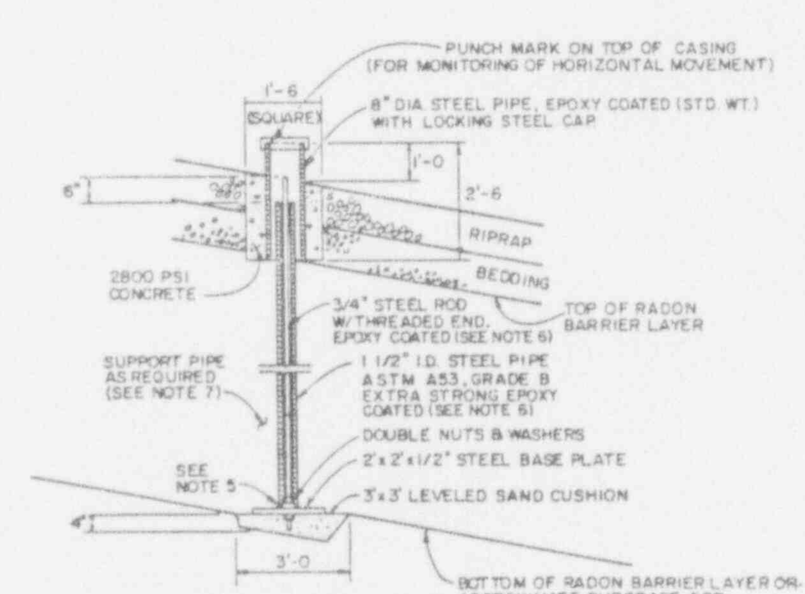




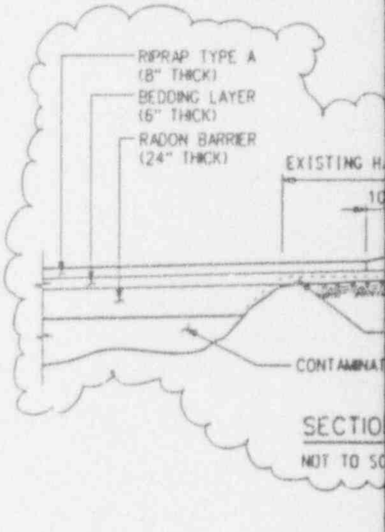
TYPICAL APRON IN FILL AREAS

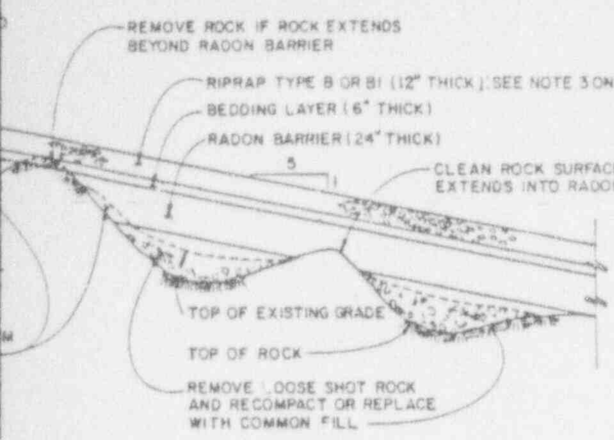
SECTION C
NOT TO SCALE 0215/0219





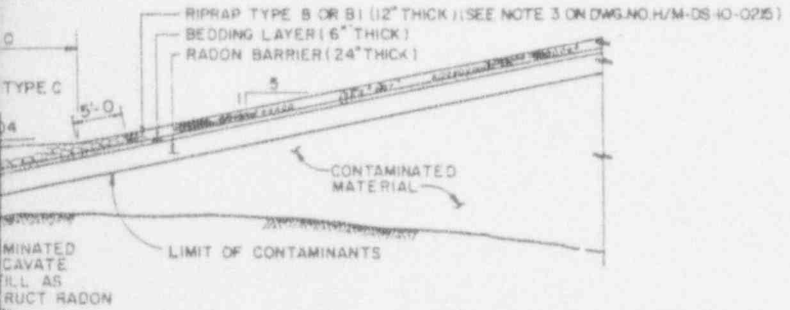
TYPICAL NEW DISPLACEMENT MONUMENT DETAIL
(H/M-05-10-0212)
NOT TO SCALE





SIDESLOPE GRADING DETAIL
(SEE NOTE 10)

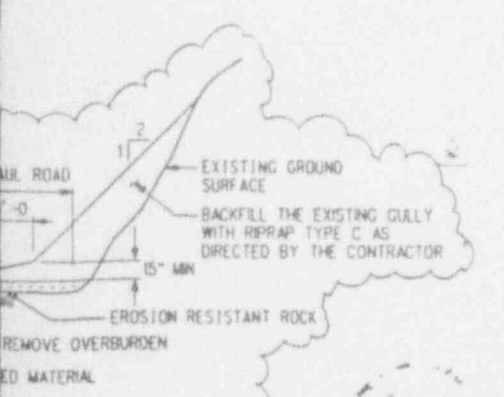
SCALE 5 0 5 10 FEET



CAL APRON IN FILL AREAS
P PROTECTION BEYOND 20' APRON

SECTION D / 0219
(SEE NOTE 11)

SCALE 10 0 10 20 FEET



N B / 213

ALE

NOTES:

