Uranium Mill Tailings Remedial Action Project (UMTRAP)

Grand Junction, Colorado

GRJ-PH-II

Calculations

Preliminary Final

Volume II

August 1990

MORRISON-KNUDSEN ENGINEERS, INC.

NOTICE OF LIMITED DISTRIBUTION

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Attachment
Letter 91-3050-388
May 9, 1991

PHASE II CONSTRUCTION
GRAND JUNCTION
CALCULATION INDEX

Calculation No.	Title
	VOLUME I
05-622-01-00	Dewatering
05-626-01-03	Tailings Excavation - Tailings Pile Limits and Quantities
05-626-02-04	Tailings Excavation - Off-Pile Excavation Limits and Quantities
05-628-01-00	Site Drainage - Hydrology Parameters
05-631-01-01	Access Road - Culvert at Indian Creek
05-631-02-01	Access and Haul Roads - Culvert Placement and Protection at Indian Creek
05-631-03-01	Access and Haul Roads - Culvert Outlet Revision
	VOLUME II
05-633-01-01	Site Grading - Restoration Quantity for Grand Junction Processing Site
05-504-01-02	Erosion Protection - Top and Sideslopes of Tailings Embankment
05-504-02-00	Erosion Protection - Time of Concentration, Cheney Disposal Site Embankment
05-504-07-00	Permanent Site Drainage - Off-Pile Drainage Swale
05-504-04-00	Disposal Site Drainage During Construction - Retention Basin and Emergency Spillway
05-504-05-02	Riprap Toe Protection

Calculation No.	Title
	VOLUME III
05-505-02-02	Rock Quality for the Erosion Protection - Cheney Disposal Site
05-505-03-02	Availability and Suitability of Materials
05-654-01-02	Hydrogeology - Dewatering
05-654-02-00	Slurry Trench at Processing Site - Quantities
05-654-03-00	Hydrogeology - Slurry Trench Seepage Windows
05-655-01-00	Surface Water Runoff Accumulation and Discharge
05-666-01-02	Construction Sequence
05-667-04-02	Quantity Estimate Summary - Phase II Construction
05-670-01-05	Radon Barrier Design - Thickness
05-670-02-03	Radon Barrier Design - Average Ra-226 Concentrations
	VOLUME IV
05-670-05-03	Embankment Design - Material Properties
05-670-06-02	Embankment Design - Settlement and Cover Cracking
	VOLUME V
05-670-07-05	Embankment Design - Slope Stability
05-670-08-01	Embankment Design - Drain Layer/Bedding Layer
05-670-09-02	Embankment Design - Depth of Frost Penetration
05-670-11-00	Radon Barrier - Ra-226 Concentrations in DOE Compound
05-670-12-00	Embankment Design - Paleochannel Remediation
05-670-13-00	Embankment Design - Infiltration

Calculation Cover Sheet

Contract No. 5025 **Discipline** ESCUP **Calc. No.** 5-633-01-~~00~~ 01 **No. of Sheets** ~~25~~ 33

Project
UMTRA / GRAND JUNCTION

Feature
SITE GRADING

Item
RESTORATION QUANTITY FOR GRAND JUNCTION PROCESSING SITE

Sources of Data MKE DWG. NO.S. GRJ-PS-10-0211
GRJ-PS-10-0212
GRJ-PS-10-0213

Sources of Formulae & References

1. US DEPT. OF ENERGY, "REMEDIAL ACTION PLAN AND SITE CONCEPTUAL DESIGN FOR STABILIZATION OF THE INACTIVE URANIUM MILL TAILINGS AT GRAND JUNCTION, COLORADO" DRAFT, JUNE 1986 (MKE DOC. NO. 5025-GRJ-R-03-00226-00, DRAFT RAP VOL. 1)
2. MKE CALCULATION NO-5-626-01-00, 9-15-86 "TAILINGS EXCAVATION/ TAILINGS PILE LIMITS AND QUANTITIES" (MKE DOC. NO. 5025-GRJ-C-01-01002-00
3. MKE CALCULATION NO. 5-626-02-00, 9-10-86 "TAILINGS EXCAVATION/ OFF-PILE EXCAVATION LIMITS AND QUANTITIES" MKE DOC. NO 5025-GRJ-C-01-01003-00

Preliminary Calc. ☐ **Final Calc.** ☒ **Supersedes Calc. No.** ______

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
1	REVISE PILE AND ADD RIVER BANK & BORDER	S.E. Botsford	1/18/88	WY Lin	1/18/88	[signature]	1/19/88
0		S.E. Botsford	7/9/87	P. Sirco	7-10-87	[signature]	7/10/87

Form 42-110

Project UMTRA - GRJ		Contract No. 5025-06	File No.
Feature		Designed SWB	Date 11/30/87
Item RESTORATION		Checked WYL	Date 1/18/88

(Rev. 1)

I. PURPOSE

THE PURPOSE OF THIS CALCULATION IS TO DETERMIN THE MATERIAL QUANTITY FOR RESTORING THE GRAND JUNCTION PROCESSING SITE DURING REMEDIAL ACTION THE REQUIRE MATERIAL WILL BE OBTAINED FROM THE DISPOSAL SITE.

II ANALYSES

GRAND JUNCTION IS LOCATED ON A FLAT TERRACE AT APPROXIMATELY 0.5% SLOPE SOUTHWEST TOWARD THE COLORADO RIVER. THE SHORELINE ADJACENT TO THE GRAND JUNCTION PROCESSING SITE IS AROUND ELEV. 4570. RESTORATION OF THE PROCESSING SITE WILL CONSIDER THE TOPOGRAPHY OF THE GRAND JUNCTION AREA AND THE LONG-TERM LAND USE PLANS AS WELL AS THE COST OF RESTORATION.

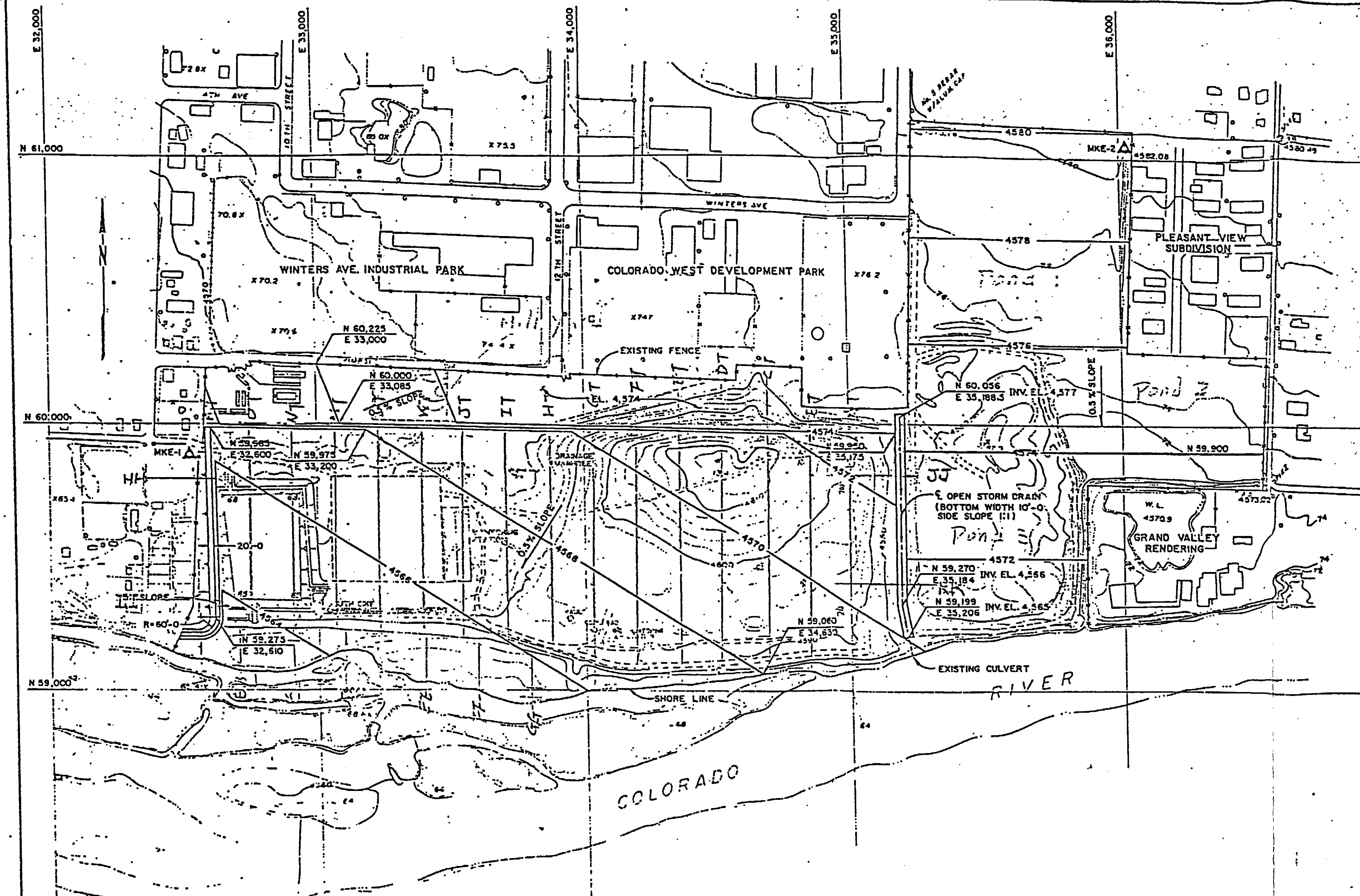
Project UMTRA -GRJ	Contract No. 5025	File No.
Feature SITE GRADING	Designed SGB	Date 11/23/8
Item RESTORATION QUANTITY FOR GRAND JUNCTION PROCESSING SITE	Checked WYL	Date 1/18/8

Rev. 1

QUANTITY SUMMARY

LOCATION	CUT (CY)	FILL (CY)
TAILINGS PILE	4281	538,973
MILL YARD		13,577
E. BORDER		15,331
W. BORDER		1,174
RIVER BANK	2456	20,548
POND NO. 1		9,582
POND NO. 2		37,341
POND NO. 3		102,392
	6,737	738,918

SHT 3



NOTES:

REFERENCE DRAWINGS:

GRJ-PS-10-0211. CONTAMINATED MATERIAL EXCAVATION PLAN SHEET 1 OF 2

GRJ-PS-10-0212 CONTAMINATED MATERIAL EXCAVATION PLAN SHEET 2 OF 2

LEGEND:

- EXISTING SITE FEATURES AND CONTOURS
- N 61,000 CONSTRUCTION GRID COORDINATE
- SITE BOUNDARY
- EXCAVATION
- EMBANKMENT
- EXISTING FENCE AND GATE
- 4568 ELEVATION CONTOUR OF FINAL GRADE
- SHORE LINE
- MKE-1 EXISTING PERMANENT SURVEY MONUMENT

Rev. 1
SGS 1-18-88
WYL 1/18/88

FINAL REVIEW		
E & O MANAGER	CHIEF ENGINEER	QA MANAGER

	△								
	△								
	△								
	△								
	0		ISSUED FOR FINAL REVIEW	—	—	—	—		
QA	NO.	DATE	REVISIONS	BY	CK	E&O MGR.	CHIEF ENG.	TAC REV	DOE

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

GRAND JUNCTION PROCESSING SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

FINAL GRADING PLAN

DESIGNED / DRAWN AMC / CHECKED / INSPECTED / RECOMMENDED / APPROVED / DATE / DOE PROJECT ENGINEER / DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. GRJ-PS-10-0213

A MORRISON KNUDSEN COMPANY

Project UNTRA - GRJT Contract No. 5025 File No.

Feature RESTORATION - MAIN PILE Designed Sw. Date 11/25/87

Item Checked WYL Date 1/18/88

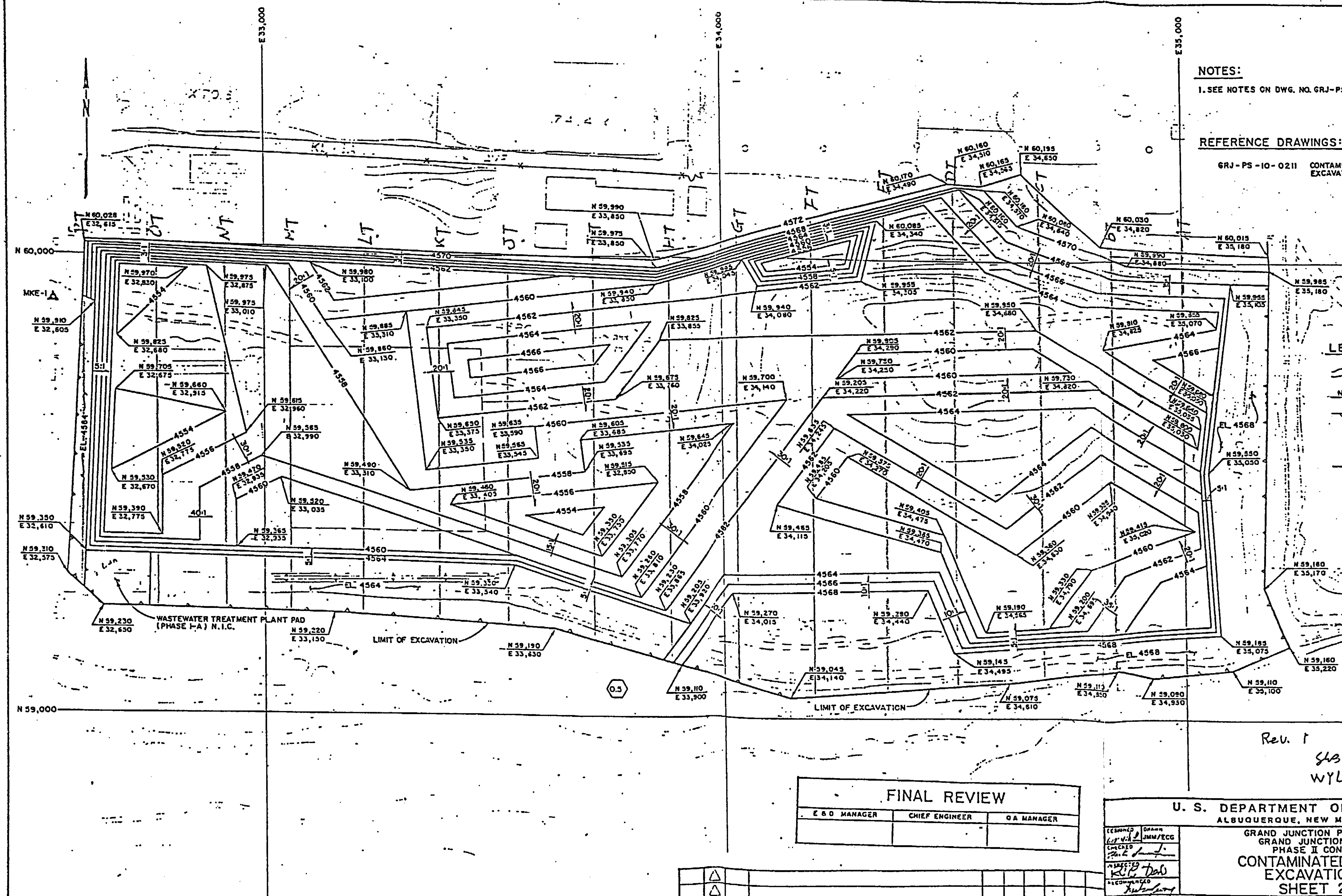
Rev. 1

Main Pile Area

SECTION	DISTANCE FT	FILL AREA FT²	FILL AV. AREA FT²	FILL VOLUME (CY)	CUT AREA (FT²)	CUT AV. AREA (FT²)	CUT VOLUME (CY)
AT		5937					
	165		6468	39,527			
BT		6998					
	165		7366	45,014			
CT		7734					
	160		7746	45,902			
DT		7758					
	165		7157	43737		47	287
ET		6556			93		
	165		6475	39569		174	1063
FT		6393			255		
	165		6037	36893		306	1870
GT		5680			357		
	160		5964	35342		179	1061
HT		6247					
	160		6146	36421			
IT		6045					
	160		5301	31413			
JT		4557					
	165		4302	26290			
KT		4046					
	155		4441	25495			
LT		4836					
	165		5057	30904			
MT		5278					
	160		5689	33713			
NT		6099					
	160		6646	39384			
OT		7192					
	160		4956	29369			
PT		2720					

FILL = 538973 CUT = 4281

SHT 5



NOTES:

1. SEE NOTES ON DWG. NO. GRJ-PS-10-0211.

REFERENCE DRAWINGS:

GRJ-PS-10-0211 CONTAMINATED MATERIAL EXCAVATION PLAN (SHEET 1 OF 2)

LEGEND:

4610	EXISTING SITE FEATURES & CONTOUR
N61,000	CONSTRUCTION GRID COORDINATE
	EXCAVATION
MKE-1	EXISTING PERMANENT SURVEY MONUMENT
4558	APPROX. ELEVATION CONTOUR OF THE BOTTOM CONTAMINATED MATERIAL TO BE EXCAVATED
2.5	DEPTH OF EXCAVATION IN FT.

Rev. 1
SWB 1/18/88
WYL 1/18/88

SCALE 100 0 100 200 FEET

FINAL REVIEW		
E & D MANAGER	CHIEF ENGINEER	QA MANAGER

NO.	DATE	REVISIONS	BY	CK	E&D MGR	CHIEF ENG	TAC REV	DOE APP
A		ISSUED FOR FINAL REVIEW	—	—	—	—		

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

GRAND JUNCTION PROCESSING SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

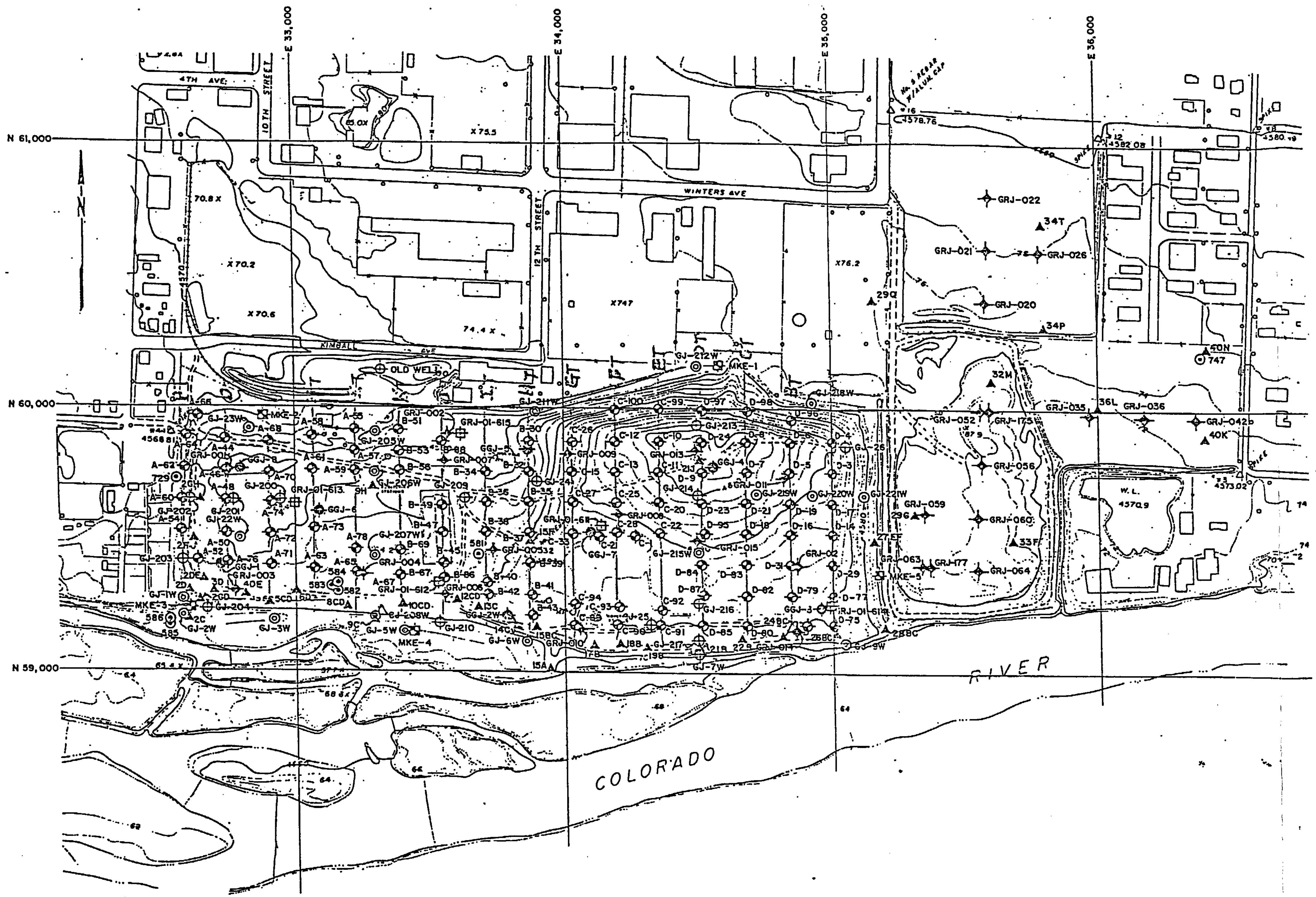
CONTAMINATED MATERIAL EXCAVATION PLAN SHEET 2 OF 2

DESIGNED / DRAWN JMM/ECG
CHECKED
INSPECTED
RECOMMENDED
APPROVED / DATE
DOE PROJECT ENGINEER / DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. GRJ-PS-10-0212 REV. B

SHT 6



NOTES:

1. GROUND WATER DATA AND SUBSURFACE EXPLORATION LOGS ARE AVAILABLE FROM THE CONTRACTOR.
2. JACOBS MONITOR WELLS NUMBERED 581 THROUGH 586 CORRESPOND TO FIELD DESIGNATION GWGJ-1 THROUGH GWGJ-6 RESPECTIVELY.
3. EXISTING CONTOURS AND FEATURES SHOWN ARE THOSE WHICH EXISTED PRIOR TO PHASE I-A CONSTRUCTION.

REFERENCE DRAWINGS:

GRJ-PS-10-0208	CONSTRUCTION FACILITIES AND SITE DRAINAGE
GRJ-PS-10-0209	SLURRY TRENCH PLAN
GRJ-PS-10-0211	CONTAMINATED MATERIAL EXCAVATION PLAN SHEET 1 OF 2
GRJ-PS-10-0212	CONTAMINATED MATERIAL EXCAVATION PLAN SHEET 2 OF 2

LEGEND:

4680	EXISTING SITE FEATURES & CONTOURS
N61,000	CONSTRUCTION GRID COORDINATE
GJ-200	AUGER BORINGS DRILLED BY COLORADO STATE UNIVERSITY (1980)
A-66, B-51, C-26, D-27	AUGER BORINGS DRILLED BY SERGENT, HAUSKINS & BECKWITH (1981)
GGJ-1	AUGER BORINGS DRILLED IN 1982, MONITORING WELLS 1982.
GJ-205W	MONITOR WELLS INSTALLED BY COLORADO STATE UNIVERSITY (1980)
724	MONITOR WELL INSTALLED BY JACOBS ENGINEERING GROUP, INC. (1985)
GRJ-01-611	TEST PITS DUG BY JACOBS ENGINEERING GROUP, INC. (1985)
MKE-1	TEST PITS DUG BY MORRISON-KNUDSEN ENGINEERS, INC. (1985)
GRJ-001	AUGER BORINGS DRILLED BY JACOBS ENGINEERING GROUP (1984)
	OLD WELL WEST OF MILL.
▲	AUGER BORINGS DRILLED BY LINCOLN DEVORE (1987)

200 0 200 400
SCALE FEET

FINAL REVIEW		
E & O MANAGER	CHIEF ENGINEER	QA MANAGER

QA MK-F	NO.	DATE	REVISIONS	BY	CK	E&O MGR.	CHIEF ENG.	TAC REV.	DOE APP.
	B		ISSUED FOR FINAL REVIEW	-	-	-	-		

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

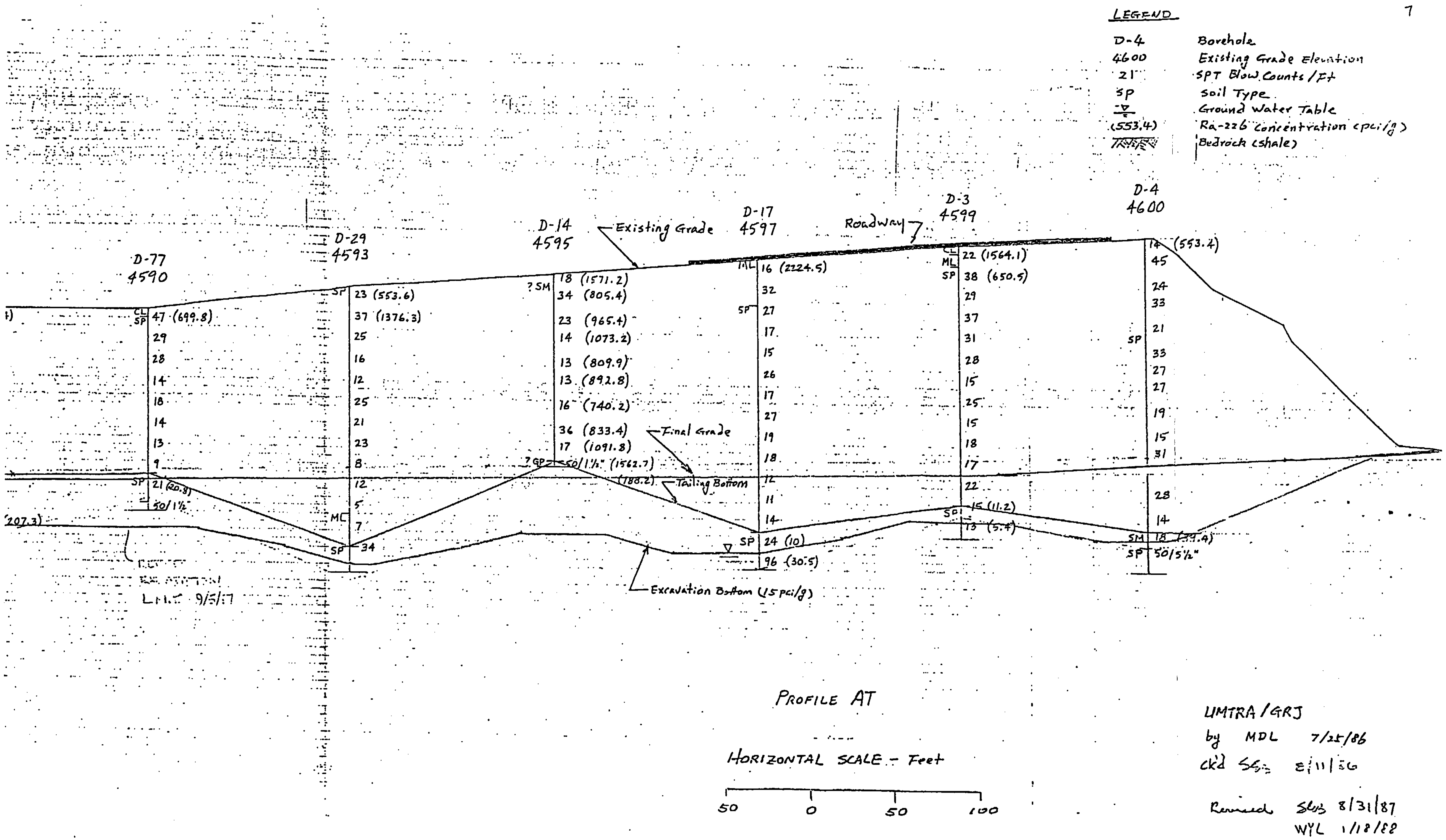
GRAND JUNCTION PROCESSING SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

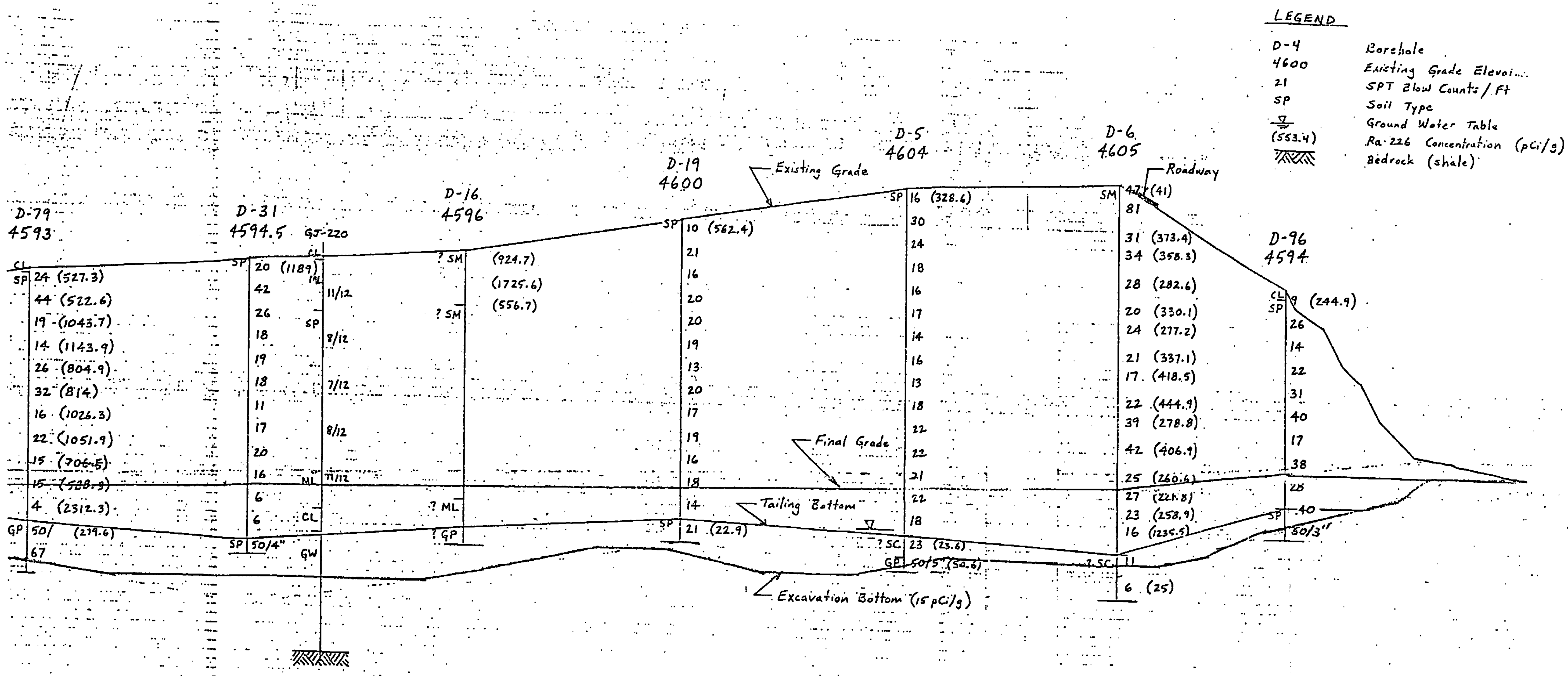
BORINGS AND TEST PITS LOCATION PLAN

DESIGNED / DRAWN RSC / CHECKED / INSPECTED / RECOMMENDED / APPROVED / DATE / DOE PROJECT ENGINEER / DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. GRJ-PS-10-0217
REV. B


LEGEND
D-4 Borehole
4600 Existing Grade Elevation
21 SPT Blow Counts / Ft
SP Soil Type
Ground Water Table
(553.4) Ra-226 Concentration (pCi/g)
Bedrock (shale)
D-77
4590
D-29
4593
D-14
4595
D-17
4597
D-3
4599
D-4
4600
Existing Grade
Roadway
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
47 (699.8)
23 (553.6)
37 (1376.3)
18 (1571.2)
34 (805.4)
23 (965.4)
14 (1073.2)
13 (809.9)
13 (892.8)
16 (740.2)
36 (833.4)
17 (1091.8)
50/1½" (1562.7)
16 (2224.5)
24 (10)
96 (30.5)
22 (1564.1)
38 (650.5)
15 (11.2)
13 (5.4)
(553.4)
50/5½"
PROFILE AT
HORIZONTAL SCALE - Feet
50 0 50 100
UMTRA / GRJ
by MDL 7/25/86
ck'd 8/11/86
Revised 8/31/87
WYL 1/18/88

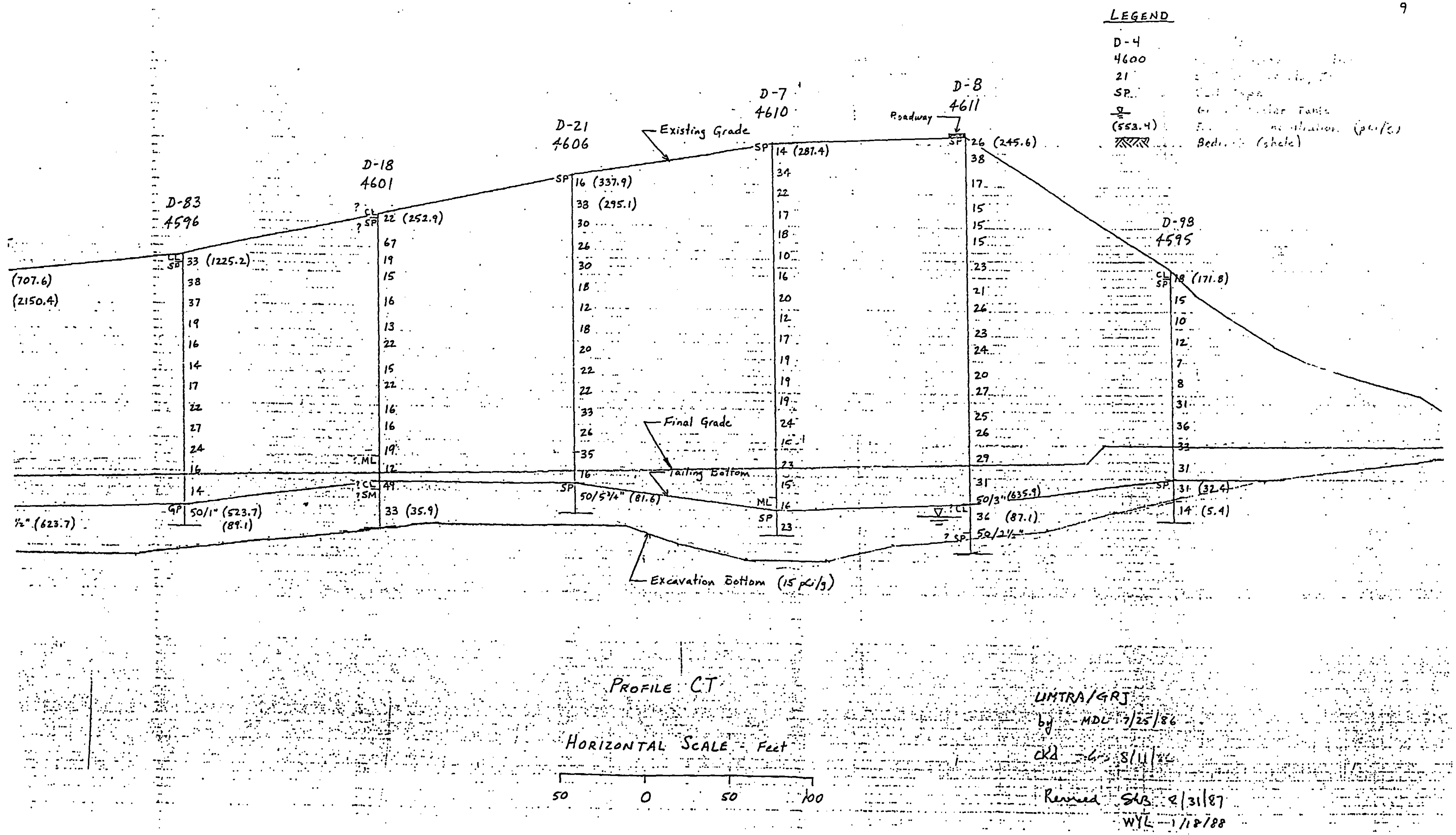


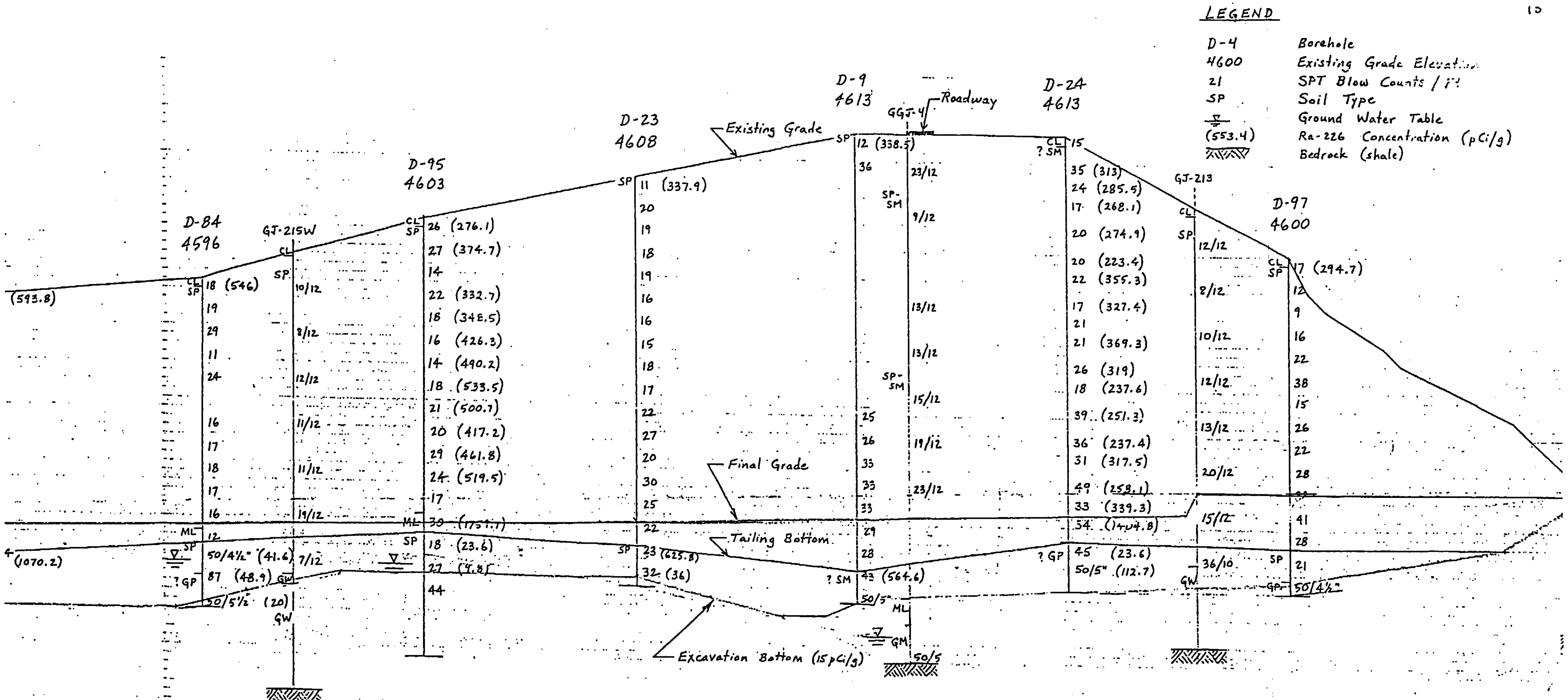
PROFILE BT

HORIZONTAL SCALE - Feet

50 0 50 100

UMTRA/GRJ
by MDL 7/25/86
WYL 1/18/88


LEGEND
D-4
4600
21
SP
(553.4)
Bedrock (shale)
D-83
4596
D-18
4601
D-21
4606
D-7
4610
D-8
4611
D-98
4595
Roadway
Existing Grade
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
(707.6)
(2150.4)
33 (1225.2)
22 (252.9)
16 (337.9)
33 (295.1)
14 (287.4)
26 (245.6)
18 (171.8)
50/1" (523.7)
(89.1)
33 (35.9)
50/5¾" (81.6)
50/3" (635.9)
36 (87.1)
31 (32.4)
14 (5.4)
PROFILE CT
HORIZONTAL SCALE - Feet
50
0
50
100
UMTRA/GRJ
by MDL 7/25/86
CKd 8/11/86
Revised SLB 8/31/87
WYL 1/18/88

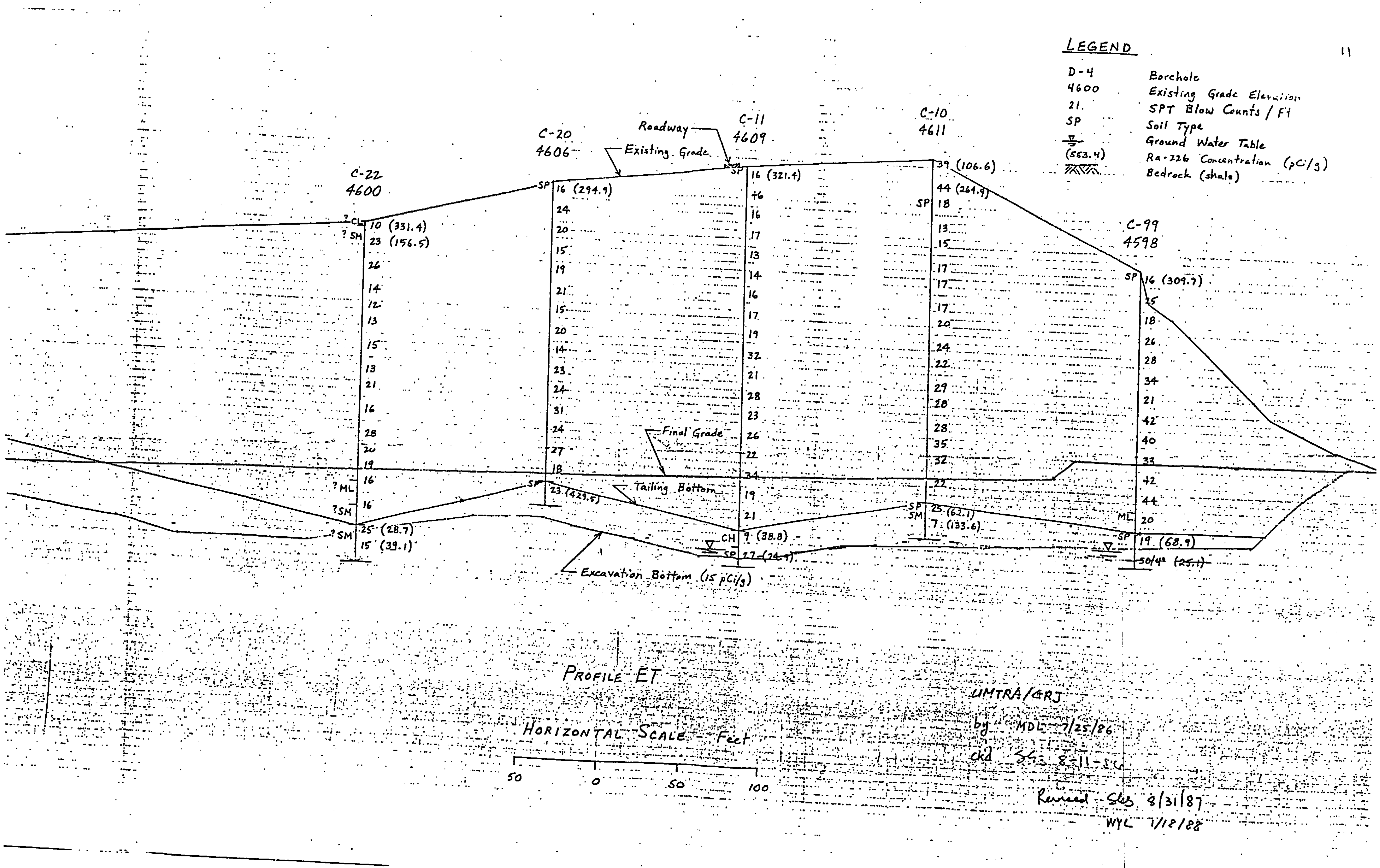


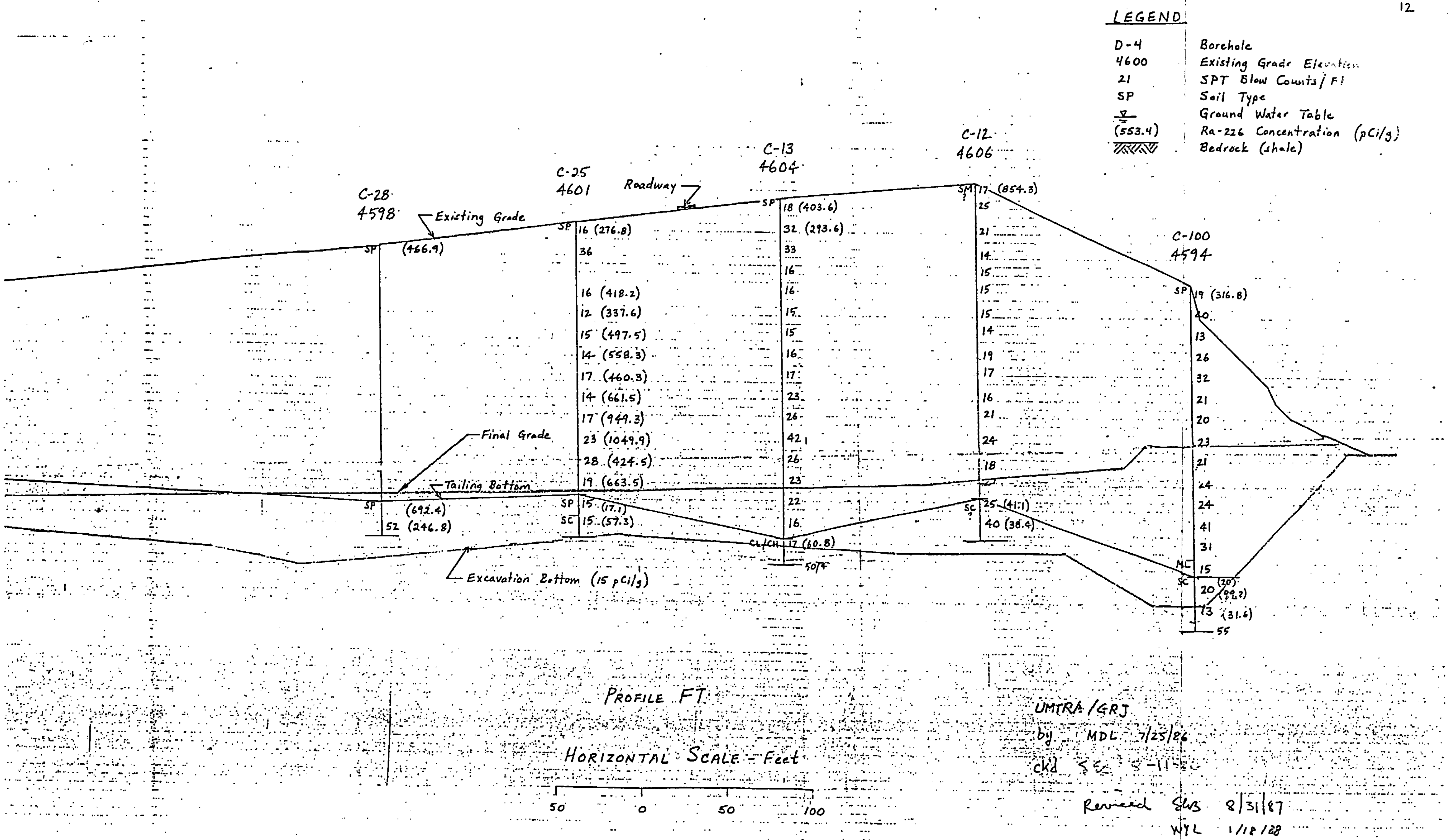
PROFILE DT

HORIZONTAL SCALE - Feet

50 0 50 100

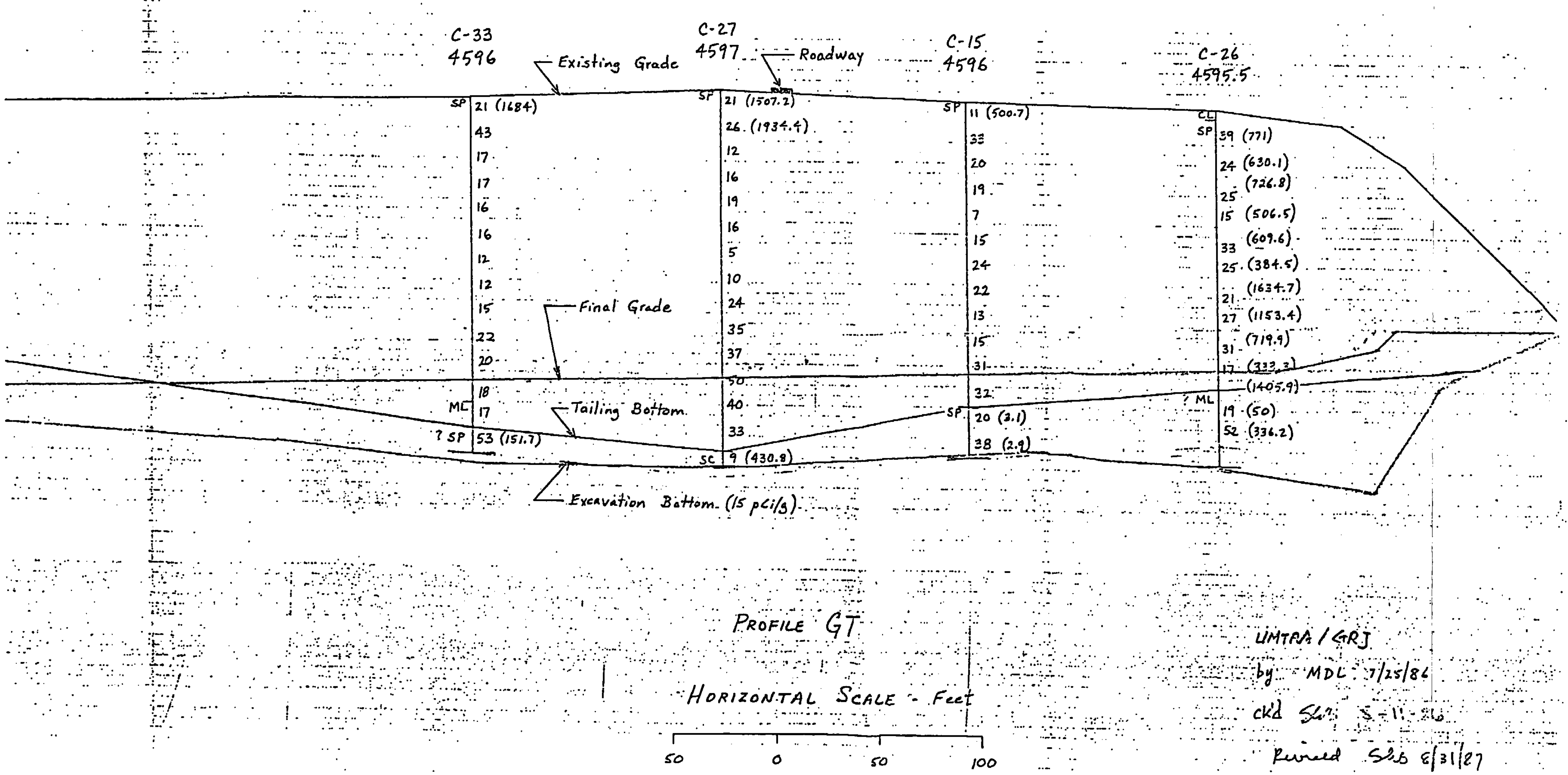
UMTRA/GRJ
by MDL 7/25/86
Ckd 9-11-86
Revised SHB 8-31-87
WYL 1/18/88


LEGEND
D-4 Borehole
4600 Existing Grade Elevation
21. SPT Blow Counts / Ft
SP Soil Type
Ground Water Table
(563.4) Ra-226 Concentration (pCi/g)
Bedrock (shale)
C-22
4600
C-20
4606
C-11
4609
C-10
4611
C-99
4598
Roadway
Existing Grade
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
PROFILE ET
HORIZONTAL SCALE - Feet
50
0
50
100
UMTRA/GRJ
by MDL 7/25/86
ckd SGS 8-11-86
Revised SGS 8/31/87
WYL 7/18/88


LEGEND
D-4 Borehole
4600 Existing Grade Elevation
21 SPT Blow Counts/Ft
SP Soil Type
Ground Water Table
(553.4) Ra-226 Concentration (pCi/g)
Bedrock (shale)
C-28
4598
C-25
4601
C-13
4604
C-12
4606
C-100
4594
Existing Grade
Roadway
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
PROFILE FT
HORIZONTAL SCALE - Feet
50 0 50 100
UMTRA/GRJ
by MDL 7/25/86
Revised SWB 8/31/87
WYL 1/18/88

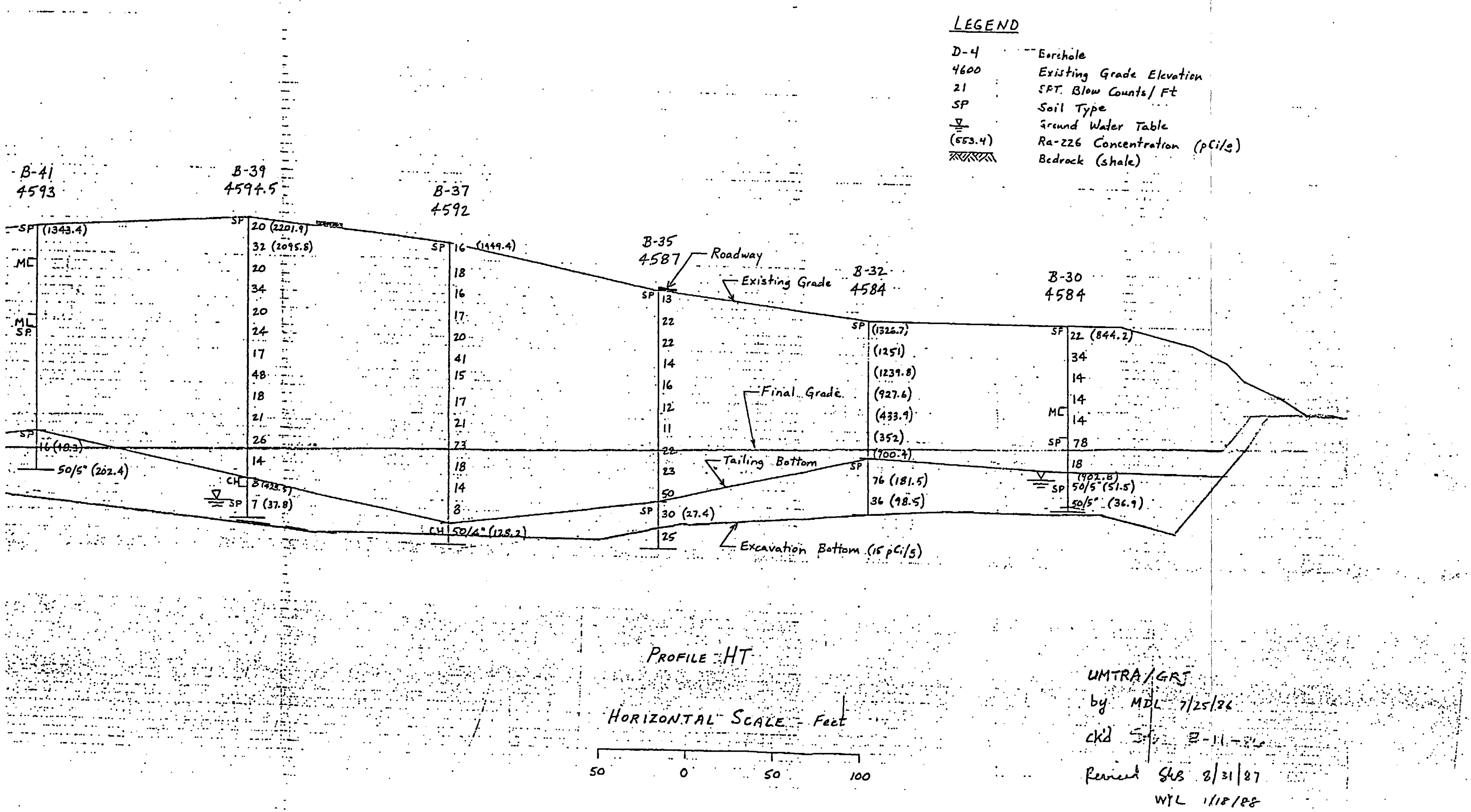
LEGEND

D-4	Borehole
4600	Existing Grade Elevation
21	SPT Blow Counts / Ft
SP	Soil Type
⊽	Ground Water Table
(553.4)	Ra-226 Concentration (pCi/g)
▨	Bedrock (shale)

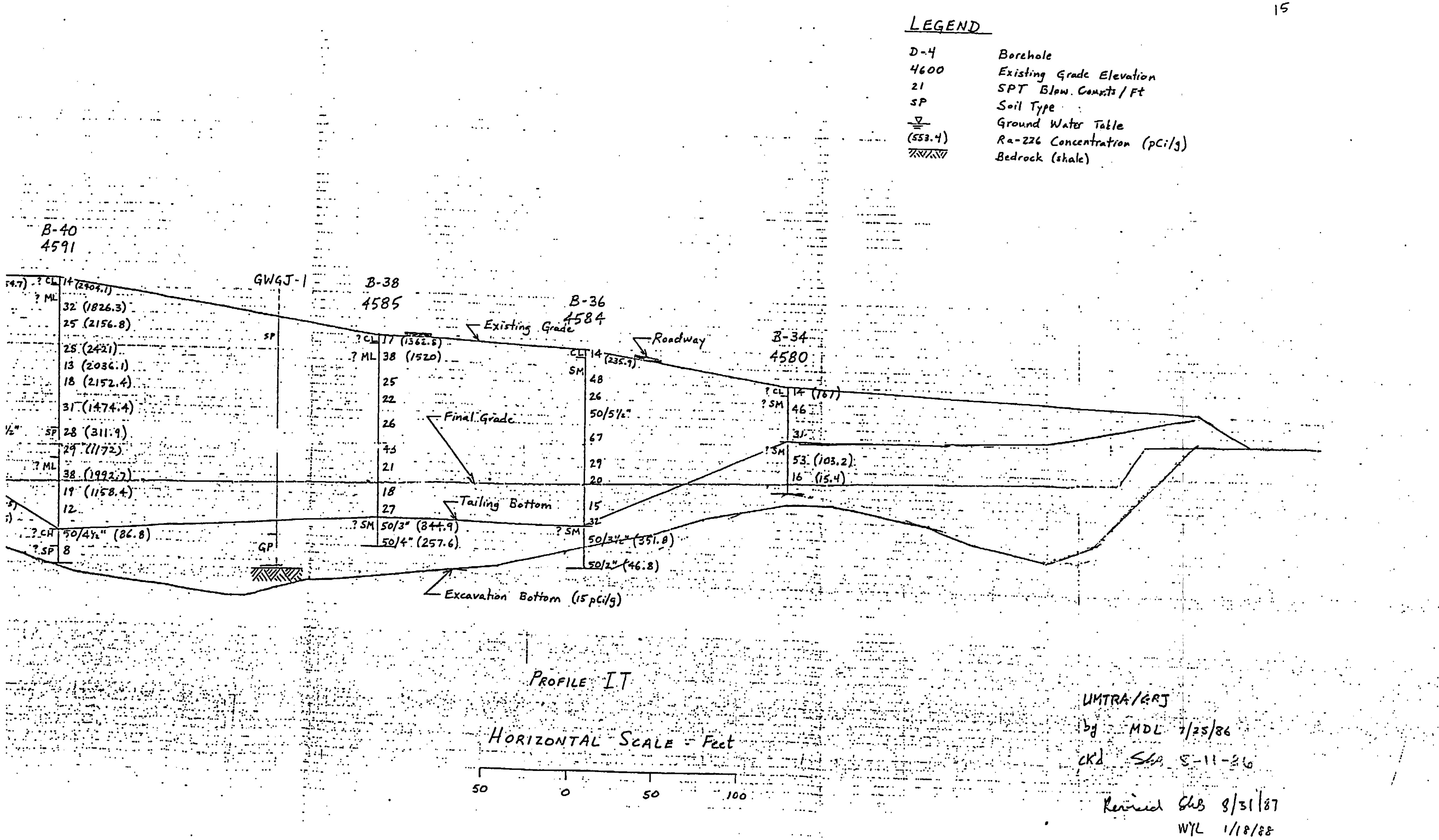


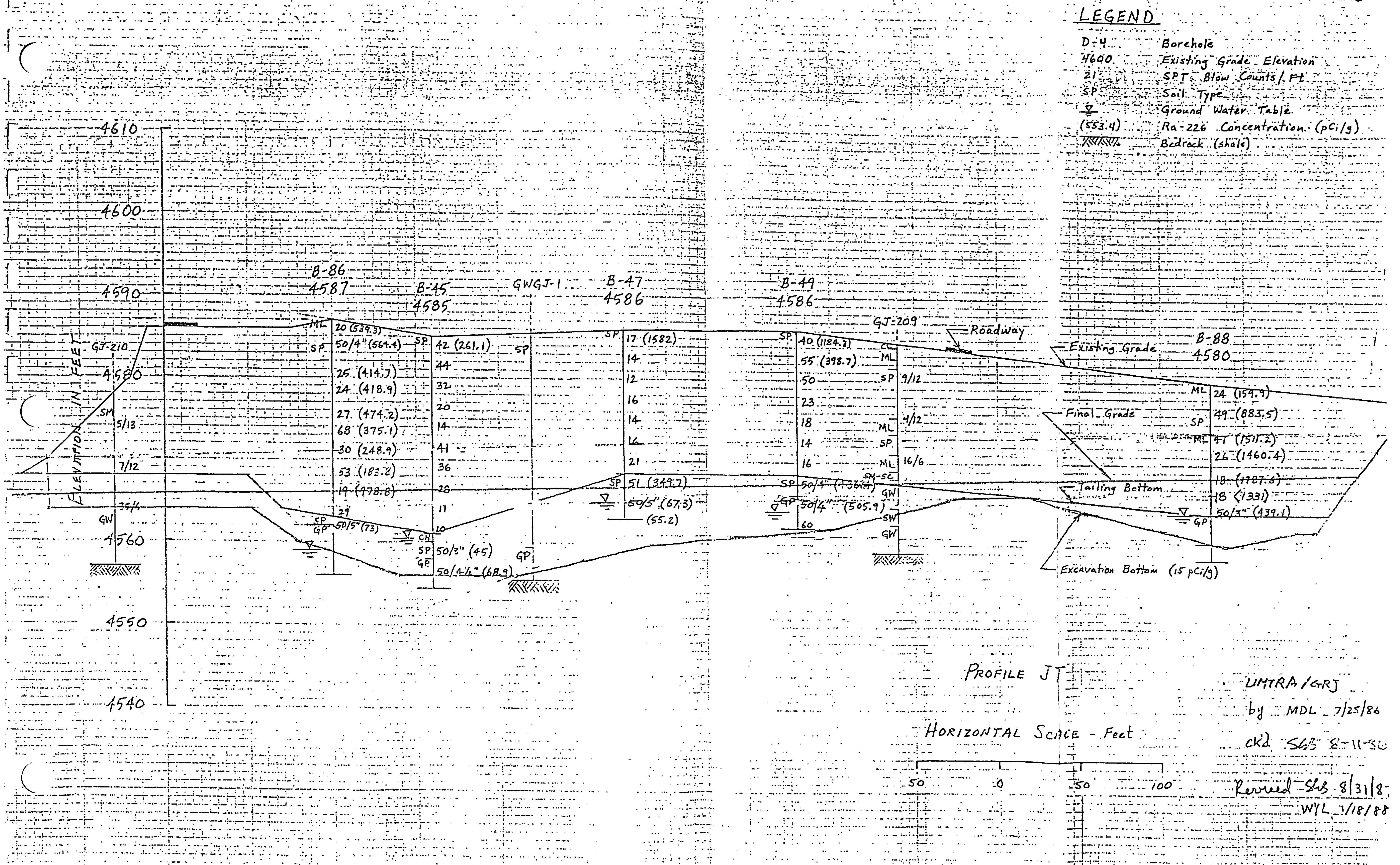
PROFILE GT

UMTRA / GRJ
by MDL 7/25/86
ck'd SLS 8-11-86
Revised SLS 8/31/87
WYL 1/18/88



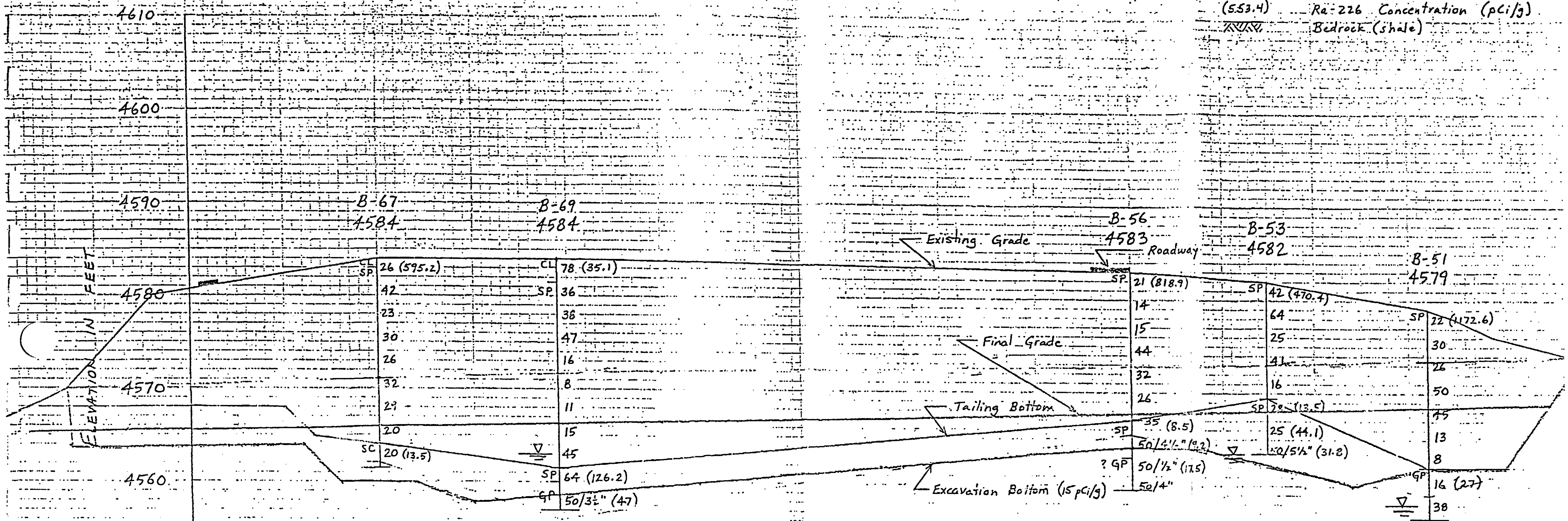
LEGEND
D-4 Borehole
4600 Existing Grade Elevation
21 SPT. Blow Counts/Ft
SP Soil Type
Ground Water Table
(553.4) Ra-226 Concentration (pCi/g)
Bedrock (shale)
B-41 4593
B-39 4594.5
B-37 4592
B-35 4587
B-32 4584
B-30 4584
Roadway
Existing Grade
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
PROFILE HT
HORIZONTAL SCALE - Feet
50 0 50 100
UMTRA/GRJ
by MDL 7/25/86
Revised SHB 8/31/87
WJL 1/18/88


LEGEND
D-4 Borehole
4600 Existing Grade Elevation
21 SPT Blow Counts / Ft
SP Soil Type
Ground Water Table
(553.4) Ra-226 Concentration (pCi/g)
Bedrock (shale)
B-40
4591
GWGJ-1
B-38
4585
B-36
4584
B-34
4580
Existing Grade
Roadway
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
14 (2904.1)
32 (1826.3)
25 (2156.8)
25 (2421)
13 (2036.1)
18 (2152.4)
31 (1474.4)
28 (311.9)
29 (1172)
38 (1992.7)
19 (1158.4)
12
50/4½" (86.8)
8
17 (1562.6)
38 (1520)
25
22
26
45
21
18
27
50/3" (844.9)
50/4" (257.6)
14 (235.9)
48
26
50/5½"
67
29
20
15
32
50/3½" (351.8)
50/2" (46.8)
14 (167)
46
31
53 (103.2)
16 (15.4)
? CL
? ML
SP
? CH
? SP
GP
? SM
SM
CL
? CL
? SM
PROFILE II
HORIZONTAL SCALE - Feet
50
0
50
100
UMTRA/GRJ
by MDL 7/25/86
ckd SLB 8-11-86
Revised SLB 8/31/87
WYL 1/18/88


LEGEND
D-4 Borehole
4600 Existing Grade Elevation
21 SPT Blow Counts / Ft
SP Soil Type
Ground Water Table
(553.4) Ra-226 Concentration (pCi/g)
Bedrock (shale)
4610
4600
4590
4580
4560
4550
4540
ELEVATION IN FEET
GJ-210
B-86
4587
B-45
4585
GWGJ-1
B-47
4586
B-49
4586
GJ-209
B-88
4580
Roadway
Existing Grade
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
20 (539.3)
50/4" (564.4)
25 (414.7)
24 (418.9)
27 (474.2)
68 (375.1)
30 (248.9)
53 (183.8)
19 (478.8)
29
50/5" (73)
42 (261.1)
44
32
20
14
41
36
28
17
10
50/3" (45)
50/4½" (68.9)
17 (1582)
14
12
16
14
16
21
51 (349.7)
50/5" (67.3)
(55.2)
40 (1184.3)
55 (398.7)
50
23
18
14
16
50/4"
50/4" (505.9)
60
9/12
4/12
16/6
5/13
7/12
24 (159.9)
49 (883.5)
47 (1511.2)
26 (1460.4)
18
18 (1331)
50/3" (439.1)
PROFILE JT
HORIZONTAL SCALE - Feet
50 0 50 100
UMTRA / GRJ
by MDL 7/25/86
ck'd SLS 8-11-86
Revised SLS 8/31/8-
WYL 1/18/88

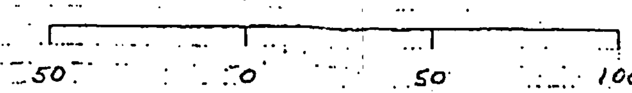
LEGEND

D-4	Borehole
4600	Existing Grade Elevation
21	SPT Blow Counts/Ft
SP	Soil Type
∇	Ground Water Table
(553.4)	Ra-226 Concentration (pCi/g)
(hatch)	Bedrock (shale)



PROFILE KT

HORIZONTAL SCALE - Feet



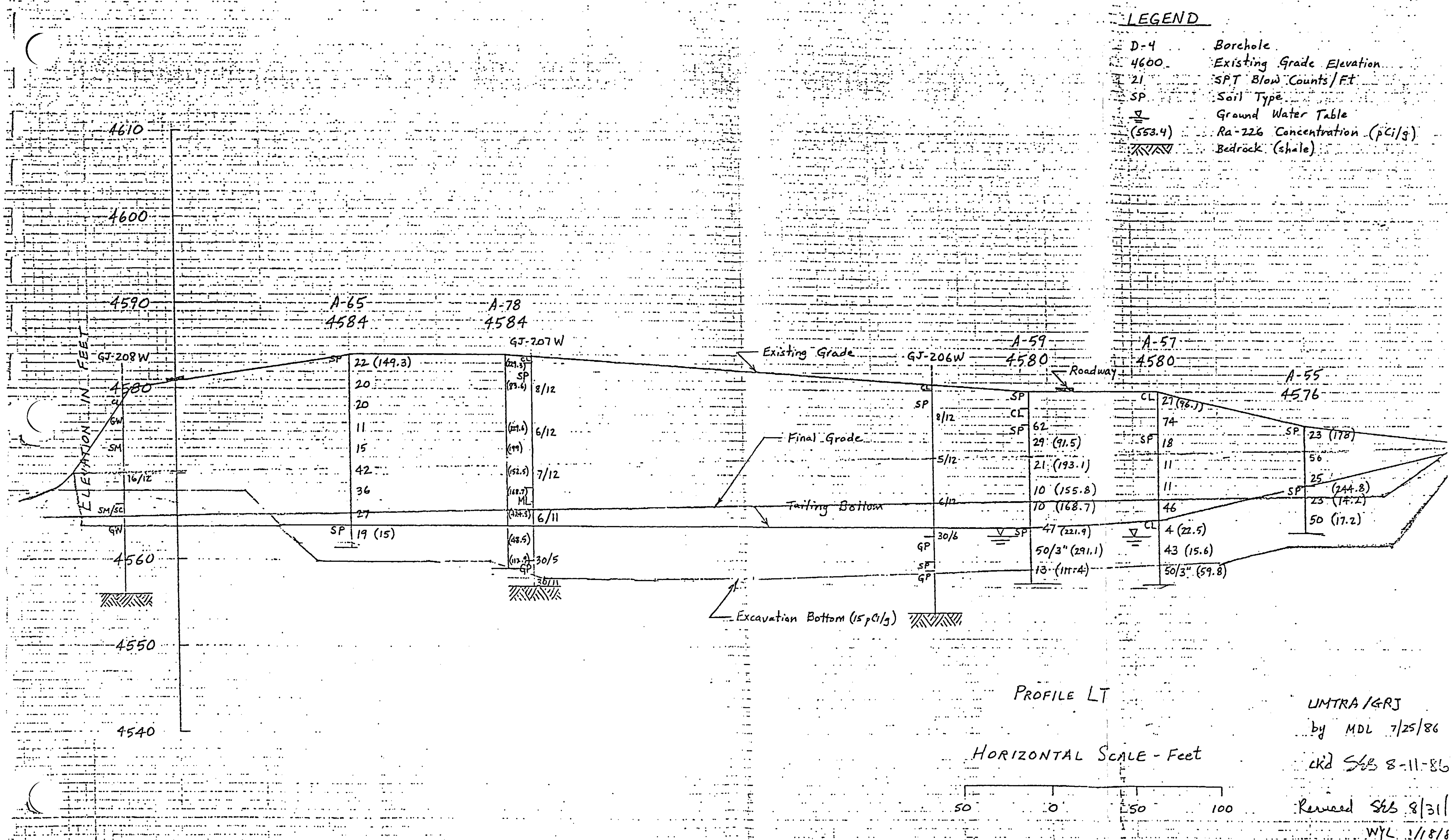
UMTRA/GRJ

by MDL 7/25/86

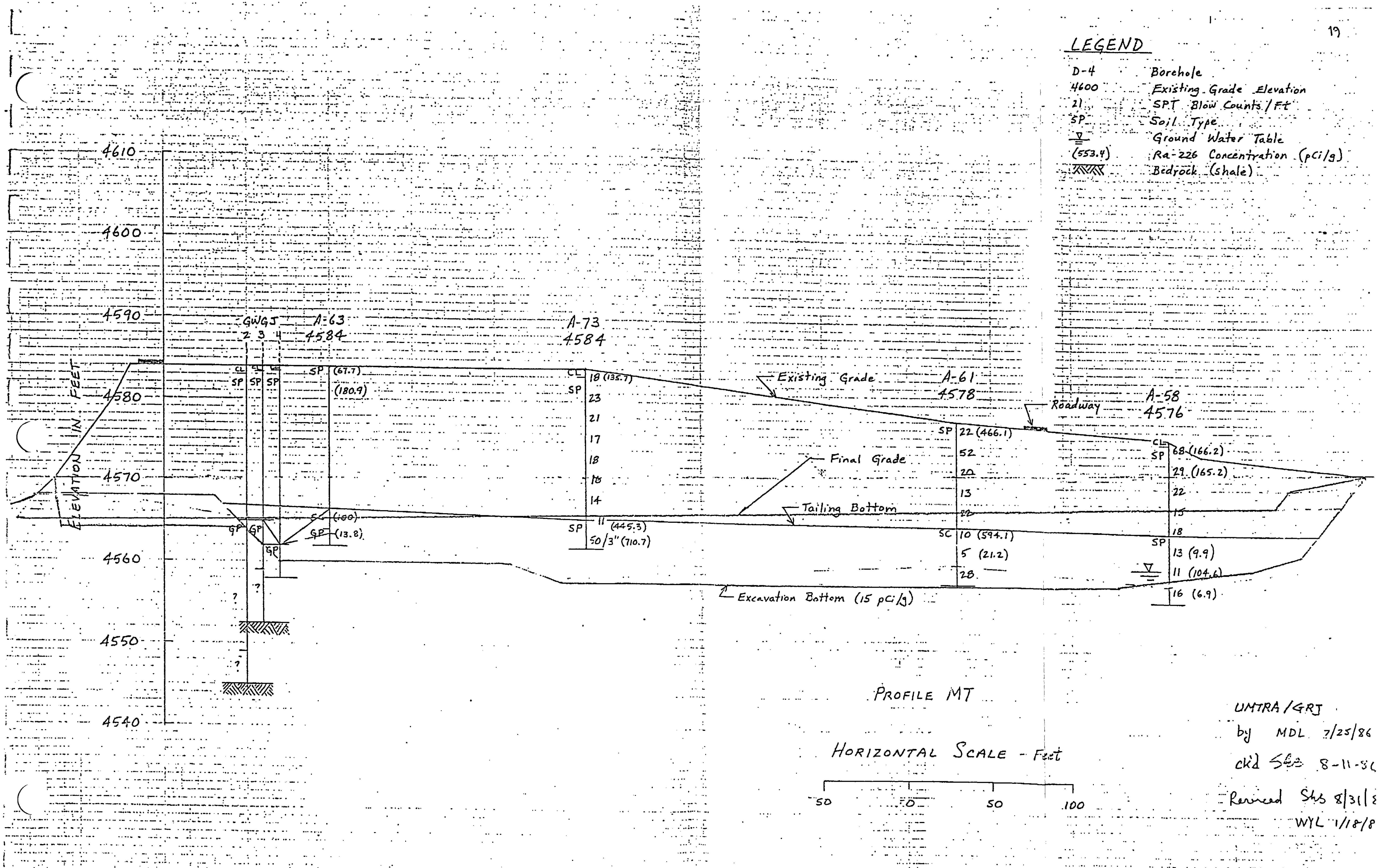
ckd SWS 8-11-

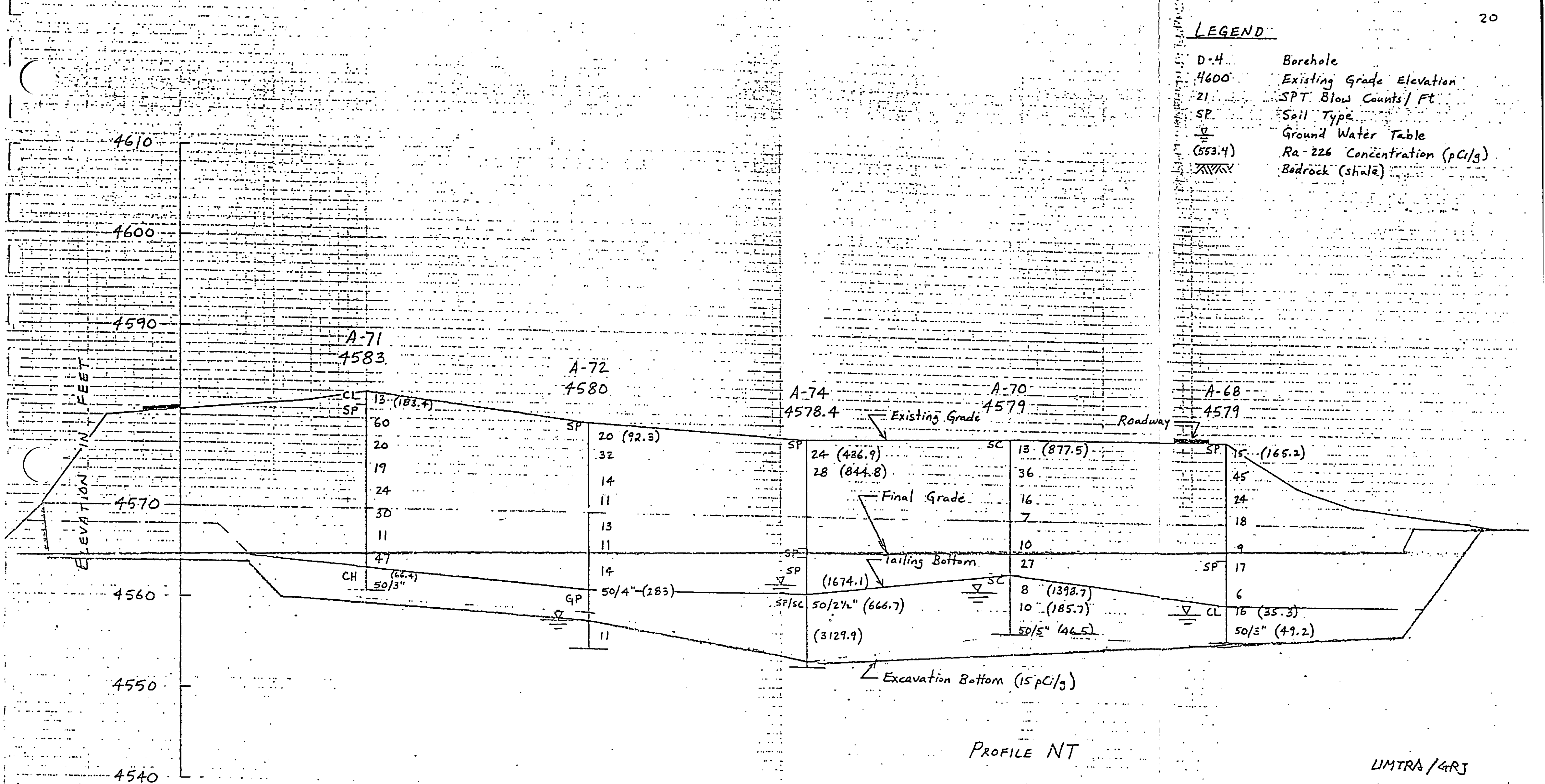
Revised SWS 8/31

WYL 1/18/



LEGEND
D-4 Borehole
4600 Existing Grade Elevation
21 SPT Blow Counts/Ft
SP Soil Type
Ground Water Table
(553.4) Ra-226 Concentration (pCi/g)
Bedrock (shale)
ELEVATION IN FEET
4610
4600
4590
4580
4560
4550
4540
GJ-208W
A-65
4584
A-78
4584
GJ-207W
Existing Grade
GJ-206W
A-59
4580
Roadway
A-57
4580
A-55
4576
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
22 (149.3)
19 (15)
29 (91.5)
21 (193.1)
10 (155.8)
10 (168.7)
47 (221.9)
50/3" (291.1)
13 (111.4)
27 (96.1)
4 (22.5)
43 (15.6)
50/3" (59.8)
23 (178)
(244.8)
23 (14.2)
50 (17.2)
PROFILE LT
HORIZONTAL SCALE - Feet
50
0
50
100
UMTRA/GRJ
by MDL 7/25/86
ckd SGS 8-11-86
Revised SGS 8/31
WYL 1/18/8

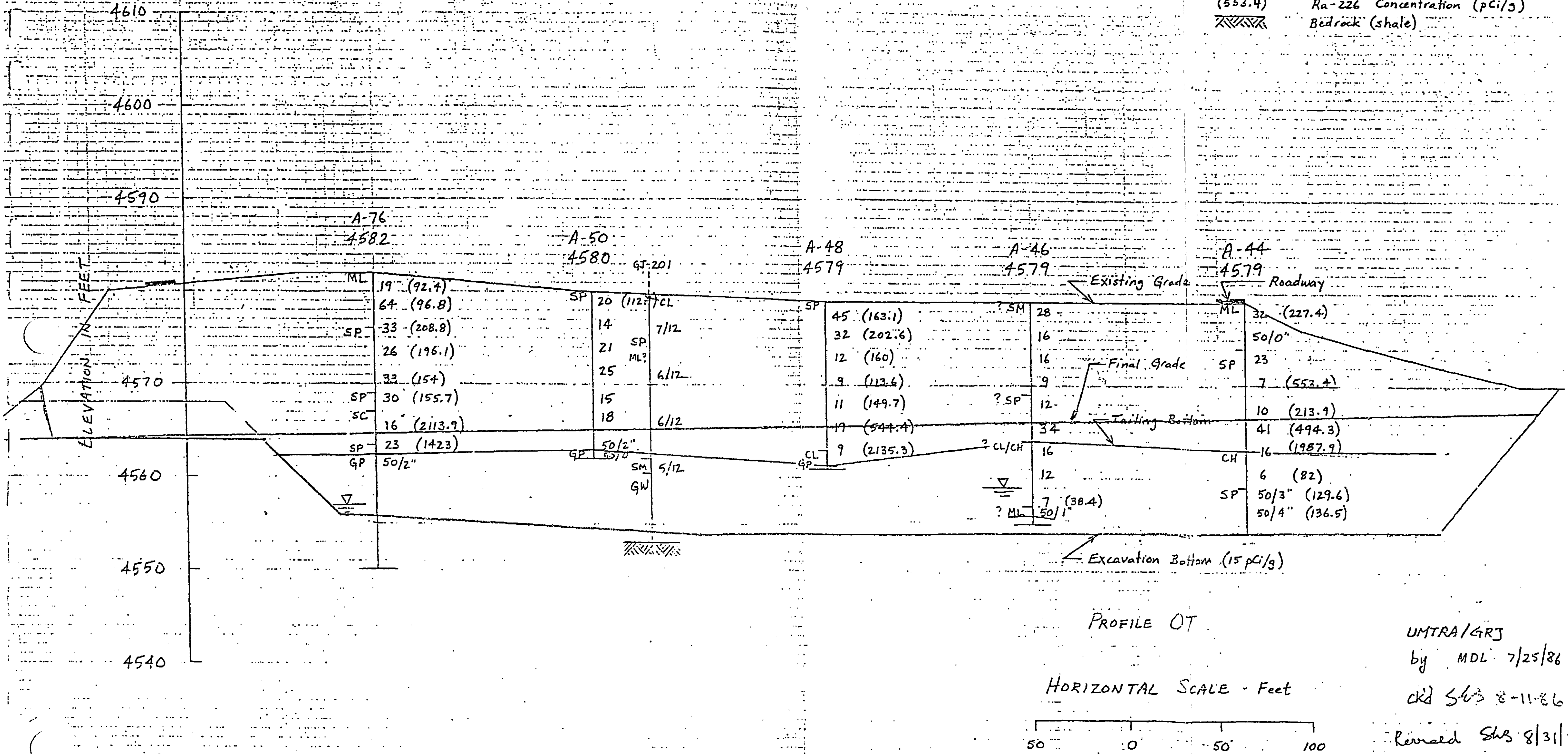

LEGEND
D-4 Borehole
4600 Existing Grade Elevation
21 SPT Blow Counts / Ft
SP Soil Type
Ground Water Table
(553.4) Ra-226 Concentration (pCi/g)
Bedrock (shale)
ELEVATION IN FEET
4610
4600
4590
4580
4570
4560
4550
4540
GWGJ
2 3 4
A-63
4584
A-73
4584
A-61
4578
A-58
4576
Existing Grade
Roadway
Final Grade
Tailing Bottom
Excavation Bottom (15 pCi/g)
CL SP SP SP SP (67.7) (180.9)
CL 18 (135.7) SP 23 21 17 18 16 14 11 (445.3) SP 50/3" (710.7)
SC (100) GP (13.8) GP GP GP
SP 22 (466.1) 52 20 13 SC 10 (594.1) 5 (21.2) 28
CL SP 68 (166.2) 29 (165.2) 22 15 18 SP 13 (9.9) 11 (104.6) 16 (6.9)
PROFILE MT
HORIZONTAL SCALE - Feet
50 0 50 100
UMTRA / GRJ
by MDL 7/25/86
ck'd SHS 8-11-86
Revised SHS 8/31/8
WYL 1/18/8



UMTRA/GRJ
by MDL 7/25/86
ck'd SG3 8-11-86
Revised SLS 8/31/8
WYL 1/18/8

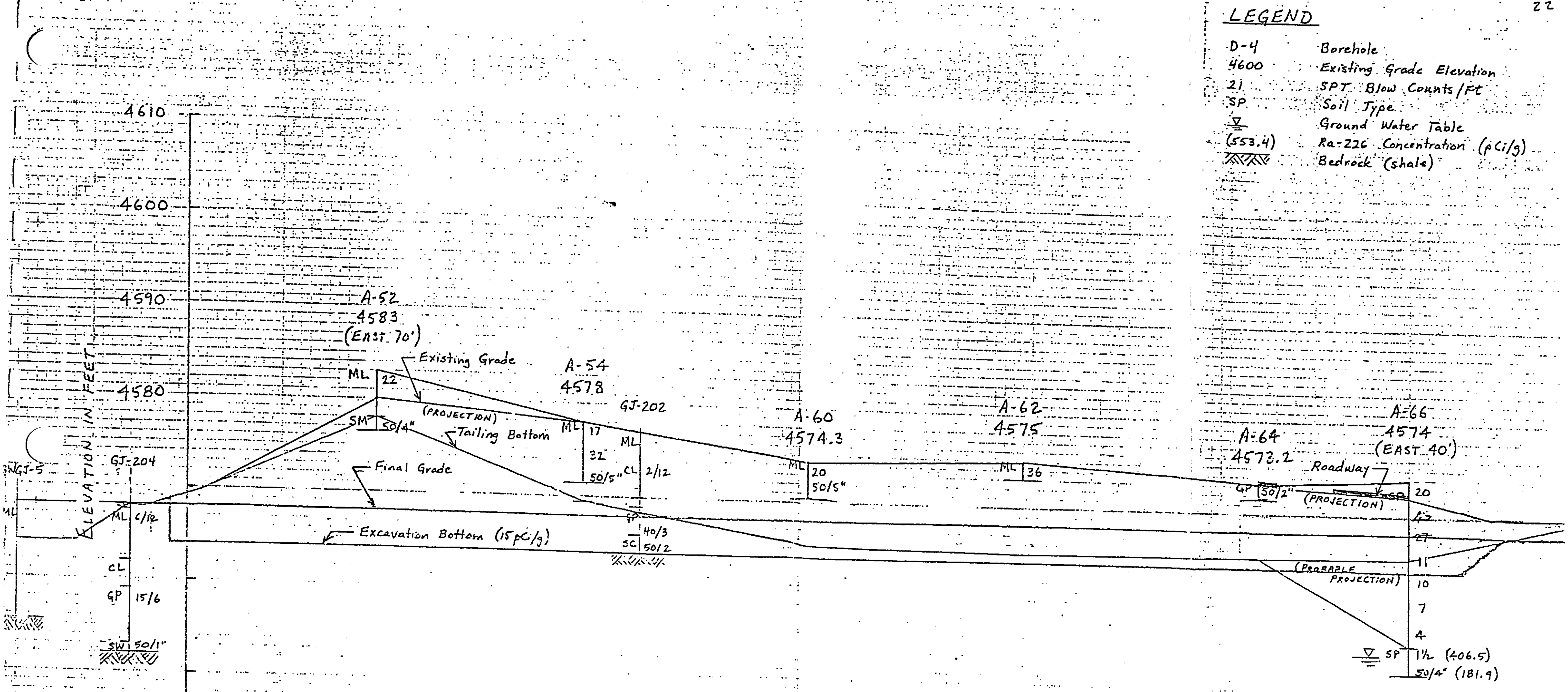
LEGEND

D-4	Borehole
4600	Existing Grade Elevation
21	SPT Blow Counts / Ft
SP	Soil Type
▽	Ground Water Table
(553.4)	Ra-226 Concentration (pCi/g)
//////	Bedrock (shale)



PROFILE OT

UMTRA/GRJ
by MDL 7/25/86
ck'd SLG 8-11-86
Revised SLG 8/31/
WYL 1/18/8



PROFILE PT

HORIZONTAL SCALE - Feet

50 0 50 100

UMTRA/GRJ

by MDL 7/25/86

ck'd

Revised

WYL

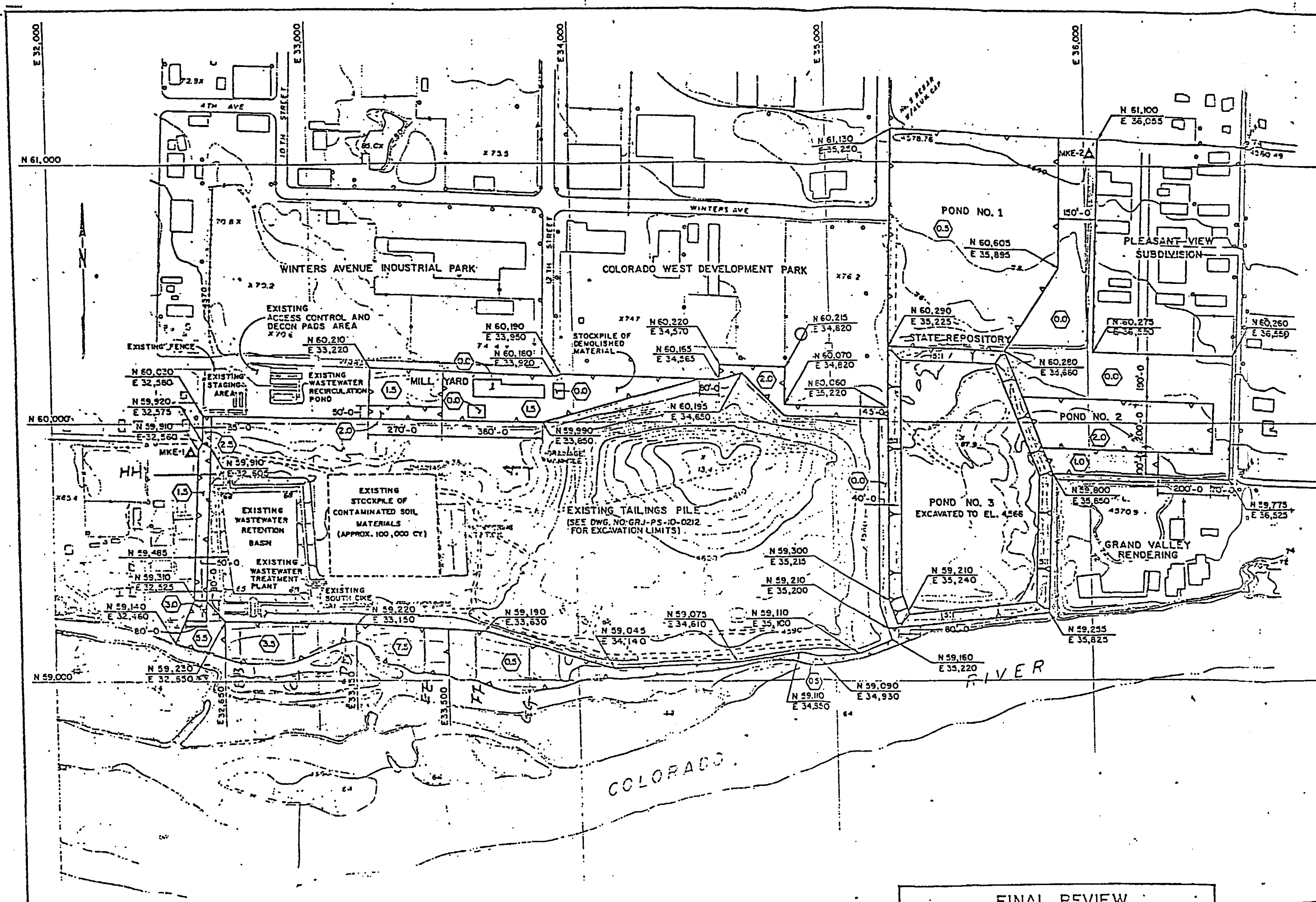
A MORRISON KNUDSEN COMPANY

Project UMTRA GRJ — Contract No. 5025 — File No.
Feature — Designed RMB — Date 10-15-87
Item — Checked SWB — Date 12-18-87

Rev. 1

Restoration for River Bank and east and west border areas.

SECTION	FILL AREA (FT²)	AVERAGE AREA (FT²)	LENGTH (FT)	VOLUME (CY)	CUT AREA (FT²)	AVG AREA (FT²)	LENGTH (FT)	VOLUME (CY)
RIVER BANK								
		732	70	1897.8				
AA	732							
		581	150	3227.8				
BB	429							
		448	200	3318.5				
CC	467							
		292	200	2163.0				
DD	117							
		538	300	5977.8				
EE	958							
		484	200	3659.3		91	200	674.1
FF	9				182			
		21	200	155.6		183	200	1355.6
GG	32				183			
		32	125	148.1		92	125	425.9
			TOTAL	20,548				2,456
WEST BORDER								
		56	100	207.4				
H-H	56							
		53	450	883.3				
I-I	50							
		50	45	83.3				
			TOTAL	1,174				
EAST BORDER								
		515	220	4,196.3				
JJ	515							
		470	400	6,963.0				
K-K	425							
		425	265	4,171.3	TOTAL 15,331 CY			



NOTES:

1. ALL EXCAVATED CUT SLOPES SHALL BE 2(H):1(V) MAXIMUM UNLESS SPECIFIED OTHERWISE IN THE CONTRACT DRAWINGS.
2. EXISTING DIKES SURROUNDING POND NO. 3 SHALL NOT BE DISTURBED DURING EXCAVATION TO THE MAXIMUM EXTENT PRACTICABLE UNTIL FINAL GRADING IS COMPLETE EXCEPT AS REQUIRED FOR EQUIPMENT ACCESS.
3. EQUIPMENT ACCESS SHALL BE PROVIDED TO POND NO. 3 SUCH THAT SURROUNDING DIKES (SEE NOTE 2) ARE NOT LOWERED AT ANY POINT.
4. EXCAVATION LIMITS SHOWN ARE APPROXIMATE. FINAL EXCAVATION LIMITS IN ALL AREAS WILL BE DETERMINED BY THE CONTRACTOR.
5. THE SUBCONTRACTOR SHALL INCLUDE IN HIS WORK, RELOCATION OF ALL CONTAMINATED MATERIALS ACCUMULATING ON THE STATE REPOSITORY TO THE DISPOSAL SITE.