1. EROSION RESISTANT ROCK IS DETERMINED BY REFUSAL OF A POWER AUGER, DRILLING VERTICALLY, USING AN AUGER BIT. TRENCH BOTTOMS WILL BE TESTED ON MAXIMUM OF 20 FOOT CENTERS. GENERALLY EROSION RESISTANT ROCK IS NATURAL, UNDISTURBED, INTACT ROCK WHICH CANNOT BE READILY RIPPED OR LOOSENED OR BROKEN BY A BACKHOE DURING NORMAL EXCAVATION AND RINGS WHEN STRUCK WITH A GEOLOGIST'S ROCK HAMMER.
2. WHERE EXCAVATIONS ARE TO GO TO EROSION RESISTANT ROCK, THE SUBCONTRACTOR SHALL EXPOSE THE EROSION RESISTANT ROCK FOR INSPECTION AND LOGGING BY THE CONTRACTOR'S GEOLOGIST. ALL LOOSE MATERIAL SHALL BE REMOVED AND THE ROCK SURFACE CLEANED TO THE ACCEPTABLE ROCK CLEANUP SURFACE. BACKFILL SHALL NOT BE PLACED UNTIL CONTRACTOR APPROVES THE ROCK SURFACE AT THE BOTTOM OF THE EXCAVATION.
3. FOR APRON AREAS REQUIRING RIPRAP PROTECTION SEE DWG. NO. H/M-DS-10-0219.
4. LENGTH OF PIPE AND ROD OF EXISTING DISPLACEMENT MONUMENT VARY ACCORDING TO ELEVATION OF BASE PLATE AS SHOWN ON DWG. NO. H/M-DS-10-0212.
5. WHERE THE BASE PLATE IS LOCATED AT THE TOP OF THE RELOCATED TAILINGS (UNDERNEATH THE RADON BARRIER) THE PIPE SHALL BE PLACED DIRECTLY ON THE PLATE. PIPES SHALL NOT BE ATTACHED TO PLATES OR RODS.
6. PIPES AND RODS WITH TOTAL LENGTH GREATER THAN FOUR FEET SHALL BE INSTALLED IN 4-FOOT SECTIONS AS FIL CONSTRUCTION PROGRESSES. RODS SHALL BE SECURELY FLUSH-COUPLED AS REQUIRED. PIPES SHALL BE SECURELY COUPLED SUCH THAT INSIDE DIAMETER IS NOT LESS THAN 1 1/2" AT ANY POINT. SUBCONTRACTOR SHALL MAKE ELEVATION MEASUREMENTS OF TOP OF ROD IMMEDIATELY BEFORE AND AFTER ADDITION OF EACH ROD SECTION. PIPES SHALL BE CAPPED AT ALL TIMES TO PREVENT ENTRANCE OF FOREIGN MATTER.
7. PIPES SHALL BE SUPPORTED BY FILL COMPACTED BY LIGHT WEIGHT TAMPERS WITHIN FIVE FEET OF PIPES TO MEET SAME COMPACTION REQUIREMENTS AS FOR ADJACENT FILL. CARE SHALL BE TAKEN TO ENSURE THAT PIPES REMAIN NOMINALLY CENTERED AROUND RODS.
8. BEYOND THE EMBANKMENT APRON, BEDDING LAYER IS NOT REQUIRED IF RIPRAP IS IN CONTACT WITH IN-SITU BEDROCK.
9. THE DEPTH TO EROSION RESISTANT ROCK BELOW POINT "A" WILL VARY. THE MINIMUM DEPTH IS 15 INCHES BELOW FINAL GRADE. THE LOCATION OF POINT "A" IS FIXED. THE 1:1 SLOPE OF RIPRAP TYPE C EXTENDS TO TOP OF THE EROSION RESISTANT ROCK. LOCATION OF POINT "B" WILL VARY.
10. SIDE SLOPE DETAIL APPLIES TO AREAS OF EXISTING SIDE SLOPE WHERE ROCK IS AT OR NEAR THE SURFACE.
11. SECTION D - APPLIES BETWEEN THE GULLIES AND THE EMBANKMENT AND OTHER AREAS WHERE DEPTH TO COMPETENT ROCK BELOW FINAL GRADE IS GREATER THAN 4'-2 1/2".

REFERENCE DRAWINGS:

H/M-DS-10-0212	TAILINGS EMBANKMENT PLAN
H/M-DS-10-0213	TAILINGS EMBANKMENT PLAN AND DITCH SECTIONS AND DETAILS
H/M-DS-10-0215	TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0219	HAT-EROSION PROTECTION PLAN AND SECTIONS

QA APPROVED FOR QUALITY REQUIREMENTS

9403040355-07

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

TAILINGS EMBANKMENT SECTIONS AND DETAILS
(SHEET 2 OF 2)

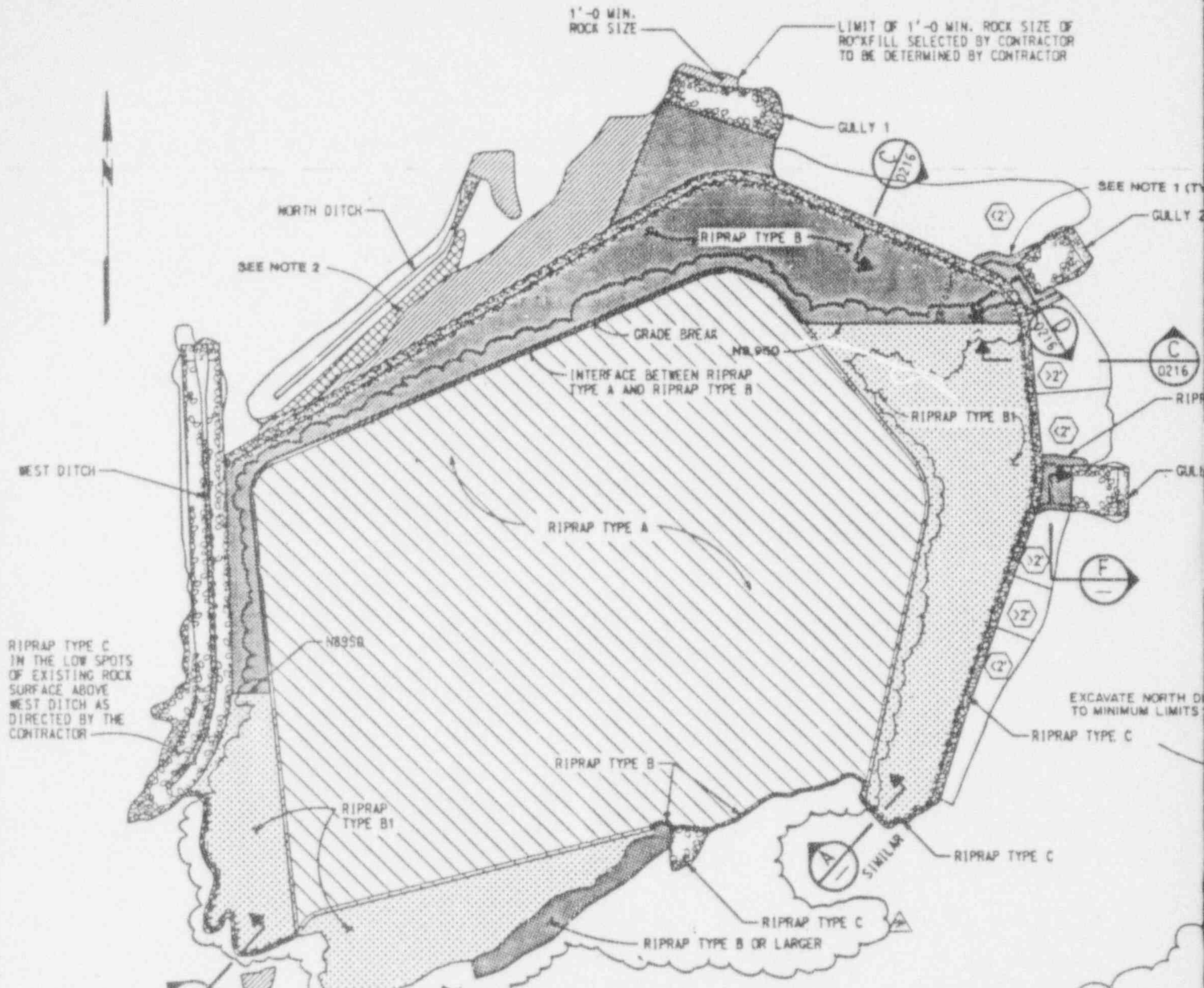
DESIGNED CW · DRAWN JMM · CHECKED · INSPECTED · RECOMMENDED · APPROVED · DATE 1/31/92 · DOE PROJECT ENGINEER · DATE 2/3/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. H/M-DS-10-0216

	REVISIONS	BY	CK	ENG MGR	CHIEF ENG	QA MGR	DOE APP
	REVISED AS PER P.I.D. NO. 09-5-20						
	REVISED AS PER P.I.D. NO. 09-5-18						
	REVISED AS PER P.I.D. NO. 09-5-17						
	REVISED AS PER P.I.D. NO. 09-5-15						
	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—
DATE							