REFERENCE DRAWINGS:

GRJ-PS-10-0203	SITE PLAN AND DEMOLITION
GRJ-PS-10-0208	CONSTRUCTION FACILITIES AND SITE DRAINAG
GRJ-PS-10-0212	CONTAMINATED MATERIAL EXCAVATION PLAN SHEET 2 OF 2.
GRJ-PS-10-0214	EXISTING UTILITIES PLAN
GRJ-PS-10-0217	BORINGS AND TEST PITS LOCATION PLAN

LEGEND:

- 4610 — EXISTING SITE FEATURES AND CONTOURS
- N 61,000 — CONSTRUCTION GRID COORDINATE
- (1.0) — APPROXIMATE DEPTH IN FEET OF CONTAMINATED MATERIAL TO BE EXCAVATED
- MKE-1 — EXISTING PERMANENT SURVEY MONUMENT
- EXISTING FENCE AND GATE
- EXCAVATION

Rev. 1
SWB 1/18/88
WYL 1/18/88

SCALE 200 0 200 400 FEET

FINAL REVIEW		
E & D MANAGER	CHIEF ENGINEER	Q A MANAGER

NO.	DATE	REVISIONS	BY	CK	E&D MGR	CHIEF ENG	TAC REV	DOE
1		ISSUED FOR FINAL REVIEW	-	-	-	-		

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

GRAND JUNCTION PROCESSING SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION
CONTAMINATED MATERIAL EXCAVATION PLAN
SHEET 1 OF 2

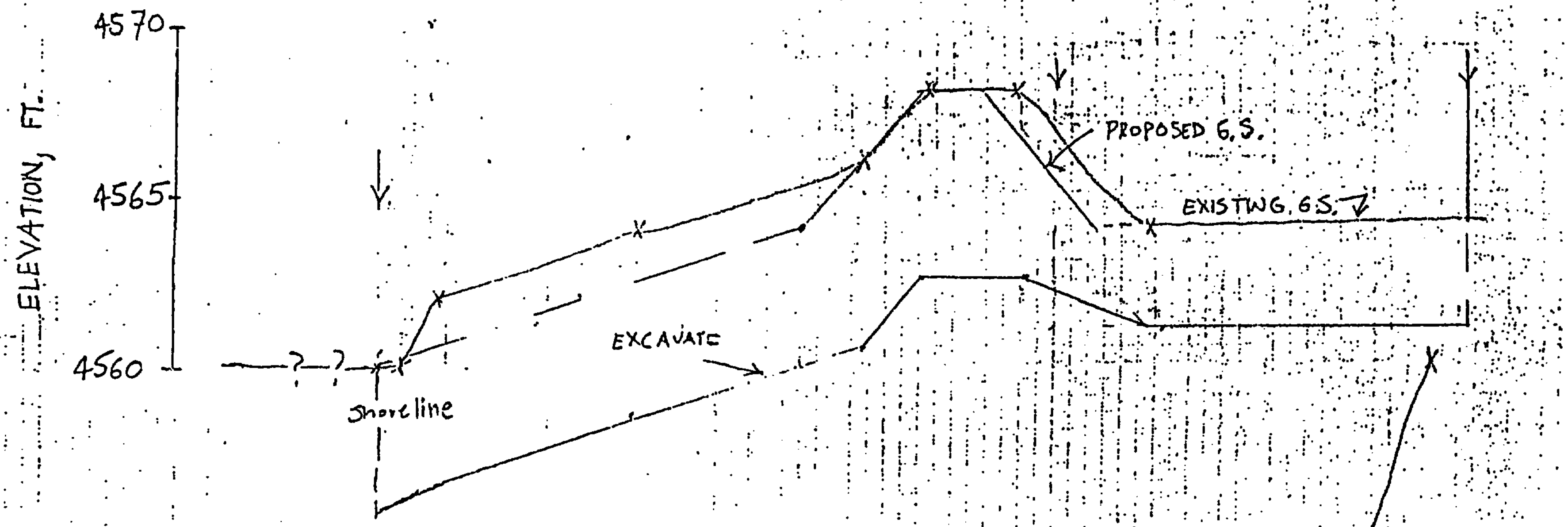
DESIGNED / DRAWN AMC / CHECKED / INSPECTED / RECOMMENDED / APPROVED / DATE / DOE PROJECT ENGINEER / DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

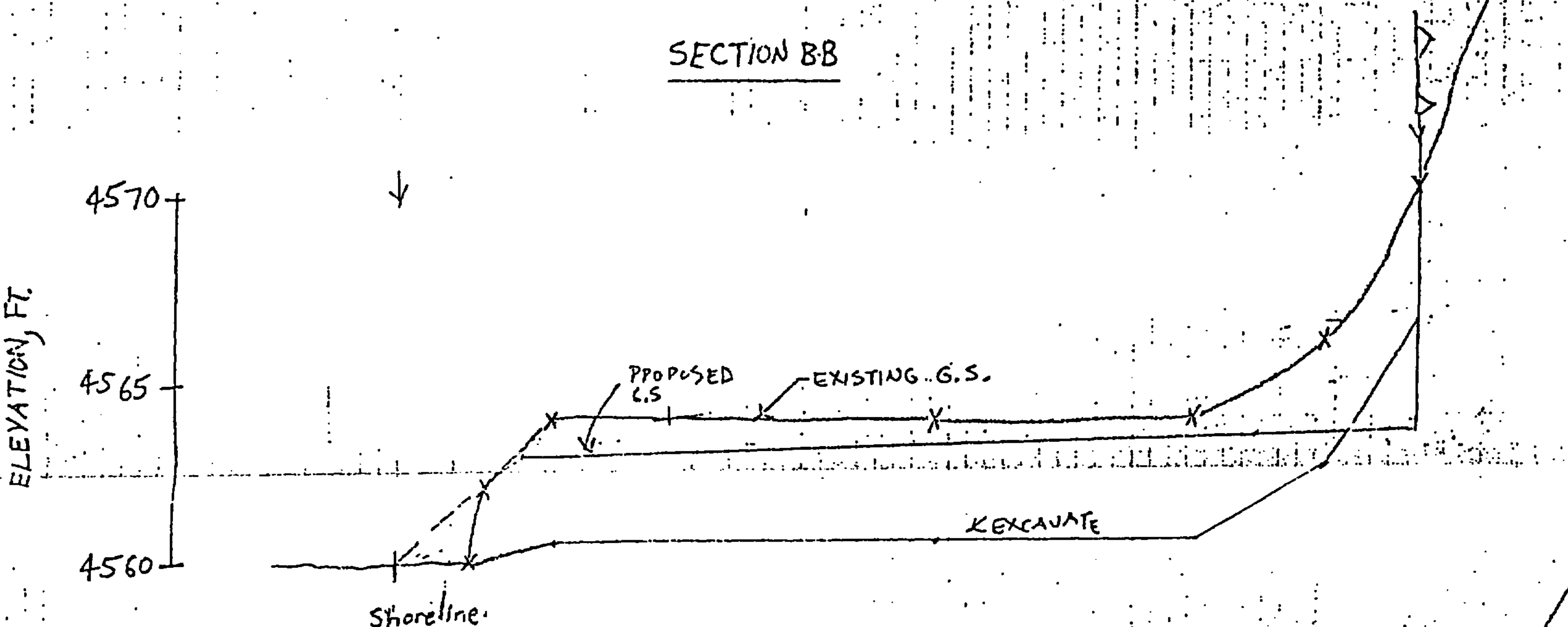
PROJECT NO. DE-AC04-83AL18796
DRAWING NO. GRJ-PS-10-0211

SCALE VERT: 1"=5'
HORIZ: 1"=30'

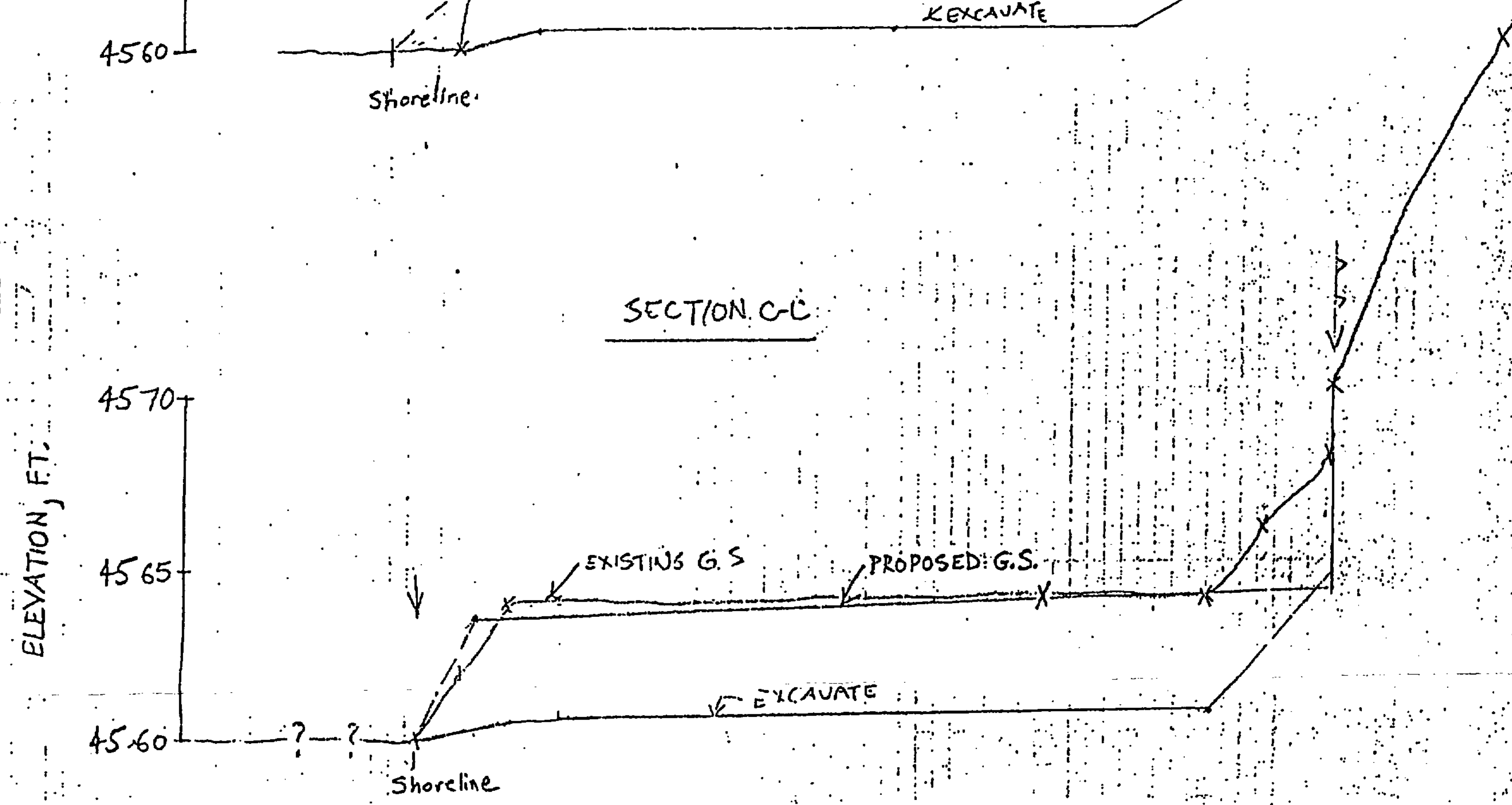
SECTION A-A



SECTION B-B



SECTION C-C

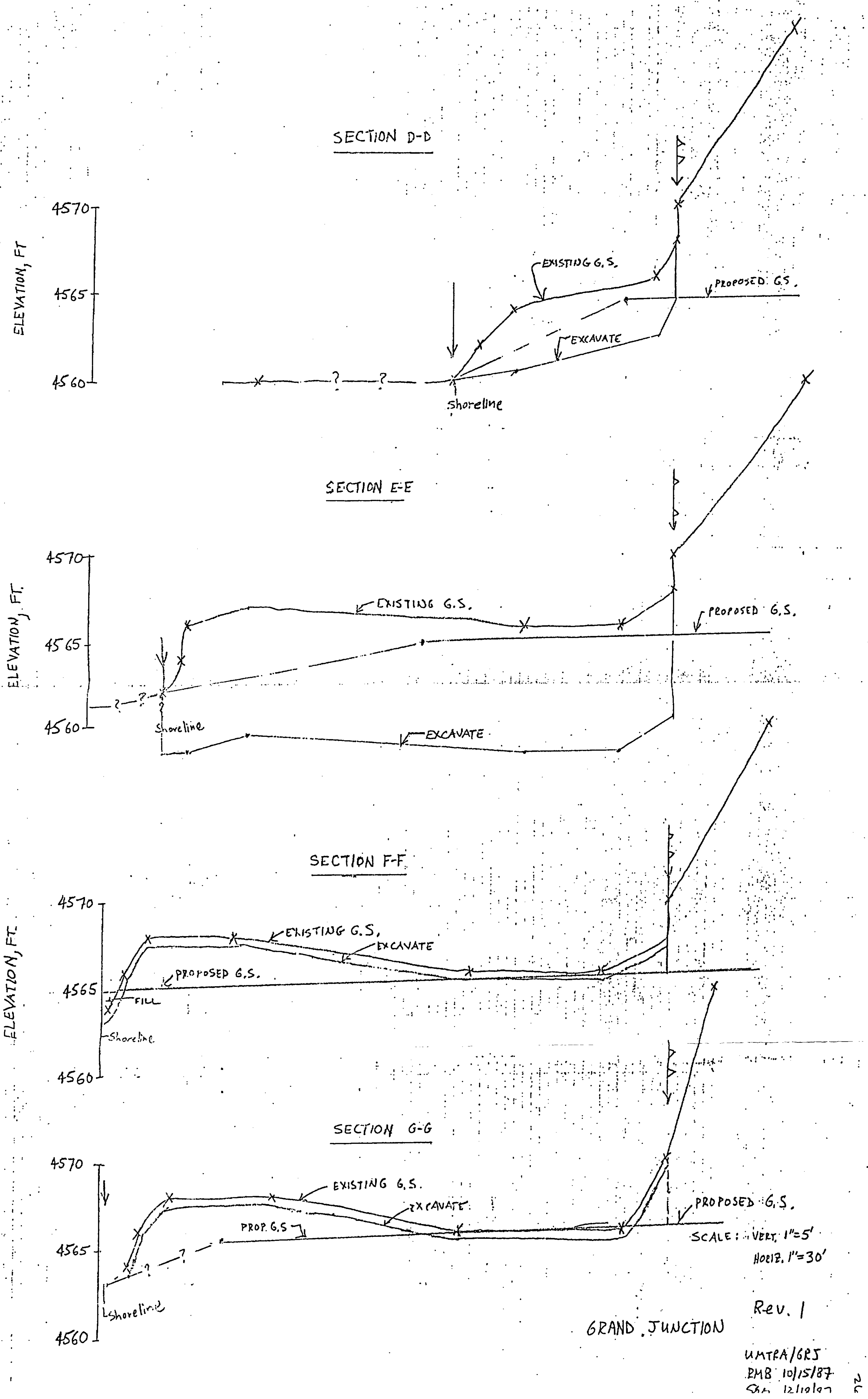


GRAND JUNCTION

Rev. 1

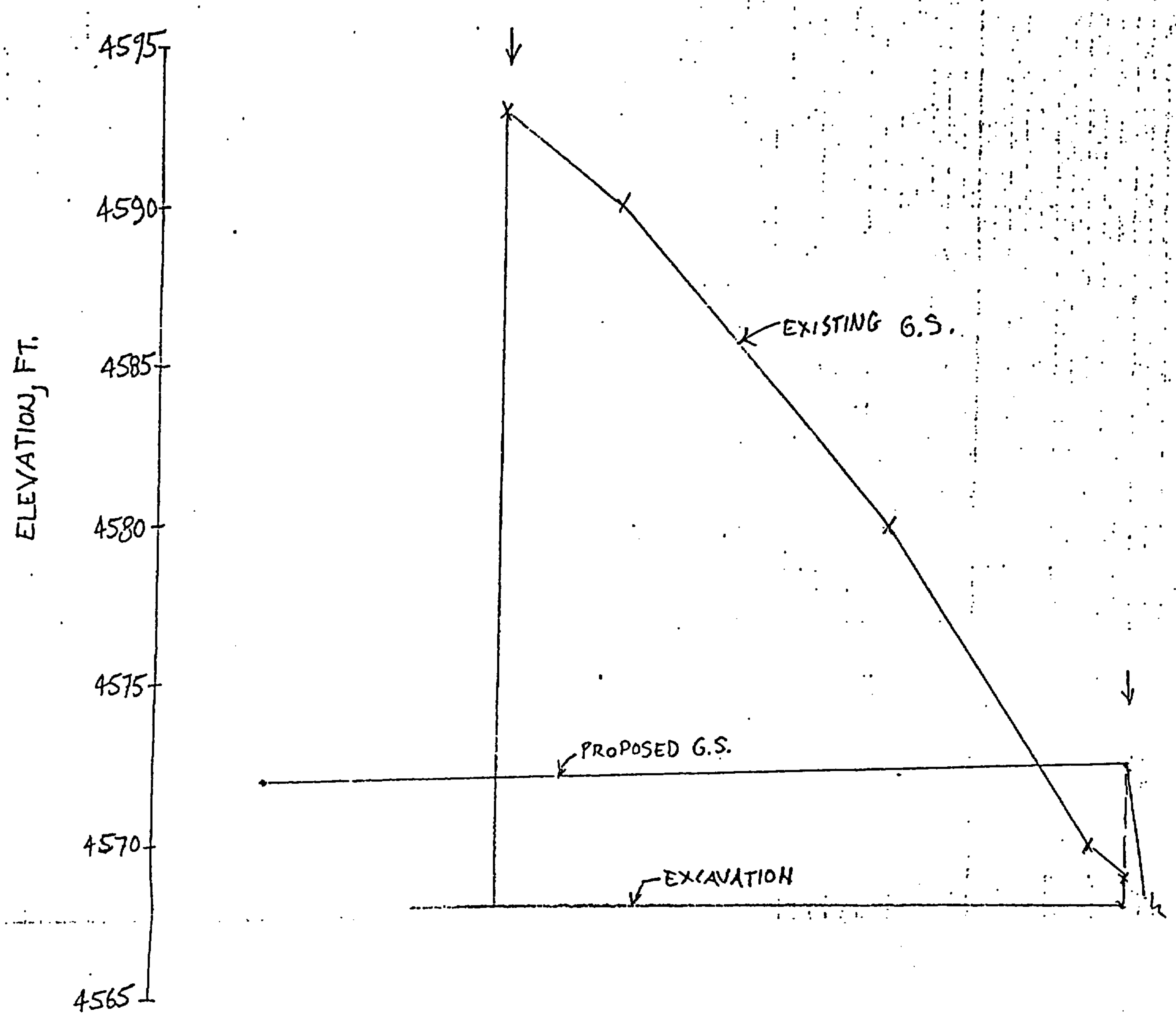
UMTRA/GRJ
RMB 10-15-87
SGS 12/18/87

PROFILES FROM DWG NO.
GRJ-PS-10-0212
"CONTAMINATED MATERIAL
EXCAVATION PLAN"

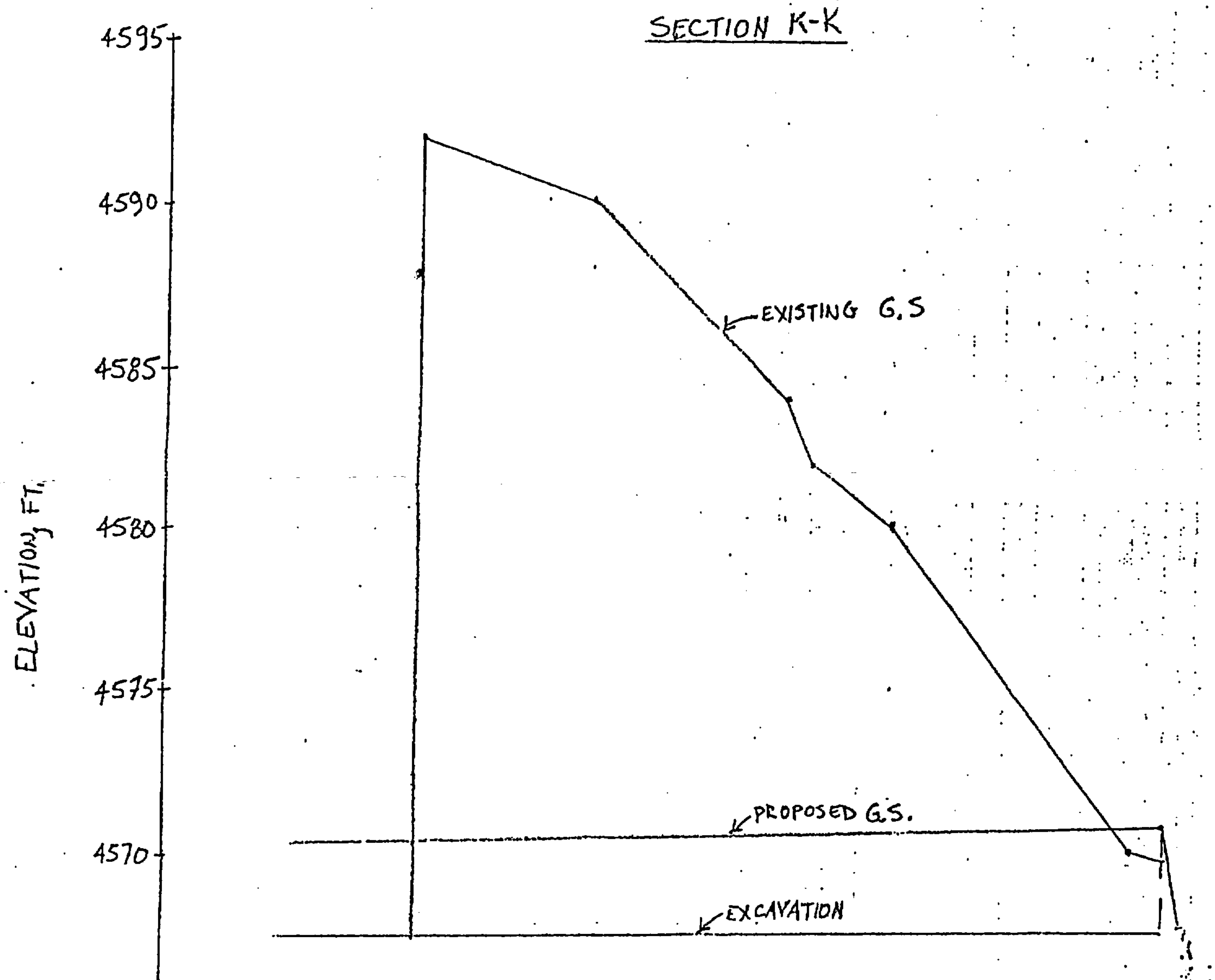

SECTION D-D
ELEVATION, FT
4570
4565
4560
EXISTING G.S.
PROPOSED G.S.
EXCAVATE
Shoreline
SECTION E-E
ELEVATION, FT.
4570
4565
4560
EXISTING G.S.
PROPOSED G.S.
EXCAVATE
Shoreline
SECTION F-F
ELEVATION, FT.
4570
4565
4560
EXISTING G.S.
EXCAVATE
PROPOSED G.S.
FILL
Shoreline
SECTION G-G
4570
4565
4560
EXISTING G.S.
EXCAVATE
PROP. G.S
PROPOSED G.S.
Shoreline
SCALE: VERT. 1"=5'
HORIZ. 1"=30'
Rev. 1
GRAND JUNCTION
UMTRA/GRJ
PMB 10/15/87

SCALE: VERT. 1" = 5'
HORIZ. 1" = 30'

SECTION J-J



SECTION K-K



Rev. 1

GRAND JUNCTION

UMTRA/GRJ
RHB 10-15-87

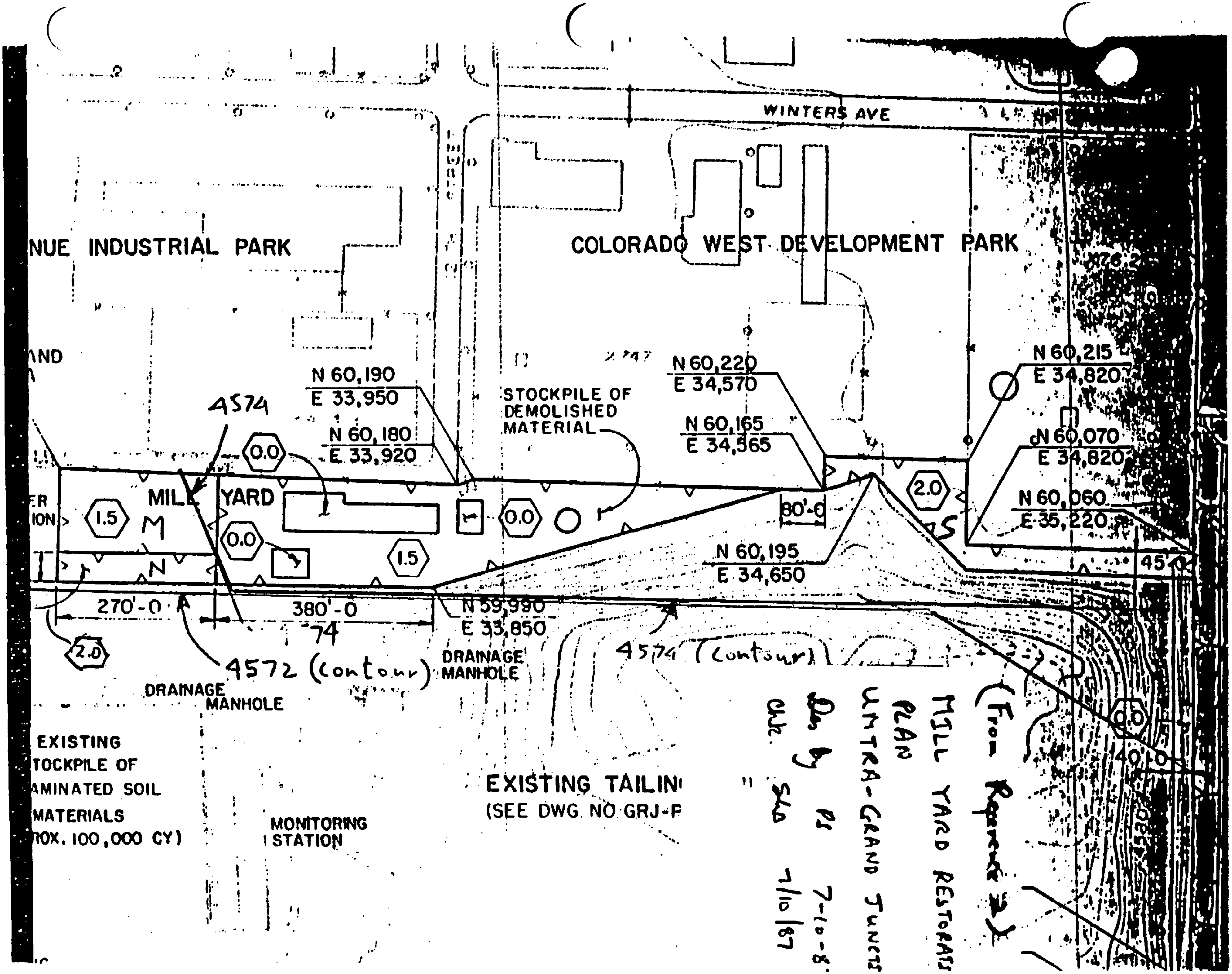
MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - GRJ Contract No. 5025 Sheet 33
Feature SITE GRADING Designed PS Date 7-10-87 File No.
Item Restoration Qty for Processing Site Checked Skg Date 7/10/87

CALCULATION FOR OFF-PILE AREA (Ref 2)

LOCATION	AREA (ft²)	FILL DEPTH (ft)	FILL VOLUME (ft³)
MILL YARD			
M	42,000	1.5	63,000
N	14,000	2.0	28,000
O	130,820	1.5	196,230
S	39,680	2.0	79,360
			366,590

TOTAL = 13,577 cy



WINTERS AVE
NUE INDUSTRIAL PARK
COLORADO WEST DEVELOPMENT PARK
N 60,190
E 33,950
N 60,180
E 33,920
STOCKPILE OF
DEMOLISHED
MATERIAL
N 60,220
E 34,570
N 60,165
E 34,565
N 60,215
E 34,820
N 60,070
E 34,820
N 60,060
E 35,220
N 60,195
E 34,650
4574
MILL YARD
0.0
1.5
2.0
80'-0
45'-0
270'-0
380'-0
74
N 59,990
E 33,850
4572 (contour)
4574 (contour)
DRAINAGE MANHOLE
DRAINAGE MANHOLE
EXISTING
TOCKPILE OF
AMINATED SOIL
MATERIALS
ROX. 100,000 CY)
MONITORING
STATION
EXISTING TAILIN
(SEE DWG. NO GRJ-P
40'-0
MILL YARD RESTORATI
PLAN
UMTRA-GRAND JUNCTI
Des by PS 7-10-8
Chk Sla 7/10/87
(From Reference 2)

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA/GRJ — Contract No. 5025 — Sheet 31 — File No.
Feature: Site Grading — Designed: MDL — Date: 8/4/86
Item: Restoration Quantity For Grand Junction Processing Site — Checked: GAB — Date: 9/16/86

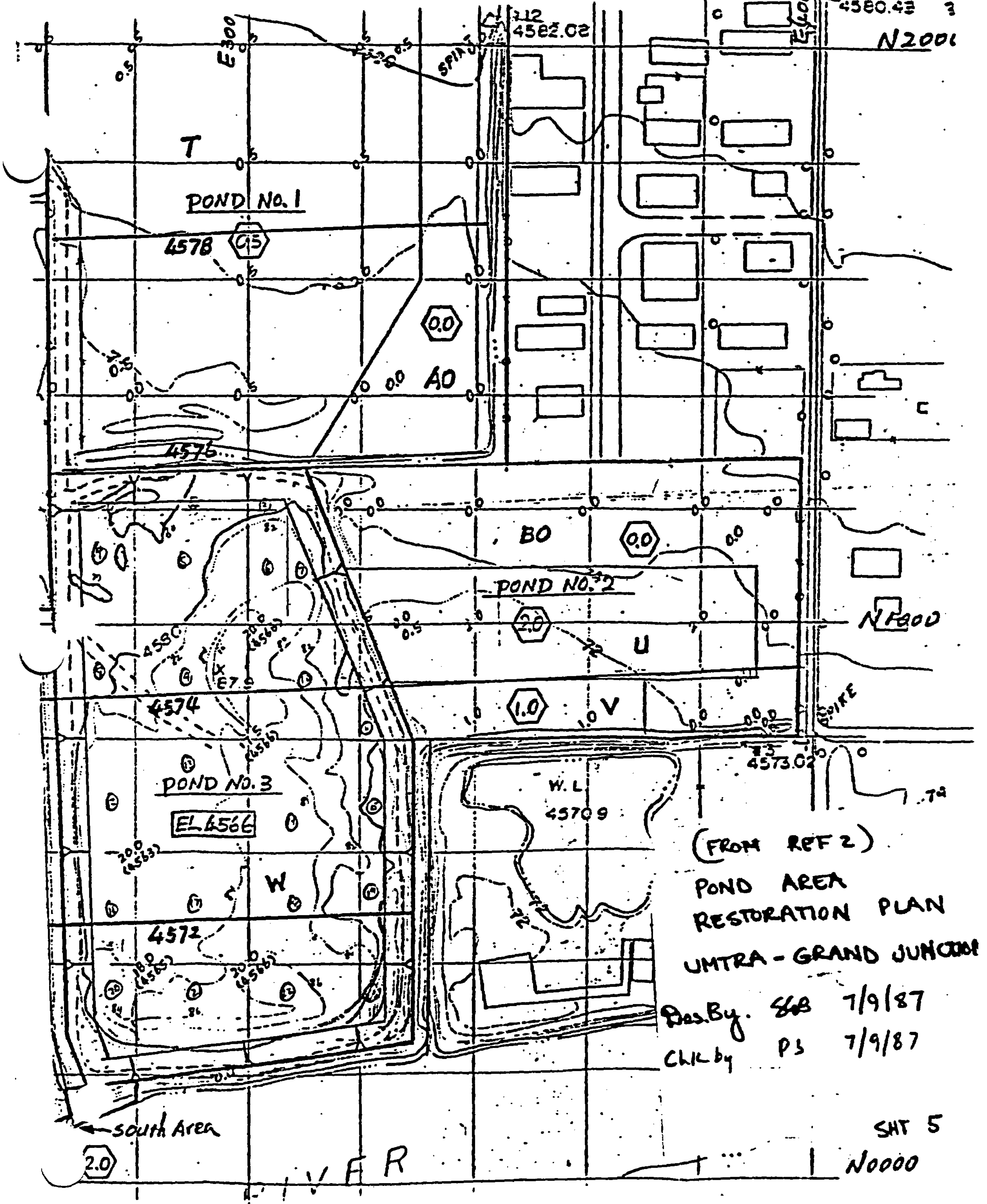
LOCATION	AREA (ft²)	Fill DEPTH (ft)	Fill VOLUME (ft³)	
Pond #1				
T	517,425	0.5	258,712.5	
AO	157,750	0.0	0	9582 yd³
Pond #2				
BO	193,700	1.0	193,700	
U	138,000	4.5	621,000	
V	43,000	4.5	193,500	37,341 yd³
Pond #3				
W	614,350	4.5	2,764,575	102,392 yd³
				149,315 yd³

~~Vicinity property — 614,350 — 0.0 — 0~~

~~Excess excavation — NA — 0.0 — 0~~

~~176,371 yd³~~

~~Total fill volume for final grade off pile = 6,225,950 ft³ = 230,590 yd³~~



N2000
4580.43
4582.02
E300
T
POND No. 1
4578
0.5
0.0
AO
4576
BO
0.0
POND NO. 2
2.0
U
N1000
1.0
V
4574
4573.02
POND NO. 3
EL 4566
W.L
4570.9
W
4572
(FROM REF 2)
POND AREA
RESTORATION PLAN
UMTRA - GRAND JUNCTION
Des. By. S&B 7/9/87
Chk by PJ 7/9/87
South Area
2.0
SHT 5
N0000

Calculation Cover Sheet

Contract No. 3885-34 Discipline Civil

Calc. No. 05-691-02-00
No. of Sheets 40

Project

UMTRA - GRAND JUNCTION

Feature

Erosion Protection

Item

Top and Side Slopes of Tailings Embankment

Sources of Data

Sources of Formulae & References

(see sheet 2)

Preliminary Calc. ☐ Final Calc. ☒ Supersedes Calc. No. 05-691-01-00

0		Feng Hong Wu	11/15/91	K.K. Chen	12/3/91	D. B[illegible]	1-6-92
Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Grand Junction Date: 11/27/90

Document: Calculations - Redesign for NRC - Erosion Protection Topslope and Sideslopes, Calc. #05-504-01-01

Commentor: Greg Smith, Victoria Dery

Comment: All references to the vegetated topslope must be removed or voided out of this calculation set. Some of the locations are:

- The Table of Contents for this calculation is incorrect. The "Rationalization of Transition Zone on Perimeter of Topslope" should be removed.
- Remove conclusion (i), "slopes with vegetation cover result in...for rock covered topslopes" on page 6 of the calculation set.
- Remove all references to vegetation cover in summary table on pg. 7.
- Void RPRPSFST runs 1-6 in Appendix B.
- Remove references to vegetated cover under conclusion (ii) on pg. 3.
- Remove reference to vegetated cover in "Note" on bottom of pg. 10.

SECTION 2

Response: ______ By: S.E. Botsford

Date: December 20, 1990

Complied. The calculation has been revised.

Plans for Implementation:

SECTION 3

Confirmation of Implementation:

Checked by: ______ Date: ______

Approved by: ______ ______

F:\UMTRA\DECDOCRV.GRJ
122690/22

UMTRA DOCUMENT REVIEW FORM

SECTION 1

Site: Grand Junction   Date: 11/27/90

Document: Calculations - Redesign for NRC - Erosion Protection Topslope and Sideslopes, Calc. #05-504-01-01

Commentor: Greg Smith

Comment:

This entire calculation is very hard to read. Since this Is an important feature to obtain concurrence from the NRC, I would suggest that the calculation should be done on a word processor including only pertinent Information and output In a neater form. I understand that the RAG QA/QC requirements will not allow previous work to be excluded. We recommend therefore that a new calculation be compiled, and the present calculation Included as an appendix to the new calc, if that Is necessary to comply with MK QA procedures.

SECTION 2

Response: ______   By: S.E. Botsford

Date: December 20, 1990

Complied.

Plans for Implementation:

Revised Calculation 05-504-01-01.

SECTION 3

Confirmation of Implementation:

Checked by: ______   Date: ______

Approved by: ______   ______

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA/GRJ Contract No. 3785-34 Sheet 1 File No.
Feature Erosion Protection Designed [illegible] Date 11/15/9[illegible]
Item Top & Side slopes of Tailings Embankment Checked [illegible] Date 12/13/91

Table of Contents

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA/GRJ — Contract No. 3885-34 — Sheet 2 — File No.

Feature Erosion Protection — Designed [illegible] — Date 11/15/[illegible]

Item Top + Side Slopes of Tailings Embankment — Checked [illegible] — Date 10/12/91

References

1. MKE, UMTRA Design Procedures, Chapter 5, Erosion Protection, Rev. 4, Dec. 1987.

2. MKE, 'RPRPSFST,' A computer program for Designing Riprap Protection for Sheet Flow Using Factor of Safety or Stephenson's Method, Sept. 1987. MKE DOC. NO. 4005-GEN-0-01-03409-00.

3. Stevens, M.A., D.B. Simons & G.L. Lewis, "Safety Factor for Riprap Protection," ASCE Journal of Hydraulic Division, Vol. 102, HY5, May 1976, PP. 637-655

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

5. MKES, Cal. no. 05-628-01-00, Site Drainage - Hydrologic Parameters, Umtra/Grand Junction.

6. MKES, Cal. no. 05-505-02-03, Rock Quality for the Erosion protection - Cheney Reservoir Site, UMTRA/GRJ.

7. U.S. Army COE, Hydraulic Design of Flood Control Channels, EM-1110-2-1611, July 1, 1970 (Reprint with Changes 1-4 included).

8. MKES Cal. No. 05-504-05-03, Embankment Design, Riprap Toe Protection, UMTRA/Grand Junction

9. MKES Calculation, UMTRA/GRJ, Erosion Protection, Bedding Layer Gradation and Thickness, 10/1991

10. DOE, Technical Development Document, Rev. 1, Dec. 1989 UMTRA-DOE/AL 050425, P. 71

1. Summary and Discussions

a. The design minimum rock sizes (D_{50}) on the top slope and side slope of the tailings embankment at the Grand Junction disposal site are:

Top slope: D_{50} (min) = 1.8", 12" thick for area above Contaminated material, and 6" thick for area above clean fill.

Side slope: D_{50} (min) = 5.5", Layer thickness = 12"

Ripraps for the top slope and side slope are designated as Type A and Type B rock respectively.

b. The required min. D_{50} for top and side slope were determined based on longest top slope and its corresponding side slope which gave the most critical condition for estimating min. D_{50} required. For shorter top slope, the required D_{50} on the side slope can be reduced. (see sheets 19 & 20).
A 15% oversizing factor was used in determining the min. D_{50} required due to the lower rock durability test score for the rock samples from the site (Ref. 6).

c. Gradation curves for Type A and Type B rocks and their bedding material obtained from Ref. 9 are presented on sheet 5. Type A & Type B Gradation bands were determined based on guidelines and practices of the U.S. Army Corps of Engineers (Refs 1 & 7), in combination with the consideration of rock available at the disposal site in order to obtain the required riprap in a cost effective way while achieving the purpose of erosion protection and long-term stability of the tailings embankment.

d. The design Type A & Type B rock can sustain the erosive force from the PMP storm runoff for a top slope (with longest length of 1650') as steep as 3.5% (φ=39°). Hence in case of unexpected increase of the contaminated material, the top slope can be increased (up to 3.5%) to accomodate additional contaminated material. (Note: the increase of top slope to 3.5% will not affect the design of the apron, since it was designed assuming the top slope = 3.5%)

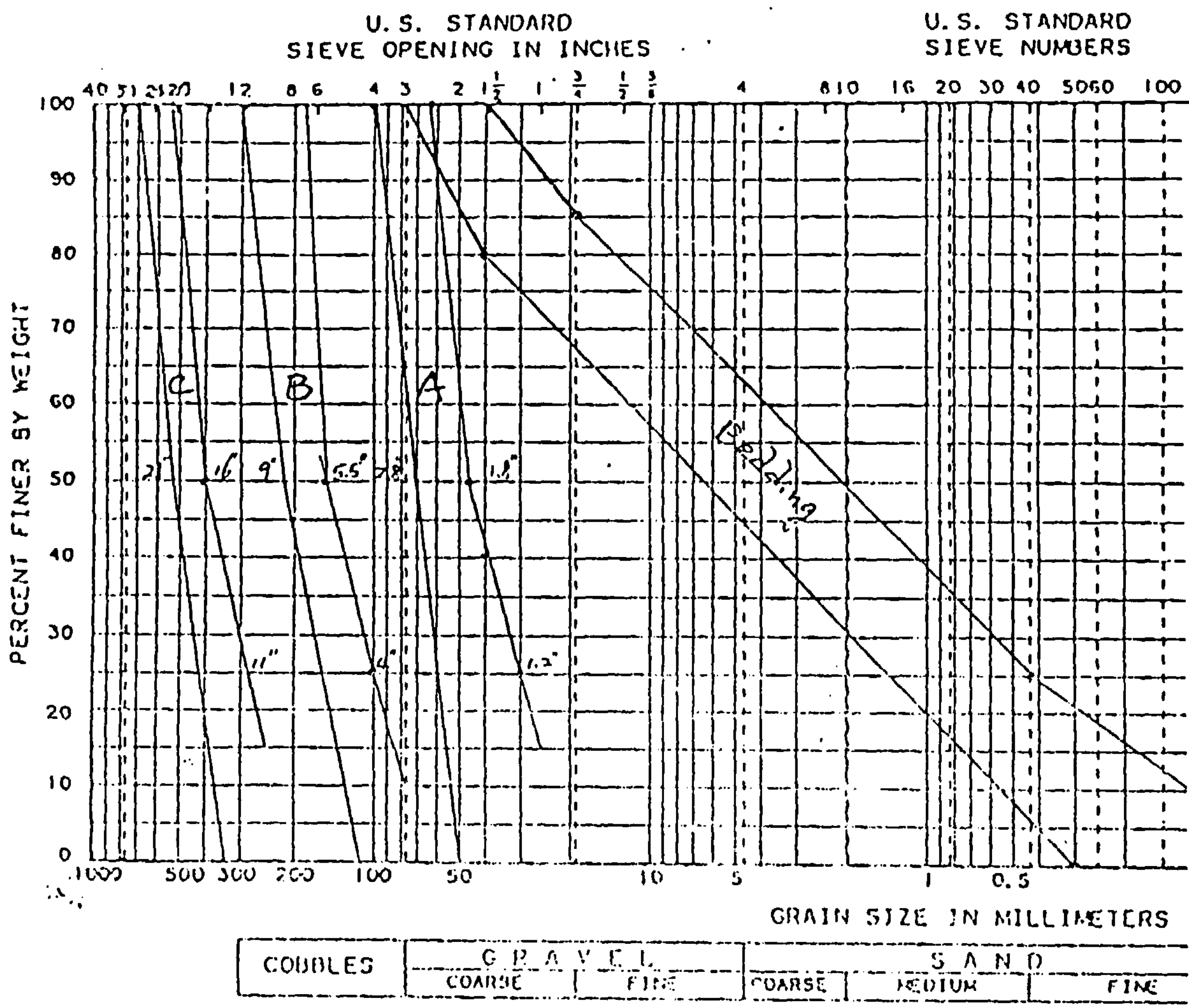
e. Typical sections of Type A & Type B rock placement for erosion protection on the top slope and side slope are shown on sheets 7 and 8.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY

UMTRA / GRJ   WYL 11/6/91
FHW 11/15/91

GRAIN SIZE ANALYSIS

UMTRA/GRJ 3885-34
Erosion Protection of Embankment
Top & Side Slopes



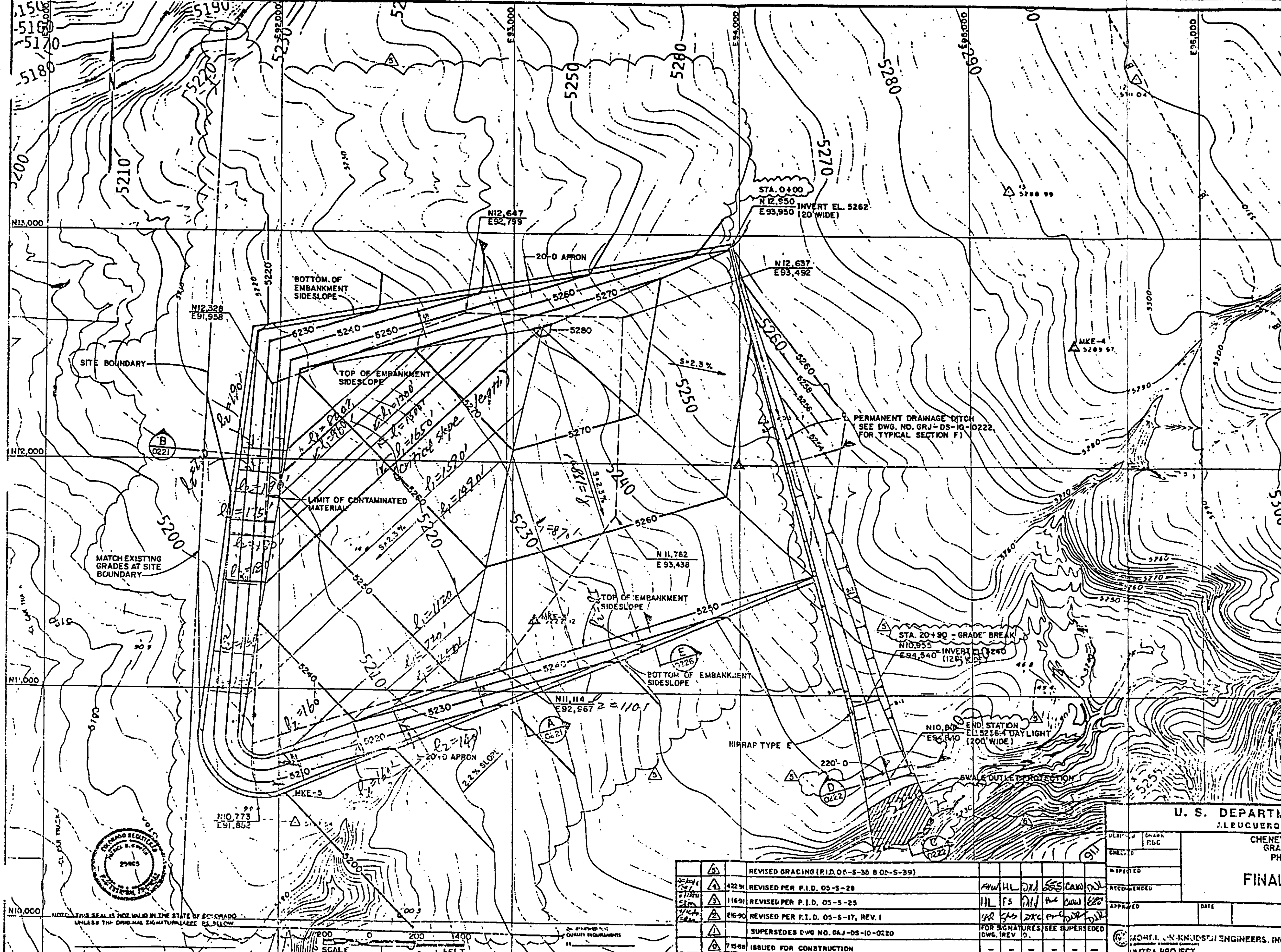
Rock Type	Sieve size	% Passing
Type A	4"	100
	2½"	35 - 95
	2"	0 - 50
	1½"	0 - 40
	1"	0 - 15
Type B	12"	100
	9"	50-100
	7"	35 - 95
	5½"	20 - 50
	3"	0 - 10
Type C	28"	100
	20"	45 - 90
	16"	20 - 50
	10"	0 - 15
Bedding	3"	100
	1"	70 - 90
	No. 4	45 - 65
	No. 40	5 - 25
	No. 200	0 - 5

SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	NAT W%	LL	PL

JOB NO.
AREA
HOLE NO.
DATE

OK 12/3/91

Sheet 5



NOTES:

sheet 6

1. WHERE CORNER CONTOURS ON THE TAILINGS EMBANKMENT ARE TOO SHARP TO BE CONSTRUCTED, CONTOURS WILL BE ROUNDED WITH A 50 FOOT RADIUS (APPROXIMATELY) IN THE PLAN VIEW.
2. THE CONTOURS OF THE TOP SLOPE ARE APPROXIMATE AND ARE DEPENDENT ON ACTUAL VOLUME OF CONTAMINATED MATERIALS RELOCATED.

UMTRA/GRJ 3885-34
Erosion Protection
Top & Side slopes of
Tailings Embankment
FHW, 11/25/91
[initials] 12/13/91

REFERENCE DRAWINGS:

GRJ-DS-10-0124	SITE PLAN
GRJ-DS-10-0125	CONSTRUCTION FACILITIES AND SITE DRAINAGE
GRJ-DS-10-0134	TAILINGS EMBANKMENT AREA B EXCAVATION PLAN
GRJ-DS-10-0221	TAILINGS EMBANKMENT-SECTIONS AND DETAILS
GRJ-DS-10-0222	DITCHES AND MISCELLANEOUS-SECTIONS AND DETAILS
GRJ-DS-10-0223	BORINGS AND TEST PITS LOCATION PLAN
GRJ-DS-10-0226	DITCH PROFILE AND MISCELLANEOUS-SECTIONS AND DETAILS

LEGEND:

5280	EXISTING SITE FEATURES AND CONTOURS
	PERMANENT DRAINAGE DITCH
5270	FINISHED GRADE CONTOURS
N10,000	CONSTRUCTION GRID COORDINATES
△	EXISTING PERMANENT SURVEY MONUMENT
	EXCAVATION

QA MK-F	NO.	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APR.
	5		REVISED GRADING (P.I.D. 05-S-35 & 05-S-39)						
[illegible]	4	4-22-91	REVISED PER P.I.D. 05-S-28	FHW	HL	DXJ	SSS	CAW	DJL
[illegible]	3	1-16-91	REVISED PER P.I.D. 05-S-25	HL	FS	DJJ	[illegible]	CAW	[illegible]
[illegible]	2	2-16-90	REVISED PER P.I.D. 05-S-17, REV. 1	[illegible]	[illegible]	DXC	[illegible]	[illegible]	DJL
	1		SUPERSEDES DWG NO. GRJ-DS-10-0220	FOR SIGNATURES SEE SUPERSEDED DWG. REV 0.					
	0	7-15-88	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

CHENEY RESERVOIR DISPOSAL SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

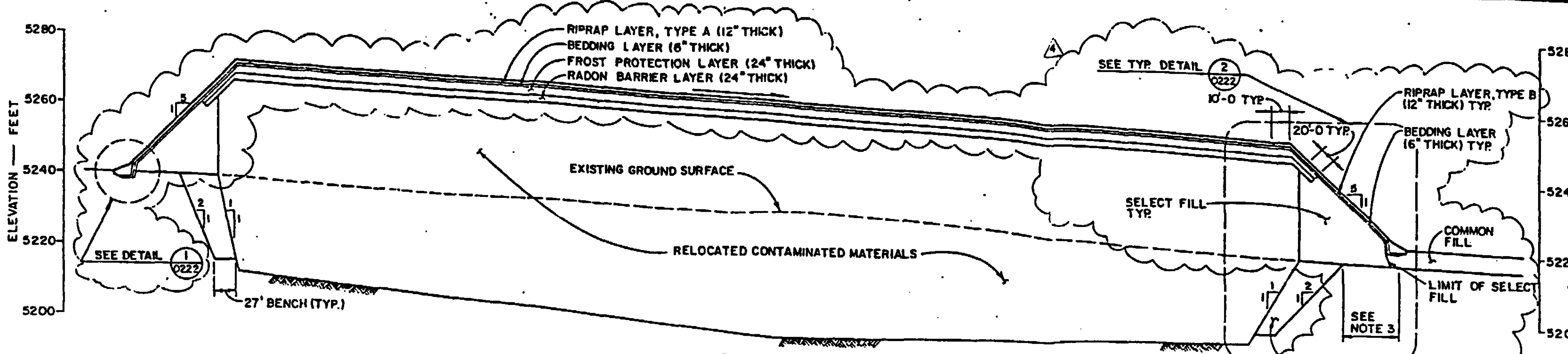
FINAL GRADING PLAN

DESIGNED: | DRAWN: RBC
CHECKED:
INSPECTED:
RECOMMENDED:
APPROVED: | DATE: | DOE PROJECT ENGINEER | DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. GRJ-DS-10-0220
REV. 5

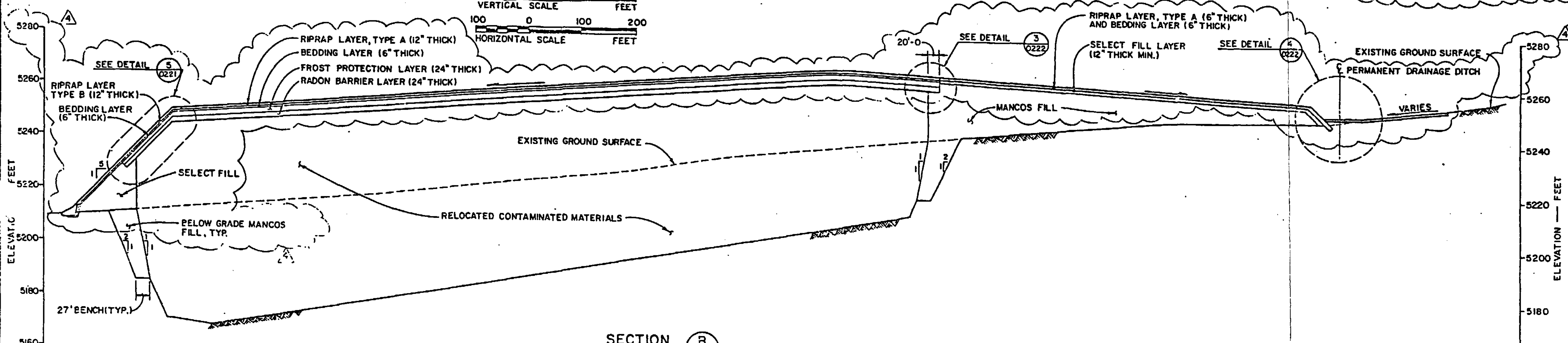
UMTRA/GRJ 3884-34
Erosion Protection
Top + Side slopes of Tailings Embankment
sheet 7
FHW 11/15/91



SECTION A (0220)

20 0 20 40 VERTICAL SCALE FEET

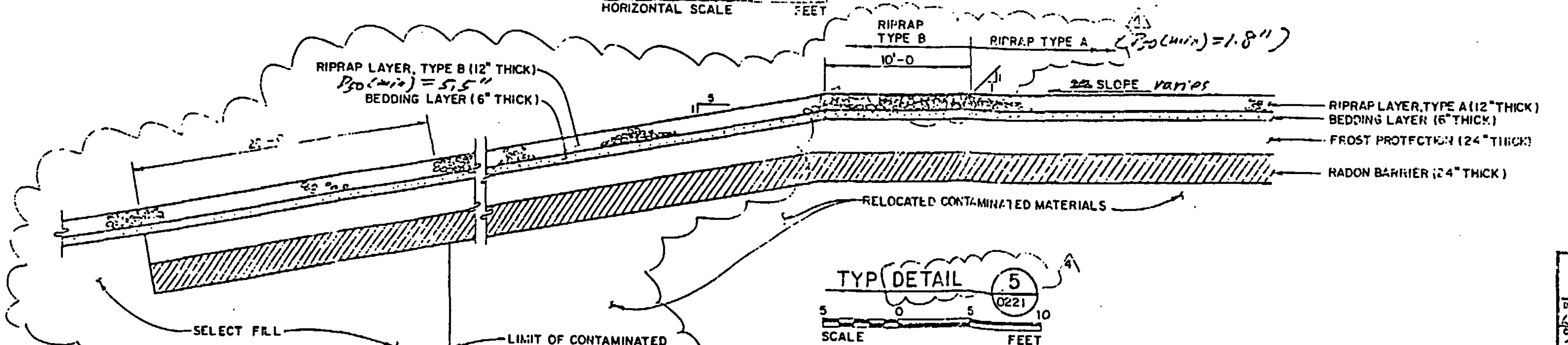
100 0 100 200 HORIZONTAL SCALE FEET



SECTION B (0220)

20 0 20 40 VERTICAL SCALE FEET

100 0 100 200 HORIZONTAL SCALE FEET



TYP DETAIL 5 (0221)

5 0 5 10 SCALE FEET

NOTES:

1. RELOCATED TAILINGS MATERIALS INCLUDE THE CONTAMINATED MATERIALS FROM THE EXISTING TAILINGS PILE, MILL YARD AND DEMOLISHED MATERIALS AND DEBRIS.
2. ELEVATIONS ARE APPROXIMATE AND ARE DEPENDENT ON ACTUAL VOLUME OF CONTAMINATED MATERIALS RELOCATED.
3. CLEAN-FILL DIKE SHALL OVERLAP EXCAVATION BY 30' MINIMUM.

PKC 12/13/91

REFERENCE DRAWINGS:

GRJ-DS-10-0125	CONSTRUCTION FACILITIES AND SITE DRAINAGE
GRJ-DS-10-0134	TAILINGS EMBANKMENT AREA EXCAVATION PLAN
GRJ-DS-10-0220	FINAL GRADING PLAN
GRJ-DS-10-0221	DITCHES AND MISCELLANEOUS SECTIONS AND DETAILS
GRJ-DS-10-0226	DITCH PROFILE AND MISCELLANEOUS SECTIONS AND DETAILS

Note: In progress Drawing subject to change. The purpose of this drawing is to show typical riprap arrangement.

NOTE: THIS SEAL IS NOT VALID IN THE STATE OF COLORADO UNLESS THE ORIGINAL SIGNATURE APPEARS BELOW.

EDWIN S. SMITH — REGISTERED PROFESSIONAL ENGINEER — STATE OF COLORADO

E.S. Smith

QA REVIEWED FOR PRIMARY REQUIREMENTS

QA	NO.	DATE	REVISIONS						
	4		REVISED COVER LAYERS AND ABOVE GRADE DIKE (P.I.D. 05-S-39)						
3/28/91	3	1-16-91	REVISED PER P.I.D. 05-S-25	HL	PS				
	2		REVISED PER P.I.D. 05-S-17, REV. 1						
	1	8-23-88	GENERAL REVISION TO INCLUDE VEGETATIVE COVER		PS			—	
	0	7-15-88	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

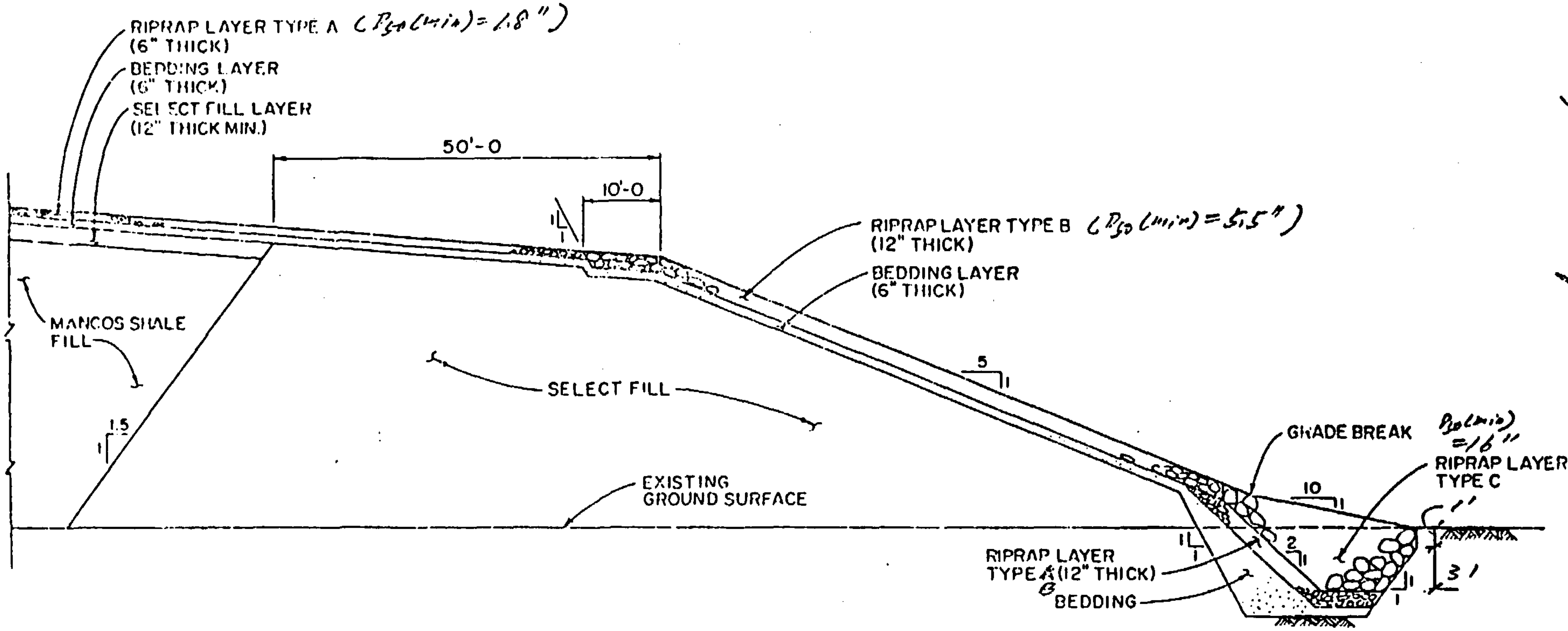
CHENEY RESERVOIR DISPOSAL SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

TAILINGS EMBANKMENT SECTIONS AND DETAILS

DESIGNED / DRAWN E.C.G./JMA
CHECKED
INSPECTED
RECOMMENDED
APPROVED — DATE 7/14/88 — E.S. Smith — 7/14/88 — DOE PROJECT ENGINEER — DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796



TYPICAL SECTION (E / 0220)

NOT TO SCALE

(See sheet 6 for location)

Project UMTRA/GRJ

Feature Erosion Protection

Item Top & Side Slopes of Tailings Embankment

Contract No. 3805-34 File No.

Designed FHW Date 11/15/?

Checked Date

2. Purpose and Scope

- To determine the minimum D_{50} of ripraps required for erosion protection on the embankment top slope and side slope for the Grand Junction Disposal site. (see sheet 6 for final grading plan.)
- To determine the gradation and layer thickness of the required riprap based on estimated min. D_{50} required and riprap materials available at the site in order to maximize the use of available material for cost savings

3. Method of Approach

a. The stable rock size (min. D_{50}) required for the top slope and side slope of the embankment under the local PMP storm-runoff condition were determined based on MKE's UMTRA Design Procedures (Ref. 1) and the computer program "RPRPSFST" developed by MKES (Ref. 2). The methods used in the computer program are Safety Factor Method (Ref. 3) for slope flatter than 10 % and Stephenson method (Ref. 4) for slope greater or equal to 10 %. Sheet flow condition was assumed in the computation. The time of concentration, PMP rainfall intensity and peak runoff along a strip of the slope were estimated by the iterative procedures within the computer. PMP rainfall intensity was represented by a regression equation (Ref. 5) (see sheet 10) with constant as input.

SHEET 10

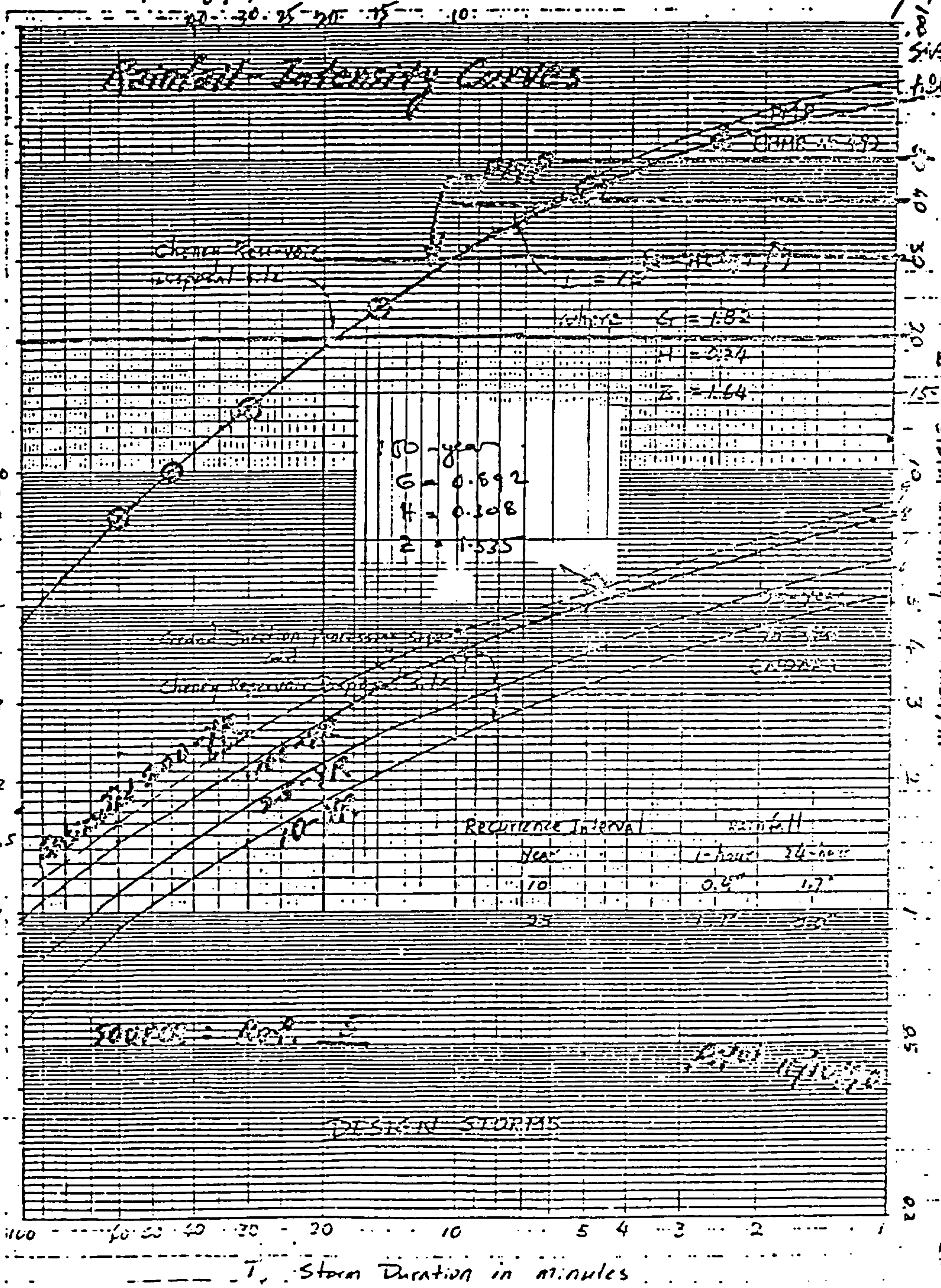
UMTRA/GRJ 3885-34
Erosion Control
Top & Side Slopes of Tailings Embankment

FHW 11/15/91
PRC 12/13/91

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project	UMTRA/GRJ	Contract No.	5025	File No.	
Feature	Site Drainage	Designed	WYL	Date	6/19/86
Item	Hydrology Parameters	Checked	FTK	Date	8/3/86

Sheet 15 21



b. The required min. D_{50} for the top slope and side slope were determined based on the longest flow length of the top slope and side slope which represents the most critical condition for stable rock size design on both embankment slopes, and also for toe apron protection (presented in other calculation, MKES Cal. no. 05-504-05-03, Riprap Toe protection).

Hence the actual min. D_{50} required for most part of the embankment top and side slopes would be smaller than the design size and are on the conservative side.

4. Calculations

a. Input parameters and Assumptions

1) Regression constants for PMP rainfall intensity-duration curve (Ref. 5) (see sheet 10):

$$I_{PMP} = 10^{(G - H(\log T_c)^Z)}, \quad G = 1.820,\ H = 0.340,\ Z = 1.640$$

2). specific gravity of rock = 2.64 (Ref. 6)

3) porosity $\varphi = 0.33$ (Assumed)

4) Embankment top slope = 2.3 % (Note: different top slopes (i.e. 2.3-3.5%) will be tried to evaluate the effect on riprap sizing.)

" side slope = 20 %

5) Flow length - top slope = 1650' (longest)

corresponding side slope = 180'

These 2 slope segment is considered to be the most critical condition for riprap sizing based on observation and trial computations.

6) coefficient "c" in Stephenson Equation = 0.22 (for gravel and pebbles).

7) The friction angle of the rock, ϕ

Assumed $\phi = 35°$ for Top slope riprap. (in the range of 1.5" ±)
$\phi = 38°$ for side slope riprap (expected rock size around 5" ±).
(see sheet 13).

8). Runoff Coefficient is assumed = 1 in the Rational Formula.

9). Factor of Safety = 1

10). No flow through rock pores is assumed to be conservative.

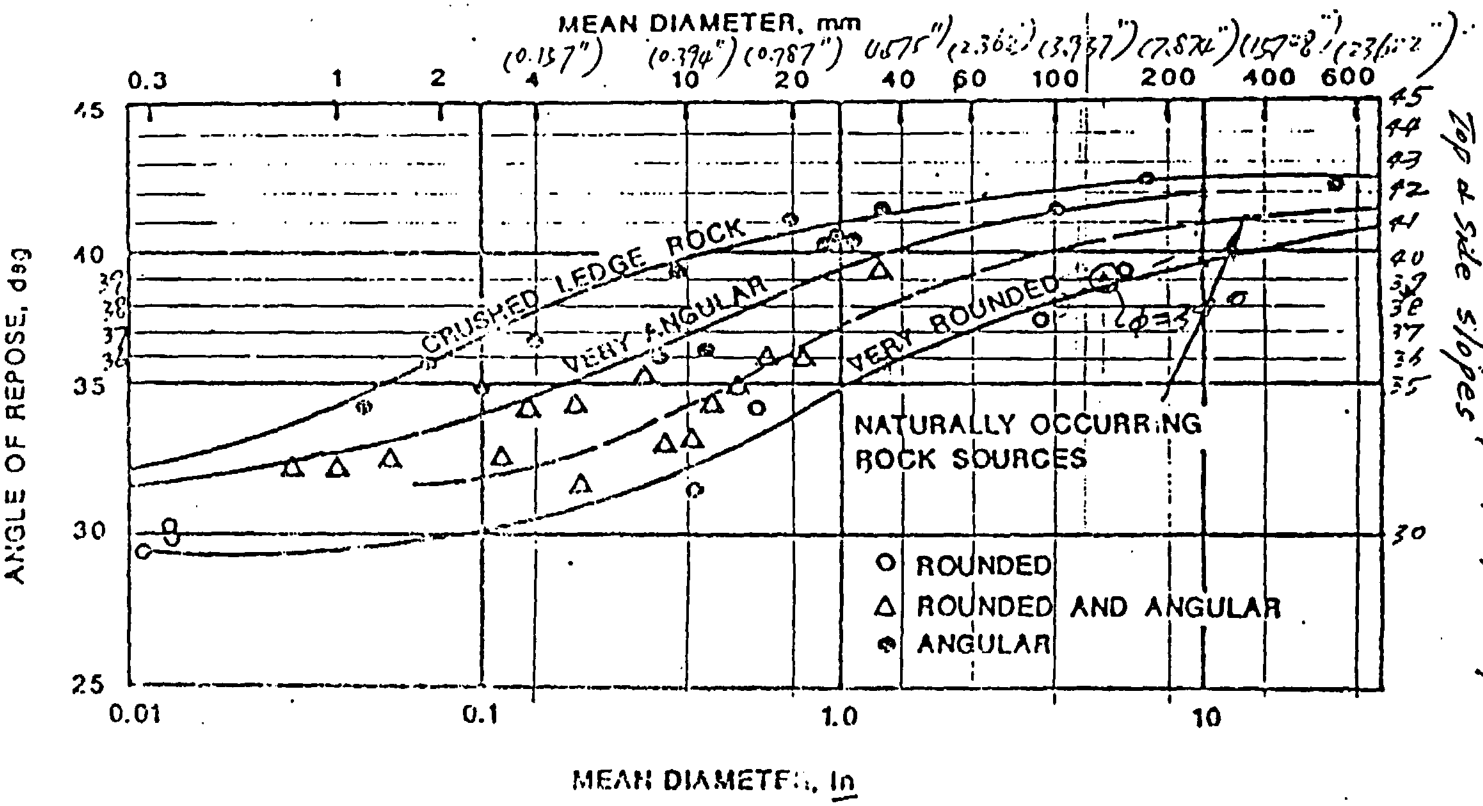
11). For top slope – Safety Factor method will be used.
For side slope – Stephenson's method will be used.

6. Computer Runs and Output

1) Base Case (With parameters spefied above)
Computer run was made based on input parameters described in a. above. Output of the computer runs are presented on sheets 14 to 17. The results are summarized below:

Top slope (2.3%): min. D_{50} required = 1.0" (see sheet 16)
Use min. D_{50} = 1.5" (see sheet 17) D_{50} (oversized) = 1.8" (15% oversized factor) (Ref. 6)
At end of 1650' - 2.3% slope:
S = 0.023, q = 1.01 cfs/ft, y = 0.27', n = 0.026, V = 3.7 fps

Side slope (5:1): Min D_{50} required = 4.7", D_{50} (oversized) = 4.7 × 1.15 = 5.4" (oversize factor = 15%, Ref. 6)).
S = 0.20, q = 1.12 cfs/ft, y = 0.21', n = 0.043, V = 5.0 fps.



ANGLE OF REPOSE FOR ROCK OF VARIOUS DIAMETERS

UMTRA/GRJ

3805-34

Source: Ref 10

FHW 11/15/91

Sheet 13

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA / GRJ — Contract No. 3885-34 — Sheet 14 — File No.

Feature: Erosion protection — Designed: FHW — Date 11/15/?

Item: Top and side slopes of Tailings Embankment — Checked: DKC — Date 12/17/91

GRJT1.OUT Page 2

Note: This sheet is output to evaluate min. D_{50} required for top slope only

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=TOP LENGTH=1650. FT. SLOPE= 2.3 %

ASSUMED D50= .0839FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.149CFS/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.	97.	.068	.000	.068	1.14	.06	.030	1.42	1.42
97.	194.	.135	.000	.135	1.58	.09	.028	1.02	2.44
194.	291.	.203	.000	.203	1.91	.11	.026	.85	3.29
291.	388.	.270	.000	.270	2.19	.12	.026	.74	4.03
388.	485.	.338	.000	.338	2.42	.14	.025	.67	4.70
485.	582.	.405	.000	.405	2.63	.15	.025	.62	5.31
582.	679.	.473	.000	.473	2.82	.17	.024	.57	5.89
679.	776.	.541	.000	.541	2.99	.18	.024	.54	6.43
776.	874.	.608	.000	.608	3.15	.19	.024	.51	6.94
874.	971.	.676	.000	.676	3.30	.20	.024	.49	7.43
971.	1068.	.743	.000	.743	3.44	.22	.024	.47	7.90
1068.	1165.	.811	.000	.811	3.58	.23	.023	.45	8.35
1165.	1262.	.878	.000	.878	3.71	.24	.023	.44	8.79
1262.	1359.	.946	.000	.946	3.83	.25	.023	.42	9.21
1359.	1456.	1.014	.000	1.014	3.95	.26	.023	.41	9.62
1456.	1553.	1.081	.000	1.081	4.06	.27	.023	.40	10.02
1553.	1650.	1.149	.000	1.149	4.17	.28	.023	.39	10.41

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)
30.32	29.53

*******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	1650.	2.3	1.0	1.149	10.4	.34	SAFETY FACTOR

↑ min. D_{50} required

```
GRJTP14.OU                11/8/91           Page 1

 **INPUT FILE PRINTOUT**

 GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP13.OUT)

 GRJ   FW    11-08 1991
   1.820  .340 1.640 2.640  .220      1  .002 1.0
    2    0
    0    0
   17    2    1650'
  TOP      *****   2.3   .33  35.0  FS
  SIDE     180.0  20.0   .33  38.0  ST
   .1250   2.0   .02083
   .1250   2.0   .00347

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


 GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP13.OUT)

  UMTRA/GRJ      RUN I.D.=FW       DATE=11-08 1991

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


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


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

           G= 1.820  H= .340  Z=1.640

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

            - - - EMBANKMENT - - -
   AREA
 (LOCATION  SEGMENT  LENGTH  SLOPE POROSITY  FRICTION
 IN PLAN)            (FT)    (%)             ANGLE
                              2.3            (DEG)
    1        TOP      1650.    2.     .33     35.  SAFETY FACTOR
    1        SIDE     180.    20.     .33     38.  STEPHENSONS

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

GRJTP14.OU 11/8/91 Page 2

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=TOP LENGTH=1650. FT. SLOPE= 2.%

ASSUMED D50= .1250FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 2.091CFS/FT AT SEGMENT END BY FS METHOD

SLOPED DISTANCE FROM (FT)	SLOPED DISTANCE TO (FT)	*****FLOWS(CFS/FT)**** ALLOC.	PORES	ROCK	VEL. (FPS)	DEPTH (FT)	MANNING N	TIME OF CONC(MIN) INT.	TOTAL
0.	97.	.123	.000	.123	1.39	.09	.032	1.16	1.16
97.	194.	.246	.000	.246	1.93	.13	.030	.84	2.00
194.	291.	.369	.000	.369	2.33	.16	.028	.69	2.69
291.	388.	.492	.000	.492	2.67	.18	.027	.61	3.30
388.	485.	.615	.000	.615	2.95	.21	.027	.55	3.85
485.	582.	.738	.000	.738	3.21	.23	.026	.50	4.35
582.	679.	.861	.000	.861	3.44	.25	.026	.47	4.82
679.	776.	.984	.000	.984	3.65	.27	.026	.44	5.26
776.	874.	1.107	.000	1.107	3.85	.29	.026	.42	5.68
874.	971.	1.230	.000	1.230	4.03	.30	.025	.40	6.09
971.	1068.	1.353	.000	1.353	4.21	.32	.025	.38	6.47
1068.	1165.	1.476	.000	1.476	4.37	.34	.025	.37	6.84
1165.	1262.	1.599	.000	1.599	4.53	.35	.025	.36	7.20
1262.	1359.	1.722	.000	1.722	4.68	.37	.025	.35	7.54
1359.	1456.	1.845	.000	1.845	4.82	.38	.025	.34	7.88
1456.	1553.	1.968	.000	1.968	4.96	.40	.025	.33	8.20
1553.	1650.	2.091	.000	2.091	5.09	.41	.025	.32	8.52

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)
55.20 *	32.95

* Note: This is not actual rainfall intensity, but the equivalent rainfall intensity under which the assumed $D_{50} = 1.5''$ can withstand.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UHTRA / GRT — Contract No. 3885-34 — Sheet 11 — File No.
Feature: Erosion Protection — Designed: FHW — Date: 11/15/91
Item: Top and Side Slopes of Tailings Embankment — Checked: [illegible] — Date: [illegible]

GRJTP14.OU 11/8/91 Page 3

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=SIDE LENGTH= 180. FT. SLOPE= 20.%

ASSUMED D50= .3957FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.120CFS/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.	97.	.059	.000	.059	.97	.06	.037	1.67	1.67
97.	194.	.119	.000	.119	1.37	.09	.033	1.18	2.85
194.	291.	.178	.000	.178	1.66	.11	.031	.97	3.82
291.	388.	.238	.000	.238	1.90	.12	.030	.85	4.67
388.	485.	.297	.000	.297	2.11	.14	.029	.77	5.44
485.	582.	.357	.000	.357	2.30	.16	.028	.70	6.14
582.	679.	.416	.000	.416	2.47	.17	.028	.65	6.79
679.	776.	.475	.000	.475	2.63	.18	.027	.62	7.41
776.	874.	.535	.000	.535	2.77	.19	.027	.58	7.99
874.	971.	.594	.000	.594	2.91	.20	.027	.56	8.55
971.	1068.	.654	.000	.654	3.04	.22	.027	.53	9.08
1068.	1165.	.713	.000	.713	3.16	.23	.026	.51	9.59
1165.	1262.	.772	.000	.772	3.27	.24	.026	.49	10.09
1262.	1359.	.832	.000	.832	3.39	.25	.026	.48	10.57
1359.	1456.	.891	.000	.891	3.49	.26	.026	.46	11.03
1456.	1553.	.951	.000	.951	3.59	.26	.026	.45	11.48
1553.	1650.	1.010	.000	1.010	3.69	.27	.026	.44	11.92
0.	90.	1.065	.000	1.065	5.26	.20	.044	.29	12.20
90.	180.	1.120	.000	1.120	5.40	.21	.043	.23	12.48

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)
26.67	26.59

*******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	1650.	2.3	1.5	2.091	8.5	1.50	SAFETY FACTOR
SIDE	180.	20.0	4.7	1.120	12.5	1.50	STEPHENSON

min. D50 used

2) D_{50} required for different top slope and ϕ (using same longest top slope = 1650 (> 2.3%))

Computer runs were also made for steeper top slope with friction angle $\phi = 38°$ and $39°$. (Note: Based on 1) base case presented above, required D_{50} (min) = 4.7" (5.4" oversized), the ϕ value can be 39° based on sheet 13). The min. D_{50} = 1.5" (1.8" oversized) and $\phi = 35°$ on the top slope are kept the same. D_{50} (min) required for the side slope (20% slope) are as follows:

	Top slope (%)	side slope (%)	$\phi°$ for side slope	D_{50} (min) required (in)	D_{50} (min) oversized (in)	q at end of 5:1 slope (cfs/ft)
(Base case)	2.3	20	38	4.7	5.4	1.12
	2.6	20	38	4.8	5.5	1.15
	2.3	20	39	4.5	5.2	1.12
	3.0	20	39	4.7	5.4	1.18
→	3.5	20	39	4.8	5.5	1.23

Thus the top slope can be as high as 3.5% for $\phi = 39°$ with a D_{50} (oversized) = 5.5" on the 20% side slope, while the min D_{50} required for the top slope still maintained at 1.8" (oversized) with $\phi = 35°$.

Hence in case of increase of contaminated materials, the extra volume of contaminated materials can be placed in a steeper slope (up to 3.5%) than the currently designated slope of 2.3%.

Output of the computer runs in addition to the base case shown above are presented in Appendix A.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

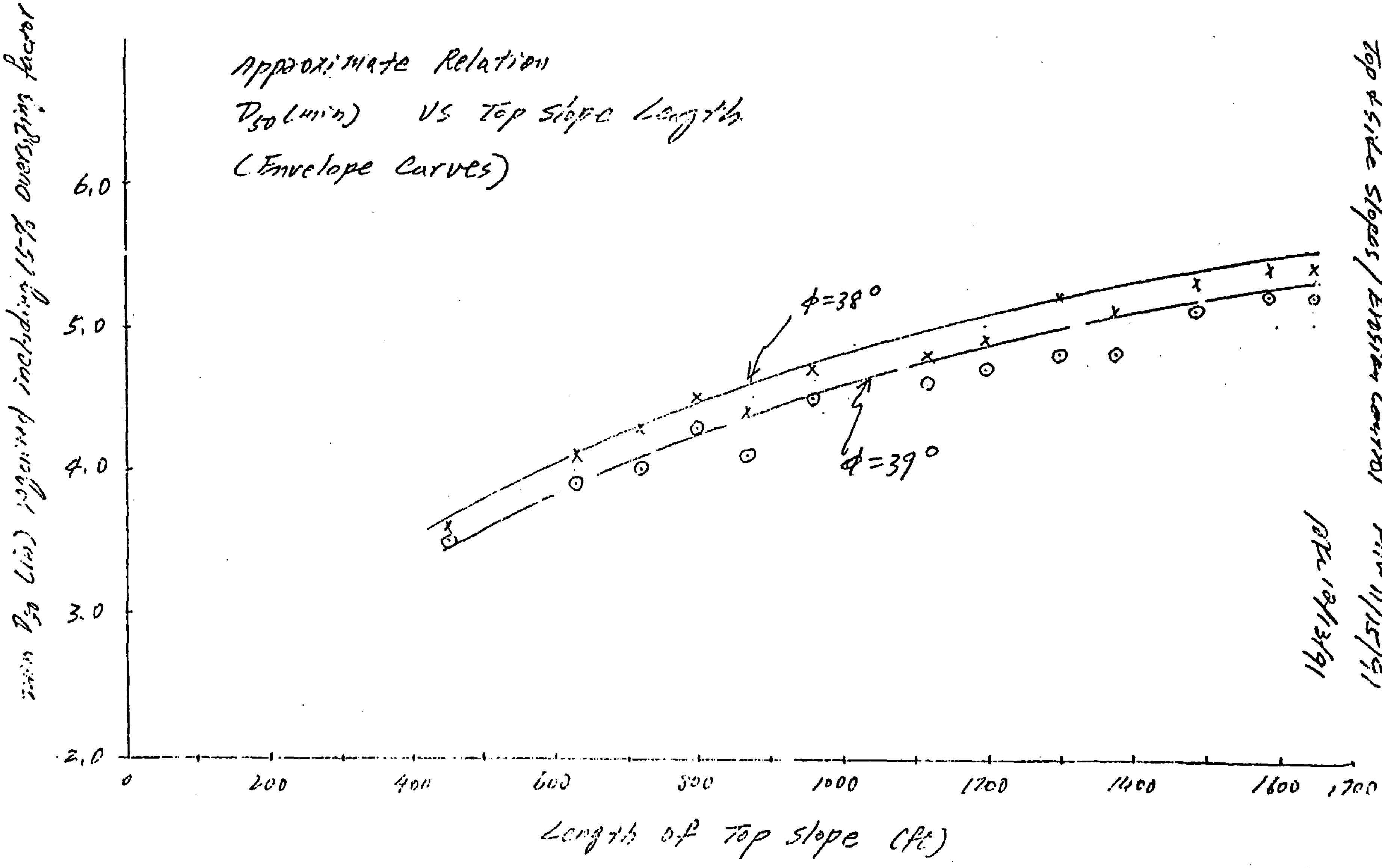
Project UMTRA / GRT — Contract No. 3885-34 — Sheet 17
Feature Erosion Protection — Designed ENd — File No.
Item Top + Side slopes of Tailings Embankment — Checked — Date 11/15/91 — Date 12/12/91

3) Check Riprap Requirements on 5:1 slope for shorter top slope length and corresponding side slope length.

The following are results based on computer runs. Output of the computer runs are not included in this cal. In each run, top slope = 2.3%, side slope = 20%, $\phi = 35°$ for top slope riprap (with $D_{50} = 1.5''$ before oversizing) (+ see sheet 6 for locations)

Top Slope Length (ft)	Side Slope Length (ft)	$\phi = 38°$ min D_{50} required (in)	$\phi = 38°$ min D_{50} oversized (in)	$\phi = 38°$ q (cfs/ft)	$\phi = 39°$ min D_{50} required (in)	$\phi = 39°$ min D_{50} oversized (in)	$\phi = 39°$ q (cfs/ft)
1650	180	4.7	5.4	1.12	4.5	5.2	1.12
1590	165	4.7	5.4	1.11	4.5	5.2	1.10
1490	165	4.6	5.3	1.08	4.4	5.1	1.07
1380	85	4.4	5.1	1.01	4.2	4.8	1.00
1300	180	4.5	5.2	1.02	4.2	4.8	1.01
1200	175	4.3	4.9	0.98	4.1	4.7	0.98
1120	160	4.2	4.8	0.93	4.0	4.6	0.94
960	190	4.1	4.7	0.89	3.9	4.5	0.89
870	110	3.8	4.4	0.81	3.6	4.1	0.81
800	200	3.9	4.5	0.83	3.7	4.3	0.84
720	160	3.7	4.3	0.77	3.5	4.0	0.77
630	190	3.6	4.1	0.75	3.4	3.9	0.74
450	140	3.1	3.6	0.60	3.0	3.5	0.61

Based on above table, the D_{50}(min) required after oversizing range from 3.5" to 5.2" for the 5:1 side slope. The use of 5.5" is conservative. Also the unit discharge q = 0.60 ~ 1.12 cfs at the end of side slope. Sheet 20 shows the approximate average curve for D_{50}(min) required (with 15% oversizing factor) vs top slope length. Note the relation is approximate, since the side slope connecting the top slope is varied.



UMTRA/GRJ 3885-34
Top & Side Slopes / Erosion Control FHW 11/15/91
DPK 12/3/91

Sheet 20

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA / GRT
Feature Erosion Protection
Item Top & Side slopes of Tailings Embankment

Contract No. 3885-34
Designed [illegible]
Checked [illegible]

Sheet A-1
File No.
Date [illegible]
Date [illegible]

Appendix A

Computer Output

Sensitivity Runs for longest top slope
For

1. $\phi = 38°$, Top slope = 2.6 % side slope = 20 %
2. $\phi = 39°$ Top slope = 2.3 % side slope = 20 %
3. $\phi = 39°$ Top slope = 3 % side slope = 20 %
4. $\phi = 39°$ Top slope = 3.5 % side slope = 20 %

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA / GRJ	Contract No. 3885-344	Sheet A-2	File No.
Feature Erosion Protection	Designed FWJ	Date 11/15/91	
Item Top and side slopes of Tailings Embankment	Checked	Date 12/13/91	

1. φ=38°, Top slope = 2.6 %   side slope = 20 %

GRJTP9.OUT   11/8/91   Page 1

INPUT FILE PRINTOUT

```
GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP9.OUT)

GRJ   FW    11-08 1991
  1.820  .340 1.640 2.640  .220      1  .002 1.0
   2    0
   0    0
  17    2     1150
 TOP       *****   2.6   .33  35.0  FS
 SIDE     180.0  20.0   .33  38.0  ST
  .1250   2.0   .02083
  .1250   2.0   .00347

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


GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP9.OUT)

 UMTRA/GRJ      RUN I.D.=FW       DATE=11-08 1991

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

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


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

          G= 1.820  H= .340  Z=1.640

  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     1650.     3.     .33     35.  SAFETY FACTOR
   1        SIDE     180.    20.     .33     38.  STEPHENSONS

 * * * * * * * * * * * END INPUT DATA * * * * * * * * * * *
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MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA / GRT — Contract No. 3885-34 — Sheet 11-3
Feature Erosion Protection — Designed FHW — File No.
Item Top and Side Slopes of Tailings Embankment — Checked [illegible] — Date 11/15/91 — Date 12/13/91

GRJTP9.OUT 11/8/91 Page 2

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=TOP LENGTH=1650. FT. SLOPE= 3.%

ASSUMED D50= .1250FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.774CFS/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.	97.	.104	.000	.104	1.33	.08	.034	1.22	1.22
97.	194.	.209	.000	.209	1.85	.11	.030	.87	2.09
194.	291.	.313	.000	.313	2.24	.14	.029	.72	2.82
291.	388.	.417	.000	.417	2.55	.16	.028	.63	3.45
388.	485.	.522	.000	.522	2.83	.18	.027	.57	4.02
485.	582.	.626	.000	.626	3.08	.20	.027	.53	4.55
582.	679.	.730	.000	.730	3.30	.22	.027	.49	5.04
679.	776.	.835	.000	.835	3.51	.24	.026	.46	5.50
776.	874.	.939	.000	.939	3.70	.25	.026	.44	5.94
874.	971.	1.043	.000	1.043	3.87	.27	.026	.42	6.35
971.	1068.	1.148	.000	1.148	4.05	.28	.026	.40	6.75
1068.	1165.	1.252	.000	1.252	4.21	.30	.025	.38	7.14
1165.	1262.	1.357	.000	1.357	4.36	.31	.025	.37	7.51
1262.	1359.	1.461	.000	1.461	4.50	.32	.025	.36	7.87
1359.	1456.	1.565	.000	1.565	4.64	.34	.025	.35	8.22
1456.	1553.	1.670	.000	1.670	4.78	.35	.025	.34	8.56
1553.	1650.	1.774	.000	1.774	4.91	.36	.025	.33	8.89

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)
46.83	32.22

GRJTP9.OUT 11/8/91 Page 3

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=SIDE LENGTH= 180. FT. SLOPE= 20.%

ASSUMED D50= .4026FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.150CFS/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.	97.	.061	.000	.061	1.01	.06	.037	1.59	1.59
97.	194.	.122	.000	.122	1.43	.09	.033	1.13	2.72
194.	291.	.183	.000	.183	1.74	.11	.031	.93	3.66
291.	388.	.244	.000	.244	1.99	.12	.030	.81	4.47
388.	485.	.305	.000	.305	2.21	.14	.029	.73	5.20
485.	582.	.366	.000	.366	2.40	.15	.028	.67	5.87
582.	679.	.427	.000	.427	2.58	.17	.028	.63	6.50
679.	776.	.488	.000	.488	2.75	.18	.028	.59	7.09
776.	874.	.549	.000	.549	2.90	.19	.027	.56	7.64
874.	971.	.610	.000	.610	3.04	.20	.027	.53	8.18
971.	1068.	.671	.000	.671	3.18	.21	.027	.51	8.69
1068.	1165.	.732	.000	.732	3.31	.22	.027	.49	9.17
1165.	1262.	.793	.000	.793	3.43	.23	.026	.47	9.65
1262.	1359.	.854	.000	.854	3.54	.24	.026	.46	10.10
1359.	1456.	.915	.000	.915	3.65	.25	.026	.44	10.55
1456.	1553.	.976	.000	.976	3.76	.26	.026	.43	10.98
1553.	1650.	1.037	.000	1.037	3.86	.27	.026	.42	11.39
0.	90.	1.093	.000	1.093	5.31	.21	.044	.28	11.68
90.	180.	1.150	.000	1.150	5.45	.21	.044	.28	11.95

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)
27.37	27.27

*******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	1650.	2.6	1.5	1.774	8.9	1.50	SAFETY FACTOR
SIDE	180.	20.0	4.8	1.150	12.0	1.50	STEPHENSON

2. $\phi = 39^{\circ}$ Top slope = 2.3 % , Side slope = 20 %

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GRJTP2.OUT              11/12/91                Page 1

 **INPUT FILE PRINTOUT**

 GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP2.OUT)

 GRJ   FW    11-08 1991
   1.820  .340 1.640 2.640  .220      1  .002 1.0
    2    0
    0    0
   17    2
  TOP     *****   2.3   .33  35.0  FS
  SIDE    180.0  20.0   .33  39.0  ST
   .1250   2.0   .02083
   .1250   2.0   .00347

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


 GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP2.OUT)

  UMTRA/CRJ      RUN I.D.=FW       DATE=11-08 1991

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


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


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

          G= 1.820  H= .340  Z=1.640

   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    1650.     2.      .33     35.  SAFETY FACTOR
     1        SIDE    180.    20.      .33     39.  STEPHENSONS

  * * * * * * * * * * * * END INPUT DATA * * * * * * * * * * * *
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GRJTP2.OUT 11/12/91 Page 2

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=TOP LENGTH=1650. FT. SLOPE= 2.%

ASSUMED D50= .1250FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 2.091CFS/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.	97.	.123	.000	.123	1.39	.09	.032	1.16	1.16
97.	194.	.246	.000	.246	1.93	.13	.030	.84	2.00
194.	291.	.369	.000	.369	2.33	.16	.028	.69	2.69
291.	388.	.492	.000	.492	2.67	.18	.027	.61	3.30
388.	485.	.615	.000	.615	2.95	.21	.027	.55	3.85
485.	582.	.738	.000	.738	3.21	.23	.026	.50	4.35
582.	679.	.861	.000	.861	3.44	.25	.026	.47	4.82
679.	776.	.984	.000	.984	3.65	.27	.026	.44	5.25
776.	874.	1.107	.000	1.107	3.85	.29	.026	.42	5.68
874.	971.	1.230	.000	1.230	4.03	.30	.025	.40	6.09
971.	1068.	1.353	.000	1.353	4.21	.32	.025	.38	6.47
1068.	1165.	1.476	.000	1.476	4.37	.34	.025	.37	6.84
1165.	1262.	1.599	.000	1.599	4.53	.35	.025	.36	7.20
1262.	1359.	1.722	.000	1.722	4.68	.37	.025	.35	7.54
1359.	1456.	1.845	.000	1.845	4.82	.38	.025	.34	7.88
1456.	1553.	1.968	.000	1.968	4.96	.40	.025	.33	8.20
1553.	1650.	2.091	.000	2.091	5.09	.41	.025	.32	8.52

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)
55.20	32.95

GRJTP2.OUT 11/12/91 Page 3

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=SIDE LENGTH= 180. FT. SLOPE= 20.%

ASSUMED D50= .3748FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.119CFS/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.	97.	.059	.000	.059	.97	.06	.037	1.67	1.67
97.	194.	.119	.000	.119	1.37	.09	.033	1.18	2.85
194.	291.	.178	.000	.178	1.66	.11	.031	.97	3.82
291.	388.	.237	.000	.237	1.90	.12	.030	.85	4.67
388.	485.	.297	.000	.297	2.11	.14	.029	.77	5.44
485.	582.	.356	.000	.356	2.30	.16	.028	.70	6.14
582.	679.	.415	.000	.415	2.47	.17	.028	.66	6.80
679.	776.	.475	.000	.475	2.63	.18	.027	.62	7.41
776.	874.	.534	.000	.534	2.77	.19	.027	.58	8.00
874.	971.	.593	.000	.593	2.91	.20	.027	.56	8.56
971.	1068.	.653	.000	.653	3.04	.22	.027	.53	9.09
1068.	1165.	.712	.000	.712	3.16	.23	.026	.51	9.60
1165.	1262.	.771	.000	.771	3.27	.24	.026	.49	10.09
1262.	1359.	.831	.000	.831	3.38	.25	.026	.48	10.57
1359.	1456.	.890	.000	.890	3.49	.26	.026	.46	11.04
1456.	1553.	.950	.000	.950	3.59	.26	.026	.45	11.49
1553.	1650.	1.009	.000	1.009	3.69	.27	.026	.44	11.93
0.	90.	1.064	.000	1.064	5.33	.20	.043	.28	12.21
90.	180.	1.119	.000	1.119	5.47	.20	.042	.27	12.48

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)
26.63	26.59

*******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	1650.	2.3	1.5	2.091	8.5	1.50	SAFETY FACTOR
SIDE	180.	20.0	4.5	1.119	12.5	1.50	STEPHENSON

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA / GRJ Contract No. 3885-34 Sheet 11-6 File No.

Feature Erosion Protection Designed FHW Date 11/15/91

Item Top & Side slopes of Tailings Embankment Checked Date 12/13/91

3. $\phi = 39°$, top slope = 3%, side slope = 20%

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GRJTP12.OUT              11/8/91          Page 1

 **INPUT FILE PRINTOUT**

 GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP12.OUT)

 GRJ   FW    11-08 1991
   1.820  .340 1.640 2.640  .220       1  .002 1.0
    2     0
    0     0
   17     2    ↙1650
  TOP       *****   3.0   .33  35.0  FS
  SIDE      180.0  20.0   .33  39.0  ST
   .1250    2.0   .02083
   .1250    2.0   .00347

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


 GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP12.OUT)

  UMTRA/GRJ      RUN I.D.=FW       DATE=11-08 1991

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


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


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

          G= 1.820  H= .340  Z=1.640

   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     1650.     3.      .33     35.  SAFETY FACTOR
    1        SIDE    180.     20.      .33     39.  STEPHENSONS

  * * * * * * * * * * * * END INPUT DATA * * * * * * * * * * * *
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GRJTP12.OU 11/8/91 Page 2

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=TOP LENGTH=1650. FT. SLOPE= 3.%

ASSUMED D50= .1250FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.460CFS/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.	97.	.086	.000	.086	1.25	.07	.035	1.30	1.30
97.	194.	.172	.000	.172	1.75	.10	.032	.92	2.22
194.	291.	.258	.000	.258	2.12	.12	.030	.76	2.98
291.	388.	.344	.000	.344	2.43	.14	.029	.67	3.65
388.	485.	.429	.000	.429	2.69	.16	.028	.60	4.25
485.	582.	.515	.000	.515	2.93	.18	.028	.55	4.80
582.	679.	.601	.000	.601	3.14	.19	.027	.51	5.32
679.	776.	.687	.000	.687	3.34	.21	.027	.48	5.80
776.	874.	.773	.000	.773	3.52	.22	.027	.46	6.25
874.	971.	.859	.000	.859	3.69	.23	.026	.44	6.70
971.	1068.	.945	.000	.945	3.86	.24	.026	.42	7.12
1068.	1165.	1.031	.000	1.031	4.01	.26	.026	.40	7.52
1165.	1262.	1.116	.000	1.116	4.15	.27	.026	.39	7.91
1262.	1359.	1.202	.000	1.202	4.30	.28	.026	.38	8.29
1359.	1456.	1.288	.000	1.288	4.43	.29	.026	.36	8.65
1456.	1553.	1.374	.000	1.374	4.56	.30	.025	.35	9.01
1553.	1650.	1.460	.000	1.460	4.69	.31	.025	.35	9.35

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)
38.54	31.34

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA / GRJ   Contract No. 3885-34   Sheet H-10   File No.
Feature Erosion Protection   Designed FMN   Date 11/15/10
Item Top + Side Slopes of Tailings Embankment   Checked [illegible]   Date 11/13/91

GRJTP12.OU   11/8/91   Page 3

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=SIDE   LENGTH= 180. FT.   SLOPE= 20.%

ASSUMED D50= .3887FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.182CFS/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.	97.	.063	.000	.063	1.07	.06	.037	1.52	1.52
97.	194.	.125	.000	.125	1.50	.08	.033	1.08	2.59
194.	291.	.188	.000	.188	1.83	.10	.031	.88	3.48
291.	388.	.251	.000	.251	2.10	.12	.030	.77	4.25
388.	485.	.313	.000	.313	2.32	.13	.029	.70	4.94
485.	582.	.376	.000	.376	2.53	.15	.029	.64	5.58
582.	679.	.439	.000	.439	2.71	.16	.028	.60	6.18
679.	776.	.501	.000	.501	2.89	.17	.028	.56	6.74
776.	874.	.564	.000	.564	3.05	.18	.027	.53	7.27
874.	971.	.627	.000	.627	3.20	.20	.027	.50	7.77
971.	1068.	.689	.000	.689	3.35	.21	.027	.48	8.26
1068.	1165.	.752	.000	.752	3.48	.22	.027	.46	8.72
1165.	1262.	.815	.000	.815	3.61	.23	.026	.45	9.17
1262.	1359.	.877	.000	.877	3.73	.24	.026	.43	9.61
1359.	1456.	.940	.000	.940	3.85	.24	.026	.42	10.03
1456.	1553.	1.003	.000	1.003	3.96	.25	.026	.41	10.43
1553.	1650.	1.065	.000	1.065	4.07	.26	.026	.40	10.83
0.	90.	1.124	.000	1.124	5.43	.21	.043	.28	11.11
90.	180.	1.182	.000	1.182	5.57	.21	.043	.27	11.38

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)
28.13	28.07

*******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	1650.	3.0	1.5	1.460	9.4	1.50	SAFETY FACTOR
SIDE	180.	20.0	4.7	1.182	11.4	1.50	STEPHENSON

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Project: UMTRA / GRJ	Contract No. 3885-34	Sheet A-11	File No.
Feature: Erosion Protection	Designed FHW	Date 11/15/91	
Item: Top & side slopes of Tailings Embankment	Checked [illegible]	Date 12/13/91	