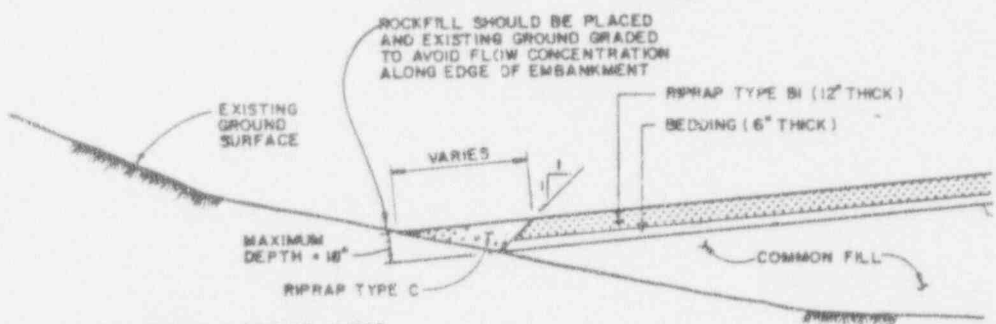


PLAN

EROSION PROTECTION

200 0 200 400

SCALE FEET



NOTE: SECTION A APPLIES WHERE EMBANKMENT SIDE SLOPES MEET EXISTING GRADE BETWEEN TOP SLOPE AND TOE OF SIDE SLOPE

SECTION A

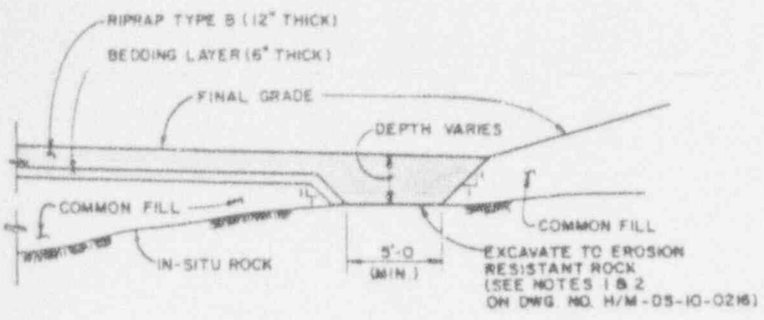
SEE NOTE 4

5 0 5 10

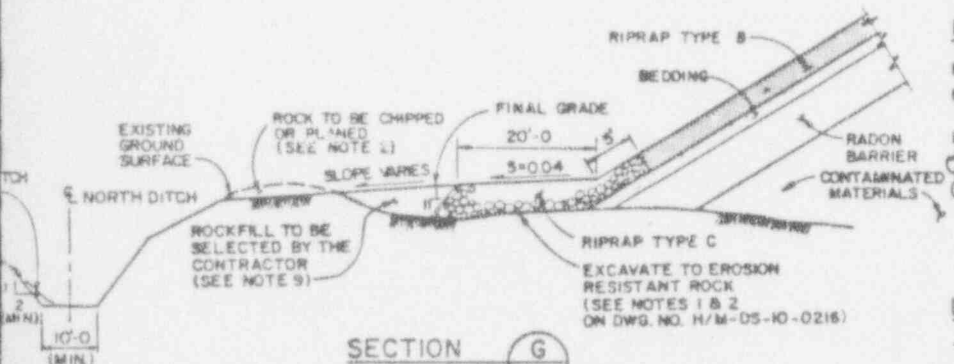
SCALE FEET

STATE OF UTAH

R A Am



TYPICAL SECTION E
NOT TO SCALE
SEE NOTE 5



SECTION G
NOT TO SCALE
(SEE NOTE 3)
0212 / 0215

NOTES:

1. THE OUTER LIMIT OF RIPRAP COVER SHOWN IS APPROXIMATE. FINAL LIMIT SHALL BE DETERMINED IN THE FIELD DURING CONSTRUCTION.
2. ROCK TO BE CHIPPED OR PLANED SHALL NOT BE RIPPED OR BLASTED.
3. SECTION G APPLIES WHERE DEPTH TO ROCK BELOW FINAL GRADE IS 3 FEET OR LESS OR AS DIRECTED BY THE CONTRACTOR.
4. SECTION A APPLIES WHERE THE EMBANKMENT SIDE SLOPE COMES IN CONTACT WITH GROUND SURFACE. DETAIL 1 ON DWG. H/M-DS-10-0215 APPLIES WHERE THE EMBANKMENT TOP SLOPE COMES IN CONTACT WITH GROUND SURFACE.
5. SECTION E APPLIES WHEREVER THERE IS A TRANSITION BETWEEN EROSION PROTECTION AND COMMON FILL BETWEEN THE EMBANKMENT APRON AND THE GULLIES.
6. TOP OF RIPRAP TYPE C SHALL BE GRADED TO PROVIDE SMOOTH TRANSITION TO TOP OF RIPRAP TYPE A.
7. WIDTH IS 13.3' MINIMUM. ACTUAL WIDTH WILL BE DETERMINED BY THE CONTRACTOR DEPENDING ON LOCAL TOPOGRAPHY.
8. NOT USED
9. ROCKFILL TO BE PLACED IN 1 FOOT LIFTS AND COMPACTED BY TRACK WALKING.

REFERENCE DRAWINGS:

H/M-DS-10-0212 TAILINGS EMBANKMENT PLAN
H/M-DS-10-0215 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 1 OF 2)
H/M-DS-10-0216 TAILINGS EMBANKMENT SECTIONS AND DETAILS (SHEET 2 OF 2)

LEGEND:

- TOP OF CUT
- TOP OF FILL
- TOP OF ROCK
- ROCK TO BE CHIPPED
- RIPRAP TYPE A
- RIPRAP TYPE BI
- RIPRAP TYPE B
- RIPRAP TYPE C
- ROCKFILL (TO BE SELECTED BY CONTRACTOR)
- (>2) APPROXIMATE DEPTH OF EXISTING FILL IN APRON IS LESS THAN 4' BUT GREATER THAN 2'
- (<2) APPROXIMATE DEPTH OF EXISTING FILL IN APRON IS LESS THAN 2'

9403040355-08

	REVISED AS PER F.I.D. NO. 09-5-20							
	REVISED AS PER F.I.D. NO. 09-5-18							
	REVISED AS PER F.I.D. NO. 09-5-17							
	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—	—
DATE	REVISIONS	BY	CK	CSD MGR.	CHIEF ENG.	QA MGR.	DOE APP.	