4. $\phi = 39°$ top slope = 3.5% side slope = 20%

```
GRJTP11.OUT            11/8/91          Page 1

 **INPUT FILE PRINTOUT**

 GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP11.OUT)

 GRJ   FW    11-08 1991
   1.820  .340 1.640 2.640  .220       1  .002 1.0
    2    0
    0    0
   17    2
  TOP      *****   3.5   .33  35.0  FS
  SIDE     180.0  20.0   .33  39.0  ST
   .1250   2.0   .02083
   .1250   2.0   .00347

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



 GRJ - TOP AND SIDE SLOPES,ZERO PORE FLOW (FILE:GRJTP11.OUT)

  UMTRA/GRJ      RUN I.D.=FW       DATE=11-08 1991

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


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


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

          G= 1.820  H= .340  Z=1.640

   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     1650.    3.5     .33     35.  SAFETY FACTOR
    1        SIDE     180.    20.     .33     39.  STEPHENSONS

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

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA / GRJ   Contract No. 3885-34   Sheet
Feature Erosion Protection   Designed EHW   Date 11/15/9
Item Top + Side slopes of Tailings Embankment   Checked DKC   Date 12/13/91   File No.

GRJTP11.OUT   11/8/91   Page 2

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=TOP   LENGTH=1650. FT. SLOPE= 4.%

ASSUMED D50= .1250FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.179CFS/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.	97.	.069	.000	.069	1.17	.06	.037	1.39	1.39
97.	194.	.139	.000	.139	1.64	.08	.033	.98	2.37
194.	291.	.208	.000	.208	2.00	.10	.031	.81	3.18
291.	388.	.277	.000	.277	2.29	.12	.030	.71	3.89
388.	485.	.347	.000	.347	2.54	.14	.029	.64	4.53
485.	582.	.416	.000	.416	2.76	.15	.028	.59	5.11
582.	679.	.485	.000	.485	2.96	.16	.028	.55	5.66
679.	776.	.555	.000	.555	3.16	.18	.028	.51	6.17
776.	874.	.624	.000	.624	3.33	.19	.027	.49	6.65
874.	971.	.693	.000	.693	3.50	.20	.027	.46	7.12
971.	1068.	.763	.000	.763	3.65	.21	.027	.44	7.56
1068.	1165.	.832	.000	.832	3.80	.22	.027	.43	7.99
1165.	1262.	.901	.000	.901	3.94	.23	.026	.41	8.40
1262.	1359.	.971	.000	.971	4.07	.24	.026	.40	8.79
1359.	1456.	1.040	.000	1.040	4.20	.25	.026	.39	9.18
1456.	1553.	1.109	.000	1.109	4.32	.26	.026	.37	9.55
1553.	1650.	1.179	.000	1.179	4.44	.27	.026	.36	9.92

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)
31.12	30.34

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Project UMTRA / GRJ — Contract No. 3885-34 — Sheet A-13 — File No.
Feature Erosion Protection — Designed EHJ — Date 11/15/91
Item Top & side slopes of Tailings Embankment — Checked — Date 12/13/91

GRJTP11.OUT 11/8/91 Page 3

DETAILED CALC TABLE WITH FINAL ROCK SIZE

SEGMENT=SIDE LENGTH= 180. FT. SLOPE= 20.%

ASSUMED D50= .3991FT. AT D/S END OF SEGMENT
CORRESPONDING Q= 1.229CFS/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.	97.	.065	.000	.065	1.13	.06	.038	1.43	1.43
97.	194.	.130	.000	.130	1.60	.08	.033	1.01	2.45
194.	291.	.196	.000	.196	1.94	.10	.031	.83	3.28
291.	388.	.261	.000	.261	2.23	.12	.030	.73	4.01
388.	485.	.326	.000	.326	2.46	.13	.029	.66	4.66
485.	582.	.391	.000	.391	2.68	.15	.029	.60	5.27
582.	679.	.456	.000	.456	2.88	.16	.028	.56	5.83
679.	776.	.522	.000	.522	3.07	.17	.028	.53	6.35
776.	874.	.587	.000	.587	3.24	.18	.027	.50	6.55
874.	971.	.652	.000	.652	3.40	.19	.027	.48	7.33
971.	1068.	.717	.000	.717	3.55	.20	.027	.46	7.78
1068.	1165.	.782	.000	.782	3.70	.21	.027	.44	8.22
1165.	1262.	.848	.000	.848	3.83	.22	.027	.42	8.64
1262.	1359.	.913	.000	.913	3.96	.23	.026	.41	9.05
1359.	1456.	.978	.000	.978	4.09	.24	.026	.40	9.45
1456.	1553.	1.043	.000	1.043	4.21	.25	.026	.38	9.83
1553.	1650.	1.108	.000	1.108	4.32	.26	.026	.37	10.21
0.	90.	1.169	.000	1.169	5.50	.21	.043	.27	10.48
90.	180.	1.229	.000	1.229	5.64	.22	.043	.27	10.74

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)
29.26	29.00

*******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	1650.	3.5	1.5	1.179	9.9	1.50	SAFETY FACTOR
SIDE	180.	20.0	4.8	1.229	10.7	1.50	STEPHENSON

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Project UMTRA / GRJ Contract No. 3885-34 Sheet B-1
File No.
Feature Erosion Protection Designed EHW Date 11/15/91
Item Top and Side Slopes of Tailings Embankment Checked MLC Date 12/13/91

Appendix B

Riprap Gradation

Appendix B - Riprap Gradation

1. Top slope : (Ref. 6)

Required D_{50} (min) with 15% oversizing factor for Top slope is 1.8". The riprap on the top slope is designated as Type A rock.

a. Gradation and Layer Thickness

1) Gradation Band :

D_{50} (min) = 1.8"

D_{100} (max) = 1.71 D_{50} (min) = 3.1" (see Ref. 1, pp. 5-13)

D_{100} (min) = 1.26 D_{50} (min) = 2.3" "

D_{25} (min) = 0.68 D_{50} (min) = 1.2" "

A gradation band for Type A rock is drawn using the above calculated values as reference and considerations of rocks available at site for seiving and seperation into three categories of rocks (i.e. Type A (D_{50} (min) = 1.8", Type B (D_{50} (min) = 5.5" (see sheet B-7), and Type C Rock D_{50} (min) = 16" (Ref. 8, Riprap Toe protection Calculation)) Gradation curve for Type A rock is shown on sheet B-6. Sheet B-6 also tabulated the % passing for several sieve sizes for Type A rock. Sheet B-7 shows several sample data from the site for Type A rock, which show that the data are within the specified Band. The gradation band also took into consideration of filter compatibility between Type A and bedding material, and between Type A and Type C rocks. The choice of the gradation limits was considered more cost effective since they are readily available at site.

About 5-10% of Type A rock contains rocks smaller than 20 mm which might include some clay clusters. However, it is judged that this will not affect the stability of the Type A rock layer. This is based on the following observations:

- Even if these clays will be washed away, it is within the limit of the guideline specified in Ref. I, which states that "the bulk volume of stone lighter than the W_{15} (15% lighter by weight) stone should not exceed the volume of voids in revetment without this lighter stone."
- Type A rock will have a layer of 12" on top slope above the contaminated fill area, and at least 6" on the clean fill area (see 2) below). The min. layer thickness required for the Type A rock is only about 4".

2) Layer Thickness (LT): (Based on Ref. 1)

$T_{min} = 1.9\ D_{50}(min) = 1.9(1.8) = 3.4"$

$= 1.5\ D_{50}(max) = 1.5(2.8) = 4.2"$

$= 12"$ (min)

A layer thickness of <u>12"</u> for Type A rock will be used on the top slope cover which protect the embankment and prevent the contaminated material from exposed. For those area that cover the clean fill, a <u>6" layer</u> is deemed sufficient and will be used.

2. Side Slope (5:1)

Required D_{50} (min) with 15% oversizing factor (Ref. 6) for the side slope is 5.5" with consideration of possible increase of top slope (from 2.3 to 3.5%) in case of increase of contaminated materials. The riprap to be used for the 5:1 side slope is designated as Type B rock.

a) Gradation and Layer Thickness:

1) Gradation Band:

D_{50} (min) after oversizing = 5.5"

D_{100} (max) = 1.71 D_{50} (min) = 9.4"

D_{100} (min) = 1.26 D_{50} (min) = 7.0"

D_{25} (min) = 0.68 D_{50} (min) = 3.7"

The gradation band for Type B rock is drawn based on the above values and materials available at site, and also the consideration filter compatibility between Type B rock and bedding material, and also between Type B & Type C rocks. Adopted gradation curve for Type B rock is shown on Sheet B-6, with % passing for several sieve sizes also tabulated. The choice of the curve is also from the cost effective point of view. The D_{100} (max) = 12" is larger than calculated above, but should not affect the stability of the rock layer. Sheet B-7 shows gradation of some of the field test samples which are mostly within the limit of the gradation.

2) Type B rock Layer Thickness

$$T_{min} = 1.9\ D_{50}\ (min) = 1.9\,(5.5) = 10.5''$$

$$= 1.5\ D_{50}\ (max) = 1.5\,(9) = 13.5''$$

Use layer thickness = 12"

3. Bedding material

Only one type of bedding material is designed for used as filter between either Type A or Type B rock and its underlying subgrade material. Based on this condition, the bedding material gradation was derived as given in Ref. 9. The derived gradation curves and the % passing for several sieve sizes from Ref. 9 are shown on sheet B-6.

The bedding layer thickness will be 6".

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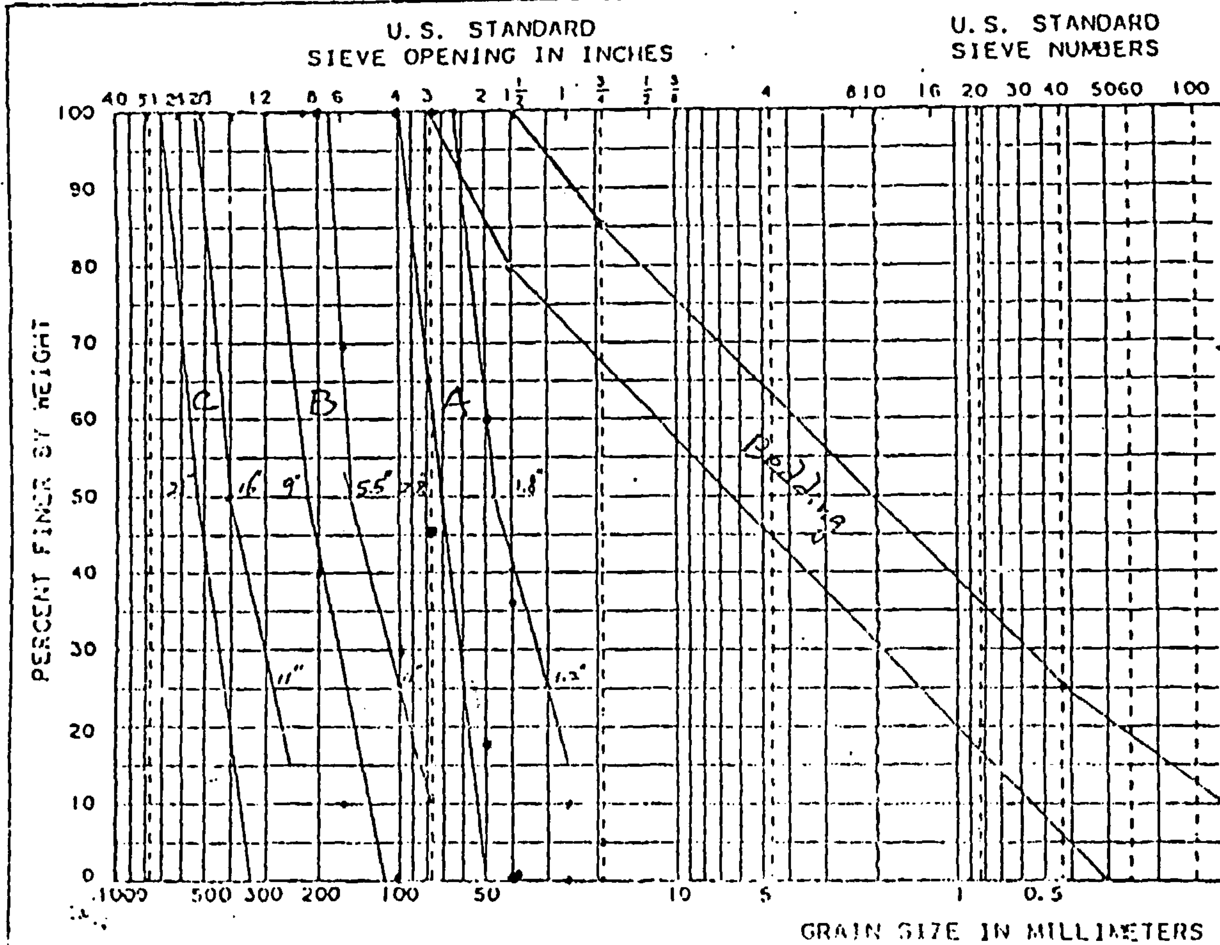
UMTRA / GRJ   WYL 11/6/91
FHW 11/15/91

UMTRA/GRJ 3885-34
Erosion Protection [illegible]
Top & side slopes [illegible]

GRAIN SIZE ANALYSIS



Rock Type	Sieve Size	% Passing
Type A	4"	100
	2½"	35 – 95
	2"	0 - 60
	1½"	0 - 40
	1"	0 – 15
Type B	12"	100
	9"	50-100
	7"	35 - 95
	5½"	20 - 50
	3"	0 - 10
Type C	28"	100
	20"	45 - 90
	16"	20 - 50
	10"	0 - 15
Bedding	3"	100
	1"	70 - 90
	No. 4	45 - 65
	No. 40	5 - 25
	No. 200	0 - 5

SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	NAT W%	LL	PL

JOB NO.

AREA

HOLE NO.

DATE

Sheet R-6

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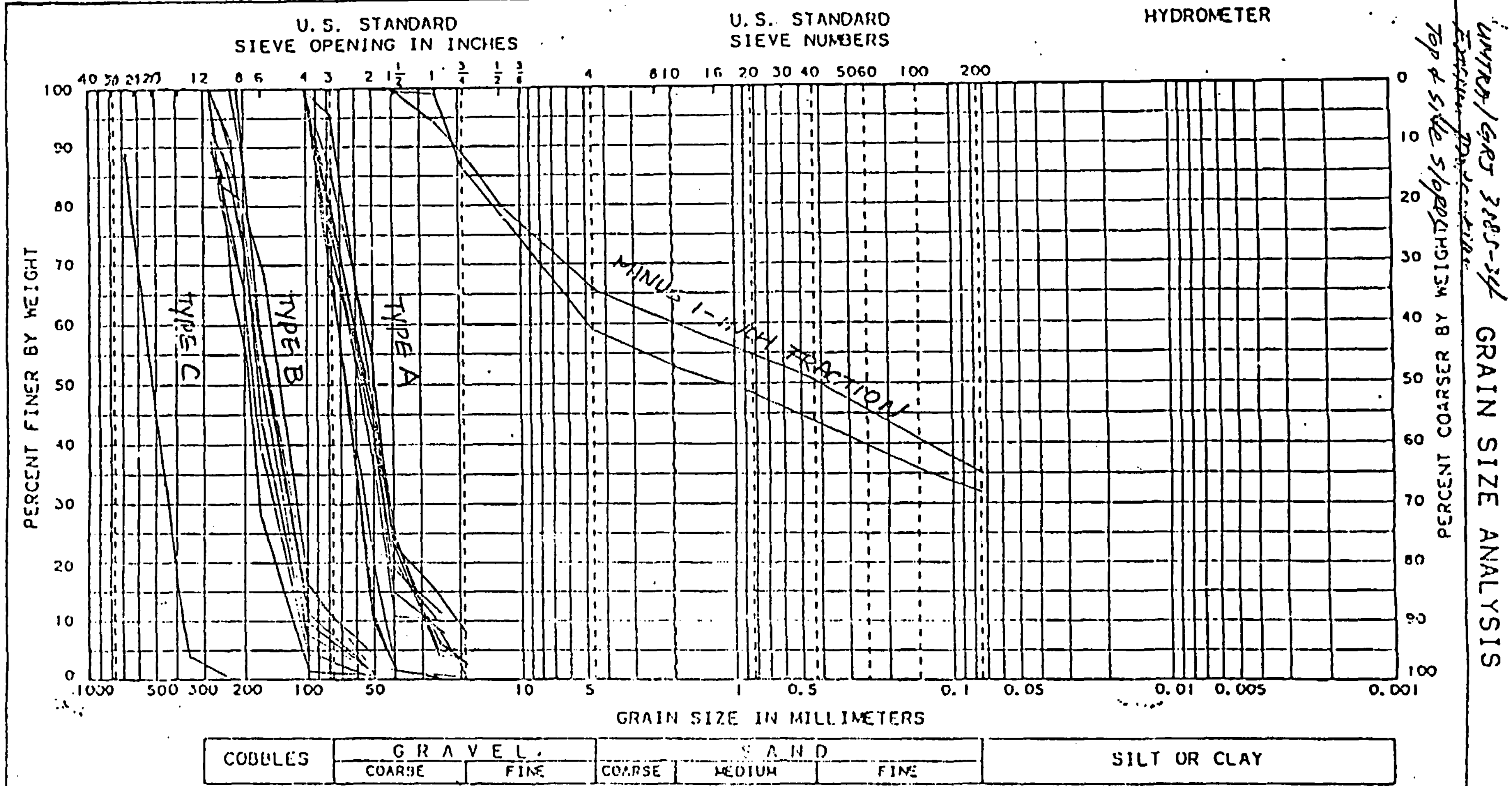

SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
MINUS 1	INCH FRACTION	2 DATA				
RIPRAP	TYPE A	17 DATA				
RIPRAP	TYPE B	9 DATA				
RIPRAP	TYPE C	1 DATA				

PROJECT	UMTRA / GRJ
JOB NO.	3885-34
AREA	CHENEY DISPOSAL SITE
HOLE NO.	GRAVEL PILE
DATE	11/8/91 WYL

check FMW 11/15/91

FIGURE 1 GRADATION CURVES

Sheet B-1

Calculation Cover Sheet

Contract No. 5025 Discipline Envirn. Calc. No. 05-504-02-00

No. of Sheets 13

Project VMTRA - GRAND JUNCTION

Feature EROSION PROTECTION

Item TIME OF CONCENTRATION
CHENEY DISPOSAL SITE EMBANKMENT

Sources of Data

SEE pg. 1&2

Sources of Formulae & References

SEE pg. 1&2

Preliminary Calc. ☑ Final Calc. ☐ Supersedes Calc. No. ____

0		[illegible]	5-?-90	H. LUBIS	5-17-90	P. Sircar	6-12-90
Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date

Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.

Project UMTRA / Grand Junction — Contract No. 5025-16 — Sheet 1

Feature Cheney Disposal Site — Designed GBS — Date 5-11-90 — File No.

Item Time of Concentration — Checked H.L. — Date 5-17-90

REFERENCES

1. ASCE, Division of Hydraulics, Proceedings of the Engineering Hydrology Symposium, Edited by Arlen D. Feldman, Williamsburg, Virginia, August, 1987. Papers presented by the following:

   a) "Application of the New SCS Time of Concentration Method", C.K. Taur and G.E. Oswald.

   b) "Time of Concentration in Small Rural Watersheds", by C.N. Papadakis and M.N. Kazan.

2. Linsley, R.K. and Franzini, J.B., Water Resources Engineering, Third Edition, McGraw-Hill, 1979.

3. Haan, C.T. and Barfield, B.J., Hydrology and Sedimentology of Surface Mined Lands, 1978.

4. U.S. Bureau of Reclamation, Design of Small Dams, Revised 1977.

5. MKES Calculation UMTRA/Grand Junction, Site drainage Hydrology Parameters, page 13.

6. Department of Transportation, Federal Aviation Administration, Airport Drainage, AC 150/5320-5B, 1970.

7. ASCE, Frontiers In Hydraulic Engineering, Conference Proceedings, August 9-12, 1983, MIT, Cambridge, Mass., Hung Tao Shen, Editor.

   a) "Estimating Time of Concentration of Urban Watersheds", by R.H. McCuen, S.L. Wong, and W.J. Rawls.

   b) "Evaluation of Tc Methods for Urban Watersheds", by D.F. Kibler and G. Aron

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Project UMTRA - GRAND JUNCTION | Contract No. 5025-16 | Sheet 6

Feature CHENEY DISPOSAL SITE | Designed GBS | File No. | Date 5-4-90

Item TIME OF CONCENTRATION | Checked H. L. | Date 5-17-9

8. MKES, UMTRA Project Procedures Manual Document Number 4005-GEN-Q-01-06596-00, February, 1989.

Project UMTRA - GRAND JUNCTION Contract No. 9025-16 File No.
Feature CHENEY DISPOSAL SITE Designed CBS Date 5-4-90
Item TIME OF CONCENTRATION Checked H. L. Date 5-17-90

Purpose: The purpose of this calculation is to determine Tc (time of concentration) for the disposal cell. This parameter (Tc) is needed in order to size the rip rap on the sides of the pile. Due to the fact that the Grand Junction site has a vegetative cover and not a rock cover, it is not possible to use the standard program to size riprap, and it is necessary to compute Tc for the calculation of riprap size.

Method: Six (6) different methods were used to compute the value of Tc. They are:

1. SCS average velocity charts
2. FAA method
3. Izzard Equation
4. SCS lag equation
5. Kirpich
6. Kinematic Wave Formula

A Tc value was computed using each of these six methods for each of the following drainage path lengths: 500 ft., 1000 ft., 1500 ft., 2000 ft., 2500 ft. (See chart page 11). This was done because 500' is approximately the shortest possible drainage path length and 2500 ft. is approximately the longest possible drainage path lengths. It is necessary to compute Tc values for each of these 5 drainage path lengths in order to determine if different segments of the sideslopes of the pile require different riprap sizes due to the drainage pattern.

Each of the six methods used to compute Tc is explained more fully below:

1. SCS average velocity charts: Ref. 8 & 7 & 1

$$T_c = \frac{L}{60V}$$

L = Length of flow path (ft.)

V = Average velocity (ft/sec.) from chart Ref. 8 pg 5-31. (For S=2% and nearly bare ground ⇒ V=1.4 ft./sec)

2. FAA Method: Ref. 6

$$T_c = \frac{1.8(1.1-C)L^{1/2}}{S^{1/3}}$$

C = Rational method Runoff coefficient (use C=.95 which is the maximum/most conservative value in Ref. 6, page 10, Table 1).

L = Length of overland flow
S = Surface slope (%)

x 3. IZZARD EQUATION : Reference 2

$$T_c = \frac{41.025\,(0.0007i + c)\,L^{.33}}{S^{0.333}\; i^{0.667}}$$

i = Rainfall Intensity (inches/hour) from PMP plot see pg 9.

c = Retardance coefficient from Table 3-2, Reference 2. (use $c = .022$ ft). see page 10

L = length of flow path (ft).

S = slope of flow path (ft/ft).

4. SCS Lag Equation Ref. 0 & 7 & 1

$$T_c = \frac{100L^{0.8}\left(\frac{1000}{CN} - 9\right)^{0.7}}{1900\, S^{0.5}}$$

L = length (ft.)

CN = SCS curve number (use .95)

S = slope %

Project UMTRA-GRAND JUNCTION	Contract No. 3025-16	File No.	
Feature CHENEY DISPOSAL SITE	Designed GBS	Date 5-4-9[illegible]	
Item TIME OF CONCENTRATION	Checked H. L.	Date 5-17-9[illegible]	

5. Kirpich Method Ref. 7

$$T_c = \frac{0.0078\, L^{0.77}}{S^{0.385}}$$

L= Length of channel or ditch from headwater to outlet (ft.)

S= average slope (ft/ft)

6. Kinematic Wave Formula: Ref. 7

$$T_c = \frac{0.94\, L^{0.6}\, n^{0.6}}{i^{0.4}\, S^{0.3}}$$

L= length of flow path (ft.)

n= Manning's roughness coefficient (n=0.05, Reference 7.

i= Rainfall intensity, (inches/hour) from PMP plot page 9

S= average overland slope (ft/ft.)

Project UMTRA-GRAND JUNCTION — Contract No. 5025-16 — Sheet — File No.
Feature CHENEY DISPOSAL SITE — Designed GBS — Date 5-4-9[illegible]
Item TIME OF CONCENTRATION — Checked H. L. — Date 5-17-9[illegible]

Results The chart on page 9 shows the different values of Tc that have been computed. For the Grand Junction site, the Kirpich method is being used to size the riprap. This is due to the fact that this method

is most applicable to the Grand Junction site. The Kirpich method is based on a combination of gulley flow and overland flow. This is similar to a "worst case" condition that would be expected at the Grand Junction site (ie: after some gulley formation has started). The Kinematic Wave Method is based primarilly for overland flow. It does, however, take into account all of the parameters which may have impact on Tc, length of flow, roughness, rainfall intensity, and slope. Since the Kirpich method, however, is more widely accepted, it was chosen instead of the kinematic wave method.

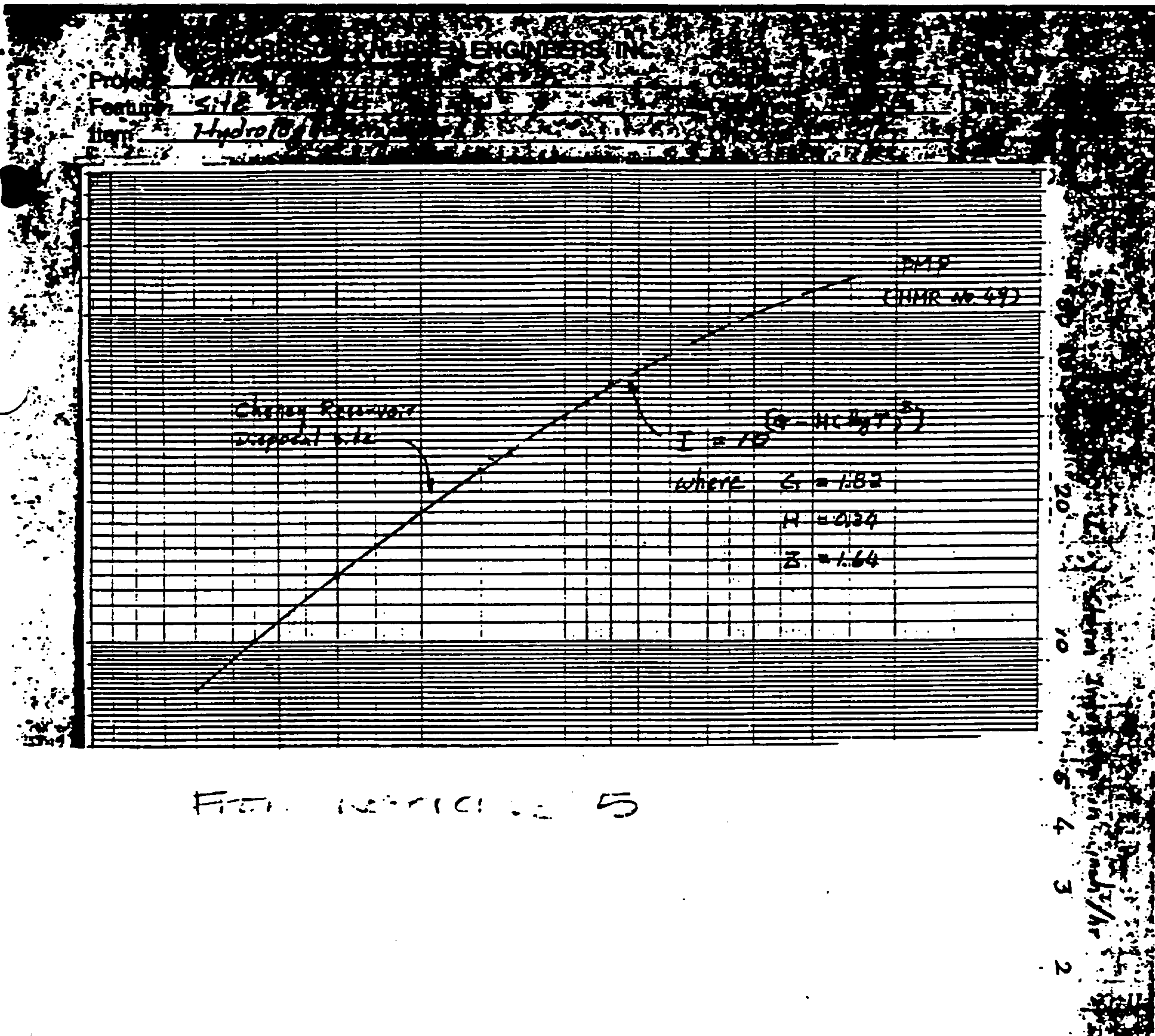
The graph on page 12 shows the results of all 6 methods of computing Tc. It is apparent that the Kirpch method, chosen to use for riprap sizing falls in the "middle" area. For sizing riprap, a small value of Tc is the most conservative. The reason that the 2 methods which produce the smallest values for Tc were not considered is that: 1) Izzard's equation was developed for overland flow for highway drainage which applies mostly to roadways and this is not appropriate for use on a vegetative cover. 2) The FAA method was derived for determining overland flow at airports. This, also, is not representative of the conditions at the Grand Junction site.

Conclusion

The values of Tc computed by the Kirpich method will be used in the computer program for sizing riprap on the sideslopes of the tailings pile at Grand Junction.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project	UMTRA - GRAND JUNCTION	Sheet	9
Contract No.	5025-16	File No.	
Feature	CHENEY DISPOSAL SITE	Designed	GBS
Date	5-4-90	Item	TIME OF CONCENTRATION
Checked	H.L.	Date	5-17-90



From Reference 2 for

Table 3-2 Values of retardance coefficient c_r in Eq. (3-11)

Surface	Value of c_r
Smooth asphalt surface	0.007
Concrete pavement	0.012
Tar and gravel pavement	0.017
Closely clipped sod	0.046
Dense bluegrass turf	0.060

c_r = .022
Use c_r = 0.022 for vegetative cover.

where L_o is the length of overland flow in feet. With L_o in meters and i in millimeters per hour, the constant is 526. The coefficient b is given by

$$b = \frac{0.0007i + c_r}{S_0^{1/3}} \tag{3-11}$$

where S_0 is the slope of the surface and c_r is a retardance coefficient (Table 3-2). In SI metric units, the multiplier for i is 2.8×10^{-5}. Equations (3-10) and (3-11) are applicable only when the product iL_o is less than 500 in English units or 4000 in SI metric units.

Time of concentration for a small basin is equal to the longest combination of overland flow time and conduit flow time which exists anywhere in the basin. Conduit flow time is commonly taken as the length of the longest channel divided by the average velocity of flow.

3-12 Unit hydrographs If two identical rainstorms could occur over a drainage basin with identical conditions prior to the rain, the hydrographs of runoff from the two storms would be expected to be the same. This is the basis of the *unit-hydrograph* concept.[1] Actually the occurrence of identical storms is very rare. Storms may vary in duration, amount, and areal distribution of rainfall. A *unit hydrograph* is a hydrograph with a volume of 1 in. (25 mm) of runoff resulting from a rainstorm of specified duration and areal pattern. Hydrographs from other storms of like duration and pattern are assumed to have the same time base, but with ordinates of flow in proportion to the runoff volumes.

A unit hydrograph may be constructed from the rainfall and streamflow data of a storm with reasonably uniform rainfall intensity and without complications from preceding or subsequent rainfall. The first step in the derivation is the separation of groundwater flow from direct runoff. The volume of runoff (area *ABCD*, Fig. 3-11) is determined and the ordinates of the unit hydrograph are found by dividing the ordinates of the direct runoff by the volume of direct runoff in inches. The resulting unit hydrograph should represent a unit volume (1 in., or

[1] L. K. Sherman, Streamflow from Rainfall by the Unit-graph Method, *Eng. News-Record*, Vol. 108, pp. 501–505, 1932.

COMPUTATION OF T_c FOR VEGETATIVE COVER (IN MINUTES)

NOTE: ALL T_c VALUES ARE BASED ON PMP

	LENGTH (FEET)				
	500'	1000'	1500'	2000'	2500'
SCS AVG. VELOCITY CHARTS	6	12	18	24	30
FAA METHOD	4.8	6.8	8.3	9.6	10.7
IZZARD EQ.	5.0	6.3	7.3	8.0	8.7
SCS LAG EQUATION	7.2	12.6	17.4	21.9	26.1
KIRPICH	4.2	7.2	9.8	12.2	14.5
KINEMATIC WAVE FORMULA	4.5	7.5	10.3	13	16

NOTES CONT'D

KIRPICH (REF. 7)

$$T_c = 0.0078 \frac{L^{0.77}}{S^{0.385}}$$

L = LENGTH OF FLOW PATH (FT)
S = SLOPE (FT/FT) → S = 0.02

KINEMATIC WAVE FORMULA BY MORGALI, RAGAN AND DURU, ARON (REF. 7)

$$T_c = \frac{0.94 L^{0.6} n^{0.6}}{i^{0.4} S^{0.3}}$$

L = LENGTH OF FLOW PATH (FT)
n = MANNING'S ROUGHNESS COEFF. (USE n = 0.05)
i = RAINFALL INTENSITY AND S = SLOPE (FT/FT) → S = 0.02
(i: THROUGH TRIAL AND ERROR FROM PMP PLOT (PAGE 9))

NOTES:

SCS AVG. VEL. CHARTS

$$T_c = \frac{L}{60 \times V}$$, WHERE:
L = LENGTH OF FLOW PATH (FT)
V = AVG. VELOCITY (FT/SEC) FROM CHART (REF. 8) WITH S = 2%, AND NEARLY BARE AND UNTILLED (OVERLAND FLOW), V = 1.4 FT/SEC.

FAA METHOD

$$T_c = \frac{1.8(1.1 - c) L^{1/2}}{S^{1/3}}$$

c = RUNOFF COEFF.
L = LENGTH OF FLOW PATH (FT)
S = SURFACE SLOPE, % → S = 2%
USE c = 0.95 (MAX. VALUE GIVEN ON REF. 6)

IZZARD METHOD (REF. 2)

$$T_c = \frac{41.025(0.0007 i + c) L^{0.33}}{S^{0.333} i^{0.667}}$$

i = RAINFALL INTENSITY (IN/HR) (THROUGH TRIAL AND ERROR FROM PMP PLOT (SEE PAGE 9))
c = RETARDANCE COEFF. (FROM TABLE 3.2 (REF. 2))
L = LENGTH OF FLOW PATH
S = SLOPE OF FLOW PATH (FT/FT)
→ S = 0.02; c = 0.022

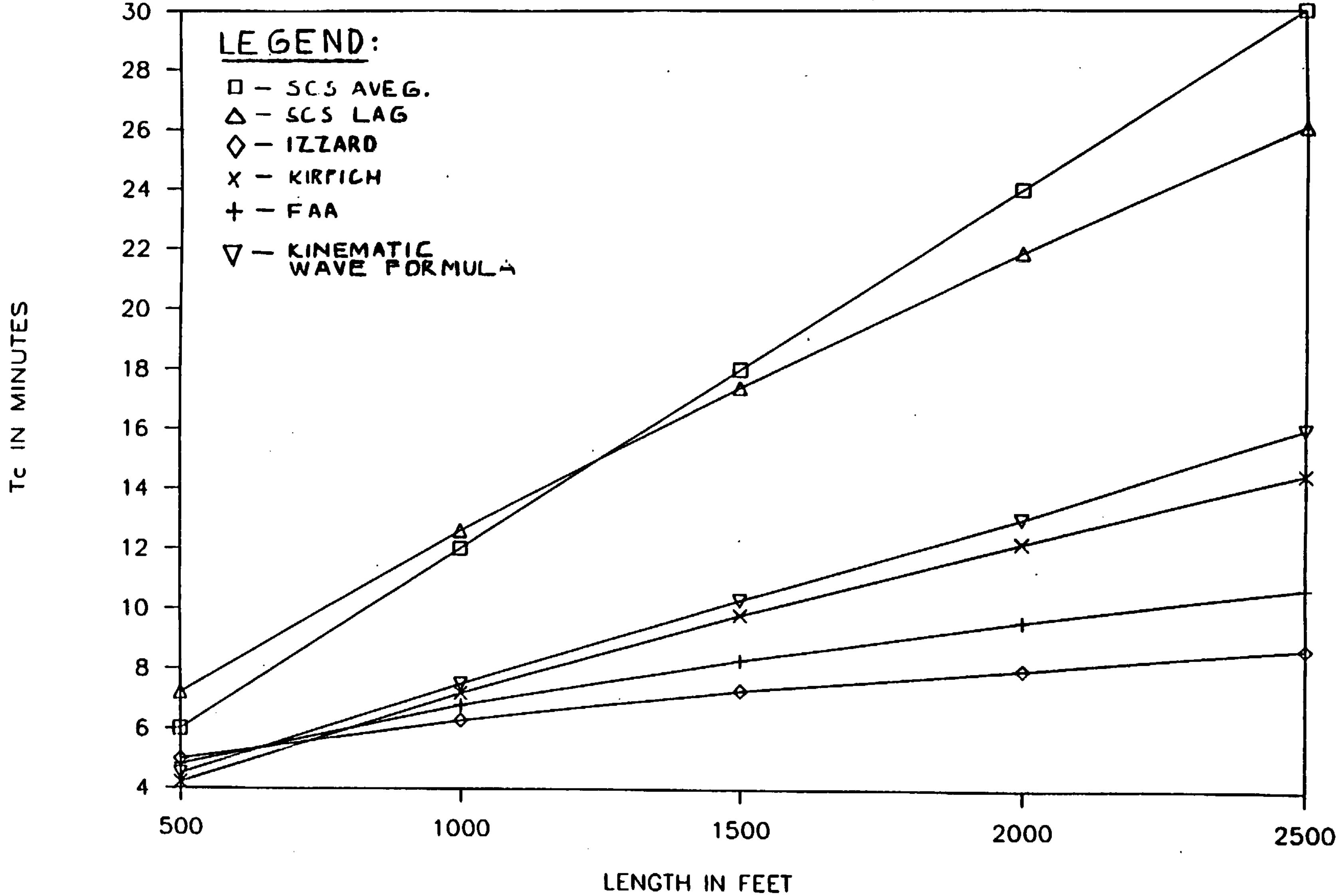
SCS LAG EQUATION

$$T_c = \frac{100 L^{0.8} \left[\frac{1000}{CN} - 9\right]^{0.7}}{1900 S^{0.5}}$$

L = LENGTH (FEET)
CN = SCS CURVE NO. USE 95
S = SLOPE, % → S = 2%

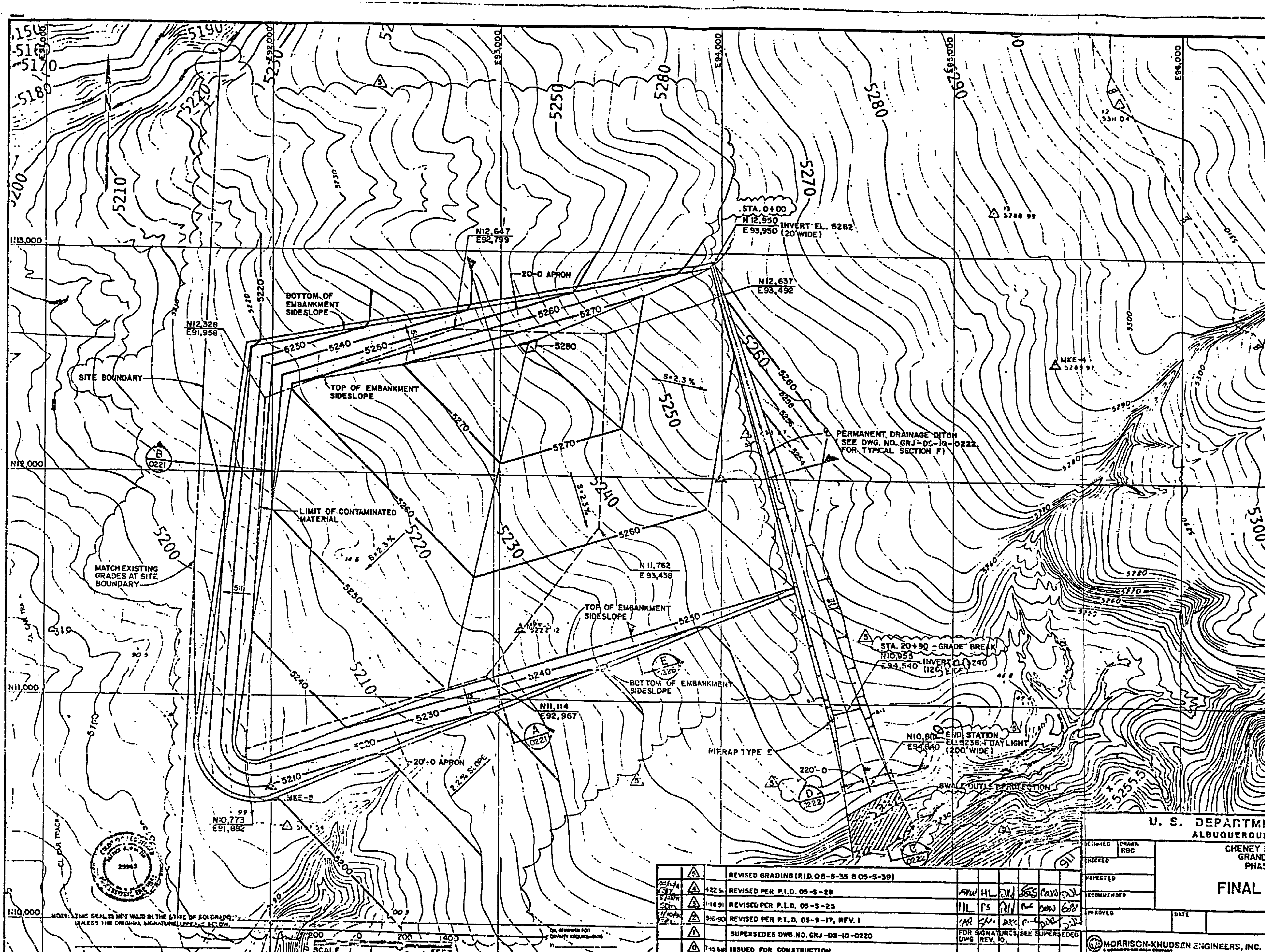
Tc FOR VEGETATIVE COVER

BASED ON VARIOUS METHODS



INTRA-GRAND JUNCTION
CHENEY DISPOSAL SITE
TIME OF CONCENTRATION

7025-16
by H.L.
checked
5-4-90



NOTES: *Sheet R-3*

1. WHERE CORNER CONTOURS ON THE TAILINGS EMBANKMENT ARE TOO SHARP TO BE CONSTRUCTED, CONTOURS WILL BE ROUNDED WITH A 50 FOOT RADIUS (APPROXIMATELY) IN THE PLAN VIEW.
2. THE CONTOURS OF THE TOP SLOPE AR[E] APPROXIMATE AND ARE DEPENDENT ON ACTUAL VOLUME OF CONTAMINATED MATERIALS RELOCATED.

UMTRA/GRJ FHW 11/20/91
Permanent Site Drainage ... PRC 12/13/91
off-site Drainage Swale

REFERENCE DRAWINGS:

GRJ-DS-10-0124	SITE PLAN
GRJ-DS-10-0125	CONSTRUCTION FACILITIES AND SITE DRAINAGE
GRJ-DS-10-0134	TAILINGS EMBANKMENT AREA & EXCAVATION PLA[N]
GRJ-DS-10-0221	TAILINGS EMBANKMENT SECTIONS AND DETAIL[S]
GRJ-DS-10-0222	DITCHES AND MISCELLA[NEOUS]-SECTIONS AND DETAILS
GRJ-DS-10-0223	BORINGS AND TEST PITS LOCATION PLAN
GRJ-DS-10-0226	DITCH PROFILE AND MISCELLANEOUS-SECTIONS AND DETAILS

LEGEND:

- 5280 — EXISTING SITE FEATURES AND CONTOURS
- PERMANENT DRAINAGE DITCH
- 5270 — FINISHED GRADE CONTOURS
- N10,000 — CONSTRUCTION GRID COORDINATES
- EXISTING PERMANENT SURVEY MONUMENT
- EXCAVATION

QA MK-F	NO.	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	5		REVISED GRADING (P.I.D. 05-S-35 & 05-S-39)						
[illegible]	4	4-22-9[illegible]	REVISED PER P.I.D. 05-S-28	FHW	HL	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3	1-16-91	REVISED PER P.I.D. 05-S-25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	2	9-16-90	REVISED PER P.I.D. 05-S-17, REV. 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1		SUPERSEDES DWG. NO. GRJ-DS-10-0220	FOR SIGNATURES SEE SUPERSEDED DWG REV. 0.					
	0	7-15-[illegible]	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED | DRAWN RBC | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE | DOE PROJECT ENGINEER | DATE

CHENEY RESERVOIR DISPOSAL SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

FINAL GRADING PLAN

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796

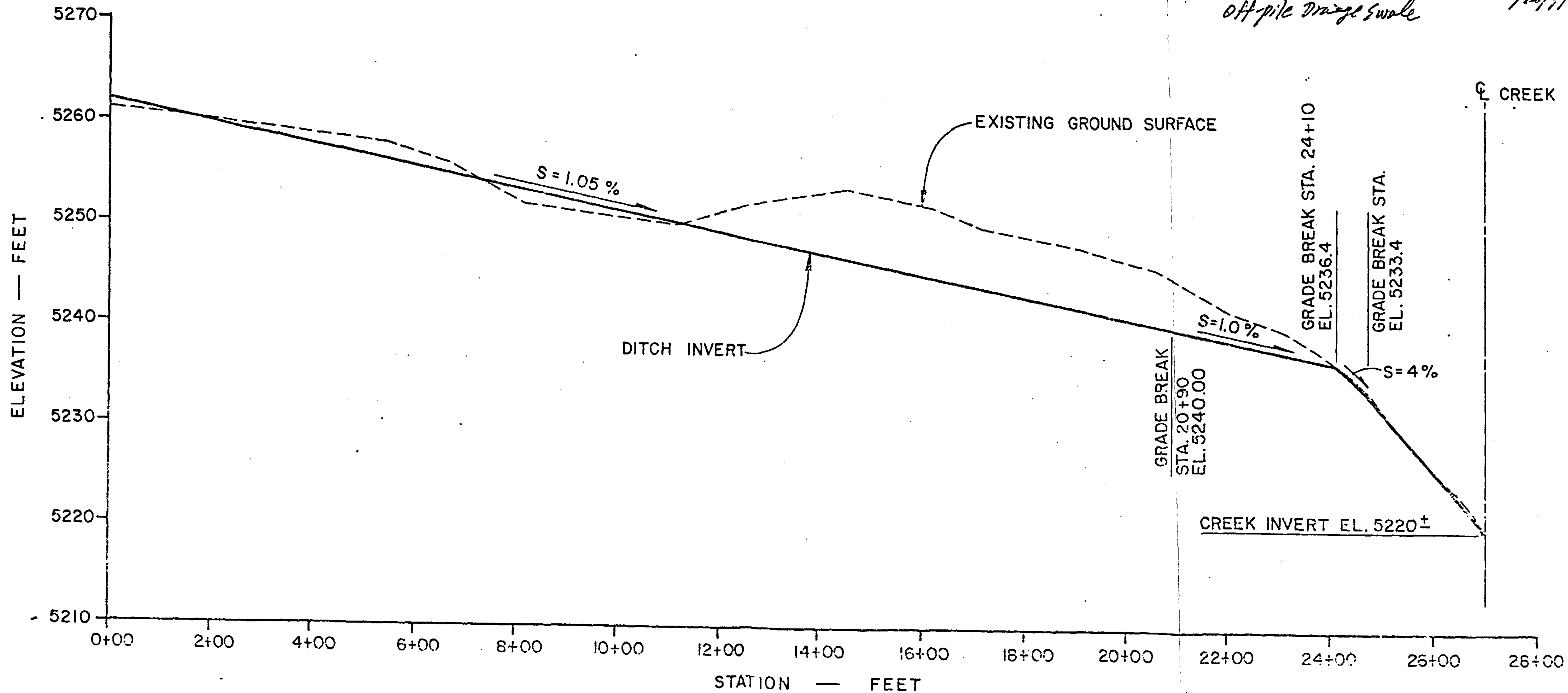
DRAWING NO. GRJ-DS-10-0220

REV.

134080

Sheet R-4

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale
FJW 11/20/91



PROFILE — DRAINAGE DITCH

(GRJ-DS-10-0220)

10 0 10 20
VERTICAL SCALE FEET

200 0 200 400
HORIZONTAL SCALE FEET

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA/GRJ	Contract No. 3885-38	Sheet 1	File No.
Feature: Permanent Site Drainage	Designed: [illegible]	Date: [illegible]	
Item: Off-pile Drainage Swale	Checked: [illegible]	Date: [illegible]	

References:

1. MKE Cal. No. 05-628-01-00, Site Drainage, Hydrologic parameters, UMTRA/Grand Junction, 8/18/86
2. U.S. Soil Conservation Service, National Engineering Handbook, Section 4, Chapter 15, August 1972
3. Nelson, et al., "Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailing Impoundments," NUREG/CR-4620, 1986.
4. U.S. Office of Surface Mining, "Surface Mining Water Diversion Design Manual," OSM/TR82, Sept. 1982
5. MKE UMTRA Design Procedures, Rev. 7. Jan. 1989, Chapter 5, Erosion Protection
6. Abt, S.R., et al., "Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase I," NUREG/CR-4651, Vol. 1, 1987
7. Chow, V.T., "Open Channel Hydraulics," McGraw-Hill Book Co., 1959
8. MKE Cal. No 05-659-01-02, "Disposal Site Erosion Protection," UMTRA-GRJ, March 1989
9. MKE Cal. No. 05-618-02-00, "Gravel Quality Evaluation," UMTRA/GRJ
10. Pemberton, E.L. & Lara, J.M., "Guide for Computing Degradation and Local Scour," U.S. Bureau of Reclamation, Oct. 1982
11. Israelsen, C.E., et. al., "Erosion Control During Highway Construction," National Cooperative Highway Research Program, Rept. No. 221, National Academy of Sciences, Wash. D.C., April 1980

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA/GRT	Contract No. 3885-34	Sheet 11	File No.
Feature Permanent Site Drainage	Designed [illegible]	Date [illegible]	
Item Off-pile Drainage Swale	Checked [illegible]	Date 11/15/90	

References (continued)

12. Umtra-Grand Junction site, "Subcontract Document, part 2 - Products, 2.1 On-site processed Materials," preliminary Final, August 1990.

13. U.S. Army Corps of Engineers, "HEC-2 Water Surface Profiles," computer program 723-X6-L202A, Sept. 82, updated Sept. 88, Hydrologic Engineering Center, Davis, CA.

14. MKE Cal. No. 05-504-01-02, "Umtra Grand Junction, Erosion protection, Top and side slopes of Tailings Embankment," 12/90

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA/GRT
Feature: Permanent Site Drainage
Item: Off-Site Drainage Swale

Contract No. 3835-24
Designed
Checked HM

Sheet 1
File No.
Date
Date

Table of Contents

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA/GRT	Contract No. 3885-74	Sheet 1a
Feature Permanent Site Drainage	Designed [illegible]	File No.
Item Off-Pile Drainage Swale	Checked UM	Date [illegible]

Table of Content (Continued).

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA/GJ(?) Contract No. 3F05-3(?) Sheet 1(?)
Feature Permanent Site Drainage Designed FMW(?) File No.
Item Off-pile Drainage Swale Checked HL(?) Date [illegible] Date [illegible]/91

Rev. △ FMW 6/17/91
HL 6/17/91

1. Introduction

A permanent drainage swale along the east side of the disposal cell embankment is required to divert surface runoff from the upland area. Since the swale is located at least 400 ft away from the contaminated materials area (see sheets 7 & 7a) and is aligned in such a direction that potential gully development along the swale would not affect the integrity of the radon barrier and would not cause the exposure of the contaminated materials. However, in order to maintain the embankment in a stable condition from the view point of public perception and sense of safety, riprap protection of the swale on the embankment side will be designed under the PMP conditions. The other portions of the swale (including invert and side slope on the upland side) will be designed with riprap protection against the PMP storm without consideration of gully development. However, the riprap protection on these other portions of the swale will be able to maintain the stable condition under a lesser flood event, such as the 200-yr storm (see Appendix C). Rev. △

2. Summary of Results and Discussions

a. The general alignment of the off-pile drainage swale and grading plan around the swale is shown on sheets 7 + 7a and the center-line profile of the swale is shown on sheet 8. The swale is generally formed by compacted fill on the embankment side and cut on the upland side. Once the swale is away from the embankment, the swale cross-section is generally formed by cut. Total length of the swale is about 2440 ft with a trapezoidal cross-section. The side slope of the swale on the embankment side is 5:1 and is varied on the upland side ranging from 5:1 or flatter (25:1 on the upstream portion). The bottom width of the swale is 20 ft at the most upstream location (invert El. 5340), and gradually widen to 120 ft at 2080 ft downstream, and daylight with El. 5236.4 at 360 ft farther downstream expanding to a width of 200 ft. Total drainage area at the outlet is about 135 acres.

b. The PMF peak discharge rates, flow depth and velocity at different locations along the swale are presented on Sheet 9 (Assume uniform flow condition). The max. discharge (PMF) at the outlet is 1680 cfs. The flow depths range from 0.7 to 2.2 ft and the velocities ranges from 4.5 to 8.2 fps. (note: Backwater study in Appendix A showed the range of velocity is 6.5 to 7.7 fps in the reach downstream from sec. 4 (see sheets A-3 + A-8 in Appendix A).

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA/GRJ — Contract No. 3885-34 — Sheet [illegible]
Feature Permanent Site Drainage — Designed [illegible] — File No.
Item Off-pile Drainage Swale — Checked [illegible] — Date [illegible]

c. The required D_{50}(min) of the riprap with 15% oversizing factor for the 5H:1V side slope along the swale on the embankment side is 11 inches (24" thick) and will be designated as Type E Riprap. The riprap will be placed above the invert of the swale as well as buried under the invert to a max. depth of 5 ft on the 5:1 slope (see sheet 10 for details). Type E riprap would protect the erosion from assumed potential gully development on the upland area and on the swale itself. Potential scour of the assumed gully development was estimated to be about 5 ft.

d. Type B riprap (D_{50}(min) = 4.8") will be provided to protect the invert and side slope of the swale on the upland portion with a layer thickness of 10 inches. No bedding will be provided since erosion (specifically under riprap) is not a major concern on these parts of the swale, nor these parts were designed with the protection from gully development. Erosion on these parts will not affect the stability of the embankment which would be protected by Type E rock (D_{50} = 11").

e. The design riprap for the 2% embankment slope will be Type A ($D_{50} = 1.7''$), 6" thick. Bedding layer 6" thick will be provided.

f. The required D_{50}(min) for the outlet toe protection would also be Type E (D_{50}(min) = 11") with a depth of 5' (for scour protection). Downstream from the outlet, a Type C riprap (D_{50}(min) = 6.2") will be placed along the swale flow path for about 60 ft (to El. 5234) to provide erosion protection immediately downstream of the outlet toe. Since the slope downstream of the outlet is steeper (4-5%), it is suggested that some large size of rock ($\geq 6''$ D_{50}) should be placed between type C rock protection area and the bank of creek "C" (approximately 220 ft long). The bank of Creek "C" in the swale outlet area (about 250' long) should be protected by oversized rock ($D_{50} \doteq 24''$) available to prevent initiation of headcutting from this area.

g. The estimated riprap quantity for the side slope protection of the swale along the embankment side is as follows: (see sheet 52)

D_{50} (min) = 11' (24" thick) = 8310 CY

Type A (D_{50} (min) = 1.7", 6" thick) = 2360 CY

Bedding material, (6" thick) = 2470 CY

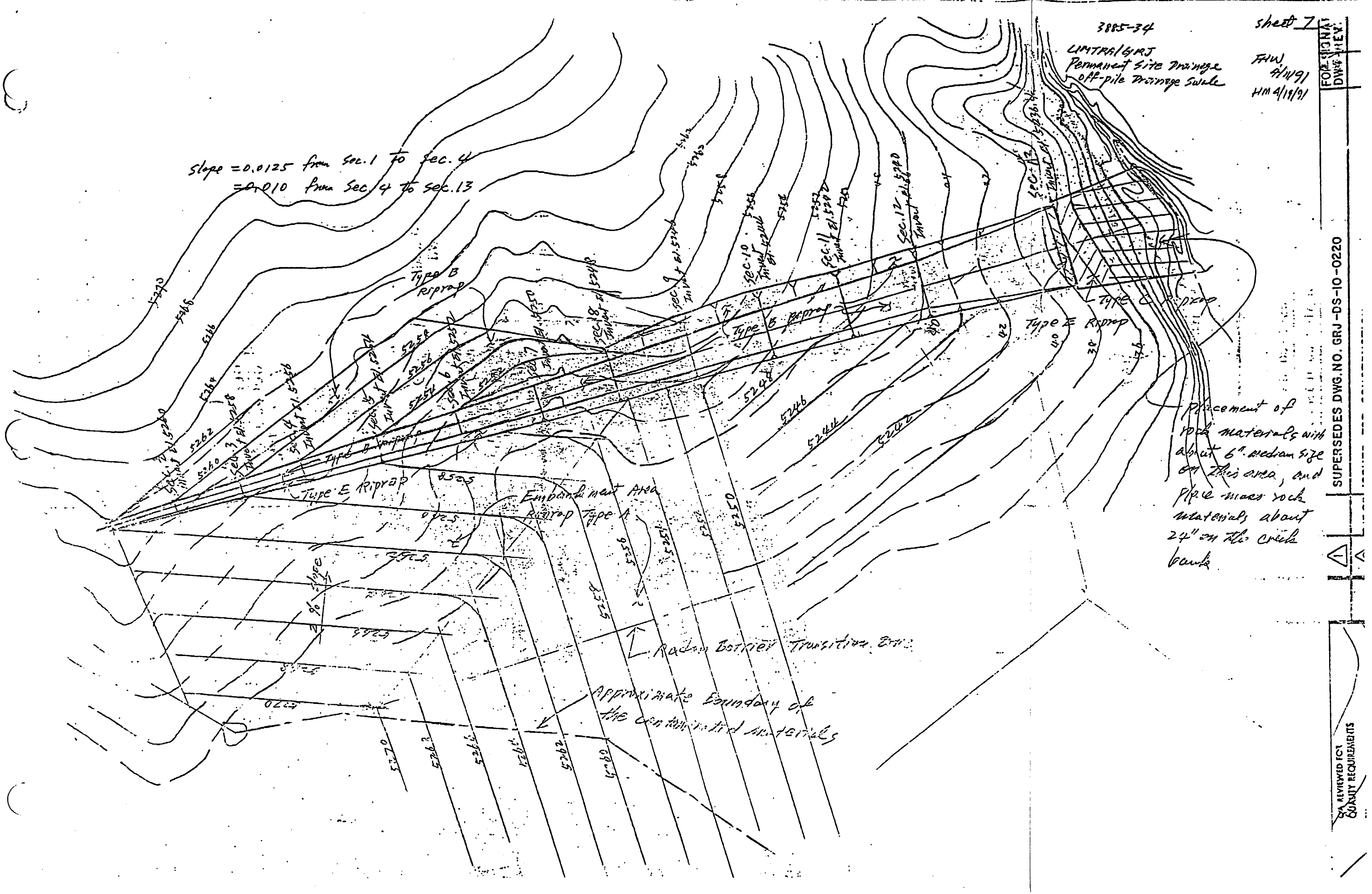
h. The estimated riprap quantity for the outlet toe protection is as follows. (see sheet 62)

D_{50} (min) = 11' = 550 CY

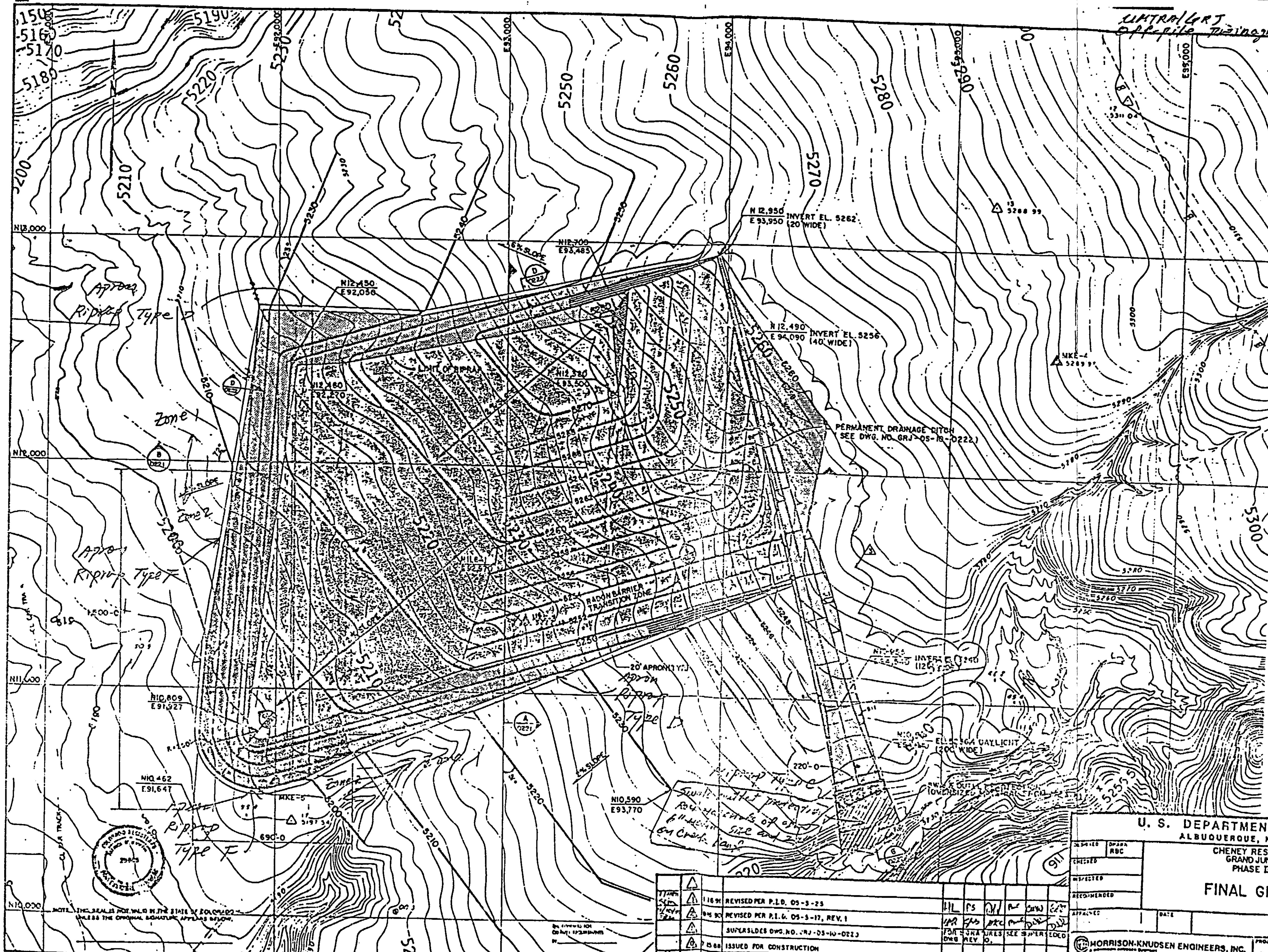
Type A Riprap ($D_{50}^{(min)}$ = 1.7") = 90 CY (12" thick)

Type C Riprap ($D_{50}^{(min)}$ = 6.2") = 490 CY (6" thick)
(D/S area - 60' long)

Bedding Material = 95 CY (6" thick)


3885-34
sheet 7
UMTRA/GRJ
Permanent Site Drainage
off-pile Drainage Swale
FHW 4/11/91
HM 4/19/91
slope = 0.0125 from sec. 1 to sec. 4
= 0.010 from sec. 4 to sec. 13
Type B Riprap
Type E Riprap
Type C Riprap
Embankment Area
Riprap Type A
Radon Barrier Transition Area
Approximate Boundary of the contaminated materials
Placement of rock materials with about 6" median size on this area, and place max rock materials about 24" on the creek bank
5250
5248
5246
5244
5242
SUPERSEDES DWG. NO. GRJ-DS-10-0220
FOR SIGNAT. DWG. REV.
QA REVIEWED FOR QUALITY REQUIREMENTS

UMTRA / GRJ Off-site Drainage Swale Sheet 79



NOTES:

1. WHERE CORNER CONTOURS ON THE TAILINGS EMBANKMENT ARE TOO SH[ARP] TO BE CONSTRUCTED, CONTOURS WI[LL] BE ROUNDED WITH A 50 FOOT RADIU[S] (APPROXIMATELY) IN THE PLAN VIEW.
2. THE CONTOURS OF THE TOP SLOPE [ARE] APPROXIMATE AND ARE DEPENDENT [ON] ACTUAL VOLUME OF CONTAMINATED MATERIALS RELOCATED.
3. TYPE D RIPRAP MAY BE SUBSTITUTED [FOR] TYPE E AND TYPE C RIPRAP MAY BE SUBSTITUTED FOR TYPE B IF A S... FALL OCCURS IN THESE MATERIALS.

FHW 4/11/91
HM 4/18/91

REFERENCE DRAWINGS:

GRJ-DS-10-0124	SITE PLAN.
GRJ-DS-10-0125	CONSTRUCTION FACILITIES AND SITE DRAINAGE
GRJ-DS-10-0134	TAILINGS EMBANKMENT AREA & EXCAVATION PL[AN]
GRJ-DS-10-0221	TAILINGS EMBANKMENT SECTIONS AND DETAIL[S]
GRJ-DS-10-0222	DITCHES AND MISCELLANEOUS SECTIONS AND DETAILS
GRJ-DS-10-0223	BORINGS AND TEST PITS LOCATION PLAN

LEGEND:

- 5280 — EXISTING SITE FEATURES AND CONTOURS
- PERMANENT DRAINAGE DITCH
- 5270 — FINISHED GRADE CONTOURS
- N10,000 — CONSTRUCTION GRID COORDINATES
- EXISTING PERMANENT SURVEY MONUMENT
- RIPRAP TYPE B
- RIPRAP TYPE C
- RIPRAP TYPE A
- EXCAVATION

SCALE 200 0 200 400 FEET

	NO.	DATE	REVISION						
	3	1 16 91	REVISED PER P.I.D. 05-3-25	HL	PS				
	2	8 15 90	REVISED PER P.I.D. 05-3-17, REV. 1						
	1		SUPERSEDES DWG. NO. GRJ-05-10-0223	FOR DWG	SIGNATURES REV. 0		SEE SUPERSEDED		
	0	7 15 88	ISSUED FOR CONSTRUCTION	-	-	-	-	-	-

NOTE: THIS SEAL IS NOT VALID IN THE STATE OF COLORADO UNLESS THE ORIGINAL SIGNATURE APPEARS BELOW.

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

CHENEY RESERVOIR DISPOSAL SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

FINAL GRADING PLAN

DESIGNED | DRAWN RBC | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE | DOE PROJECT ENGINEER | DATE

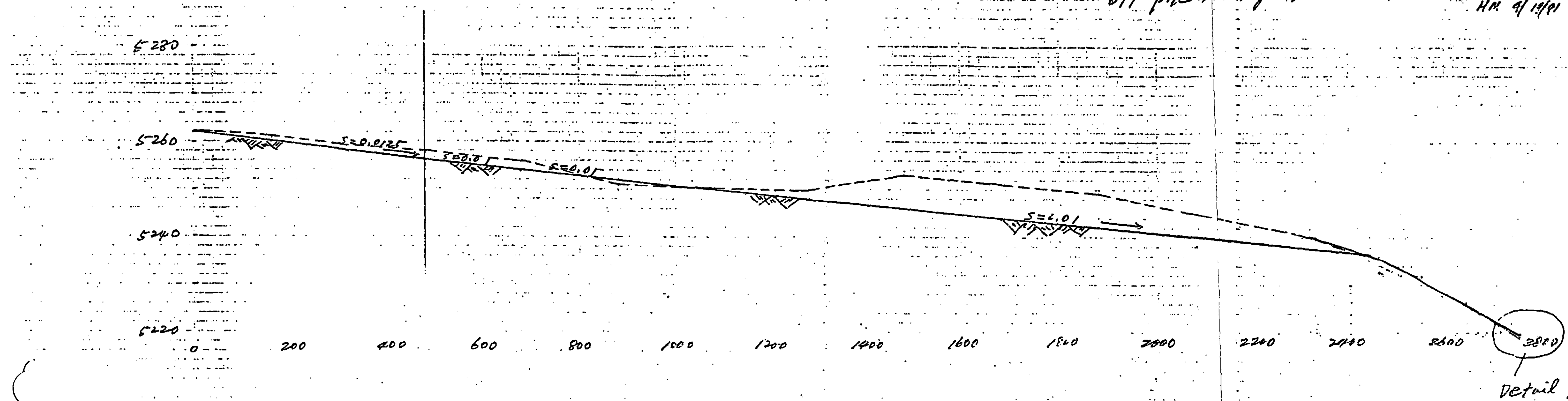
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

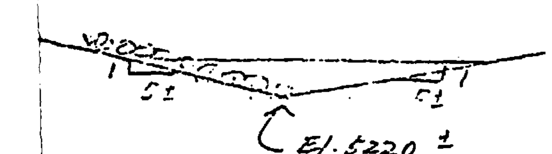
PROJECT NO. DE-AC04-83AL18796

Sheet 8

UMTRA/GRJ
permanent Site Drainage
off-pile Drainage Swale

FHW 4/9/91
HM 4/19/91





Detail 1
Approx. channel bank slope
Check "C"

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

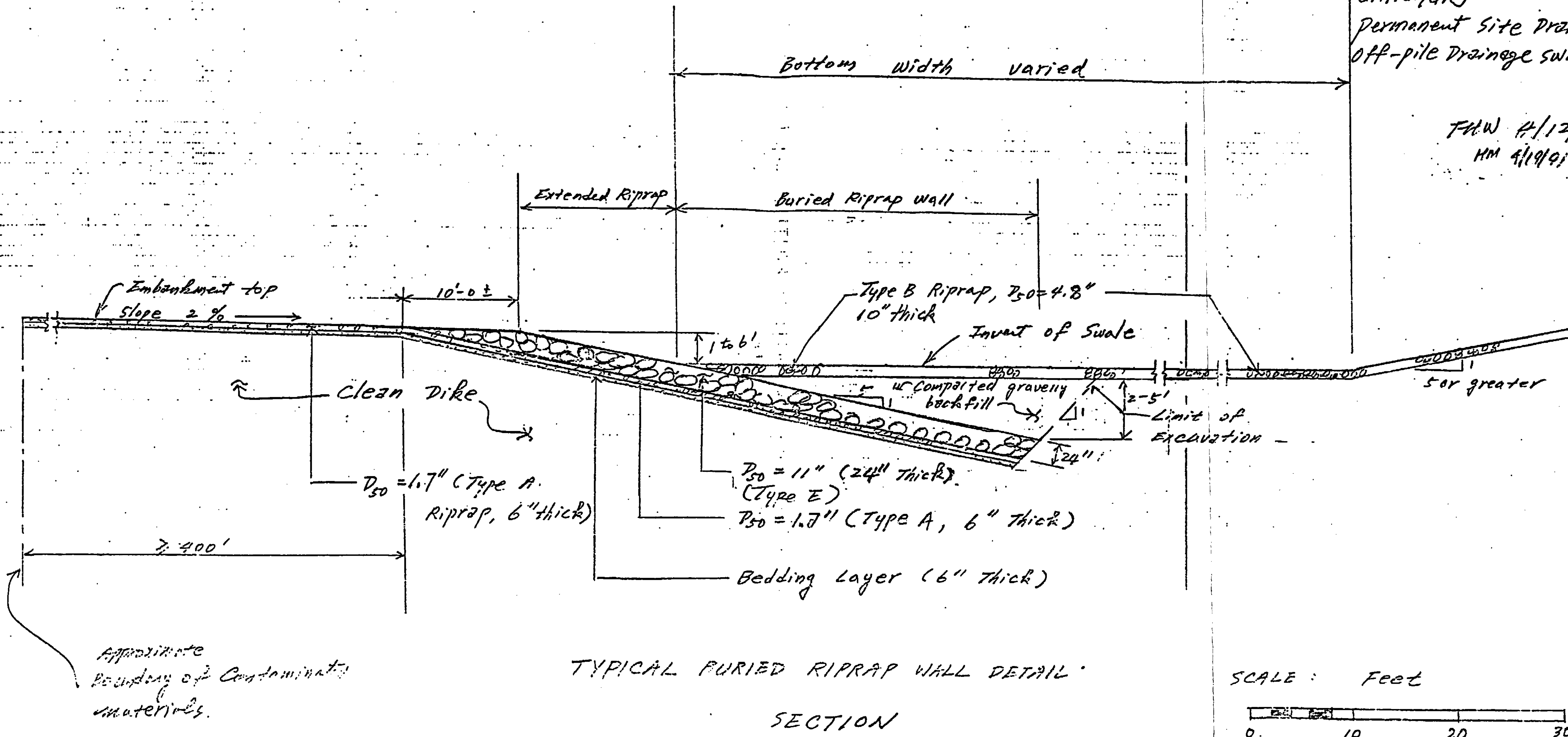
Project: UMTRA / GRJ
Feature: Permanent Site Drainage
Item: Off-Pile Drainage Swale
Contract No. 3A85-?? | Sheet 4
File No. ___
Designed: [illegible] | Date: [illegible]
Checked: [illegible] | Date: 4/10/01

Summary of Flow characteristics ~ off pile swale under PMP condition
(side slope = 5H:1V on the Embankment side)

Sec. (sec)	Drainage Area (Acres)	Discharge (cfs)	Bottom width (ft)	Side slope upland side	Accum. Distance (ft)	Invert Elev (ft)	Long. slope	Flow Depth (ft)	Top width (ft)	Velocity (fps)	Height of Swale (ft)	Min. D_{50} required (in)	Min. D_{50} used – Embankment side (in)	Min. D_{50} used – upland side (in)
1	-	-	20		0	5262	0.0125	-	-	-	-	-	↑	↑
2	7.3	94	26.7	25:1	160	5260	0.0125	0.70	47.7	4.4	1.0	1.7		
3	7.9	200	33.3	25:1	320	5258	0.0125	0.90	60.3	5.2	2.0	2.1	Use D_{50} (min) = 11" (22" thick) based on design condition	Use Type B (D_{50} (min) = 4.8") (9" thick) based on Min D_{50} computed here and overland flow from upland area
4	14.4	360	40	25:1	480	5256	0.0125	1.10	73.0	6.0	3.3	2.5		
5	100.5	1410	50	25:1	680	5254	0.010	2.20	116.0	7.7	4.0	4.0		
6	101.5	1410	60	25:1	880	5252	0.010	2.10	123.0	7.4	5.0	3.8		
7	115.6	1550	70	25:1	1080	5250	0.010	2.10	133.0	7.5	5.5	3.9		
8	121.5	1630	80	5:1	1280	5248	0.010	2.20	101.0	8.6	6.0	4.1		
9	123.0	1630	90	5:1	1480	5246	0.010	2.00	110.0	8.2	4.0	3.7		
10	124.5	1630	100	5:1	1680	5244	0.010	1.90	117.0	8.0	4.5	3.5		
11	126.0	1640	110	5:1	1880	5242	0.010	1.80	128.0	7.7	4.5	3.3		
12	130.1	1670	120	5:1	[illegible]	5240	0.010	1.70	137.0	7.8	5.0	3.1	↓	↓
13	155.7	1680	200 ([illegible])	[illegible]	2440	5236.0	0.010	1.26	200	6.7	-	2.5		

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage swale

FHW 4/12/91
HM 4/19/91



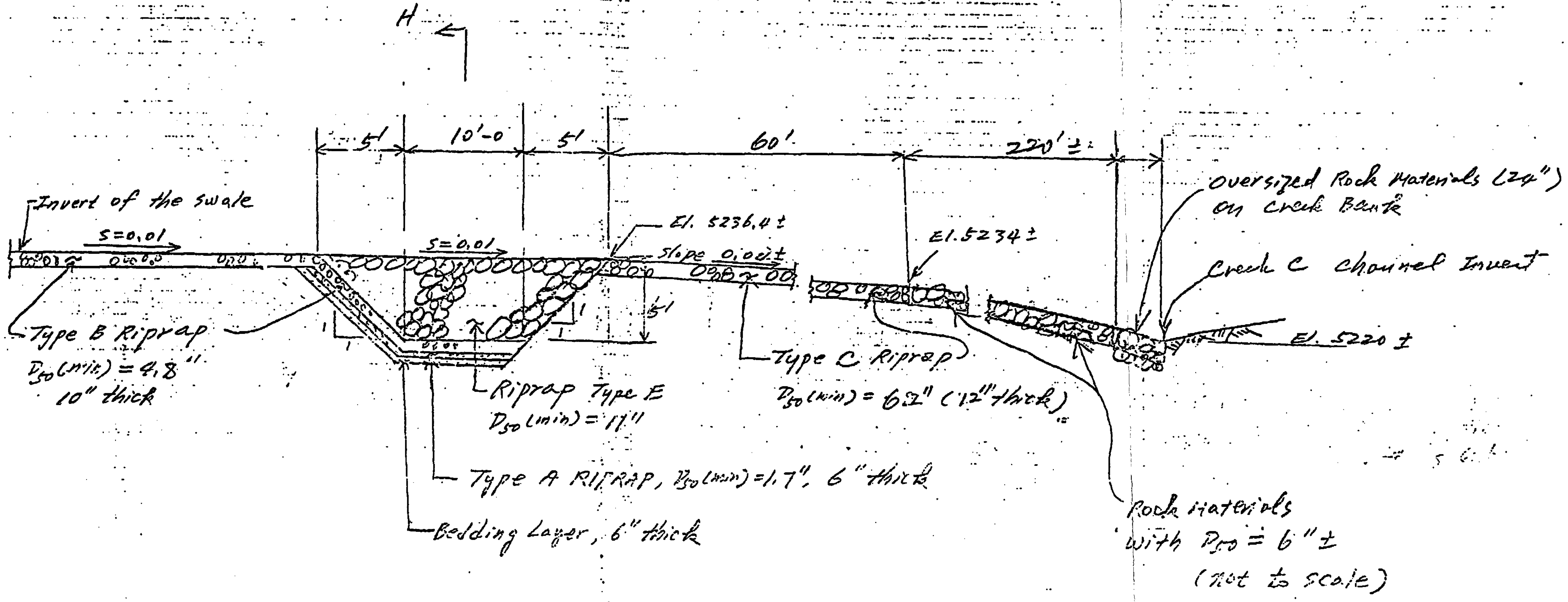
TYPICAL BURIED RIPRAP WALL DETAIL

SECTION

Sheet 11

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale

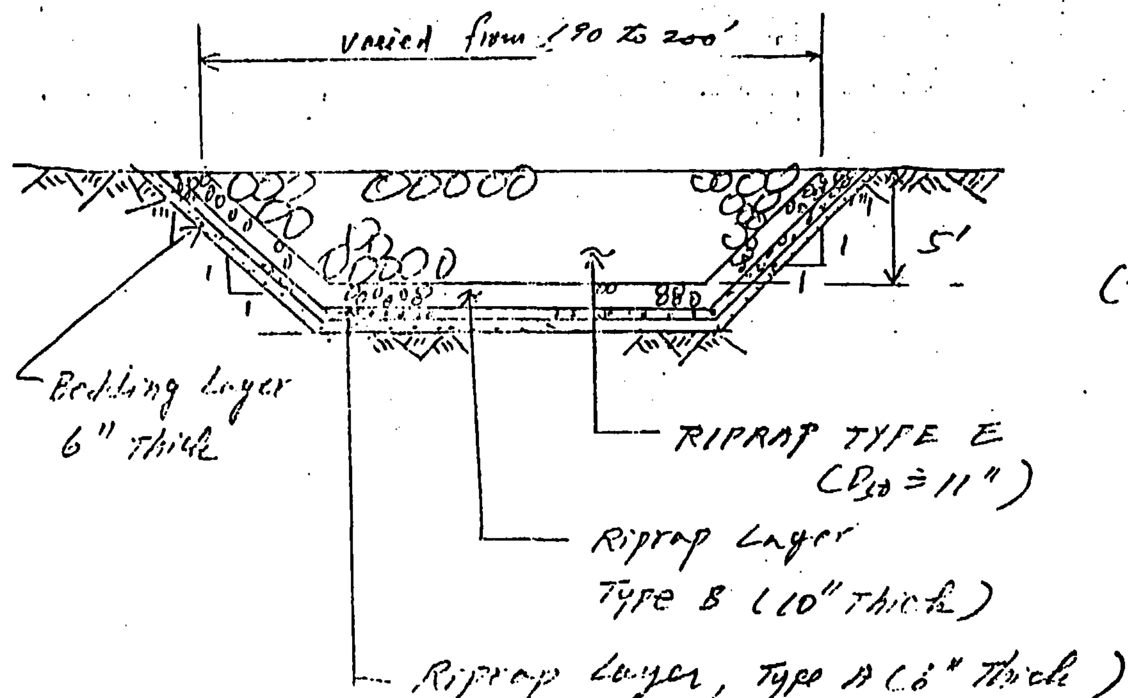
FHW 4/11/91
HM 4/19/91



Typical Swale Outlet Toe Protection Section

UMTRA/GJT
Permanent Site Drainage
Off-pile Drainage Swale

Sec. H. (Typical)



(not to scale)

Sheet 119
Fnvs 9/11/91
HA 9/19/91

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Project: UMTRA/GRJ	Contract No. 3885-34	Sheet 16
Feature: Permanent Site Drainage	Designed FWL	Date 11/13/90	
Item: Off-pile Drainage Swale	Checked WYL	Date 11/15/90	

Rev △ FWL 6/17/91
HL 6/17/91

3. Purpose

a. To estimate riprap requirements on the embankment side of the swale (5:1 side slope) in order to protect the embankment from erosion, including scour under PMP condition

b. To estimate riprap requirements for protection of potential scour immediately downstream of the swale outlet under PMP condition.

c. To evaluate riprap requirements on the top of the 2% slope embankment connected to the swale under PMP condition

d. To estimate riprap requirement on the bottom and upland side of the swale under PMP and 200-yr storm condition (see introduction below).

Rev △

The main objective of riprap design on the embankment side of the swale with a 5:1 slope is to provide a long-term stability of the embankment. To provide a sound riprap protection along the embankment side of the swale, erosion potential and riprap requirements will be evaluated from three different flow conditions under PMP storm. They are: PMP flow in the swale itself; overland flow from the 2% embankment slope; and potential gully-developed flow from the upland area. Erosion protection under PMP condition at the swale outlet will also be provided to prevent gully development migrating upward along the swale.

The rest portions of the swale (including the invert portion and side slop on the upland side) will be protected with riprap designed under PMP storm without ~~[illegible]~~ consideration of gully erosion. Under gully erosion, these two portion might not be stable, however, the embankment side will still be well protected and would not affect the integrity of the embankment.

4. Methods and Procedures

a. Drainage Area Estimates — measure drainage areas at different locations.

b. Peak Discharge Computation under PMP — The peak discharge due to PMP storm were computed using the Rational Formula, $Q = CIA$, since the drainage area at the swale outlet is only 13.5 Acres.

1) The rainfall intensity, I, was determined based on Tc (time of concentration) values and rainfall intensity-duration curves for the PMP and 200-yr storm (Ref. 1), (see sheet 28)

2). Tc values were estimated and selected from both SCS velocity method (Ref. 2) and Kirpich Equation (Ref. 2).

3) A runoff coefficient of C=1 was used for the PMP condition (conservative)

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: UMTRA/GRJ
Feature: Permanent Site Drainage
Item: Off-site Drainage Swale
Contract No. 3805-34
Designed: [illegible]
Checked: WYL
Sheet 14
File No.
Date [illegible]
Date 11/5/90

C. Riprap Required for the 5:1 Side slope of the swale along Embankment side under PMP.

Riprap requirement for the 5:1 side slope was evaluated based on three different flow conditions under PMP storm, and the one that presents the most critical design would be selected:

1) Riprap Requirements due to PMP flow on the swale itself.

a) Compute the hydraulic conditions on the swale under PMP peak discharge.

b) Use the Safety Factor Method (Ref. 5) to determine the minimum D_{50} riprap required on the 5:1 side slope

2) Riprap Requirement Due to PMP overland flow from the Embankment

a) The most critical overflow length on the embankment was used to estimate the peak discharge per unit width.

b) Min. D_{50} Riprap requirement on the 5:1 side slope of the swale immediately below the embankment was estimated using the Stephenson method (applicable for slope > 10%) (Ref 5). A flow concentration factor of "3" was selected for the discharge per unit width.

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: UMTRA / GJ
Feature: Permanent Site Drainage
Item: Off-pile Drainage Swale

Sheet: 15
Contract No.: 3885-3K
File No.:
Designed:
Date:
Checked: WYL
Date: 11/15/90

3) Riprap Required Due to Potential Gully-Developed Flow from Upland Area

a) Estimate potential scour due to assumed gully-developed flow on the upland side of the swale.

- Assume a most critical case with a developed gully covers a certain drainage area. (see sheet 40A).
- Estimate potential scour/erosion due to peak PMP discharge on the developed gully (assuming a triangular shape with a typical side slope of 7:1 (existing gullies have side slope around 7~10:1)).
- Assume the estimated scour depth will also occur on the embankment side of the swale, and the riprap protection should be as deep as this scour depth.

b). Assumed the gully will also be developed (with a triangular shape, with 5:1 & 7:1 side slopes) along the embankment side of the swale.
The riprap (min. D_{50}) required on the 5:1 side slope below the invert of the swale was then estimated using the Safety Factor Method.

4) Compare the riprap requirements from 1) through 3) above and select the most critical one. The riprap protection will then be provided from the top of the swale to the potential scour depth below the invert of the swale.

5) The quantity of riprap required was also estimated.

d. Riprap protection for other portions of the swale (i.e. on the invert and on the side slope of the upland portion).

The PMP storm will be used for the riprap design.

The side slope on the upland side will be evaluated with two different flow conditions:

- Safety Factor method with flow along the swale itself
- Stephenson Method (for slope >10%) with overland flow and a flow concentration factor of 3.
- The larger riprap size computed from above 2 method and flow condition will then be selected.

1) Riprap Requirements on the side slope (5H:1V) along the upland side (from Sec. 8 to 12) due to overland flow:

Riprap required with flow along the swale itself was analyzed on Item C.1) previously. Riprap required for overland flow using Stephenson method will be used here. Then the larger riprap required will be selected.

2) Riprap required for Invert and other portions of the side slope about $25^H:1^V$ from the upland side.

(will use the results from Item C.1).)

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA/GRJ
Feature Permanent Site Drainage
Item Off pile Drainage Swale

Contract No. 3885-34 File No.
Designed Date
Checked Date

Sheet 11

e. Riprap required on the 2% Embankment slope. Due to overland flow under PMP condition

1) Determine the most critical flow length and flow per unit width, and use a flow concentration factor of 3.

2) use Safety Factor method (for plan slope) to size the riprap.

f. Erosion and Scour Protection at Swale Outlet

1) The effective flow width of the swale at daylight with El. 5240 is about 360 ft with a divergent angle of 9 (longitu to 1 (horizontal) ratio.

2) Determine potential scour immediately downstream of the outlet (see sheet 60). This will be the depth of the outlet toe protection

3) Determine the required size of the riprap protection due to scour/erosion.

g. Evaluation of Flow Condition on East Tributary (Creek C) and Erosion Protection at Swale Exit Location Under PMP

The PMF peak discharge on Creek C will be estimated approximately based on a previous Calculation (Ref. 8) and extrapolated to the outlet location. Potential Scour under PMF on Creek C will then be estimated and proper bank protection will be provided.

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA / GRJ	Contract No. 3805-34	Sheet 18	File No.
Feature Permanent Site Drainage	Designed [illegible]	Date [illegible]	
Item Off-pile Drainage Swale	Checked HM	Date 4/10/91	

5. Calculations

a. Drainage Area Estimates (Approx.) for Watershed area (see sheet 25)

① = ½ · 1420 · 190 = 134,900 ft²

② = ½ · 1700 · 380 = 323,000 ft²

③ = ½ · 1700 · 150 = 127,500 ft²

④ = ½ · 2660 · 370 = 492,100 ft²

⑤ = ½ · 470 · 470 = 110,450 ft²

⑥ = ½ · 470 · 490 = 115,150 ft²

⑦ = ½ · 860 · 350 = 150,150 ft²

⑧ = ½ · 3180 · 180 = 286,200 ft²

⑨ = ½ · 3180 · 370 = 588,300 ft²

⑩ = ½ · 800 · 250 = 100,000 ft²

⑪ = ½ · 1020 · 170 = 86,700 ft²

⑫ = ½ · 2730 · 350 = 477,750 ft²

⑬ = ½ · 430 · 80 = 17,200 ft² Σ ① - ⑬ = 3,009,[illegible]

⑭ = ½ · 2010 · 60 = 60,300 ft²

⑮ = ½ · 1800 · 270 = 243,000 ft²

⑯ = ½ · 1280 · 70 = 44,800 ft² Σ ① - ⑯ = 3,[illegible]

⑰ = ½ · (1410 + 1100) · 60 = 75,300 ft²

⑱ = ½ · 960 · 180 = 86,400 ft²

⑲ = ½ · 2010 · 100 = 100,500 ft²

⑳ = ½ · 990 · 220 = 108,900 ft²

" Note: Drainage areas delineated were based on a previous superseded calc. (Calc. No. 05-504-03-03, dated 1/15/91). These values will be used to estimated approx. drainage area at the revised section locations

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Project: UMTRA / GRJ	Contract No. 3885-34	Sheet 11	File No.
Feature: Permanent Site Drainage	Designed	Date 10/15/90	
Item: Off-pile Drainage Swale	Checked WYL	Date 11/15/90	

Area

(21) $= \frac{1}{2} \cdot 990 \cdot 290 = 143{,}550\ ft^2$

(22) $= \frac{1}{2} \cdot 570 \cdot 220 = 62{,}700\ ft^2$

(23) $= \frac{1}{2} \cdot 1000 \cdot 245 = 122{,}500\ ft^2$

(24) $= \frac{1}{2} \cdot 1000 \cdot 140 = 70{,}000\ ft^2$

(25) $= \frac{1}{2} \cdot 460 \cdot 230 = 52{,}900\ ft^2$

(26) $= \frac{1}{2} \cdot 1010 \cdot 270 = 136{,}350\ ft^2$

(27) $= \frac{1}{2} \cdot 800 \cdot 250 = 100{,}000\ ft^2$

(28) $= \frac{1}{2} \cdot 1300 \cdot 50 = 32{,}500\ ft^2$

(29) $= \frac{1}{2} \cdot 500 \cdot 90 = 22{,}500\ ft^2$

(30) $= \frac{1}{2} \cdot 700 \cdot 140 = 49{,}000\ ft^2$

(31) $= \frac{1}{2} \cdot 800 \cdot 170 = 68{,}000\ ft^2$

(32) $= \frac{1}{2} \cdot 630 \cdot 150 = 47{,}250\ ft^2$

~~(33) = ½ 630 330 = 103,950 ft²~~

(34) $= \frac{1}{2} \cdot 520 \cdot 190 = 49{,}400\ ft^2$

(35) $= \frac{1}{2} \cdot 540 \cdot 180 = 48{,}600\ ft^2$

(36) $= \frac{1}{2} \cdot 650 \cdot 150 = 48{,}750\ ft^2$

(37) $= \frac{1}{2} \cdot 800 \cdot 130 = 52{,}000\ ft^2$

(38) $= \frac{1}{2} \cdot 1270 \cdot 180 = 114{,}300\ ft^2$

(39) $= \frac{1}{2} \cdot 1450 \cdot 180 = 130{,}500\ ft^2$

(40) $= \frac{1}{2} \cdot 1450 \cdot 90 = 65{,}250\ ft^2$

(41) $= \frac{1}{2} \cdot 950 \cdot 60 = 28{,}500\ ft^2$

(42) $= \frac{1}{2} \cdot 900 \cdot 160 = 72{,}000\ ft^2$

(43) $= \frac{1}{2} \cdot 950 \cdot 150 = 71{,}250\ ft^2$

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: UMTRA / GRJ
Feature: Permanent Site Drainage
Item: Off-pile Drainage Swale
Contract No.: 3CP5-34
Designed: [illegible]
Checked: WYL
Sheet: 60
File No.:
Date: [illegible]
Date: 11/15/90

Area.

$E\text{-}1 = \frac{1}{2} \cdot 360 \cdot 150 = 27{,}000\ ft^2$

$E\text{-}2 = \frac{1}{2} \cdot (360+600) \cdot 150 = 72{,}000\ ft^2$

$E\text{-}3 = \frac{1}{2}(600+630) \cdot 150 = 92{,}250\ ft^2$

$E\text{-}4 = \frac{1}{2}(630+660) \cdot 210 = 135{,}450\ ft^2$

$E\text{-}5 = \frac{1}{2}(660+630) \cdot 35 = 22{,}575\ ft^2$

$E\text{-}6 = \frac{1}{2} \cdot (630+380) \cdot 230 = 116{,}150\ ft^2$

$E\text{-}7 = \frac{1}{2}(380+150) \cdot 230 = 60{,}950\ ft^2$

$E\text{-}8 = \frac{1}{2} \cdot (150+60) \cdot 90 = 9{,}450\ ft^2$

$E\text{-}9 = \frac{1}{2} \cdot (60+70) \cdot 110 = 7{,}150\ ft^2$

$E\text{-}10 = \frac{1}{2} \cdot (70+80) \cdot 200 = 15{,}000\ ft^2$

$E\text{-}11 = \frac{1}{2}(80+90) \cdot 200 = 17{,}000\ ft^2$

$E\text{-}12 = \frac{1}{2}(90+100) \cdot 200 = 19{,}000\ ft^2$

$E\text{-}13 = \frac{1}{2}(100+110) \cdot 270 = 28{,}350\ ft^2$

$622{,}325\ ft^2 = 14.3$ acres

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: UMTRA / GRJ — Contract No. 3805-34 — Sheet 21
Feature: Permanent Site Drainage — Designed: [illegible] — File No.
Item: Off-pile Drainage Swale — Checked: WYL — Date 10/[illegible] — Date 11/15/90

Drainage Area at Diffent Locations. (see sheet 23)

At location (1) D.A. = 0.

location (2) D.A. = Area (42 + E-1)
= 72000 + 27,000 = 99,000 ft² = 2.27 Ac.

location (3) D.A. = 99,000 + Area (E-2 + 43 + 41 + 17)
= 99,000 + (72000 + 71250 + 28500 + 75300)
= 346,050 ft² = 7.94 Ac.

location (4) D.A. = 346,050 + Area (E-3 + 18 + 19)
= 346,050 + 92,250 + 86,400 + 100,500
= 625,200 ft² = 14.4 Ac.

location (5) D.A. = 625,200 + Area (E-4 + E-5 + 1~16 + 20 + 21)
= 625,200 + 135,450 + 22,575 + 3,357,500 + 108,900 + 143,550 = 4,393,175 ft² = 100.9 Ac.

location (6) D.A. = 4,393,175 + Area (E-6 + 27 + 28 + 29)
= 4,393,175 + 116,150 + 62,700 + 32,500 + 22500
= 4,627,025 ft² = 106.2 Ac

location (7) D.A. = 4,627,025 + Area (E-7 + 23~27 + 30~32)
= 4,627,025 + 60,950 + 122,500 + 70,000 + 53,900 + 136,350 + 100,000 + 49,000 + 68,000 + 47,250
= 5,286,725 ft² = 121.4 Ac.

location (8) D.A. = 5,286,725 + Area (E-8 + E-9 + 34)
= 5,286,725 + 9,450 + 7,150 + 49,400
= 5,352,725 ft² = 122.9 Ac

Location (9) D.A. = 5,352,725 + Area (E-10 + 35)
= 5,352,725 + 15,000 + 48600 = 5,416,325 ft^2
= 124.3 Ac.

Location (10) D.A. = 5,416,325 + Area (E-11 + 36)
= 5,416,325 + 17,000 + 48,750 = 5,482,075 ft^2
= 125.9 Ac

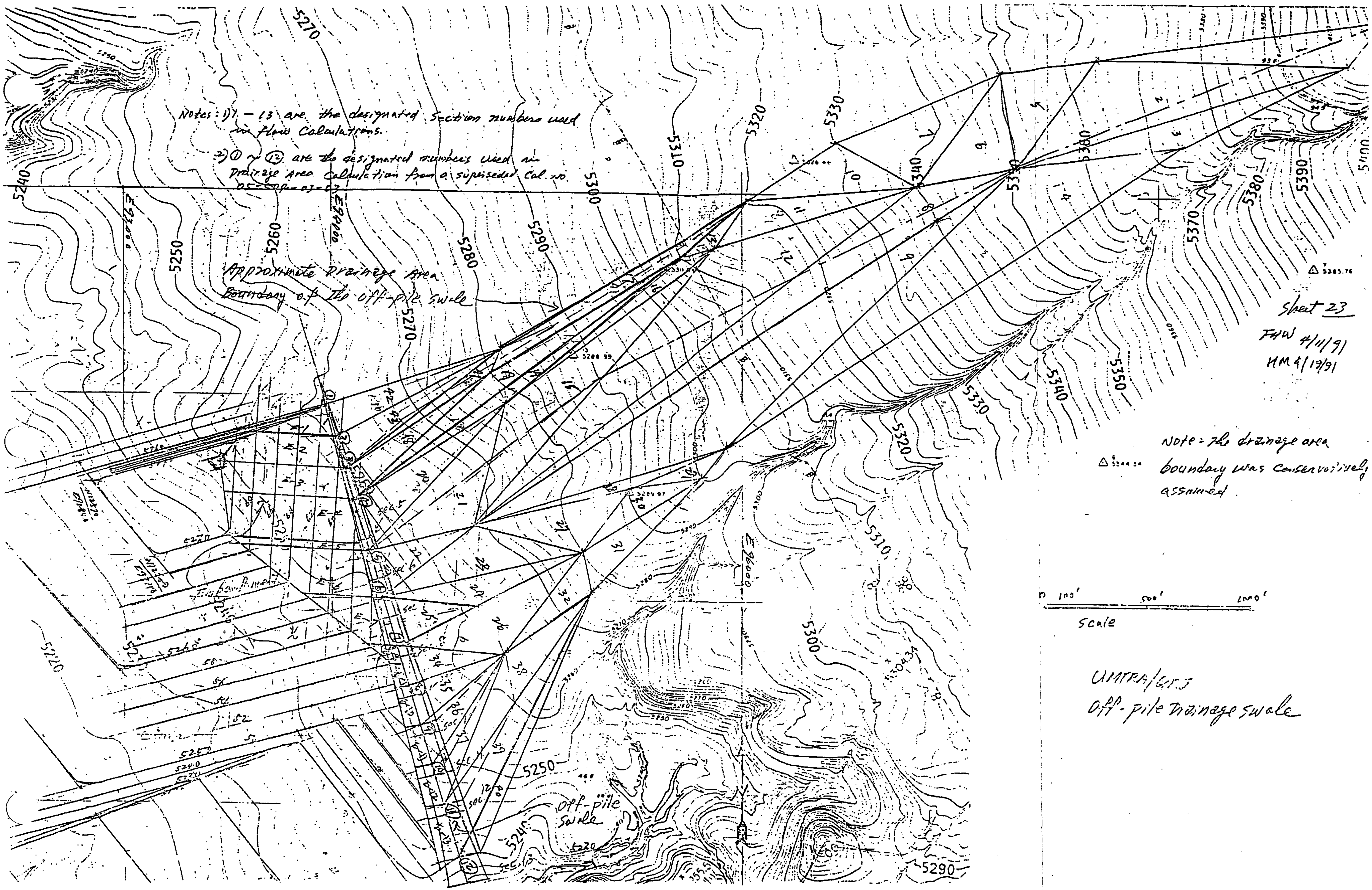
Location (11) D.A. = 5482075 + Area (E-12 + 37 + 38)
= 5,482,075 + 19,000 + 52,000 + 114,300
= 5,667,375 ft^2 = 130.1 Ac

Location (12) D.A. = 5,667,375 + Area (E-13 + 39 + 40)
= 5,667,375 + 28,[illegible] + 139,500 + [illegible]
= 5,891,475 ft^2 = 135.2 Ac

The drainage area at sec's 1 through 13 (see sheet 27) are slightly different from Locations (1)–(12). Their drainage areas are shown on sheet 9, (also sheet 28) and summarized below:

sec.	D.A (Acres)
1	0
2	2.3
3	7.9
4	14.4
5	100.5
6	101.5
7	107.0
8	121.5

sec.	D.A (Acres)
9	123.0
10	124.5
11	126.0
12	130.1
13	135.2


Notes: 1) 1 – 13 are the designated Section numbers used in Flow Calculations.
2) ① ~ ⑫ are the designated numbers used in Drainage Area Calculation from a superseded Cal. no.
Approximate Drainage Area Boundary of the off-pile swale
Sheet 23
FHW 4/11/91
HM 4/19/91
Note: the drainage area boundary was conservatively assumed
Scale
Off-pile swale
Off-pile Drainage swale

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA / GRJ		Contract No. 3885-74	Sheet 24
Feature Permanent Site Drainage		Designed FHW	File No.
Item Off-pile Drainage Swale		Checked WYL	Date 10/23/90
			Date 11/15/90

6. Peak Discharge Computation under PMP

At Sec. 2, D.A. = 2.27 Ac (See sheet 23)

Longest flow path, $l \doteq 900'$ $\Delta H/l = (5282-5260)/900 = 0.024$

SCS Velocity Method (Ref. 2)

For Bare Soil $V \doteq 1.5$ fps, use 2 fps, $T_c = 900/(2 \times 60) = 7.5$ min.

For upland Gullies $V \doteq 3$ fps. $T_c = 900/(3 \times 60) = 5$ min.

Kirpich Equ. (Ref. 3).

$T_c = 0.0078\, l^{0.77} / \left(\frac{\Delta H}{l}\right)^{0.385} = 6.2$ min.

Use $T_c = 6$ min. $I_{PMP} = 41.5$ in/hr (Ref. 1)

$Q = CIA = 1.0\,(41.5)(2.27) = \underline{94 \text{ cfs}}$ (See sheet 25)

At Sec. 3, D.A. = 7.94 Ac.

Longest flow path, $l \doteq 2350$ ft. $\Delta H/l = (5321-5258)/2350 = 0.026$

SCS velocity method

For bare soil $V \doteq 1.7 \approx 2.0$ fps
upland Gullies $V = 3.2$ fps
} Say $V_{avg} = 2.6$ fps. $T_c \doteq 15$ min.

Kirpich Equ.

$T_c = 0.0078\,(2350)^{0.77} / (0.026)^{0.385} = 12.5$ min. $\doteq 13$ min.

for $T_c = 13$ min. $I_{PMP} = 25.5$ in/hr. $\underline{Q \doteq 200 \text{ cfs}}$

Note: See sheets 30 – 32 for cross-section dimensions, fills and cuts

MORRISON-KNUDSEN ENGINEERS, INC.
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Item: Off-pile Drainage Swale	Checked	Date 4/15/91	

At. Sec. 4, D.A. = 144 Ac.

Longest flow path, $l = 2440'$, $\Delta H/l = (5320-5256)/2440 = 0.026$.

SCS vel. method

For bare soil $V \doteq 1.7$ fps $\doteq 2$ fps
upland Gullies $V = 3.2$ fps. } Say Avg = 2.6 fps. $T_c = 15.6$ min

Kirpich Equ.

$T_c = 0.0078 \cdot 2440^{0.77} / (0.026)^{0.385} = 13$ min. ($V = 3.1$ fps)

Assume an Avg. $V = 3$ fps. $T_c \doteq 13.5$ min.

$I_{PMP} \doteq 25$ in/hr. $Q = 1.0(25)(144) = \underline{360\ cfs}$.

At. Sec. 5, D.A. = 100.5 Ac.

Longest flow path, $l \doteq 5510$ $\Delta H/l = (5410-5256)/5510 = 0.028$

SCS Velocity method

For bare soil $V \doteq 1.7$ fps $\doteq 2$ fps
upland Gullies $V = 3.3$ fps } Avg $\doteq 2.6$ fps $T_c = 35$ min

Kirpich Equ.

$T_c = 0.0078 (5510)^{0.77} / (0.028)^{0.385} = 23.5$ min Avg $V = 3.9$ fps

For such a long narrow watershed, an average velocity of about 3 fps is reasonable, $T_c \doteq 30$ min

$I_{PMP} = 14$ in/hr. $Q = CIA = 1.0(14)(100.5) = \underline{1410}$ cfs.

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Project: UMTRA / GRJ	Contract No. 3885-3C	Sheet 20	File No.
Feature: Permanent Site Drainage	Designed	Date	
Item: Off-pile Drainage Swale	Checked	Date	

At Sec. 6.

D.A. = 101.5 AC.

Longest flow path, $l = 5610$ ft, $\Delta H / l = (5410 - 5253)/5610 = 0.028$

SCS velocity method

for bare soil $\doteq$ 2 fps
upland Gullies $\doteq$ 3.2 fps } Avg $\doteq$ 2.6 fps, T_c = 36 min.

Kirpich Eqn. $T_c = 0.0078 (5610)^{0.77} / 0.028^{0.385} = 24$ min. Avg V = 3.9 ft.

for Avg. V $\doteq$ 3 fps. T_c = 31.1 min.

use T_c = 31 min., I_{PMP} = 13.7 in/hr

$Q = CIA = 1.0 (13.7)(101.5) = \underline{1410}$ cfs

At Sec. 7.

D.A. = 115.6 Ac, $T_c = T_c$ at Sec 6 + 200/(3.0×60)

= 31.1 + 200/(3.0×60) = 31.6 min

I_{PMP} = 13.4 in/hr, $Q = 1.0 (13.5)(115.6) = \underline{1550}$ cfs

At Sec. 8.

D.A. = 121.5 Ac., $T_c = T_c$ at Sec 7 + 200/(3.5×60)

= 31.6 + 200/(3.5×60) = 32.0 min

I_{PMP} = 13.4 in/hr, $Q = 1.0 (13.2)(121.5) \doteq \underline{1630}$ cfs

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA / GRJ — Contract No. 3805-34 — Sheet 21 — File No.

Feature Permanent Site Drainage — Designed [illegible] — Date 4/[illegible]

Item Off-pile Drainage Swale — Checked HM — Date [illegible]

At. sec. 9.

D.A. = 123.0 Ac $T_c = T_c$ at sec. 8 + $l_{8-9}/(V_{8-9} \times 60)$

$= 32.0 + 200/(7.5 \times 60) = 32.5$ min.

$I_{PMP} \doteq 13.2$ in/hr $Q = 1.0(13.1)(124.3) = \underline{1630}$ cfs.

At. Sec. 10.

D.A. = 124.5 Ac $T_c = T_c$ at sec. 9 + $l_{9-10}/(V_{9-10} \cdot 60)$

$= 32.5 + 200/(7.0 \times 60) = 32.9$ min.

$I_{PMP} \doteq 13.1$ in/hr. $Q = 1.0(13.0)(125.9) = \underline{1630}$ cfs

At. sec. 11.

D.A. = 126.0 Ac. $T_c = 32.9 + l_{10-11}/(V_{10-11} \cdot 60)$

$= 32.9 + 200/(7.0 \times 60) = 33.4$ min

$I_{PMP} = 13.0$ in/hr, $Q = 1.0(13.0)(126.0) = \underline{1640}$ cfs

At. Sec. 12.

D.A. = 130.1 Ac., $T_c = 33.4 + l_{11-12}/(V_{11-12} \cdot 60)$

$= 33.4 + 200/(5 \times 60) = 34.0$ min

$I_{PMP} = 12.8$ in/hr. $Q = 1.0(12.8)(130.1) = \underline{1670}$ cfs.

At. sec. 13.

D.A. = 135.2 $T_c = 34.0 + 360/(15 \times 60) = 35$ min

$I_{PMP} = 12.4$ $Q = 1.0(12.4)(135.2) = 168[illegible]$ cfs

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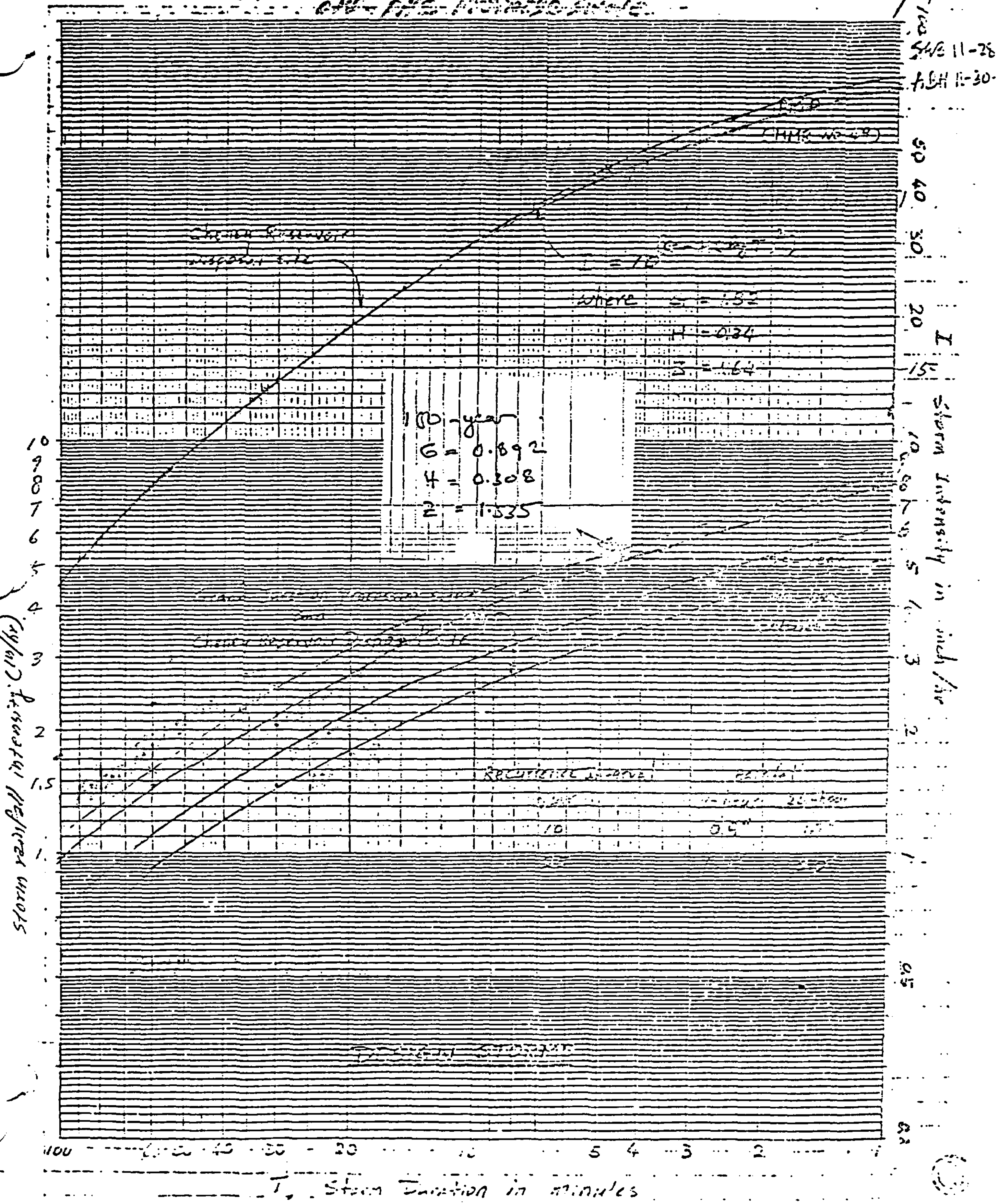
Project: UMTRA / GRJ
Contract No. (5025)
File No.

Feature: Site Drainage
Designed: WYL
Date: 6/19/86

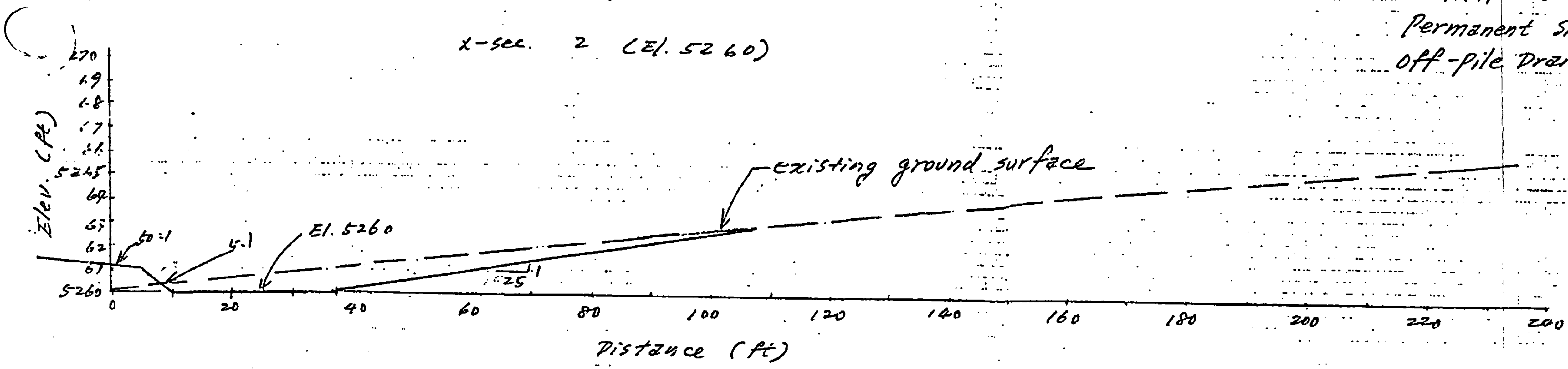
Item: Hydrology Parameters
Checked: [illegible]
Date: [illegible]

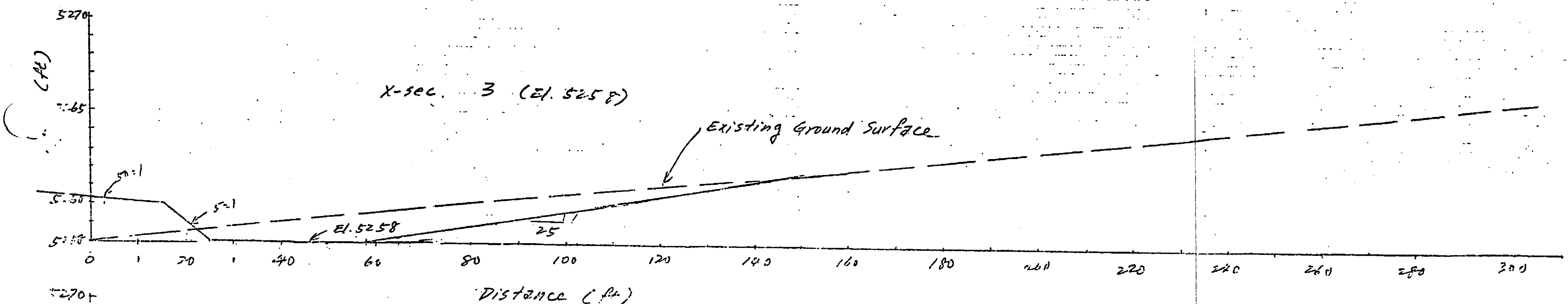


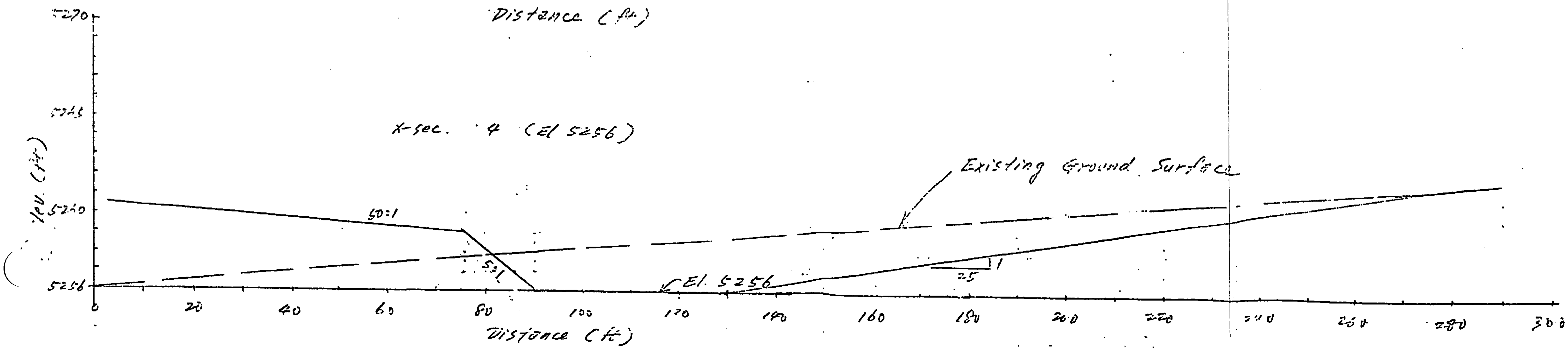
Sheet 29

UMTRA/GRJ
Permanent Site Drainage
Off-Pile Drainage Swale

FHW 4/9/91
HM 4/18/91



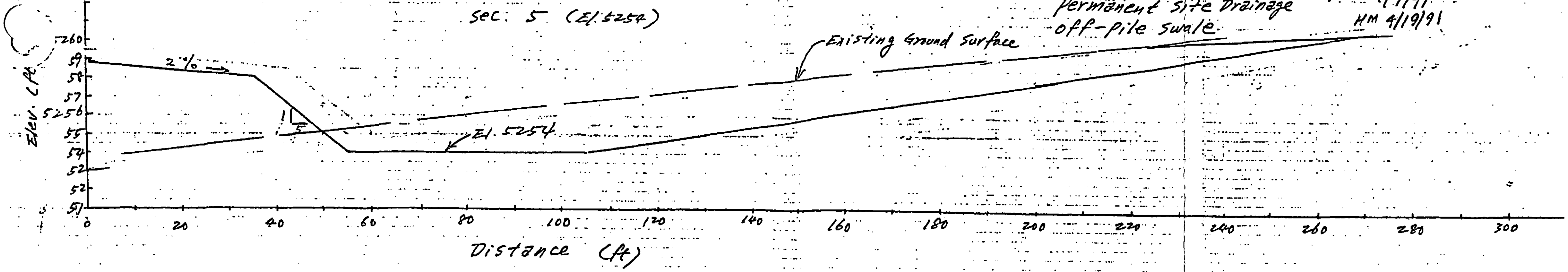


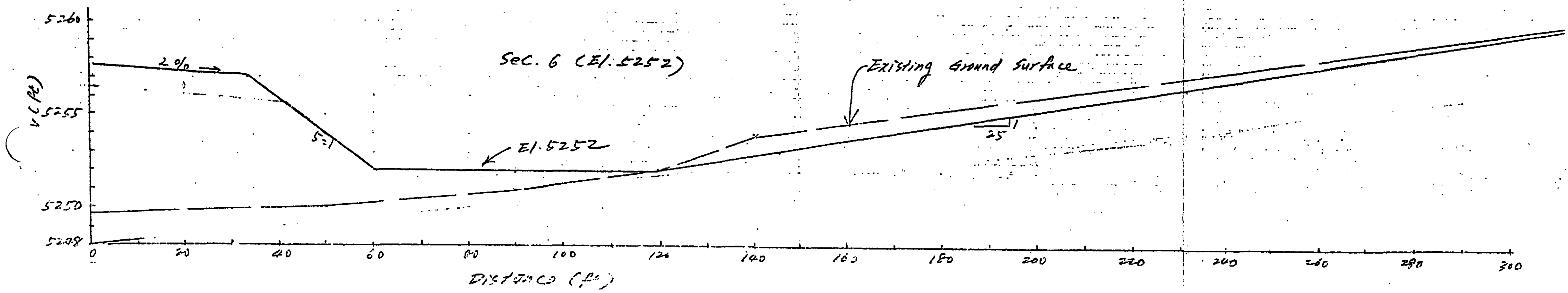


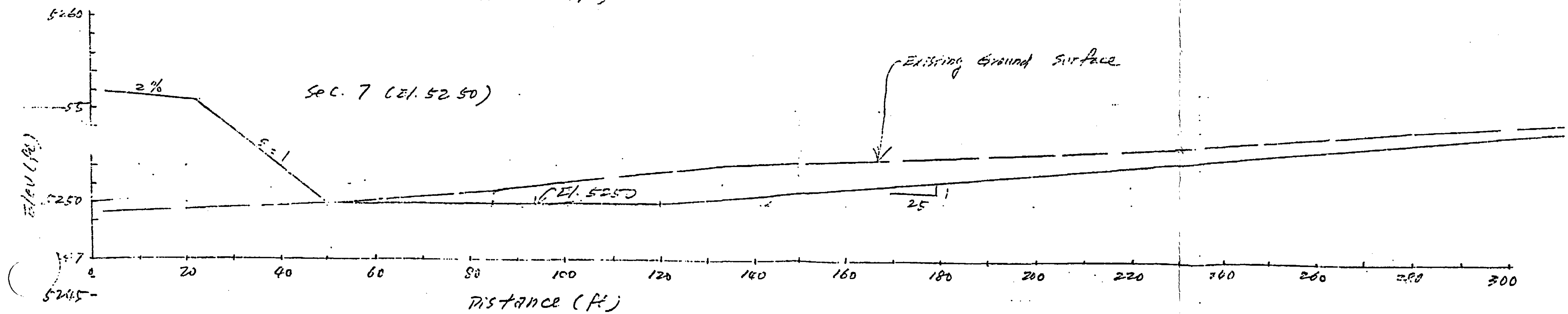
Sheet 30

UMTRA/GRJ
Permanent Site Drainage
off-pile swale

FHW 4/9/91
HM 4/19/91



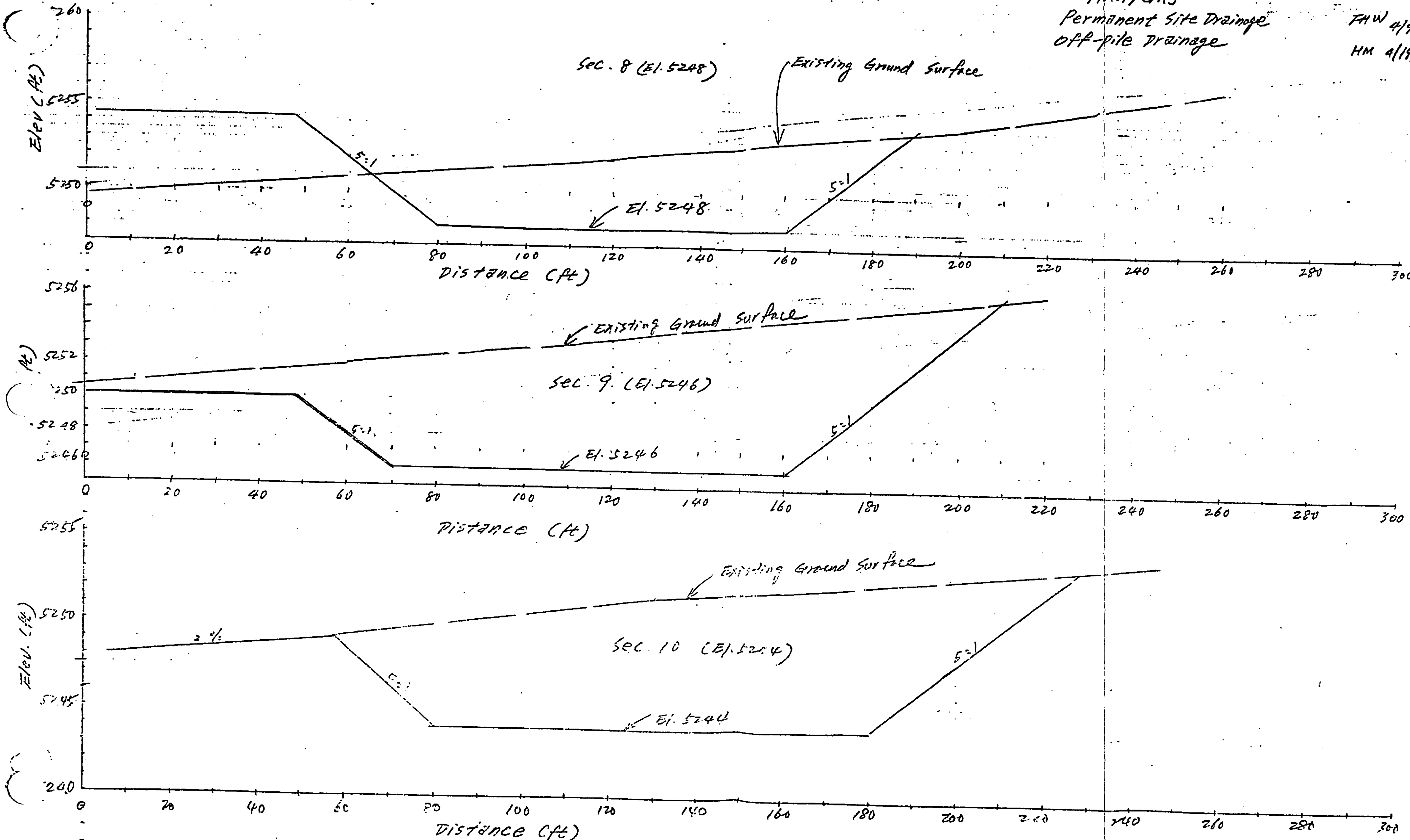




UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage

Sheet 31

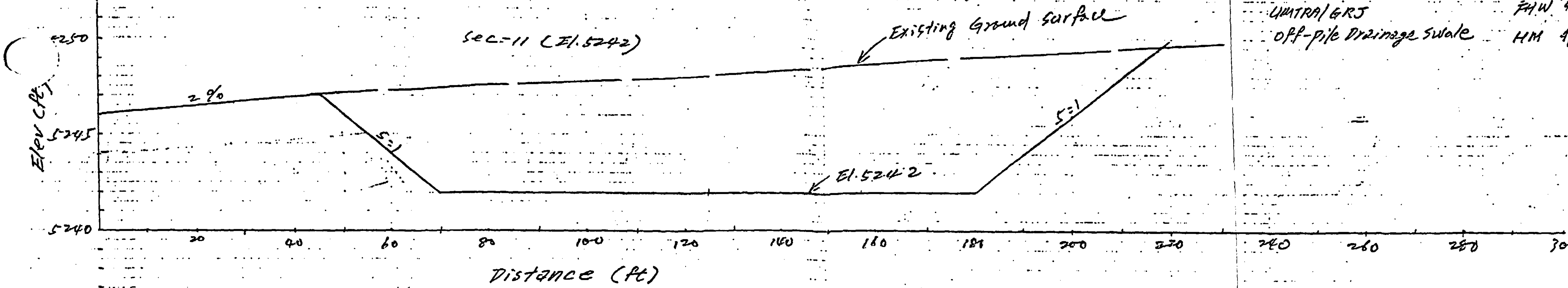
FHW 4/9/91
HM 4/19/91

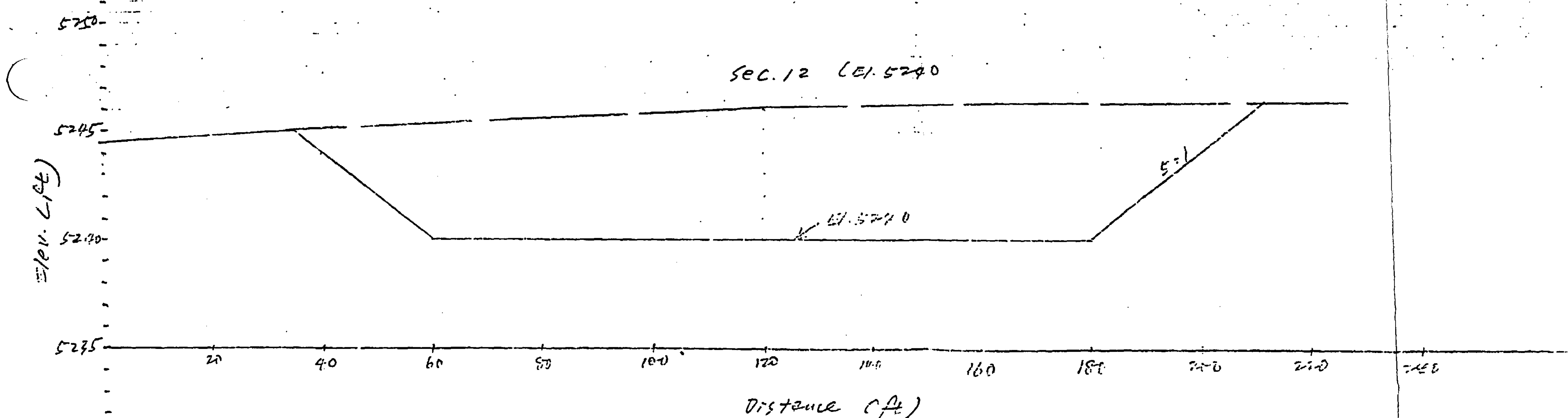


sheet 32

UMTRA/GRJ
Off-pile Drainage Swale

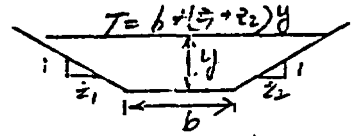
FHW 4/9/91
HM 4/12/91





C. Riprap Required for the 5:1 side slope of the swale along the Environment side

1) Riprap Required based on PMP flow on the swale itself:



At. Sec. 2:

$Q = 94$ cfs, $S = 0.0125$, Assume $n = 0.025$, $b = 26.7$

$V = \frac{1.486}{n} R^{2/3} S^{1/2}$, $Q = AV$, $A = by + \frac{1}{2}(z_1 + z_2) y^2$

$P = (\sqrt{z_1^2+1} + \sqrt{z_2^2+1})y + b$

$R = \frac{A}{P}$, $D = \frac{A}{T}$

for $z_1 = 5$, $z_2 = 25$

let $y = 0.7$: $A = 26.04$, $P = 47.8$, $R = 0.545$, $T = 47.7$

$V = 4.43$, $Q = 115 > 94$ o.k.; $\tau_{max} = \gamma y s = 62.4(0.7)0.0125 = 0.546$ lb/ft²

$F_r = \frac{V}{\sqrt{gD}} = 1.06 > 1$ supercritical flow

use Safety Factor Method to size D_{50} (Ref. 5)

let $D_{50} = 1.7''$, $\phi = 36°$

$\eta_s = 21\, \tau_{max} / (G_s - 1) \gamma_w \cdot D_{50}$, $G_s = 2.55$ +, $\gamma_w = 62.4$

$= 0.837$

$\theta = 11.31$, $\alpha = \tan^{-1}(0.0125) = 0.716°$

$\lambda = \sin^{-1}(\sin\alpha / \sin\theta) = 3.65°$, (Ref. 5)

$\beta = \tan^{-1}\left[\cos\lambda \Big/ \left(\frac{2\sin\theta}{\eta_s \tan\phi} + \sin\lambda\right)\right] = 54.6°$ (Ref. 5)

$S.F = \cos\theta \cdot \tan\phi \Big/ \left\{0.5(1 + \sin(\lambda + \beta))\, \eta_s \tan\phi + \sin\theta \cos\beta\right\}$ (Ref. 5)

$= 1.05$

check n value $n = D^{1/6} / [21.85 + 21.95 \log_{10}(y/D_{50})]$ (Ref. 5)

$= 0.024$ o.k.

+ Ref. 14 use $G_s = 2.74$. The use of 2.55 is conservative eventhough not consistent with Ref. 14.

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Project: UMTRA / GRJ | Contract No. 2885-34 | Sheet 24
Feature: Permanent Site Drainage | Designed | File No.
Item: Off-pile Drainage Swale | Checked | Date

At Sec. 3

$Q = 200$ cfs, $S = 0.0125$, Assume $n = 0.025$, $b = 33.3$

$z_1 = 5$, $z_2 = 25$

Let $y = 0.9$, $A = 42.15$, $P = 60.44$, $R = 0.697$, $T = 60.3$

$V = 5.23$, $Q = 220 > 200$ O.K. $\tau_{max} = 0.702$, $F_r = 1.10$

Let $D_{50} = 2.1''$ $\eta_s = 0.871$ $\phi = 37°$, $\theta = 11.31°$, $\alpha = 0.716°$, $\lambda = 3.65°$

$\therefore \beta = 56.5°$ S.F. = 1.02 check $n \doteq 0.025$ O.K.

At. Sec. 4

$Q = 360$ cfs, $S = 0.0125$, $b = 40$ Assume $n = 0.025$

For $z_1 = 5$, $z_2 = 25$

let $y = 1.1$ $A = 62.15$, $P = 73.1$, $R = 0.85$, $T = 73$

$V = 6.0$ $Q = 370 > 360$ O.K. $\tau_{max} = 0.8??$ $F_r = 1.14$

let $D_{50} = 2.5''$, $\phi = 30°$, $\eta_s = 0.894$, $\theta = 11.31°$, $\alpha = ...$ $\lambda = 3.65°$

$\beta = 57.9°$, S.F. = 1.01, check n for $D_{50} = 2.5''$, $n \doteq 0.026$ OK

At. Sec. 5

$Q = 1410$ cfs $S = 0.01$ $b = 50$, Assume $n = 0.026$

$z_1 = 5$, $z_2 = 25:1$

let $y = 2.2$, $A = 182.6$, $P = 116.3$, $R = 1.57$, $T = 115$,

$V = 7.72$ $Q = 1410$ O.K. $\tau_{max} = 1.373$ $^{lb}/_{ft^2}$, $F_r = 1.09$

let $D_{50} = 4.0''$ $\eta_s = 0.894$, $\phi = 30°$, $\theta = 11.31°$, $\alpha = \tan^{-1}(0.01) = 0.573°$

$\lambda = 2.92°$, $\beta = 58.5°$, S.F. = 1.01

check n for $D_{50} = 4.0''$, $n \doteq 0.027$ O.K.

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Project: UMTRA/GRT
Feature: Permanent Site Drainage
Item: Off-pile Drainage Swale

Contract No. 3881-[illegible] | Sheet [illegible] | File No.
Designed [illegible] | Date [illegible]
Checked [illegible] | Date [illegible]

At Sec. 6

$Q = 1410$ cfs, $S = 0.01$, $b = 60$ Assume $n = 0.027$

$z_1 = 5$, $z_2 = 25$

let $y = 2.1'$ $A = 192.15$, $P = 123.2$, $R = 1.56$, $T = 123$

$V = 7.4$ fps, $Q = 1421 > 1410$, ok. $\tau_{max} = 1.310$ lb/ft², $F_r = 1.04$

let $D_{50} = 3.8''$ $\eta_s = 0.898$, $\phi = 38°$, $\theta = 11.31°$, $\lambda = 0.573°$, $\delta = 2.92°$

$\beta = 58.6°$, $S.F. = 1.01$ check n value for $D_{50} = 3.8''$, $n = 0.027$ ok.

At Sec. 7

$Q = 1550$ cfs. $S = 0.01$ $b = 70$, Assume $n = 0.027$

$z_1 = 5$, $z_2 = 25$.

let $y = 2.1'$, $A = 213.15$, $P = 133.2$, $R = 1.60$, $T = 133$

$V = 7.5$, $Q = 1605 > 1550$ ok $\tau_{max} = 1.310$ lb/ft². $F_r = 1.04$

let $D_{50} = 3.9''$ $\eta_s = 0.875$, $\phi = 38°$, $\theta = 11.31°$, $\lambda = 0.573°$ $\delta = 2.92°$

$\beta = 58.0°$, $S.F. = 1.03$, check n for $D_{50} = 3.9''$ $= 0.027$ o.k.

At Sec. 8.

$Q = 1630$ cfs $S = 0.01$, $b = 80'$, Assume $n = 0.027$

$z_1 = z_2 = 5$.

Let $y = 2.2'$, $A = 200.2$, $P = 102.4$, $R = 1.955$, $T = 101$

$V = 8.6$ $Q = 1722 > 1630$, o.k., $\tau_{max} = 1.373$, $F_r = 1.08$

let $D_{50} = 4.1''$, $\eta_s = 0.873$, $\theta = 11.31°$. $\lambda = \tan^{-1}(0.01) = 0.573°$. $\delta = 2.92°$,

$\phi = 38°$, $\beta = 57.9$, $S.F. = 1.03$

check n value, for $D_{50} = 4.1''$, $n = 0.027$ ok.

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Project: UMTRA / GRJ — Contract No. 3885-34 — Sheet 20
Feature: Permanent Site Drainage — Designed: [illegible] — File No. — Date: 4/11/91
Item: Off-Pile Drainage Swale — Checked: HM — Date: [illegible]

At. Sec. 9

$z_1 = z_2 = 5$

$Q = 1630$ cfs. $s = 0.01$. $b = 90'$, , Assume $n = 0.027$

let $y = 2.0$, $A = 200$, $P = 110.4$, $R = 1.86$, $T = 110$

$V = 8.2$ $Q = 1636$ cfs > 1630 o.k., $\tau_{max} = 1.248$ lb/ft², $F_r = 1.07$

let $D_{50} = 3.7''$ $\eta_s = 0.879$, $\phi = 38°$, $\theta = 11.31°$, $\alpha = 0.573°$, $\lambda = 2.92°$.

$\beta = 58.1°$, S.F. $= 1.03$, check n ($D_{50} = 3.7''$) $\doteq 0.027$ ok.

At. Sec. 10.

$Q = 1630$ cfs, $s = 0.01$, $b = 100'$, let $n = 0.027$, $z_1 = z_2 = 5$

let $y = 1.9'$. $A = 208.1$, $P = 119.4$, $R = 1.74$, $T = 119$.

$V = 8.0$ fps. $Q = 1658$ cfs > 1630, $\tau_{max} = 1.186$, $F_r = 1.07$

let $D_{50} = 3.5''$ $\eta_s = 0.883$, $\phi = 38°$, $\theta = 11.31°$, $\alpha = 0.573°$, $\lambda = 2.92°$.

$\beta = 58.2°$, S.F. $= 1.02$. check n ($D_{50} = 3.5''$) $\doteq 0.027$ o.k.

At. Sec. 11

$Q = 1640$ cfs, $s = 0.01$, $b = 110$, let $n = 0.027$, $z_1 = z_2 = 5$

let $y = 1.8'$ $A = 214.2$ $P = 128.4$, $R = 1.67$, $T = 128$

$V = 7.7$, $Q = 1659 > 1640$ o.k. $\tau_{max} = 1.123$ lb/ft². $F_r = 1.05$

let $D_{50} = 3.3''$ $\eta_s = 0.887$, $\phi = 38°$, $\theta = 11.31°$, $\alpha = 0.573°$, $\lambda = 2.92°$.

$\beta = 58.3°$, S.F. $= 1.02$. check n ($D_{50} = 3.3''$) $= 0.026$. OK

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Project UMTRA / GRJ	Contract No. 3885-34	Sheet 23	File No.
Feature Permanent Site Drainage	Designed [illegible]	Date [illegible]	
Item Off-pile Drainage Swale	Checked [illegible]	Date [illegible]	

At Sec. 12.

Q = 1670 cfs. S = 0.01. b = 120. let n = 0.026.

$z_1 = z_2 = 5$

let y = 1.7. A = 218.45, P = 137.3, R = 1.59. T = 137

V = 7.8. Q = 1700 > 1670. ok. τ_{max} = 1.061, F_r = 1.09

let D_{50} = 3.1", η_s = 0.892, ϕ = 38°. θ = 11.31°, ∂ = 0.578, η' = 2.92

β = 58.4°, S.F. = 1.01. check n (D_{50} = 3.1") = 0.026. o.k.

At Sec. 13

Q = 1680 cfs. daylight at this location. 200' wide

q = 1680/200 = 8.4 cfs/ft, S = 0.01. Let n = 0.026

$y = \left\{ 8.4 \cdot 0.026 / 1.486 \cdot (0.01)^{1/2} \right\}^{0.6} = 1.26$. τ_{max} = 0.786

V = 6.7 fps, F_r = 1.05

Let D_{50} = 2.5", η_s = 0.822, S.F. = 1.13

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Project: UMTRA / GRJ
Feature: Permanent Site Drainage
Item: Off-Pile Drainage Swale
Contract No. 3A85-26
Designed: [illegible]
Checked: [illegible]
Sheet: [illegible]
File No. [illegible]
Date: [illegible]
Date: [illegible]

Summary of Computation – Flow Characteristics, off-Pile swale
side slope on the embankment side is 5:1

Location	D.A (A.c)	Q (cfs)	B (ft)	Side slope upland side	Distance*2 (ft)	Invert El. (ft)	Long. slope	Flow Depth (ft)	V (fps)	τ_{max} (lb/ft²)	Top width (ft)	Fr	Min. D_{50} (in)	Estimated n Value
1	0.	—	20	25:1	0	5262	0.0125	—		...	-			
2	2.27	94	26.7	25:1	160	5260	0.0125	0.70	4.4	0.546	47.7	1.06	1.7"	0.025
3	7.94	200	33.3	25:1	160	5258	0.0125	0.90	5.2	0.702	60.3	1.10	2.1	0.025
4	14.4	360	40.0	25:1	160	5256	0.0125	1.10	6.0	0.858	73.0	1.14	2.5	0.025
5	100.5	1410	50.0	25:1	200	5254	0.010	2.20	7.7	1.080	116.0	1.08	4.0"	0.026
6	101.5	1410	60.0	25:1	200	5252	0.010	2.10	7.4	1.310	123.0	1.04	3.8"	0.027
7	115.6	1550	70.0	25:1	200	5250	0.010	2.10	7.5	1.310	133.0	1.04	3.9"	0.027
8	121.5	1630	80.0	5:1	200	5248	0.010	2.20	8.6	1.373	101.0	1.08	4.1"	0.027
9	123.0	1630	90.0	5:1	200	5246	0.010	2.00	8.2	1.248	110.0	1.07	3.7"	0.027
10	124.5	1630	100.0	5:1	200	5244	0.010	1.90	8.0	1.186	119.0	1.07	3.5"	0.027
11	126.0	1640	110.0	5:1	200	5242	0.010	1.80	7.7	1.123	128.0	1.05	3.3"	0.026
12	130.1	1670	120.0	5:1	200	5240	0.010	1.70	7.8	1.061	137.0	1.09	3.1"	0.026
13	135.2	1680	200*1	5:1	360	5236.4	0.010	1.26	6.7	0.786	200	1.05	2.5	0.026

*1 Expand at 9:1

*2 Distance between 2 sections

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Project UMTRA/GRJ	Contract No. 3855-34	Sheet 41
Feature Permanent Site Drainage	Designed FMH	File No.
Item Off-Pile Drainage Swale	Checked HM	Date 4/1/??

2) Riprap(D_{50}(min)) required for side slope (5:1) of the swale due to Overland Flow from Embankment

Assume the same rainfall intensity (42.7 in/hr) at end of 2% embankment slope

a) If flow concentration factor = 1

$q = 1.0\ (42.7)\ (610+57.5)/43560 = 0.37$ cfs/ft, $S = 0.2$

Manning n: use Abt empirical formula $n = 0.0456\ (D_{50}(in)\cdot S)^{0.15}$ (Ref. 6)

For slope > 10% use Stephenson method (Ref 5), to estimate Min Riprap (D_{50}) requirement:

$$D_{50} = \left[q\cdot(\tan\alpha)^{7/6}\ n^{1/6} \Big/ \left\{ C\cdot g^{1/2}\cdot\left[(1-n)(G_s-1)\cdot\cos\alpha\ (\tan\phi-\tan\alpha)\right]^{5/3} \right\} \right]^{2/3}$$

where q = discharge/unit width = cfs/ft

α = side slope = 5:1 = 11.31°

g = Acceleration of gravity = 32.2 ft/sec²

G_s = specific gravity of the riprap material, assumed = 2.64*

ϕ = riprap angle of repose

n = riprap material porosity, let $n = 0.33$*

$C = 0.22$

∴ $D_{50} = 0.27' = 3.2''$

b) If flow concentration of 3 is considered, $q_c = 1.09$ cfs.

$D_{50} = 0.56' = 6.7''$

For a flow concentration factor = 3, the required D_{50}(min) from embankment overland flow would be larger than those computed from item c (see sheet 38).

* use these values to be consistent with Ref. 14.

3) Riprap Required Due to Flow from potentially Developed Gully in the upland Area :

a) Assumed Gully Development Conditions

For observation of the topographic condition in the upland area, it is assumed that several gullies might develop and the most critical one is the one shown on sheet 40a.

Drainage Area $\doteq \frac{1}{2}\,1810^{(a)}\cdot 360 + \frac{1}{2}\cdot 860^{(b)}\cdot 280 + \frac{1}{2}\,870^{(c)}\cdot 340 + \frac{1}{2}\,900^{(d)}\cdot 310$
$+ \frac{1}{2}\cdot 1350^{(e)}\cdot 180 = 875{,}900\ ft^2 = 20.1$ Acres.

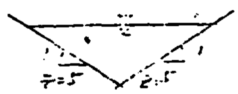
Longest flow length $\doteq 3570'$, $\Delta H = 5350 - 5254 = 96'$

$\Delta H/L = 0.0269$, $T_c = 0.0078\,(3570)^{0.77} / (0.0269)^{0.385} = 17$ min.

$I_{PMP} \doteq 21.5$ in/hr. $Q = CIA = 21.5\,(20.1) \doteq 430$ cfs.

Assume a triangular X-sec. with 5H:1V side slopes (the side slope of existing gully east of the site is around 7:1–10:1)
let $n = 0.025$.

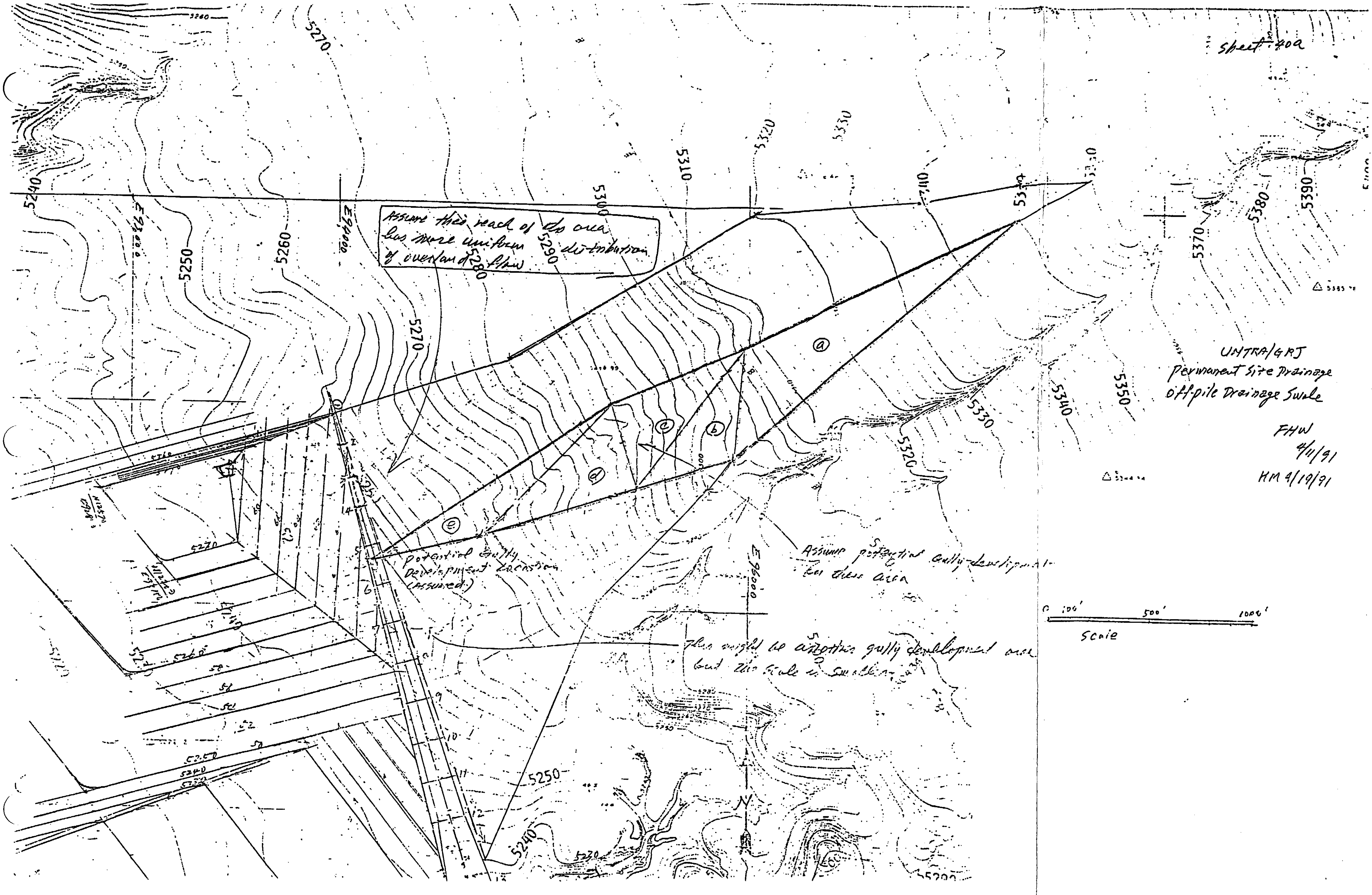
$$y = \left\{ Qn \Big/ 1.486\, z \left(\frac{z}{2\sqrt{z^2+1}}\right)^{2/3} S^{1/2} \right\}^{3/8}$$



Assume Gully slope ≈ upland slope = 0.025.

then $y = 2.74'$, $A = 37.6\ ft^2$, $V = 11.5$ fps $\tau = 4.27\ lb/ft^2$, $T = 27.4'$
$F_r = 1.72$

Since the velocity and tractive force is much larger than the allowable shear stress and velocity (see sheet 41), scour would occur.



Sheet 40a
UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale
FHW
4/11/91
HM 4/19/91
Assume this reach of the area has more uniform distribution of overland flow
Potential Gully Development Location (assumed)
Assume potential gully development for these area
This might be another gully development area but the scale is smaller
0 100' 500' 1000'
Scale
a
b
c
d
e
5240
5250
5260
5270
5280
5290
5300
5310
5320
5330
5340
5350
5370
5380
5390
E94000
E96000

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Project UMTRA/GRT — Contract No. 3885-3A — Sheet 41
Feature Permanent Site Drainage — Designed [illegible] — File No.
Item Off-pile Drainage Swale — Checked WYL — Date 10/[illegible] — Date 11/15/90

b) Max. allowable velocity and critical tractive force for materials at site:

(1) Surface soils at GRJ Disposal site are generally sandy clay / alluvial silts, colloidal

The max. permissible mean velocity is about 3.0–5.0 fps with water transporting colloidal silt (Ref. 7)

The critical tractive force is in the range of about 0.26 to 0.66 lb/ft². (Ref. 7).

Use V_a (allowable) = 3.0 fps, τ_o (allowable) = 0.26 lb/ft²

(2) For soils about 3' below the surface – the soils are gravelly soil contain appreciable quantity of gravel and some cobbles (similar to graded loam to cobble when non-colloidal). The max. permissible velocity is 4 fps in clear water and can be as high as 5 fps with water transporting colloidal soils. The critical tractive force would be about 0.38 – 0.66 lb/ft² (Ref. 7).

Use $V_a \doteq 4.5$ fps, $\tau_o \doteq 0.6$ lb/ft²

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Project: UMTRA / GRJ
Feature: Permanent Site Drainage
Item: Off-pile Drainage Swale

Contract No. 3885-3C
Designed: F...
Checked: HM

Sheet: 42
File No.:
Date: 4/...
Date: 4/10/91

c) Estimate of Scour Depth

(1) Based on Critical Tractive Force Method

Assume scour depth is the depth at which the slope of the gully become stable with tractive force $\tau \le \tau_c$ (critical tractive force).

For depth 3' or lower at the site, $\tau_c \doteq 0.6$ lb/ft² (see sheet 43).

Estimate stable slope by trial and error:

when stable slope $S_s = 0.0022$ $n = 0.025$, $z = 5$ $Q = 430$ cfs

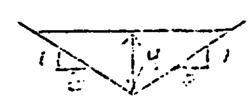
then $\underline{y \doteq 4.3}$ $\tau = 0.59 \le 0.6$ O.K. Hence the stable slope will be about $S_s = 0.00135$ and the gully-developed depth will be about 7'.

(2) Based on max. allowable velocity

For depth 3' or lower at the site, $V_a = 4.5$ fps (see sheet 43).

For $Q = 430$ cfs, $z = 5$

$z \cdot y^2 = Q/V$, $5y^2 = 430/4.5$



$y = 4.4'$ (possible scour depth)

(3) Based on an approximate correlation of gully depth vs Drainage Area. The projected gully depth for the drainage area (sec. 11-7) of ≈0.1 Ac would be approximately from 1.6 to 3.6 ft (from Ref. 8, see sheet 45).

<u>A potential scour depth of 5' is adopted.</u>

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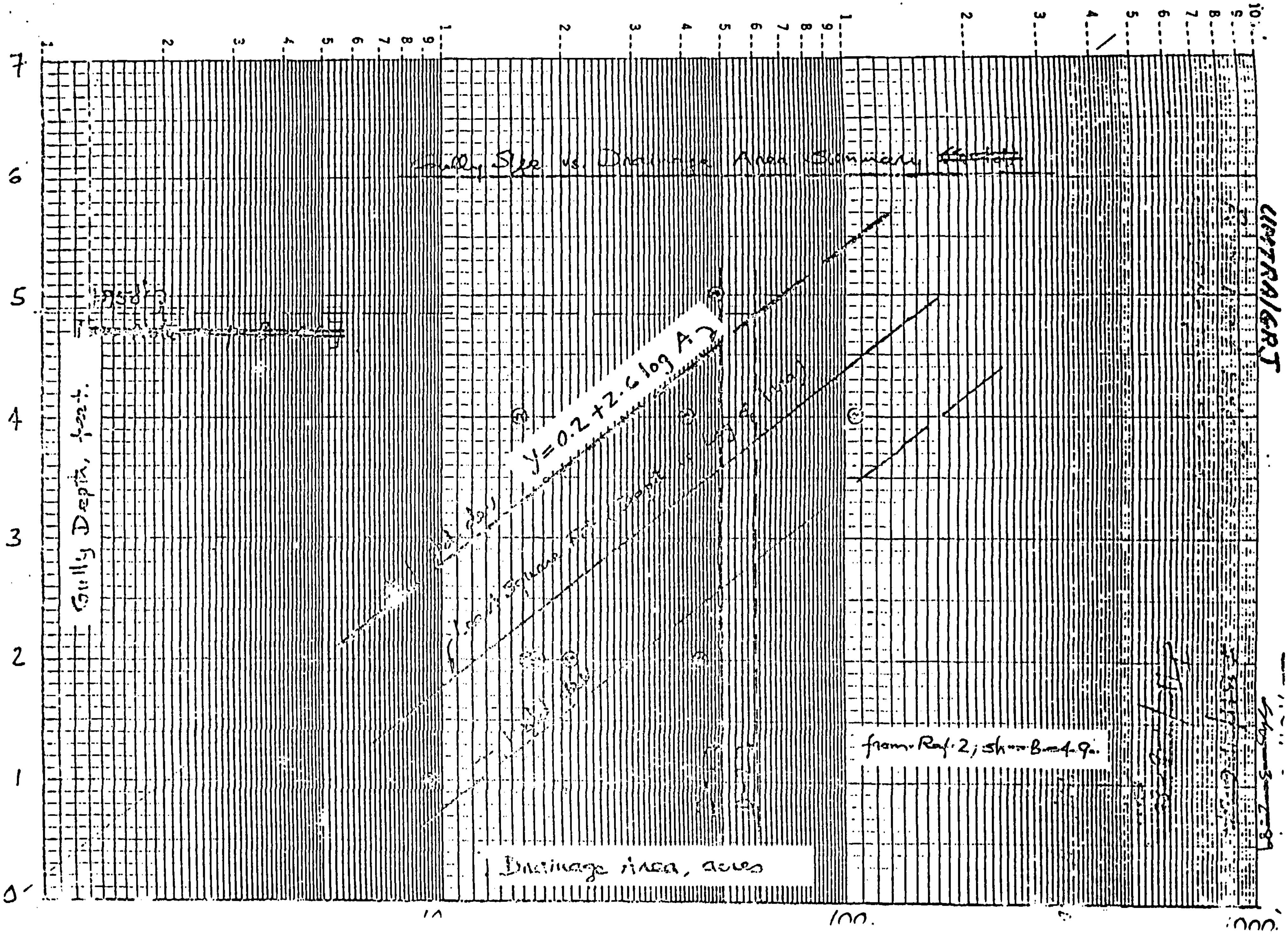


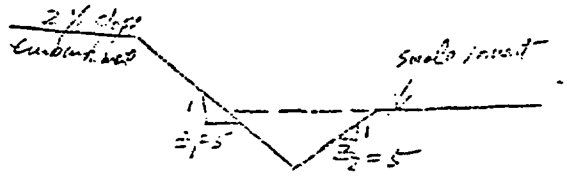
d) Estimate of Riprap Requirement Due to Erosion

(1) Assumptions

① Due to erosion potential from the assumed upland gully flow, a buried riprap wall will be provided along the embankment side of the swale (5:1 slope side) to a depth of 7' (the estimated scour depth due to PMP)

② For calculation purpose, it is assumed that a gully X-sec. will also be formed along the edge of the swale on the embankment side (5:1 slope)

Also assume a side slope of 5:1 on the other side of the gully which is typical from existing gully condition.



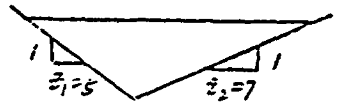
(2) Riprap Size Estimation

Critical location for the gully development would be around Sections 4 to 7 as observed from the topo. The developed gully could follow the swale direction and extend along the upland side of the swale. Hence the same gully cross-section is assumed to be developed along the swale. It is also assumed that the gully will be developed on the embankment side eventhough the upland side might subject to erosion and gully development first. The slope of the gully is assumed to be the same as the swale (S=0.01) since erosion protection is provided on the invert and at the outlet.

At Sec. 7. $Q \doteq 1550$ cfs

Assume a triangular gully will be developed.

$z_1 = 5$ (side slope of swale to be protected buried riprap).



$z_2 = 7$ (typical side slope of existing gully east of the disposal cell is 7~10 :1)

so $$y = \left\{ nQ \Big/ 1.486 \cdot \tfrac{1}{2}(z_1+z_2) \cdot \left[\frac{\frac{1}{2}(z_1+z_2)}{\sqrt{z_1^2+1}+\sqrt{z_2^2+1}} \right]^{2/3} s^{1/2} \right\}^{3/8}$$

$Q = 1550$ cfs, $s = 0.01$, let $n = 0.03$.

then $y = 5.26'$, $\tau_{max} = 3.28$ lb/ft², $V = 9.3$ fps, $F_r = 1.01$

D_{50}: by Safety Factor Method : $G_s = 2.64$

Let $D_{50} = 9''$ $\phi = 40°$, $\theta = 11.31°$, $\alpha = 0.573$ ($s=0.01$), $\lambda = 2.92°$

$\eta_s = 0.897$ $\beta = 60.2°$, S.F. $= 1.02$ check $n = 0.031$ O.K.

② At Sec. 8 :

$Q = 1630$ cfs, $z_1 = 5$, $z_2 = 7$, $n = 0.03$, $S = 0.01$. $G_s = 2.64$.

$y = 5.36'$ $\tau_{max} = 3.34$ lb/ft², $V = 9.5$ fps, $F_r = 1.02$.

(use Safety Factor Method to size D_{50} :)

Let $D_{50} = 9.5''$, $\phi = 40°$, $\eta_s = 0.917$, $\theta = 11.31°$, $\alpha = \tan^{-1}(0.01) = 0.573°$.

$\lambda = 2.92°$, $\beta = 60.7°$, S.F. $= 1.00$.

check n for $D_{50} = 9.5''$, $n = 0.031 \approx 0.03$ O.K.

* Hence use $D_{50} = 9.5''$ to a depth 5' below the invert of the swale for locations from 4 through 12.

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Project: UMTRA / GRJ | Contract No. 3885-3? | Sheet 46
Feature: Permanent Site Drainage | Designed: FMJ | File No.
Item: Off-pile Drainage Swale | Checked: HM | Date 4/1?/91

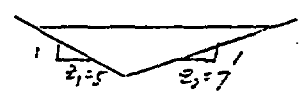
③ At sec. 4

Since upstream of sec. 4 does not receive much of the flow from the upland area. An evaluation of gully erosion (Assuming a gully developed at sec. 4) and riprap size required will be evaluated using the flow at sec. 4

① Assume gully x-sec. with $z_1 = 5$, $z_2 = 7$

$Q = 360$ cfs, $S = 0.0125$, let $n = 0.03$.

then



$y = 2.92'$, $\tau_{max} = 2.275$ lb/ft², $V = 7.1$ fps, $F_r = 1.04$

Let $D_{50} = 6.5''$, $\phi = 40°$, $\theta = 11.31°$, $\alpha = \tan^{-1}(0.0125) = 0.716°$
(Safety Factor Method) $\lambda = 3.65°$.

$\eta_s = 0.912$, $\beta = 60.0°$, S.F. $= 1.00$ check n value ∴ 0.03 O.K.

⑪ Depth of protection required (scour depth).

a) Critical tractive force method $\tau_c = 0.6$ lb/ft²

at a stable slope, $S_s = 0.0024$,

then $y = 4.0'$ $V = 3.8$ fps, $\tau = 0.6 \approx \tau_c$

Scour depth $= 4.0 - 2.9 = 1.1$ ft

b) Max. allowable Velocity $= 4.5$, $\frac{1}{2}(z_1+z_2)y^2 = \frac{Q}{V}$

$\frac{1}{2}(5+7) \cdot y^2 = 360/4.5$, $y = 3.7'$

Scour depth $= 3.7 - 2.9 = 0.81$

c) From gully depth VS Drainage Area Correlation, projected gully depth (if developed) will be about 1.2 to 3.2 ft.

* Hence use a depth of 3' at sec. 4 for riprap protection. However, use the same $D_{50} = 9.5$ inches as determined at sec. 5 (see sheet 45).

4) Summary of Riprap Requirement for 5:1 side slope of the Swale along the Embankment

(a). The D_{50}(min) required for the 5:1 slope on the embankment side range from 1.5 to 2.8" (see sheet 38) based on PMP flow on the swale itself above the invert.

(b) D_{50}(min) required due to PMP overland flow from the embankment was estimated to be about 7" based on the most critical flow path and with a flow concentration factor of 3. (see sheet 39)

(c) D_{50}(min) required for erosion protection due to assumed gully development and scour potential was estimated to be 6.5" to a depth of 3' at Sec. 4 and 9.5" to a depth of 5' at sec. 8 (see sheets 40 to 46)

(d) Based on above results, it is recommend that a D_{50}(min) of 9.5" (before oversizing consideration) should be used for the 5:1 side slope of the swale along the embankment. However, the depth of riprap protection will be 2' at Sec. 1 and gradually increased to 3' at sec. 4, and then gradually increased to 5' at Sec. 5 through Sec. 13.

(e) Details of Riprap arrangement are shown on sheet 10.

5) Estimate of Riprap Oversizing and Layer Thickness for 5:1 side slope along the Embankment

$D_{50} = 9.5''$ for all section, for frequently saturated area use a 15% oversizing factor. (Ref. 9)., then based on Ref. 5

$D_{50}(min) = 9.5 \times 1.15 = 10.9''$ use 11''

$D_{100}(max) = 1.71\ (10.9) = 18.7''$ " 19''

$D_{100}(min) = 1.26\ (10.9) = 13.8''$ " 14''

take $D_{50}(max) = \frac{1}{2}\left[D_{100}(max) + D_{100}(min)\right]$

$= 16.3''$ use 16''

$D_{25}(min) = 0.68\ D_{50}(min) = 7.4''$ use 7.5''

see plot on sheet 49 for approx. gradation

Layer Thickness:

$T_{min} = 1.9\ D_{50}(min) = 1.9(10.9) = 21''$, or

$T_{min} = 1.5\ D_{50}(max) = 1.5(16) = \underline{24''}$ (used)

Check Filter Requirement:

For buried wall riprap, as plotted on sheet 49 from above information

$D_{15}(max)$ for riprap $= 9.5''$

$d_{85}(min)$ for bedding $\doteq 0.26''$

$D_{15}/d_{85} = 9.5/0.26 > 7.5$ (need secondary bedding, or filter)

For Secondary bedding:

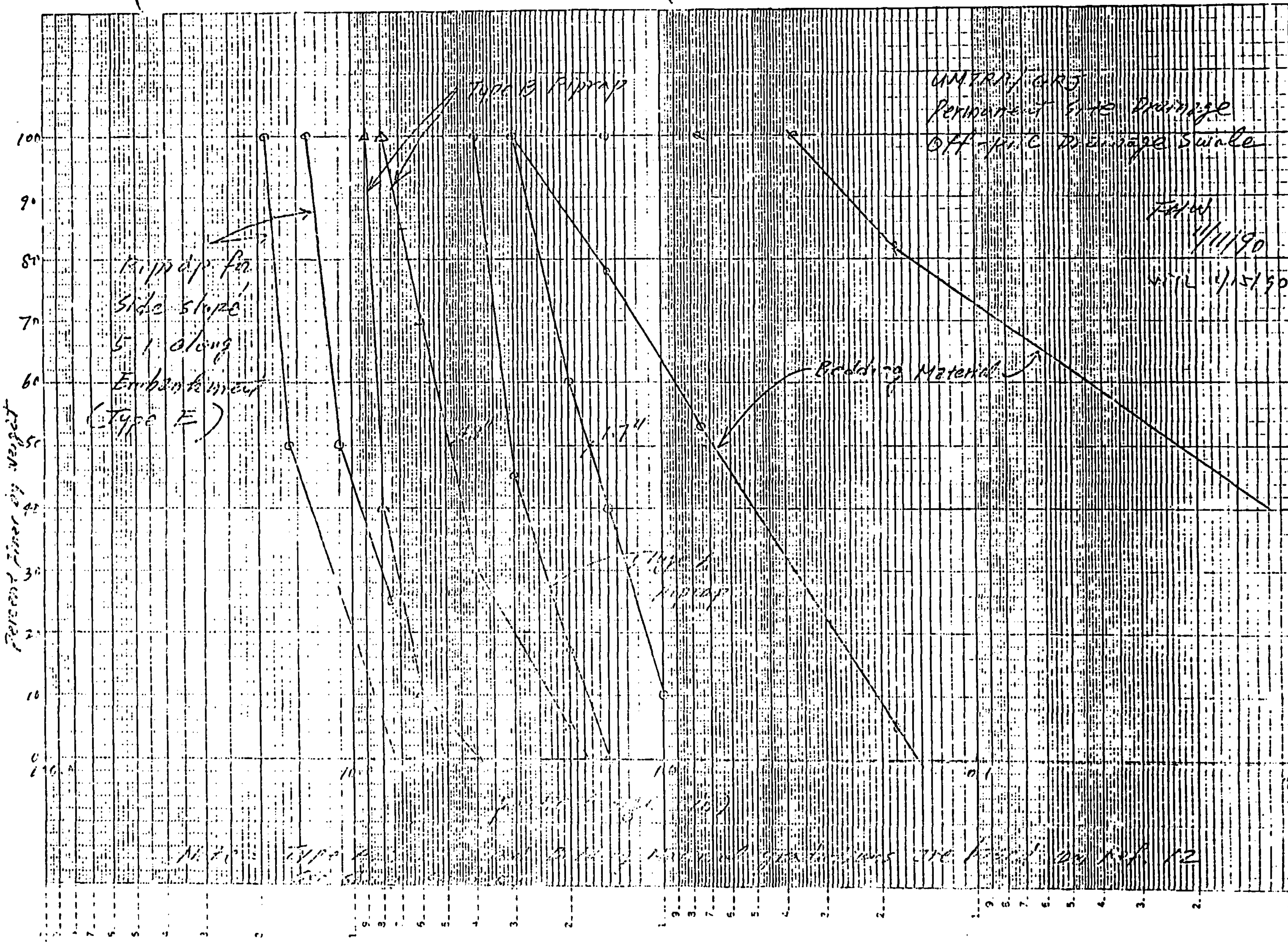
Use Type A Riprap $d_{85}(min) \doteq 2''$, $d_{100}(max) = 3''$ (see sheet

$D_{15}/d_{85} = 9.5/2 = 4.8 < 7.5$, o.k.

Layer Thickness $= 1.1\ d_{100}(max) = 1.1(3) = 3.3''$, use $\underline{6''}$

Bedding Layer – 6''

(Type A) $D_{15}(max)/d_{85}(min)$ (bedding) $= 1.9/0.26 = 7.3 < 7.5$, o.k.



Sheet 47

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Sheet 50

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale

FHW 11/11/90
WYL 11/15/90

1.4 DEFINITIONS

A. Tailings Embankment: See Section 02200.

B. Cover: See Section 02200.

PART 2 - PRODUCTS

2.1 ONSITE PROCESSED MATERIALS

A. Gradation: All materials shall be reasonably well graded within the following gradation limits:

1. Riprap Materials:

a. Type A:

U.S. Standard Sieve Size Square Openings	Percent Passing by Weight
[4-inch	100
3-inch	45-100
2-inch	17-60
1-1/2-inch	0-40
1-inch	0-10]*

b. Type B:

U.S. Standard Sieve Size Square Openings	Percent Passing by Weight
[9-inch	100
8-inch	40-100
6-inch	10-70
4-inch	0-30]*
2-inch	0-5

c. Type C:

U.S. Standard Sieve Size Square Openings	Percent Passing by Weight
[11-inch	100
10-inch	65-100
8-inch	26-85
6-inch	0-48
4-inch	0-30
2-inch	0-5]*

* P.I.D. 05-S-17, Rev. 1

Sheet 51

UMTRA/GRJ
Off-pile Drainage Swale

FHW 11/11/90
WYL 11/15/90

[d. Type D:

U.S. Standard Sieve Size Square Openings	Percent Passing by Weight
22-inch	100
18-inch	50-100
15-inch	30-100
12-inch	0-40
8-inch	0-18
6-inch	0-10]*

2. Choked Rock:

U.S. Standard Sieve Size Square Openings	Percent Passing by Weight
3-inch	100
1-1/2-inch	75-100
3/4-inch	50-85
3/8-inch	35-65
No. 4	20-50
No. 10	5-30
No. 20	0-7

3. Bedding Materials:

U.S. Standard Sieve Size Square Openings	Percent Passing by Weight
[3-inch	100
1-1/2-inch	78-100
3/4-inch	53-100
No. 4	5-82
No. 50	0-30
No. 200	0-5]*

B. Bedding materials shall be from crushed rock retained on the 8-inch sieve. Alternatively, the Subcontractor may opt to supply bedding materials from his own sources. In such a case, the requirements in Section 2.2.A shall apply.

C. Mulch Rock: Gradation shall vary in size from 0-2 inch.

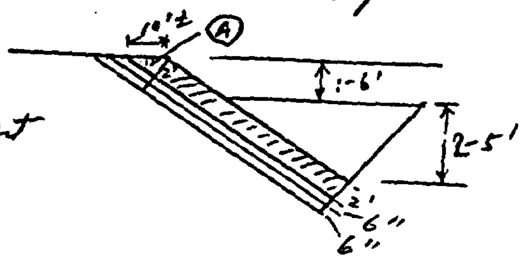
D. Separate stockpiles shall be maintained for each type of material.

E. Rock quality test results will be evaluated by the Contractor using the criteria listed in Table 02278-A. The score for each test will be determined by multiplying

* P.I.D. 05-S-17, Rev. 1

Source: Ref. 12

6) Riprap Material Quantity Estimate for 5:1 side slope on the Embankment side:



(A) $D_{50} = 11''$ riprap Quantity:

Sec. 1 → 2 : Depth above + below invert

at 1 = 0 + 2 = 2

2 = 1 + 2 = 3

Length = 160'. $Vol. = \frac{1}{2}(2+3)\cdot\sqrt{26}\cdot 160\cdot 2 = 2.5\cdot 2\cdot 160\cdot\sqrt{26}$

Sec. 2 → 3   2 : 1 + 2 = 3
3 : 2 + 4 = 6 , Length = 160'. $vol. = \frac{1}{2}(3+6)\cdot 2\cdot 160\sqrt{26}$
$= 4.5\cdot 2\cdot 160\cdot\sqrt{26}$

Sec. 3 - 4   4 : 3.3 + 5 = 8.3

Length = 160. $vol. = \frac{1}{2}(6+8.3)\cdot 2\cdot 160\cdot\sqrt{26}$
$= 7.15\cdot 2\cdot 160\cdot\sqrt{26}$.

Sec. 4 - 5   5 : 4 + 5 = 9

L = 200' $Vol. = \frac{1}{2}(8.3+9)\cdot 2\cdot 200\sqrt{26} = 8.65\cdot 2\cdot 200\sqrt{26}$.

Sec. 5 - 6   6 : 5 + 5 = 10

L = 200 $Vol. = \frac{1}{2}(9+10)\cdot 2\cdot 200\sqrt{26} = 9.5\cdot 2\cdot 200\cdot\sqrt{26}$

Sec 6 - 7   7 : 5.5 + 5 = 10.5

L = 200 $vol. = \frac{1}{2}(10+10.5)\cdot 2\cdot 200\sqrt{26} = 10.25\cdot 2\cdot 200\cdot\sqrt{26}$

Sec. 7 - 8   8 : 6 + 5 = 11

L = 200. $V = \frac{1}{2}(10.5+11)\cdot 2\cdot 200\sqrt{26} = 10.75\cdot 2\cdot 200\cdot\sqrt{26}$

Sec. 8 - 9   9 : 4 + 5 = 9

L = 200. $V = \frac{1}{2}(11+9)\cdot 2\cdot 200\sqrt{26} = 10\cdot 2\cdot 200\cdot\sqrt{26}$

Sec. 9 - 10   10 : 4.5 + 5 = 9.5

L = 200. $V = \frac{1}{2}(9+9.5)\cdot 2\cdot 200\sqrt{26} = 9.25\cdot 2\cdot 200\cdot\sqrt{26}$

Sec. 10-11 : 11 : 4.5+5 = 9.5

$L = 200.\quad V = 9.5 \cdot 2 \cdot 200 \cdot \sqrt{26}$

Sec. 11-12 : 12 : 5+5 = 10

$L = 200,\quad V = \frac{1}{2}(9.5+10) \cdot 2 \cdot 200 \sqrt{26} = 9.75 \cdot 2 \cdot 200 \cdot \sqrt{26}$

Sec. 12-13 : 13 : 0

$L = 360.\quad V = 5 \cdot 2 \cdot 360 \sqrt{26}$

Total Vol $= \{(2.5+4.5+7.15)\, 160 \cdot 2\sqrt{26}$
$+ (8.65 + 9.5 + 10.25 + 10.75 + 10 + 9.75) \cdot 200 \cdot 2\sqrt{26} + 5 \cdot 360$
$+ Ⓐ \cdot 2440/27$

10.19

$= 19594 \cdot 2\sqrt{26}/27 + 10 \cdot 2440/27$

$= 7400 + 904 \doteq 8310\ yd^3$

(b) 2nd bedding, Type A - 6" thick

Quantity $= 19594 \times 0.5 \sqrt{26}/27 + 11.25 \times 0.5 \times 2440/27$

$= 2360$ CY

(c) bedding layer 6" thick

Quantity $= 19594 \times 0.5 \sqrt{26}/27 + 13.75 \cdot 0.5 \cdot 2440/27$

$= 2470$ CY

7) Verfication of flow condition on the swale based on Backwater Computation (under riprap placement condition)

A backwater computation using HEC-2 computer program (Ref. 13) was performed to check the flow depths and velocities along the swale. The computations are presented in Appendix A. Computed velocities along the swale range from 6.5 to 7.7 fps and the flow depths from 1.3 to 2.4 ft. The flows depths are slightly deeper and the velocities are less than those computed assuming uniform flow (see sheet 38). The reason is a larger n value = 0.032 was used in the backwater computation due to riprap placement on the swale (Type B, $D_{50}(min) = 4.8''$ on invert and upland side and $D_{50}(min) = 11''$ on embankment side compared to computed $D_{50}(min)$ required = 1.5 to 2.8"), and the other reason is the backwater effect tends to flatten the energy slope.

d. Riprap Protection for Other Portion of the Swale (i.e. Invert and Side slope on Upland Portion):

1) Riprap Required on the side slope along the upland side (sec. 7 to 12) due to upland overland flow:

(a) Between Sec. 8 + 9 (200 ft), at sec 9

T_c : flow length $l_1 \doteq 400'$, $\Delta H/l_1 = (5260-5256)/200 = 0.02$

$l_2 \doteq 50'$, $\Delta H/l_2 = 0.2$

$T_c = 0.0078 \, l^{0.77} / (\frac{\Delta H}{l})^{0.385} = 3.6 + 0.3 \doteq 3.9$ min.

For PMP Condition $I_{pmp} = 47$ in/hr

$q = CIA = 1.0 (47)(450/43560) = 0.485$ cfs/ft

Assume a flow concentration factor of 2 since this area appears to have less potential of gully development, and erosion on this side would have no effect on the stability of the embankment. Hence $q_c = 2q = 0.97$ cfs/ft.

use Stephenson method to find required D_{50} (min):

$$V_s = \left[q (\tan \alpha)^{7/6} \eta^{1/6} \Big/ \left\{ C g^{1/2} \left[(1-\eta)(G_s - 1) \cdot \cos\alpha \, (\tan\phi - \tan\alpha) \right]^{5/3} \right\} \right]^{2/3}$$

η = porosity $\doteq 0.33$ G_s = specific gravity = 2.64

$C = 0.22$. $\alpha = \tan^{-1}(0.2) = 11.31°$

Hence $D_{50} = 0.359' = 4.3''$

use Type B riprap with D_{50}(min) = 4.8"

* Note: Sec 1 – 7 were not analyzed since their side slope are mild.

(b) Between Sec. 9 & 10

T_c: flow length $l_1 \doteq 500$ $\Delta H/l_1 = (5264-5254)/500 = 0.02$

$l_2 = 50.$ $\Delta H/l_2 = 0.2$

$T_c = 0.0078\, l^{0.77}/(\frac{\Delta H}{l})^{0.385} = 4.2 + 0.3 = 4.5$ min, $I_{PMP} = 44.5$

$q = 1.0\,(44.5)(550/43560) = 0.56$ cfs/ft

D_{50} required:

1) Flow concentration factor = 1 $D_{50} = 3.0''$

2) " " " = 1.5 $D_{50} = 3.9''$

3) " " " = 2.0 $D_{50} = 4.7''$

Use Type B riprap — based on a flow concentration factor of 1.5 ~ 2.0

(c) Between 10 - 11.

T_c: Flow length $l_1 \doteq 560'$. $\Delta H/l_1 = (5264-5252)/560 = 0.0214$

$l_2 = 50$ $\Delta H/l_2 = 0.2$

$T_c = 4.5 + 0.3 = 4.8$ min, $I_{PMP} = 42.8$ in/hr

$q = 1.0\,(42.8)(610/43560) = 0.60$ cfs/ft

D_{50}:

1) flow concentration factor = 1 $D_{50} = 3.1''$

1.5 $D_{50} = 4.1''$

Use Type B riprap assuming a flow concentration factor of 1.5

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Sheet 55
Project UMTRA/GRJ
Contract No. 3884-3K
File No.
Feature Permanent Site Drainage
Designed FHW
Date 4/11/91
Item Off-Pile Drainage Swale
Checked HM
Date 4/22/91

(d) Between Sec. 11-12

Longest Length = 1130'

$\Delta H/L = (5276-5246)/1130 = 0.0265$

$T_c = 0.0078 \cdot (1130)^{0.77} / 0.0265^{0.385}$

$= 7.1$ min.

$I_{PMP} = 36.5$ in/hr

$q = 1.0\,(36.5)\,(1130/43560) = 0.95$ cfs/ft

At sec. 11 location, actually part of the water is turning away parallel to the swale (see sheet 7

so let flow concentration factor = 1

$D_{50} = 4.2''$ use Type B riprap.

(e) between Sec. 12-13

Flow is almost parallel to the swale, erosion potential is minimized. use Type B riprap along 5:1 slope.

i) Riprap for Invert and side slope on the upland side of the swale u/s of sec. 7

(a) Riprap required for these two portions of the swale will be based on the computations perfomed on item c. 1) - Riprap required based on PMP flow on the swale itself.

(b) use Type B riprap, D_{50} (min) = 4.8", 10" thick (see sheets 49 ~ 51 for gradation)

No bedding layer will be used for the invert and upland side slope of the swale since their protection are not as significant as the side slope on the embankment side where protection has been considered under erosion and scour conditions

e. Riprap (D_{50} (min)) Required on 2% Embankment Slope Due to Overland Flow :

The most critical location is near upstream side of sec. 5 of the swale.

Longest flow length, $\ell = 610'$, $S = 0.02$

T_c : SCS velocity method: for bare soil $V \doteq 1.5$ fps
for upland gully $V = 2.8$ fps

Assume average of above 2 condition, $V \doteq 2.1$ fps

$T_c = 610/(2.1 \times 60) \doteq 4.8$ min.

Kirpich Equ. $T_c = 0.0078 \cdot (610)^{0.77} / (0.02)^{0.385} = 5$ min

use $T_c = 5$ min, $I_{PMP} = 42.7$

$q = 1.0 (42.7)(610/43560) = 0.60$ cfs/ft

1) Assume no flow concentration since the embankment surface is to be protected by riprap (i.e. no gully will be developed)

$y = \left(\frac{nq}{1.486 S^{1/2}} \right)^{0.6}$, with $q = 0.60$ $n = 0.025$, + $S = 0.02$,

then $y = 0.21'$, $V = q/y = 2.9$ fps and tractive force $\tau = \gamma y S = 62.4(0.21)(0.02)$
$= 0.262$ lb/ft²

Based on critical tractive force and max. allowable velocity for the top soil in the embankment (see sheet 41), the flow condition is near the threshold condition and might cause erosion.

Riprap Required :

Based on Factor of Safety method for plane slope :

$\tau = 0.262$ lb/ft², θ = slope $= \tan^{-1}(0.02) = 1.146°$,

Let $D_{50} = 0.8''$. then $\phi \doteq 36°$. $\eta_s = 0.953$. S.F. = 1.13

2) If flow concentration is considered.

let flow concentration factor = 3, $q_c = 3q = 1.80$ cfs/ft

let $n = 0.025$. $y = \left(\frac{n q_c}{1.486 S^{1/2}}\right)^{3/5} = 0.40'$, $V = 4.6$ fps,

$\tau = \gamma y s = 62.4(0.40)(0.02) = 0.50$ lb/ft²

Let $D_{50} = 1.5"$, $\phi = 38°$, $\eta_s = 0.886$, S.F. = 1.10

$\theta = 1.146°$

check n value for $D_{50} = 1.5"$, $n \doteq 0.025$. O.K

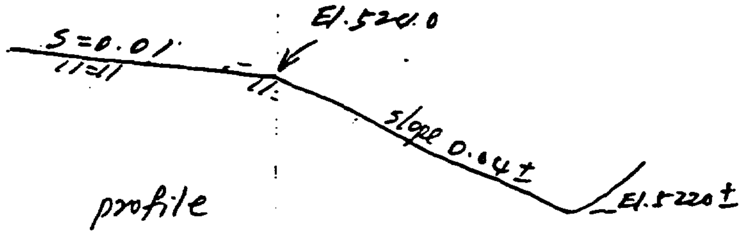
3) use Type A Riprap with D_{50}(min) = 1.7 inches (6 inch thick) for the 2% Embankment slope

use Bedding material – 6" thick

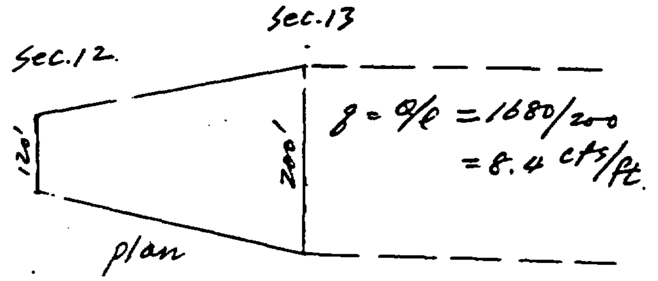
f. Erosion Protection at Swale Outlet

1) Evaluate Flow Conditions and Riprap Requirement Immediately upstream and downstream of the outlet:

Since the swale daylight at El. 5236.4, the flow become sheet flow at the outlet.



D/s of the daylight location, the slope is about 4 - 5 %.



$$q = \frac{1.486}{n} y^{5/3} S^{1/2}$$

(a) Immediately u/s (sec. 13)

$q = 8.4$ cfs/ft, $S \doteq 0.01$ let $n = 0.032$

then $y = 1.46'$. $\tau_{max} = 0.913$ lb/ft² $V = 6.0$ fps. $F_r = 0.88$

D_{50} required: use Safety Factor Method

Let $D_{50} = 4.6''$. $\eta_s = 0.940$; $\phi = 39°$. $\alpha = \tan^{-1}(0.04) = 2.29°$.

$$S.F = \frac{\cos\alpha \tan\phi}{\eta_s \tan\phi + \sin\alpha} = 1.01$$ check $n \doteq 0.033 \approx 0.032$

(b) Immediately D/s. $S=0.04$

$q = 8.4$ cfs. let $n=0.032$

$y=0.94'$ $\tau_{max} = 2.346$ lb/ft² $V=8.9$. $F_r=1.62$

D_{50} required: use Safety Factor method

$\alpha = \tan^{-1}(0.04) = 2.29^{\circ}$ $S.F. = \dfrac{\tan\phi \cos\alpha}{\eta_s \tan\phi + \sin\alpha}$.

Let $D_{50} = 6.2''$ $\phi = 39^{\circ}$ $\eta_s = 0.932$, $S.F. = 1.02$

(c) Use Type E riprap $D_{50} = 11''$ for outlet toe protection.

2) Toe Trench Dimension.

Assume no riprap protection immediately downstream of the outlet, then there is potential scour/erosion immediately downstream; potential depth of scour was estimated on sheets 60—61. A depth of 5' was estimated. Hence toe trench should be 5' depth with Type E riprap to be placed at Sec. 13, outlet location.

To reduce potential of scouring/gully development, Type C riprap will also be placed immediately downstream of the outlet toe protection for about 80' expanding on a 12:1 divergent angle. The rest of the area between type C riprap and creek C bank will be placed with oversize rock available.

3) Potential scour depth immediately downstream of the swale outlet

(a) By Critical Tractive force., $\tau_c = 0.6$ lb/ft² (for gravelly soil 3' below topsoil)

Stable slope:

$q = \frac{1.486}{n} \cdot y^{5/3} S_s^{1/2}$, $\tau_c = \gamma_w y S_s$, let $q = 3 \times 8.4 = 25.2$ cfs (Assume flow concentration factor = 3)

$\therefore S_s = \left\{ \frac{1.486 \ \tau_c^{5/3}}{n q \cdot (\gamma_w^{5/3})} \right\}^{6/7}$, let: $n = 0.03$, $\gamma_w = 62.4$.

then $S_s = 0.0023$

$y = 4.1'$ (scour depth to reach stable slope)

(b) By Max. allowable velocity –

Assume a triangular x-sec with 2:1 slope

$Q = 25.2$ cfs $V_a = 4.5$ fps

$A = 5.6$ ft² $= zy^2$ $y = 2.4'$

(C) Assume Lacey's Regime Eqn. Can be applied. (Ref. 10)

$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3}$, $d_s = z \cdot d_m$

d_m = mean flow depth. f = Lacey's silt factor $= 1.76 \sqrt{D_{50}(mm)}$, let $D_{50} = 10$ mm (gravelly soil) $= 5.6$

d_s = depth of scour

z = multiplying factor = 1.5 for moderate bend.

$Q = 1680$ cfs.

$\therefore d_m = 3.1'$ $d_s = 4.7$ ft

(d) Assume Zimmerman & Maniok Equation for local scour below a stilling basin is applicable here. (Ref. 10)

$$d_s\,(ft) = K \cdot \left(\frac{q^{0.82}}{D_{85}^{\;0.23}}\right)\left(\frac{y}{q^{2/3}}\right)^{0.93} - y, \text{ where}$$

Scour depth

y = tailwater depth

D_{85} = particles 85% finer (in mm)

q = discharge / unit width

$K = 1.95$

Assume a flow concentration factor of 3, then

$q = 25.2$ cfs/ft, $y = 1.75$ ft (d/s of outlet with a slope of 0.04 and $n = 0.03$)

let D_{85} (mm) $\doteq 10$ mm (assumed)

then $d_s = 2.0$ ft.

(e) U.S DOT equation for scour

$$D_s = 0.82\,(y_e)\left(\frac{Q}{y_e^{2.5}}\right)^{0.375}(T)^{0.1}$$

Let $Q = 3q = 25.2$ cfs, $T = 30$ min.

y_e = flow u/s. = 2.76' (for $s = 0.01$, $n = 0.032$)

Hence $D_s = 4.1$ ft

(f) Use a scour depth of 5 ft. (i.e. Toe Trench will be 5 ft depth).

6) Estimates of Riprap Quantity for outlet Erosion protection.

a) $D_{50}(min) = 11''$

$Vol./ft = \frac{1}{2}[10 + (5+10+5)] \cdot 5 = 75\ ft^3/ft = 2.8\ cy/ft$

$Quantity = 2.8 \times \frac{1}{2}(200 + 190)$

$= 550\ cy$

b) Type A Riprap ($D_{50}(min) = 1.7''$)

$Quantity = (\sqrt{5^2+5^2} + 10 + \sqrt{5^2+5^2}) \times 0.5 \times 200/27 = 90\ cy$

c) Type C Riprap ($D_{50}(min) = 4.8''$) 12" thick

$Quantity = 60 \times 220 \times 1\ /27 = 490\ cy$

d) Bedding materials

$Quantity = (\sqrt{5.5^2+5.5^2} + 10.5 + \sqrt{5.5^2+5.5^2}) \times 0.5 \times 200/27$

$= 95\ cy$

9. Evaluation of Flow Conditions on East Tributary at Swale Exit Location and Erosion Protection:

1) The PMF peak discharge on the natural drainage of the East Tributary had been estimated on a previous superseded calculation (05-659-01-02, "Disposal Site Erosion Protection, Riprap for Embankment and Drainage Ditch" (Ref. 8)) at a location with channel invert El. 5256. The estimated PMF peak discharge and other relevant parameters at this location are listed below:

   ① peak discharge = 2860 cfs
   ② D.A. = 673 Acres
   ③ Average slope of the channel = 0.03
   ④ Average flow depth = 3-6 ft
   ⑤ Average flow velocity = 9-11 ft/sec. and the flow condition was critical to supercritical.

2) The PMF peak discharge value near the swale exit (at about El. 5200 invert) can be extrapolated approximately as follow:

D.A. at about El. 5220 invert on Natural drainage

≈ 673 + D.A. from the swale ≐ 673+135.2 ≐ 810 Acres,

the PMP peak discharge on the East tributary at drainage swale exit is approximately $= 2860 \cdot \left(\frac{810}{673}\right)^{0.71 *}$

$\doteq 3260 \doteq 3300$ cfs

* peak discharge is approximately proportional to the drainage area ratio with an exponential constant of 0.71 in the area

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Project: UMTRA / GRJ	Contract No. 3885-34	Sheet 64	File No.
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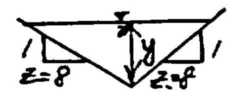
Item: Off-pile Drainage Swale	Checked: WYL	Date 11/15/90	

3) Assume a Triangular section at El. 5220 Location of the East Tributary. The side slope of the drainage channel is approximately 8:1.

then $y = \left[nQ/1.486 \cdot z \cdot \left(\frac{z}{2\sqrt{z^2+1}}\right)^{2/3} S^{1/2} \right]^{3/8}$



The Avg. slope of the East Tributary channel at El. 5220 invert location is about $S = 0.020$.

$Q = 3300$ cfs, $z = 8$, let $n = 0.040$.

then $\underline{y = 6.1'}$, $V = 11$ fps, $\tau_{max} = 7.64$ lb/ft², $F_r = 1.11$

Riprap protection required on the 8:1 side slope.

use Safety Factor Method:

$\theta = \tan^{-1}(\frac{1}{8}) = 7.125°$, $\alpha = \tan^{-1}(0.02) = 1.146°$, $\lambda = \sin^{-1}(\sin\alpha / \sin\theta) = 9.277°$

$\tau_{max} = 7.64$ lb/ft².

Let $D_{50} = 21''$ $\quad \eta_s = 21\,\tau_{max} / ((G_s - 1)\gamma_w \cdot D_{50}) = 0.948$, $\phi = 40°$. ($G_s = 2.55$)

$\beta = \tan^{-1}\left(\cos\lambda \Big/ \left(\frac{2\sin\theta}{\eta_s \tan\phi} + \sin\lambda\right)\right) = 64.4°$, $\quad S.F = \cos\theta \tan\phi \Big/ \left[0.5(1+\sin(\theta+\lambda))\eta_s \tan\phi + \sin\theta\cos\beta\right]$

$= 1.00$.

Use $\underline{D_{50} = 24''}$ considering 15% oversizing factor.

4) Potential Scour of the Tributary channel at swale exit Location:

a) Based on Critical Tractive Force

Assume $\tau_c = 0.6\ lb/ft^2$ (gravelly soil with some cobble).
By trial and error,
stable slope $\simeq 0.0008$, then

$y_{max} = 11.2$, $\tau = 0.56 < 0.60$ o.k. $V = 3.3$ fps.

Since $y = 6.1'$ before erosion occurred, so depth of scour $= 11.2 - 6.1 = 5.1$ ft.

b) Based on Max. allowable Velocity, $V_a = 4.5$ fps for gravelly soil

$z y^2 = Q/V_a$ $\quad 8y^2 = 3300/4.5$, $\quad y = 9.6'$

Scour $= 9.6 - 6.1 = 3.5$ ft

c) Assume Lacey's Regime Equation Can be applied here

$d_m = 0.47 (Q/f)^{1/3}$, $\quad d_s = z \cdot d_m$

d_m = mean flow depth, d_s = scour depth

z = multiply factor = 1.5 for moderate bend.

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

Q = discharge cfs

Assume $D_{50} = 10$ mm for gravelly soil

then $d_m = 3.95'$, $\quad d_s = 5.9'$

d) Use 6' as potential depth of scour

5) check flow from the swale:

At the bank of the creek, the flow will be spreaded in a width of about 270'. Hence $q = 1680/270 = 6.2$ cfs/ft.

Use Stephenson Method to evaluate D_{50} required:

$$D_{50} = \left[q (\tan\theta)^{7/6} (\eta)^{1/6} \Big/ \left\{ c\, g^{1/2} \left[(1-\eta)(G_s - 1) \cdot \cos\theta \, (\tan\phi - \tan\theta) \right]^{5/3} \right\} \right]^{2/3}$$

slope of the bank $\simeq 1/8 = 0.125$,
$\theta = \tan^{-1}(1/8) = 7.125°$, $c = 0.22$, $\eta = 0.33$ $G_s = 2.64$ $\phi = 40°$.

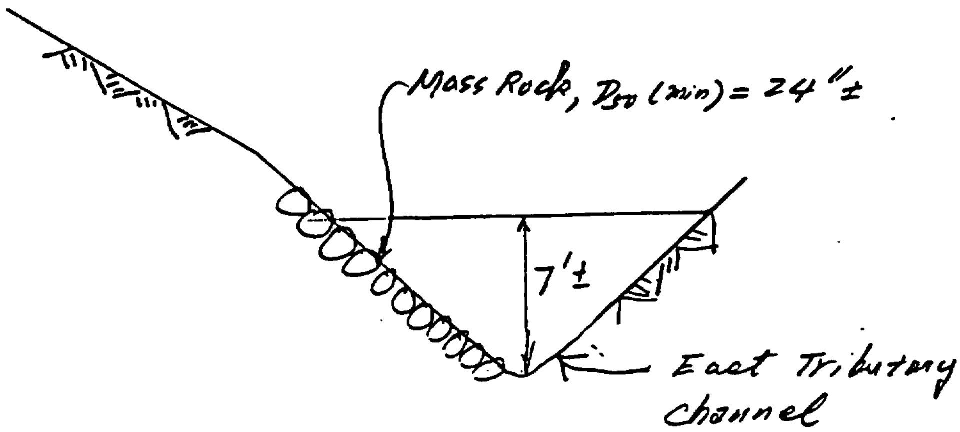
$D_{50} = 0.67' = 8.1''$

If flow concentration of 3 is considered, $q = 18.6$ cfs/ft

$D_{50} = 1.40' = \underline{17''}$

So the river flow controls ($D_{50} = 24''$) (see sheet 64)

6. Erosion protection along channel bank of the East Tributary (creek "C")



For D_{50} (min) = 24" Riprap

D_{100} (max) = 1.71 (24) = 41"

D_{100} (min) = 1.26 (24) = 30"

D_{25} (min) = 0.68 (24) = 16"

D_{50} (max) $\doteq \frac{1}{2}[D_{100}(max) + D_{100}(min)] \doteq 36$"

Layer Thickness: $T_{min} \doteq 1.9\ D_{50}$ (min) = 46"
= 1.5 D_{50} (max) = 54" (use this)

Note: Since scouring protection will be provided at the swale outlet location, it is suggested that ungraded mass rock with D_{50} (min) around 24" be placed along the tributary channel bank near the swale outlet.

APPENDIX A

Backwater Computation Along the Swale

1. PMP condition
2. 200-year Storm.
3. 100-year Storm
4. 25-year Storm.
5. 10-year Storm

Note: The purpose of the backwater computations was to evaluate flow condition (flow velocity and depth) under different storm conditions and to evaluate potential movement of sediment flowing into or deposited on the swale due to upland sediment yield

Appendix A - Backwater Computation along the swale

1. Method

The U.S. Army Corps of Engineers computer program "HEC-2, Water Surface profiles" was used to compute flow depths and velocities along the swale. The computations were done for the PMP, 100-yr, 25-yr and 10-yr storms.

2. Input Data

An weighted n value of 0.032 was used for all cross-sections. Critical flow was assumed at the starting section (the most downstream sec. 13) since the slope break there from 0.01 to a steep slope of about 0.04 ~0.05, and the sec. at sec 13 was widen. The flow was subcritical under the estimated n value.

Discharges at each section are varied according to the computed values. The PMP discharges at each section are shown on sheet 9. The peak discharges for the 100-yr, 25-yr and 10-yr storms are calculated as shown on sheet A-4.

Input cross-sectional data are shown on sheets A-6 + A-7 as part of the output for PMP condition.

3. Output

Summary input data and output for PMP are shown on sheets A-4 through A-8. Summary output for 200-yr, 100-yr,

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Project UMTRA/GRJ
Feature Permanent Site Drainage
Item Off-pile Drainage Swale

Contract No. 3885-34
Designed FHW
Checked HM

Sheet A-3
File No.
Date 4/11/91
Date 4/24/91

25-yr and 10-yr storms are shown on sheets A-10 through A-15. The flow velocity and flow depth under different storm conditions are summarized below.

(slope=0.01)
Sec. 5-13

Storm Condition	Avg V (fps)	Avg flow depth (ft)
PMP	6.5~7.7 fps	1.3~2.4 ft
200-yr storm	2.6-3.7 fps	0.3~0.76 ft
100-yr storm	2.5-3.6 fps	0.3~0.7 ft
25-yr storm	2.2~3.3 fps	0.25~0.6 ft
10-yr storm	2.1~3.1 fps	0.22~0.52 ft

Runoff contributing areas between sec 1~4 are relatively small and their channel slope is steeper and could have created supercritical flow. Their flows are not significant, and their values are not listed here since sediment contribution to these sec's will also be small.

2. Peak Discharges for 100-, 25- and 10-year Storms

use $Q = CIA$. , Assume T_c approx. the same as T_c under PMP condition for all location (approx.)
use $C = 0.65$ (Ref. 4).

Q = cfs
I = in/hr. A = Acres , I values obtained from sheet 28 based on T_c.

Sec.	A (Acres)	T_c (min)	100-yr		25-yr		10-yr	
			I_{100}	Q_{100}	I_{25}	Q_{25}	I_{10}	Q_{10}
2	2.3	6	4.7	7.0	3.6	5.3	3.0	4.4
3	7.9	13	3.46	18	2.7	14	2.2	11
4	14.4	13.5	3.42	32	2.65	25	2.15	20
5	100.5	30	2.26	148	1.75	115	1.44	94
6	101.5	31	2.21	148	1.71	115	1.40	94
7	115.6	31.7	2.16	162	1.69	127	1.40	105
8	121.5	31.7	2.16	170	1.69	133	1.40	110
9	123.0	32.1	2.15	172	1.68	134	1.40	112
10	124.5	32.6	2.13	172	1.67	135	1.38	112
11	126.0	33.0	2.10	172	1.65	135	1.35	112
12	130.1	33.5	2.09	177	1.62	137	1.34	113
13	135.2	34.5	2.06	177	1.60	140	1.32	116

Note: peak discharges for PMP are shown on sheet 38 and peak discharges for 200-yr storm are shown on sheet ~~ ~~ of Appendix C.

Sheet A-5

GRDCHPB.OT1 4/11/91 Page 1

```
*********************************************************
*  WATER SURFACE PROFILES                               *
*  VERSION OF SEPTEMBER 1988                            *
   RROR: 01,02                                          *
   DATED:  4 APRIL     1989                             *
    DATE      4/11/91    TIME     15:26:25              *
*********************************************************
```

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*****************************************
*  U.S. ARMY CORPS OF ENGINEERS         *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*  609 SECOND STREET, SUITE D           *
*  DAVIS, CALIFORNIA 95616-4687         *
*  (916) 756-1104, (916) 551-1748       *
*****************************************
```

UMTRA/GRJ
permanent Site Drainage
Off-pile Drainage Swale

TH/?
4/11/91
HM
4/24/91

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

END OF BANNER

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale

FHW 4/11/91
HM 4/22/91

THIS RUN EXECUTED 4/11/91 15:26:25

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*************************************************
HEC2 RELEASE DATED SEP 88 UPDATED APR  1989

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

Input Data

```
T1 UMTRA PROJECT/GRAND JUNCTION
T2 BACKWATER STUDY-LOCAL PMP
T3 OFF-PILE DRAINAGE SWALE(W/O SEDIMENT DEPOSITION)      FILE:GRDCHPB.DAT

J1  ICHECK     INQ       NINV      IDIR      STRT      METRIC    HVINS     Q        WSEL      FQ

      0         0          0         0        -1         0         0     1680.    5241.0

J2  NPROF      IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW      CHNIM     ITRACE

     -1         0         -1         0         0         0        -1        0         0         0

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

     38        43          8         1         2         5         4       25        26        17
     39        42         33        38        43         8         1        2         5        26
     17        39         42        33        68        67

    LPRNT     NUMSEC                    ********REQUESTED SECTION NUMBERS********

    -10       -10

NC     .032      .032      .032        .1        .3
X1       13         4        0.      200.        0.        0.        0.
X2     1680.
GR     5240.        0.    5236.4        0.    5236.4      200.     5240.      200.

X1       12         4        0.      160.      360.      360.      360.
X2     1670.
GR     5244.        0.     5240.       20.     5240.      140.     5244.      160.

X1       11         4        0.     150.0      200.      200.      200.
X2     1640.
GR     5246.        0.     5242.       20.     5242.     130.0     5246.     150.0

X1       10         4        0.     140.0      200.      200.      200.
X2     1630.
GR     5248.        0.     5244.       20.     5244.     120.0     5248.     140.0
```

UMTRA/GRJ
Permanent Site Drainage
off-pile Drainage Swale

FHW 4/11/91
HM 4/24/91

	9	4	0.	130.0	200.	200.	200.		
	1630.								
GR	5250.	0.	5246.	20.	5246.	110.0	5250.	130.0	
X1	8	4	0.	120.0	200.	200.	200.		
X2	1630.								
GR	5252.	0.	5248.	20.	5248.	100.0	5252.	120.0	
X1	7.75	4	0.	137.5	50.	50.	50.		
X2	1610.								
GR	5252.5	0.	5248.5	20.	5248.5	97.5	5252.5	137.5	
X1	7.5	4	0.	155.	50.	50.	50.		
X2	1590.								
GR	5253.0	0.	5249.0	20.	5249.	95.	5253.	155.0	
X1	7	4	0.	190.0	100.	100.	100.		
X2	1550.								
GR	5254.	0.	5250.	20.	5250.	90.0	5254.	190.0	
X1	6	4	0.	180.0	200.	200.	200.		
X2	1410.								
GR	5256.	0.	5252.	20.	5252.	80.0	5256.	180.0	
X1	5	4	0.	170.0	200.	200.	200.		
X2	1410.								
GR	5258.	0.	5254.	20.	5254.	70.0	5258.	170.0	
	4	4	0.	130.0	200.	200.	200.		
	360.								
	5259.	0.	5256.	15.	5256.	55.0	5259.	130.0	
X1	3	4	0.	93.33	160.	160.	160.		
X2	200.								
GR	5260.	0.	5258.	10.	5258.	43.33	5260.	93.33	
X1	2	4	0.	56.67	160.	160.	160.		
X2	94.								
GR	5261.	0.	5260.	5.	5260.	31.67	5261.	56.67	

Note: These two x-sec's are interpolated from sec. 8 + sec. 7

UMTRA/GRJ
Permanent Site Drainage
off-pile Drainage Swale

THW 4/11/91
HM 4/22/91

THIS RUN EXECUTED 4/11/91 15:26:29

****

HEC2 RELEASE DATED SEP 88 UPDATED APR 1989

output : PMP

ERROR CORR - 01,02
MODIFICATION -

****

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

OFFILE DRAINAGE SWALE, LOCAL PMP

SUMMARY PRINTOUT

	SECNO	Q (cfs)	Flow DEPTH (ft)	Computed W.S.El (ft) CWSEL	Critical W.S.El (ft) CRIWS	Energy slope 10^{-4} 10*KS	Top Width (ft) TOPWID	Flow Area (ft²) AREA	Flow Velocity (fps) VCH	Manning n 10^{-3} K*XNCH	Distance between Sec's (ft) XLCH	Invert El (ft) ELMIN	Channel slope 10^{-3} K*CHSL
*	13.000	1680.00	1.29	5237.69	5237.69	141.70	200.00	258.40	6.50	32.00	.00	5236.40	.00
	12.000	1670.00	1.90	5241.90	5241.77	99.44	139.04	246.58	6.77	32.00	360.00	5240.00	10.00
	11.000	1640.00	1.93	5243.93	5243.85	109.26	129.25	230.32	7.12	32.00	200.00	5242.00	10.00
	10.000	1630.00	2.05	5246.05	5245.95	104.01	120.54	226.52	7.20	32.00	200.00	5244.00	10.00
	9.000	1630.00	2.14	5248.14	5248.08	111.56	111.35	214.92	7.58	32.00	200.00	5246.00	10.00
	8.000	1630.00	2.30	5250.30	5250.22	107.56	103.02	210.68	7.74	32.00	200.00	5248.00	10.00
✝	7.750	1610.00	2.52	5251.02	5250.70	75.37	115.35	243.32	6.62	32.00	50.00	5248.50	10.00
✝	7.500	1590.00	2.42	5251.42	5251.17	83.75	123.45	240.36	6.62	32.00	50.00	5249.00	10.00
	7.000	1550.00	2.34	5252.34	5252.11	87.94	140.06	245.30	6.32	32.00	100.00	5250.00	10.00
	6.000	1410.00	2.23	5254.23	5254.13	110.62	126.78	207.90	6.78	32.00	200.00	5252.00	10.00
	5.000	1410.00	2.40	5256.40	5256.29	106.84	122.14	206.98	6.81	32.00	200.00	5254.00	10.00
	4.000	360.00	2.23	5258.23	5257.16	12.81	106.78	163.37	2.20	32.00	200.00	5256.00	10.00
*	3.000	200.00	.89	5258.89	5258.89	173.40	60.14	41.76	4.79	32.00	160.00	5258.00	12.50
	2.000	94.00	.90	5260.90	5260.64	51.54	53.90	36.57	2.57	32.00	160.00	5260.00	12.50

✝ X-sec's interpolated

GRDCHPB.OT1 4/11/91 Page 5

UNTRA/GRJ
Permanent site Drainage
Off-site Drainage swale
output - PMP

Sheet A-9

4/11/91 15:26:25

PAGE 4

FHW 4/11/91
HM 4/24/91

[illegible] E DRAINAGE SWALE, LOCAL PMP

SUMMARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	VCH	K*XNCH	XLCH	ELMIN	K*CHSL	FRCH (Froude No.)	SHEAR (Avg shear force (lb/ft2))
*	13.000	1680.00	1.29	5237.69	5237.69	141.70	6.50	32.00	.00	5236.40	.00	1.01	1.14
	12.000	1670.00	1.90	5241.90	5241.77	99.44	6.77	32.00	360.00	5240.00	10.00	.90	1.10
	11.000	1640.00	1.93	5243.93	5243.85	109.26	7.12	32.00	200.00	5242.00	10.00	.94	1.21
	10.000	1630.00	2.05	5246.05	5245.95	104.01	7.20	32.00	200.00	5244.00	10.00	.93	1.22
	9.000	1630.00	2.14	5248.14	5248.08	111.56	7.58	32.00	200.00	5246.00	10.00	.96	1.34
	8.000	1630.00	2.30	5250.30	5250.22	107.56	7.74	32.00	200.00	5248.00	10.00	.95	1.37
	7.750	1610.00	2.52	5251.02	5250.70	75.37	6.62	32.00	50.00	5248.50	10.00	.80	.99
	7.500	1590.00	2.42	5251.42	5251.17	83.75	6.62	32.00	50.00	5249.00	10.00	.84	1.02
	7.000	1550.00	2.34	5252.34	5252.11	87.94	6.32	32.00	100.00	5250.00	10.00	.84	.96
	6.000	1410.00	2.23	5254.23	5254.13	110.62	6.78	32.00	200.00	5252.00	10.00	.93	1.13
	5.000	1410.00	2.40	5256.40	5256.29	106.84	6.81	32.00	200.00	5254.00	10.00	.92	1.13
	4.000	360.00	2.23	5258.23	5257.16	12.81	2.20	32.00	200.00	5256.00	10.00	.31	.12
*	3.000	200.00	.89	5258.89	5258.89	173.40	4.79	32.00	160.00	5258.00	12.50	1.01	.75
	2.000	94.00	.90	5260.90	5260.64	51.54	2.57	32.00	160.00	5260.00	12.50	.55	.22

A-10

4/12/91 15:20: 0

UMTRA/GRJ
Permanent Site Drainage
off-pile Drainage Swale

FHW 4/11/91
HM 4/12/91

THIS RUN EXECUTED 4/12/91 15:20: 7

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HEC2 RELEASE DATED SEP 88 UPDATED APR 1989

ERROR CORR - 01,02
MODIFICATION -

****

output – 200-yr storm

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

OFFPILE DRAINAGE SWALE, 200-YEAR STORM

SUMMARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	TOPWID	AREA	VCH	K*XNCH	XLCH	ELMIN	K*CHSL
*	13.000	194.00	.31	5236.71	5236.71	225.34	200.00	61.33	3.16	32.00	.00	5236.40	.00
*	12.000	194.00	.61	5240.61	5240.43	62.16	126.09	74.98	2.59	32.00	360.00	5240.00	10.00
*	11.000	193.00	.47	5242.47	5242.46	170.61	114.73	53.17	3.63	32.00	200.00	5242.00	10.00
	10.000	193.00	.65	5244.65	5244.48	70.96	106.50	67.15	2.87	32.00	200.00	5244.00	10.00
	9.000	193.00	.56	5246.56	5246.52	144.77	95.60	51.93	3.72	32.00	200.00	5246.00	10.00
	8.000	193.00	.72	5248.72	5248.56	79.69	87.16	59.87	3.22	32.00	200.00	5248.00	10.00
	7.750	191.00	.66	5249.16	5249.06	110.82	87.31	53.92	3.54	32.00	50.00	5248.50	10.00
	7.500	189.00	.70	5249.70	5249.57	96.07	88.75	56.29	3.36	32.00	50.00	5249.00	10.00
	7.000	185.00	.68	5250.68	5250.57	101.16	90.61	55.17	3.35	32.00	100.00	5250.00	10.00
	6.000	165.00	.70	5252.70	5252.58	100.65	80.99	49.33	3.35	32.00	200.00	5252.00	10.00
	5.000	165.00	.76	5254.76	5254.65	106.64	72.71	46.43	3.55	32.00	200.00	5254.00	10.00
*	4.000	36.00	.51	5256.51	5256.28	29.16	55.50	24.67	1.46	32.00	200.00	5256.00	10.00
*	3.000	20.00	.22	5258.22	5258.22	259.81	39.79	7.87	2.54	32.00	160.00	5258.00	12.50
	2.000	7.50	.25	5260.25	5260.13	35.59	34.04	7.46	1.01	32.00	160.00	5260.00	12.50

Permanent Site Drainage
Off-pile Drainage Swale
output - 200 yr Storm HM 4/25/91

THW 4/11/91

LE DRAINAGE SWALE, 200-YEAR STORM

SUMMARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	VCH	K*XNCH	XLCH	ELMIN	K*CHSL	FRCH	SHEAR
*	13.000	194.00	.31	5236.71	5236.71	225.34	3.16	32.00	.00	5236.40	.00	1.01	.43
*	12.000	194.00	.61	5240.61	5240.43	62.16	2.59	32.00	360.00	5240.00	10.00	.59	.23
*	11.000	193.00	.47	5242.47	5242.46	170.61	3.63	32.00	200.00	5242.00	10.00	.94	.49
*	10.000	193.00	.65	5244.65	5244.48	70.96	2.87	32.00	200.00	5244.00	10.00	.64	.28
	9.000	193.00	.56	5246.56	5246.52	144.77	3.72	32.00	200.00	5246.00	10.00	.89	.49
	8.000	193.00	.72	5248.72	5248.56	79.69	3.22	32.00	200.00	5248.00	10.00	.69	.34
	7.750	191.00	.66	5249.16	5249.06	110.82	3.54	32.00	50.00	5248.50	10.00	.79	.43
	7.500	189.00	.70	5249.70	5249.57	96.07	3.36	32.00	50.00	5249.00	10.00	.74	.38
	7.000	185.00	.68	5250.68	5250.57	101.16	3.35	32.00	100.00	5250.00	10.00	.76	.38
	6.000	165.00	.70	5252.70	5252.58	100.65	3.35	32.00	200.00	5252.00	10.00	.76	.33
	5.000	165.00	.76	5254.76	5254.65	106.64	3.55	32.00	200.00	5254.00	10.00	.78	.42
	4.000	36.00	.51	5256.51	5256.28	29.16	1.46	32.00	200.00	5256.00	10.00	.39	.08
*	3.000	20.00	.22	5258.22	5258.22	259.81	2.54	32.00	160.00	5258.00	12.50	1.01	.32
	2.000	7.50	.25	5260.25	5260.13	35.59	1.01	32.00	160.00	5260.00	12.50	.38	.05

Sheet A-12

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale

4/11/91 15:27:33

PAGE 3

FHW 4/11/91
HM 4/24/91

THIS RUN EXECUTED 4/11/91 15:27:37

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HEC2 RELEASE DATED SEP 88 UPDATED APR 1989

ERROR CORR - 01,02
MODIFICATION -

****

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

OFFPILE DRAINAGE SWALE - 100 YEAR STORM

SUMMARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	TOPWID	AREA	VCH	K*XNCH	XLCH	ELMIN	K*CHSL
*	13.000	177.00	.29	5236.69	5236.69	238.90	200.00	57.03	3.10	32.00	.00	5236.40	.00
*	12.000	177.00	.59	5240.59	5240.40	60.18	125.83	71.60	2.47	32.00	360.00	5240.00	10.00
*	11.000	172.00	.43	5242.43	5242.42	179.45	114.35	48.80	3.52	32.00	200.00	5242.00	10.00
	10.000	172.00	.61	5244.61	5244.45	68.45	106.14	63.26	2.72	32.00	200.00	5244.00	10.00
	9.000	172.00	.51	5246.51	5246.48	151.74	95.15	47.69	3.61	32.00	200.00	5246.00	10.00
	8.000	170.00	.67	5248.67	5248.51	76.13	86.73	56.13	3.03	32.00	200.00	5248.00	10.00
	7.750	168.00	.60	5249.10	5249.02	115.78	86.48	49.08	3.42	32.00	50.00	5248.50	10.00
	7.500	166.00	.65	5249.65	5249.52	91.61	87.92	52.62	3.15	32.00	50.00	5249.00	10.00
	7.000	162.00	.62	5250.62	5250.53	105.51	88.85	49.91	3.25	32.00	100.00	5250.00	10.00
	6.000	148.00	.67	5252.67	5252.55	98.64	79.83	46.22	3.20	32.00	200.00	5252.00	10.00
	5.000	148.00	.70	5254.70	5254.60	106.46	71.36	43.20	3.43	32.00	200.00	5254.00	10.00
*	4.000	32.00	.47	5256.47	5256.26	30.98	54.24	22.36	1.43	32.00	200.00	5256.00	10.00
*	3.000	18.00	.20	5258.20	5258.20	278.93	39.28	7.20	2.50	32.00	160.00	5258.00	12.50
	2.000	7.00	.24	5260.24	5260.12	34.90	33.79	7.17	.98	32.00	160.00	5260.00	12.50

sheet A-13

4/11/91 15:27:33

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale

PAGE 4
FHW 4/11/91
MM 4/24/91

r '.E DRAINAGE SWALE - 100 -YEAR STORM

SUMMARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	VCH	K*XNCH	XLCH	ELMIN	K*CHSL	FRCH	SHEAR
*	13.000	177.00	.29	5236.69	5236.69	238.90	3.10	32.00	.00	5236.40	.00	1.02	.43
*	12.000	177.00	.59	5240.59	5240.40	60.18	2.47	32.00	360.00	5240.00	10.00	.58	.21
*	11.000	172.00	.43	5242.43	5242.42	179.45	3.52	32.00	200.00	5242.00	10.00	.95	.48
*	10.000	172.00	.61	5244.61	5244.45	68.45	2.72	32.00	200.00	5244.00	10.00	.62	.25
*	9.000	172.00	.51	5246.51	5246.48	151.74	3.61	32.00	200.00	5246.00	10.00	.90	.47
	8.000	170.00	.67	5248.67	5248.51	76.13	3.03	32.00	200.00	5248.00	10.00	.66	.31
	7.750	168.00	.60	5249.10	5249.02	115.78	3.42	32.00	50.00	5248.50	10.00	.80	.41
	7.500	166.00	.65	5249.65	5249.52	91.61	3.15	32.00	50.00	5249.00	10.00	.72	.34
	7.000	162.00	.62	5250.62	5250.53	105.51	3.25	32.00	100.00	5250.00	10.00	.76	.37
	6.000	148.00	.67	5252.67	5252.55	98.64	3.20	32.00	200.00	5252.00	10.00	.74	.36
	5.000	148.00	.70	5254.70	5254.60	106.46	3.43	32.00	200.00	5254.00	10.00	.78	.40
	4.000	32.00	.47	5256.47	5256.26	30.98	1.43	32.00	200.00	5256.00	10.00	.39	.08
*	3.000	18.00	.20	5258.20	5258.20	278.93	2.50	32.00	160.00	5258.00	12.50	1.03	.32
	2.000	7.00	.24	5260.24	5260.12	34.90	.98	32.00	160.00	5260.00	12.50	.37	.05

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale

sheet A-14

4/11/91 15:28: 2

PAGE 3

FHW 4/11/91
HM 4/24/91

THIS RUN EXECUTED 4/11/91 15:28: 7

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HEC2 RELEASE DATED SEP 88 UPDATED APR 1989

ERROR CORR - 01,02
MODIFICATION -

****

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

OFFPILE DRAINAGE SWALE - 25-YEAR STORM

SUMMARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	TOPWID	AREA	VCH	K*XNCH	XLCH	ELMIN	K*CHSL
*	13.000	140.00	.25	5236.65	5236.65	245.73	200.00	49.12	2.85	32.00	.00	5236.40	.00
*	12.000	137.00	.51	5240.51	5240.34	58.01	125.05	61.92	2.21	32.00	360.00	5240.00	10.00
*	11.000	135.00	.37	5242.37	5242.36	190.69	113.70	41.34	3.27	32.00	200.00	5242.00	10.00
	10.000	135.00	.54	5244.54	5244.38	65.75	105.38	55.20	2.45	32.00	200.00	5244.00	10.00
*	9.000	134.00	.44	5246.44	5246.41	161.02	94.36	40.19	3.33	32.00	200.00	5246.00	10.00
*	8.000	133.00	.59	5248.59	5248.44	73.11	85.89	48.84	2.72	32.00	200.00	5248.00	10.00
	7.750	132.00	.52	5249.02	5248.94	118.63	85.23	41.91	3.15	32.00	50.00	5248.50	10.00
	7.500	131.00	.56	5249.56	5249.44	89.94	86.30	45.56	2.88	32.00	50.00	5249.00	10.00
	7.000	127.00	.54	5250.54	5250.46	108.82	86.22	42.22	3.01	32.00	100.00	5250.00	10.00
	6.000	115.00	.59	5252.59	5252.46	94.79	77.34	39.70	2.90	32.00	200.00	5252.00	10.00
	5.000	115.00	.61	5254.61	5254.51	109.94	68.33	36.14	3.18	32.00	200.00	5254.00	10.00
*	4.000	25.00	.41	5256.41	5256.22	31.92	52.25	18.83	1.33	32.00	200.00	5256.00	10.00
*	3.000	14.00	.10	5258.10	.00	1674.26	36.35	3.50	3.99	32.00	160.00	5258.00	12.50
*	2.000	5.30	.26	5260.26	5260.11	13.73	34.61	8.11	.65	32.00	160.00	5260.00	12.50

Sheet A- 15

4/11/91 15:28: 2

UMTRA/GRJ
Permanent Site Drainage
off-pile Drainage Swale

FHW 4/11/91
HM 4/24/91

[illegible] E DRAINAGE SWALE - 25-YEAR STORM

SUMMARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	VCH	K*XNCH	XLCH	ELMIN	K*CHSL	FRCH	SHEAR
*	13.000	140.00	.25	5236.65	5236.65	245.73	2.85	32.00	.00	5236.40	.00	1.01	.38
*	12.000	137.00	.51	5240.51	5240.34	58.01	2.21	32.00	360.00	5240.00	10.00	.55	.18
*	11.000	135.00	.37	5242.37	5242.36	190.69	3.27	32.00	200.00	5242.00	10.00	.95	.43
*	10.000	135.00	.54	5244.54	5244.38	65.75	2.45	32.00	200.00	5244.00	10.00	.60	.21
*	9.000	134.00	.44	5246.44	5246.41	161.02	3.33	32.00	200.00	5246.00	10.00	.90	.43
*	8.000	133.00	.59	5248.59	5248.44	73.11	2.72	32.00	200.00	5248.00	10.00	.64	.26
	7.750	132.00	.52	5249.02	5248.94	118.63	3.15	32.00	50.00	5248.50	10.00	.79	.36
	7.500	131.00	.56	5249.56	5249.44	89.94	2.88	32.00	50.00	5249.00	10.00	.70	.30
	7.000	127.00	.54	5250.54	5250.46	108.82	3.01	32.00	100.00	5250.00	10.00	.76	.33
	6.000	115.00	.59	5252.59	5252.46	94.79	2.90	32.00	200.00	5252.00	10.00	.71	.30
	5.000	115.00	.61	5254.61	5254.51	109.94	3.18	32.00	200.00	5254.00	10.00	.77	.36
	4.000	25.00	.41	5256.41	5256.22	31.92	1.33	32.00	200.00	5256.00	10.00	.39	.07
*	3.000	14.00	.10	5258.10	.00	1674.26	3.99	32.00	160.00	5258.00	12.50	2.27	1.01
*	2.000	5.30	.26	5260.26	5260.11	13.73	.65	32.00	160.00	5260.00	12.50	.24	.02

UMTRA/GRJ
Permanent Site Drainage
Off-pile Drainage Swale

4/11/91 15:28:52

THW 4/11/91
HN 4/24/91

THIS RUN EXECUTED 4/11/91 15:28:56

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HEC2 RELEASE DATED SEP 88 UPDATED APR 1989

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

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

OFFPILE DRAINAGE SWALE , 10-YEAR STORM

SUMMARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	TOPWID	AREA	VCH	K*XNCH	XLCH	ELMIN	K*CHSL
*	13.000	116.00	.22	5236.62	5236.62	235.59	200.00	44.43	2.61	32.00	.00	5236.40	.00
*	12.000	113.00	.45	5240.45	5240.30	58.53	124.49	54.92	2.06	32.00	360.00	5240.00	10.00
*	11.000	112.00	.33	5242.33	5242.32	189.74	113.31	36.96	3.03	32.00	200.00	5242.00	10.00
	10.000	112.00	.48	5244.48	5244.33	65.72	104.81	49.25	2.27	32.00	200.00	5244.00	10.00
*	9.000	112.00	.39	5246.39	5246.36	161.21	93.92	36.01	3.11	32.00	200.00	5246.00	10.00
*	8.000	110.00	.53	5248.53	5248.39	72.44	85.27	43.58	2.52	32.00	200.00	5248.00	10.00
	7.750	109.00	.46	5248.96	5248.89	118.47	84.40	37.23	2.93	32.00	50.00	5248.50	10.00
	7.500	107.00	.50	5249.50	5249.39	88.68	85.07	40.29	2.66	32.00	50.00	5249.00	10.00
	7.000	105.00	.48	5250.48	5250.40	111.31	84.41	37.10	2.83	32.00	100.00	5250.00	10.00
	6.000	94.00	.52	5252.52	5252.41	91.54	75.59	35.22	2.67	32.00	200.00	5252.00	10.00
	5.000	94.00	.54	5254.54	5254.46	114.21	66.14	31.25	3.01	32.00	200.00	5254.00	10.00
*	4.000	20.00	.36	5256.36	5256.19	30.85	50.87	16.46	1.21	32.00	200.00	5256.00	10.00
*	3.000	11.00	.15	5258.15	5258.15	271.93	37.81	5.31	2.07	32.00	160.00	5258.00	12.50
	2.000	4.40	.18	5260.18	.00	37.14	32.00	5.21	.84	32.00	160.00	5260.00	12.50

Sheet A-17

4/11/91 15:28:52

UMTRA/GRJ
Permanent Site Drainage
off-pile Drainage Swale

FHW 4/11/91
HM 4/24/91

ILE DRAINAGE SWALE, 10-YEAR STORM

ARY PRINTOUT

	SECNO	Q	DEPTH	CWSEL	CRIWS	10*KS	VCH	K*XNCH	XLCH	ELMIN	K*CHSL	FRCH	SHEAR
*	13.000	116.00	.22	5236.62	5236.62	235.59	2.61	32.00	.00	5236.40	.00	.98	.33
*	12.000	113.00	.45	5240.45	5240.30	58.53	2.06	32.00	360.00	5240.00	10.00	.55	.16
*	11.000	112.00	.33	5242.33	5242.32	189.74	3.03	32.00	200.00	5242.00	10.00	.93	.39
*	10.000	112.00	.48	5244.48	5244.33	65.72	2.27	32.00	200.00	5244.00	10.00	.58	.19
*	9.000	112.00	.39	5246.39	5246.36	161.21	3.11	32.00	200.00	5246.00	10.00	.89	.39
*	8.000	110.00	.53	5248.53	5248.39	72.44	2.52	32.00	200.00	5248.00	10.00	.62	.23
	7.750	109.00	.46	5248.96	5248.89	118.47	2.93	32.00	50.00	5248.50	10.00	.78	.33
	7.500	107.00	.50	5249.50	5249.39	88.68	2.66	32.00	50.00	5249.00	10.00	.68	.26
	7.000	105.00	.48	5250.48	5250.40	111.31	2.83	32.00	100.00	5250.00	10.00	.75	.31
	6.000	94.00	.52	5252.52	5252.41	91.54	2.67	32.00	200.00	5252.00	10.00	.69	.27
	5.000	94.00	.54	5254.54	5254.46	114.21	3.01	32.00	200.00	5254.00	10.00	.77	.34
	4.000	20.00	.36	5256.36	5256.19	30.85	1.21	32.00	200.00	5256.00	10.00	.38	.06
*	3.000	11.00	.15	5258.15	5258.15	271.93	2.07	32.00	160.00	5258.00	12.50	.97	.24
	2.000	4.40	.18	5260.18	.00	37.14	.84	32.00	160.00	5260.00	12.50	.37	.04

4. Flow velocity for the assumed gully as presented on sheet 40 for 100-, 25- and 10-yr storm. (see note below):

1) 100-yr. peak discharge

$T_c = 17$ min. $I_{100} = 3.0$ in/hr., $A = 20.1$ Ac

$Q_{100} = CIA = 0.65(3.0)(20.1) = 39$ cfs

$$y = \left\{ Qn / 1.486 \cdot z \cdot \left(\frac{z}{2\sqrt{z^2+1}}\right)^{2/3} S^{1/2} \right\}^{3/8}$$

let $n = 0.03$, $z = 5$ $S = 0.025$

then $y = 1.19'$ $V = 5.5$ fps

2) 25-yr peak discharge

$T_c = 17$ min. $I_{25} = 2.38$ in/hr. $A = 20.1$ Ac

$Q_{25} = 0.65 \cdot 2.38 \, 20.1 = 31$ cfs

for $n = 0.03$, $z = 5$ $S = 0.025$, then

$y = 1.10'$, $V = 5.2$ fps

3) 10-yr peak discharge

$T_c = 17$ min., $I_{10} = 1.93$ in/hr, $A = 20.1$ Ac

$Q_{10} = 0.65 \cdot 1.93 \, 20.1 = 25$ cfs

for $n = 0.03$, $z = 5$ $S = 0.025$ then

$y = 1.01'$, $V = 4.9$ fps

Note: The purpose of this cal. is to show what range of sediment size might be move under 100-, 25- and 10-yrs storms based on permissible velocity shown on sheet A-19.

4). For 200-yr storm, $V = 6.5$ fps (see sheet C-12 appendix C)
For PMP. $V = 11.5$ fps, see sheet 40.

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA/GRJ
Feature Permanent site Drainage
Item Off-pile Drainage

Contract No. 3885-34
Designed FHW
Checked WYL

Sheet A-17
File No.
Date 12/13/90
Date 12/21/90

5. Evaluation of sediment movement:

a. Top soil on the upland area:

Based on the gradation curves presented on sheets D-11 to D-13, the size distribution and permissible velocity for the corresponding grain size (non-cohesive soil) from Ref. 7 are summarized below:

range of Grain size from 3 samples (mm)	% finer	permissible velocity (fps)
80	100	8.2
7-15	95	3-4
0.9-6.6	90	1.7-2.8
0.25-2.0	85	1.0-2.0
0.15-0.3	80	0.9-1.1
0.09-0.13	70	0.8
0.07-0.08	60	0.75
0.04-0.055	50	0.7

Based on above table and potential gully velocity as shown on sheet A-18 most of the top soil that will be showed would be less than 15 mm which could also be flushed away from the swale itself under 10 to 200-yr storm conditions as evident from the velocities computed from the HEC-2 output (see sheets A-3, & A-5 thru A-17). Hence the swale itself should be able to flush away most of the sediment produced from upland area (90% of the top soils are finer than 7 mm) except larger particles. Potential sediment yields from upland area above the swale are estimated in Appendix B.

MKS

Appendix B

Evaluation of Potential Sediment Yield from the upland Area of the swale

purpose : 1. To assess accumulated sediment volumes in 200- & 1000-yrs period

2. To assess how long the sediment can be accumulated in the swale before it's filled (assume no flushing capability)

Appendix B —
Evaluation of potential sediment yield from the upland area

a. Method

Sediment yields at different locations along the swale will be estimated using the Universal Soil Loss Equation:

$$\text{Soil Loss} = R \cdot K \cdot LS \cdot CM \quad (\text{tons/Ac/yr}) \quad (\text{Ref. 11})$$

where R = Rainfall factor (ft-tons/acre/hr)

K = Soil Erodibility factor (tons/Ac/yr/unit R)

LS = Topographic (slope-length) factor (Dimensionless)

VM = Erosion Control factor (Dimensionless)

For Grandjunction site. R = 16 (Ref. 11), see sheet B-7

K = 0.32, see sheets B-8 to B-12.

and VM = 0.2 — [Based on observation of photographs and reconnaissance of the site, it appears that a minimum of 30% ground covered with herbaceous plants, 0% tall weed: > 0.5 m, and From Fig. 2-9 Ref. 11 (see sheet B-13) VM = 0.2]

LS factor will be estimated separately from each segment of the swale.

R K and VM values will be assumed to be applicable to all area

b. Sediment Inflow Volume at Different parts of the Swale (Note: sediment yields were estimated based on location ① through ⑫ as shown on sheet 23 instead of sec. 1 thru 13)

1) Location ①-② (160')

D.A. = 2.27 Ac = 98,880 ft^2,

weight l = 98,880/160 = 618 ft

$$LS \text{ factor} = \left\{ \frac{65.41\, S^2}{S^2+10,000} + \frac{4.56(S)}{\sqrt{S^2+10,000}} + 0.065 \right\} \left(\frac{l}{72.6}\right)^m \quad \text{(Ref. 11)}$$

where S = slope in % for simplified computation, assume S = 3% for all computation (actually around 2-3%)

l = length of slope segment (Assume one slope segment for simplified computation)

m = 0.3 for slope 1-3% (Ref. 11).

So $LS = 0.26 \left(\frac{l}{72.6}\right)^{0.3}$

$\therefore LS = 0.26 \left(\frac{618}{72.6}\right)^{0.3} = 0.26 \cdot 1.9 = 0.494$

Soil Loss (sec 1-2) = R·K·LS·VM

= (16)(0.32)(0.494)(0.2) = 0.51 ton/yr/Ac

let γ_{soil} = 100 lb/ft³
1 ton = 2000 lb.

= 10.2 ft³/yr/Ac = 23.2 ft³/yr

2) Location ②-③ (160 ft)

D.A. = 7.94 − 2.27 = 5.67 Ac = 246,985 ft^2

weighted l = 246,985/160 = 1544' $\left(\frac{l}{72.6}\right)^{0.3} = 2.5$

LS = 0.26·2.5 = 0.65

Soil Loss = (16)(0.32)(0.65)(0.2) = 0.67 ton/yr/Ac

= 13.3 ft³/yr/Ac = 75.5 ft³/yr

MORRISON-KNUDSEN ENGINEERS, INC.
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Project	UMTRA/GRT	Contract No.	3885-34	Sheet	B-4
Feature	Permanent Site Drainage	Designed	FHW	Date	11/12/90
Item	Off-pile Drainage Swale	Checked	WVL	Date	11/15/90

3) Location ③-④ (160')

D. A. = 14.4 - 7.94 = 6.46 Ac = 281,398 ft²

weighted l = 281,398/160 = 1759', $\left(\frac{l}{72.6}\right)^{0.3}$ = 2.6

LS = 0.26 · 2.6 = 0.68

Soil Loss = (16) (0.32) (0.68) (0.2) = 0.70 tons/yr/Ac

= 13.9 ft³/yr/Ac = 89.5 ft³/yr

4) Location ④-⑦ (750 ft)

D.A. = 121.4 - 14.4 = 107 Ac = 4,660,920 ft²

weighted l = 4,660,920/750 = 6215 ft $\left(\frac{l}{72.6}\right)^{0.3}$ = 3.8

LS = (0.26)(3.8) = 0.99

Soil Loss = (16)(0.32) (0.99) (0.2) = 1.01 tons/yr/Ac

= 20.2 ft³/yr/Ac = 2165 ft³/yr

5) Location ⑦-⑩ (600 ft)

D. A. = 125.9 - 121.4 = 4.5 Ac = 196,020 ft²

weighted l = 196,020/600 = 327 ft $\left(\frac{l}{72.6}\right)^{0.3}$ = 1.57

LS = 0.26(1.57) = 0.41

Soil Loss = (16)(0.32) (0.41) (0.2) = 0.42 tons/yr/Ac

= 8.4 ft³/yr/Ac = 38 ft³/yr.

6) Location ⑩-⑫ (470 ft)

D. A. = 135.2 - 125.9 = 9.3 Ac = 405,108 ft²

weighted l = 862 ft. $\left(\frac{l}{72.6}\right)^{0.3}$ = 2.10

LS = 0.26 (2.10) = 0.55

Soil Loss = (16) (0.32) (0.55) (0.2) = 0.56 tons/yr/Ac

= 11.2 ft³/yr/Ac = 104 ft³/yr

7). Summary of Sediment Inflow

Location	Sediment Yield ft³/yr	Length (ft)	Sediment Yield/ft. ft³/yr/ft	Sed Yield 100-yr (ft³/ft)	Sed Yield 200-yr (ft³)	Sed Yield 1000-yr (ft³)
①-②	23	160	0.144	14.4	4600	23,000
②-③	76	160	0.475	47.5	15,200	76,000
③-④	90	160	0.563	56.3	18,000	90,000
④-⑦	2165	750	2.887	288.7	433,000	2165,000
⑦-⑩	38	600	0.063	6.3	7600	38,000
⑩-⑫	104	470	0.221	22.1	20800	104,000
Total	2496 ft³	2300 ft			499,200 ft³	2,496,000 ft³

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Project UMTRA/GRJ — Contract No. 3885-34 — Sheet B-6 — File No.

Feature Embankment Design — Designed FHW — Date 4/12/9[illegible]

Item Off-pile Drainage Swale — Checked — Date

c. Estimate of Capacity (Volume) of the Swale.

Sec No.	Approx Height on 5:1 side Slope (ft)	Bottom width (ft)	Side slope upland side	Top width (ft)	X-sec Area (ft^2)	Distance (ft)	Volume (ft^3)	Accum. Vol. (ft^3)
1	0	20	–	20	0			
2	1	26.6	25:1	56.6	42	160	3,360	3,360
3	2	33.3	25:1	93.3	127	160	13,520	16,880
4	3.3	40	25:1	139	295	160	33,760	50,640
5	4	50	25:1	170	440	200	73,500	124,140
6	5	60	25:1	210	675	200	111,500	235,640
7	5.5	70	25:1	235	839	200	151,400	387,040
8	6	80	5:1	140	660	200	149,900	536,940
9	4	90	5:1	130	440	200	110,000	646,940
10	4.5	100	5:1	145	551	200	99,100	746,040
11	4.5	110	5:1	155	596	200	114,700	860,740
12	5	120	5:1	170	725	200	132,100	992,840
13	0	200	5:1	200	0	360	87,000*	1079,840

* $\frac{1}{3}(725+0)\cdot 360 = 87,000$

d. Discussion

Based on potential sediment yields summarized on sheet B-5 and capacity of the swale shown on sheet B-6, it is possible for the sediment inflows to be accumulated in the swale for a period of 400 yrs without flushing away from the swale. However, the swale itself is capable of flushing away certain amount of sediment under the ordinary storms (say 10 to 100 yrs. storms) conditions. Hence sediment clogging on the swale would not be a serious problem. For the most critical case in the far future (maybe 1000 yrs later), the swale itself could be covered by the sediment inflow from the upland area, a natural swale would probably be form with the side slope on the embankment side as flat as 2%. This naturally formed swale can still divert the runoff from the upland area. The swale is at least 400 ft away from the contaminated materials in the disposal cell, and would not cause the exposure of the contaminated materials.

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Project UMTRA - GRJ — Contract No. 3885-34 — Sheet — File No.
Feature SWALE — Designed SLB — Date 10.1.9.
Item SEDIMENT YIELD — Checked RMW — Date 11/14/90

UMTRA/GRJ
permanent Site Drainage
Off-pile Drainage Swale

RAINFALL FACTOR (R)

THE CHENEY RESERVOIR DISPOSAL SITE IS LOCATED APPROXIMATELY 19 MILES SOUTHEAST OF GRAND JUNCTION COLORADO

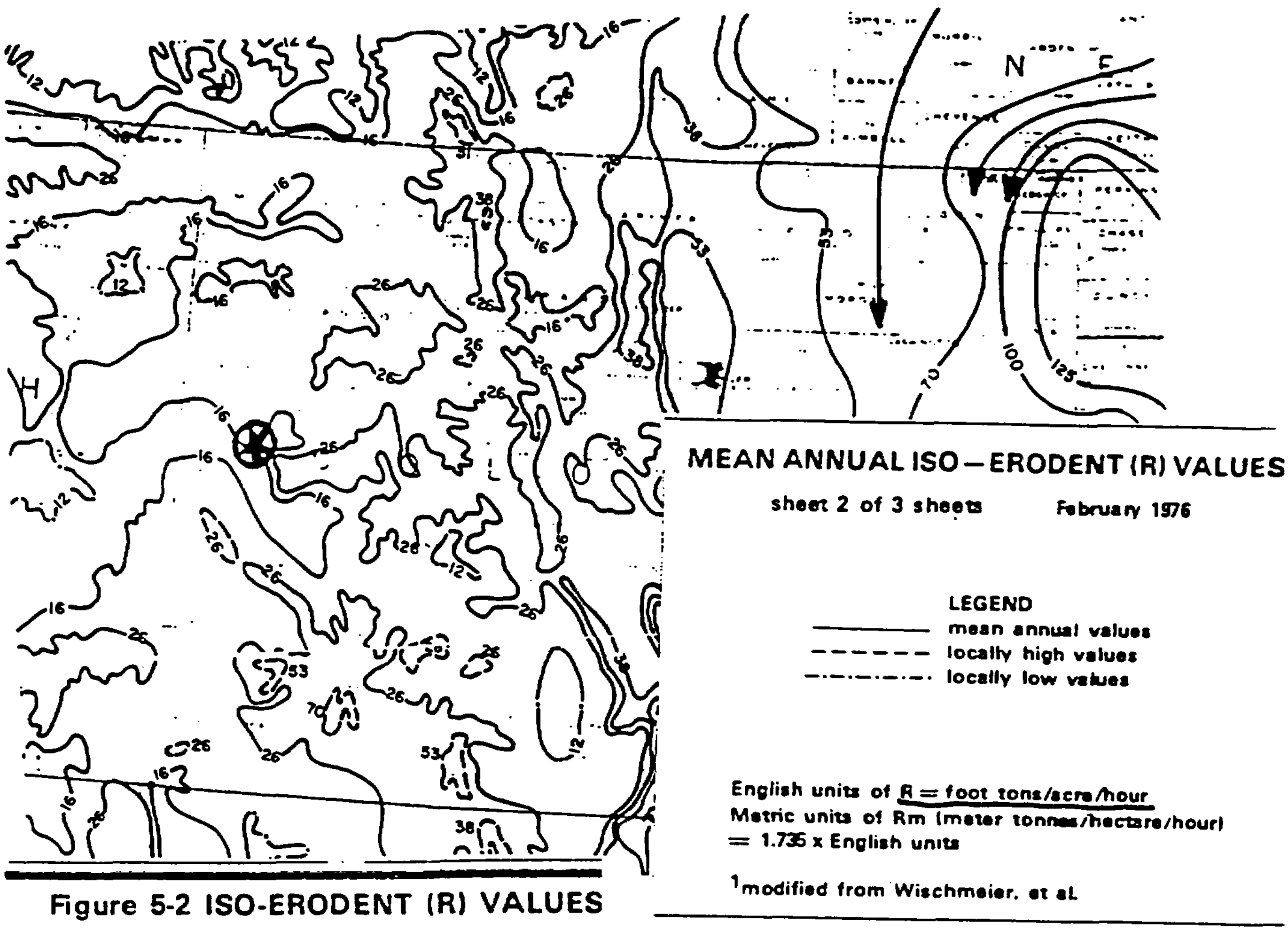


Figure 5-2 ISO-ERODENT (R) VALUES

THE ABOVE INFORMATION WAS TAKEN FROM Ref. 11.

FROM THE FIGURE R = 16.

Permanent Site Drainage
Off-pile Drainage Swale

SOIL ERODIBILITY FACTOR (K)

GRADATION CURVES FOR TOPSOIL AT THE SITE ARE SHOWN ON SHEETS 4-6.

SAMPLE No.	.002 - .10 mm SILT AND FINE SAND %	.10 - 2.0 mm SAND %
1	44	20
2	54	20
3	54	17
AVERAGE	51	19

ORGANIC = 0 (ASSUMED)

FROM FIGURE 2.2 (REFERENCE 1) SHEET 7:

SILT AND FINE SAND = 51%
SAND = 19%
ORGANIC CONTENT = 0% → K = .30

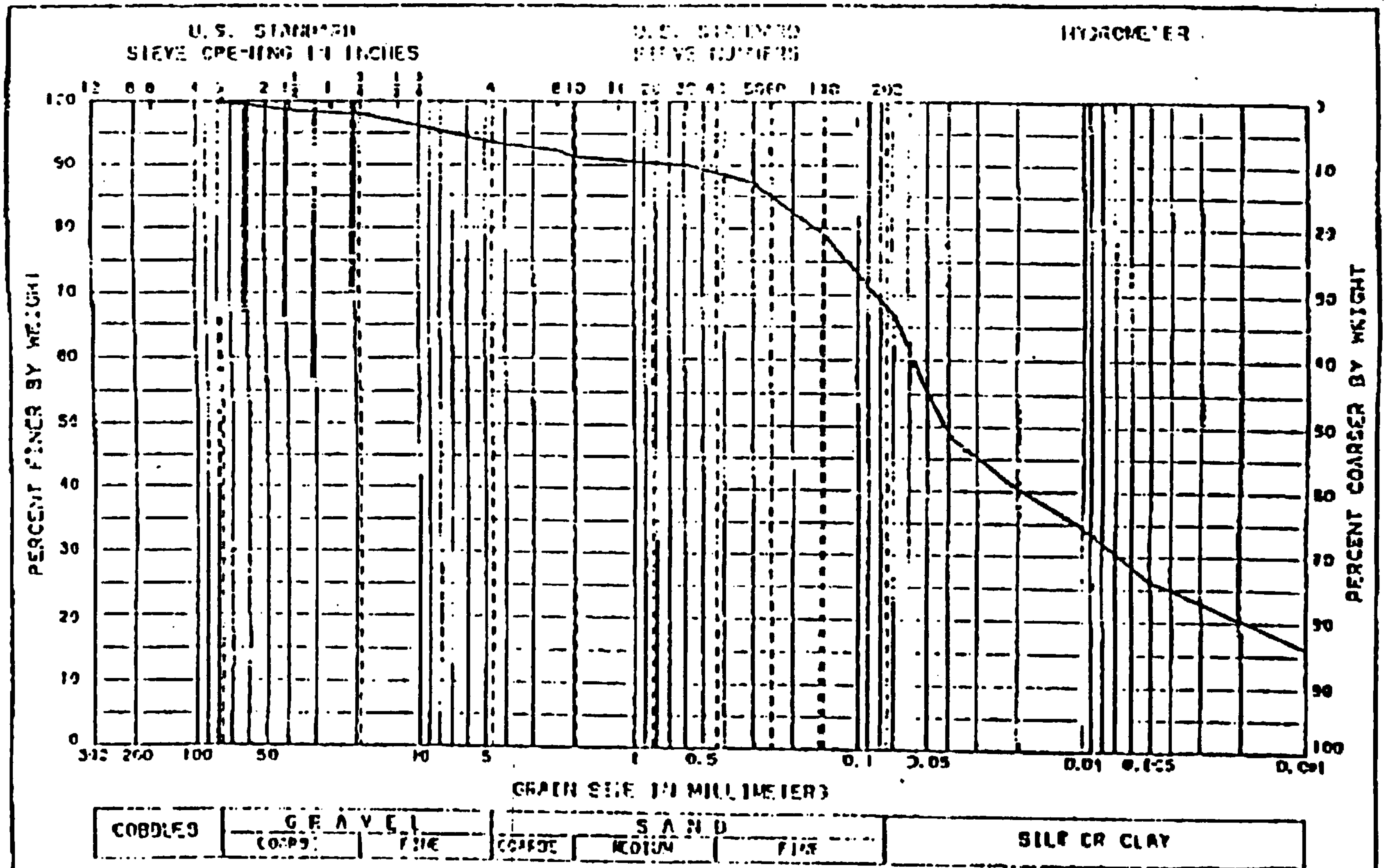
FROM FIGURE 2.3 (REFERENCE 11) SHEET 7:

VERY FINE GRANULAR SOIL
SLOW PERMEABILTY → K = .32

USE K = .32

MK-FERGUSON

[illegible]



Sample No. 1

GRAIN SIZE ANALYSIS

UMTRA/GRJ off-pile Drainage swale

SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI

PROJECT UMTRA- G.J.

JOB NO. 4 210 89

AREA

FILE NO. 1 N

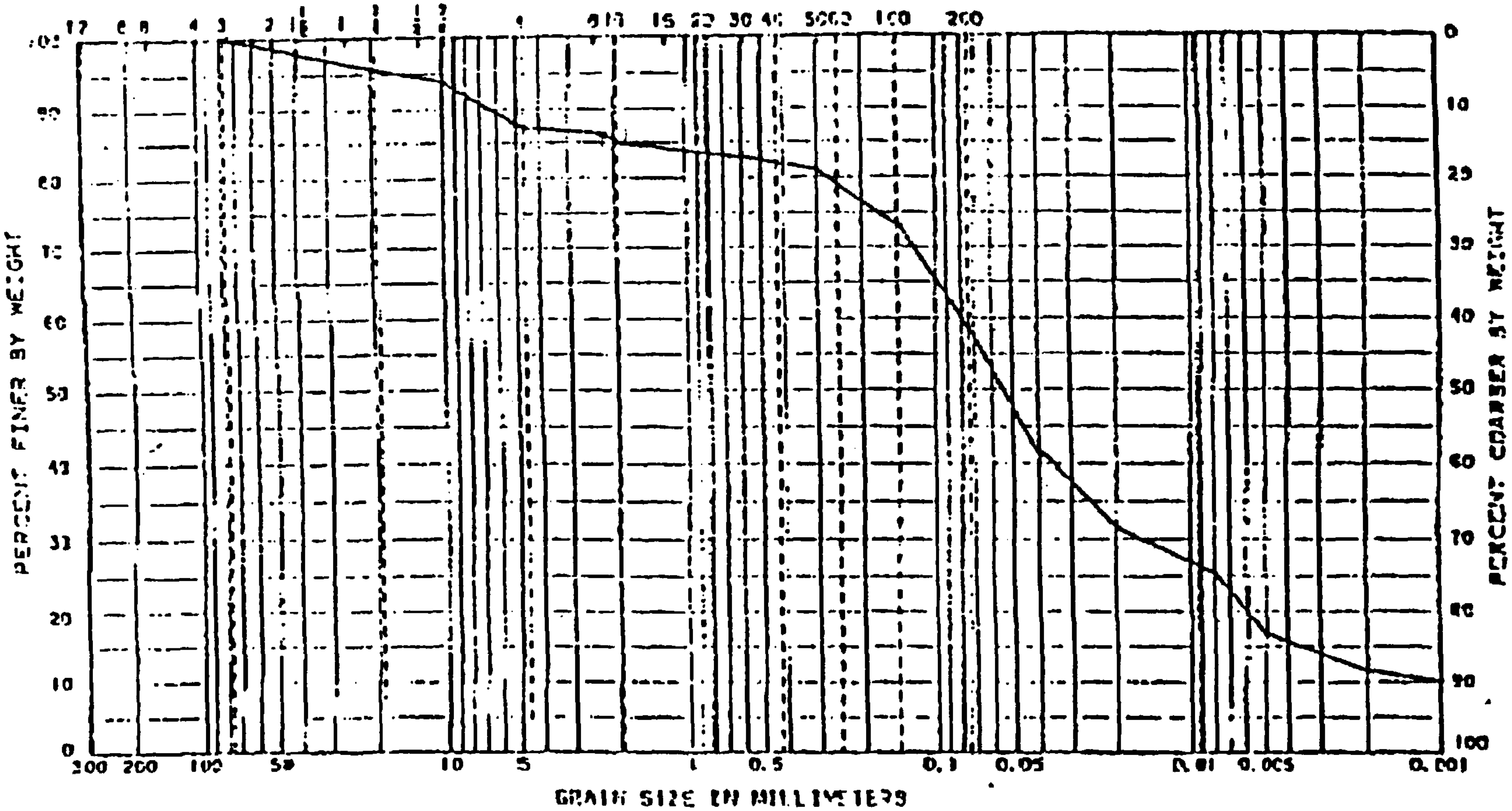
DATE 6-13-90

FAW 11/14/90

WYL 11/15/90

Sheet B-9

MK-FERGUSON



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

GRAIN SIZE ANALYSIS

SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI

PROJECT UMTRA - G.J.

JOB NO. 5 240 89

AREA

HOLE NO. i E

UMTRA/GJT Off-pile Drainage Swale sheet B-10

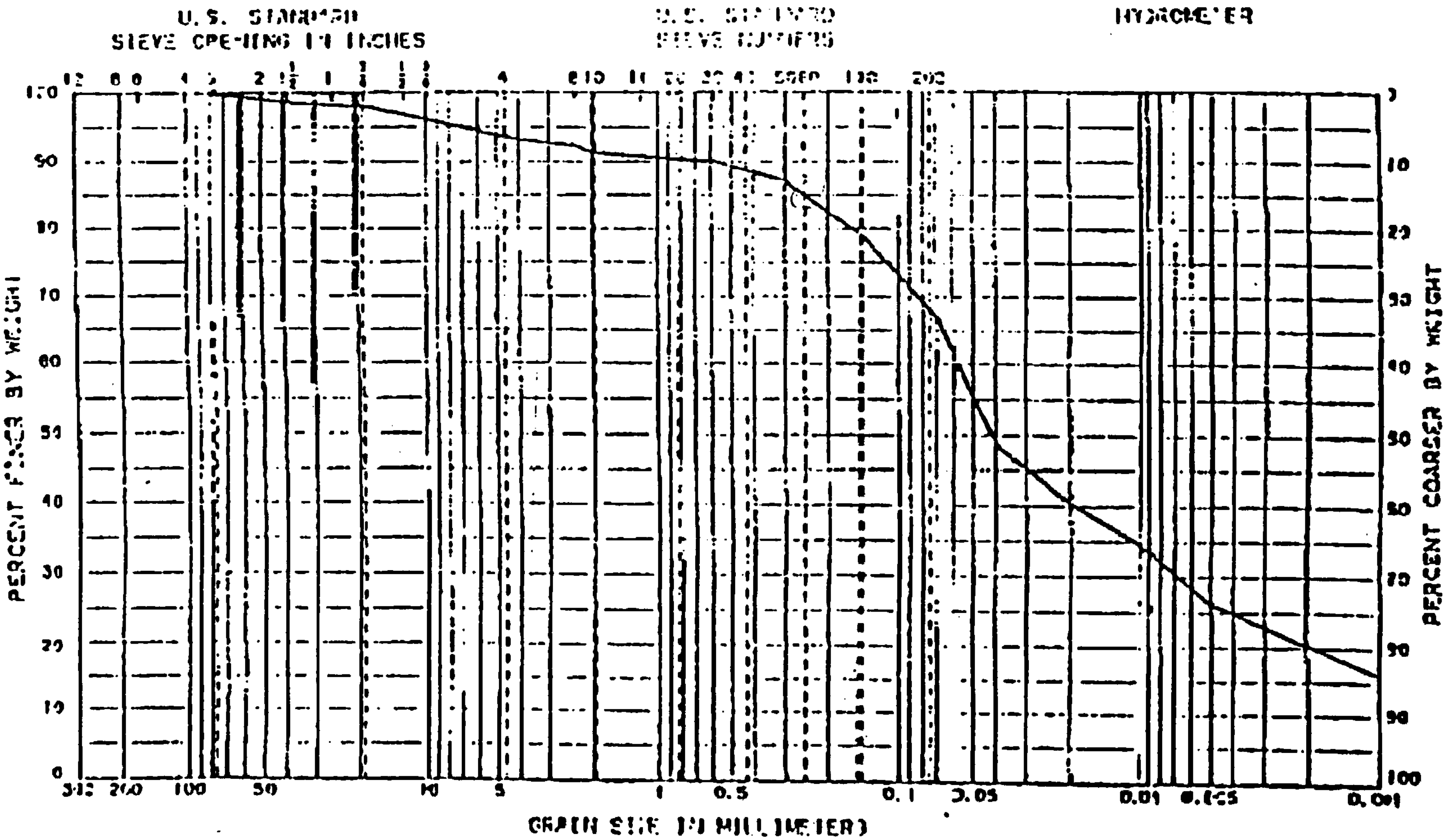
FWW 11/14/90

WYL 11/15/90

MK-FERGUSON

[illegible]

GRAIN SIZE ANALYSIS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI

PROJECT UMTRA- G.J.
JOB NO. 4 210 89
AREA
FILE NO. 1 N
DATE 6-13-90

Sample No. 3
UMTRA/GRJ
Off-pile Drainage Swale
Sheet B-11
FHW 11/14/90
WYL 11/15/90

Sheet # B-12

UMTRA/GRJ
Off-pile Drainage Swale

FHW 11/14/90
WYL 11/15/90

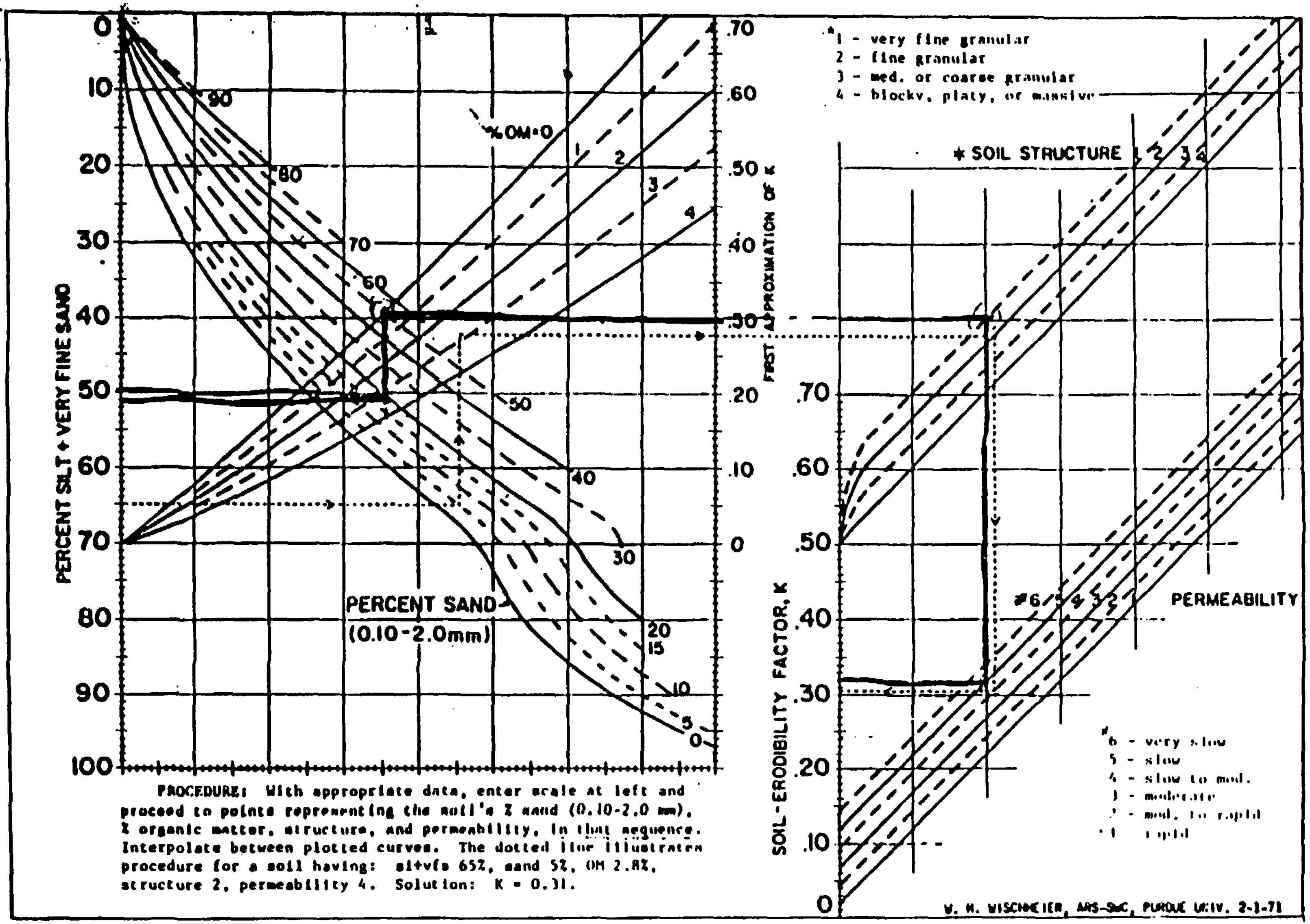


Figure 2-2. Nomograph for determining soil erodibility factor K.

Source: Ref. 11

Off-pile Drainage Swale   Sheet B-13

FHW 11/14/90

WYL 11/15/90

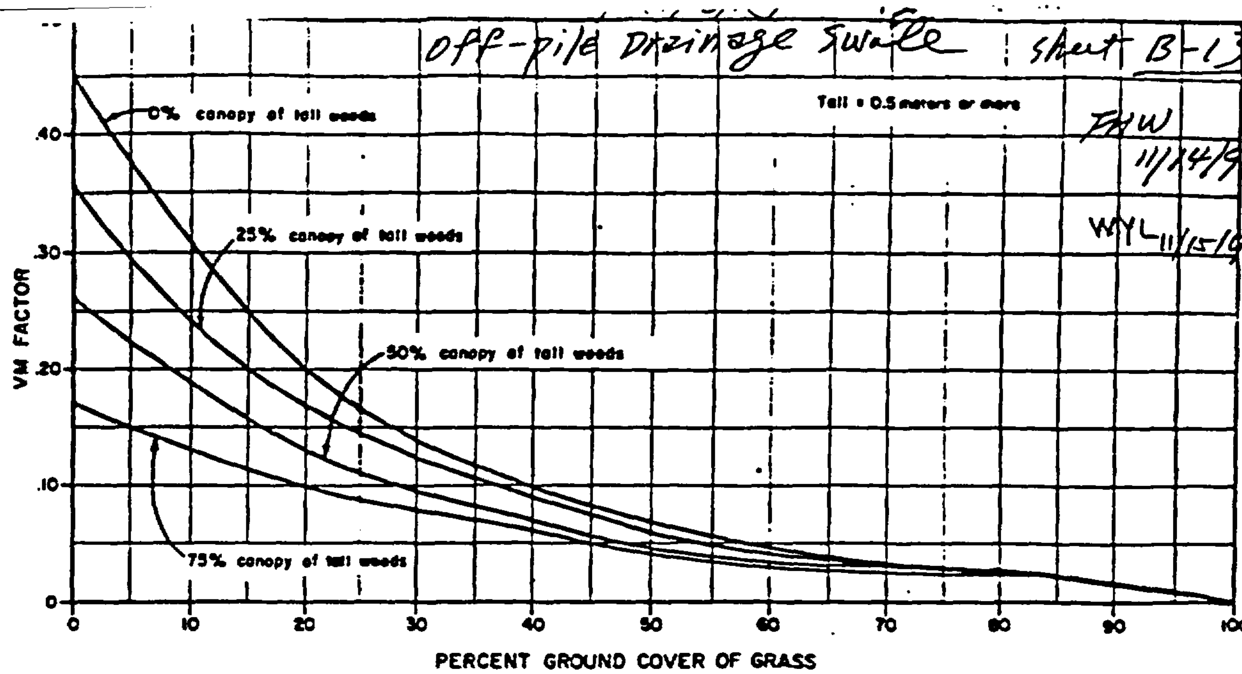


Figure 2-8. Relationship between grass density and VM factor.

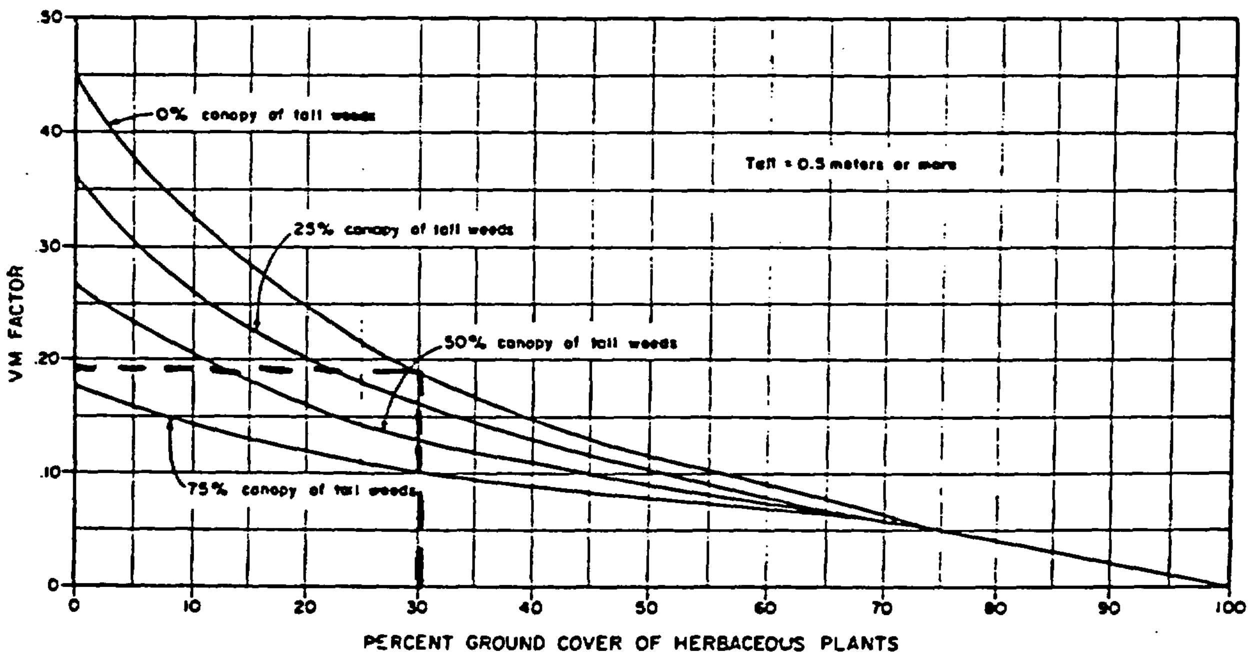


Figure 2-9. Relationship between forb density and VM factor.

Source: Ref. 11

Appendix C

Evaluation Of Flow Conditions and Riprap Protection Requirement under 200-year Storm

Note: The purpose of the Appendix is to evaluate flow condition and riprap Requirement under a minimum of 200-yr storm Condition

Project UMTRA (GR) Contract No. 3885-34 File No.

Feature Permanent Site Drainage Designed FMW Date 11/10/9

Item Off-Pile Drainage Swale Checked WYL Date 11/15/9

Appendix C

Evaluation of Flow Condition and Riprap Requirements under 200-yr Sto.

1. Extrapolation of 200-yr Storm.

200-yr 1-hr storm rainfall depth was obtained approximately from extrapolation of the 1-hr storm rainfall depth frequency curve. The frequency curve was constructed approximately using the 2-, 10-, 25- and 100-yr storm data obtained from Ref. 1. (see sheet 3 for frequency curve).

The 200-yr rainfall intensity-duration curve is shown on sheet 28 based on the following computed table:

Duration (min)	Ratio to 1HR	200-yr Rainfall Depth (in)	200-yr Rainfall intensity (in/hr)
5	0.29	0.46	5.57
10	0.45	0.72	4.32
15	0.57	0.91	3.65
30	0.79	1.26	2.53
60	1.00	1.60	1.60

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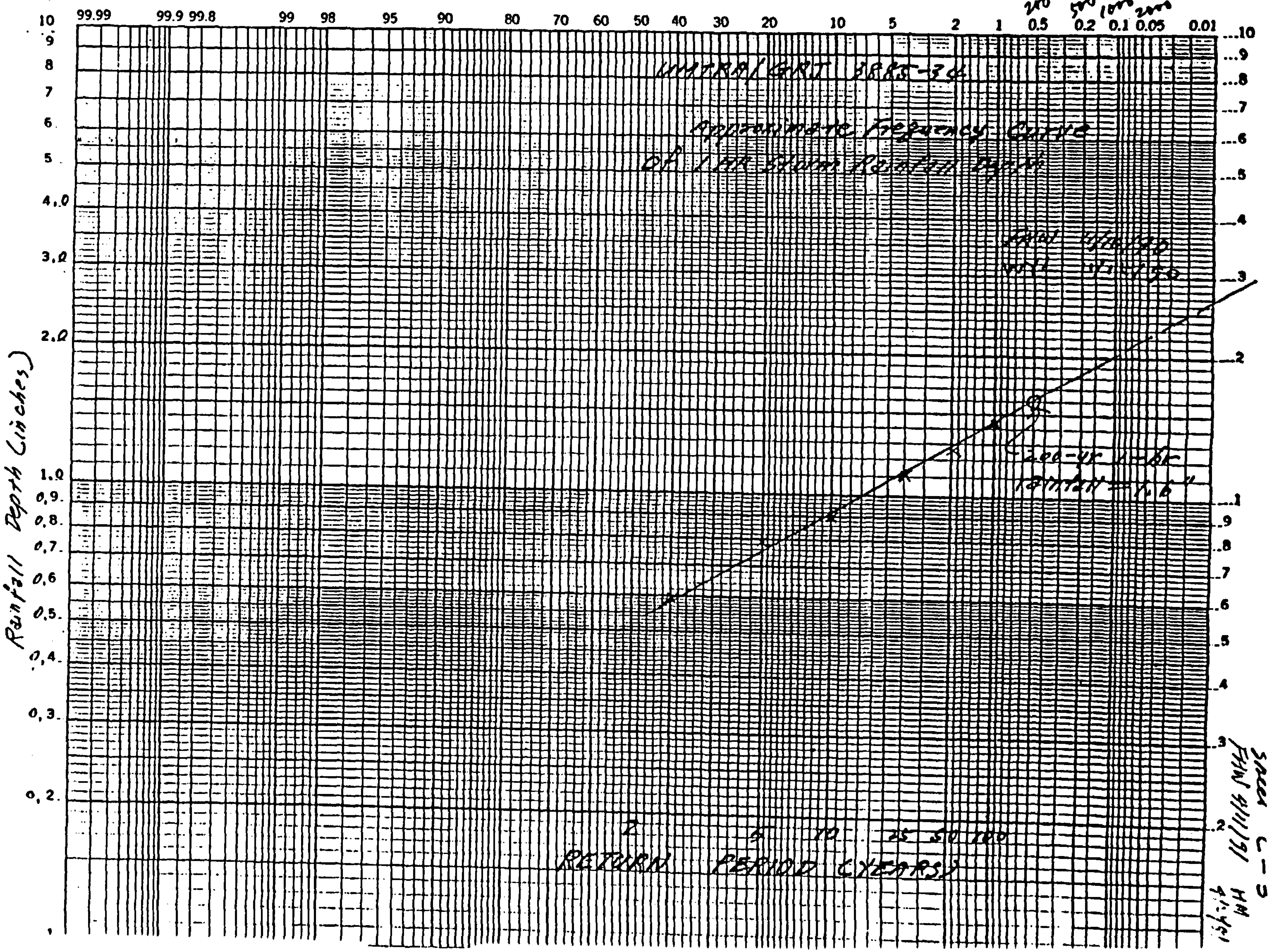

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: UMTRA / GRJ
Feature: Permanent Site Drainage
Item: Off-pile Drainage Swale

Sheet: C-4
Contract No.: 3885-34
File No.:
Designed: FMW
Date: 4/12/91
Checked: HM
Date: 4/24/91

2. 200-yr peak Discharge Estimate:

Assume same T_c as computed for PMP condition (conservat

1) At Sec. 4.

D.A. = 14.4 Ac. T_c = 13.5 min, I_{200} = 3.8 in/hr. (see sheet 28

$Q_{200} = CIA$ — let C = 0.65 for 200-yr storm condition (Ref. 4)

≐ 36 cfs.

2) At. Sec. 5

D.A. = 100.5 Ac, T_c ≐ 30 min. I_{200} = 2.53 in/hr.

$Q_{200} = CIA = 0.65 (2.53)(100.5) \doteq 165$ cfs

3) At. Sec. 6.

D.A. = 101.5 Ac, T_c = 31 min. I_{200} = 2.5 in/hr.

$Q_{200} = CIA = 0.65 (2.50)(101.5) = 165$ cfs

4) At. Sec. 7

D.A. = 115.6 Ac, T_c ≐ 31.6 min. I_{200} = 2.46 in/hr.

$Q_{200} = CIA = 0.65 (2.46)(115.6) = 185$ cfs.

5) At Sec. 8.

D.A. = 121.5 Ac, T_c ≐ 32 min. , I_{200} = 2.45 in/hr

$Q_{200} = 0.65 (2.45)(121.5) \doteq 193$ cfs

(see sheet C-5 for sec. 2 & sec 3)

MORRISON-KNUDSEN ENGINEERS, INC.
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Project: UMTRA / GAT	Contract No. 3885-24	Sheet: C-5	File No.
Feature: Permanent Site Drainage	Designed: FHW	Date: 4/12/91	
Item: Off-Pile Drainage Swale	Checked: UM	Date: 4/14/91	

6) At Sec. 9.

$D.A. = 123$ Ac, $T_c = 32 + 200/(4 \times 60) \doteq 32.8$ min. Assume V = 4 fps

$I_{200} = 2.40$ in/hr, $Q_{200} = 0.65(2.40)(123.) = 192 \doteq 193$ cfs

7) At Sec. 10.

$D.A. = 124.5$ Ac, $T_c = 32.8 + 200/(4 \times 60) \doteq 33.6$ min.

$I_{200} = 2.36$ in/hr. $Q_{200} = 0.65(2.36)(124.5) = 19 \doteq 193$ cfs

8) At Sec. 11

$D.A. = 126.0$ Ac, $T_c = 33.6 + 200/(4 \times 60) = 34.4$ min.

$I_{200} = 2.33$ in/hr, $Q_{200} = 0.65(2.33)(126.) = 193$ cfs

9) At Sec. 12

$D.A. = 130.1$ Ac, $T_c = 34.4 + 200/(4 \times 60) = 35.2$ min.

$I_{200} = 2.29$ in/hr, $Q_{200} = 194$ cfs

10) At Sec. 13

$D.A. = 135.2$ Ac, $T_c = 35.2 + 360/(3 \times 60) = 37.2$ min.

$I_{200} = 2.21$ in/hr. $Q_{200} = 194$ cfs

At Sec. 2.

$D.A. = 2.27$ Ac. $T_c = 6$ min. $I_{200} = 5.0$ $Q = 7.5$ cfs

At Sec 3

$D.A. = 7.9$ Ac. $T_c = 13$ min., $I_{200} = 3.85$, $Q = 20$ cfs.

MORRISON-KNUDSEN ENGINEERS, INC. A MORRISON KNUDSEN COMPANY

Sheet C-6

Project UMTRA/GRJ | Contract No. 3885-34 | File No.

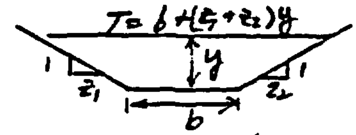
Feature Permanent Site Drainage | Designed FHW | Date 4/12/9

Item Off-pile Drainage Swale | Checked HM | Date 4/27/9

3. Riprap Required for the 5:1 side slope of the swale along the Embankment side

200-yr storm

1) Riprap Required based on flow on the swale itself:



At. Sec. 2:

$Q = 7.5$ cfs, $S = 0.0125$, Assume $n = 0.025$, $b = 26.7$

$V = \frac{1.486}{n} R^{2/3} S^{1/2}$, $Q = AV$, $A = by + \frac{1}{2}(z_1+z_2)y^2$

$P = (\sqrt{z_1^2+1} + \sqrt{z_2^2+1})y + b$

$R = \frac{A}{P}$, $D = \frac{A}{T}$

for $z_1 = 5$, $z_2 = 25$

let $y = 0.2'$ $A = 5.94$; $P = 32.7$ $R = 0.18$ $T = 32.7'$

$V = 2.1$, $Q = 12.6 > 7.5$ o.k. $\tau_{max} = \gamma y S = 62.4(0.2)0.0125 = 0.156$ lb/ft²

$F_r = \frac{V}{\sqrt{g \cdot D}} = 0.87$

use Safety Factor Method to size D_{50} (Ref. 5)

let $D_{50} = 0.5''$, $\phi = 36°$

$\eta_s = 21\, \tau_{max} / (G_s - 1)\gamma_w \cdot D_{50}$, $G_s = 2.55$, $\gamma_w = 62.4$

$= 0.813$

$\theta = 11.31$, $\alpha = \tan^{-1}(0.0125) = 0.716°$.

$\lambda = \sin^{-1}(\sin\alpha / \sin\theta) = 3.65°$, (Ref. 5)

$\beta = \tan^{-1}\left[\cos\lambda \Big/ \left(\frac{2\sin\theta}{\eta_s \tan\phi} + \sin\lambda\right)\right] = 53.9°$ (Ref. 5)

$S.F = \cos\theta \cdot \tan\phi \Big/ \{0.5(1+\sin(\lambda+\beta)) \cdot \eta_s \cdot \tan\phi + \sin\theta \cos\beta\}$ (Ref. 5)

$= 1.08$

check n value $n = y^{1/6} / [23.85 + 21.95 \log(y/D_{50})]$ (Ref. 5)

$\doteq 0.020 < 0.025$ conservative

o.k.

At Sec. 3

$Q = 20$ cfs. $S = 0.0125$. Assume $n = 0.025$. $b = 33.3$

$z_1 = 5$, $z_2 = 25$

Let $y = 0.25$, $A = 9.26$ $P = 40.8$ $R = 0.227$ $T = 40.8$

$V = 2.5$. $Q = 23 > 20$ O.K. $\tau_{max} = 0.195$ $F_r = 0.91$

Let $D_{50} = 0.6''$ $\eta_s = 0.847$ $\phi = 36°$ $\theta = 11.31°$, $\alpha = 0.716°$ $\lambda = 3.65$

$\therefore \beta = 54.9°$ S.F. $= 1.04$ check $n \doteq 0.020 < 0.025$ O.K. conservative

At Sec. 4

$Q = 36$ cfs $S = 0.0125$, $b = 40$ Assume $n = 0.025$

For $z_1 = 5$, $z_2 = 25$

let $y = 0.3$ $A = 13.35$, $P = 49.0$, $R = 0.272$, $T = 49$

$V = 2.8$ $Q = 37 > 36$ o.k. $\tau_{max} = 0.234$ $F_r = 0.95$

let $D_{50} = 0.8''$, $\phi = 36°$ $\eta_s = 0.762$, $\theta = 11.31°$, $\alpha = 0.716°$, $\lambda = 3.65°$

$\beta = 52.3°$, S.F. $= 1.14$, check n for $D_{50} = 0.8''$, $n \doteq 0.021 < 0.025$ O.K.

At Sec. 5

$Q = 165$ cfs $S = 0.01$ $b = 50$, Assume $n = 0.025$

$z_1 = 5$, $z_2 = 25:1$

let $y = 0.7$ $A = 42.35$, $P = 71.1$, $R = 0.596$, $T = 71$.

$V = 4.2$ $Q = 178$ O.K. $\tau_{max} = 0.437$ lb/ft², $F_r = 0.96$

let $D_{50} = 1.3''$ $\eta_s = 0.876$, $\phi = 37°$, $\theta = 11.31°$, $\alpha = \tan^{-1}(0.01) = 0.573°$

$\lambda = 2.92°$, $\beta = 57.1°$, S.F. $= 1.02$

check n for $D_{50} = 1.3''$, $n \doteq 0.023 < 0.025$ O.K.

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Project UMTRA/GRT — Contract No. 3881-34 — Sheet C-8
Feature Permanent Site Drainage — Designed FHW — File No. — Date 4/12/91
Item Off-pile Drainage Swale — Checked HM — Date 4/2?/9?

At Sec. 6

$Q = 165$ cfs, $S = 0.01$, $b = 60$ Assume $n = 0.025$

$z_1 = 5$, $z_2 = 25$

let $y = 0.65$ $A = 45.3$, $P = 79.6$, $R = 0.57$, $T = 79.5$

$V = 4.1$ fps, $Q = 185 > 165$, ok. $\tau_{max} = 0.406$ lb/ft², $F_r = 0.96$

let $D_{50} = 1.3''$ $\eta_s = 0.814$ $\phi = 37°$, $\theta = 11.31°$, $\alpha = 0.573°$ $\lambda = 2.92°$

$\beta = 55.3°$, S.F. $= 1.09$ check n value for $D_{50} = 1.3''$, $n = 0.023 < 0.025$ ok.

At. Sec. 7

$Q = 185$ cfs. $S = 0.01$ $b = 70$, Assume $n = 0.025$

$z_1 = 5$, $z_2 = 25$.

let $y = 0.65$, $A = 51.8$, $P = 89.6$, $R = 0.579$, $T = 89.5$

$V = 4.1$, $Q = 214 > 185$ ok $\tau_{max} = 0.406$ lb/ft². $F_r = 0.95$

let $D_{50} = 1.3''$ $\eta_s = 0.814$, $\phi = 37°$, $\theta = 11.31°$, $\alpha = 0.573°$ $\lambda = 2.92°$

$B = 55.3°$, S.F. $= 1.09$, check n for $D_{50} = 1.3''$, $\doteq 0.023 < 0.025$ o.k.

At. Sec. 8.

$Q = 193$ cfs $S = 0.01$, $b = 80'$, Assume $n = 0.025$

$z_1 = z_2 = 5$.

let $y = 0.65$, $A = 54.1$, $P = 86.6$, $R = 0.625$, $T = 86.5$

$V = 4.3$ $Q = 233 > 193$. o.k., $\tau_{max} = 0.406$, $F_r = 0.97$

let $D_{50} = 1.3''$, $\eta_s = 0.814$, $\theta = 11.31°$. $\alpha = \tan^{-1}(0.01) = 0.573°$. $\lambda = 2.92°$,

$\phi = 37°$. $B = 55.3$. S.F. $= 1.09$

check n value, for $D_{50} = 1.3''$; $n \doteq 0.023 < 0.025$ o.k.

At. Sec. 9

$Q = 193$ cfs. $s=0.01$. $b=90'$. , $z_1 = z_2 = 5$, Assume $n=0.025$

let $y=0.6$, $A=55.8$, $P=96.1$, $R=0.58$, $T=96$

$V=4.1$ $Q=230$ cfs >193 OK, $\tau_{max}=0.374$ lb/ft², $F_r=0.95$

let $D_{50}=1.3''$ $\eta_s=0.750$, $\phi=38°$, $\theta=11.31°$, $\lambda=0.573°$, $\lambda=2.92°$.

$\beta=53.3°$, $S.F.=1.1671$, check n ($D_{50}=1.3$) $\doteq 0.024$ OK.

At. Sec. 10.

$Q=193$ cfs, $s=0.01$, $b=100'$, let $n=0.025$, $z_1=z_2=5$

let $y=0.55$. $A=56.5$, $P=105.6$, $R=0.535$, $T=105.5$

$V=3.9$ fps. $Q=221$ cfs >193, $\tau_{max}=0.343$, $F_r=0.94$

let $D_{50}=1.2''$ $\eta_s=0.745$, $\phi=37°$, $\theta=11.31°$, $\lambda=0.573°$, $\lambda=2.92°$.

$\beta=53.1°$, $S.F.=1.17$; check n ($D_{50}=1.2''$) $\doteq 0.023$ O.K.

At. Sec. 11

$Q=193$ cfs, $s=0.01$, $b=110$, let $n=0.025$, $z_1=z_2=5$

let $y=0.5$ $A=56.3$ $P=115.1$; $R=0.49$, $T=115$

$V=3.7$, $Q=207>193$. OK $\tau_{max}=0.312$ lb/ft², $F_r=0.93$

let $D_{50}=1.0''$ $\eta_s=0.812$ $\phi=36°$, $\theta=11.31°$, $\lambda=0.573°$, $\lambda=2.92°$.

$\beta=54.4°$, $S.F.=1.08$. check n ($D_{50}=1.0''$) $=0.022 < 0.025$ OK

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Project: UMTRA / GRJ — Contract No. 3885-34 — Sheet C-10 — File No. __
Feature: Permanent Site Drainage — Designed: ZWW — Date 4/12/91
Item: Off-pile Drainage Swale — Checked: HM — Date 4/24/91

At Sec. 12

$Q = 194$ cfs. $S = 0.01$. $b = 120$. let $n = 0.024$

$Z_1 = Z_2 = 5$

let $y = 0.45$. $A = 55.0$; $P = 124.6$, $R = 0.44$, $T = 124.5$

$V = 3.6$, $Q = 197 > 194$. o.k. $\tau_{max} = 0.281$, $F_r = 0.95$

let $D_{50} = 0.9''$, $\eta_s = 0.813$, $\phi = 36°$. $\theta = 11.31°$, $\alpha = 0.573$, $\lambda = 2.92$

$\beta = 54.4°$, $S.F. = 1.08$. check $n(D_{50} = 0.9'') = 0.021 < 0.024$ o.k.

At Sec. 13

$Q = 194$ cfs. daylight at this location. 200' wide

$q = 194/200 = 0.97$ cfs/ft, $S = 0.01$. let $n = 0.024$

$y = \left\{ 0.97 \cdot 0.024 / 1.486 \cdot (0.01)^{1/2} \right\}^{0.6} = 0.33$, $\tau_{max} = 0.205$

$V = 2.9$ fps, $F_r = 0.90$

Let $D_{50} = 0.8''$, $\eta_s = 0.668$, $S.F. = 1.05$

Summary of Computation – Flow characteristics, off-pile swale

side slope on the embankment side is 5:1

Location	D.A (A.C)	Q (cfs)	B (ft)	Side slope upland side	Distance*2 (ft)	Invert El. (ft)	Long. slope	Flow Depth (ft)	V (fps)	τ_{max} (lb/ft²)	Top width (ft)	Fr	Min. D_{50} (in)	Estimated n Value
1	0.	—	20	25:1	0	5262	0.0125	—						
2	2.27	7.5	26.7	25:1	160	5260	0.0125	0.2	2.1	0.156	32.7	0.87	0.5"	0.025
3	7.94	20	33.3	25:1	160	5258	0.0125	0.25	2.5	0.195	40.8	0.91	0.6"	0.025
4	14.4	36	40.0	25:1	160	5256	0.0125	0.3	2.8	0.234	49	0.95	0.8	0.025
5	100.5	165	50.0	25:1	200	5254	0.010	0.7	4.2	0.437	71	0.96	1.3	0.025
6	101.5	165	60.0	25:1	200	5252	0.010	0.65	4.1	0.406	79.5	0.96	1.3	0.025
7	115.6	185	70.0	25:1	200	5250	0.010	0.65	4.1	0.406	89.5	0.95	1.3	0.025
8	121.5	193	80.0	5:1	200	5248	0.010	0.65	4.3	0.406	86.5	0.97	1.3	0.025
9	123.0	193	90.0	5:1	200	5246	0.010	0.60	4.1	0.374	96.0	0.95	1.3	0.025
10	124.5	193	100.0	5:1	200	5244	0.010	0.55	3.9	0.343	105.5	0.94	1.2	0.025
11	126.0	193	110.0	5:1	200	5242	0.010	0.50	3.7	0.312	115.0	0.93	1.0	0.025
12	130.1	194	120.0	5:1	200	5240	0.010	0.45	3.6	0.281	124.5	0.95	0.9	0.024
13	135.2	194	200*1	5:1	360	5236.4	0.010	0.33	2.9	0.205	—	0.90	0.8	0.024

*1 Expand at 9:1

*2 Distance between 2 sections

2) Riprap (D_{50}(min)) Required for side slope (5:1) of the swale Due to Overland Flow from Embankment

Assume the same T_c at end of 2% embankment slope

$T_c = 5$ min, $I_{100} = 5.15$ in/hr.

a) If flow concentration factor = 1

$q = 1.0\,(5.15)\,(610 + 5\times5)/43560 = 0.05$ cfs/ft, $S = 0.2$

Manning n: use Abt empirical formula $n = 0.0456\,(D_{50}(in)\cdot S)^{0.1}$ (Ref. 6)

For slope > 10% use Stephenson method (Ref. 5) to estimate Min Riprap (D_{50}) requirement:

$$D_{50} = \left[q\cdot(\tan\alpha)^{7/6}\, n^{1/6} \Big/ \left\{ C\cdot g^{1/2}\cdot\left[(1-\eta)(G_s-1)\cdot\cos\alpha\,(\tan\phi-\tan\alpha)\right]^{5/3} \right\} \right]^{2/3}$$

where q = discharge/unit width = cfs/ft

α = side slope = 5:1 = 11.31°.

g = Acceleration of gravity = 32.2 ft/sec².

G_s = specific gravity of the riprap material, assumed = 2.64

ϕ = riprap angle of repose

η = riprap material porosity, let $\eta \doteq 0.33$

$C = 0.22$

∴ $D_{50} = 0.7''$

b) If flow concentration of 3 is considered, $q_c = 0.15$ cfs.

$D_{50} = 1.5''$

For a flow concentration factor = 3, the required D_{50}(min) from embankment overland flow would be larger than those computed from item 3.1). (see sheet C-11)

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Sheet C-12
Project UMTRA/GRJ Contract No. 3885-36 File No.
Feature Permanent Site Drainage Designed FHW Date 4/9/9
Item Off-Pile Drainage Swale Checked HM Date 4/24/9

3) Riprap Required Due to flow from potentially Developed Gully in the upland Area :

a) Assumed Gully Development Conditions .

For observation of the topographic condition in the upland are it is assumed that several gullies might develop and the most critical one is the one shown on sheet 40a.

Drainage Area $\doteq \frac{1}{2} 1810 \cdot 360 + \frac{1}{2} \cdot 860 \cdot 280 + \frac{1}{2} \cdot 800 \cdot 340 + \frac{1}{2} 900 \cdot 360 + \frac{1}{2} \cdot 1350 \cdot 180 = 875,900 \ ft^2 = 20.1$ Acres.

Longest flow length $\doteq 3570'$, $\Delta H = 5350 - 5254 = 96'$

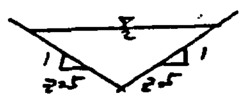
$\Delta H / L = 0.0269$, $T_c = 0.0078 (3570)^{0.77} / (0.0269)^{0.385} = 17$ min.

$I \doteq 3.4$ in/hr. $Q = CIA = (0.65)(3.4)(20.1) \doteq 44$ cfs.

Assume a triangular X-sec. with 5H:1V side slopes (the side slope of existing gully east of the site is around 7:1~10:1)

let $n = 0.025$.

$$y = \left\{ Qn \Big/ 1.486\, z \left(\frac{z}{2\sqrt{z^2+1}}\right)^{2/3} S^{1/2} \right\}^{3/8}$$



Assume Gully slope ≈ upland slope ≈ 0.025.

then $y = 1.17$, $A = 6.8\ ft^2$, $V = 6.5$ fps $\tau = 1.825\ lb/ft^2$, $T = 11.7$

$F_r = 1.50$

Since the velocity and tractive force is much larger than the allowable shear stress and velocity (see sheet 41), scour would occur.

b) Estimate of Scour Depth

(1) Based on Critical Tractive Force Method

Assume scour depth is the depth at which the slope of the gully become stable with tractive force $\tau \leq \tau_c$ (critical tractive force).

For depth less than 3' at the site, $\tau_c \doteq 0.26$ lb/ft² (see sheet 41)

Estimate stable slope by trial and error :

when stable slope $S_s = 0.0025$ $n = 0.025$, $z = 5$ $Q = 44$ cfs

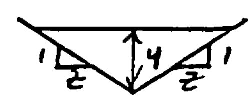
then $y \doteq 1.87$ $\tau = 0.23 \leq 0.26$ O.K.

(2) Based on max. allowable velocity.

For depth less than 3' at the site, $V_a = 3$ fps (see sheet 41)

For $Q = 44$ cfs, $z = 5$

$z \cdot y^2 = Q/V$, $5y^2 = 44/3$



$y = 1.7'$ (possibe scour depth)

(3) Assume Zimmerman & Maniok Equation for local scour below a stilling basin is applicable here. (Ref. 10)

$d_s\,(ft) = K \cdot \left(\frac{q^{0.82}}{D_{85}^{\;0.23}}\right)\left(\frac{y}{q^{2/3}}\right)^{0.93} - y$, where

Scour depth

y = tailwater depth

D_{85} = particles 85% finer (in mm)

q = discharge/unit width

$K = 1.95$

Assume a flow concentration factor of 3, then

$q = 2.91$ cfs/ft, $y \doteq 0.48$ ft (d/s of outlet with a slope of 0.04 and $n = 0.03$)

let D_{85} (mm) $\doteq$ 5 mm (assumed)

then $d_s = 0.4$ ft.

(4) U.S. DOT equation for scour

$D_s = 0.82\,(y_e)\left(\frac{Q}{y_e^{2.5}}\right)^{0.375}(T)^{0.1}$

Let $Q = 3q = 2.91$ cfs, $T = 30$ min.

y_e = flow u/s. = 0.73 (for $s = 0.01$, $n = 0.03$)

Hence $D_s = 1.7$ ft.

Hence under 200-yr storm condition, the possible max. scour depth would be about 2 ft.

c) Riprap Sizing :

① At Sec. 7. $Q \doteq 185$ cfs

Assume a triangular gully will be developed.

$z_1 = 5$ (side slope of swale to be protected buried riprap)

$z_2 = 7$ (typical side slope of existing gully east of the disposal cell is 7~10 :1)

so $y = \left\{ nQ \Big/ 1.486 \cdot \frac{1}{2}(z_1+z_2) \cdot \left[\frac{\frac{1}{2}(z_1+z_2)}{\sqrt{z_1^2+1}+\sqrt{z_2^2+1}} \right]^{2/3} S^{1/2} \right\}^{3/8}$

$Q = 185$ cfs. $S = 0.01$, let $n = 0.03$.

then $y = 2.37$. $\tau_{max} = 1.48$ lb/ft². $V = 5.5$ fps. $F_r = 0.89$

D_{50}: by Safety Factor Method : $G_s = 2.64$

Let $D_{50} = 4.5$ $\phi = 38°$, $\theta = 11.31°$, $\alpha = 0.573$ ($s=0.01$), $\lambda = 2.92°$

$\eta_s = 0.857$ $\beta = 57.5°$. S.F. = 1.05 check $n = 0.028 < 0.03$ O.K.

② At Sec. 8 :

$Q = 193$ cfs. $z_1 = 5$, $z_2 = 7$. let $n = 0.03$, $S = 0.01$. $G_s = 2.64$

$y = 2.41'$ $\tau_{max} = 1.51$ lb/ft² $V = 5.54$ fps. $F_r = 0.89$.

(use Safety Factor Method to size D_{50} :)

Let $D_{50} = 4.5''$, $\phi = 38°$. $\eta_s = 0.874$. $\theta = 11.31°$, $\alpha = \tan^{-1}(0.01) = 0.573°$.

$\lambda = 2.92°$, $\beta = 58.0°$. S.F. = 1.03.

check n for $D_{50} = 4.5''$. $n = 0.028 < 0.03$. O.K

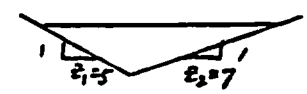
③ At sec. 4

Since upstream of sec. 4 does not receive much of the flow from the upland area. An evaluation of gully erosion (Assuming a gully developed at sec. 4) and riprap size required will be evaluated using the flow at sec. 4.