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

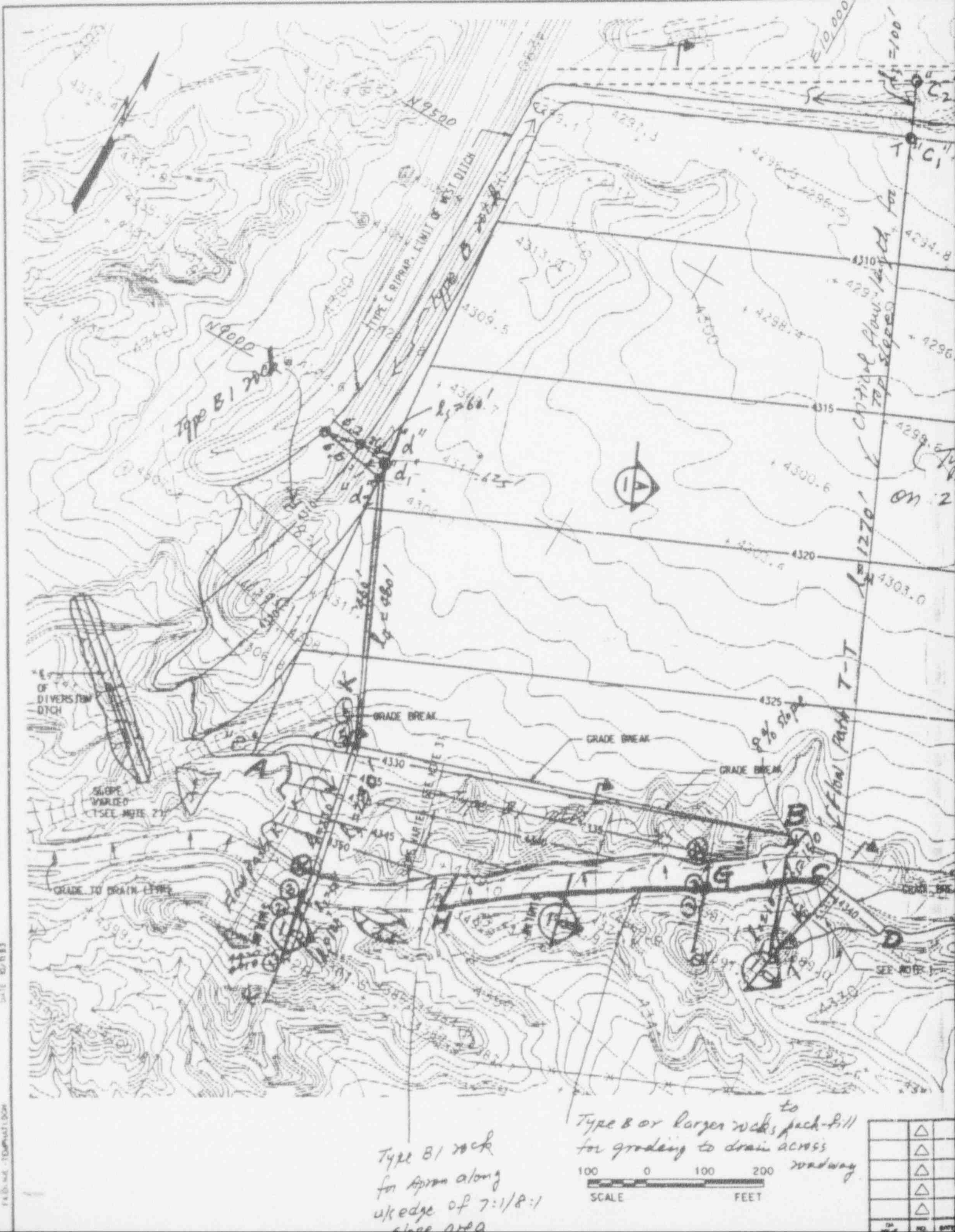
MEXICAN HAT - MONUMENT VALLEY SITES
MEXICAN HAT, UTAH - MONUMENT VALLEY, ARIZONA
COMPLETION

HAT - EROSION PROTECTION
PLAN AND SECTIONS

DESIGNED CLW · DRAWN JWM · CHECKED · INSPECTED · APPROVED · DATE 1/10/92 · DOE PROJECT ENGINEER Steve Hamp · DATE 2/4/92

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. H/M-DS-10-0219
REV. *



N9500
N9000
E10,000
TYPE C RIPRAP, LIMIT OF WEST DITCH
Type B rock
Type B1 rock
GRADE BREAK
GRADE BREAK
GRADE BREAK
GRADE TO DRAIN LINES
OF DIVERSION DITCH
SLOPE VARIED (SEE NOTE 2)
SEE NOTE 1
4310
4315
4320
4325
4330
4335
4345
4350
4340
4330
4300
4298.4
4300.6
4303.0
4309.5
4313.8
4296.5
Critical flow length for top slope
T-T Flow Path
l = 1270'
8% slope
Flow path K-K
Type B1 rock
for apron along
ukedge of 7:1/8:1
slope area
Type B or larger rocks to pack-fill
for grading to drain across
roadway
100 0 100 200
SCALE FEET