ⓘ Assume gully x-sec. with $z_1 = 5$, $z_2 = 7$

$Q = 36$ cfs, $S = 0.0125$, let $n = 0.03$.

then



$y = 1.23'$, $\tau_{max} = 0.96$ lb/ft², $V = 4.0$ fps, $F_r = 0.90$

Let $D_{50} = 3''$, $\phi = 38°$, $\theta = 11.31°$, $\alpha = \tan^{-1}(0.0125) = 0.716°$
(Safety Factor Method) $\lambda = 3.65°$

$\eta_s = 0.834$, $\beta = 56.3°$, S.F. $= 1.07$. check n value $\doteq 0.027$ O.K. < 0.03

ⓘⓘ Depth of protection required (scour depth).

a) Critical tractive force method $\tau_c = 0.26$ lb/ft² (top soil)

at a stable slope, $S_s = 0.0025$

then $y = 1.66$ $V = 2.2$ fps, $\tau = 0.26 \approx \tau_c$

Scour depth $= 1.7 - 1.2 = 0.5$ ft

b) Max. allowable Velocity $=$ 3 fps $\frac{1}{2}(z_1+z_2)y^2 = \frac{Q}{V}$

$\frac{1}{2}(5+7)\cdot y^2 = 36/3$ $y = 1.4'$

scour depth $= 1.4 - 1.2 = 0.2$ ft

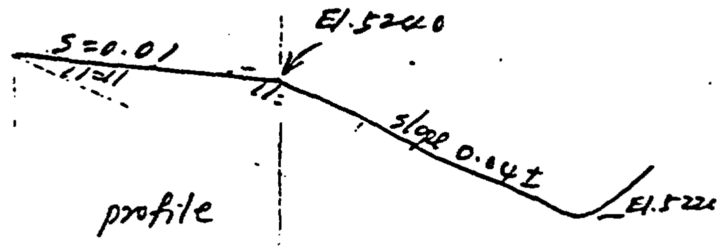
c) From gully depth vs Drainage Area Correlation, projected gully depth (if developed) will be about $0.5'$

Hence potential scour at sec. 4 would be about 0.5 ft under 200-yr flood.

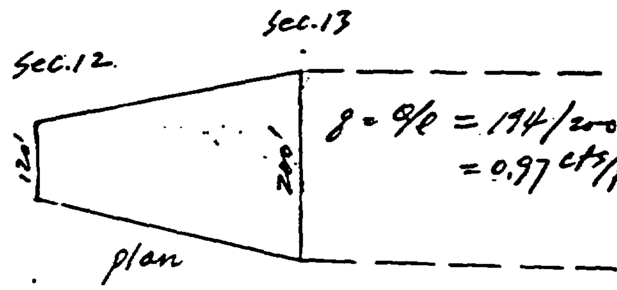
4. Erosion Protection at Swale Outlet under 200 yr storm

1) Evaluate Flow Condition and Riprap Requirement Immediately upstream and downstream of the outlet:

Since the swale daylight at El. 5236.4, the flow become sheet flow at the outlet.



D/s of the daylight location, the slope is about 4-5 %.



$q = Q/L = 194/200 = 0.97\ cfs/ft.$

$q = \frac{1.486}{n} y^{5/3} S^{1/2}$

(a) Immediately u/s (sec. 13)

$q = 0.97$ cfs/ft, $S \doteq 0.01$ let $n = 0.03$

then $y = 0.38$. $\tau_{max} = 0.235\ lb/ft^2$ $V = 2.5$ fps, $F_r = 0.74$

D_{50} required: use Safety Factor Method

Let $D_{50} = 0.7''$, $\eta_s = 0.874$ $\phi = 36°$, $\alpha = \tan^{-1}(0.04) = 2.29°$

$S.F = \cos\alpha \tan\phi / (\eta_s \tan\phi + \sin\alpha) = 1.08$ check $n = 0.02 < 0.03$ (conservative)

Sheet C-10

Project: UNTRALGAJ	Contract No. 3885-34	File No.	
Feature: Permanent Site Drainage	Designed: FHW	Date: 4/12/91	
Item: Off-pile Drainage Swale	Checked: HM	Date: 4/24/91	

(b) Immediately D/s. $S = 0.04$

$q = 0.97$ cfs. let $n = 0.03$

$y = 0.25$ $\tau_{max} = 0.619$ lb/ft². $v = 3.9$ $F_r = 1.38$

D_{50} required : use Safety Factor method

$\alpha = \tan^{-1}(0.04) = 2.29^\circ$ $S.F. = \frac{\tan\phi \cos\alpha}{\eta_s \tan\phi + \sin\alpha}$.

Let $D_{50} = 4.8''$, $\phi = 37^\circ$, $\eta_s = 0.896$, $S.F = 1.02$

Assume flow concentration factor = 3. $q = 2.91$ cfs/ft.

let $n = 0.03$, $y = 0.48'$, $\tau_{max} = 1.2$ lb/ft².

$v = 6.1$ fps, $F_r = 1.54$.

Let $D_{50} = 3.5''$, $\phi = 38^\circ$. $\eta_s = 0.893$, $S.F = 1.06$.

Hence under 200-yr flood condition, Type B Riprap is sufficient to protect outlet erosion.

2) Potential scour depth immediately downstream of the swale outlet

(a) By Critical Tractive force., $\tau_c = 0.26$ lb/ft² (for soil within 3' of topsoil).

Stable slope:

$q = \frac{1.486}{n} \cdot y^{5/3} S_s^{1/2}$, $\tau_c = \gamma_w y S_s$, let $q = 3 \times 0.97 = 2.91$ cfs (Assume flow concentration factor = 3)

$\therefore S_s = \left\{ \frac{1.486 \cdot \tau_c^{5/3}}{n q \cdot (\gamma_w^{5/3})} \right\}^{6/7}$ let: $n = 0.03$, $\gamma_w = 62.4$.

then $S_s = 0.0045$

$y = 0.92$ (Scour depth to reach stable slope)

(b) By Max. allowable velocity –

Assume a triangular x-sec with 2:1 slope.

$Q = 2.91$ cfs $V_a = 3$ fps

$A = 0.97$ ft² $= 2y^2$ $y = 0.98'$

(C) Assume Lacey's Regime Eqn. can be applied. (Ref. 10)

$d_m = 0.47 \left(\frac{Q}{f}\right)^{1/3}$, $d_s = Z \cdot d_m$

d_m = mean flow depth, f = Lacey's silt factor $= 1.76 \sqrt{D_{50}(mm)}$, let $D_{50} = 5$ mm $= 3.94$

d_s = depth of scour

Z = multiplying factor = 1.5 for moderate bend.

$Q = 194$ cfs.

$\therefore d_m = 1.7'$ $d_s = 2.6$ ft

Hence a potential scour depth of about 2.5' downstream of the outlet would occur under 200-year storm condition.

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Project: UMTRA/GRJ	Contract No. 3885-34	Sheet C-20	File No.
Feature: Permanent Site Drainage	Designed: FHW	Date 4/12/91	
Item: Off-pile Drainage Swale	Checked: KM	Date 4/22/91	

5. Summary of Results
(under 200-yr storm condition)

1. Under 200-yr storm condition, the max. D_{50}(min) on the 5:1 slope of the embankment required is 4.5" (Type B) with a scour depth protection of 2 ft

2. The invert and upland side would only need a D_{50}(min) of about 1.5" (Type A).

3. At swale outlet, the max. D_{50}(min) required is 3.5" (Type B) with a scour protection of 2.5 ft

Calculation Cover Sheet

MKO

Calc. No. 05-504-04-00

Contract No. 5025-16 Discipline ESCUP No. of Sheets 55

Project

UMTRA - GRJ

Feature

DISPOSAL SITE DRAINAGE DURING CONSTRUCTION

Item RETENTION BASIN AND EMERGENCY SPILLWAY

Sources of Data

SEE PAGE 1.

Sources of Formulae & References

SEE PAGE 1.

Preliminary Calc. ☐ Final Calc. ☒ Supersedes Calc. No. 05-628-03-01

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
0		S.E. Botsford	1/24/90	H. LUBIS	6/8/90	P. Sircar	6/8/90

Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA / GRJ	Contract No. 5025-IL	Sheet 1	File No.
Feature: DISPOSAL SITE DRAINAGE	Designed SKA	Date 1-24-90	
Item	Checked H. L.	Date 6/6/90	

REFERENCES

1. MKE UMTRA GRAND JUNCTION CALC. NO. 05-628-03-01 "DISPO SITE DRAINAGE DURING CONSTRUCTION"

2. ISRAELSON, C.E., ET AL. "EROSION CONTROL DURING HIGHWAY CONSTRUCTION" WASHINGTON, D.C. TRANSPORTATION RESEARCH BOARD, APRIL 1980

3. LAMBE, T. WILLIAM, AND ROBERT V. WHITMAN SOIL MECHANICS NEW YORK JOHN WILEY AND SONS, 1969

4. MKE UMTRA GRAND JUNCTION CALC. NO. 05-628-01-00. "SITE DRAINAGE - HYDROLOGY PARAMETERS"

5. RAWLS, WALTER J., ET AL. "GREEN-AMPT INFILTRATION PARAMETERS FROM SOILS DATA" JOURNAL OF HYDRAULIC ENGINEERING, VOL. 109, JANUARY 1983

6. U.S. DEPARTMENT OF ENERGY "DRAFT REMEDIAL ACTION PLAN AND SITE CONCEPTUAL DESIGN FOR STABILIZATION OF THE INACTIVE URANIUM MILL TAILINGS AT GRAND JUNCTION COLORADO" JUNE 1986

7. MKE "UMTRA DESIGN PROCEDURES MANUAL" CHAPTER 4, SITE DRAINAGE, REV. 2 APRIL 17 1986

11. MKE UMTRA GRAND JUNCTION CALC. NO. 05-639-01-00 "EMBANKMENT DESIGN - MATERIAL PROPERTIES"

12. MKE UMTRA GRAND JUNCTION CALC. NO. 05-655-01-00 "SURFACE WATER RUNOFF ACCUMULATION AND DISCHARGE.

13. MKE DRAWING NO. GRJ-DS-10-0134 REV. 2 "EXCAVATION PLAN.

14. KIBLER, D.F. AND ARON, G. "EVALUATION OF T_c METHODS FOR URBAN WATERSHEDS", FRONTIERS IN HYDRAULIC ENGINEERING ASCE CONF. PROCEED. AUG 9-12, 1983 MIT, CAMBRIDGE MA.

INTRODUCTION

THE RETENTION BASIN WAS ORIGINALLY SIZED FOR BOTH EMBANKMENT AND STOCKPILE AREAS. IN CALCULATION #05-628-03-01 (REF 1), SINCE THAT TIME TWO MAJOR DECISIONS WERE MADE HAVING IMPACT ON THE ORIGINAL RETENTION BASIN DESIGN:

1.) THE EMBANKMENT WAS MOVED TO THE WESTERN END OF THE SITE.

2.) A DECISION WAS MADE TO ALLOW SURFACE WATER FROM THE STOCKPILE AREAS TO FLOW OFF-SITE SINCE THE WATER IN THESE AREAS IS UNCONTAMINA

THE DECISION NOT TO DIRECT 'OFF-PILE' WATER TO THE RETENTION BASIN ALLOWS FOR A MUCH SMALLER BASIN, HOWEVER THE EXTRA CAPACITY MAY BE ADVANTAGEOUS IF CONSTRUCTION WATER USE HAS BEEN UNDER-ESTIMATED.

THEREFORE, THE ORIGINAL RETENTION BASIN DESIGN SHALL BE CHECKED FOR THE NEW CONDITIONS AND HOPEFULLY THE ORIGINAL SIZING CAN BE RETAINED.

THE ASSUMPTION IS THAT THE SUBCONTRACTOR WILL BUILD DIVERSION DITCHES IN A MANNER TO PREVENT UNCONTAMINATED SURFACE WATER FROM ENTERING THE EXCAVATION. STOCKPILE AREAS ARE CONSIDERED UNCONTAMINATED. ALSO WATER USED FOR PROCESSIN WILL NOT BE COLLECTED IN THE RETENTION BASIN.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA - GRJ | Contract No. 5025-16 | Sheet 45 D
Feature: RETENTION BASIN | Designed SKG | File No. | Date 1-23-90
Item: DISPOSAL SITE | Checked H.L. | Date 6/6/9

PURPOSE

CHECK ORIGINAL BASIN DESIGN FOR NEW LOCATION. EXCERPTS FROM THE ORIGINAL CALC. ARE ATTACHED.

NEW RUN-OFF AREA = 59.8 AC (EXCAVATION AREA FROM REF 1

NEW 57.0 ≅ OLD 59.7 AC. USED IN "ON-PILE" PORTION OF RETENTION BASIN CALC. NO. 05-628-03-01 (RE

RUNOFF FOR 59.7 AC = 1.83 AC-FT (REF 1 p.38) SHT 22

SEDIMENT YIELD FOR 59.7 AC = 1.4 AC-FT

CONSTRUCTION WATER = 0.797 AC-FT (SEE WATER BALANC ACCUM. VOLUME SHT 6

THE EMERGENCY SPILLWAY WAS DESIGNED FOR THE LARGE CAPACITY BASIN AND SHOULD BE RETAINED AS IS. = 1.3 FT DEPTH [ASSUME 350' x 500' BASI (REF 1 p 58)

$1.83 + 1.4 + 0.797 = 4.0$ AC-FT $= 175416$ FT^3

$$\frac{175416 \text{ FT}^3}{350 (500) \text{ FT}^2} = 1.0 \text{ FT DEPTH CAPACITY}$$

TOTAL DEPTH = CAPACITY + SPILLWAY + FREEBOARD

$= 1.0 + 1.3 + 1.0$

$= 3.3$ FT

<u>CONCLUSION</u>: $3.3 < 5$ FT ∴ OLD DESIGN IS ADEQUATE.

CHECK TIME OF CONCENTRATION FOR NEW EMBANKMENT

$$T_c = T_{c_{OVERLAND}} + \cancel{T_{c_{DITCH}}} \to 0$$

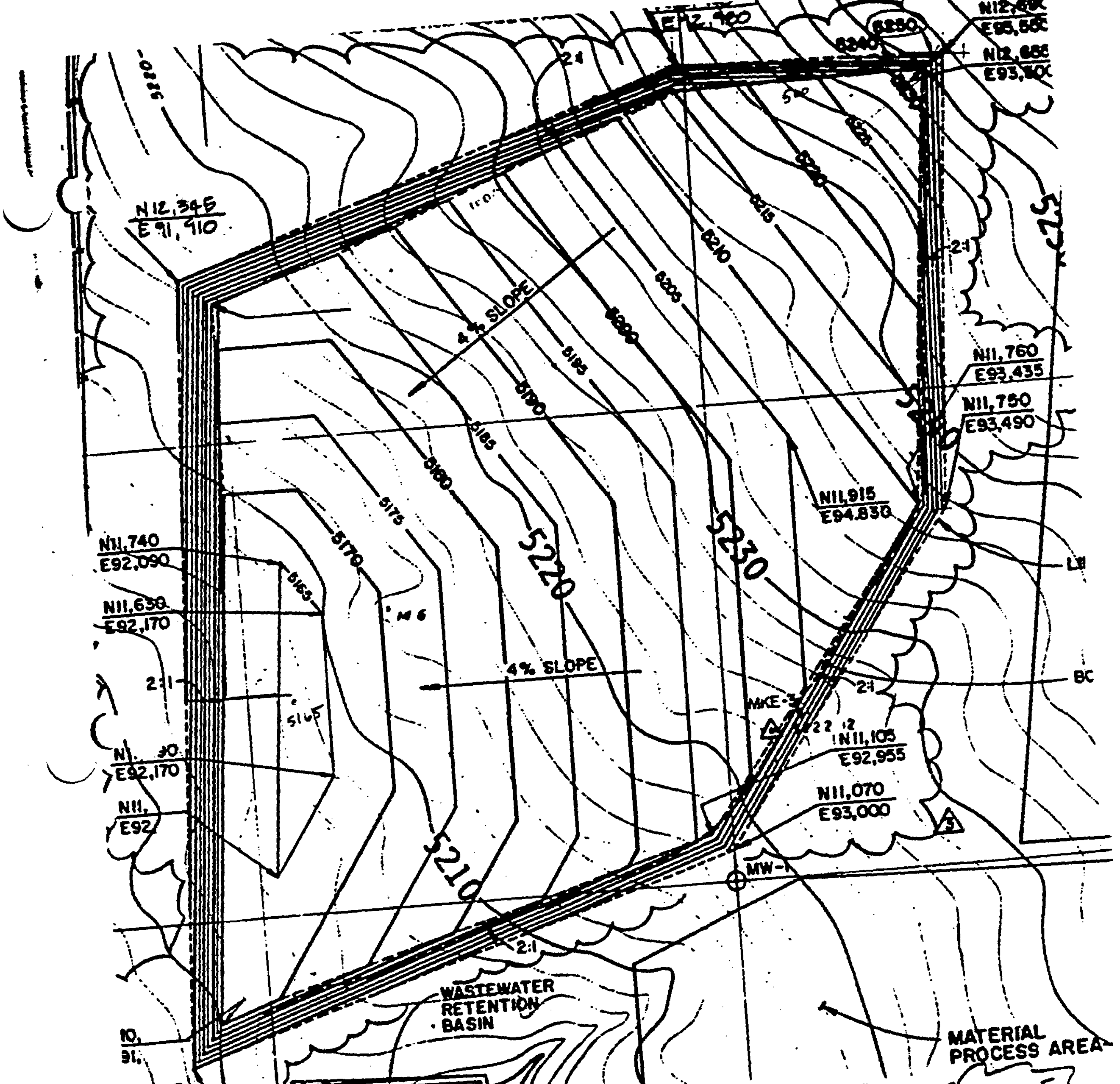
$$T_c = .0078\ L^{0.77}\ S^{-.385}$$ KIRPICH REF. 14

$$L = 2600 \text{ FT}$$

$$S = \frac{5250 - 5165}{2600} = .03 \text{ FT/FT}$$

$$T_c = .0078\ (2600)^{.77}\ (.03)^{-.385}$$

T_c = 12.5 min USE 14 min USED IN OLD CELL AS BASIS FOR SBUHYD (SEE SHEET 30)



UMTRA – GRJ
5025–16
Retention Basin and Emergency Spillw

SAB 6/8/
Ckd · H.L.
6/8/9

$\Delta H = 5250 - 5165 = 85'$

$L = 2600$

$S = \frac{85}{2600} = .032$

WATER BALANCE
LOTUS SPREADSHEET

[illegible] 1-24-90
H.L. 6/6/9

PROJECT ________ CONTR. NO. ________ FILE NO. ________ SHEET ________
FEATURE ________ DESIGNED ________ DATE ________
ITEM ________ CHECKED ________ DATE ________

"GRAND JUNCTION" DISPOSAL SITE — DATE: 01/23/90
RUNOFF AREA (ACRES) = 99.7
RETENTION BASIN CAPACITY (AC-FT) = 9.18
POND EVAP. AREA (ACRES) = 4.02
% ANN. LAKE EVAPORAT'N (IN.) = 55

	MONTH	SOIL SCS HYD. GRP. (NOTE A)	MEAN NO. DAYS PRECIP. >0.1" (EACH)	MEAN TEMP. (DEG. F)	MEAN PRECIP. (IN.)	MEAN SNOW (IN.)	SNOW (IN. WTR.)	RAIN-FALL (IN. WTR.)	SUBLIMATION (IN.)	ACCUM. SNOWPACK (NOTE B) (INCHES OF WTR.)	SNOW-MELT (IN. WTR.)	TOTAL RAINFALL & SNOWMLT. (IN. WTR.)	NUMBER OF EVENTS	WATER PER EVENT (IN. WTR.)	"S" -SCS- (IN.)	TOTAL RUNOFF VOLUME (AC-FT)	INPUTS ASSUMED TAILINGS CONSTR. WATER REQ'D (AC-FT)	INPUTS ASSUMED DE-WATERING INFLOW (AC-FT)	NON-ACCUM. EST. EVAPTN. (AC-FT)	NON-ACCUM. ACTUAL CONSTR. WATER USAGE (AC-FT)	NON-ACCUM. SURPLUS WATER (AC-FT)	ACCUM. EST. EVAPTN. (AC-FT)	ACCUM. ACTUAL CONSTR. WATER USAGE (AC-FT)	ACCUM. WTR. VOLUME (AC-FT)	INPU EVA DIST FT
1989	SEP	[illegible]	2	68.3	0.98	0	0	0.98	0	0.000	0.000	0.98	1	0.98	1.364	1.282	6.7	0	0.921	0.200	0.000	1.282	0.000	0.000	0.1
	OCT	[illegible]	2	56.7	1.06	0.3	0	1.06	0	0.000	0.000	1.06	1	1.06	1.364	1.434	6.7	0	0.645	0.789	0.000	1.298	0.144	0.000	0.0
	NOV	[illegible]	2	41.9	0.73	1.6	0	0.73	0	0.000	0.000	0.73	1	0.73	1.364	0.571	6.7	0	0.276	0.295	0.000	0.553	0.019	0.000	0.0
	DEC	[illegible]	2	31.1	0.57	4.5	0.562	0.01	0.5	0.563	0.000	0.01	1	0.01	0.526	0.000	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.0
1990	JAN	[illegible]	2	28.2	0.52	5.3	0.52	0.00	0.5	0.583	0.000	0.00	1	0.00	0.526	0.000	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.0
	FEB	[illegible]	2	35.6	0.56	3.2	0	0.56	0	0.083	0.083	0.64	1	0.64	0.526	1.358	0	0	0.276	0.000	1.074	0.553	0.000	0.797	0.0
	MAR	[illegible]	3	43.6	0.88	3.1	0	0.88	0	0.000	0.000	0.88	2	0.44	1.364	0.182	6.47	0	0.182	0.000	0.000	0.979	0.000	0.000	0.0
	APR	[illegible]	3	53.2	0.82	0.4	0	0.82	0	0.000	0.000	0.82	2	0.41	1.364	0.125	6.47	0	0.125	0.000	0.000	0.125	0.000	0.000	0.0
	MAY	[illegible]	2	63.0	0.87	0.1	0	0.87	0	0.000	0.000	0.87	2	0.44	1.364	0.172	6.47	0	0.172	0.000	0.000	0.172	0.000	0.000	0.1
	JUN	[illegible]	1	72.9	0.58	0	0	0.58	0	0.000	0.000	0.58	1	0.58	1.364	0.162	6.47	0	0.162	0.000	0.000	0.162	0.000	0.000	0.1
	JUL	[illegible]	2	79.4	0.68	0	0	0.68	0	0.000	0.000	0.68	1	0.68	1.364	0.315	6.47	0	0.315	0.000	0.000	0.315	0.000	0.000	0.1
	AUG	[illegible]	2	76.5	0.97	0	0	0.97	0	0.000	0.000	0.97	2	0.49	1.364	0.284	6.47	0	0.284	0.000	0.000	0.284	0.000	0.000	0.14
	SEP	[illegible]	2	68.3	0.98	0	0	0.98	0	0.000	0.000	0.98	1	0.98	1.364	1.282	6.47	0	0.921	0.200	0.000	1.282	0.000	0.000	0.10
	OCT	[illegible]	2	56.7	1.06	0.3	0	1.06	0	0.000	0.000	1.06	1	1.06	1.364	1.434	6.47	0	0.645	0.789	0.000	1.298	0.144	0.000	0.07
	NOV	[illegible]	2	41.9	0.73	1.6	0	0.73	0	0.000	0.000	0.73	1	0.73	1.364	0.571	6.47	0	0.276	0.295	0.000	0.553	0.019	0.000	0.03
	DEC	[illegible]	2	31.1	0.57	4.5	0.562	0.01	0.5	0.563	0.000	0.01	1	0.01	0.526	0.000	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.02
1991	JAN	[illegible]	2	28.2	0.52	5.3	0.52	0.00	0.5	0.583	0.000	0.00	1	0.00	0.526	0.000	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.02
	FEB	[illegible]	2	35.6	0.56	3.2	0	0.56	0	0.083	0.083	0.64	1	0.64	0.526	1.358	0	0	0.276	0.000	1.074	0.553	0.000	0.797	0.03
	MAR	[illegible]	3	43.6	0.88	3.1	0	0.88	0	0.000	0.000	0.88	2	0.44	1.364	0.182	6.7	0	0.182	0.000	0.000	0.979	0.000	0.000	0.04
	APR	[illegible]	3	53.2	0.82	0.4	0	0.82	0	0.000	0.000	0.82	2	0.41	1.364	0.125	6.7	0	0.125	0.000	0.000	0.125	0.000	0.000	0.00
	MAY	[illegible]	3	63.0	0.87	0.1	0	0.87	0	0.000	0.000	0.87	2	0.44	1.364	0.172	6.7	0	0.172	0.000	0.000	0.172	0.000	0.000	0.13
	JUN	[illegible]	2	72.9	0.58	0	0	0.58	0	0.000	0.000	0.58	1	0.58	1.364	0.162	6.7	0	0.162	0.000	0.000	0.162	0.000	0.000	0.16
	JUL	[illegible]	2	79.4	0.68	0	0	0.68	0	0.000	0.000	0.68	1	0.68	1.364	0.315	6.7	0	0.315	0.000	0.000	0.315	0.000	0.000	0.16
	AUG	[illegible]	2	76.5	0.97	0	0	0.97	0	0.000	0.000	0.97	2	0.49	1.364	0.284	6.7	0	0.284	0.000	0.000	0.284	0.000	0.000	0.14
	SEP	[illegible]	2	68.3	0.98	0	0	0.98	0	0.000	0.000	0.98	1	0.98	1.364	1.282	6.7	0	0.921	0.200	0.000	1.282	0.000	0.000	0.10
	OCT	[illegible]	2	56.7	1.06	0.3	0	1.06	0	0.000	0.000	1.06	1	1.06	1.364	1.434	6.7	0	0.645	0.789	0.000	1.298	0.144	0.000	0.071
	NOV	[illegible]	2	41.9	0.73	1.6	0	0.73	0	0.000	0.000	0.73	1	0.73	1.364	0.571	6.7	0	0.276	0.295	0.000	0.553	0.019	0.000	0.032
	DEC	[illegible]	2	31.1	0.57	4.5	0.562	0.01	0.5	0.563	0.000	0.01	1	0.01	0.526	0.000	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.028
1992	JAN	[illegible]	2	28.2	0.52	5.3	0.52	0.00	0.5	0.583	0.000	0.00	1	0.00	0.526	0.000	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.028
	FEB	[illegible]	2	35.6	0.56	3.2	0	0.56	0	0.083	0.083	0.64	1	0.64	0.526	1.358	0	0	0.276	0.000	1.074	0.553	0.000	0.797	0.038
	MAR	[illegible]	2	43.6	0.88	3.1	0	0.88	0	0.000	0.000	0.88	2	0.44	1.364	0.182	0	0	0.182	0.000	0.000	0.979	0.000	0.000	0.048
	APR	[illegible]	3	53.2	0.82	0.4	0	0.82	0	0.000	0.000	0.82	2	0.41	1.364	0.125	0	0	0.125	0.000	0.000	0.125	0.000	0.000	0.000
	MAY	[illegible]	3	63.0	0.87	0.1	0	0.87	0	0.000	0.000	0.87	2	0.44	1.364	0.172	0	0	0.172	0.000	0.000	0.172	0.000	0.000	0.138
	JUN	[illegible]	1	72.9	0.58	0	0	0.58	0	0.000	0.000	0.58	1	0.58	1.364	0.162	0	0	0.162	0.000	0.000	0.162	0.000	0.000	0.168
	JUL	[illegible]	2	79.4	0.68	0	0	0.68	0	0.000	0.000	0.68	1	0.68	1.364	0.315	0	0	0.315	0.000	0.000	0.315	0.000	0.000	0.168
	AUG	[illegible]	2	76.5	0.97	0	0	0.97	0	0.000	0.000	0.97	2	0.49	1.364	0.284	0	0	0.284	0.000	0.000	0.284	0.000	0.000	0.140
	SEP	[illegible]	2	68.3	0.98	0	0	0.98	0	0.000	0.000	0.98	1	0.98	1.364	1.282	0	0	0.921	0.000	0.200	1.282	0.000	0.000	0.100
	OCT	[illegible]	2	56.7	1.06	0.3	0	1.06	0	0.000	0.000	1.06	1	1.06	1.364	1.434	0	0	0.645	0.000	0.789	1.298	0.000	0.144	0.070
	NOV	[illegible]	2	41.9	0.73	1.6	0	0.73	0	0.000	0.000	0.73	1	0.73	1.364	0.571	0	0	0.276	0.000	0.295	0.553	0.000	0.162	0.038
	DEC	[illegible]	2	31.1	0.57	4.5	0.562	0.01	0.5	0.563	0.000	0.01	1	0.01	0.526	0.000	0	0	0.000	0.000	0.000	0.162	0.000	0.081	0.028
1993	JAN	[illegible]	2	28.2	0.52	5.3	0.52	0.00	0.5	0.583	0.000	0.00	1	0.00	0.526	0.000	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.028
	FEB	[illegible]	2	35.6	0.56	3.2	0	0.56	0	0.083	0.083	0.64	1	0.64	0.526	1.358	0	0	0.276	0.000	1.074	0.553	0.000	0.797	0.038
	MAR	[illegible]	2	43.6	0.88	3.1	0	0.88	0	0.000	0.000	0.88	2	0.44	1.364	0.182	0	0	0.182	0.000	0.000	0.979	0.000	0.000	0.048
	APR	[illegible]	2	53.2	0.82	0.4	0	0.82	0	0.000	0.000	0.82	2	0.41	1.364	0.125	0	0	0.125	0.000	0.000	0.125	0.000	0.000	0.000
	MAY	[illegible]	3	63.0	0.87	0.1	0	0.87	0	0.000	0.000	0.87	2	0.44	1.364	0.172	0	0	0.172	0.000	0.000	0.172	0.000	0.000	0.138
	JUN	[illegible]	2	72.9	0.58	0	0	0.58	0	0.000	0.000	0.58	1	0.58	1.364	0.162	0	0	0.162	0.000	0.000	0.162	0.000	0.000	0.168
	JUL	[illegible]	2	79.4	0.68	0	0	0.68	0	0.000	0.000	0.68	1	0.68	1.364	0.315	0	0	0.315	0.000	0.000	0.315	0.000	0.000	0.168
	AUG	[illegible]	2	76.5	0.97	0	0	0.97	0	0.000	0.000	0.97	2	0.49	1.364	0.284	0	0	0.284	0.000	0.000	0.284	0.000	0.000	0.140
	SEP	[illegible]	2	68.3	0.98	0	0	0.98	0	0.000	0.000	0.98	1	0.98	1.364	1.282	0	0	0.921	0.000	0.200	1.282	0.000	0.000	0.100
	OCT	[illegible]	2	56.7	1.06	0.3	0	1.06	0	0.000	0.000	1.06	1	1.06	1.364	1.434	0	0	0.645	0.000	0.789	1.298	0.000	0.144	0.070
	NOV	[illegible]	2	41.9	0.73	1.6	0	0.73	0	0.000	0.000	0.73	1	0.73	1.364	0.571	0	0	0.276	0.000	0.295	0.553	0.000	0.162	0.038

RETENTION BASIN

PURPOSE:

At the disposal site, a retention basin will be constructed to store the runoff volume from a 10-year 24-hour storm and the sediment yield transported by the runoff during the construction of the tailings embankment. An emergency spillway will also be constructed to pass the peak runoff of a 25-year 1-hour storm.

METHOD:

A computerized version of the Santa Barbara Urban Hydrograph Method (SBUHYD) is used to calculate the runoff volumes for sizing the retention basin and to calculate the required peak flow capacity for the spillways. Documentation and a description of the SBUHYD method is provided in the MKE UMTRA Project Design Procedures manual (Ref. 7, p. 4-5).

The volume of the sediment yield is calculated using the modified universal soil loss equation (Ref 2, p 5).

SBUHYD INPUT PARAMETERS:

The following design parameters are required for input into the SBUHYD program for sizing of the retention basin.

1) 10-year 24-hour storm and hyetograph
2) drainage area
3) soil parameters

1) The 10-year 24-hour storm and hyetograph are as follows (derived from MKE Calc No. 05-628-01-00 (Ref 4)).

RAINFALL DURATION (MINUTES)	RAINFALL DURATION (HOURS)	HYETOGRAPH (INCHES)
0	0.0	.000
30	0.5	.005
60	1.0	.005
90	1.5	.005
120	2.0	.005
150	2.5	.010
180	3.0	.010
210	3.5	.010
240	4.0	.010
270	4.5	.010
300	5.0	.010
330	5.5	.010
360	6.0	.010
390	6.5	.015
420	7.0	.015
450	7.5	.015
480	8.0	.015
510	8.5	.015
540	9.0	.015
570	9.5	.015
600	10.0	.015
630	10.5	.020
660	11.0	.020
690	11.5	.020
720	12.0	.020
750	12.5	.020
780	13.0	.020
810	13.5	.025
840	14.0	.025
870	14.5	.040
900	15.0	.040
930	15.5	.190
960	16.0	.730
990	16.5	.030
1020	17.0	.030
1050	17.5	.025
1080	18.0	.025
1110	18.5	.020
1140	19.0	.020
1170	19.5	.020
1200	20.0	.020
1230	20.5	.015
1260	21.0	.015
1290	21.5	.015
1320	22.0	.015
1350	22.5	.015
1380	23.0	.015
1410	23.5	.015
1440	24.0	.015
		1.700

3) Soil parameters for the SBUHYD program are estimated using Green and Ampt parameters as well as information given in the draft RAP.

On-pile tailings area: (OLD CALC. PILE AREA IS SIMILAR TO NEW PILE AREA)

Area = 59.66 acres

From the pile sections in the draft RAP, the composition of the tailings pile is as follows:

fine sand	~40 %	Rough estimates
sand + slime	~40 %	
silt	~20 %	

From the soil triangle of the basic soil textural classes prepared by the U.S. Soil Conservation Service, the tailings are, in general, "loamy sand" The Green & Ampt parameters for loamy sand are:

Soil Suction Head Ψ = 6.13 cm = 2.41 inches

Hydraulic Conductivity K = 2.99 cm/hr = 1.18 in/hr

From Calc no. 05-639-01-00 (Ref. 11):

more conservative, so use this.

Hydraulic Conductivity $K = 3.5 \times 10^{-4}$ cm/sec = 0.50 in/hr (sand-slime tailings)
K = 1.26 cm/hr

∴ Soil Suction Head Ψ = 10.57 cm = 4.16 in
(Ref 5, p. 67)

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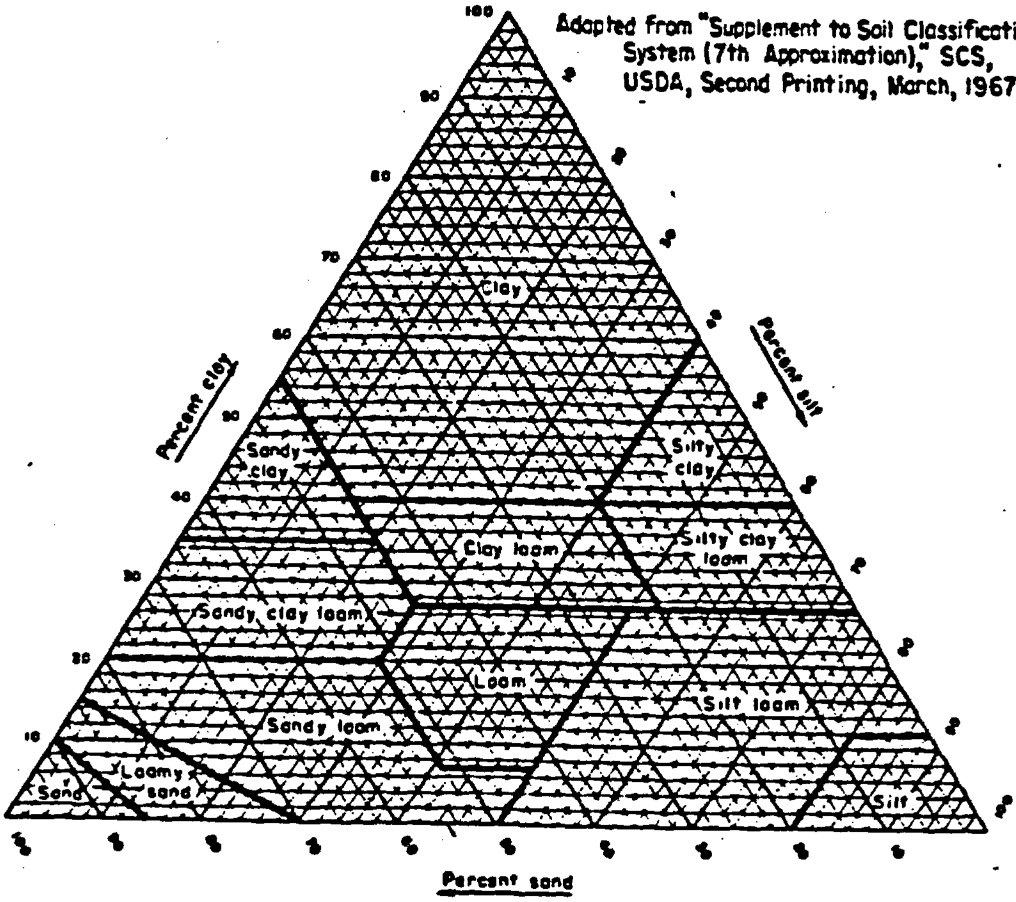
Project UMTRA / GJT	Contract No. 5025-06	Sheet 26	File No.
Feature DISPOSAL SITE DRAINAGE DURING CONST.	Designed MDL	Date 12/8/86	
Item RETENTION BASIN + EMERGENCY SPILLWAY	Checked ABH	Date 12/30/86	

Adapted from "Supplement to Soil Classification System (7th Approximation)," SCS, USDA, Second Printing, March, 1967.



Soil Triangle of the Basic Soil Textural Classes

(Ref. 5, p. 121)

Soil texture class (1)	Horizon (2)	Sample size (3)	Total porosity, ϕ, in cubic centimeters per cubic centimeters (4)	Effective porosity, θ_e, in cubic centimeters per cubic centimeters (5)	Wetted front capillary pressure, ψ_f,[c] in centimeters (6)	Hydraulic conductivity, K[b] in centimeters per hour, (7)
Sand[c]		762	0.437 0.374–0.500[d]	0.417 (0.354–0.480)	4.95 (0.97–25.36)	11.78
	A	370	0.452 (0.396–0.508)	0.431 (0.375–0.487)	5.34 (1.24–23.06)	
	B	185	0.440 (0.385–0.495)	0.421 (0.365–0.477)	6.38 (1.31–31.06)	
	C	127	0.424 (0.385–0.463)	0.408 (0.365–0.451)	2.07 (0.32–13.26)	
Loamy sand		338	0.437 (0.363–0.506)	0.401 (0.329–0.473)	6.13 (1.35–27.94)	2.99
	A	110	0.457 (0.385–0.529)	0.424 (0.347–0.501)	6.01 (1.58–22.87)	
	B	49	0.447 (0.379–0.515)	0.412 (0.334–0.490)	4.21 (1.03–17.24)	
	C	36	0.424 (0.372–0.476)	0.385 (0.323–0.447)	5.16 (0.76–34.85)	
Sandy loam		666	0.453 (0.351–0.555)	0.412 (0.283–0.541)	11.01 (2.67–45.47)	1.09
	A	119	0.505 (0.399–0.611)	0.469 (0.330–0.608)	15.24 (5.56–41.76)	
	B	219	0.466 (0.352–0.580)	0.428 (0.271–0.585)	8.89 (2.02–39.06)	
	C	66	0.418 (0.352–0.484)	0.389 (0.310–0.468)	6.79 (1.16–39.65)	
Loam		383	0.463 (0.375–0.551)	0.434 (0.334–0.534)	8.89 (1.33–59.38)	0.34
	A	76	0.512 (0.427–0.597)	0.476 (0.376–0.576)	10.01 (2.14–46.81)	
	B	67	0.512 (0.408–0.616)	0.498 (0.382–0.614)	6.40 (1.01–40.49)	
	C	47	0.412 (0.350–0.474)	0.382 (0.305–0.459)	9.27 (0.87–99.29)	
Silt loam		1,206	0.501 (0.420–0.582)	0.486 (0.394–0.578)	16.68 (2.92–95.39)	0.65
	A	361	C.527 (0.444–0.610)	0.514 (0.425–0.603)	10.91 (1.89–63.05)	
	B	267	0.533 (0.430–0.636)	0.515 (0.387–0.643)	7.21 (0.86–60.82)	
	C	73	0.470 (0.409–0.531)	0.460 (0.396–0.524)	12.62 (3.94–40.45)	
Sandy clay loam		498	0.398 (0.332–0.464)	0.330 (0.235–0.425)	21.85 (4.42–108.0)	0.15
	A	—[e]	— —	— —	— —	
	B	198	0.393 (0.310–0.476)	0.330 (0.223–0.437)	26.10 (4.79–142.30)	
	C	32	0.407 (0.359–0.455)	0.332 (0.251–0.413)	23.90 (5.51–103.75)	
Clay loam		366	0.464 (0.409–0.519)	0.309 (0.279–0.501)	20.88 (4.79–91.10)	0.10
	A	28	0.497 (0.434–0.560)	0.430 (0.328–0.532)	27.00 (6.13–118.9)	
	B	99	0.451 (0.401–0.501)	0.397 (0.228–0.530)	18.52 (4.36–78.73)	
	C	55	0.452 (0.412–0.492)	0.400 (0.320–0.480)	15.21 (3.79–61.01)	
Silty clay loam		689	0.471 (0.418–0.524)	0.432 (0.347–0.517)	27.30 (5.67–131.50)	0.10
	A	65	0.509 (0.449–0.569)	0.477 (0.410–0.544)	13.97 (4.20–46.53)	
	B	191	0.469 (0.423–0.515)	0.441 (0.374–0.508)	18.56 (4.08–84.44)	
	C	39	0.475 (0.436–0.514)	0.451 (0.386–0.516)	21.54 (4.56–101.7)	
Sandy clay		45	0.430 (0.370–0.490)	0.321 (0.207–0.435)	23.90 (4.08–140.2)	0.06
	A	—	— —	— —	— —	
	B	23	0.435 (0.371–0.499)	0.335 (0.220–0.450)	36.74 (8.33–162.1)	
	C	—	— —	— —	— —	
Silty clay		127	0.479 (0.425–0.533)	0.423 (0.334–0.512)	29.22 (6.13–139.4)	0.05
	A	—	— —	— —	— —	
	B	38	0.476 (0.445–0.507)	0.424 (0.345–0.503)	30.66 (7.15–131.5)	
	C	21	0.464 (0.430–0.498)	0.416 (0.346–0.486)	45.65 (18.27–114.1)	
Clay		291	0.475 (0.427–0.523)	0.385 (0.269–0.501)	31.63 (6.39–156.5)	0.03
	A	—	— —	— —	— —	
	B	70	0.470 (0.426–0.514)	0.412 (0.309–0.515)	27.72 (6.21–123.7)	
	C	25	0.483 (0.441–0.525)	0.419 (0.294–0.544)	54.65 (10.59–282.0)	

[a]Antilog of the log mean and standard deviation.
[b]Values for Rawls, et al. (13).
[c]Values for the texture class.
[d]Numbers in ( ) ± one standard deviation.
[e]Insufficient sample to determine parameters.

Green and Ampt Parameters According to Soil Texture Classes and Horizons

(Ref 5, p. 67)

Initial Moisture Content:

All equations found in Ref. 3, p.30.

$m = \frac{V_w}{V}$ (defined as volumetric moisture content)

where $V_w = \frac{W_w}{\gamma_w}$

$W_w = w W_s$

$W_s = \gamma_d V$ (V = total volume of sample)

$\gamma_w = 62.4$ pcf

$w = w_{initial} = w_{opt} = 0.189$ (Ref. 6, p. B-33)

$\gamma_d = 1.650$ g/cc $= 102.93$ pcf (Ref. 6, p B-34,35,36)

$$\therefore m_{initial} = \frac{W_w / \gamma_w}{V} = \frac{w W_s}{V \gamma_w} = \frac{w \gamma_d V}{V \gamma_w} = \frac{w \gamma_d}{\gamma_w}$$

$$= \frac{(0.189)(102.93)}{62.4} = \underline{\underline{0.31}}$$

Final Moisture Content:

$m_{final} = n$ (assume fully saturated)

where $n = 1 - \frac{W_s}{G V \gamma_w} = 1 - \frac{\gamma_d}{G \gamma_w}$

$$\therefore m_{final} = 1 - \frac{102.93}{(2.74)(62.4)} = \underline{\underline{0.40}}$$

Off-pile uncontaminated area:

NOTE: SURFACE WATER FROM THE STOCK PILE AREA IS NO LONGER POSSIBLE TO ENTER RETENTION BASIN - INCLUSION OF THIS AREA IS CONSERVATIVE

$115.38 - 59.66 = 55.72$

Area = 55.72 acres

From Ref. 6, p. E-114, the classification for the soil at the disposal site is "silty clay." The Green & Ampt parameters for silty clay are:

Soil Suction Head $\psi = 29.22$ cm $= 11.5$ in

Hydraulic Conductivity $K = 0.05$ cm/hr $= 0.02$ in/hr

The only available information on the soil at the Cheney Reservoir site is from in situ tests. Using in situ parameters will give us conservative results for runoff. Parameters are in Ref. 6, p. E-114.

$$m_{initial} = \frac{w\,\gamma_d}{\gamma_w} = \frac{(0.101)(85.1)}{62.4} = \underline{\underline{0.14}}$$ (derivation of equation on sheet 28)

$$m_{final} = 1 - \frac{\gamma_d}{G\,\gamma_w} = 1 - \frac{85.1}{(2.74)(62.4)} = \underline{\underline{0.50}}$$

(derivation of equation on sheet 28)

From Calc. no 05-639-01-00 (Ref. 11), using layer #1:

Hydraulic Conductivity $K = 4.1 \times 10^{-8}$ cm/sec $= 0.0001$ in/hr

$\therefore$ Soil Suction Head $\psi = 24.09$ cm $= 9.48$ in (Ref 5, p. 67)

SBUHYD Program (for Run-off Volumes).

SUMMARY OF INPUTS

	on-pile	off-pile
Drainage Area (acres)	59.7	55.7
Impervious Area (acres)	0	4.0
Time of Concentration (min)	14	~~14~~
Time Increment (min)	30.	30.
Rainfall Distribution	See sheet 22	
Initial Saturation	0.31	0.14
Final Saturation	0.40	0.50
Soil Suction Head (inch).	4.16	9.48
Hydraulic Conductivity (inch/hour)	0.50	0.0001
Number of Rainfall Incr	48	48
Number of Output Steps	60	60

SUMMARY OF OUTPUTS

Run-offs. (ac-ft) 1.83 6.78, 0.57 } 7.35

9.18

1.83 IS THE ONLY CONTRIBUTING AREA

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SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987

MDL 12/8/86
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INPUT DATA

TITLE1: UMTRA / GRAND JUNCTION
TITLE2: DISPOSAL SITE RETENTION BASIN DESIGN

RAINFALL DATA

TYPE OF DATA: 1
  1 = RAINFALL IN INCHES
  2 = PERCENT OF TOTAL DEPTH
TIME STEP: 30.0 MINUTES
NUMBER OF RAINFALLS: 48
RAINFALLS IN INCHES:

```
0.005 0.005 0.005 0.005 0.010 0.010 0.010 0.010 0.010 0.010
0.010 0.010 0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015
0.020 0.020 0.020 0.020 0.020 0.020 0.025 0.025 0.040 0.040
0.190 0.730 0.030 0.030 0.025 0.025 0.020 0.020 0.020 0.020
0.015 0.015 0.015 0.015 0.015 0.015 0.015 0.015
```

DRAINAGES

NUMBER OF DRAINAGE AREAS: 2

NAME OF THE 1st DRAINAGE AREA: ON-PILE
DRAINAGE AREA: 59.7 ACRES
IMPERVIOUS AREA: 0.0 ACRES
TIME OF CONCENTRATION: 14.0 MINUTES

SOIL PARAMETERS:
INITIAL SOIL MOISTURE CONTENT: 0.3100
SATURATED SOIL MOISTURE CONTENT: 0.4000
SOIL SUCTION HEAD: 4.16 INCHES
HYDRAULIC CONDUCTIVITY: 0.5000000000 IN/HR

NAME OF THE 2nd DRAINAGE AREA: OFF-PILE
DRAINAGE AREA: 55.7 ACRES
IMPERVIOUS AREA: 4.0 ACRES
TIME OF CONCENTRATION: 14.0 MINUTES

SOIL PARAMETERS:
INITIAL SOIL MOISTURE CONTENT: 0.1400
SATURATED SOIL MOISTURE CONTENT: 0.5000
SOIL SUCTION HEAD: 9.48 INCHES
HYDRAULIC CONDUCTIVITY: 0.0001000000 IN/HR

MORRISON-KNUDSEN ENGINEERS, INC.
SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987

MDL 12/8/86
ABH 12/30/86.

RAINFALL-RUNOFF COMPUTATION

TITLE1: UMTRA / GRAND JUNCTION
TITLE2: DISPOSAL SITE RETENTION BASIN DESIGN

NAME OF DRAINAGE AREA: ON-PILE
DRAINAGE AREA: 59.7 ACRES
IMPERVIOUS AREA: 0.0 ACRES
IMPERVIOUS PORTION: 0.0000
TIME OF CONCENTRATION: 14.0 MINUTES

SOIL PARAMETERS:
INITIAL SOIL MOISTURE CONTENT: 0.3100
SATURATED SOIL MOISTURE CONTENT: 0.4000
SOIL SUCTION HEAD: 4.16 INCHES
HYDRAULIC CONDUCTIVITY: 0.5000000000 IN/HR

TOTAL RAINFALL: 1.700 INCHES
TIME STEP: 30.0 MINUTES
NUMBER OF RAINFALLS: 48

RUNOFF VOLUME:
IMPERVIOUS: 0.00 INCHES OR 0.00 AC-FT
PERVIOUS: 0.37 INCHES OR 1.83 AC-FT
TOTAL: 0.37 INCHES OR 1.83 AC-FT

PEAK FLOW: 23.0 CFS AT 16.00 HRS

NUMB	TIME (HRS)	RAINFALL DEPTH (IN)	INFILTRATION (IN)	IMPERVIOUS RUNOFF (IN)	PERVIOUS RUNOFF (IN)	TOTAL RUNOFF (IN)	INSTANT HYDROGRAPH (CFS)	FINAL HYDROGRAPH (CFS)
0	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
1	0.500	0.005	0.005	0.000	0.000	0.000	0.0	0.0
2	1.000	0.005	0.005	0.000	0.000	0.000	0.0	0.0
3	1.500	0.005	0.005	0.000	0.000	0.000	0.0	0.0
4	2.000	0.005	0.005	0.000	0.000	0.000	0.0	0.0
5	2.500	0.010	0.010	0.000	0.000	0.000	0.0	0.0
6	3.000	0.010	0.010	0.000	0.000	0.000	0.0	0.0
7	3.500	0.010	0.010	0.000	0.000	0.000	0.0	0.0
8	4.000	0.010	0.010	0.000	0.000	0.000	0.0	0.0
9	4.500	0.010	0.010	0.000	0.000	0.000	0.0	0.0
10	5.000	0.010	0.010	0.000	0.000	0.000	0.0	0.0
11	5.500	0.010	0.010	0.000	0.000	0.000	0.0	0.0
12	6.000	0.010	0.010	0.000	0.000	0.000	0.0	0.0
13	6.500	0.015	0.015	0.000	0.000	0.000	0.0	0.0
14	7.000	0.015	0.015	0.000	0.000	0.000	0.0	0.0
15	7.500	0.015	0.015	0.000	0.000	0.000	0.0	0.0
16	8.000	0.015	0.015	0.000	0.000	0.000	0.0	0.0
17	8.500	0.015	0.015	0.000	0.000	0.000	0.0	0.0
18	9.000	0.015	0.015	0.000	0.000	0.000	0.0	0.0
19	9.500	0.015	0.015	0.000	0.000	0.000	0.0	0.0
20	10.000	0.015	0.015	0.000	0.000	0.000	0.0	0.0
21	10.500	0.020	0.020	0.000	0.000	0.000	0.0	0.0

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22	11.000	0.020	0.020	0.000	0.000	0.000	0.0	0.0
23	11.500	0.020	0.020	0.000	0.000	0.000	0.0	0.0
24	12.000	0.020	0.020	0.000	0.000	0.000	0.0	0.0
25	12.500	0.020	0.020	0.000	0.000	0.000	0.0	0.0
26	13.000	0.020	0.020	0.000	0.000	0.000	0.0	0.0
27	13.500	0.025	0.025	0.000	0.000	0.000	0.0	0.0
28	14.000	0.025	0.025	0.000	0.000	0.000	0.0	0.0
29	14.500	0.040	0.040	0.000	0.000	0.000	0.0	0.0
30	15.000	0.040	0.040	0.000	0.000	0.000	0.0	0.0
31	15.500	0.190	0.190	0.000	0.000	0.000	0.0	0.0
32	16.000	0.730	0.361	0.000	0.369	0.369	44.4	23.0
33	16.500	0.030	0.030	0.000	0.000	0.000	0.0	22.2
34	17.000	0.030	0.030	0.000	0.000	0.000	0.0	0.0
35	17.500	0.025	0.025	0.000	0.000	0.000	0.0	0.0
36	18.000	0.025	0.025	0.000	0.000	0.000	0.0	0.0
37	18.500	0.020	0.020	0.000	0.000	0.000	0.0	0.0
38	19.000	0.020	0.020	0.000	0.000	0.000	0.0	0.0
39	19.500	0.020	0.020	0.000	0.000	0.000	0.0	0.0
40	20.000	0.020	0.020	0.000	0.000	0.000	0.0	0.0
41	20.500	0.015	0.015	0.000	0.000	0.000	0.0	0.0
42	21.000	0.015	0.015	0.000	0.000	0.000	0.0	0.0
43	21.500	0.015	0.015	0.000	0.000	0.000	0.0	0.0
44	22.000	0.015	0.015	0.000	0.000	0.000	0.0	0.0
45	22.500	0.015	0.015	0.000	0.000	0.000	0.0	0.0
46	23.000	0.015	0.015	0.000	0.000	0.000	0.0	0.0
47	23.500	0.015	0.015	0.000	0.000	0.000	0.0	0.0
48	24.000	0.015	0.015	0.000	0.000	0.000	0.0	0.0
49	24.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
50	25.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
51	25.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
52	26.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
53	26.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
54	27.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
55	27.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
56	28.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
57	28.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
58	29.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
59	29.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
60	30.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
TOTALS		1.700	1.331	0.000	0.369	0.369	44.4	45.1

MORRISON-KNUDSEN ENGINEERS, INC.
SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987

MDL 12/8/86
ABH 12/30/86.

RAINFALL-RUNOFF COMPUTATION

TITLE1: UMTRA / GRAND JUNCTION
TITLE2: DISPOSAL SITE RETENTION BASIN DESIGN

NAME OF DRAINAGE AREA: OFF-PILE
DRAINAGE AREA: 55.7 ACRES
IMPERVIOUS AREA: 4.0 ACRES
IMPERVIOUS PORTION: 0.0718
TIME OF CONCENTRATION: 14.0 MINUTES

SOIL PARAMETERS:
INITIAL SOIL MOISTURE CONTENT: 0.1400
SATURATED SOIL MOISTURE CONTENT: 0.5000
SOIL SUCTION HEAD: 9.48 INCHES
HYDRAULIC CONDUCTIVITY: 0.0001000000 IN/HR

TOTAL RAINFALL: 1.700 INCHES
TIME STEP: 30.0 MINUTES
NUMBER OF RAINFALLS: 48

RUNOFF VOLUME:
IMPERVIOUS: 0.12 INCHES OR 0.57 AC-FT
PERVIOUS: 1.46 INCHES OR 6.78 AC-FT
TOTAL: 1.58 INCHES OR 7.35 AC-FT

PEAK FLOW: 52.8 CFS AT 16.00 HRS

NUMB	TIME (HRS)	RAINFALL DEPTH (IN)	INFILTRATION (IN)	IMPERVIOUS RUNOFF (IN)	PERVIOUS RUNOFF (IN)	TOTAL RUNOFF (IN)	INSTANT HYDROGRAPH (CFS)	FINAL HYDROGRAPH (CFS)
0	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
1	0.500	0.005	0.005	0.000	0.000	0.000	0.0	0.0
2	1.000	0.005	0.005	0.000	0.000	0.000	0.0	0.0
3	1.500	0.005	0.005	0.000	0.000	0.000	0.0	0.0
4	2.000	0.005	0.005	0.000	0.000	0.000	0.0	0.0
5	2.500	0.010	0.007	0.001	0.003	0.003	0.4	0.2
6	3.000	0.010	0.006	0.001	0.004	0.005	0.5	0.5
7	3.500	0.010	0.005	0.001	0.005	0.005	0.6	0.6
8	4.000	0.010	0.004	0.001	0.005	0.006	0.7	0.6
9	4.500	0.010	0.004	0.001	0.006	0.006	0.7	0.7
10	5.000	0.010	0.004	0.001	0.006	0.007	0.7	0.7
11	5.500	0.010	0.003	0.001	0.006	0.007	0.8	0.8
12	6.000	0.010	0.003	0.001	0.006	0.007	0.8	0.8
13	6.500	0.015	0.003	0.001	0.011	0.012	1.4	1.1
14	7.000	0.015	0.003	0.001	0.011	0.012	1.4	1.4
15	7.500	0.015	0.003	0.001	0.011	0.012	1.4	1.4
16	8.000	0.015	0.003	0.001	0.011	0.013	1.4	1.4
17	8.500	0.015	0.003	0.001	0.012	0.013	1.4	1.4
18	9.000	0.015	0.002	0.001	0.012	0.013	1.4	1.4
19	9.500	0.015	0.002	0.001	0.012	0.013	1.4	1.4
20	10.000	0.015	0.002	0.001	0.012	0.013	1.4	1.4
21	10.500	0.020	0.002	0.001	0.016	0.018	2.0	1.7

22	11.000	0.020	0.002	0.001	0.017	0.018	2.0	2.0
23	11.500	0.020	0.002	0.001	0.017	0.018	2.0	2.0
24	12.000	0.020	0.002	0.001	0.017	0.018	2.0	2.0
25	12.500	0.020	0.002	0.001	0.017	0.018	2.0	2.0
26	13.000	0.020	0.002	0.001	0.017	0.018	2.0	2.0
27	13.500	0.025	0.002	0.002	0.021	0.023	2.6	2.3
28	14.000	0.025	0.002	0.002	0.021	0.023	2.6	2.6
29	14.500	0.040	0.002	0.003	0.035	0.038	4.3	3.5
30	15.000	0.040	0.002	0.003	0.035	0.038	4.3	4.3
31	15.500	0.190	0.002	0.014	0.175	0.188	21.2	13.0
32	16.000	0.730	0.002	0.052	0.676	0.728	81.8	52.0
33	16.500	0.030	0.002	0.002	0.026	0.028	3.2	42.1
34	17.000	0.030	0.002	0.002	0.026	0.028	3.2	1.8
35	17.500	0.025	0.002	0.002	0.022	0.023	2.6	2.9
36	18.000	0.025	0.002	0.002	0.022	0.023	2.6	2.6
37	18.500	0.020	0.002	0.001	0.017	0.018	2.1	2.3
38	19.000	0.020	0.002	0.001	0.017	0.019	2.1	2.1
39	19.500	0.020	0.002	0.001	0.017	0.019	2.1	2.1
40	20.000	0.020	0.002	0.001	0.017	0.019	2.1	2.1
41	20.500	0.015	0.002	0.001	0.012	0.014	1.5	1.8
42	21.000	0.015	0.002	0.001	0.013	0.014	1.5	1.5
43	21.500	0.015	0.002	0.001	0.013	0.014	1.5	1.5
44	22.000	0.015	0.001	0.001	0.013	0.014	1.5	1.5
45	22.500	0.015	0.001	0.001	0.013	0.014	1.5	1.5
46	23.000	0.015	0.001	0.001	0.013	0.014	1.5	1.5
47	23.500	0.015	0.001	0.001	0.013	0.014	1.5	1.5
48	24.000	0.015	0.001	0.001	0.013	0.014	1.5	1.5
49	24.500	0.000	0.000	0.000	0.000	0.000	0.0	0.7
50	25.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
51	25.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
52	26.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
53	26.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
54	27.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
55	27.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
56	28.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
57	28.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
58	29.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
59	29.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
60	30.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
TOTALS		1.700	0.126	0.122	1.461	1.583	177.9	177.9

MDL 12/8/86
ABH 12/30/86

MORRISON-KNUDSEN ENGINEERS, INC. MDL 12/8/86
SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987 ABH 12/30/86

RAINFALL-RUNOFF COMPUTATION

TITLE1: UMTRA / GRAND JUNCTION
TITLE2: DISPOSAL SITE RETENTION BASIN DESIGN

COMBINED OUTFLOWS:

NUMB	TIME (HRS)	OUTFLOW @ AREA(1) (CFS)	OUTFLOW @ AREA(2) (CFS)	COMBINED OUTFLOW (CFS)
0	0.00	0.0	0.0	0.0
1	0.50	0.0	0.0	0.0
2	1.00	0.0	0.0	0.0
3	1.50	0.0	0.0	0.0
4	2.00	0.0	0.0	0.0
5	2.50	0.0	0.2	0.2
6	3.00	0.0	0.5	0.5
7	3.50	0.0	0.6	0.6
8	4.00	0.0	0.6	0.6
9	4.50	0.0	0.7	0.7
10	5.00	0.0	0.7	0.7
11	5.50	0.0	0.8	0.8
12	6.00	0.0	0.8	0.8
13	6.50	0.0	1.1	1.1
14	7.00	0.0	1.4	1.4
15	7.50	0.0	1.4	1.4
16	8.00	0.0	1.4	1.4
17	8.50	0.0	1.4	1.4
18	9.00	0.0	1.4	1.4
19	9.50	0.0	1.4	1.4
20	10.00	0.0	1.4	1.4
21	10.50	0.0	1.7	1.7
22	11.00	0.0	2.0	2.0
23	11.50	0.0	2.0	2.0
24	12.00	0.0	2.0	2.0
25	12.50	0.0	2.0	2.0
26	13.00	0.0	2.0	2.0
27	13.50	0.0	2.3	2.3
28	14.00	0.0	2.6	2.6
29	14.50	0.0	3.5	3.5
30	15.00	0.0	4.3	4.3
31	15.50	0.0	13.0	13.0
32	16.00	23.0	52.8	75.8
33	16.50	22.2	42.1	64.3
34	17.00	0.0	1.8	1.8
35	17.50	0.0	2.9	2.9
36	18.00	0.0	2.6	2.6
37	18.50	0.0	2.3	2.3
38	19.00	0.0	2.1	2.1
39	19.50	0.0	2.1	2.1
40	20.00	0.0	2.1	2.1
41	20.50	0.0	1.8	1.8
42	21.00	0.0	1.5	1.5
43	21.50	0.0	1.5	1.5

44	22.00	0.0	1.5	1.5
45	22.50	0.0	1.5	1.5
46	23.00	0.0	1.5	1.5
47	23.50	0.0	1.5	1.5
48	24.00	0.0	1.5	1.5
49	24.50	0.0	0.7	0.7
50	25.00	0.0	0.0	0.0
51	25.50	0.0	0.0	0.0
52	26.00	0.0	0.0	0.0
53	26.50	0.0	0.0	0.0
54	27.00	0.0	0.0	0.0
55	27.50	0.0	0.0	0.0
56	28.00	0.0	0.0	0.0
57	28.50	0.0	0.0	0.0
58	29.00	0.0	0.0	0.0
59	29.50	0.0	0.0	0.0
60	30.00	0.0	0.0	0.0

MDL 12/8/86
ABH 12/30/86

SBUHYD Output

Runoff volumes:

1) On-pile tailings area = 1.83 ac·ft

2) Off-pile uncontaminated area = 7.35 ac ft   NOT USED

Total runoff due to 10-year storm = 9.18 ac·ft → 1.83 AC-FT USED

SEDIMENT YIELD FOR RETENTION BASIN:

The retention basin at the disposal site will be designed to retain the sediment yield from a 3-year construction period. The volume of yearly sediment is calculated using the universal soil loss equation presented in Ref. 2, p 5. The basic equation is as follows:

$$A = R \cdot K \cdot LS \cdot VM \quad \ldots \ldots \ldots \quad (2\text{-}1)$$

in which

- A = computed amount of soil loss per unit area for the time interval represented by factor R, generally expressed as tons per acre per year
- R = rainfall factor
- K = soil erodibility factor in tons per acre per year per unit of R
- LS = topographic factor (length and steepness of slope) (dimensionless)
- VM = erosion control factor (vegetative and mechanical measures) (dimensionless)

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA / ERT — Contract No. 5025-06 — Sheet 35 — File No.
Feature DISPOSAL SITE DRAINAGE DURING CONST. — Designed MDL — Date 12/9/86
Item RETENTION BASIN + EMERGENCY SPILLWAY — Checked ABH — Date 12/31/86

Revision 1 Changes:
MDL 4/16/87
ABH 4/22/87

R Factor:

From Ref. 2, Fig. 5-2: R = 16 (SEE SHT. 24)

K Factor:

From Ref 2, Fig 5-9 indicates that for Cheney Reservoir, the K factor range is 0.24 - 0.32 for the "natural soils." Since most of the runoff will be from stockpiled soil, a value of K in the upper part of the range is appropriate — say 0.30.

(SEE SHT. 25)

LS Factor:

The disposal site will be divided into 3 areas (A, B, + C) to determine sediment yield volume. Area A has a slope of 3%; Area B has slopes 4% and 20%; and Area C has a slope of 7%.

The single slope equation (Ref 2, p. C-3) will be used for Areas A and C. The multiple slope equation (Ref 2, p. C-4) will be used for Area B.

Rev. 1 { In actuality, Area A has a slope of 1.9%, but we will keep the 3% slope from the original calculation to remain conservative.

MORRISON-KNUDSEN ENGINEERS, INC.
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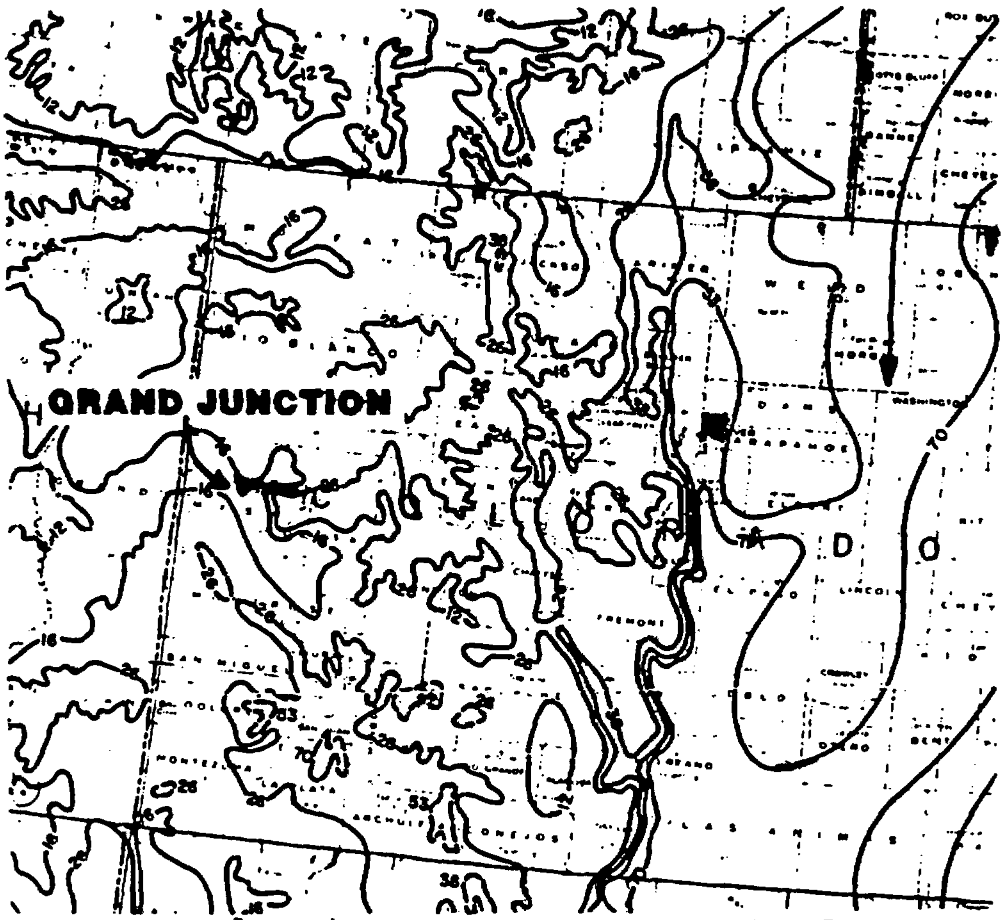
Project UMTRA - GRJ | Contract No. 3885-34 | Sheet
Feature DISPOSAL SITE DRAINAGE DURING CONST. | Designed H. L. | File No.
Item RETENTION BASIN + EMERGENCY SPILLWAY | Checked | Date 5-17-90
Date

ERODENT (R) VALUES



MEAN ANNUAL ISO–ERODENT (R) VALUES[1]

sheet 2 of 3 sheets February 1978

LEGEND
- ———— mean annual values
- ------ locally high values
- -·-·-·- locally low values

English units of R = foot tons/acre/hour
Metric units of Rm (meter tonnes/hectare/hour) = 1.735 x English units

[1] modified from Wischmeier, et al.

(FROM FIGURE 5.2, REF. 2)

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - GRJ
Feature DISPOSAL SITE DRAINAGE DURING CONST.
Item RETENTION BASIN & EMERGENCY SPILLWAY

Contract No. 3885-34
Designed H. L.
Checked SWB

Sheet
File No.
Date 5-17-90
Date 6-8-90

SOIL ERODIBILITY INDEX (K)

SOIL ERODIBILITY INDEX (K)[1]

sheet 2 of 3 sheets February 1976

LEGEND

- low erodibility, K value ranges from 0.10-0.20
- medium erodibility, K value ranges from 0.24-0.32
- high erodibility, K value ranges from 0.37-0.49

English units of K = tons/acre/EI
Metric units of Km (tonnes/hectare/EI = 1.292 x English units (K)

[1]As extrapolated from National Soil Survey

(FROM FIGURE 5.9, REF. 2)

$$L = \left(\frac{\ell}{72.6}\right)^m \quad \text{. . . . . (C-2)}$$

in which

ℓ = slope length in feet

m =
- 0.2 for slope gradients of 0 to 1 percent
- 0.3 for slope gradients of 1 to 3 percent
- 0.4 for slope gradients of 3.5 to 4.5 percent
- 0.5 for slope gradients greater than 5 percent

Combining the steepness and length factors gives the product LS. Therefore

$$LS = \left(\frac{65.41\, s^2}{s^2 + 10{,}000} + \frac{4.56\, s}{\sqrt{s^2 + 10{,}000}} + 0.065\right)\left(\frac{\ell}{72.6}\right)^m$$

. . . . (C-3)

Single Slope Equation (Ref. 2, p. C-1)

$$LS = \{[(L_{\lambda_1} S_{s_1})\lambda_1 - (L_{\lambda_0} S_{s_1})\lambda_0] + [(L_{\lambda_2} S_{s_2})\lambda_2 - (L_{\lambda_1} S_{s_2})\lambda_1] + [(L_{\lambda_3} S_{s_3})\lambda_3 - (L_{\lambda_2} S_{s_3})\lambda_2] + \ldots [L_{\lambda_n} S_{s_n})\lambda_n - (L_{\lambda_{n-1}} S_{s_n})\lambda_{n-1}]\}/(\ell_1 + \ell_2 + \ell_3 \ldots \ell_n)$$

. . . . (C-4)

in which $L_{\lambda n}$

L_n = length factor for slope segment n
= $(\ell_n/72.6)^m$ . . . . (C-5)

ℓ_n = length of slope segment n

m =
- 0.2 for slope gradient of 0 to 1 percent
- 0.3 for slope gradient of 1 to 3 percent
- 0.4 for slope gradient of 3.5 to 4.5 percent
- 0.5 for slope gradients greater than 5 percent

S_n = slope factor for slope segment n

$$= \frac{65.41\, s_n^2}{s_n^2 + 10{,}000} + \frac{4.56\, s_n}{\sqrt{s_n^2 + 10{,}000}} + 0.065$$

s_n = slope gradient, in percent, of segment n

λ_n = the sum of the slope segment lengths from the top of the slope to the bottom of slope segment n

Multiple Slopes Equation (Ref 2, p. C-3)

VM Factor:

The VM factor varies according to surface conditions of the soil. Table 2-2 in Ref 2 will be used to assign VM values

For Area B which is compacted fill, the range of values for VM is 1.24 - 1.71. A value in the middle of the range will be taken — say 1.48.

The remaining area is mostly stockpiled soil (or uncompacted fill). A value very high in the compacted fill range will be taken — say 1.70.

Total Sediment Yield:

See revision

$$\text{Area A} = (16)(0.30)(0.59)(1.70) = 4.81 \text{ tons/acre/year}$$

$$4.81 \text{ tons/acre/year} \cdot \frac{28.57 \text{ acres} \times 3 \text{ years}}{\frac{85.1}{2000} \text{ tons/ft}^3} = \underline{\underline{9689 \text{ cf}}}$$

$$\text{Area B} = (16)(0.30)(1.15)(1.48) = 8.17 \text{ tons/acre/year}$$

$$8.17 \text{ tons/acre/year} \cdot \frac{59.66 \text{ acres} \times 3 \text{ years}}{\frac{85.1}{2000} \text{ tons/ft}^3} = \underline{\underline{34,366 \text{ cf}}}$$

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Sheet 44
Project UMTRA / GRJ Contract No. 5025-06 File No.
Feature DISPOSAL SITE DRAINAGE DURING CONST. Designed MDL Date 12/9/86
Item RETENTION BASIN + EMERGENCY SPILLWAY Checked ABH Date 12/31/86

Area C = (16)(0.30)(1.45)(1.70) = 11.83 tons/acre/year

$$11.83 \text{ tons/acre/year} \cdot \frac{27.15 \text{ acres} \times 3 \text{ years}}{\frac{85.1}{2000} \text{ tons/ft}^3} = 22,645 \text{ cf}$$

Total Sediment Yield = 66,700 cf = 1.53 ac·ft

Table 2-2. Typical VM factor values reported in the literature.[a]

Condition	VM Factor
1. Bare soil conditions	
freshly disked to 6-8 inches	1.00
after one rain	0.89
loose to 12 inches smooth	0.90
loose to 12 inches rough	0.80
compacted bulldozer scraped up and down	1.30
same except root raked	1.20
compacted bulldozer scraped across slope	1.20
same except root raked across	0.90
rough irregular tracked all directions	0.90
seed and fertilize, fresh	0.64
same after six months	0.54
seed, fertilizer, and 12 months chemical	0.38
not tilled algae crusted	0.01
tilled algae crusted	0.02
compacted fill	1.24-1.71
undisturbed except scraped	0.66-1.30
scarified only	0.76-1.31
sawdust 2 inches deep, disked in	0.61
2. Asphalt emulsion on bare soil	
1250 gallons/acre	0.02
1210 gallons/acre	0.01-0.019
605 gallons/acre	0.14-0.57
302 gallons/acre	0.28-0.60
151 gallons/acre	0.65-0.70
3. Dust binder	
605 gallons/acre	1.05
1210 gallons/acre	0.29-0.78
4. Other chemicals	
1000 lb. fiber Glass Roving with 60-150 gallons asphalt emulsion/acre	0.01-0.05
Aquatain	0.68
Aerospray 70, 10 percent cover	0.94
Curasol AE	0.30-0.48
Petroset SB	0.40-0.66
PVA	0.71-0.90
Terra-Tack	0.66
[b]Wood fiber slurry, 1000 lb/acre fresh	0.05 -0.73
[b]Wood fiber slurry, 1400 lb/acre fresh	0.01 -0.36
[b]Wood fiber slurry, 3500 lb/acre fresh	0.009-0.10
Portland cement + Latex	
1000 lbs/ac + 8 gals/ac	0.13
1500 lbs/ac + 12 gals/ac	0.006
5. Seedings	
temporary, 0 to 60 days	0.40
temporary, after 60 days	0.05
permanent, 0 to 60 days	0.40
permanent, 2 to 12 months	0.05
permanent, after 12 months	0.01
6. Brush	0.35
7. Excelsior blanket with plastic net	0.04-0.10
8. Mulch (see Figures 2-4, 2-5, 2-6, 2-7)	

(from Ref 2, p. 14)

CHECK SEDIMENT YIELD USING MULTIPLE SLOPE EQUATION

$\ell_1 = 200'$ $s_1 = .25$
$\ell_2 = 1600'$ $s_2 = .04$

$L_1 = \left(\frac{200}{72.6}\right)^{.5} = 1.66$

$S_1 = \frac{65.41 (25)^2}{25^2 + 10{,}000} + \frac{4.56 (25)}{\sqrt{(25)^2 + 10{,}000}} + .065$

$3.85 + 1.11 + .065 = 5.02$

$LS = [1.66 (5.02) 200^{1.5} - 0] + [3.44 (.351) 1800^{1.5} - 1.66 (.351) (200)^{1.5}] / (200 + 1600)^{.5}$

$L_2 = \left(\frac{1600}{72.6}\right)^{.4} = 3.44$

$S_2 = \frac{65.41 (4)^2}{4^2 + 10{,}000} + \frac{4.56 (4)}{\sqrt{4^2 + 10{,}000}} + .065$

$= .104 + .182 + .065 = .351$

$LS = 2.06$

SEDIMENT = (16) (.30 (2.06) (1.48) = 14.63 TON/AC/YR

$14.63 \left(\frac{59.7 \text{ AC} \times 3 \text{ YR}}{\frac{85.1}{2000} \text{ T/FT}^3}\right) = 61580$ CF

= 1.4 AC-FT

EMERGENCY SPILLWAY:

The emergency spillway is designed to pass a 25-year 1-hour storm (Ref. 7, p. 4-6). The SBUHYD program will be used to determine the required depth of reservoir, depth of channel, and maximum outflow.

Input Parameters:

The following parameters are required for input into the SBUHYD program for design of the emergency spillway:

1) The 25-year 1-hour storm and hyetograph (from MKE Calc. no 05-628-01-00 (Ref. 4)) is as follows:

RAINFALL DURATION (MINUTES)	HYETOGRAPH (INCHES)
0	0.0
5	0.32
10	0.18
15	0.13
20	0.09
25	0.08
30	0.07
35	0.04
40	0.05
45	0.04
50	0.04
55	0.03
60	0.03

Total = 1.1 in.

2) One program with 2 drainage areas will be run for the emergency spillway: 1) on-pile and 2) off-pile.

The on-pile parameters are the same as before:

Drainage Area = 59.66 acres

Soil Suction Head Ψ = 4.16 in

Hydraulic Conductivity K = 0.50 in/hr

Initial Soil Moisture Content = 31 %

Final Soil Moisture Content = 40 %

Time of Concentration = 14.0 min. (from the temporary drainage ditches calculation. The t_c for the tailings embankment is the same as the t_c for drainage area #2.)

NOTE: T_c = 14 min for CHENEY II EMBANKMENT

OFF PILE AREA NOT USED IN CHENEY II CALC.

The off-pile parameters are also the same as before:

Drainage Area = 55.72 acres (impervious area = 4.02 acres)

Soil Suction Head Ψ = 9.48 in.

Hydraulic Conductivity K = 0.04 in/hr

NOT INCLUDED

Initial Soil Moisture Content = 13 %

Final Soil Moisture Content = 48 %

Time of Concentration = 14.0 min. (from the temporary drainage ditches calculation. The t_c for the off-pile area is the same as the t_c calculated for drainage area #1.)

3) The outlet structure will be a broad-crested weir with the following parameters required for input.

a) Reservoir Area

b) Discharge Coefficient

c) Length of Crest

The reservoir area will be taken as the top surface area of the retention basin.

Bottom dimensions = 350' × 500' with 3:1 sideslopes

Top dimensions = 359' × 509' = 182,731 ft² = 4.19 acres

SBUHYD Program (for Runoff Hydrograph).

SUMMARY OF INPUTS.

	on-pile	off-pile
Drainage Area (acres)	59.7	55.7
Impervious Areas (acres)	0	4.0
Time of Conc. (min).	14.0	14.0
Time Incre (min).	2.5	2.5
Rainfall Distrib	see following sheet.	
Initial Saturation	0.40	0.32
Final Saturation	0.40	0.50
Soil Suction Head (inch).	4.16	9.48
Hydr. Conduct. (inch/hr)	0.50	0.0001
Numb. of Rainfall hrs	24	24
Numb. of Output Steps.	60	60

SPILLWAY INPUTS

Reservoir Area	4.0 acres
Type of Outlet	Broad-crested weir
Discharge Coefficient	2.68
Length of Crest of Weir	15 ft

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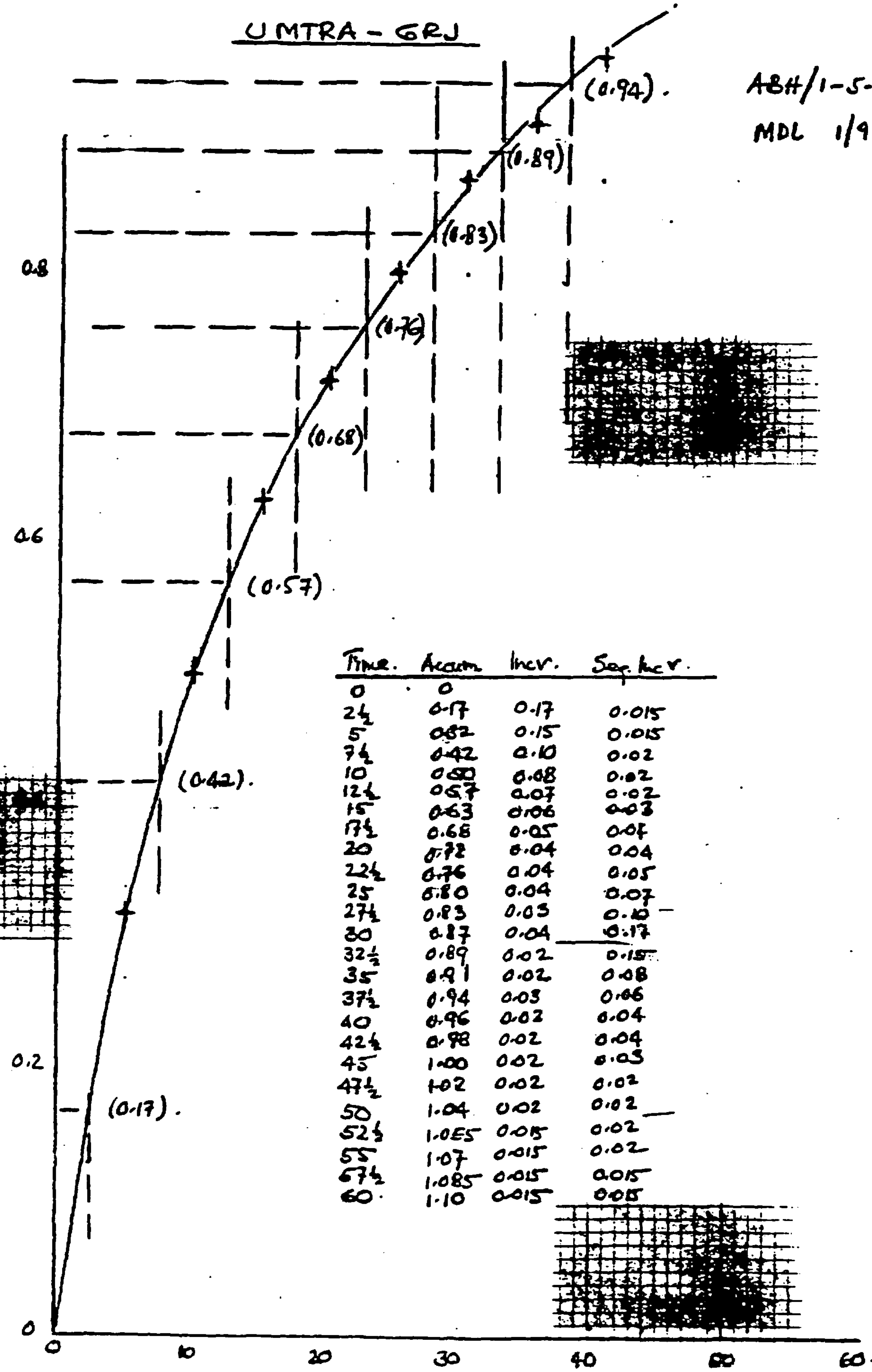
ABH/1-5-87.
MDL 1/9/87



Time.	Accum	Incr.	Seq. Incr.
0	0		
2½	0.17	0.17	0.015
5	0.32	0.15	0.015
7½	0.42	0.10	0.02
10	0.50	0.08	0.02
12½	0.57	0.07	0.02
15	0.63	0.06	0.03
17½	0.68	0.05	0.04
20	0.72	0.04	0.04
22½	0.76	0.04	0.05
25	0.80	0.04	0.07
27½	0.83	0.03	0.10
30	0.87	0.04	0.17
32½	0.89	0.02	0.15
35	0.91	0.02	0.08
37½	0.94	0.03	0.06
40	0.96	0.02	0.04
42½	0.98	0.02	0.04
45	1.00	0.02	0.03
47½	1.02	0.02	0.02
50	1.04	0.02	0.02
52½	1.055	0.015	0.02
55	1.07	0.015	0.02
57½	1.085	0.015	0.015
60	1.10	0.015	0.015

MORRISON-KNUDSEN ENGINEERS, INC.
SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987

MDL 12/12/86
ABH 1/5/87

INPUT DATA

TITLE1: UMTRA / GRAND JUNCTION
TITLE2: DISPOSAL SITE SPILLWAY DESIGN

RAINFALL DATA

TYPE OF DATA: 1
1 = RAINFALL IN INCHES
2 = PERCENT OF TOTAL DEPTH
TIME STEP: 2.5 MINUTES
NUMBER OF RAINFALLS: 24
RAINFALLS IN INCHES:
0.015 0.015 0.020 0.020 0.020 0.030 0.040 0.040 0.050 0.070
0.100 0.170 0.150 0.080 0.060 0.040 0.040 0.030 0.020 0.020
0.020 0.020 0.015 0.015

DRAINAGES

NUMBER OF DRAINAGE AREAS: 2

NAME OF THE 1st DRAINAGE AREA: ON-PILE
DRAINAGE AREA: 59.7 ACRES
IMPERVIOUS AREA: 0.0 ACRES
TIME OF CONCENTRATION: 14.0 MINUTES

SOIL PARAMETERS:
INITIAL SOIL MOISTURE CONTENT: 0.4000
SATURATED SOIL MOISTURE CONTENT: 0.4000
SOIL SUCTION HEAD: 4.16 INCHES
HYDRAULIC CONDUCTIVITY: 0.5000000000 IN/HR

NAME OF THE 2nd DRAINAGE AREA: OFF-PILE
DRAINAGE AREA: 55.7 ACRES
IMPERVIOUS AREA: 4.0 ACRES
TIME OF CONCENTRATION: 14.0 MINUTES

SOIL PARAMETERS:
INITIAL SOIL MOISTURE CONTENT: 0.3200
SATURATED SOIL MOISTURE CONTENT: 0.5000
SOIL SUCTION HEAD: 9.48 INCHES
HYDRAULIC CONDUCTIVITY: 0.0001000000 IN/HR

MDL 12/12/86
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MORRISON-KNUDSEN ENGINEERS, INC.
SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987

RAINFALL-RUNOFF COMPUTATION

TITLE1: UMTRA / GRAND JUNCTION
TITLE2: DISPOSAL SITE SPILLWAY DESIGN

NAME OF DRAINAGE AREA: ON-PILE
DRAINAGE AREA: 59.7 ACRES
IMPERVIOUS AREA: 0.0 ACRES
IMPERVIOUS PORTION: 0.0000
TIME OF CONCENTRATION: 14.0 MINUTES

SOIL PARAMETERS:
INITIAL SOIL MOISTURE CONTENT: 0.4000
SATURATED SOIL MOISTURE CONTENT: 0.4000
SOIL SUCTION HEAD: 4.16 INCHES
HYDRAULIC CONDUCTIVITY: 0.5000000000 IN/HR

TOTAL RAINFALL: 1.100 INCHES
TIME STEP: 2.5 MINUTES
NUMBER OF RAINFALLS: 24

RUNOFF VOLUME:
IMPERVIOUS: 0.00 INCHES OR 0.00 AC-FT
PERVIOUS: 0.63 INCHES OR 3.13 AC-FT
TOTAL: 0.63 INCHES OR 3.13 AC-FT

PEAK FLOW: 87.3 CFS AT 0.58 HRS

NUMB	TIME (HRS)	RAINFALL DEPTH (IN)	INFILTRATION (IN)	IMPERVIOUS RUNOFF (IN)	PERVIOUS RUNOFF (IN)	TOTAL RUNOFF (IN)	INSTANT HYDROGRAPH (CFS)	FINAL HYDROGRAPH (CFS)
0	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
1	0.042	0.015	0.015	0.000	0.000	0.000	0.0	0.0
2	0.083	0.015	0.015	0.000	0.000	0.000	0.0	0.0
3	0.125	0.020	0.020	0.000	0.000	0.000	0.0	0.0
4	0.167	0.020	0.020	0.000	0.000	0.000	0.0	0.0
5	0.208	0.020	0.020	0.000	0.000	0.000	0.0	0.0
6	0.250	0.030	0.021	0.000	0.009	0.009	13.2	1.1
7	0.292	0.040	0.021	0.000	0.019	0.019	27.7	4.3
8	0.333	0.040	0.021	0.000	0.019	0.019	27.7	8.1
9	0.375	0.050	0.021	0.000	0.029	0.029	42.1	12.5
10	0.417	0.070	0.021	0.000	0.049	0.049	71.0	19.7
11	0.458	0.100	0.021	0.000	0.079	0.079	114.4	31.7
12	0.500	0.170	0.021	0.000	0.149	0.149	215.5	53.5
13	0.542	0.150	0.021	0.000	0.129	0.129	186.6	77.7
14	0.583	0.080	0.021	0.000	0.059	0.059	85.5	87.3
15	0.625	0.060	0.021	0.000	0.039	0.039	56.6	84.6
16	0.667	0.040	0.021	0.000	0.019	0.019	27.7	77.7
17	0.708	0.040	0.021	0.000	0.019	0.019	27.7	69.5
18	0.750	0.030	0.021	0.000	0.009	0.009	13.2	61.4
19	0.792	0.020	0.020	0.000	0.000	0.000	0.0	52.4
20	0.833	0.020	0.020	0.000	0.000	0.000	0.0	43.8
21	0.875	0.020	0.020	0.000	0.000	0.000	0.0	36.7

22	0.917	0.020	0.020	0.000	0.000	0.000	0.0	30.6
23	0.958	0.015	0.015	0.000	0.000	0.000	0.0	25.6
24	1.000	0.015	0.015	0.000	0.000	0.000	0.0	21.4
25	1.042	0.008	0.000	0.000	0.000	0.000	0.0	17.9
26	1.083	0.000	0.000	0.000	0.000	0.000	0.0	15.0
27	1.125	0.000	0.000	0.000	0.000	0.000	0.0	12.5
28	1.167	0.000	0.000	0.000	0.000	0.000	0.0	10.5
29	1.208	0.000	0.000	0.000	0.000	0.000	0.0	8.8
30	1.250	0.000	0.000	0.000	0.000	0.000	0.0	7.3
31	1.292	0.000	0.000	0.000	0.000	0.000	0.0	6.1
32	1.333	0.000	0.000	0.000	0.000	0.000	0.0	5.1
33	1.375	0.000	0.000	0.000	0.000	0.000	0.0	4.3
34	1.417	0.000	0.000	0.000	0.000	0.000	0.0	3.6
35	1.458	0.000	0.000	0.000	0.000	0.000	0.0	3.0
36	1.500	0.000	0.000	0.000	0.000	0.000	0.0	2.5
37	1.542	0.000	0.000	0.000	0.000	0.000	0.0	2.1
38	1.583	0.000	0.000	0.000	0.000	0.000	0.0	1.7
39	1.625	0.000	0.000	0.000	0.000	0.000	0.0	1.5
40	1.667	0.000	0.000	0.000	0.000	0.000	0.0	1.2
41	1.708	0.000	0.000	0.000	0.000	0.000	0.0	1.0
42	1.750	0.000	0.000	0.000	0.000	0.000	0.0	0.9
43	1.792	0.000	0.000	0.000	0.000	0.000	0.0	0.7
44	1.833	0.000	0.000	0.000	0.000	0.000	0.0	0.6
45	1.875	0.000	0.000	0.000	0.000	0.000	0.0	0.5
46	1.917	0.000	0.000	0.000	0.000	0.000	0.0	0.4
47	1.958	0.000	0.000	0.000	0.000	0.000	0.0	0.3
48	2.000	0.000	0.000	0.000	0.000	0.000	0.0	0.3
49	2.042	0.000	0.000	0.000	0.000	0.000	0.0	0.2
50	2.083	0.000	0.000	0.000	0.000	0.000	0.0	0.2
51	2.125	0.000	0.000	0.000	0.000	0.000	0.0	0.2
52	2.167	0.000	0.000	0.000	0.000	0.000	0.0	0.1
53	2.208	0.000	0.000	0.000	0.000	0.000	0.0	0.1
54	2.250	0.000	0.000	0.000	0.000	0.000	0.0	0.1
55	2.292	0.000	0.000	0.000	0.000	0.000	0.0	0.1
56	2.333	0.000	0.000	0.000	0.000	0.000	0.0	0.1
57	2.375	0.000	0.000	0.000	0.000	0.000	0.0	0.1
58	2.417	0.000	0.000	0.000	0.000	0.000	0.0	0.0
59	2.458	0.000	0.000	0.000	0.000	0.000	0.0	0.0
60	2.500	0.000	0.000	0.000	0.000	0.000	0.0	0.0
TOTALS		1.180	0.471	0.000	0.629	0.629	909.0	908.8

MDL 12/12/86
ABH 1/5/87

MORRISON-KNUDSEN ENGINEERS, INC.
SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987

MDL 12/12/86
ABH 1/5/87

RAINFALL-RUNOFF COMPUTATION

TITLE1: UMTRA / GRAND JUNCTION
TITLE2: DISPOSAL SITE SPILLWAY DESIGN

NAME OF DRAINAGE AREA: OFF-PILE
DRAINAGE AREA: 55.7 ACRES
IMPERVIOUS AREA: 4.0 ACRES
IMPERVIOUS PORTION: 0.0718
TIME OF CONCENTRATION: 14.0 MINUTES

SOIL PARAMETERS:
INITIAL SOIL MOISTURE CONTENT: 0.3200
SATURATED SOIL MOISTURE CONTENT: 0.5000
SOIL SUCTION HEAD: 9.48 INCHES
HYDRAULIC CONDUCTIVITY: 0.0001000000 IN/HR

TOTAL RAINFALL: 1.100 INCHES
TIME STEP: 2.5 MINUTES
NUMBER OF RAINFALLS: 24

RUNOFF VOLUME:
IMPERVIOUS: 0.08 INCHES OR 0.37 AC-FT
PERVIOUS: 1.00 INCHES OR 4.66 AC-FT
TOTAL: 1.08 INCHES OR 5.03 AC-FT

PEAK FLOW: 105.8 CFS AT 0.58 HRS

NUMB	TIME (HRS)	RAINFALL DEPTH (IN)	INFILTRATION (IN)	IMPERVIOUS RUNOFF (IN)	PERVIOUS RUNOFF (IN)	TOTAL RUNOFF (IN)	INSTANT HYDROGRAPH (CFS)	FINAL HYDROGRAPH (CFS)
0	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
1	0.042	0.015	0.004	0.001	0.010	0.011	15.5	1.3
2	0.083	0.015	0.002	0.001	0.012	0.014	18.3	3.8
3	0.125	0.020	0.001	0.001	0.017	0.019	25.5	6.8
4	0.167	0.020	0.001	0.001	0.018	0.019	25.7	9.9
5	0.208	0.020	0.001	0.001	0.018	0.019	25.8	12.5
6	0.250	0.030	0.001	0.002	0.027	0.029	39.4	15.8
7	0.292	0.040	0.001	0.003	0.036	0.039	53.0	20.8
8	0.333	0.040	0.001	0.003	0.036	0.039	53.1	26.1
9	0.375	0.050	0.001	0.004	0.046	0.049	66.6	31.6
10	0.417	0.070	0.001	0.005	0.064	0.069	93.6	39.5
11	0.458	0.100	0.001	0.007	0.092	0.099	134.1	51.7
12	0.500	0.170	0.001	0.012	0.157	0.169	228.4	73.0
13	0.542	0.150	0.001	0.011	0.139	0.150	201.5	96.2
14	0.583	0.080	0.001	0.006	0.074	0.080	107.2	105.8
15	0.625	0.060	0.000	0.004	0.055	0.060	80.3	103.8
16	0.667	0.040	0.000	0.003	0.037	0.040	53.3	97.7
17	0.708	0.040	0.000	0.003	0.037	0.040	53.3	90.4
18	0.750	0.030	0.000	0.002	0.027	0.030	39.9	83.3
19	0.792	0.020	0.000	0.001	0.018	0.020	26.4	75.0
20	0.833	0.020	0.000	0.001	0.018	0.020	26.4	67.1
21	0.875	0.020	0.000	0.001	0.018	0.020	26.4	60.4

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22	0.917	0.020	0.000	0.001	0.018	0.020	26.4	54.8
23	0.958	0.015	0.000	0.001	0.014	0.015	19.7	49.6
24	1.000	0.015	0.000	0.001	0.014	0.015	19.7	44.7
25	1.042	0.000	0.000	0.000	0.000	0.000	0.0	39.0
26	1.083	0.000	0.000	0.000	0.000	0.000	0.0	32.6
27	1.125	0.000	0.000	0.000	0.000	0.000	0.0	27.3
28	1.167	0.000	0.000	0.000	0.000	0.000	0.0	22.8
29	1.208	0.000	0.000	0.000	0.000	0.000	0.0	19.1
30	1.250	0.000	0.000	0.000	0.000	0.000	0.0	15.9
31	1.292	0.000	0.000	0.000	0.000	0.000	0.0	13.3
32	1.333	0.000	0.000	0.000	0.000	0.000	0.0	11.1
33	1.375	0.000	0.000	0.000	0.000	0.000	0.0	9.3
34	1.417	0.000	0.000	0.000	0.000	0.000	0.0	7.8
35	1.458	0.000	0.000	0.000	0.000	0.000	0.0	6.5
36	1.500	0.000	0.000	0.000	0.000	0.000	0.0	5.4
37	1.542	0.000	0.000	0.000	0.000	0.000	0.0	4.6
38	1.583	0.000	0.000	0.000	0.000	0.000	0.0	3.8
39	1.625	0.000	0.000	0.000	0.000	0.000	0.0	3.2
40	1.667	0.000	0.000	0.000	0.000	0.000	0.0	2.7
41	1.708	0.000	0.000	0.000	0.000	0.000	0.0	2.2
42	1.750	0.000	0.000	0.000	0.000	0.000	0.0	1.9
43	1.792	0.000	0.000	0.000	0.000	0.000	0.0	1.6
44	1.833	0.000	0.000	0.000	0.000	0.000	0.0	1.3
45	1.875	0.000	0.000	0.000	0.000	0.000	0.0	1.1
46	1.917	0.000	0.000	0.000	0.000	0.000	0.0	0.9
47	1.958	0.000	0.000	0.000	0.000	0.000	0.0	0.8
48	2.000	0.000	0.000	0.000	0.000	0.000	0.0	0.6
49	2.042	0.000	0.000	0.000	0.000	0.000	0.0	0.5
50	2.083	0.000	0.000	0.000	0.000	0.000	0.0	0.4
51	2.125	0.000	0.000	0.000	0.000	0.000	0.0	0.4
52	2.167	0.000	0.000	0.000	0.000	0.000	0.0	0.3
53	2.208	0.000	0.000	0.000	0.000	0.000	0.0	0.3
54	2.250	0.000	0.000	0.000	0.000	0.000	0.0	0.2
55	2.292	0.000	0.000	0.000	0.000	0.000	0.0	0.2
56	2.333	0.000	0.000	0.000	0.000	0.000	0.0	0.2
57	2.375	0.000	0.000	0.000	0.000	0.000	0.0	0.1
58	2.417	0.000	0.000	0.000	0.000	0.000	0.0	0.1
59	2.458	0.000	0.000	0.000	0.000	0.000	0.0	0.1
60	2.500	0.000	0.000	0.000	0.000	0.000	0.0	0.1
TOTALS		1.100	0.019	0.079	1.004	1.083	1459.5	1459.1