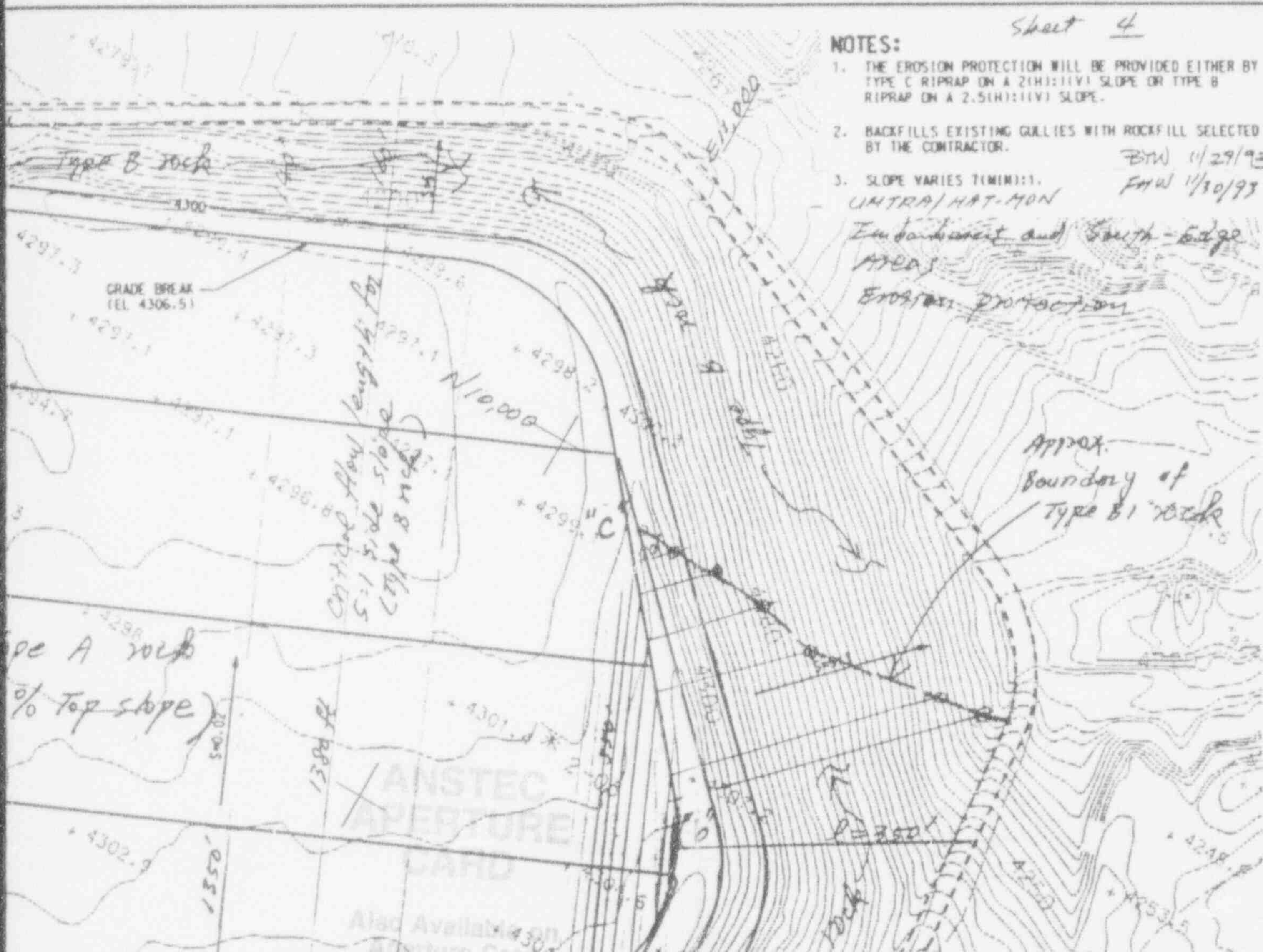
Sheet 4

NOTES:

1. THE EROSION PROTECTION WILL BE PROVIDED EITHER BY TYPE C RIPRAP ON A 2(H):1(V) SLOPE OR TYPE B RIPRAP ON A 2.5(H):1(V) SLOPE.
2. BACKFILLS EXISTING GULLIES WITH ROCKFILL SELECTED BY THE CONTRACTOR.
3. SLOPE VARIES 7(MIN):1.

BTW 11/29/93
FHW 11/30/93

UMTRA/HAT-MON
Embankment and South-Edge Areas
Erosion Protection

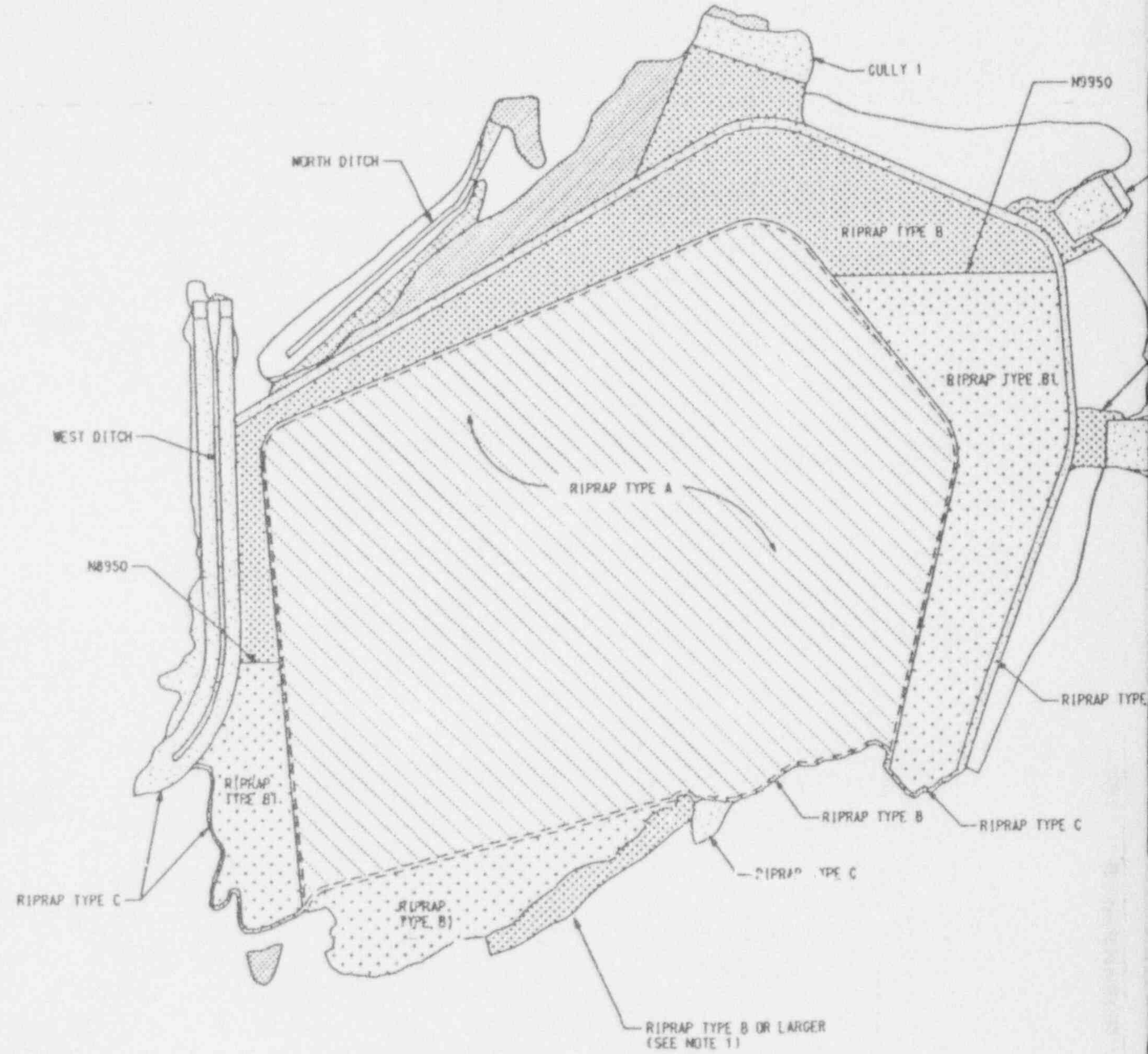


DRAFT

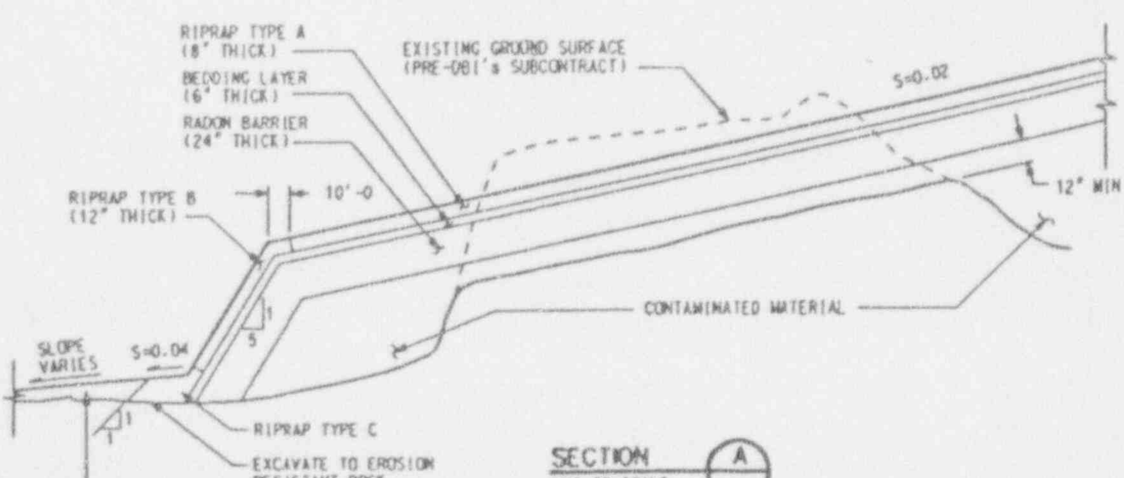
9403040355-09

U.S. DEPARTMENT OF ENERGY ALBUQUERQUE, NEW MEXICO	
MEXICAN HAT SITE MEXICAN HAT, UTAH	3885-58
SITE PLAN	
MORRISON-KNUDSEN ENGINEERS, INC. UMTRA PROJECT	DE-AC04-83AL18796

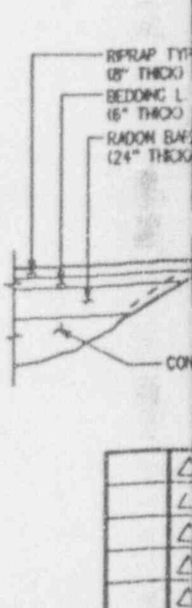
Type B rock for Apron at intersection of 2% top slope and natural slope