MORRISON-KNUDSEN ENGINEERS, INC.
SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987

MDL 12/12/86
ABH 1/5/87

RAINFALL-RUNOFF COMPUTATION

TITLE1: UMTRA / GRAND JUNCTION
TITLE2: DISPOSAL SITE SPILLWAY DESIGN

COMBINED OUTFLOWS:

NUMB	TIME (HRS)	OUTFLOW @ AREA(1) (CFS)	OUTFLOW @ AREA(2) (CFS)	COMBINED OUTFLOW (CFS)
0	0.00	0.0	0.0	0.0
1	0.04	0.0	1.3	1.3
2	0.08	0.0	3.8	3.8
3	0.13	0.0	6.8	6.8
4	0.17	0.0	9.9	9.9
5	0.21	0.0	12.5	12.5
6	0.25	1.1	15.8	16.9
7	0.29	4.3	20.8	25.0
8	0.33	8.1	26.1	34.2
9	0.37	12.5	31.6	44.1
10	0.42	19.7	39.5	59.3
11	0.46	31.7	51.7	83.4
12	0.50	53.5	73.0	126.5
13	0.54	77.7	96.2	173.9
14	0.58	87.3	105.8	193.0
15	0.63	84.6	103.8	188.4
16	0.67	77.7	97.7	175.4
17	0.71	69.5	90.4	159.9
18	0.75	61.4	83.3	144.7
19	0.79	52.4	75.0	127.5
20	0.83	43.8	67.1	110.9
21	0.88	36.7	60.4	97.1
22	0.92	30.6	54.8	85.5
23	0.96	25.6	49.6	75.3
24	1.00	21.4	44.7	66.2
25	1.04	17.9	39.0	56.9
26	1.08	15.0	32.6	47.6
27	1.13	12.5	27.3	39.8
28	1.17	10.5	22.8	33.3
29	1.21	8.8	19.1	27.8
30	1.25	7.3	15.9	23.3
31	1.29	6.1	13.3	19.4
32	1.33	5.1	11.1	16.3
33	1.37	4.3	9.3	13.6
34	1.42	3.6	7.8	11.4
35	1.46	3.0	6.5	9.5
36	1.50	2.5	5.4	7.9
37	1.54	2.1	4.6	6.6
38	1.58	1.7	3.8	5.6
39	1.62	1.5	3.2	4.6
40	1.67	1.2	2.7	3.9
41	1.71	1.0	2.2	3.2
42	1.75	0.9	1.9	2.7
43	1.79	0.7	1.6	2.3

44	1.83	0.6	1.3	1.9
45	1.87	0.5	1.1	1.6
46	1.92	0.4	0.9	1.3
47	1.96	0.3	0.8	1.1
48	2.00	0.3	0.6	0.9
49	2.04	0.2	0.5	0.8
50	2.08	0.2	0.4	0.6
51	2.12	0.2	0.4	0.5
52	2.17	0.1	0.3	0.5
53	2.21	0.1	0.3	0.4
54	2.25	0.1	0.2	0.3
55	2.29	0.1	0.2	0.3
56	2.33	0.1	0.2	0.2
57	2.37	0.1	0.1	0.2
58	2.42	0.0	0.1	0.2
59	2.46	0.0	0.1	0.1
60	2.50	0.0	0.1	0.1

MDL 12/12/86
ABH 1/5/87

MORRISON-KNUDSEN ENGINEERS, INC.
SANTA BARBARA URBAN HYDROGRAPH MODEL: SBUHYD, Version 2.2, January 8, 1987

RESERVOIR ROUTING COMPUTATION

TITLE1: UMTRA / GRAND JUNCTION
TITLE1: DISPOSAL SITE SPILLWAY DESIGN

OUTLET STRUCTURE: BROAD-CRESTED WEIR
RESERVOIR AREA: 4.0 ACRES
DISCHARGE COEFFICIENT: 2.6800
LENGTH OF CREST: 15.0 FEET

NUMB	TIME (HRS)	INFLOW (CFS)	SUM OF INFLOWS (CFS)	STORAGE INDICAT(1) (CFS)	STORAGE INDICAT(2) (CFS)	DEPTH OF RESERVOIR (FT)	DEPTH OF CHANNEL (FT)	HEADLOSS (FT)	OUTFLOW (CFS)
0	0.00	0.0	1.3	0.0	0.0	0.000	0.000	0.000	0.0
1	0.04	1.3	5.1	1.3	1.3	0.001	0.001	0.000	0.0
2	0.08	3.8	10.6	6.4	6.4	0.003	0.003	0.000	0.0
3	0.13	6.8	16.6	16.9	17.0	0.007	0.007	0.000	0.0
4	0.17	9.9	22.3	33.4	33.6	0.014	0.014	0.000	0.1
5	0.21	12.5	29.3	55.5	55.8	0.024	0.024	0.000	0.1
6	0.25	16.9	41.9	84.2	84.8	0.036	0.036	0.000	0.3
7	0.29	25.0	59.2	125.1	126.1	0.054	0.054	0.000	0.5
8	0.33	34.2	78.2	182.5	184.3	0.079	0.079	0.000	0.9
9	0.37	44.1	103.3	257.8	260.8	0.112	0.112	0.000	1.5
10	0.42	59.3	142.7	356.3	361.2	0.154	0.154	0.000	2.4
11	0.46	83.4	209.9	491.1	499.0	0.213	0.213	0.000	4.0
12	0.50	126.5	300.4	687.8	700.9	0.299	0.299	0.000	6.6
13	0.54	173.9	367.0	966.3	988.2	0.421	0.421	0.000	11.0
14	0.58	193.0	381.4	1299.0	1333.3	0.567	0.567	0.000	17.1
15	0.63	188.4	363.8	1632.0	1680.4	0.713	0.713	0.000	24.2
16	0.67	175.4	335.3	1933.5	1996.0	0.846	0.846	0.000	31.3
17	0.71	159.9	304.6	2193.5	2269.2	0.960	0.960	0.000	37.8
18	0.75	144.7	272.2	2411.1	2498.5	1.057	1.057	0.000	43.7
19	0.79	127.5	238.4	2586.6	2683.7	1.134	1.134	0.000	48.6
20	0.83	110.9	208.0	2720.0	2824.8	1.193	1.193	0.000	52.4
21	0.88	97.1	182.5	2817.0	2927.5	1.236	1.236	0.000	55.3
22	0.92	85.5	160.7	2885.3	2999.9	1.267	1.267	0.000	57.3
23	0.96	75.3	141.4	2929.3	3046.6	1.286	1.286	0.000	58.6
24	1.00	66.2	123.1	2952.4	3071.1	1.296	1.296	0.000	59.3
25	1.04	56.9	104.5	2956.8	3075.8	1.298	1.298	0.000	59.5
26	1.08	47.6	87.4	2943.6	3061.8	1.292	1.292	0.000	59.1
27	1.13	39.8	73.1	2915.0	3031.4	1.280	1.280	0.000	58.2
28	1.17	33.3	61.1	2874.3	2988.2	1.262	1.262	0.000	57.0
29	1.21	27.8	51.1	2824.7	2935.7	1.240	1.240	0.000	55.5
30	1.25	23.3	42.7	2768.5	2876.2	1.215	1.215	0.000	53.8
31	1.29	19.4	35.7	2706.8	2810.8	1.188	1.188	0.000	52.0
32	1.33	16.3	29.8	2641.7	2742.0	1.159	1.159	0.000	50.1
33	1.37	13.6	25.0	2575.6	2672.1	1.129	1.129	0.000	48.2
34	1.42	11.4	20.9	2508.3	2601.0	1.100	1.100	0.000	46.4
35	1.46	9.5	17.4	2439.8	2528.7	1.069	1.069	0.000	44.5
36	1.50	7.9	14.6	2372.5	2457.7	1.040	1.040	0.000	42.6
37	1.54	6.6	12.2	2305.1	2386.7	1.010	1.010	0.000	40.8
38	1.58	5.6	10.2	2238.8	2316.9	0.980	0.980	0.000	39.0
39	1.62	4.6	8.5	2174.7	2249.4	0.952	0.952	0.000	37.3

40	1.67	3.9	7.1	2111.6	2183.1	0.924	0.924	0.000	35.7
41	1.71	3.2	6.0	2050.0	2119.2	0.897	0.897	0.000	34.2
42	1.75	2.7	5.0	1991.0	2056.4	0.871	0.871	0.000	32.7
43	1.79	2.3	4.2	1933.5	1996.0	0.846	0.846	0.000	31.3
44	1.83	1.9	3.5	1878.1	1937.9	0.821	0.821	0.000	29.9
45	1.87	1.6	2.9	1824.4	1881.6	0.798	0.798	0.000	28.6
46	1.92	1.3	2.4	1772.3	1827.1	0.775	0.775	0.000	27.4
47	1.96	1.1	2.0	1722.4	1774.9	0.753	0.753	0.000	26.3
48	2.00	0.9	1.7	1674.1	1724.4	0.731	0.731	0.000	25.1
49	2.04	0.8	1.4	1627.6	1675.7	0.711	0.711	0.000	24.1
50	2.08	0.6	1.2	1582.6	1628.8	0.691	0.691	0.000	23.1
51	2.12	0.5	1.0	1539.3	1583.4	0.672	0.672	0.000	22.2
52	2.17	0.5	0.8	1497.7	1540.2	0.654	0.654	0.000	21.3
53	2.21	0.4	0.7	1457.7	1498.5	0.636	0.636	0.000	20.4
54	2.25	0.3	0.6	1419.4	1458.6	0.619	0.619	0.000	19.6
55	2.29	0.3	0.5	1382.1	1419.8	0.603	0.603	0.000	18.8
56	2.33	0.2	0.4	1346.6	1382.8	0.587	0.587	0.000	18.1
57	2.37	0.2	0.3	1312.1	1346.9	0.572	0.572	0.000	17.4
58	2.42	0.2	0.3	1278.7	1312.2	0.558	0.558	0.000	16.7
59	2.46	0.1	0.2	1247.0	1279.2	0.544	0.544	0.000	16.1
60	2.50	0.1	0.1	1216.4	1247.5	0.530	0.530	0.000	15.5

MDL 12/12/86
ABH 1/5/87

Depth of retention basin = 2.66 ft (10-yr storm + sediment) + 1.30 ft. (25-yr storm) + 1.0 ft (freeboard) = 4.96 ft

⇒ use 5.0 ft minimum

DEPTH OF CHENEY II BASIN = 1.0 FT + [illegible]

YR 24 HR = 1.83 AC-FT
SEDIMENT = [illegible] AC-FT
[illegible] AC-FT

4.0 [illegible] = 1.0 FT depth

SEE SHT 3

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: IMTRA - GRT	Contract No. 5225.1[illegible]	Sheet	
Feature: RETENTION BASIN SIZING	Designed [illegible]	File No.	
Item	Checked H.L.	Date [illegible]	Date [illegible]

$$V = \frac{h}{3}\left(b_1 + b_2 + \sqrt{b_1 b_2}\right)$$

WANT CAPACITY = 9.18 AC-FT

ASSUME 5 FT DEPTH + 1 FT FREEBOARD

SIDE SLOPE = 3:1

BOTTOM = 360' x 440' ∴ b_1 = 360 x 440 = 158400, b_2 = 390 x 470 = 183300

1.3' → 1.5' SPILLWAY

$$V = \frac{5}{3}\left(158400 + 183300 + \sqrt{[illegible]}\right)$$

= 853492 FT³ = 19.6 AC-FT

$$V = \frac{3}{3}\left(158400 + 173124 + \sqrt{[illegible]}\right)$$ b_1 = 360 x 440 = 158400

= [illegible] FT³ = [illegible] AC-FT b_2 = 378 x 458 = 173124

$$V = \frac{2}{3}\left(158400 + 167[illegible] + \sqrt{158400(167[illegible])}\right)$$ b_1 = 360 x 440 = 158400

= 326425 FT³ = 7.5 AC-FT b_2 = [illegible]

$$V = \frac{2.5}{3}\left(158400 + 170625 + \sqrt{158400 \cdot 170625}\right)$$ b_1 = [illegible]

= 411187 = 9.44 AC-FT b_2 = 375 x 455 = 170625

2.5 + 1 FT FREEBOARD + 1.5 FT SPILLWAY = 5 FT [illegible]

TOP DIMENSIONS = 390 x 470

BOTTOM DIMENSIONS = 360 x 440'

DEPTH = 5'

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA - GRJ
Feature: RETENTION BASIN DESIGN
Item: CUT & FILL QUANTITIES

Sheet: 45
Contract No.: 5025-16
File No.:
Designed: RB
Date: 1.17.90
Checked: SKS
Date: 1-18-90

SECTION	DISTANCE(L) (ft)	CUT AREA (sq. ft)	AVG CUT AREA(A) (sq. ft)	CUT VOLUME ($\frac{A \times L}{27}$) (cu. yd)
A		0		
	35		1463.9	1897.6
B		2927.8		
	50		2780.8	5149.6
C		2633.8		
	50		2402.5	4449.1
D		2171.2		
	50		1976.7	3660.6
E		1782.1		
	50		1720.6	3186.3
F		1659.1		
	50		1394.5	2582.4
G		1129.9		
	50		1030.7	1908.7
H		931.4		
	50		716.8	1327.4
I		502.2		
	50		267	494.4
J		31.8		
	50		21.5	39.8
K		11.2		
	30		5.6	6.2
L		0		

TOTAL CUT VOLUME : 24702.1 Cu.Yd

Say 24,700 Cu. Yd.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA - GRJ
Feature: RETENTION BASIN DESIGN
Item: CUT & FILL QUANTITIES

Contract No.:
Designed: RB
Checked: [illegible]

Sheet: 4
File No.:
Date: 1.17.90
Date: 1-18-90

SECTION	DISTANCE (d) (ft)	FILL AREA (sq.ft)	AVG FILL AREA (a) (sq.ft)	FILL VOLUME $\left(\frac{a \times d}{27}\right)$ (Cu.Yd)
A		0		
	35		13.2	17.1
B		26.4		
	50		33.2	61.5
C		40		
	50		22	40.7
D		4		
	50		19	35.2
E		34		
	50		63	116.7
F		92		
	50		196.1	363
G		300.1		
	50		454.7	842
H		609.3		
	50		805.9	1492.4
I		1002.5		
	50		1130.3	2093.1
J		1258.1		
	50		1942.1	3596.5
K		2626.1		
	30		2918.8	3243.1
L		3211.5		
	30		5028.8	5587.6
M		6846		
	10		6841.2	2533.8
N		6836.3		
	30		4938.2	5486.9
O		3040		
	50		1520	2814.8
P		0		

TOTAL FILL VOLUME: 28324.4 Cu.Yd.

Say 28,300 Cu Yd.

UMTRA - GRJ
5025-16
RETENTION BASIN AND
EMERGENCY SPILLWAY

CHK: H.L
6/6/90

Cut

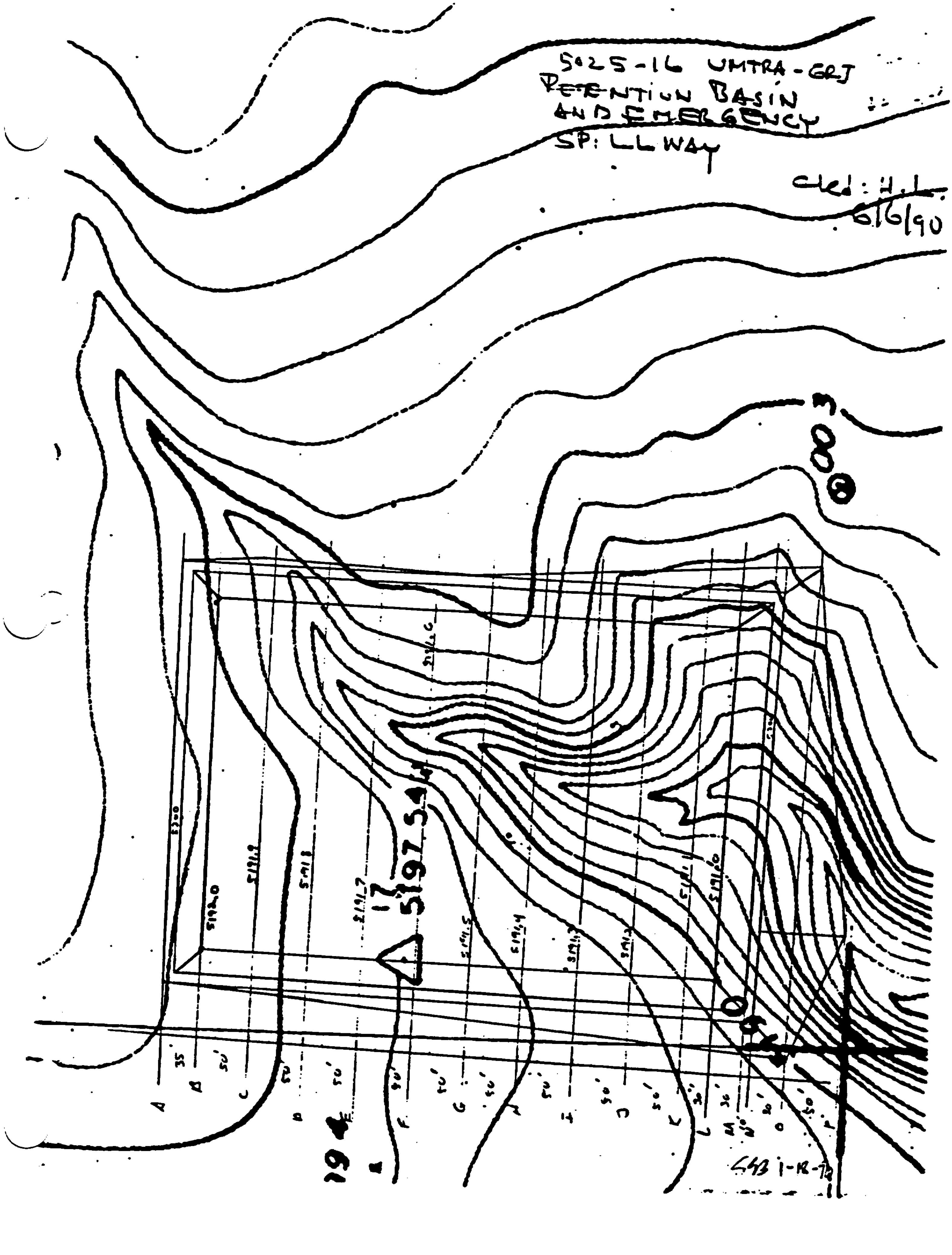
A	0	1464.1 x 50 = 73205.0	=>	2711.3 yd³
B	2928.2	2756.1 x 50 = 137807.5	=>	5104.0 yd³
C	2584.1	2381.2 x 50 = 119060.0	=>	4409.6 yd³
D	2178.3	1980.6 x 50 = 99030.0	=>	3667.8 yd³
E	1782.9	1720.9 x 50 = 86047.5	=>	3186.9 yd³
F	1659.0	1394.3 x 50 = 69715.0	=>	2582.0 yd³
G	1129.6	1031.2 x 50 = 51560.0	=>	1909.6 yd³
H	932.8	717.5 x 50 = 35875.0	=>	1328.7 yd³
I	502.2	267.0 x 50 = 13350.0	=>	494.4 yd³
J	31.8	21.5 x 50 = 1075.0	=>	39.8 yd³
K	11.2	5.6 x 50 = 280.0	=>	10.4 yd³
L	0			

25,444.5 yd³ Total Cut.

Fill

A	0	13.2 x 50.0 = 660.0	=>	24.4 yd³
B	26.4	33.2 x 50.0 = 1660.0	=>	61.5 yd³
C	40.0	22.0 x 50.0 = 1100.0	=>	40.7 yd³
D	4.0	19.0 x 50.0 = 950.0	=>	35.2 yd³
E	34.0	63.0 x 50.0 = 3150.0	=>	116.6 yd³
F	92.0	195.9 x 50.0 = 9797.5	=>	362.8 yd³
G	299.9	454.5 x 50.0 = 22,725.0	=>	841.6 yd³
H	609.2	805.8 x 50.0 = 40,292.5	=>	1492.3 yd³
I	1002.5	1130.2 x 50.0 = 56510.0	=>	2092.9 yd³
J	1257.9	1941.9 x 50.0 = 97095.0	=>	3596.1 yd³
K	2625.9	2926.7 x 30.0 = 87801.0	=>	3251.8 yd³
L	3227.5	5036.7 x 30.0 = 151102.5	=>	5596.3 yd³
M	6846.0	6831.2 x 10.0 = 68312.0	=>	2530.1 yd³
N	6816.4	4343.2 x 30.0 = 130296.0	=>	4825.7 yd³
O	1870.0	935.0 x 50.0 = 46,750.0	=>	1731.5 yd³
P	0			

26,599.5 yd³ Total Fill.


5025-16 UMTRA-GRJ
RETENTION BASIN
AND EMERGENCY
SPILLWAY
Chkd: H.L.
6/6/90
5197.54
17
194

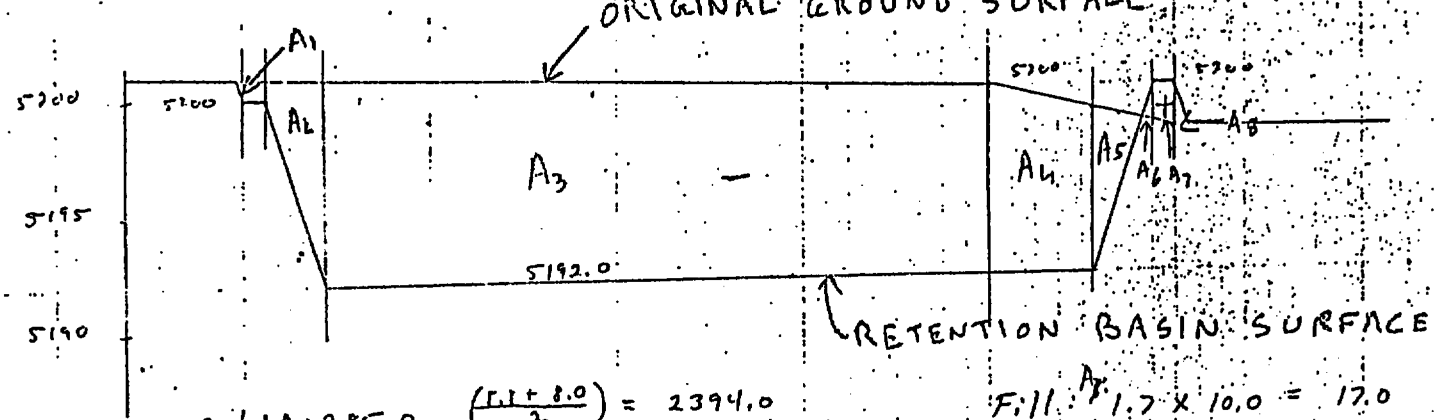
CROSS-SECTIONAL AREAS   1-18-90

SCALE: 1" : 8' (VERTICAL)
1" : 80' (HORIZONTAL)

− CUT AREA
+ FILL AREA

A: Cut: 0 (NEGLIGIBLE)
Fill: 0

B



cut: A_3: $285.0 \times \left(\frac{8.8+8.0}{2}\right) = 2394.0$

A_2: $25.0 \times \left(\frac{8.8-0.8}{2}\right) = 120.0$

A_1: $10.0 \times 0.9 = 9.0$

A_4: $45.0 \times \left(\frac{8.0+7.0}{2}\right) = 337.5$

A_5: $(\frac{1}{2})\ 6.7 \times 20.1 = 67.3$

2927.8 ft²

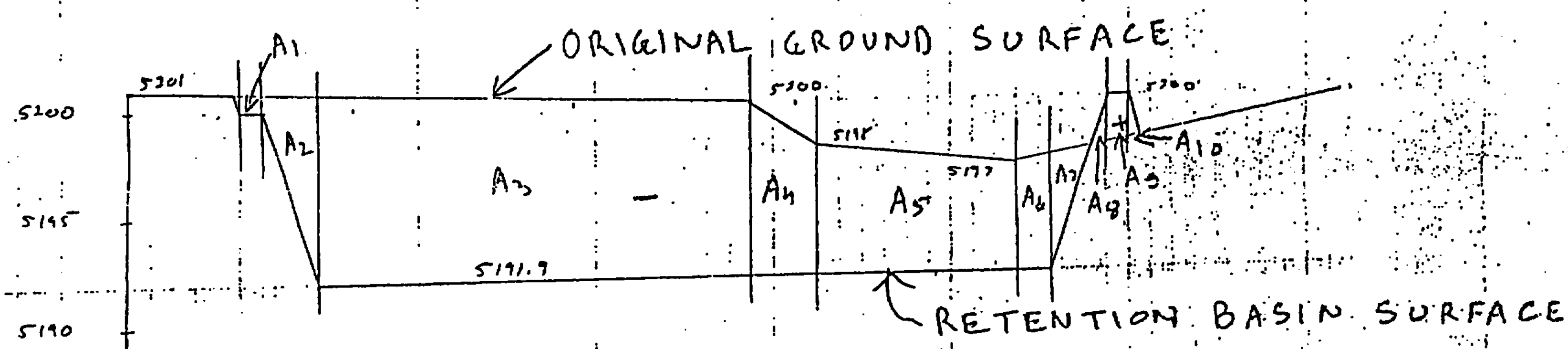
Fill: A_7: $1.7 \times 10.0 = 17.0$

A_8: $(\frac{1}{2})\ 2.0 \times 6.0 = 6.0$

A_6: $(\frac{1}{2})\ 1.5 \times 4.5 = 3.4$

26.4 ft²

C



cut: A_3: $175.0 \times \left(\frac{9.1+9.1}{2}\right) = 1642.8$

A_2: $25.0 \times \left(\frac{0.7+8.8}{2}\right) = 118.8$

A_1: $10.0 \times 0.8 = 8.0$

A_4: $30.0 \times \left(\frac{8.1+6.1}{2}\right) = 213.0$

A_5: $90.0 \times \left(\frac{6.1+5.1}{2}\right) = 504.0$

A_6: $15.0 \times \left(\frac{5.1+5.4}{2}\right) = 78.8$

A_7: $(\frac{1}{2})\ 6.5 \times 19.5 = 63.4$

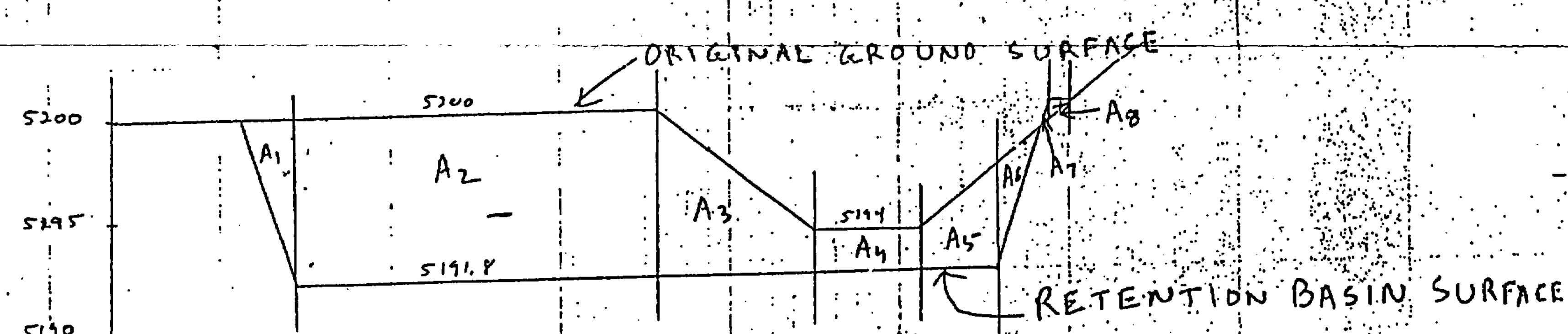
2633.8 ft²

Fill: A_9: $2.0 \times 10.0 = 20.0$

$A_8 + A_{10}$: $(2)(\frac{1}{2})\ 2.0 \times 10.0 = 20.0$

40.0 ft²

D



cut: A_2: $170.0 \times 8.2 = 1394.0$

A_1: $(\frac{1}{2})\ 8.2 \times 24.6 = 100.9$

A_3: $75.0 \times \left(\frac{8.2+2.2}{2}\right) = 390.0$

A_4: $50.0 \times 2.2 = 110.0$

A_5: $35.0 \times \left(\frac{2.2+5.2}{2}\right) = 129.5$

A_6: $(\frac{1}{2})\ 5.2 \times 18.0 = 46.8$

2171.2 ft²

Fill: A_8: $(\frac{1}{2})\ 0.5 \times 10.0 = 2.5$

A_7: $(\frac{1}{2})\ 1.0 \times 3.0 = 1.5$

4.0 ft²

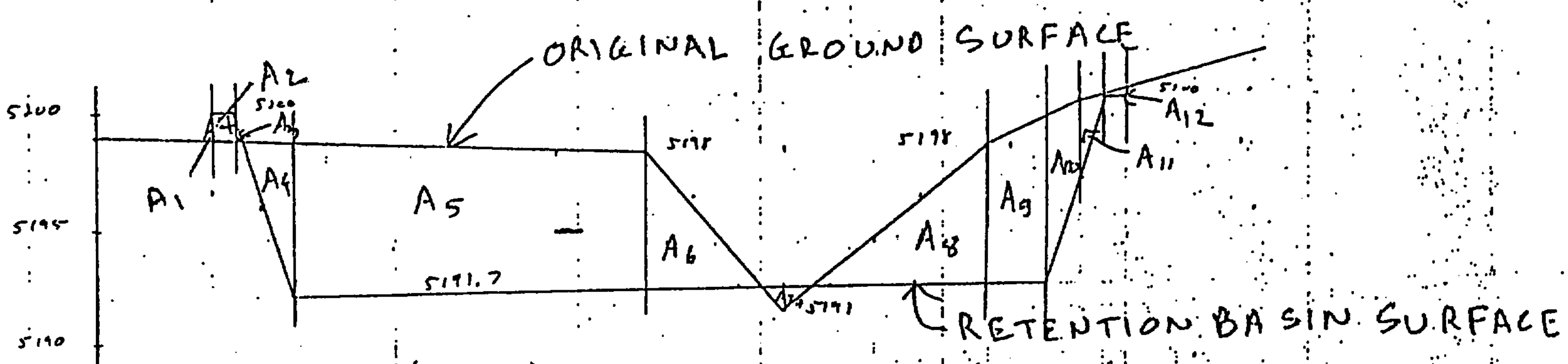
G.H. 1-6-90
Chkd. H.L. 6/6/90
UMTRA-GJO
5025-IC
RETENTION BASIN
DRAINAGE
SHT 49

-18-90

− CUT AREA
+ FILL AREA

SCALE: 1" : 8' (VERTICAL)
1" : 80' (HORIZONTAL)

E



Cut: A_5: $155.0 \times \left(\frac{7.0 + 6.3}{2}\right) = 1030.8$

A_4: (½) 7.0 × 21.0 = 73.5

A_6: (½) 6.3 × 50.0 = 157.5

A_8: (½) 6.3 × 75.0 = 236.3

A_9: $25.0 \times \left(\frac{6.3 + 7.6}{2}\right) = 173.8$

A_{10}: $15.0 \times \left(\frac{7.6 + 3.8}{2}\right) = 85.5$

A_{11}: (½) 3.8 × 11.4 = 21.7

0.3 × 10.0 = 3.0

1782.1 ft²

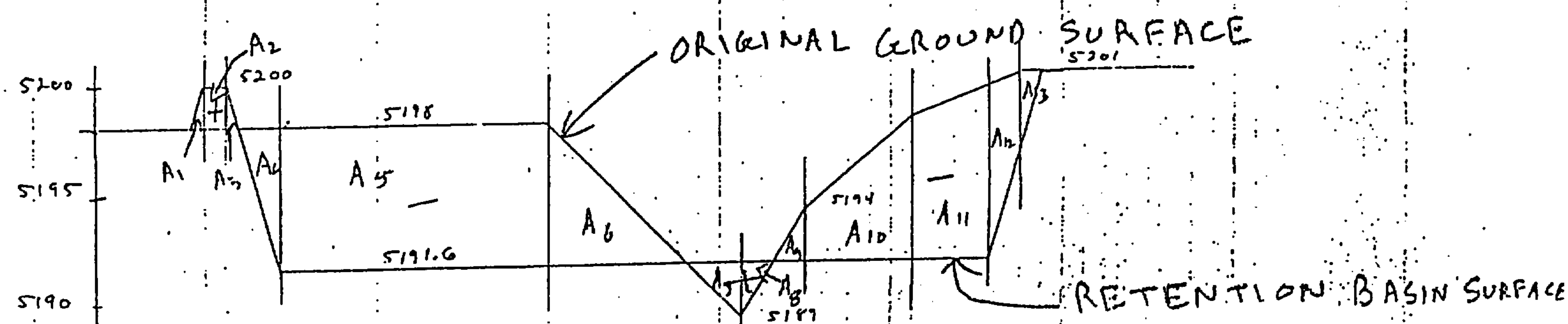
Fill: A_2: 1.2 × 10.0 = 12.0

$A_1 + A_3$: (2) (½) 1.2 × 10.0 = 12.0

A_7: (2) (½) 1.0 × 10.0 = 10.0

34.0 ft²

F.



Cut: A_5: 6.4 × 125.0 = 800.0

A_4: (½) 6.4 × 19.2 = 61.4

A_6: (½) 6.4 × 65.0 = 208.0

A_9: (½) 2.4 × 15.0 = 18.0

A_{10}: $50.0 \times \left(\frac{2.4 + 6.4}{2}\right) = 220.0$

A_{11}: $35.0 \times \left(\frac{6.4 + 7.8}{2}\right) = 248.5$

A_{12}: $15.0 \times \left(\frac{7.8 + 3.5}{2}\right) = 84.8$

A_{13}: (½) 3.5 × 10.5 = 18.4

1659.1 ft²

Fill: A_7: (½) 25.0 × 2.6 = 32.5

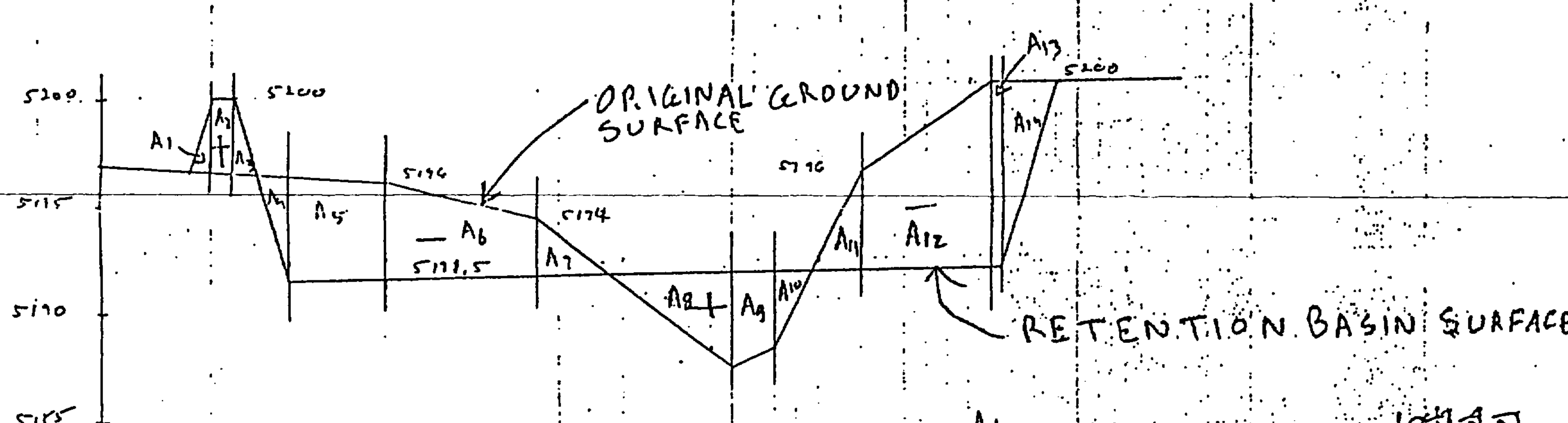
A_8: (½) 15.0 × 2.6 = 19.5

A_2: 2.0 × 10.0 = 20.0

$A_1 + A_3$: (2) (½) 2.0 × 10.0 = 20.0

92.0 ft²

G



Cut: A_5: $45.0 \times \left(\frac{4.5 + 4.8}{2}\right) = 209.3$

A_4: (½) 4.8 × 14.4 = 34.6

A_6: $70.0 \times \left(\frac{4.5 + 2.5}{2}\right) = 245.0$

A_7: (½) 35.0 × 2.5 = 43.8

A_{11}: (½) 25.0 × 4.5 = 56.3

A_{12}: $60.0 \times \left(\frac{4.5 + 8.5}{2}\right) = 390.0$

A_{13}: 5.0 × 8.5 = 42.5

A_{14}: (½) 8.5 × 25.5 = 108.4

1129.9 ft²

Fill: A_2: 3.5 × 10.0 = 35.0

$A_1 + A_3$: (2) (½) 3.5 × 10.0 = 35.0

A_8: (½) 55.0 × 4.5 = 123.8

A_9: $20.0 \times \left(\frac{4.5 + 3.5}{2}\right) = 80.0$

A_{10}: (½) 3.5 × 15.0 = 26.3

300.1 ft²

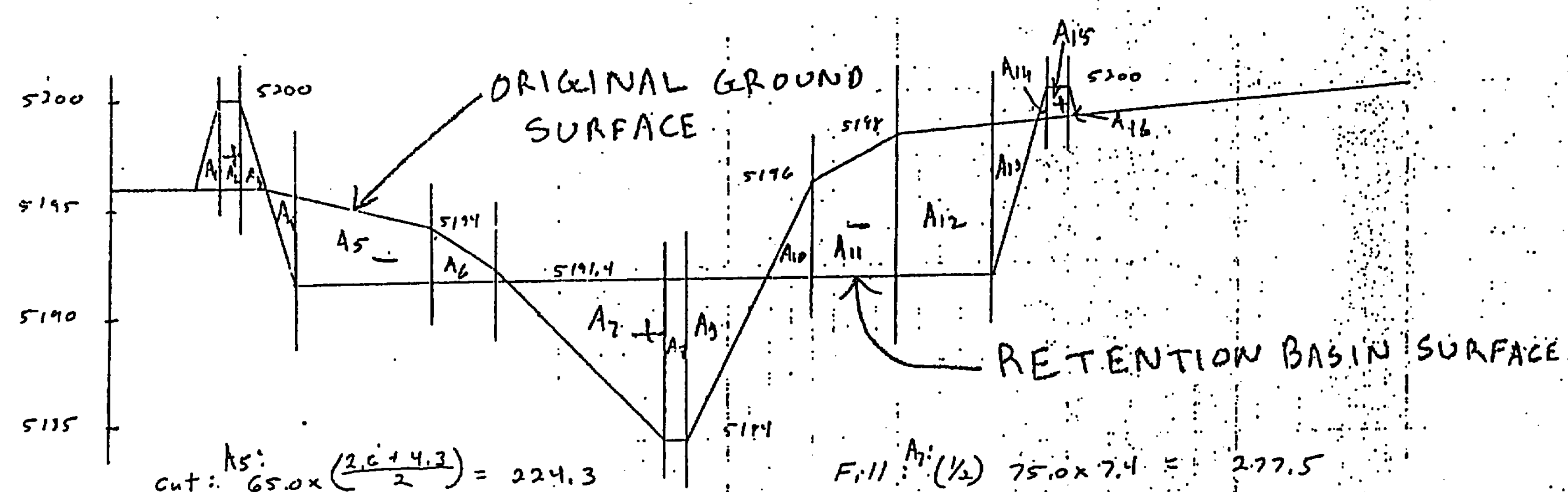
UMTRA 5025-… RETENTION BASIN AND EMERGENCY SPILLWAY SHT 50
G.H.

GS 1-16-?0

− CUT AREA
+ FILL AREA

SCALE: 1" : 8' (VERTICAL)
1" : 80' (HORIZONTAL)

H.



Cut: A5: $65.0 \times \left(\frac{2.6+4.3}{2}\right) = 224.3$

A4: $(1/2)\ 4.3 \times 13.0 = 28$

A6: $30.0 \times \left(\frac{2.6+0.6}{2}\right) = 48.0$

A10 $(1/2)\ 12.0 \times 4.6 = 27.6$

A11: $40.0 \times \left(\frac{4.6+6.6}{2}\right) = 224.0$

A12: $45.0 \times \left(\frac{6.6+7.0}{2}\right) = 306.0$

A13: $(1/2)\ 7.0 \times 21.0 = 73.5$

931.6 ft²

Fill: A7: $(1/2)\ 75.0 \times 7.4 = 277.5$

A8: $10.0 \times 7.4 = 74.0$

A9: $(1/2)\ 7.4 \times 40.0 = 148.0$

A2: $4.0 \times 10.0 = 40.0$

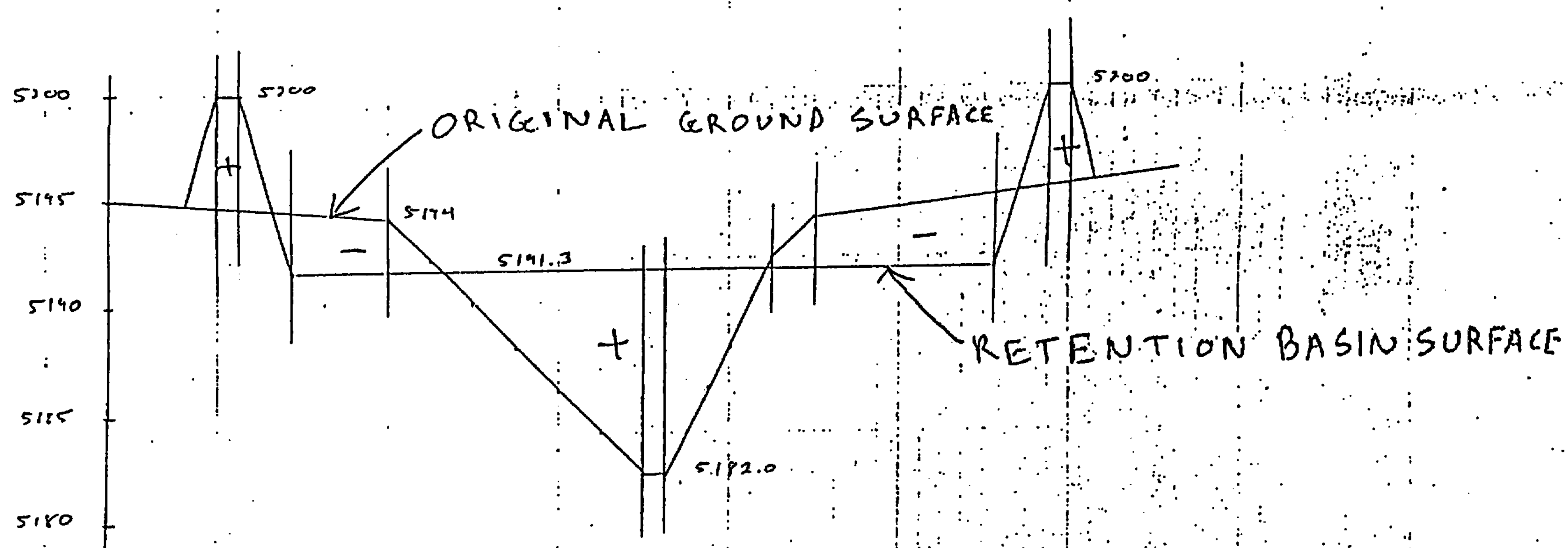
A1+A3: $(2)(1/2)\ 4.0 \times 12.0 = 48.0$

A15: $1.5 \times 10.0 = 15.0$

A14+A16: $(2)(1/2)\ 1.5 \times 4.5 = 6.8$

609.3 ft²

I.



Cut: $45.0 \times \left(\frac{3.0+2.7}{2}\right) = 128.3$

$(1/2)\ 3.0 \times 9.0 = 13.5$

$(1/2)\ 2.7 \times 25.0 = 33.7$

$(1/2)\ 0.7 \times 0.5 = 0.2$

$20.0 \times \left(\frac{0.7+2.7}{2}\right) = 34.0$

$85.0 \times \left(\frac{2.7+3.7}{2}\right) = 272.0$

$(1/2)\ 3.7 \times 11.1 = 20.5$

502.2 ft²

Fill: $5.4 \times 10.0 = 54.0$

$(2)(1/2)\ 5.4 \times 16.2 = 87.5$

$(1/2)\ 95.0 \times 9.3 = 441.7$

$10.0 \times 9.3 = 93.0$

$(1/2)\ 9.3 \times 45.0 = 209.2$

$4.8 \times 10.0 = 48.0$

$(2)(1/2)\ 4.8 \times 14.4 = 69.1$

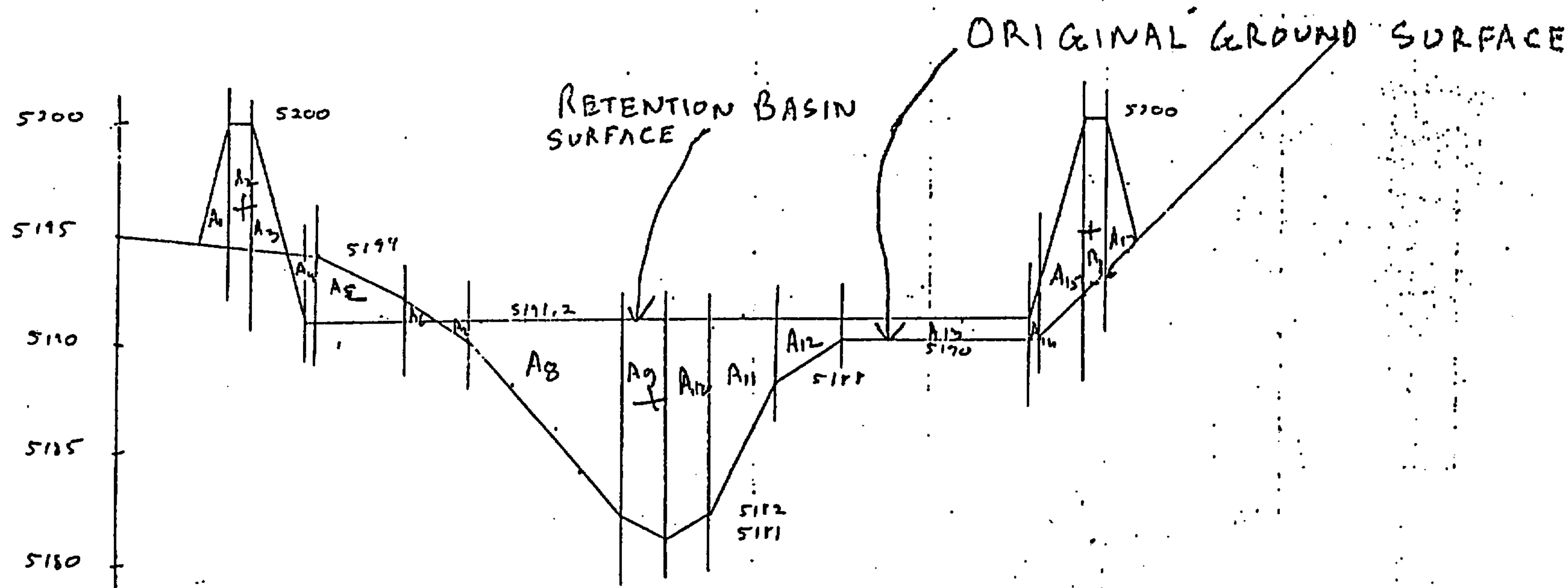
1002.5 ft²

5025-16
CMTPA-GRQ: SHT 51
RETENTION BASIN
AND EMERGENCY
SPILLWAY
G.H. 1-16-?
CK'd: H.L.
6/6/9?

− CUT AREA
+ FILL AREA

SCALE: 1" : 8' (VERTICAL)
1" : 80' (HORIZONTAL)

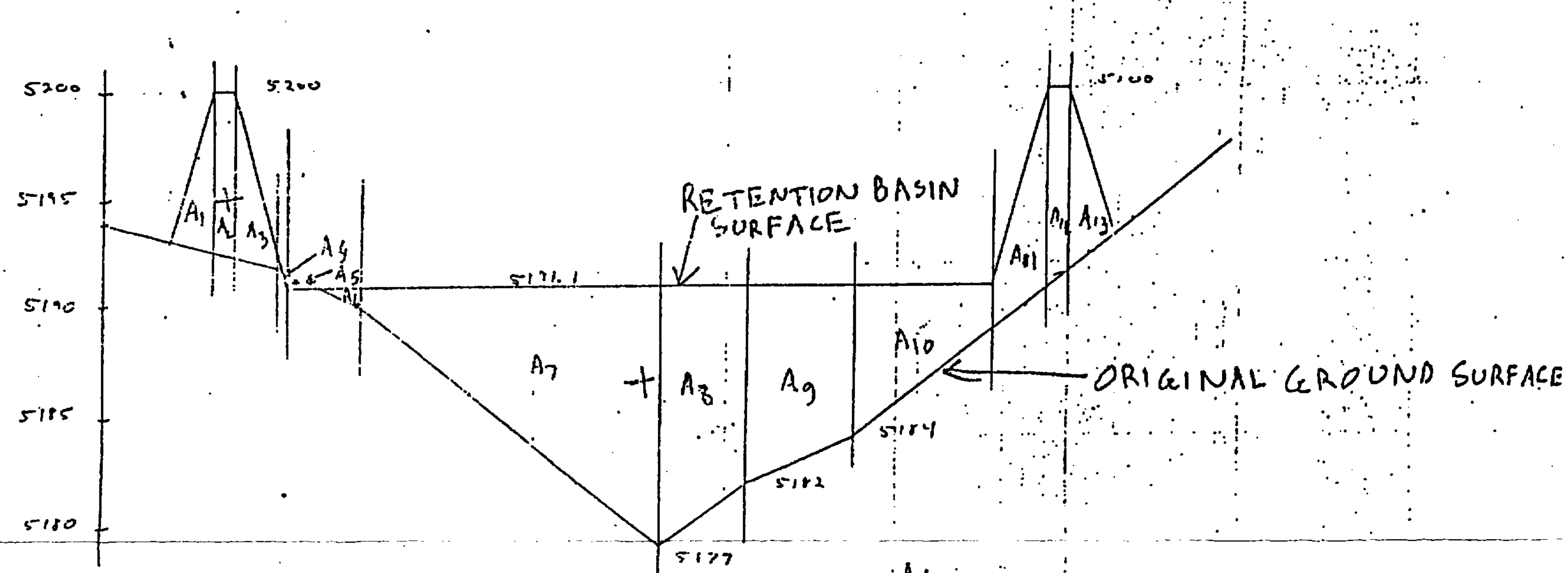
J



Cut: A5: 5.0 × 2.8 = 14.0
A4: (½) 2.8 × 8.4 = 11.8
A6: (½) 0.8 × 15.0 = 6.0
31.8 ft²

Fill: A2: 5.5 × 10.0 = 55.0
A1 + A3: (2)(½) 5.5 × 16.5 = 90.8
A7: (½) 0.8 × 15.0 = 6.0
A8: 70.0 × ((0.8 + 9.2)/2) = 350.0
A9 + A10: (2) 20.0 × ((9.2 + 10.2)/2) = 194.0
A11: 30.0 × ((9.2 + 3.2)/2) = 186.0
A12: 30.0 × ((3.2 + 1.2)/2) = 66.0
A13: 85.0 × 0.8 = 68.0
A14: 5.0 × ((0.8 + 2.5)/2) = 8.3
A15: 20.0 × ((2.5 + 8.0)/2) = 105.0
A16: 10.0 × 7.5 = 75.0
A17: (½) 6.0 × 18.0 = 54.0
1258.1 ft²

K



Cut: A4: 15.0 × 0.7 = 10.5
A5: (½) 0.7 × 2.1 = 0.7
11.2 ft²

Fill: A2: 7.5 × 10.0 = 75.0
A1 + A3: (2)(½) 7.5 × 22.5 = 168.7
A6: ½ × 1.1 × 20 = 11.1
A7: 140.0 × ((1.1 + 12.1)/2) = 924.0
A8: 40.0 × ((12.1 + 9.1)/2) = 424.0
A9: 50.0 × ((9.1 + 7.1)/2) = 405.0
A10: 65.0 × ((7.1 + 2.1)/2) = 299.0
A11: 27.0 × ((2.1 + 9.0)/2) = 149.9
A12: 8.5 × 10.0 = 85.0
A13: (½) 7.5 × 22.5 = 84.4
2626.1 ft²

SCR 5-16
CMTRA-GRJ
RETENTION BASIN
AND EMERGENCY
SPILLWAY

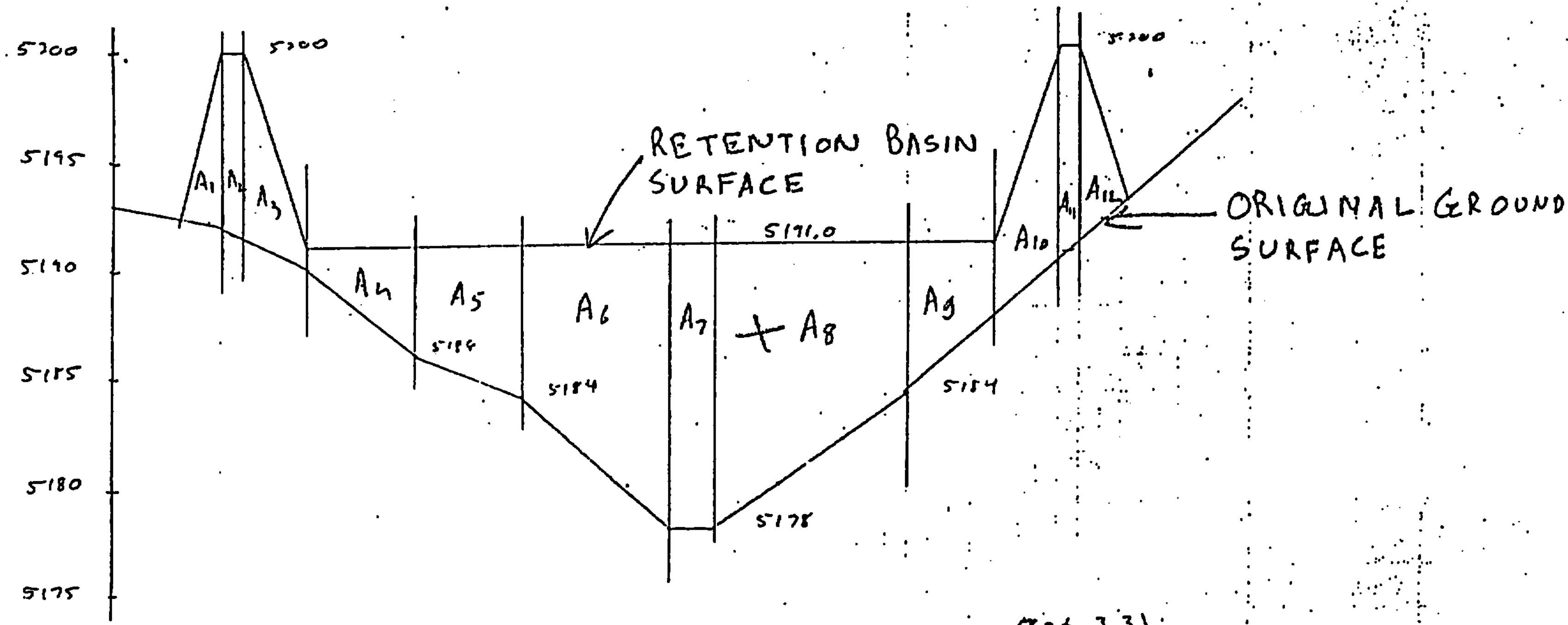
Ckd: H. G.H. 6/6

SHT 52

SCALE: 1" : 8' (VERTICAL)
1" : 80' (HORIZONTAL)

− CUT AREA
+ FILL AREA

L



Cut: 0

Fill: A_1: (½) 8.0 × 20.0 = 80

A_2: 10.0 × 8.4 = 84.0

A_3: $30.0 \times \left(\frac{8.4 + 1.0}{2}\right) = 141.0$

A_4: $50.0 \times \left(\frac{1.0 + 5.0}{2}\right) = 150.0$

A_5: $50.0 \times \left(\frac{5.0 + 7.0}{2}\right) = 300.0$

A_6: $70.0 \times \left(\frac{7.0 + 13.0}{2}\right) = 700.0$

A_7: 20.0 × 13.0 = 260.0

A_8: $90.0 \times \left(\frac{13.0 + 7.0}{2}\right) = 900.0$

A_9: $40.0 \times \left(\frac{7.0 + 3.3}{2}\right) = 206.0$

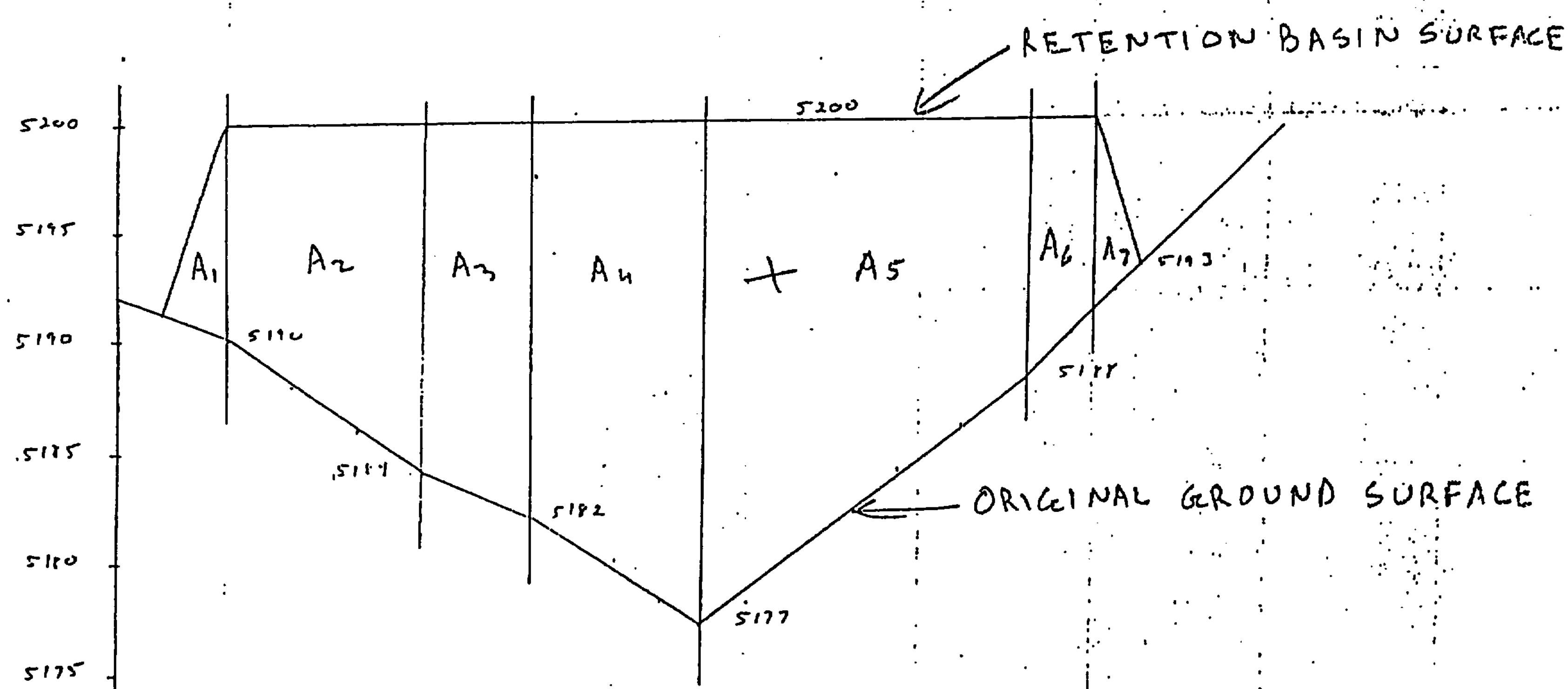
A_{10}: $30.0 \times \left(\frac{10.0 + 3.3}{2}\right) = 199.5$

A_{11}: 9.5 × 10.0 = 95.0

A_{12}: (½) 8.0 × 24.0 = 96.0

3211.5 ft²

M



Cut: 0

Fill: A_2: $90.0 \times \left(\frac{10.0 + 16.0}{2}\right) = 1170.0$

A_1: (½) 10.0 × 30.0 = 150.0

A_3: $50.0 \times \left(\frac{16.0 + 18.0}{2}\right) = 850.0$

A_4: $80.0 \times \left(\frac{18.0 + 23.0}{2}\right) = 1640.0$

A_5: $150.0 \times \left(\frac{23.0 + 12.0}{2}\right) = 2625.0$

A_6: $30.0 \times \left(\frac{12.0 + 9.0}{2}\right) = 315.0$

(½) 8.0 × 24.0 = 96.0

6846.0 ft²

UMTRA-GRJ
5025-16
RETENTION BASIN
AND EMERGENCY
SPILLWAY

G.H. 1-6

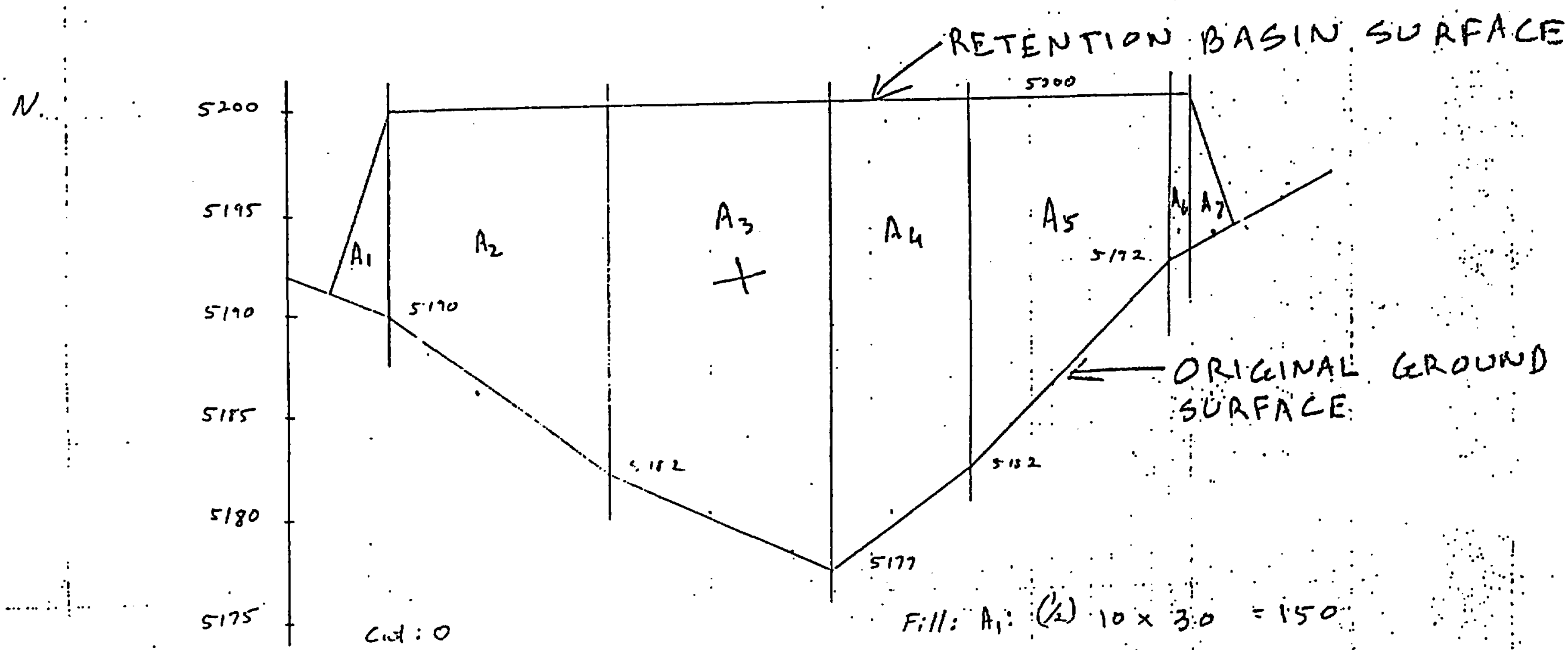
CK'D: H.L
6/6/90

SHT 5

− CUT AREA
+ FILL AREA

SCALE: 1" : 8' (VERTICAL)
1" : 80' (HORIZONTAL)

N



Fill: A_1: (½) 10 × 3.0 = 15.0

A_2: $110.0 \times \left(\frac{10.0 + 18.0}{2}\right) = 1540.0$

A_3: $110.0 \times \left(\frac{18.0 + 23.0}{2}\right) = 2255.0$

A_4: $70.0 \times \left(\frac{23.0 + 18.0}{2}\right) = 1435.0$

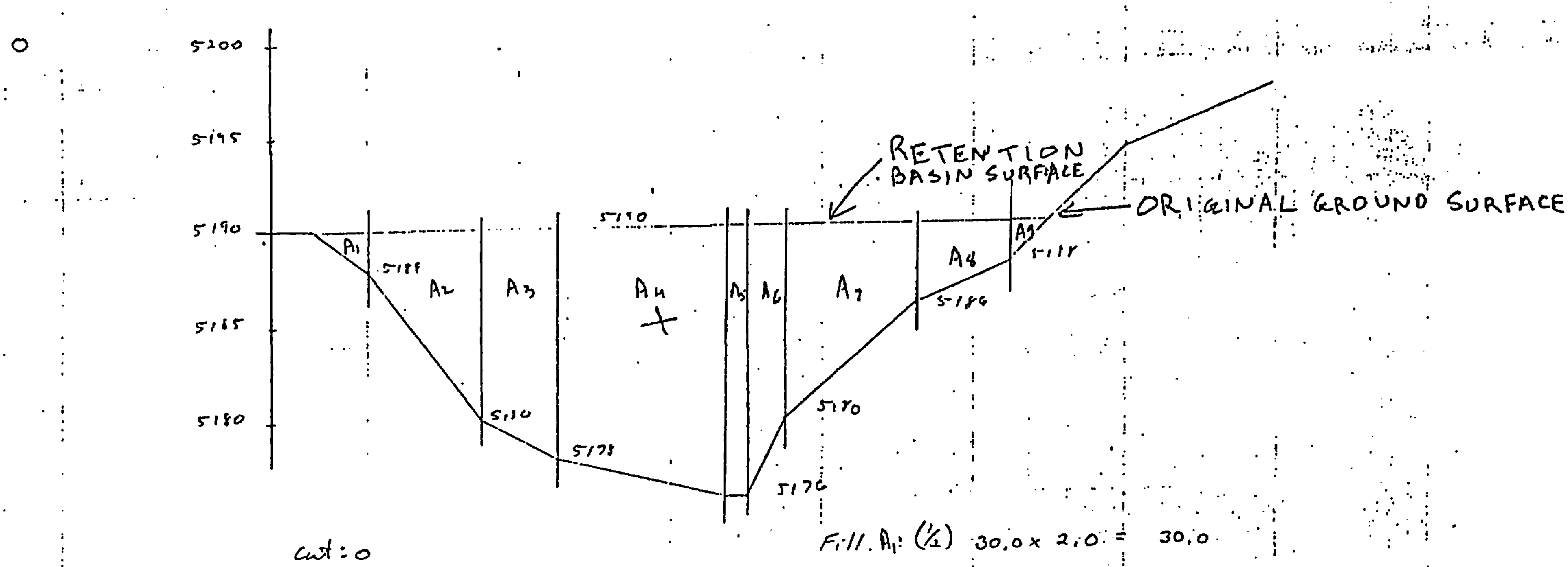
A_5: $100.0 \times \left(\frac{18.0 + 8.0}{2}\right) = 1300.0$

A_6: $10.0 \times \left(\frac{8.0 + 7.5}{2}\right) = 77.5$

(½) 7.5 × 21.0 = 78.8

6836.3 ft²

O



Fill. A_1: (½) 30.0 × 2.0 = 30.0

A_2: $60.0 \times \left(\frac{2.0 + 10.0}{2}\right) = 360.0$

A_3: $40.0 \times \left(\frac{10.0 + 12.0}{2}\right) = 440.0$

A_5: 10.0 × 14.0 = 140.0

A_6: $20.0 \times \left(\frac{14.0 + 10.0}{2}\right) = 240.0$

A_7: $70.0 \times \left(\frac{10.0 + 4.0}{2}\right) = 490.0$

A_8: $50.0 \times \left(\frac{4.0 + 2.0}{2}\right) = 150.0$

A_9: (½) 20.0 × 2.0 = 20.0

A_4: $90 \left(\frac{12 + 14}{2}\right) = 1170$

3040 sq. ft

P Cut: 0 Fill: 0

UMTRA - GRJ
5025-16
RETENTION BASIN AND EMERGENCY SPILLWAY

SHT 54

Chk: [illegible] 6/6/[illegible]

G.H. [illegible]

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY

5025-16
RETENTION BASIN AND EMERGENCY SPILLWAY

UMTRA PROJECT

INTER-OFFICE CORRESPONDENCE

H.L. 6/6/9.

TO: J. G. Oldham Attention: R. E. Cooney	DATE: February 27, 1990
LOCATION: MKF-Boise	DOC. NO.: 5025-GRJ-I-01-04042-00
SUBJECT: UMTRA-Project-GRJ Re: Transmittal to J. Pepin February 16, 1990	FROM: F. J. Feliz
	LOCATION: San Francisco

On a transmittal to J. Pepin dated February 16, 1990 we included cut and fill quantities for the retention basin at the Cheney Reservoir disposal site. These quantities have been revised and are as follows:

Bid Item	Description	Quantity
220	Excavation of Uncontaminated Material for Wastewater Retention Basin at Disposal Site	24,700 cy
222	Placement of Excavated Uncontaminated Material as Fill for Wastewater Retention Basin at Disposal Site	28,300 cy

F.J. Feliz

F. J. Feliz
FJF/ESB/nad

cc: J. Pepin

IOCTRANS.GRJ

Calculation Cover Sheet

Calc. No. 05-691-03-02
No. of Sheets 37

Contract No. 3885-34 Discipline Hydraulics

Project

UMTRA - GRAND JUNCTION

Feature

EMBANKMENT DESIGN

Item

RIPRAP TOE PROTECTION

Sources of Data

Sources of Formulae & References

see sheets 2 and 3.

Preliminary Calc. ☐ Final Calc. ☒ Supersedes Calc. No. [illegible]

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
0		Fang Hong Wu	11/15/91	[illegible]	[illegible]	[illegible]	1-8-92

Form 42-[illegible]

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA/GRJ
Feature Embankment Design
Item Riprap Toe Protection

Contract No. 3885-34
Designed FHW
Checked DKC

Sheet 1
File No.
Date 11/1/51
Date 12/12/91

Table of Contents

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA/GRJ
Feature Embankment Design
Item Riprap Toe Protection

Sheet 2
Contract No. 3885-34
File No.
Designed F.H.W.
Date 11/15/?
Checked R.T.C.
Date 12/1/?

References

1. MKE, UMTRA Design Procedures, Chapter 5, Erosion Protection, Rev. 4, Dec. 1987

2. MKES Cal. No. 05-504-01-03, UMTRA/GRJ, Erosion protection, Top and Side slopes of Tailings Embankment

3. MKES Cal. No. 05-504-07-01, UMTRA/GRJ, Permanent Site Drainage, off-pile Drainage Swale.

4. MKES Cal. No. 05-505-02-03, UMTRA/GRJ, Rock Quality for the Erosion protection - Cheney Disposal Site

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

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

7. U.S. Army COE, Hydraulic Design of Spillway, EM 1110-2-1603, March 31, 1965 (Reprint with change 1).

8. U.S. Army COE, Hydraulic Design of Flood Control Channels, EM-1110-2-1601, July 1, 1970 (Reprint with changes 1-4 included)

9. Chow, V.T., Open Channel Hydraulics, McGraw Hill Book Co., N.Y., 1959

10. U.S. Dept. of Transportation, Hydraulic Design of Energy Dissipators for culverts and Channels, Hydraulic Engineering Circular No. 14, Dec. 1975

11. Davis and Sorensen, Handbook of Applied Hydraulics, 3rd Edition, McGraw Hill Book Co., N.Y., 1969

References (continued)

12. DOE, Technical Approach Document, Rev. 11, Dec. 1989. UMTRA-DOE-AL 050425.0002, Fig. 4.1, P. 71.

13. Pemberton, E.L. & Lara, J.M., Guide for Computing Degradation and Local Scour, U.S. Bureau of Reclamation, Oct. 1982

14. Abt, Steven R. & Terry L. Johnson, "Riprap Design for Overtopping Flow," Proc. ASCE, Journal Hydraulic Engineering, Vol. 117, No. 8, August 1991

1. Summary and Discussion

a. This calculation presents the design of riprap toe (apron) protection around the base of the tailings embankment at Grand Junction disposal site. The toe apron was designed from the following considerations:

- provide the stable rock size against runoff from the embankment top and side slopes due to local PMP storm.
- provide adequate depth of toe apron for protection against local scour due to local PMP, and to prevent gully development due to headcutting.
- provide a smooth transition between the embankment side slope and the existing grade (or regraded ground surface) to promote (to the extent possible) uniform runoff to the adjacent ground and to minimize flow concentration.

b. Results: A 20 ft long apron will be provided on the north, west and south sides of the embankment (the east side is connected with a drainage swale (see Ref. 3 for permanent drainage swale design). The depth of the apron (toe trench) was estimated to be 4 feet from the consideration of protection against local scour due to PMP storm and gully development due to headcutting. The apron plan and section are shown on sheets 8 + 9 respectively.

The average stable rock size (D_{50} (min)) was estimated to be 16 inches. This is corresponding to Type C rock (see apron section on sheet 9 for riprap arrangement). Gradation of the type C rock is presented in Appendix A. Filter (Type B rock) and bedding material's gradations are also presented in Appendix A.

Final site grading plan for the disposal site is also shown on sheet 8. The areas in the vicinity of the embankment will be graded (within the site boundary) in such a way to minimize concentrated flow and promote sheet flow. Oversized rocks (≥16") will be placed on the existing gully on the south-west side of the embankment to prevent further headcutting and gully development.

c. Discussion

1) The designed riprap toe protection with min. D_{50} = 16" and a depth of 4 ft is conservative since the design was based on the longest flow length on the top slope plus the side slop which gives the largest discharge per unit width. The design was also based on evaluations at different critical locations along the apron using several empirical equations/methods. Sheet 7 summarizes the results

of these calculations. Based on these results, it is judged that a $D_{50}(min) = 16$ inches is reasonable and conservative for most of the apron area along the base of the embankment. The min. D_{50} required estimated from different empirical equations are all less than 16" (including oversizing factor of 15% (Ref. 4)). The most critical condition for riprap sizing is at the assumed collapsed slope (3:1) area (see sheet 13), where the $D_{50}(min) = 16$" can sustain an assumed flow concentration factor (FCF) of at least 2 with the rock friction angle (ϕ) at 41° based on Stephenson method (Ref. 5). Based on COE Stilling Basin equation (Ref. 6) and Stephenson's equation for stones in flowing water (Ref. 5), the 16" rock can sustain the flow with FCF = 3. For D_{50}=16", an assumed FCF = 2 is reasonable since FCF usually decreased with increased in rock size based on experimental results (Ref. 14).

2) Either Type A rock (D_{50} (min) = 1.8") or Type B rock (D_{50}(min) = 5.5") can be used as the filter between Type C rock (D_{50}(min) = 16") and the bedding material for the apron (see Appendix A). Type B rock will be selected here for convenient in connecting with Type B rock to be placed on the embankment side slope (Ref. 2).

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA / GRJ
Feature Embankment Design
Item Riprap Toe Protection

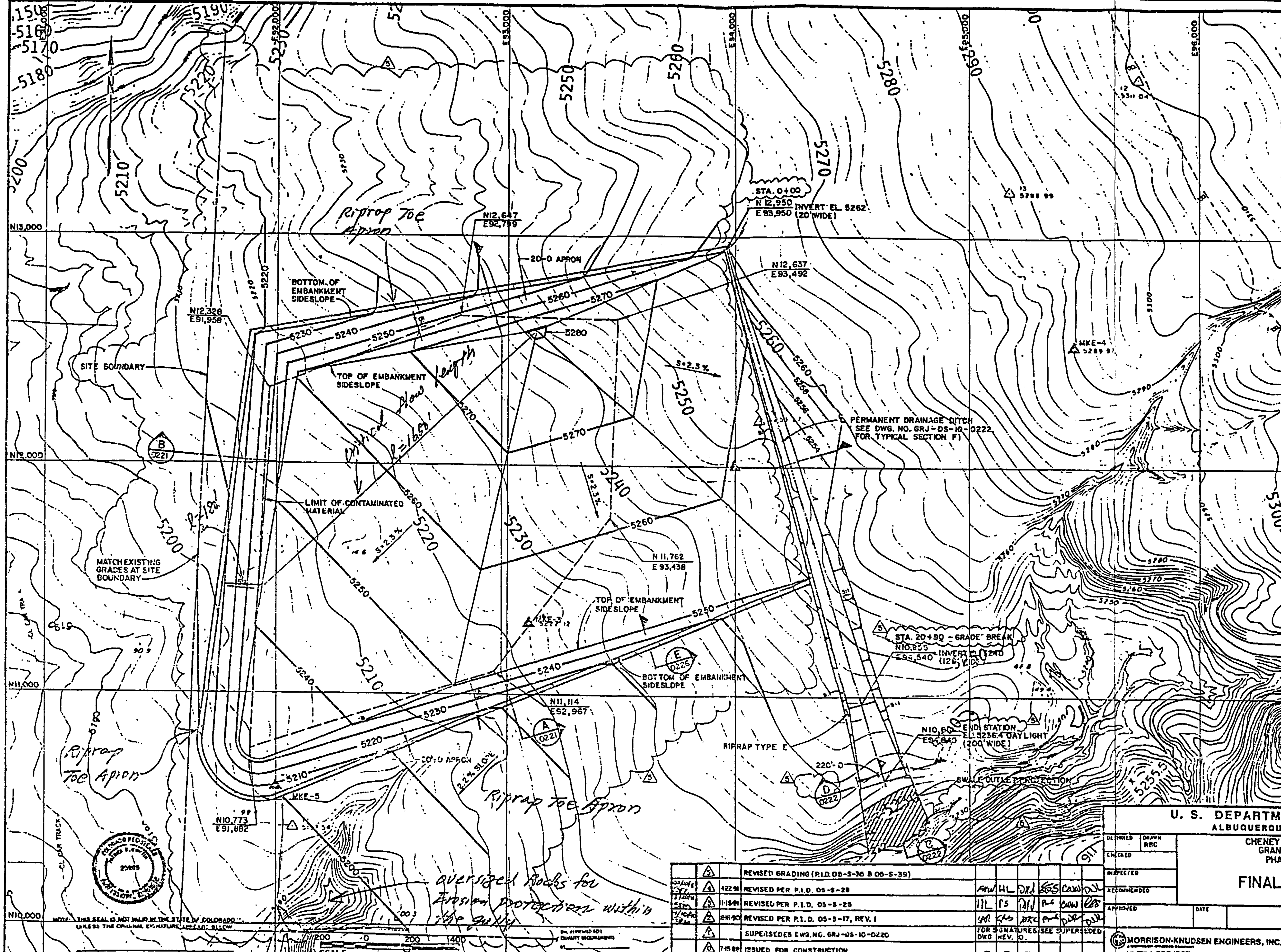
Contract No. 38[illegible]-34 File No. ____ Sheet 1
Designed [illegible] Date 11/13/[illegible]
Checked [illegible] Date 12/12/01

Summary of Calculations – Riprap Sizing for Toe Apron

in (inches)

Location	Method	FCF	q (cfs/ft)	slope S	n	Flow depth, y (ft)	V (fps)	τ (lb/ft²)	τ_d (lb/ft²)	Φ	θ	E	D50 (required)	D50 (over sized)	Remarks
U/S end Apron	Safety Factor Method *1	1	1.22	0.20	0.045	0.224	5.5	2.8	2.8	39°	5.71° (10:1)	–	7.9	9.1	
									4.2	40	"	–	11.8	13.6	$\tau_d = 1.5\tau$
	Stephenson *3 Sheet flow	1	1.22	0.20	0.045	0.224	5.5	2.8	–	39°	11.31° (5:1)	–	4.7	5.4	C=0.22
		3	3.66	0.20	0.060	0.574	7.1	6.4	–	39°	11.31°	–	9.9	11.4	C=0.22 (Conservative for FCF=3)
	U.S. COE Stilling Basin *2	1	1.22	0.20	0.045	0.224	5.5	2.8	–	–	11.31°	0.86	5.9	6.8	E=0.86 high turbulence
												0.62	11.4	13.1	E=0.62 isolated cube
	Stephenson stone in flowing water *2	1	1.22	0.20	0.045	0.224	5.5	2.8	–	39°		–	5.7	6.6	
D/S end Apron (Collapsed slope at 3:1	Stephenson Sheet flow *4	1	1.22	0.333	0.056	0.219	5.6	–	–	40°	18.43 (3:1)	–	9.1	10.4	C=0.22
		2	2.44	0.333	0.063	0.356	6.8	–	–	41°	18.43	–	13.5	15.5	C=0.22
		3	3.66	0.333	0.065	0.463	7.9	–	–	41°	18.43	–	17.7	20.3	C=0.22
		3	3.66	0.333	0.065	0.463	7.8	–	–	41°	18.03	–	15.4	17.7	C=0.245 (Assumed Average)
										42°	18.43	–	14.5	16.6	C=0.27 (Assumed)
	U.S. COE Stilling Basin *4	1	1.22	0.333	0.056	0.219	5.6	–	–	–	18.43°	0.86	7.6	8.8	
		2	2.44	0.333	0.063	0.356	6.8	–	–	–	18.43	0.86	11.4	13.0	
		3	3.66	0.333	0.065	0.463	7.9	–	–	–	18.43	0.86	15.0	17.0	
	Stephenson [illegible] for stone in flowing water *4	1	1.22	0.333	0.056	0.219	5.6	–	–	40	18.43	–	7.4	8.5	
		2	2.44	0.333	0.063	0.356	6.8	–	–	41	18.43	–	10.3	11.9	
		3	3.66	0.333	0.065	0.463	7.9	–	–	41	18.43	–	13.9	16.0	
10:1 slope Apron		1	1.22	0.10	0.073	0.37	3.3	2.31	2.31	39	5.71	–	6.5	7.5	
		2	2.44	0.10	0.062	0.57	4.8	3.18	3.18	39	5.71	–	9.0	10.3	
		3	3.66	0.10	0.056	0.61	6.0	3.81	3.81	39	5.71	–	10.8	12.4	

NOTE:
1. $G_s = 2.64$
2. See sheets through for detailed calculations and equations & symbols
3. *1 – use shear force on the 5:1 slope as shear force for estimating D_{50} required on 10:1 slope.
4. *2 – use velocity on the 5:1 slope for estimating D_{50} on the 10:1 slope
5. *3 – use 5:1 slope
6. *4 – use 3:1 slope & 3:1 slope flow condition.



NOTES: *Sheet 8*

1. WHERE CORNER CONTOURS ON THE TAILINGS EMBANKMENT ARE TOO SHARP TO BE CONSTRUCTED, CONTOURS WILL BE ROUNDED WITH A 50 FOOT RADIUS (APPROXIMATELY) IN THE PLAN VIEW.
2. THE CONTOURS OF THE TOP SLOPE ARE APPROXIMATE AND ARE DEPENDENT ON ACTUAL VOLUME OF CONTAMINATED MATERIALS RELOCATED.

UMTRA/GRJ
Embankment Design
Riprap Toe protection
FHW 11/15/91
PKC 12/12/91

REFERENCE DRAWINGS:

GRJ-DS-10-0124	SITE PLAN
GRJ-DS-10-0125	CONSTRUCTION FACILITIES AND SITE DRAINAGE
GRJ-DS-10-0134	TAILINGS EMBANKMENT AREA B EXCAVATION PLAN
GRJ-DS-10-0221	TAILINGS EMBANKMENT-SECTIONS AND DETAILS
GRJ-DS-10-0222	DITCHES AND MISCELLANEOUS-SECTIONS AND DETAILS
GRJ-DS-10-0223	BORINGS AND TEST PITS LOCATION PLAN
GRJ-DS-10-0226	DITCH PROFILE AND MISCELLANEOUS-SECTIONS AND DETAILS

LEGEND:

5280	EXISTING SITE FEATURES AND CONTOURS
	PERMANENT DRAINAGE DITCH
5270	FINISHED GRADE CONTOURS
N10,000	CONSTRUCTION GRID COORDINATES
△	EXISTING PERMANENT SURVEY MONUMENT
	EXCAVATION

QA MK-F	NO.	DATE	REVISIONS	BY	CK	E&D MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	5		REVISED GRADING (P.I.D. 05-S-38 & 05-S-39)						
	4	4-22-91	REVISED PER P.I.D. 05-S-28	FHW	HL	DXJ	SGS	CWW	DJL
	3	1-15-91	REVISED PER P.I.D. 05-S-25	HL	FS	DJJ		CWW	
	2	8-16-90	REVISED PER P.I.D. 05-S-17, REV. 1			PKC			DJL
	1		SUPERSEDES DWG. NO. GRJ-DS-10-0220	FOR SIGNATURES SEE SUPERSEDED DWG REV. 0.					
	0	7-15-88	ISSUED FOR CONSTRUCTION	—	—	—	—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

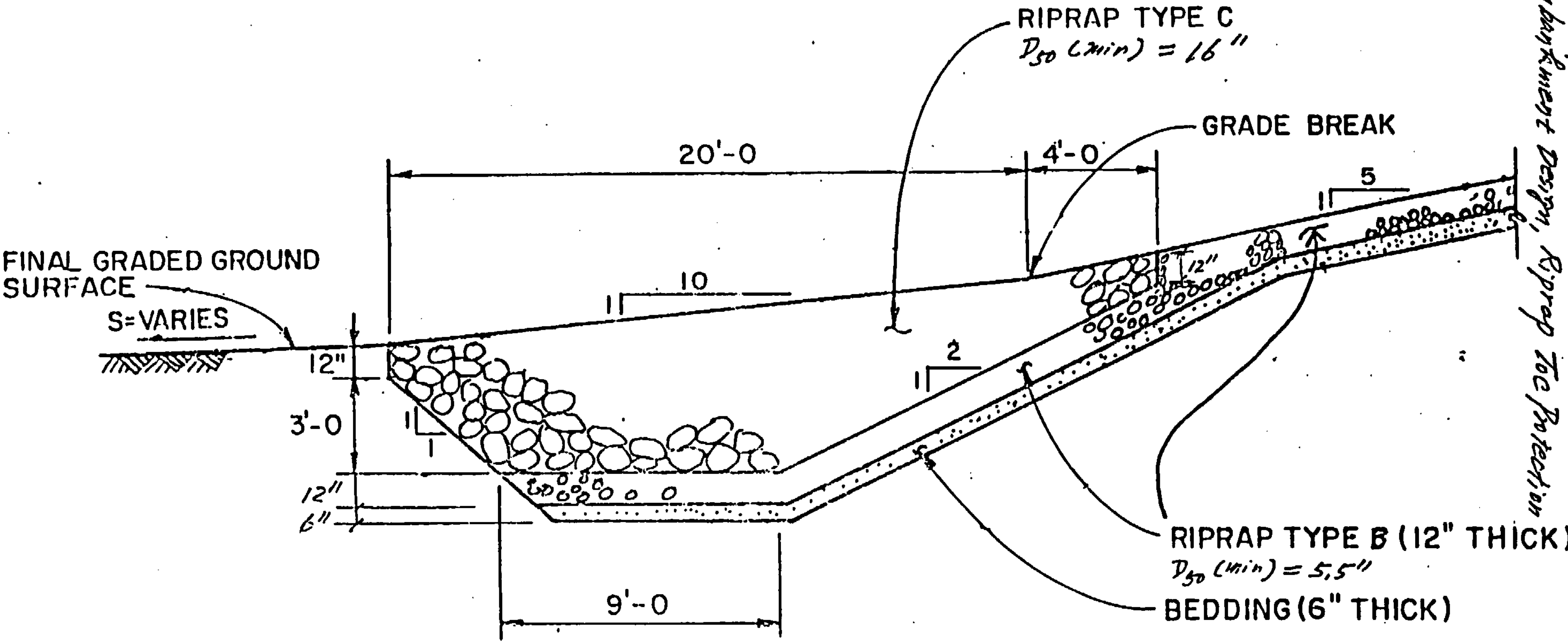
DESIGNED | DRAWN RBC
CHECKED
INSPECTED
RECOMMENDED
APPROVED | DATE | DOE PROJECT ENGINEER | DATE

CHENEY RESERVOIR DISPOSAL SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

FINAL GRADING PLAN

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. GRJ-DS-10-0220
REV. 5



TYPICAL EMBANKMENT APRON - DETAIL

UMTRA/GJT
Embankment Design, Riprap Toe Protection

Sheet 9
FHW 11/15/91
PTC 12/12/91

2. Purpose and Scope

The purpose of this calculation is sizing of the riprap toe apron at the base of the Grand Junction tailings embankment for protection against erosion/scour and gully development resulting from local intense rainfall-runoff (such as PMP storm) from the embankment top and side slopes.

Erosion protection on top and side slopes of the embankment was determined in other calculation (Ref. 2, Cal. no. 05-504-01-02, Erosion protection, Top and side slopes of Tailings Embankment, UMTRA/GRJ).

3. Method of Approach

a. General Design Consideration

The apron shall be designed with adequate riprap size to resist the force from runoff due to local intense PMP storm; to provide a uniform/gentle grade, to the extent possible, along the apron and adjacent ground with flow uniformly distributed at the end of the apron in order to minimize flow concentration and erosion of the adjacent ground; and to provide an adequate depth of toe apron for preventing undercutting due to local scour from PMP storm runoff or long-term headcutting and gully development.

MORRISON-KNUDSEN ENGINEERS, INC.
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Project UMTRA/GRJ	Contract No. 3885-34	Sheet 11	File No.
Feature Embankment Design	Designed FHW	Date 11/15/	
Item Riprap Toe Protection	Checked RKC	Date 12/15/	

The critical locations to be considered in the sizing of the riprap for the apron include :

1) At the grade break between the side slope (5:1) and apron (10:1 slope) : At this location, the PMP storm runoff from the top and side slopes will impinge on the apron and create turbulence condition, and is subject to greater shear force than ordinary flow condition.

2) At the end of the apron where it joins with the adjacent natural or regraded ground surface : At this location, potential scour and gully might be developed due to surface runoff from the embankment slopes. Portion of the apron is assumed to be collapsed due to scour or long-term erosion, and is assumed to be collapsed on a stable slope of 3H:1V. (See sheet 13).

3) The 10% slope apron area : This area is subject to shear force and velocity from normal flow conditions and general would required small rock for erosion protection.

A typical section of the apron is shown on sheet 9 (also sheet 13 with collapsed slope).

b. Stable Rock Size Determination

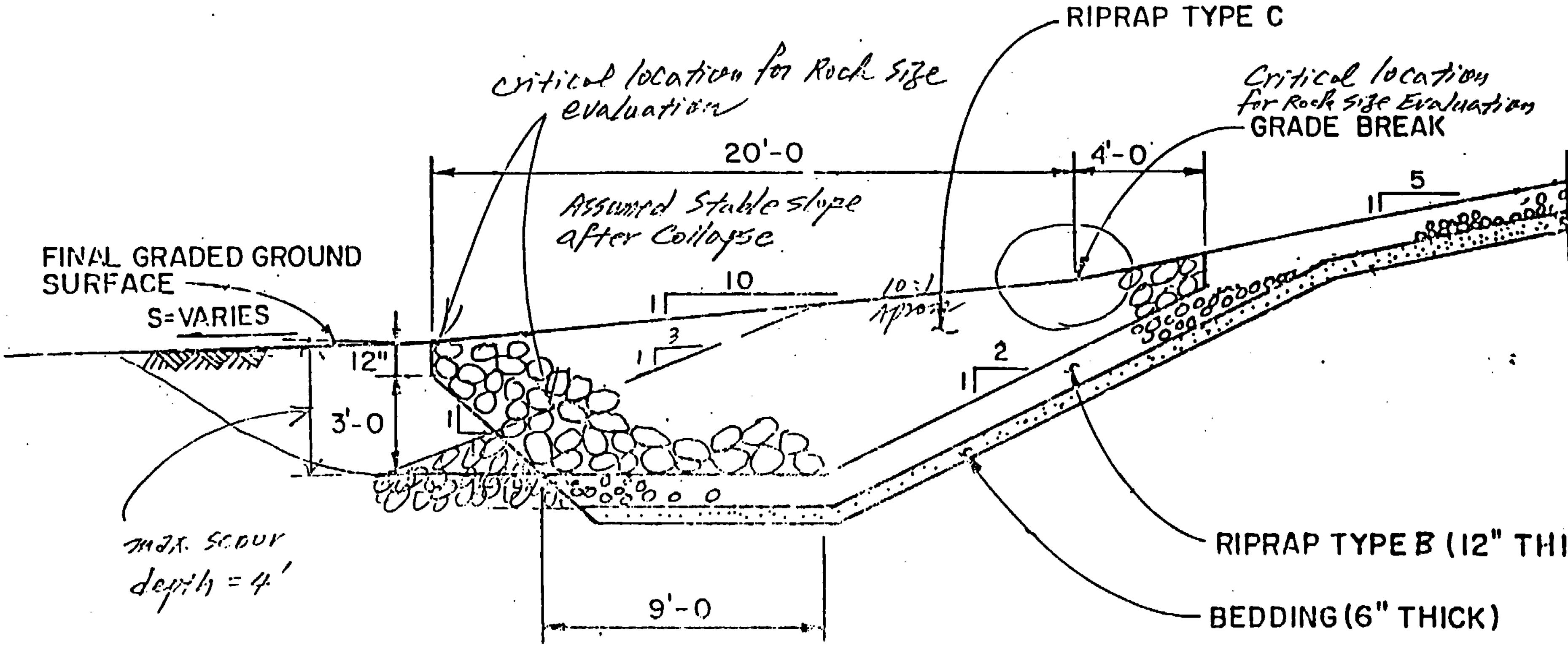
Stable rock size for the apron will be estimated for the locations described above (see sheets 11 +13). Several methods will be applied (as appropriate) including Safety Factor method (Ref. 5), Stephenson's methods (Ref. 6), and U.S. Army COE equation for stilling basin (Ref. 7). The flow condition on the side slope or apron will be evaluated based on Manning formula for sheet flow.

Details of these equations will be presented in the calculations to be followed. Based on these calculations, a suitable rock size (D_{50} (min)) will be chosen as judged reasonable and the rock size is also readily available.

Rock gradation will also be determined based on rock availability and procedures presented in Ref. 1.

c. Depth of Apron

Depth of apron will be determined based on potential scour on the adjacent grade of the apron due to PMP storm runoff. Several empirical methods, including Critical tractive force method (Ref. 9), U.S. DOT empirical equation (Ref. 10), Laceys Regime equation (Ref. 11), and USBR empirical equation (Ref. 12) will be used.



TYPICAL EMBANKMENT APRON - DETAIL

UMTRA/GRJ
Embankment Design, Riprap Toe Protection

Sheet 13

FHW 11/15/91

PKE 12/12/91

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Project: UMTRA/GRJ	Contract No. 3885-34	File No.	Sheet 17
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Item: Riprap Toe protection	Checked: PKC	Date 12/12/91	

4. Calculations

a. Peak Discharge.

Based on Ref. 2, $q_{max} = 1.12$ cfs/ft at end of the embankment side slope (based on the longest flow length of 1650' on the 2.3% top slope and 180 ft long on the 5:1 side slope). A more critical condition with $q = 1.22$ cfs/ft will be used here based on the assumption that embankment top slope might be increased (say up to 3.5%) due to increase volume of contaminated materials.

b. Estimate of Stable Rock Size

1) At upstream End of Apron (Grade Break between Embankment Side Slope and Apron)

The flow from the 5:1 side slope will impinge on the Apron slope (10:1) creating turbulent flow condition and subject to higher shear force. Stable rock size is evaluated below by several methods using the flow condition and shear stress on the 5:1 side slope:

a) Safety Factor Method (Ref. 5)

$q = 1.22$ cfs/ft.

Based on Manning formula: $q = \frac{1.486}{n} y^{5/3} S^{1/2}$, or

$$y = (nq/1.486 S^{1/2})^{0.6}$$

where: n = Manning Roughness Coeff.,
S = Slope. y = flow depth (ft). q = cfs/ft.

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Item: Riprap Toe Protection	Checked: ???	Date: 12/1?/01	

Flow Condition:

let $S = 0.20$, $n = 0.045$ (based on $D_{50} = 5.5"$ after oversizing) on side slope.

then $y = 0.224'$, $V = 5.5$ fps.

$\tau = \gamma y S = 2.80$ lb/ft², $F_r = \frac{V}{\sqrt{\frac{g y \cos\theta}{\alpha}}} = 2.3$, $\theta = \tan^{-1}(0.2) = 11.3°$, α = energy coeff. = 1.3 (Ref. 9)

Check $n = y^{1/6} / [23.85 + 21.98 \log(\frac{y}{D_{50}})] = 0.045$, ok (Ref. 8).

D_{50} Required:

(1). Let $\tau_d = \tau = 2.8$ lb/ft²,

then $D_{50} = 21\,\tau_d / (G_s - 1)\cdot\eta\,\gamma_w$, and $\eta = \cos\theta\,(\frac{1}{S.F.} - \frac{\tan\theta}{\tan\phi})$.

Where: G_s = specific gravity of rock.

θ = slope angle, ϕ = rock friction angle.

S.F. = Safety Factor = 1.0 for PMP flow conditions.

γ_w = 62.4 lb/ft².