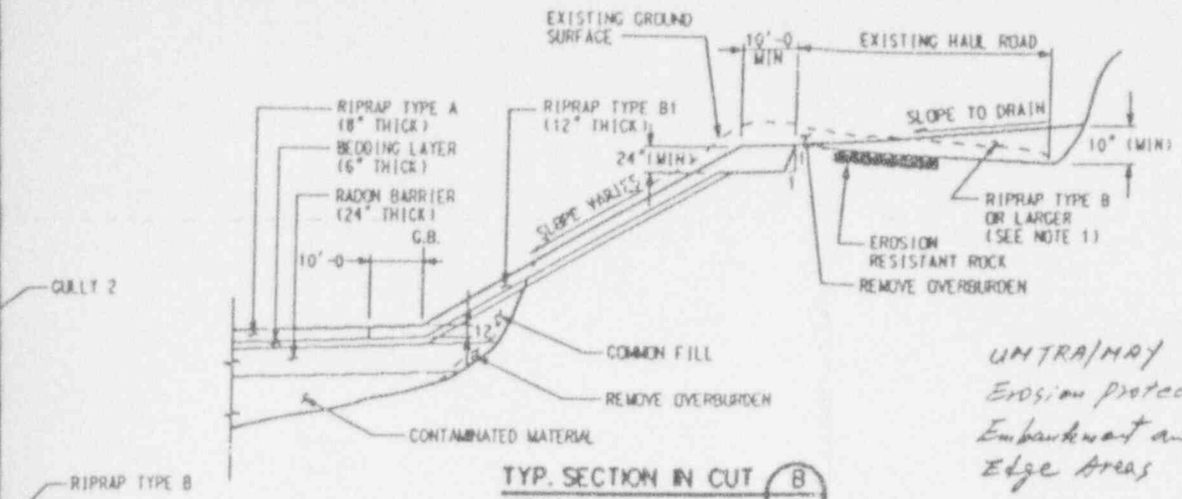
EROSION PROTECTION PLAN
NOT TO SCALE



SECTION (A)
NOT TO SCALE



Sheet 5



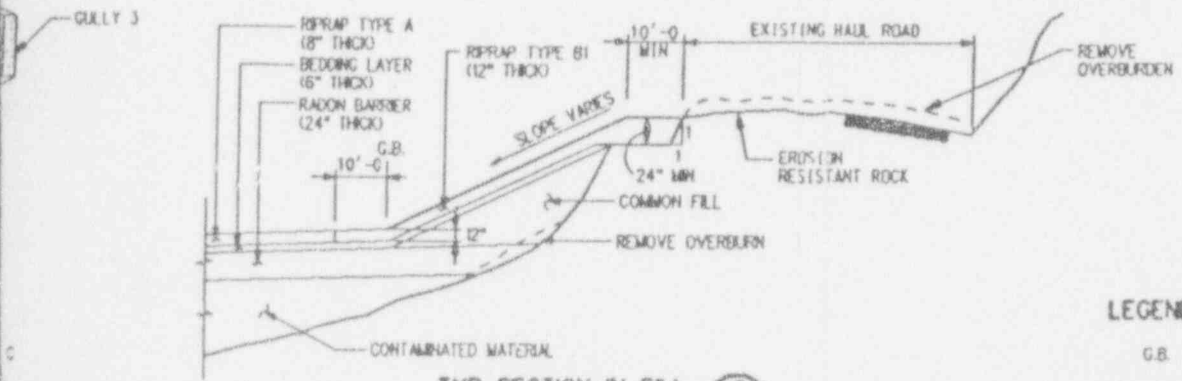
TYP. SECTION IN CUT (B)
NOT TO SCALE

NOTES:

1. EXACT LOCATION AND SLOPE OF RIPRAP TO BE PLACED ON EXISTING HAUL ROAD SHALL BE AS DIRECTED BY THE CONTRACTOR.

UMTRA/MHY
Erosion Protection
Embankment and South Edge Areas

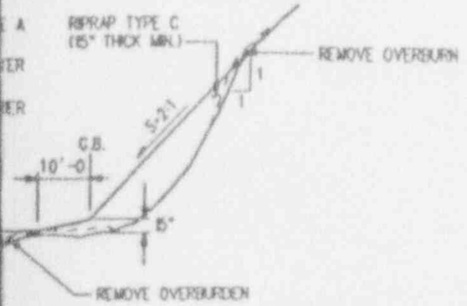
BYW 11/29/93
FHW 11/30/93



TYP. SECTION IN FILL (C)
NOT TO SCALE

LEGEND:

G.B.	GRADE BREAK
	ROCK TO BE CHIPPED
	RIPRAP TYPE A
	RIPRAP TYPE B1
	RIPRAP TYPE B
	RIPRAP TYPE C
	ROCKFILL TO BE SELECTED BY THE CONTRACTOR



SECTION (D)
NOT TO SCALE

DRAFT

9403040355-10

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

MEXICAN HAT SITE
MEXICAN HAT, UTAH

EROSION PROTECTION PLAN AND SECTIONS

DESIGNED	DRAWN
CHECKED	
INSPECTED	
RECOMMENDED	
APPROVED	DATE
DOE PROJECT ENGINEER	DATE
PROJECT NO.	DE-AC04-83AL18796
DRAWING NO.	

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

DATE	REVISION	BY	CK				