For $S = 0.10$ (apron slope), $\theta = 5.71°$, let $\phi = 37°$ (Ref. 12, see sheet 16)

then $D_{50} = 7.9"$, use oversizing factor of 15% (Ref. 4)

Required $D_{50} = 7.9(1.15) = 9.1"$

(2) Let $\tau_d = 1.5\,\tau = 4.2$ lb/ft² (Assume shear stress increases 50% due to turbulent), use $\phi = 40°$ (Ref. 12)

the $D_{50} = 11.8"$, D_{50} (oversized) $= 13.6"$

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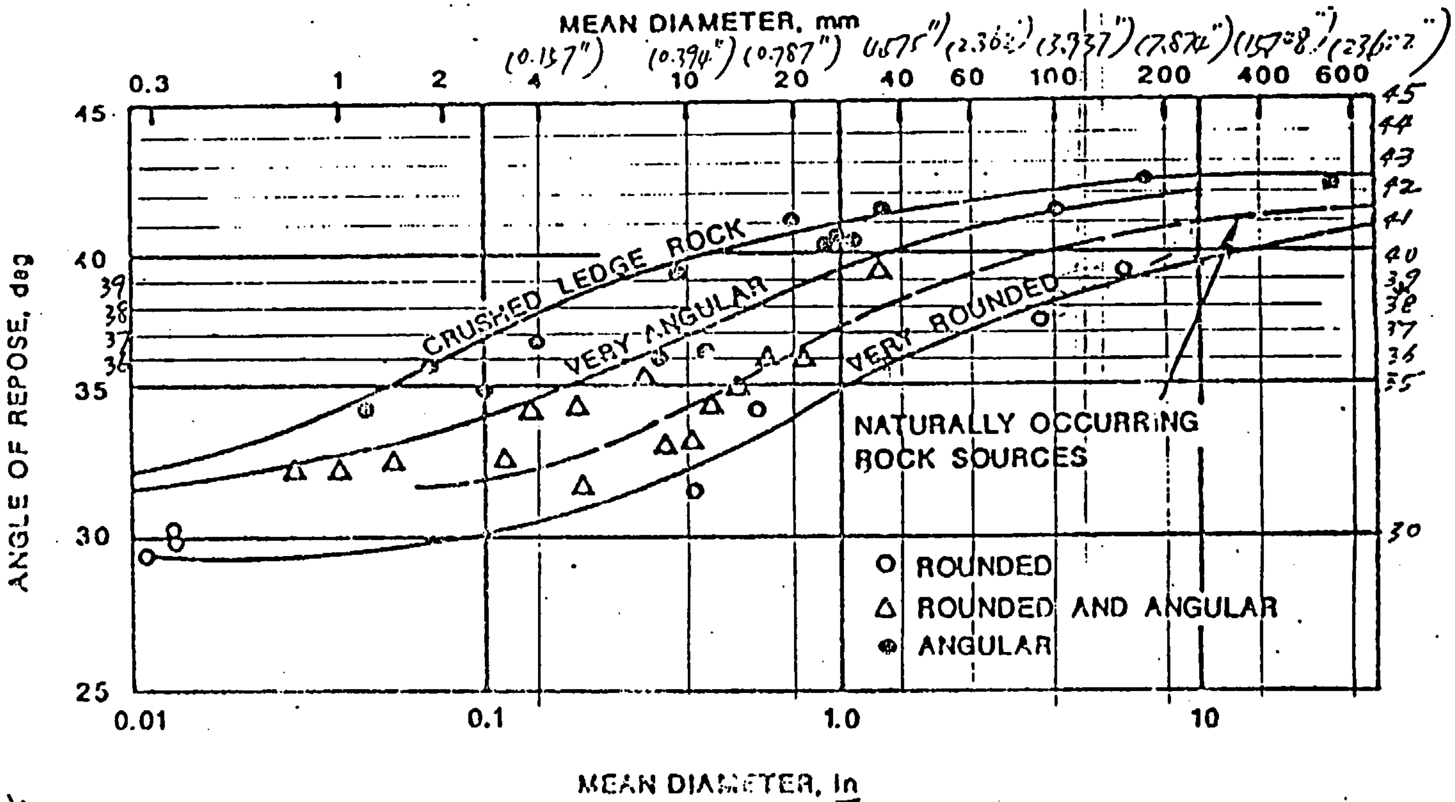
Embankment Design / Riprap Toe Protection



Source: Ref. 12

ANGLE OF REPOSE FOR ROCK OF VARIOUS DIAMETERS

PTK 12/10/91

FHW 11/15/91

Sheet 16

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Project UNTRA/GRJ — Contract No. 3885-34 — Sheet 11 — File No.
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Item Riprap Toe protection — Checked — Date 12/12/91

b) Stephenson's Equation (for sheet flow):

$$D_{50}^{(ft)} = \left\{ q(\tan\theta)^{7/6}(P)^{1/6} / c \cdot g^{1/2} \cdot [(1-P)(G_s-1)\cos\theta\,(\tan\phi - \tan\theta)]^{5/3} \right\}^{2/3}$$

where: P = porosity (assumed = 0.33).

c = empirical factor = 0.22 for gravel and pebbles
= 0.27 for crushed granite

others than same as previously defined.

use 5:1 slope, this is similar to riprap sizing for embankment side slope in other calculations. (Ref. 2).

For $q = 1.22$ cfs, $\phi = 39°$, $C = 0.22$, $\theta = 11.31°$ (5:1)

$D_{50} = 4.8''$ — D_{50} (oversized) $= 4.8 \times 1.15 = 5.5''$

For $q = 3.66$ (FCF=3), $\phi = 39°$, $D_{50} = 9.9''$, D_{50} (oversized) $= 11.4''$

c) U.S. Army COE - Stilling Basin Method (Ref. 7):

$$D_{50}^{(ft)} = V_{min}^2 / [E^2 \cdot 2g \cdot (G_s - 1) \cdot (\cos\theta - \sin\theta)],$$

where, V_{min} = min. velocity to move the stone. (fps)

E = empirical constant = 0.86 (high turbulence)
= 1.20 (low turbulence)
= 0.62 (isolated cube).

θ - slope angle of apron

G_s = specific gravity of rock = 2.64

use the velocity from the 5:1 side slope with $q = 1.22$ cfs/ft. and the slope angle of 5:1 ($\theta = 11.31°$):

$V = 5.5$ fps, $D_{50} = 0.3651/E^2$.

E = 0.86 (high turbulence), $D_{50} = 5.9''$, D_{50} (oversized) $= 6.8''$
= 0.62 (isolated cube), $D_{50} = 11.4''$, D_{50} (oversized) $= 13.1''$

d). Stephenson's Equation for Stone in Flowing Water (Ref. 6).

$D_{50}^{(ft)} = 0.25\, V^2 / [g(G_s - 1)\cdot \cos\theta\,(\tan\phi - \tan\theta)]$, where

θ = slope angle of apron, use (5:1, $\theta = 11.31°$).
ϕ = friction angle of rock.
$G_s = 2.64$.
The constant 0.25 was derived based on the rock shape and drag coefficient. Assume this coeff. could be double to 0.5 for conservative (i.e. double the size of D_{50} from above equation).
Hence:

For $\phi = 39°$, $V = 5.5$ fps, $D_{50} = 5.7''$, D_{50} (oversized) $= 6.6''$

2) At Downstream End of Apron:
It is assumed that the apron would collapse to a 3H:1V slope due to cumulative local scour at its end (see sheet 13).
Required stable rock size after collapse to 3:1 slope is estimated below:

a) Stephenson's Equation (see sheet 17 for equation):
use $G_s = 2.64$, $\theta = 18.43°$ (3:1), $\rho = 0.33$, $c = 0.22$.

FCF = 1.0, $q = 1.22$ cfs/ft, $\phi = 40°$, $D_{50} = 9.1''$, D_{50} (oversized) $= 10.4''$ (used)
$\phi = 41°$, $D_{50} = 8.5''$, D_{50} (oversized) $= 9.8''$
FCF = 2.0, $q = 2.44$ cfs/ft, $\phi = 40°$, $D_{50} = 14.4''$, D_{50} (oversized) $= 16.5''$
(use this) → $\phi = 41°$, $D_{50} = 13.5''$, D_{50} (oversized) $= 15.5''$ (used)
FCF = 3.0, $q = 3.66$ cfs/ft, $\phi = 40°$, $D_{50} = 18.8''$, D_{50} (oversized) $= 21.7''$
($c = 0.22$) $\phi = 41°$, $D_{50} = 17.7''$, D_{50} (oversized) $= 20.3''$
$c = \frac{1}{2}(0.22 + 0.27) = 0.245$, $\phi = 41°$, $D_{50} = 15.4''$, D_{50} (oversized) $= 17.7''$
$c = 0.27$, $\phi = 42°$, $D_{50} = 14.5''$, D_{50} (oversized) $= 16.6''$

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b). U.S. Army COE - Stilling Basin Equ. (See sheet 17 for Equation).

$\theta = 18.43°$ (3:1 slope). $s = 0.333$

$y = (n q / 1.486 s^{1/2})^{0.6}$, use $E = 0.86$ (assume high turbulent).

(1) FCF = 1.0, $q = 1.22$ cfs/ft., let $n = 0.056$

$y = 0.219'$, $V = q/y = 5.6$ fps.

$D_{50} = 7.6''$. D_{50} (oversized) $= 8.8''$

(2) FCF = 2.0, $q = 2.44$ cfs/ft; let $n = 0.063$

$y = 0.356'$, $V = 6.8$ fps

$D_{50} = 11.4''$, D_{50} (oversized) $= 13''$

(3) FCF = 3.0, $q = 3.66$ cfs/ft, let $n = 0.065$

$y = 0.463'$. $V = 7.9$ fps.

$D_{50} = 15''$. D_{50} (oversized) $= 17''$

c) Stephenson's Equ. for Stones in Flowing Water (See sheet 18 for Equ.)

$\theta = 18.43°$, ($s = 1/3$), $G_s = 2.64$, Assume same velocity used above.
Assume constant 0.25 could be double as 0.5 (i.e. estimated D_{50} could be double).

FCF = 1.0, $q = 1.22$ cfs/ft, $V = 5.6$ fps.

$\phi = 40°$, $D_{50} = 7.4''$, D_{50} (oversized) $= 8.5''$

$\phi = 41°$ $D_{50} = 7.0''$, D_{50} (oversized) $= 8.1''$

FCF = 2.0 $q = 2.44$ cfs/ft, $V = 6.8$ fps

$\phi = 40°$ $D_{50} = 10.9''$, D_{50} (oversized) $= 12.6''$

$\phi = 41°$ $D_{50} = 10.3''$, D_{50} (oversized) $= 11.9''$

FCF = 3.0 $q = 3.66$ cfs/ft, $V = 7.9$ fps

$\phi = 40°$ $D_{50} = 14.8''$, D_{50} (oversized) $= 17''$

$\phi = 41°$ $D_{50} = 13.9''$, D_{50} (oversized) $= 16''$

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			Date 12/10/91

3) Within 10:1 slope Apron (assume apron is not collapsed)

a) Flow Condition (with assumed $D_{50} = 10''$)

FCF=1.0, $q=1.22$ cfs/ft, $n=0.073$, $y=0.37'$, $V=3.3$ fps, $F_r=1.10$, $\tau=2.31$ lb/ft²

=2.0, $q=2.44$, $n=0.062$, $y=0.51$, $V=4.8$ fps, $F_r=1.36$, $\tau=3.18$ lb/ft²

=3.0, $q=3.66$, $n=0.056$, $y=0.61'$, $V=6.0$ fps, $F_r=1.55$, $\tau=3.81$ lb/ft²

b) check D_{50} required. ($\theta=5.71°$) using Safety Factor Method

FCF=1.0, $\tau=2.31$ lb/ft², $\phi=38°$, $D_{50}=6.6''$, D_{50} (oversized) = 7.5''
$\phi=39°$, $D_{50}=6.5''$, D_{50} (oversized) = 7.5''

FCF=2.0 $\tau=3.18$ lb/ft², $\phi=38°$, $D_{50}=9.0''$, D_{50} (oversized) = 10.4''
$\phi=39°$, $D_{50}=9.0''$, D_{50} (oversized) = 10.3''

FCF=3.0 $\tau=3.81$ lb/ft², $\phi=38°$ $D_{50}=10.8''$, D_{50} (oversized) = 12.4''
$\phi=39°$ $D_{50}=10.8''$, D_{50} (oversized) = 12.4''

Sheet 7 summarizes the results of estimated D_{50} required based on above computations.

C. Depth of Apron

Depth of apron (toe trench) will be determined based on consideration of potential local scour at its downstream end due to PMP flow condition.

1) Soil near the Apron Area

Based on boring and test pit logs information available (see Appendix E), the top soils for the area near the apron are generally sandy clay clayed sand with gravel and cobbles (say within the top 5').
For establishing the maximum permissible velocity and critical shear stress of the soils, the following criteria will be adopted:

a) For top 1-2' soils — Assume sandy clay / alluvial silts, colloidal condition, the maximum permissible velocity that will not cause erosion is 3.7 to 5.0 fps for clear water or water transporting colloidal silts (Ref. 9). The corresponding critical shear stress is 0.26 to 0.46 lb/ft² (see sheet 22)
For conservative, use $V_{allowable} = 3.7$ fps, $\tau_c = 0.26$ lb/ft²

b) For soils 2-5' deep — Assume graded loam to cobbles when colloidal, or graded silts to cobbles when colloidal according to Ref. 9. The max. allowable velocity will be 3.7 to 5.5 fps and critical shear stress will be 0.4 to 0.8 lb/ft² (see sheet 22)
use $V_{allowable} = 4$ fps. and $\tau_c = 0.6$ lb/ft²

of Reclamation and is tentatively recommended for design of erodible channels. It should be noted that either method at the present stage will serve only as a guide and will not supplant experience and sound engineering judgment.

7-9. The Maximum Permissible Velocity. The *maximum permissible velocity*, or the *nonerodible velocity*, is the greatest mean velocity that will not cause erosion of the channel body. This velocity is very uncertain and variable, and can be estimated only with experience and judgment. In general, old and well-seasoned channels will stand much higher veloci-

TABLE 7-3. MAXIMUM PERMISSIBLE VELOCITIES RECOMMENDED BY FORTIER AND SCOBEY AND THE CORRESPONDING UNIT-TRACTIVE-FORCE VALUES CONVERTED BY THE U.S. BUREAU OF RECLAMATION*
(For straight channels of small slope, after aging)

Material	n	Clear water		Water transporting colloidal silts	
		V, fps	τ_0, lb/ft²	V, fps	τ_0, lb/ft²
Fine sand, colloidal	0.020	1.50	0.027	2.50	0.075
Sandy loam, noncolloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	0.020	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	0.020	2.00	0.048	3.50	0.15
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.26	5.00	0.46
Shales and hardpans	0.025	6.00	0.67	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	0.030	3.75	0.38	5.00	0.66
Graded silts to cobbles when colloidal	0.030	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	0.025	4.00	0.30	6.00	0.67
Cobbles and shingles	0.035	5.00	0.91	5.50	1.10

* The Fortier and Scobey values were recommended for use in 1926 by the Special Committee on Irrigation Research of the American Society of Civil Engineers.

ties than new ones, because the old channel bed is usually better stabilized, particularly with the deposition of colloidal matter. When other conditions are the same, a deeper channel will convey water at a higher mean velocity without erosion than a shallower one. This is probably because the scouring is caused primarily by the bottom velocities and, for the same mean velocity, the bottom velocities are greater in the shallower channel.

2). Estimation of Scour Depth.

The flow condition to be used for scour depth estimation is as follow:

Assume FCF = 3, $q = 1.22 \times 3 = 3.66$ cfs/ft.

- For 10 % Apron:

$q = 3.66$ cfs/ft, $n = 0.056$, $y = 0.61'$, $V = 6.0$ fps. $\tau = 3.81$ lb/ft².

- For ground surface downstream of Apron:

slope of ground surface ≈ 6 % = 0.06, use $n = 0.03$

$q = 3.66$, $y = 0.487'$, $V = 7.5$ fps, $\tau = 1.82$ lb/ft².

Depth of scour was estimated based on several methods:

a). U.S. D.O.T Empirical Equation for Scour below Culvert outlet (Ref. 10).

The equation was developed based on a sand channel bed and assumed applicable here.

$$D_s = 0.82 \cdot (y_e) \left(q / y_e^{2.5} \right)^{0.375} (t)^{0.1}, \quad \text{(Ref. 10)},$$

where, D_s = scour depth (ft), $q = 3.66$ cfs

y_e = flow depth (ft) = 0.61' (flow depth on apron).

t = flow duration (min), assume = 60 min (conservative).

Hence $D_s = 1.95 \doteq 2.0$ ft

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b) Critical Tractive Force Method.

$\tau_c = 0.26$ lb/ft² for top soil (see sheet 21).

The stable slope under critical tractive force assuming sheet flow is:

$$S_s = \left(1.486\,\tau_c^{5/3} / n\,q\,(\gamma_w)^{5/3}\right)^{6/7} \longleftrightarrow \left(\text{derived from: } q = \frac{1.486}{n}\,y^{5/3} S_s^{1/2} \;\&\; \tau_c = \gamma y S_s\right)$$

where $\gamma_w = 62.4$ lb/ft³

n = Manning roughness coeff $\doteq 0.03$

$q = 3.66$ cfs (FCF = 3), $\tau_c = 0.26$

Assume local scour near the apron toe will flatten the slope in the local area so that shear force from the flow until $\tau \le \tau_c$. The flow depth under this stable slope will be approximately the depth of scour.

$$S_s = \left(1.486 \cdot (0.26)^{5/3} / (0.03)(3.66)(62.4)^{5/3}\right)^{6/7} = 0.0037$$

$$D_s \doteq y = \left(n\,q / 1.486 \cdot S_s^{1/2}\right)^{0.6} = \underline{\underline{1.1 \text{ ft}}}$$

$V = q/y = 3.3$ fps < 3.7 fps

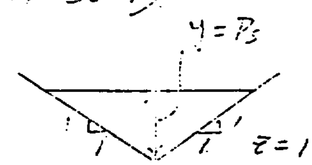
$\tau = \gamma y S = 62.4(1.1)(0.0037)$

$= 0.25 < 0.26$ O.K.

c). Critical Tractive Force Method.

use same $\tau_c = 0.26$ lb/ft², but assume a V shape gully with side slope 1:1 ($z=1$)

use same basis discussed above:



$$y = \left\{ n\,Q / 1.486 \cdot z \cdot \left(\frac{z}{2\sqrt{z^2+1}}\right)^{2/3} S_s^{1/2} \right\}^{3/8}$$

Assume FCF = 4, $Q = 4 \times 1.22 = 4.9$ cfs, $z = 1$, $n = 0.03$

Assume $S_s = 0.002$.

$y = 1.75$ ft. $V = 1.6$ fps < 3.7 fps $\tau = \gamma y S = 0.22 < 0.26$

Hence $D_s \doteq \underline{1.8'}$

d). Lacey's Regime Equation for Weir and Guide Bank Apron (Ref. 11).

$R = 0.9\,(q^2/f)^{1/3}$, and $D_s + y = XR$

where, D_s = scour depth (ft), y = flow depth (ft)

q = flow rate (cfs/ft) = 3.66. (FCF = 3.0).

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

X = multiplying factor = 1.75 ~ 2.25, use 2.25 to be conservative for downstream apron that allows for flow concentration.

Assume $D_{50} = 1^{mm}$, $f = 1.76$, $R = 1.77'$, $XR = 4'$, $y = 0.6'$, $D_s = 3.4'$

$D_{50} = 2^{mm}$, $f = 2.49$, $R = 1.58'$, $XR = 3.5'$, $y = 0.6'$, $D_s = 2.9'$

$D_{50} = 5^{mm}$, $f = 3.94$, $R = 1.35'$, $XR = 3.0'$, $y = 0.6'$, $D_s = 2.4'$

For gravelly soil below 3', it is reasonable to assume $D_{50} \approx 1^{mm}$ hence $D_s \approx 3.4'$

e). USBR Empirical Equation (Ref. 13)

$D_s = 2.45\,(q)^{0.24}$ — the equation was developed from data on ephimeral stream in South-west U.S. for $D_{50} = 0.5 - 0.7^{mm}$, $S = 0.002 - 0.008$

$q = 3.66$ cfs/ft $D_s = 3.3$ ft.

f) Based on above estimates, a scour depth of 4 ft below the toe apron is adopted and the apron toe trench will be design at 4 ft.

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Project UMTRA / GRJ	Contract No. 3865-34	Sheet A-1	File No.
Feature Embankment Design	Designed [illegible]	Date 11/15/9[illegible]	
Item Riprap Toe Protection	Checked [illegible]	Date [illegible]	

Appendix A

Riprap Gradation

Appendix A — Riprap Gradation.

Required D_{50} (min) with oversizing factor of 1.15 was determined to be = 16 inches and will be designated as Riprap Type C (or Type C Rock).

1. Gradation and Layer Thickness of Type C Rock

D_{50} (min) = 16" (with 15% oversizing factor considered) (Ref. 4)

then D_{100} (max) = 1.71 D_{50} (min) = 27.4" ≐ 28" (see pages 5-13, Ref. 1)

D_{100} (min) = 1.26 D_{50} (min) = 20.2" ≐ 21" "

D_{25} (min) = 0.68 D_{50} (min) = 10.9" = 11" "

A gradation band for Type C rock is drawn based on above calculated values as shown on sheet A-4. Sheet A-4 also lists the % passing for several sieve sizes for Type C rock.

Layer Thickness:

Tmin ≐ 1.9 D_{50} (min) = 1.9(16) ≐ 30" (Ref. 1)

= 1.5 D_{50} (max) = 1.5(21) ≐ 31"

Use Layer Thickness = 30" on the 5:1 slope.

on the Apron part — thickness = 4' as determined from scour protection.

2: <u>Filter / Bedding for Type C Rock</u>

Type A & Type B rocks (and their bedding materials) which are used for erosion protection at the embankment top and side slopes (see Ref. 2) will be used as filter between Type C and bedding if both are suitable.

Gradation curves for Type A & Type B rocks and Bedding materials from Ref. 2 are also shown on Sheet A-4. Both Type A and Type B rocks are compatible with the bedding material (i.e $D_{15}(max)$ of Type A or Type B rock / $D_{85}(min)$ bedding material ≤ 7.5 (Ref 1)) based on computation of Ref. 2.

a. <u>Type A rock as Filter.</u>

Type C rock – $D_{15}(max) = 390$ mm (see sheet A-3)

Type A rock – $D_{85}(max) = 56$ mm.

$D_{15}(max)$ Type C / $D_{85}(min)$ Type A $= 390/56 = 7.0 \leq 7.5$ O.K.

(see page 5-14, Ref. 1)

b). <u>Type B rock as Filter</u>

Type C rock – $D_{15}(max) = 380$ mm

Type B rock – $D_{85}(min) = 175$ mm

$D_{15}(max)$ Type C / $D_{85}(min)$ Type B $= 390/175 = 2.2 < 7.5$ O.K

(see page 5-14, Ref. 1).

c) Hence both Type A & Type B rock can be used as filter between Type C rock and bedding materials, and will be used alternatively at appropriate locations.

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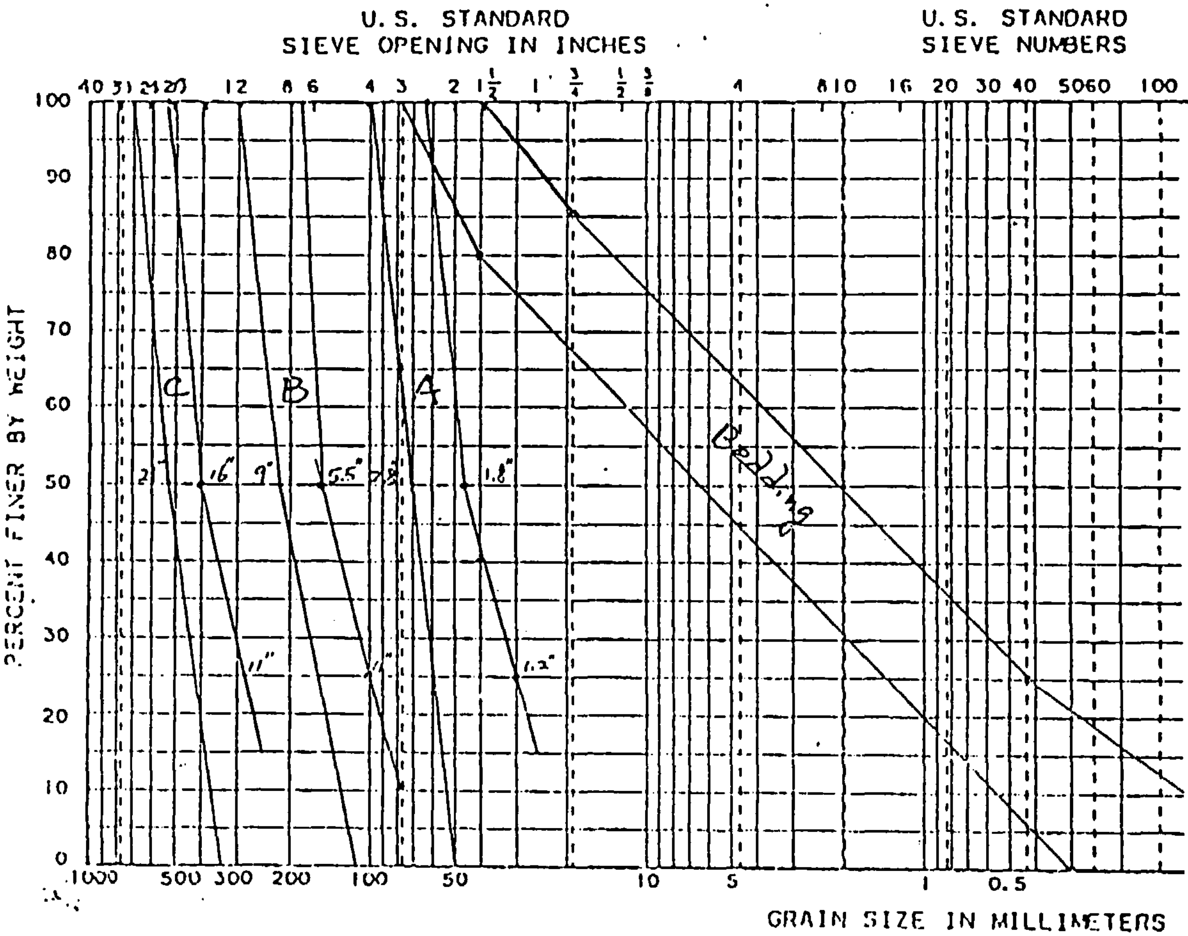
GRAIN SIZE ANALYSIS

UMTRA/GRJ 3885-36
Embankment Design
Riprap Toe Protection



Rock Type	Sieve size	% Passing
Type A	4"	100
	2½"	35 – 95
	2"	0 – 60
	1½"	0 – 40
	1"	0 – 15
Type B	12"	100
	9"	50-100
	7"	35 – 95
	5½"	20 – 50
	3"	0 – 10
Type C	28"	100
	20"	45 – 90
	16"	20 – 50
	10"	0 – 15
Bedding	3"	100
	1"	70 – 90
	No. 4	45 – 65
	No. 40	5 – 25
	No. 200	0 – 5

COBBLES	GRAVEL: COARSE	GRAVEL: FINE	SAND: COARSE	SAND: MEDIUM	SAND: FINE

SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	NAT W%	LL	PL

JOB NO.
AREA
HOLE NO.
DATE

NOTE: Gradations of Type A, Type B & bedding material are from Ref. 2

Sheet A-4
[illegible]

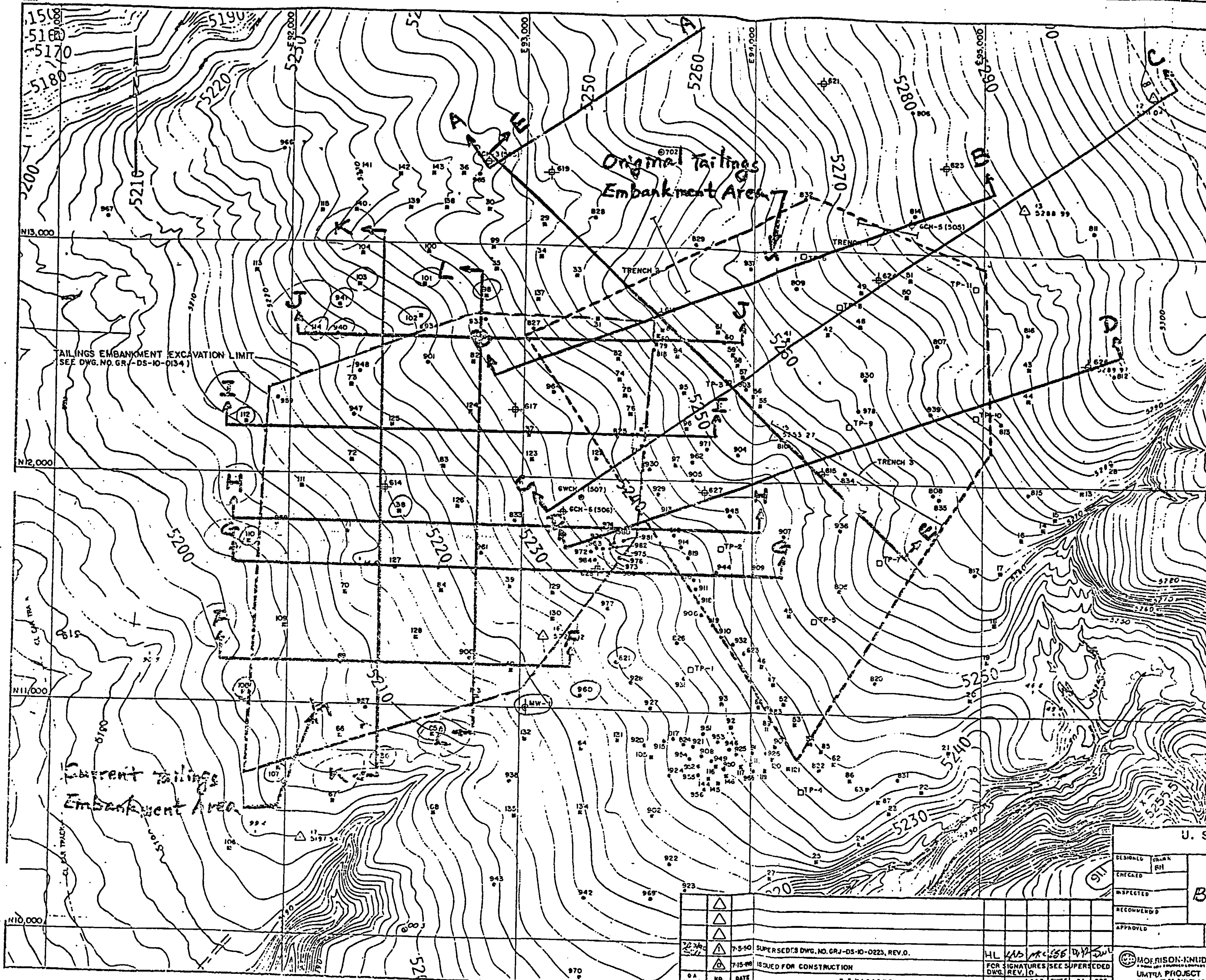
MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA / GRJ	Contract No. 3885-34	Sheet B-1	File No.
Feature Embankment Design	Designed FHW	Date 11/15/91	
Item Riprap Toe Protection	Checked PTC	Date 12/12/91	

Appendix B

Boring and Test Pit Logs Information near Embankment Apron Area.

Sheet B-2



BOREHOLES & TEST PITS	COORDINATES	
GWCH-2 (506)	N14,170	E96,180
GWCH-3(509)	N14,335	E94,140
GCH-1 (501)	N15,240	E95,360
GCH-2(502)	N14,280	E94,160
GCH-4(504)	N14,140	E96,240
613	N15,270	E95,100
701	N14,460	E95,020
26	N10,170	E93,985
935	NOT DRILLED	
985	NOT DRILLED	

UMTRA/GRJ 3885-34
Embankment Design
Riprap Toe Protection
FAW 11/15/91 BKC 12/12

NOTE:

1. GROUND WATER DATA AND SUBSURFACE EXPLORATION LOGS ARE AVAILABLE FROM THE CONTRACTOR.
2. BOREHOLES AND TEST PITS NOT SHOWN ON DRAWING ARE LISTED ON TABLE ABOVE.

REFERENCE DRAWINGS:

- GRJ-DS-10-0125 CONSTRUCTION FACILITIES AND SITE DRAINAGE
- GRJ-DS-10-0134 TAILINGS EMBANKMENT AREA EXCAVATION PLAN

LEGEND:

- 5240 — EXISTING SITE FEATURES AND CONTOURS
- N12,000 — CONSTRUCTION GRID COORDINATE
- GCH-6 — BORINGS DRILLED BY NUS IN 1982
- GWCH-3 — MONITOR WELLS INSTALLED IN 1982
- 701 — MONITOR WELLS INSTALLED BY TAC IN 1985
- 616 — TEST PITS DUG BY TAC IN 1984
- 617 — TEST PITS DUG BY LINCOLN DEVORE/MKE IN 1985
- TP-5 — TEST PITS DUG BY WESTERN ENG./MKE IN 1987
- MW-1 — EXISTING WATER SUPPLY WELL BY MKE IN 1987
- 41 — TEST PIT BY TAC IN 1989
- 930 — WELL-BOREHOLE BY TAC IN 1989

SCALE 200 0 200 400 FEET

NO.	DATE	REVISIONS
1	7-5-90	SUPERSEDES DWG. NO. GRJ-DS-10-0223, REV. 0.
0	7-15-88	ISSUED FOR CONSTRUCTION

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

CHENEY RESERVOIR DISPOSAL SITE
GRAND JUNCTION, COLORADO
PHASE II CONSTRUCTION

B. BORINGS AND TEST PITS LOCATION PLAN

DESIGNED | DRAWN BH | CHECKED | INSPECTED | RECOMMENDED | APPROVED | DATE | DOE PROJECT ENGINEER | DATE

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. GRJ-DS-10-0223
REV.

UMTRA/GRJ Embankment Design 3881-34 FHW 11/15/91 Sheet B-3 DEC 10/15

PROJECT GRAND JUNCTION Riprap Toe protection
CHENEY RESERVOIR

JOB NO. GRJ-03 DATE 8/11/89

LOG OF TEST PIT NO. 65

GROUNDWATER		
DEPTH	HOUR	DATE
	NONE	

BACKHOE TYPE KOEHRING 666E
LOCATION N10,885 E92,627
ELEVATION 5,210
DATUM MSL

Depth in Feet	Sample Type	Unified Soil Classification
0	D	
1		SC
2	D	
3		SC
4	D	
5		
		GC
	D	
		GP
	D	
		SC
10		
	D	
		GP
	D	
15		
	D	Sh
20		
25		

REMARKS	VISUAL CLASSIFICATION
dry,roots	TOPSOIL: CLAYEY SAND, some gravel & cobbles, fine sand, weak lime cementation, low plasticity, light red
dry	CLAYEY SAND, trace gravel, fine sand, weak to moderate lime cementation, low plasticity, light orange-brown.
slightly moist	CLAYEY GRAVEL, COBBLES & BOULDERS, boulders < 3 feet in diameter, predominately medium - coarse subangular - subrounded gravels and cobbles, medium - coarse angular sand, moderate lime cementation, some gypsum, low to medium plasticity, light browm.
dry	SANDY GRAVEL, COBBLES & BOULDERS, boulders < 3 feet in diameter, predominately coarse subrounded gravel & cobbles, medium to coarse angular sand, weak to moroderate lime cementation, non-plastic, pale gray-brown. note: contact below is approximately 2 feet higher on east side of pit
slightly moist	CLAYEY SAND, trave gravel, medium sand, stratified sandy clay & medium sand, weak lime cementation, some pinhole size holes in matrix, low plasticity, light olive brown.
slightly moist	SANDY GRAVEL & COBBLES, some boulders, predominately medium to coarse subrounded gravels, medium sand, weakly lime cemented, non-plastic, light gray-brown note: coarser gravel & cobbles below 14 feet. note: heavy limonite @ 16 feet.
slightly moist	MANCOS FORMATION: CLAYEY SHALE, Claystone, moderately weathered, moderately soft to soft, very thinly bedded, pale olive gray.

SAMPLE TYPE
B - Undistured Block Sample.
D - Disturbed Bulk Sample.

Sheet B-3
FMW 11/15/91

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

Page 1 of 2 PTL 10/16

UMTRA/GRJ 3885-34
Embankment Design/Riprap Toe Protection

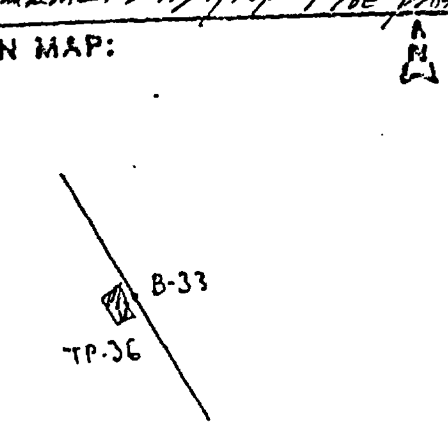
TEST PIT LOG

SITE ID: TP-36 LOCATION ID: B-33

APPROX. SITE COORDINATES (ft)
N ______ E ______

GROUND ELEV. (FT. MSL) ______
DATE EXCAVATED: 7/29/89
BACKHOLE TYPE: KOEHRING 666E
CONTRACTOR: ICC
FIELD REP: K. DONNELSON
REHAB. DATE: —

LOCATION MAP:



GROUNDWATER LEVELS			
DATE	TIME	DEPTH (ft)	EST. FLOW (GAL/MIN)
7/29/89	1140 hrs	23'	2±

LOCATION DESCRIPTION ______
SITE CONDITION ______

DEPTH (ft.)	SAMPLE INT	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
	X	D		CL	TOPSOIL: SANDY CLAY, tr f ang gravel, f sand, wk lime cem, med PI, Lt red brn. dry, some roots
	X	D		SC/CL	CLAYEY SAND - SANDY CLAY, consid silt, tr - some c rnd gravel, wk lime cem, med PI, Lt orange brn, moist
5	X	D		CL	
	X	D		CL	SILTY CLAY, consid silt, some - consid coarse blk ang basalt gravel, wk lime cem, low - med PI, Lt brn - pale yel brn, moist. Note: silt balls pale yel brn, calcareous, soft
10	X	D		SM/SC	
	X	D		CL	GRAVELLY CLAY, predom f subrnd gravel, some f sand, wk lime cem, med PI Lt brn, moist, some limonite & hematite & carbonate spotting, moist
	X	D			
15	X	P		CL	
	X	D			SILTY SAND, some clay, consid silt consid f subrnd - subang gravel, some c rnd gravel, wk lime cem, some carbonate spotting, low PI, Pale yel brn. Moist. tr cobbles.
20				GM	
	X	D			GRAVELLY CLAY, some cobbles & boulders, < 1' consid c & f subrounded gravel, mod-wk lime cem, some c sand, med PI Med brn moist
25	X	P		SP/GP	
29	X	D		MANCOS SH	CLAY, tr gravels, mod lime cem, med PI, Lt olive brn. moist, blocky, tr cobbles & gravel.

COMMENTS: ______

SAMPLE TYPE
B - Undisturbed Block Sample
D - Disturbed Bulk Sample

JEG-AL-ENG-7 (3/84)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

Sheet B-4
Fin 9/15/91 pre 1/92

UMTRA/GRJ 3885-34
Embankment Design/Riprap Toe Protection

TEST PIT LOG

Page 1 of 1

LOCATION MAP:

N

(J)

SITE ID: GRJ-03 LOCATION ID: TP-107
APPROX. SITE COORDINATES (ft)
N 10718 E 91971
GROUND ELEV. (FT. MSL) 5202
DATE EXCAVATED: 8-25-89
BACKHOLE TYPE: KOEHRING 666E
CONTRACTOR: ICC
FIELD REP: K. DONNELSON
REHAB. COMPLETE: (Y or N) ______

GROUNDWATER LEVELS			
DATE	TIME	DEPTH (ft)	EST. FLOW (GAL/MIN)
8-25-89	5:15pm	NONE	

LOCATION DESCRIPTION ______
SITE CONDITION ______

DEPTH (ft.)	SAMPLE INT	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
1–2	X	D		CL	TOPSOIL: SANDY CLAY, some gravel & cobbles, f sand, wk lime cem, low-med PI, lt orange brn, dry, roots.
2–4				GM/GC	SILTY & CLAYEY GRAVEL & COBBLES, f sand, m-c subrnd gravel & cobbles, few boulders, wk-mod lime cem, calichified, beige-pale brn dry, low PI-np.
4	X	D		GP	SANDY GRAVEL & COBBLES, some small boulders, f-m sand, predom m-c subrnd gravel & cobbles, wk lime cem, np, lt gray-tan, dry, trace gypsum
11–12	X	D		SM/SC/CL	SILTY & CLAYEY SAND & SANDY CLAY, fine sand, stratified, wk-mod lime cem, low PI, lt olive brn-tan slightly moist.
18	X	D		GC/GM	SILTY & CLAYEY GRAVEL, COBBLES & BOULDERS. Several boulders 2-3' diam, predom m-c subrnd gravel & cobbles, f-m sand, mod lime cem, low PI, lt olive brn-tan, dry
22	X	D		GM	SILTY GRAVEL, predom f subrnd gravel, strongly lime cem, np, lt gry, dry. Some silt & clay infilling. limonite & MnOx coating in voids
23	X	D		CL/CH	CLAY, tr-some f gravel, mod lime cem v. stiff, med-hi PI, moist, lt-mod olive brn to lt brn w/depth. some calcareous fragments, some pin-hole structure.
28		D		MANCOS SH	MANCOS SHALE: MUDSTONE: hi weath, mod soft-soft, v. thin bdd, fissile, pale yel brn & gry brn, slightly moist

STOPPED BACKHOE AT 28 FT

COMMENTS: ______

SAMPLE TYPE
B - Undisturbed Block Sample
D - Disturbed Bulk Sample

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

Sheet B-5
FHW 1/15/91 pke

UMTRA/GRJ 3485-34
Embankment Design/Riprap Toe Protection

TEST PIT LOG

Page 1 of 1

LOCATION MAP:

(c)

SITE ID: GRJ-03 LOCATION ID: TP-108
APPROX. SITE COORDINATES (ft)
N 11034 E 9/814
GROUND ELEV. (FT. MSL) 5201
DATE EXCAVATED: 8-28-89
BACKHOLE TYPE: KOEHRING 666E
CONTRACTOR: I.C.C.
FIELD REP: K. DONNELSON
REHAB. COMPLETE: (Y or N) ____

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft)	EST. FLOW (GAL/MIN)
8-28-89	9am	NONE	

LOCATION DESCRIPTION ____
SITE CONDITION ____

DEPTH (ft.)	SAMPLE INT	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
1	X	D		CL/SC	TOPSOIL: SANDY CLAY - CLAYEY SAND tr gravel, f sand, wk lime cem, low-med PI, Lt orange brn, dry, roots
2	X	D		CL	SANDY CLAY, some 2' diam boulders, f sand, wk-mod lime cem, mod PI, Lt brn, dry, roots
5	X	D		GP/SP	GRAVELLY SAND, consid f-m subang-subrnd gravel, some c gravel & cobbles, f-m sand, tr clay, mod gypsum cem, np, Lt brn, dry. Consid gypsum
8	X	D		GP	SANDY GRAVEL & COBBLES, f-m sand, predom m-c subrnd gravel, wk-mod cem, np, Lt gry brn, dry, consid-some gypsum, some f gravel, Note: Some cobbles & boulders from 9-11'
12	X	D		GP/CL	SANDY GRAVEL & CLAY, stratified, predom sandy gravel w/ interbeds of gray, med PI clay, f-m subrnd gravel, mod sand, some cobbles & boulders, mod lime cem w/ some strong local zones, np, Lt red orange, dry
15	X	D		CL	SANDY CLAY, tr gravel, f sand, mod lime cem, mod PI, Lt gry brn, moist, stiff. Note: changes to olive gray below 16'
17	X	D			
19	X	D		MANCOS SH	MANCOS SHALE: CLAYSTONE, mod wthrd, mod soft, thin bdd, Lt - pale olive gray, slightly moist, some limonite & black dendrites
21		STOPPED BACKHOE AT 20 FEET			

COMMENTS: ____

SAMPLE TYPE
B - Undisturbed Block Sample
D - Disturbed Bulk Sample

Sheet 8-6

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

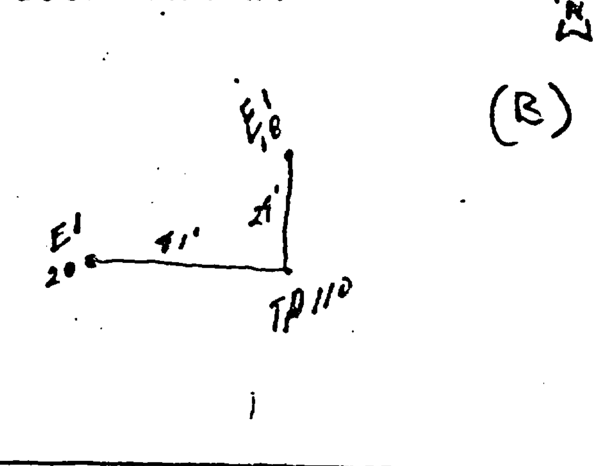
FHOS 11/15/91 BCL 12/13/

UMTRA/GRJ 3885-34
Embankment Design / Riprap Toe Protection

TEST PIT LOG

Page 1 of 1

LOCATION MAP:



SITE ID: GRT-03 LOCATION ID: TP 110
APPROX. SITE COORDINATES (ft)
N 11695 E 9182 7
GROUND ELEV. (FT. MSL) 5204
DATE EXCAVATED: 8-28-89
BACKHOLE TYPE: Cat 225
CONTRACTOR: ICC
FIELD REP: Mike Best
REHAB. COMPLETE: (Y or N) ____

GROUNDWATER LEVELS			
DATE	TIME	DEPTH (ft)	EST. FLOW (GAL/MIN)
8-29-89	8:00	26'	No Water

LOCATION DESCRIPTION ____
SITE CONDITION ____

DEPTH (ft.)	SAMPLE INT	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
1–2	X	D		SC/CL	Sandy Clays; fine sands some gravel -3" subrounded sulfates reddish orange med plastic moisture ± 4% some roots
3–9	X	D		GP/SM matrix	Gravels Poorly Graded; silty sand matrix med to low plastic little sulfates tan to brown max size -8" moisture ± 3% med density, gravels subrounded
10–19	X	D		GP/SC matrix	Gravels Poorly Graded; silty clay matrix med plastic, sulfates, some cementing weak, clay lumps, tan to brown max size -8" ± 6% moisture, med density, gravels subrounded, white gypsum Large boulders @ 18' ± 36" Dia
20–24	X	D		CL	Lean Clay; med plastic sulfates some crystals, olive green max size #4 ± 10% moisture, very stiff 8-28-89 end 5:30 pm
					Continued to excavate CL zone.
25–29	X			TD 26'	Mancos Shale; med to high plastic sulfates highly weathered, some sulfates, very fractured layered light grey in color

COMMENTS: Start @ 3:30 PM End 5:30 PM, Started 7:00 8-29-89 completed @ 8:00 AM

SAMPLE TYPE
B - Undisturbed Block Sample
D - Disturbed Bulk Sample

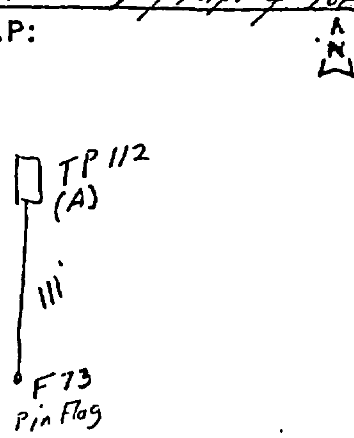
JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

Sheet B-7
FHW 1/15/91 [illegible]

UMTRA/GRJ 3885-34
Embankment Design / Riprap Toe protection

TEST PIT LOG

LOCATION MAP:



SITE ID: GRJ-03 LOCATION ID: TP112
APPROX. SITE COORDINATES (ft)
N ________ E ________
GROUND ELEV. (FT. MSL) ________
DATE EXCAVATED: 8-29-89 11:15
BACKHOLE TYPE: Cat 225 / Koehring 666
CONTRACTOR: Ice
FIELD REP: Mike Best
REHAB. COMPLETE: (Y or N) ______

GROUNDWATER LEVELS			
DATE	TIME	DEPTH (ft)	EST. FLOW (GAL/MIN)
8-30-89	9:30	21	No water
8-31-89	8:00	26	" "

LOCATION DESCRIPTION ________
SITE CONDITION ________

DEPTH (ft.)	SAMPLE INT	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS.	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
1	X	D		SC/SM	Topsoil: Sand Clay, some subrounded Gravels -6" size med to low plastic some sulfate strings med to low density redish brown, ~~w~~ root zones moisture ±4%
2–3	X	D		GM/SM matrix	
4–5, 10					Silty Gravel: Poorly Graded sub rounded gravels max size ±6" Some 30" Boulders, high sulfate content large crystals ±½" size crusts fine grained sand mix with silts, med-low plastic moisture ±4% tan to olive green with white crystals, med density
	X	D		GC	
15		8-29-89 / 8-30-89			Gravely Clay; CL, gravels subrounded maxsize ±13" med-high plastic, sulfate crystals in clay ± ½ size, some cementing of the gravels moisture ±6% tan to brown in color some white gypsum present, med density
	X	D		CL	
20	X	D		Mancos shale	Lean Clay; CL some sands fine grained maxsize 1" ± 5% of the sample, med to high plastic, sulfates & some white gypsum, brown ± 8% moisture, med density, stiff.
		TD = 26'			
25	X	D			Mancos Shale, Highly, Highly weathered tan to olivegreen, bedding plans showed in sample 1/16 + 1/8 in hole in sampler, med to high plastic sulfates ±8% moisture med to better density.
		finished @ 8:00		8-31-89	

COMMENTS: Ran out of Fuel @ 1:30 could not get more untill later this afternoon. Was told by Brad @ 2:30 that fuel would not be here untill 8-30-89 went home after talking to Ken & Don. Complete pit excavation at 9:35 AM 8-29-89

SAMPLE TYPE
B - Undisturbed Block Sample
D - Disturbed Bulk Sample

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

Sheet B-8
FHW 11/15/91

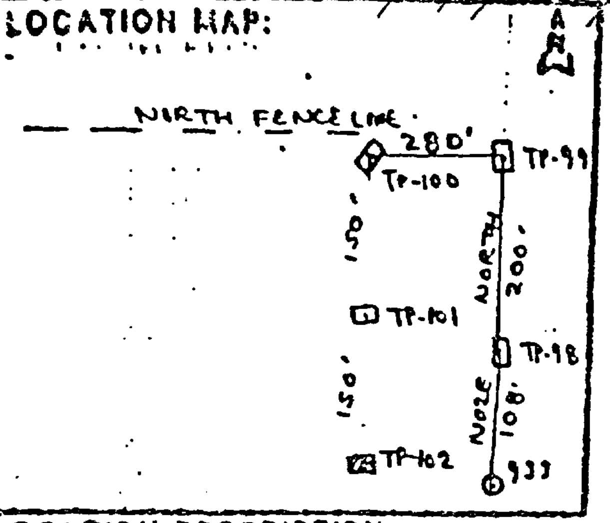
UMTRA/GRJ 3885-34
Embankment Design / Riprap Toe Protection

TEST PIT LOG

Page 1 of 1

pkc 12/12/91

LOCATION MAP:



SITE ID: TP-102 LOCATION ID:
APPROX. SITE COORDINATES (ft)
N 12678 E 92558
GROUND ELEV. (FT. MSL) 5028
DATE EXCAVATED: 8-29-89
BACKHOLE TYPE: KOEHRING 666E
CONTRACTOR: ICC
FIELD REP: K. DONNELSON
REHAB. DATE:

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft)	EST. FLOW (GAL/MIN)
8-29-89	11:55	NONE	

LOCATION DESCRIPTION
SITE CONDITION

DEPTH (ft.)	SAMPLE INT	SAMPLE TYPE	SAMPLE ID	UNIFIED SOIL CLASS	VISUAL CLASS.: DENSITY, COLOR, STRENGTH, PLASTICITY, CONDITION, ETC.
1	X	D		CL	TOPSOIL: SANDY CLAY, some gravel & cobbles, f sand, wk lime cem, low-med PI, lt orange brn, dry, roots
2–3	X	D		CL	
4–5					SILTY CLAY, some gravel, some f sand, wk-mod lime cem, med PI, beige-pale brn, calichified, dry.
6–7	X	D		CL/SC	
8	X	D			SANDY CLAY & CLAYEY SAND, some-consid f subang gravel, f-m sand, wk-mod lime cem, low-med PI, med brn - med olive brn, slightly moist, consid gypsum & wht carbonate spotting
9–10					
11	X	D		GM ①	
12–14				GM	SILTY GRAVEL, predom v.f subang gravel & v.c sand, some cobbles, wk cem, lt yel brn - lt brn, np, slightly moist.
15				GM	
16–17	X	D		GM	SILTY GRAVEL, COBBLES & BOULDERS, boulders < 20" diam, predom c subang gravel & cobbles, f-m sand, wk cem, np, dry, lt yel brn - brn gry.
18–19					SILTY GRAVEL, f-m sand, predom f-m subang gravel, mod lime cem, np, dry, lt brn gry.
20	X	D		MANCOS SH	SILTY GRAVEL, f-m sand, predom f-m subrnd - subang gravel, tr-some cobbles, strongly lime cem, np, dry, lt brn gry
21–24		STOPPED		BACKHOE AT 20 FT	MANCOS SHALE: CLAYSTONE, wk-mod wthd, mod soft, thin bdd, med gry brn, slightly moist

COMMENTS: ① ATYPICAL UNIT FROM 10-12'

SAMPLE TYPE
B - Undisturbed Block Sample
D - Disturbed Bulk Sample

MKES Doc. No.
3885-GRJ-C-01-05924-02

Calculation Cover Sheet

Calc. No. ~~05-505-02-01~~ 05-505-02-02

Contract No. 5025-16 Discipline GEOSCIENCES No. of Sheets ~~54~~ 60

Project

UMTRA - GRAND JUNCTION

Feature

CHENEY DISPOSAL SITE

Item

ROCK QUALITY FOR THE EROSION PROTECTION

Sources of Data / REFERENCES

1. RESULTS OF LARGE SCALE SIEVE TESTS, MKES DOC. NO. 5025-GRJ-R-09-03559-00
2. INTER OFFICE CORRESPONDENCE, "ROCK HAMMER TEST RESULTS, SELECTION TENSILE STRENGTH SAMPLES," MKES DOC. NO. 5025-GRJ-I-01-03762-00
3. RESULTS OF THE BRAZIL TEST, GRAIN SIZE ANALYSIS, MOISTURE DENSITY RELATIONSHIP, LIQUID AND PLASTIC LIMITS, AND PETROGRAPHIC EXAMINATION, MKES DOC. NO. 5025-GRJ-R-09-03[illegible]
4. "PERMANENT SITE DRAINAGE - OFF-PILE DRAINAGE SWALE," MKES CALC. NO. ~~05-504-07-02~~ 05-504-07-00 REV. 2
5. "EMBANKMENT DESIGN - RIPRAP TOE PROTECTION," MKES CALC. NO. 05-504-05-~~01~~ 02 REV. 2

Preliminary Calc. ☒ Final Calc. ☐ Supersedes Calc. No. ______

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
02	SWALE, TOE PROTECTION	H. LUBIS	5/17/91	J. Cercone	5/31/91	D Bolk	8-22-91
01	TO INCLUDE NEW FINAL GRADING, SWALE	H. LUBIS	1/10/91	P. Sircar	1/15/91	P. Sircar	2/1/91
00		H. LUBIS	1-16-90	J. CERCONE	1/31/90	P. Sircar	5/1/90

Form 42-110

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - GRJ	Contract No. 5025-16	Sheet i
Feature CHENEY DISPOSAL SITE	Designed H.L.	File No.
Item ROCK QUALITY FOR ERO. PRO.	Checked	Date 6-4-90
		Date

TABLE OF CONTENTS

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project: UMTRA – [illegible]	Contract No. [illegible]	Sheet [illegible]	File No.
Feature: [illegible]ENEY DISPOSAL SITE	Designed [illegible]	Date H. L	
Item: ROCK QUALITY FOR EROSION	Checked J. CERLONE	Date 1/30/90	

are summarized as follows:

1. The five preliminary rock quality scoring tests indicate 66.7 to [illegible] percents for all samples. Scoring based on all tests, indicate [illegible] to 83.1.

2. The rock are reasonably acceptable for occasionally saturated areas (top slopes and side slopes) with appropriate oversizing.

3. Petrographic examination indicates that most of the rock properties are satisfactory.

4. We recommend that the score of 65 percent be used for oversizing, since there is considerable variation in the rock sample selected for laboratory tests, and the presence of high percentage of -1" material in the samples.

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

Project UMTRA - GRJ | Contract No. 5025-16 | Sheet 4
Feature CHENEY DISPOSAL SITE | Designed H.L. | File No.
Item ROCK QUALITY | Checked J. CERCONE | Date 12/18/89 | Date 1/30/90

V. OVERSIZING

$(D_{50})_{MIN}$ should be oversizing based on hydraulic consideration. It should be increased by:

(80 - S) percent

where S = score of the rock in percent.

$$D_{50}, \text{after oversizing}_{MIN} = \left[(D_{50})_{MIN} \text{ based on RPRP/SFST} \right] \times \left[1 + \frac{(80-S)}{S} \right]$$

Based on the Laboratory Test Results, we recommended that the score of 65 be used. $(D_{50})_{MIN}$ after oversizing will be:

$$\left[(D_{50})_{MIN} \text{ based on RPRP/SFST} \right] \times \left[1 + \frac{(80-65)}{80} \right]$$

$$\left[(D_{50})_{MIN} \text{ based on RPRP/SFST} \right] \times 1.1875$$

Types of rocks and size range:

AREA (SEE MAP, APP. B)	DESCRIPTION	SIZE RANGE
A TOP SLOPE, ABOVE CLEAN-DIKE, BURIED RIPRAP OUTLET TOE APRON	Riprap Type A:	1" — 4"
B SIDESLOPE, SWALE BOTTOM	Riprap Type B:	4" — 9"
C SIDE SLOPE, OUTLET TOE REV.2	Riprap Type C:	5" — 11" REV.2
D APRON	Riprap Type D:	~~6" — 22"~~ 7.5" — 27"
E OUTLET TOE PROTECTION, BURIED RIPRAP WALL	Riprap Type E:	5" — 19"
F APRON	Riprap Type F:	10" — 34"

REV.1 HL 1/16/91 PS 1/16/91

REV.2 HL 5/17/91 JC 5/30/91

TABLE 5-2

ROCK QUALITY SCORING CRITERIA

	Weighting Factor			Score										
	Lime-stone	Sand-stone	Igne-ous	10	9	8	7	6	5	4	3	2	1	0
Specific Gravity	12	5	9	2.75	2.70	2.65	2.60	2.55	2.50	2.45	2.40	2.35	2.30	<2.3
Absorption (%)	13	5	2	0.1	0.3	0.5	0.67	0.83	1.0	1.5	2.0	2.5	3.0	>3.0
Sodium Sulfate (%)*	4	3	11	1	3	5	6.7	8.3	10	12.5	15	20	25	>25
Abrasion (%)**	1	8	1	1	3	5	6.7	8.3	10	12.5	15	20	25	>25
Schmidt Hammer	11	13	3	70	65	60	54	47	40	32	24	16	8	<8
Tensile Strength (psi)	5	4	10	1400	1200	1000	833	666	500	400	300	200	100	<100

R-4

1. Scores derived from Tables 6.2 and 6.7 of Ref. 5-19.

2. Any rock to be used must be qualitatively rated at least "fair" in a petrographic examination conducted by a geologist experienced in petrographic analysis.

3. Weighting Factors derived from Table 7 of Ref. 5-28, based on inverse of ranking of test methods for each rock type. Other tests may be used; weighting factors for these tests may be derived using Table 7. Typical compressive strength values are given in Table 5.4.

4. Test methods should be standardized (ASTM, e.g.) and should be those used in Ref. 5-28.

---

* 5 cycles
**100 revolutions

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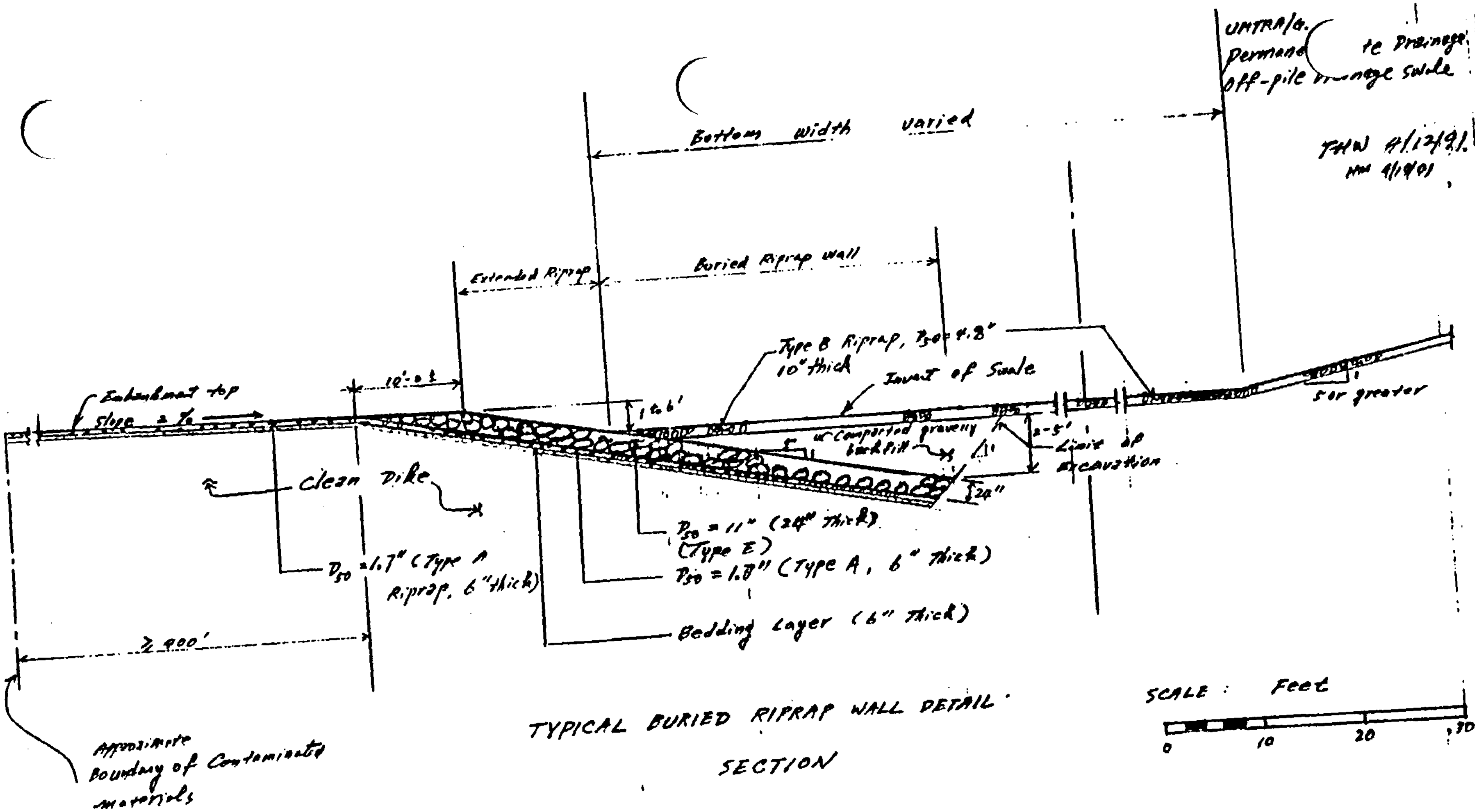
Project [illegible]	Contract No. [illegible]	Sheet	
Feature CHENEY DISPOSAL SITE	Designed H. L.	File No.	
Item ROCK QUALITY	Checked [illegible signature]	Date 110190	Date 1/28/90

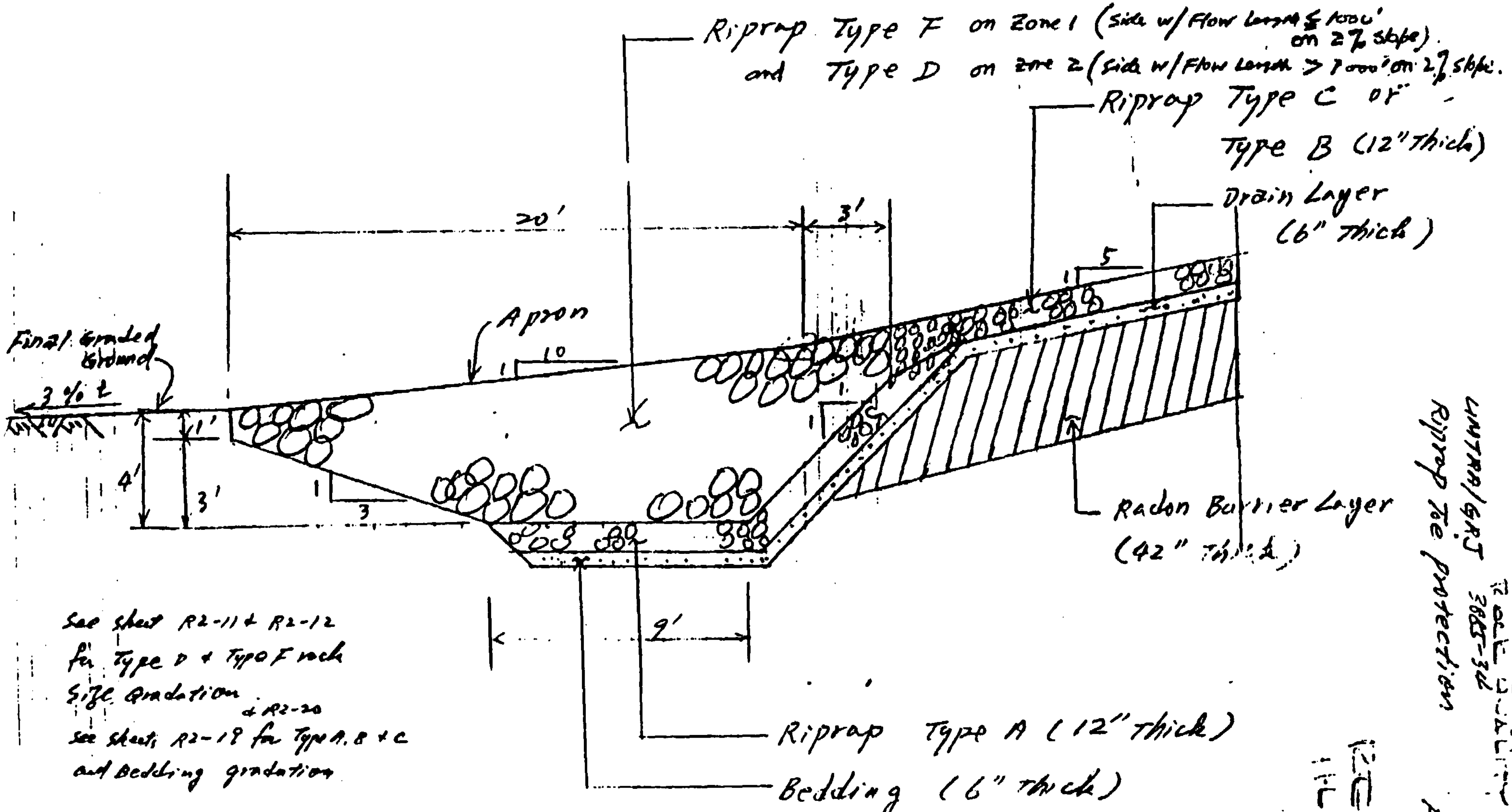
APPENDIX B

DATA BASE



TYPICAL BURIED RIPRAP WALL DETAIL

SECTION



RIPRAP TOE PROTECTION (TYPICAL)

UMTRA/GRJ 3865-36
Riprap Toe protection
Sheet R2-18
FHW 4/11/91
REV. 2
5/17/91

H.L. 1-19-90
JAE 1-31-90

MKE DOC. 5025-GRJ-R-09-03589-00

SAMPLE #1, Cheney Reservoir, LD #71177J
M.K. FERGUSON, P.O. #3050-511-10002

TOTAL DRY SAMPLE WEIGHT - 18,152 pounds
AVERAGE % MOISTURE..-1" - 3.47%

SAMPLE LOCATION T.P.#	DEPTH	SIEVE SIZE	% EACH SIEVE	% PASSING	DELETERIOUS MAT. % of TOTAL
70					
71					
72		18"	7.38	92.62	
73					
114		8"	7.33	82.29	
100					
101		6"	1.81	83.48	
102		5"	2.6	80.88	
		4"	4.12	71.76	0.16% Sedim. Rocks
		3"	4.56	72.2	0.32% Sedim. Rocks
		2	8	64.2	0.71% Sedim. Rocks
		1"	11.75	52.45	1.03% Sedim. Rocks
		3/4"		52.19	
		1/2"		49.67	
		3/8"		47.52	
		#4		43.53	
		#10		38.08	
		#20		34.51	
		#40		31.47	
		#100		24.23	
		#200		19.51	

2.58% Sulfate and clay lumps in the +1" material, included in the -1" sieve.

SIEVE SIZE	SPECIFIC GRAVITY Bulk	SSD	Appar.	ABSORP. %	SULFATE SOUND. % Loss	L.A. ABRASION % LOSS after 100 Rev	500 Rev
1"-3"	2.559	2.617	2.717	2.28%	3.48%	5.9%	26.1%
3"-8"	2.597	2.642	2.719	1.72%	2.84%	5.1%	21.8%
8"-18"	2.568	2.6	2.654	1.26%	1.91%	5.0%	23.9%

Notes:

ASTM C-88 SODIUM SULFATE SOUNDNESS Loss after 5 Cycles
ASTM C-131 LOS ANGELES ABRASION
ASTM C-127 AGGREGATE SPECIFIC GRAVITY & ABSORPTION

LINCOLN DeVORE ENGINEERS GEOLOGISTS | COLORADO: COLORADO SPRINGS GRAND JUNCTION, PUEBLO,

H L 1-19-90
JAC 1-31-90

SAMPLE #3, Cheney Reservoir, LD #71177J
M.K. FERGUSON, P.O. #3050-511-10002

SAMPLE LOCATION	
T.P.#	DEPTH
122	2.5'-7.0'
122	7'-12'
123	6'-10.5'
124	5'-15'
125	8'-12'
127	4'-9'
128	2'-7'
133	1.5-3.5'
133	3.5-11'

TOTAL DRY SAMPLE WEIGHT - 19656 pounds
AVERAGE % MOISTURE..-1" - 4.90%

SIEVE SIZE	% EACH SIEVE	% PASSING	DELETERIOUS MAT. % of TOTAL
18	4.93	95.07	
8"	2.00 6.38	88.69	0.13% Sedi. Rocks
6"	4.08	84.61	0.17% Sedi. Rocks
5"	2.11	82.5	0.08% Sedi. Rocks
4"	3.16	79.34	0.16% Sedi. Rocks
3	3.34	76	0.20% Sedi. Rocks
2"	7.16	68.84	0.38% Sedi. Rocks
1	8.46	60.37	0.47% Sedi. Rocks
3/4		59.46	
1/2"		57.59	
3/8"		55.06	
#4		51.44	
#10		46.12	
#20		41.66	
#40		35.15	
#100		29.4	
#200		23	

0.41% Sulfate and clay lumps in the +1" material, included in the -1" Sieve

SIEVE SIZE	SPECIFIC GRAVITY Bulk	SSD	Appar.	ABSORP. %	SULFATE SOUND. % Loss	L.A. ABRASION % LOSS after 100 Rev	500 Rev
1"-3"	2.612	2.665	2.757	2.01%	3.47	6.9%	27.1%
3"-8"	2.663	2.711	2.798	1.82%	2.34	5.9%	25.0%
8"-18	2.615	2.66	2.737	1.71%	2.52	5.8%	25.0%

Notes:

ASTM C-88 SODIUM SULFATE SOUNDNESS Loss after 5 Cycles
ASTM C-131 LOS ANGELES ABRASION
ASTM C-127 AGGREGATE SPECIFIC GRAVITY & ABSORPTION

LINCOLN DeVORE ENGINEERS GEOLOGISTS
COLORADO: COLORADO SPRINGS GRAND JUNCTION, PUEBLO,

1.13

F.L 1-19-90
JAC 1-31-90

SAMPLE #5, Cheney Reservoir, LD #71177J
M.K. FERGUSON, P.O. #3050-511-10002

TOTAL DRY SAMPLE WEIGHT - 21216 pounds
AVERAGE % MOISTURE..-1 - 4.35%

SAMPLE LOCATION T.P.#	DEPTH
133	3.5'-11'
133	15'-18'
132	10'-18'
131	11.5'-17'
134	2'-5'
134	5'-8'
135	21'-27'
135	9'-13'

SIEVE SIZE	% EACH SIEVE	% PASSING	DELETERIOUS MAT. % of TOTAL
18"	1.46	98.54	
	1.00		
8"	5.58	92.96	
6"	1.62	91.34	
5"	1.7	89.64	
4"	3.64	86	0.14% Sedi. Rocks
3	4.41	81.59	0.24% Sedi. Rocks
2	6.26	75.33	0.45% Sedi. Rocks
1"	10.53	64.8	0.91% Sedi. Rocks
3/4		62.86	
1/2		60.26	
3/8		57.48	
#4		53.2	
#10		47.17	
#20		41.99	
#40		35.96	
#100		22.67	
#200		16.85	

1.17% Sulfate and clay lumps in the +1" material, included in the -1" Sieve

SIEVE SIZE	SPECIFIC GRAVITY Bulk	SSD	Appar.	ABSORP. %	SULFATE SOUND. % Loss	L.A. ABRASION % LOSS after 100 Rev	500 Rev
1"-3"	2.558	2.628	2.752	2.77%	4.26	6.2%	25.9%
3"-8"	2.595	2.64	2.717	1.73%	2.66	5.3%	23.0%
8"-18	2.679	2.72	2.792	1.51%	2.08	4.5%	20.6%

Notes:
ASTM C-88 SODIUM SULFATE SOUNDNESS Loss after 5 Cycles
ASTM C-131 LOS ANGELES ABRASION
ASTM C-127 AGGREGATE SPECIFIC GRAVITY & ABSORPTION

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P. 15

H.L 1-19-90
JAC 1-21-90

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

DURABILITY TEST SCORE SHEET

Spec. 02278, Rev. 4, Part 2.B.4

PROJECT UMTRA - GRJ (5025-16 DATE 10/2/89

ROCK TYPE BASALT (95%) SS (5%) SAMPLE NO. 1 (1"-3")

Bedding = 65% or better
Type A Riprap = 50% or better
Type B,C,D Riprap = 75% or better

Test Performed	Lab Data	Raw Score	Weight (F)	Total Weighted	Maximum Value	Total (Max)
Bulk Specific Gravity	2.62	7.4	9	66.6	10x9	90
Absorption	2.28	2.4	2	4.9	10x2	20
Sodium Sulfate (5 Cycles)	3.48	8.8	11	96.8	10x11	110
Abrasion (100 Cycles)	5.90	7.5	1	7.5	10x1	10
Schmidt Hammer	53	6.9	3	20.7	[illegible]	[illegible]
Tensile Strength	[illegible]	7.3	10	[illegible]	[illegible]	[illegible]

Total (Max) 360

RATIO = Weighted Value / Total (Max) = 269.5 / 360 = 74.9 Score

PASS / FAIL

DESIGNED H.L. Date 12/13/89

CHECKED [signature] Date 12/20/89

Remarks

P. 17
H.L. 1-19-90
JAC-1-31-90

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DURABILITY TEST SCORE SHEET

Spec. 02278, Rev. 4, Part 2.B.4

PROJECT UMTRA - GRJ (5025-16) DATE 10/2/89

ROCK TYPE BASALT (95%+) SS (5%) SAMPLE NO. 1 (8" - 18")

Bedding = 65% or better
Type A Riprap = 50% or better
Type B,C,D Riprap = 75% or better

Test Performed	Lab Data	Raw Score	Weight (F)	Total Weighted	Maximum Value	Total (Max)
Bulk Specific Gravity	2.60	7.0	9	63.0	10x9	90
Absorption	1.26	4.5	2	9.0	10x2	20
Sodium Sulfate (5 Cycles)	N/A	-	11	-	10x11	110
Abrasion (100 Cycles)	5.0	8.0	1	8.0	10x1	10
Schmidt Hammer	53	6.9	3	20.7	10x3	30
Tensile Strength	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]

Total (Max) [illegible]

RATIO = Weighted Value / Total (Max) = [illegible] / 250 = 69.5 Score

PASS / FAIL

DESIGNED H. Lubis Date 12/13/89

CHECKED [signature] Date 12/20/89

Remarks

P. 19

H.L. 1-19-90
JAC 1-31-90

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DURABILITY TEST SCORE SHEET

Spec. 02278, Rev. 4, Part 2.B.4

PROJECT UMTRA - GRJ (5025-16) DATE 10/02/89

ROCK TYPE BASALT (95%+) SS (5%) SAMPLE NO. 2 (3"-8")

Bedding = 65% or better
Type A Riprap = 50% or better
Type B,C,D Riprap = 75% or better

Test Performed	Lab Data	Raw Score	Weight (F)	Total Weighted	Maximum Value	Total (Max)
Bulk Specific Gravity	2.65	8.0	9	72.0	10x9	90
Absorption	1.96	3.1	2	6.2	10x2	20
Sodium Sulfate (5 Cycles)	2.50	9.3	11	102.3	10x11	110
Abrasion (100 Cycles)	5.4	7.8	1	7.8	10x1	10
Schmidt Hammer	33	6.9	3	20.7	10x3	30
Tensile Strength	330	7.3	10	73	10x10	100

Total (Max) 360

RATIO = Weighted Value / Total (Max) = 282 / 360 = 78.3 Score

PASS / FAIL

DESIGNED H. LUBIS Date 12/13/89

CHECKED JA [signature] Date 12/20/89

Remarks

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H.L. 1-19-90
JAC 1-31-90

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Spec. 02278, Rev. 4, Part 2.B.4

PROJECT UMTRA GRJ (5025-16) DATE 10/02/89

ROCK TYPE BASALT (95%+) SS (5%) SAMPLE NO. 3 (1" to 3")

Bedding = 65% or better
Type A Riprap = 50% or better
Type B,C,D Riprap = 75% or better

Test Performed	Lab Data	Raw Score	Weight (F)	Total Weighted	Maximum Value	Total (Max)
Bulk Specific Gravity	2.67	8.4	9	75.6	10x9	90
Absorption	2.01	3	2	6	10x2	20
Sodium Sulfate (5 Cycles)	3.47	8.8	11	96.8	10x11	110
Abrasion (100 Cycles)	6.9	6.9	1	6.9	10x1	10
Schmidt Hammer	53	6.9	3	20.7	10x3	30
Tensile Strength	100	7.3	10	73	10x10	100

Total (Max) 360

RATIO = Weighted Value / Total (Max) = 279 / 360 = 77.5 Score

PASS / FAIL

DESIGNED H. LUBIS Date 12/13/89

CHECKED J. Accuno Date 12/20/89

Remarks

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DURABILITY TEST SCORE SHEET

Spec. 02278, Rev. 4, Part 2.B.4

PROJECT UMTRA - GRJ (5025-16) DATE 10/02/89

ROCK TYPE BASALT (95%+) SS (5%) SAMPLE NO. 3 (8" to 18")

Bedding = 65% or better
Type A Riprap = 50% or better
Type B,C,D Riprap = 75% or better

Test Performed	Lab Data	Raw Score	Weight (F)	Total Weighted	Maximum Value	Total (Max)
Bulk Specific Gravity	2.66	8.2	9	73.8	10x9	90
Absorption	1.71	3.6	2	7.2	10x2	20
Sodium Sulfate (5 Cycles)	2.52	9.2	11	101.2	10x11	110
Abrasion (100 Cycles)	5.8	7.5	1	7.5	10x1	10
Schmidt Hammer	52	[illegible]	3	29.7	[illegible]	[illegible]
Tensile Strength	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]

Total (Max) [illegible]

RATIO = Weighted Value / Total (Max) = [illegible] / 360 = [illegible] Score

PASS / FAIL

DESIGNED H. LUBIS Date 12/13/89

CHECKED [signature] Date 12/20/89

Remarks

7.25
H L 1-19-90
JAC 1-31-90

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A MORRISON KNUDSEN COMPANY

DURABILITY TEST SCORE SHEET

Spec. 02278, Rev. 4, Part 2.B.4

PROJECT UMTRA - GRJ (5025-16) DATE 10-02-89

ROCK TYPE BASALT (95%+) SS (5%) SAMPLE NO. 4 (3" to 8")

Bedding = 65% or better
Type A Riprap = 50% or better
Type B,C,D Riprap = 75% or better

Test Performed	Lab Data	Raw Score	Weight (F)	Total Weighted	Maximum Value	Total (Max)
Bulk Specific Gravity	2.59	6.8	9	61.2	10x9	90
Absorption	1.87	3.3	2	6.6	10x2	20
Sodium Sulfate (5 Cycles)	2.27	9.4	11	103.4	10x11	110
Abrasion (100 Cycles)	5.9	7.5	1	7.5	10x1	10
Schmidt Hammer	33	6.9	3	20.7	10x3	30
Tensile Strength	[illegible]		10	[illegible]	10x10	100

Total (Max) [illegible]

RATIO = Weighted Value / Total (Max) = [illegible] / 360 = [illegible] Score

PASS / FAIL

DESIGNED H. LUBIS Date 12/13/89

CHECKED [illegible] Date 12/20/89

Remarks

H.L. 1-19-90
JAC -1-31-90

MORRISON-KNUDSEN ENGINEERS, INC.
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DURABILITY TEST SCORE SHEET

Spec. 02278, Rev. 4, Part 2.B.4

PROJECT UMTRA - GRJ (5025-16) DATE 10/02/89

ROCK TYPE BASALT (95%+) SS (5%) SAMPLE NO. 5 (1" to 3")

Bedding = 65% or better
Type A Riprap = 50% or better
Type B,C,D Riprap = 75% or better

Test Performed	Lab Data	Raw Score	Weight (F)	Total Weighted	Maximum Value	Total (Max)
Bulk Specific Gravity	2.63	7.6	9	68.4	10x9	90
Absorption	2.77	1.5	2	3.0	10x2	20
Sodium Sulfate (5 Cycles)	4.26	8.4	11	92.4	10x11	110
Abrasion (100 Cycles)	6.2	7.3	1	7.3	10x1	10
Schmidt Hammer	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tensile Strength	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Total (Max) 360

RATIO = Weighted Value / Total (Max) = [illegible] / 360 = [illegible] Score

PASS / FAIL

DESIGNED H. LUBIS Date 12/13/89

CHECKED [illegible] Date 12/20/89

Remarks

H.L. 1-19-90
JAC 1-31-90

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON KNUDSEN COMPANY

DURABILITY TEST SCORE SHEET

Spec. 02278, Rev. 4, Part 2.B.4

PROJECT UMTRA - GRJ (5025-16) DATE 10/02/89

ROCK TYPE BASALT (95%+) SS (5%) SAMPLE NO. 5 (8" to 18")

Bedding = 65% or better
Type A Riprap = 50% or better
Type B,C,D Riprap = 75% or better

Test Performed	Lab Data	Raw Score	Weight (F)	Total Weighted	Maximum Value	Total (Max)
Bulk Specific Gravity	2.72	9.4	9	84.6	10x9	90
Absorption	1.51	4.0	2	8.0	10x9	20
Sodium Sulfate (5 Cycles)	2.08	9.5	11	104.5	10x11	110
Abrasion (100 Cycles)	4.5	8.3	1	8.3	10x1	10
Schmidt Hammer	57	6.9	3	20.7	10x3	30
Tensile Strength	850	7.3	10	73	10x10	100

Total (Max) 360

RATIO = Weighted Value / Total (Max) = 299.1 / 360 = 83.1 Score

PASS / FAIL

DESIGNED H. LUBIS Date 12/13/89

CHECKED J. R. Cinacore Date 12/20/89

Remarks

TABLE I
SCHMIDT HAMMER READINGS
(Continued)

o Sample S3:
- Lowest Reading : 40
- Highest Reading: 56
- Average : 52.8

Average Schmidt value for rock scoring: 53
Rock ~~Quality~~ Scoring Value: (6.9)

TABLE II
TENSILE STRENGTH VALUES

Sample No.	MPA	PSI
Sample S1-A	7.78	1,128
Sample S1-B	4.69	680
Sample S2-A	6.72	975
Sample S2-B	4.26	617
Sample S-3	6.88	998
		4,398 / 5

Average Tensile Strength Value for Rock Scoring: 880
Rock ~~Quality~~ Scoring Value: (7.3)
(Raw)

JAC/sww

H.L 1-19-90
JAC 1-31-90
MKE DOC. 5025-GRJ-L-09-03799-00

Lincoln DeVore, Inc.
Geotechnical Consultants
1441 Motor St.
Grand Junction, CO 81505
(303) 242-8968

DECEMBER 20, 1989

M. K. FERGUSON
P.O. Box 9136
Albuquerque, NM 87119

Re: LD Job #71177J
Cheney Reservoir Samples
BRAZIL TEST (New Samples)
Soil Proctors & Classifications

P.O. #3050-511-10002

Gentlemen;

Enclosed herewith are the results of INDIRECT TENSILE STRENGTH by the BRAZIL TEST, I.S.R.M. testing of samples selected by Mr. Jose Cercone, of M.K. Ferguson. These results supercede the results presented to M.K. Ferguson on November 22, 1989.

Also enclosed herewith are the results of GRAIN SIZE ANALYSIS,(ASTM D422), MOISTURE DENSITY RELATIONSHIP, (ASTM D698) & LIQUID AND PLASTIC LIMITS (ASTM D4318).

These tests were performed on portions of soil and rock samples from the Cheney Reservoir Disposal Site. These specimens were the subject of the Large-scale Sieve Analysis of this Purchase Order.

If any further information is required, please do not hesitate to contact this office.

Respectfully submitted,

Lincoln-DeVore, Inc

Edward M. Morris

Engineer/ Western Slope Manager

RECEIVED-MKE

UMTRA-S.F.

JAC-1-31-90

PROJECT: M. K. FERGUSON
SAMPLE: CHENEY RES. SAMPLE S-1-A
DATE: 12-20-89

I.S.R.M.
INDIRECT TENSILE STRENGTH by the BRAZIL TEST

SOURCE OF SAMPLE: Test Pits by M.K. Ferguson
STORAGE ENVIRONMENT: Open air for approx. 7 weeks
DATE OF SAMPLING: 9-6-89 DATE OF TESTING: 12-2-89
SAMPLE DESCRIPTION: Gray Black Basalt Boulder
Red, Yellow Stain. Vesicular, visually 2% to 5%

SAMPLE MOISTURE CONDITION: Air Dry
LOADING PLATENS/SAMPLE CONTACT: Masking Tape wrap on sample
Failure between 20 to 45 seconds
Equipment FORNEY model QC 150 DR

SPECIMEN	LENGTH	DIAMETER	WEIGHT	MOISTURE	LOAD	STRENGTH
1	1.073	2.025	131.71		2650	775.67
2	1.075	2.031	132.53		2400	699.12
3	1.029	2.032	127.49		2450	745.22
4	1.065	2.032	131.03		2050	602.47
5	1.061	2.03	131.28		2150	634.87
6	1.035	2.028	125.33		2100	[illegible].31
7	1.07	2.031	129.99		2050	599.95
8	1.069	2.034	133.18		2350	687.38
9	1.082	2.033	135.66		2150	621.63
10	1.059	2.032	130.19		2650	783.22

SPECIMENS 10. AVERAGE STRENGTH 678.58 psi

LINCOLN DeVORE ENGINEERS GEOLOGISTS
COLORADO: COLORADO SPRINGS
GRAND JUNCTION, PUEBLO,

H.L. 1-19-90
JAC 1-31-90

PROJECT: M. K. FERGUSON
SAMPLE: CHENEY RES. SAMPLE S-2-A
DATE: 12-20-89

I.S.R.M.
INDIRECT TENSILE STRENGTH by the BRAZIL TEST

SOURCE OF SAMPLE: Test Pits by M.K. Ferguson
STORAGE ENVIRONMENT: Open air for approx. 7 weeks
DATE OF SAMPLING: 9-8-89 DATE OF TESTING: 12-2-89
SAMPLE DESCRIPTION: Gray black Basalt Boulder
Medium to Large vesicles, visually 10% to 30%

SAMPLE MOISTURE CONDITION: Air Dry
LOADING PLATENS/SAMPLE CONTACT: Masking Tape wrap on sample
Failure between 20 to 45 seconds
Equipment FORNEY model QC 150 DR

SPECIMEN	LENGTH	DIAMETER	WEIGHT	MOISTURE	LOAD	STRENGTH
1	1.045	2.033	127.38		1900	568.8
2	1.035	2.03	127.97		2150	650.82
3	1.042	2.032	129.88		2400	720.9
4	1.066	2.036	132.07		1850	542.12
5	1.028	2.032	127.55		2150	654.6
6	1.055	2.035	131.88		2250	666.53
7	1.054	2.03	129.11		1750	520.19
8	1.025	2.028	126.18		1900	581.32
9	1.035	2.03	127.79		2150	650.82
10	1.038	2.029	128.17		2050	619.06

SPECIMENS 10. AVERAGE STRENGTH 617.52 psi

39
H.L. 1-14-9?
[illegible] 1-3?-9?

PROJECT Cheney Reservoir - Grand Junction

CLIENT M.K. Ferguson

SAMPLE LOCATION Test pile #1

SOIL TYPE Sample scalped on #4 sieve

TEST NO. 71177-1 #1

DATE 12-1-80

TEST BY DPW

TYPE TEST ASTM D-698-A

MAX. DRY DENSITY 114.3 pcf

OPTIMUM MOISTURE 15.8 %

FRACT. [illegible] #4

MOLD [illegible] .033 cu. ft.

SIEVE SIZE	% PASSING (Total sample)
1 1/2"	
1"	100
3/4"	97.5
1/2"	92.4
3/8"	89.0
4	81.4
10	71.4
20	62.6
40	59.4
100	48.0
200	36.0
.0200	
.005	

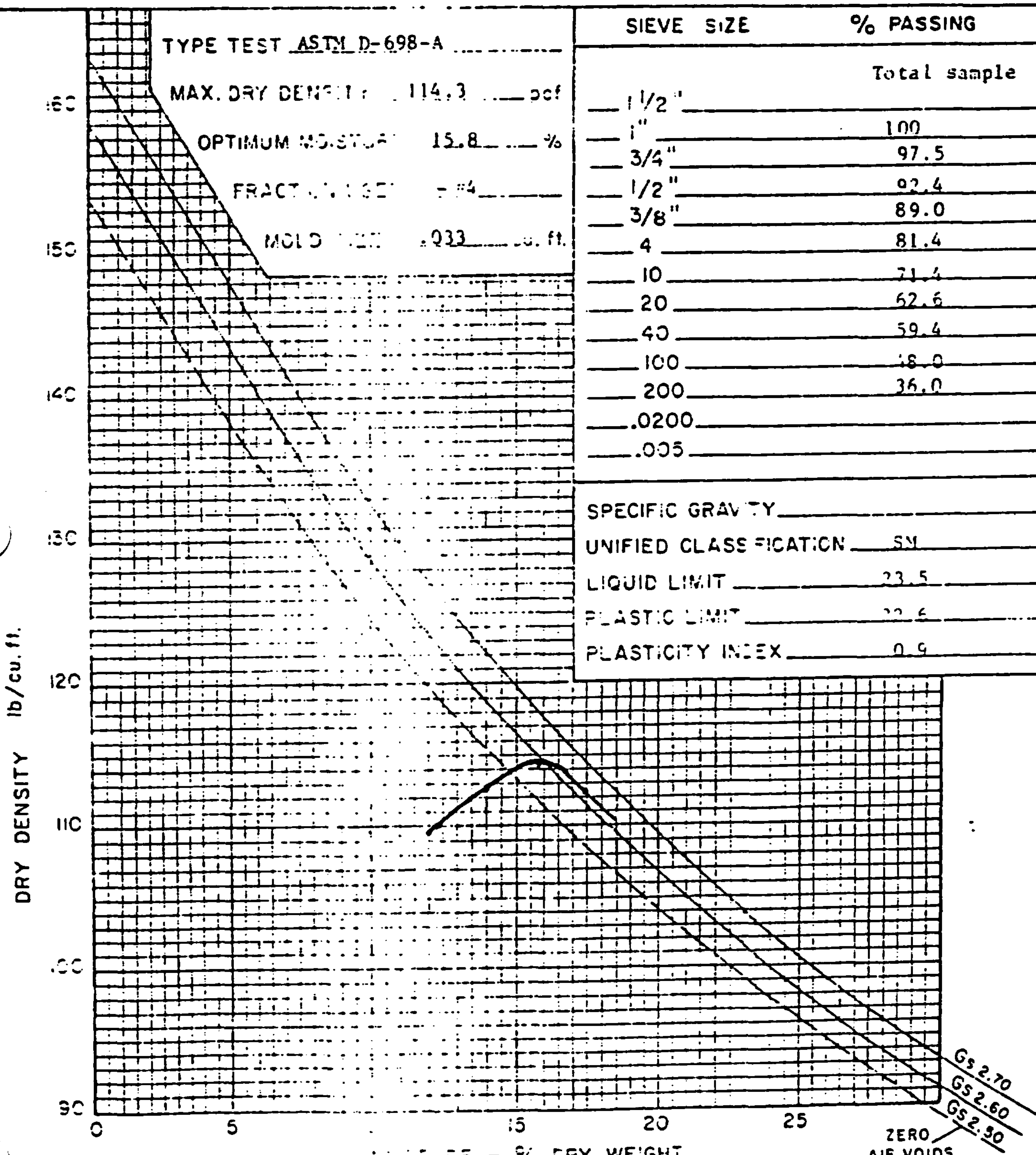
SPECIFIC GRAVITY

UNIFIED CLASSIFICATION SM

LIQUID LIMIT 23.5

PLASTIC LIMIT 22.6

PLASTICITY INDEX 0.9



MOISTURE — DENSITY RELATION

LINCOLN DeVORE ENGINEERS · GEOLOGISTS

COLORADO: COLORADO SPRINGS, GRAND JUNCTION, PUEBLO, GLENWOOD SPRINGS
WYOMING: EVANSTON

M-L-1-19-9

PROJECT Cheney Reservoir - Grand Junction	TEST NO. 71177-J #3
CLIENT M.K. Ferguson	DATE 12-1-89
SAMPLE LOCATION Test Pile #3	TEST BY DPW
SOIL TYPE Sample scalped on #4 sieve	

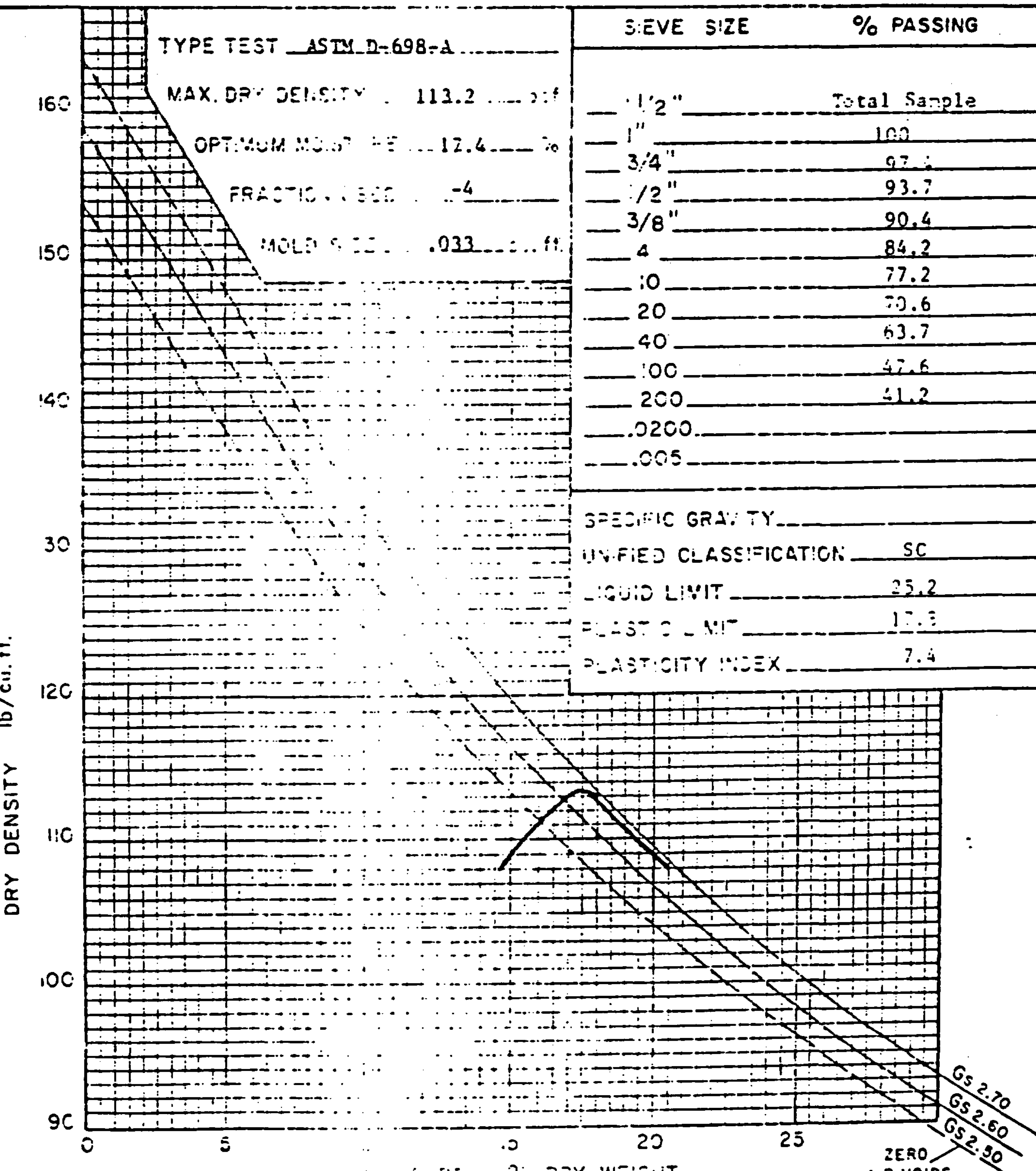
TYPE TEST ASTM D-698-A

MAX. DRY DENSITY 113.2 pcf

OPTIMUM MOISTURE 17.4 %

FRACTION USED -4

MOLD SIZE .033 cu. ft.



SIEVE SIZE	% PASSING
1 1/2"	Total Sample
1"	100
3/4"	97.[illegible]
1/2"	93.7
3/8"	90.4
4	84.2
10	77.2
20	70.6
40	63.7
100	47.6
200	41.2
.0200	
.005	

SPECIFIC GRAVITY

UNIFIED CLASSIFICATION SC

LIQUID LIMIT 25.2

PLASTIC LIMIT 17.8

PLASTICITY INDEX 7.4

MOISTURE — DENSITY RELATION

LINCOLN DeVORE ENGINEERS · GEOLOGISTS

COLORADO: COLORADO SPRINGS, GRAND JUNCTION, PUEBLO, GLENWOOD SPRINGS
WYOMING: EVANSTON

?·45 ?4
H·L. 1-19-90

PROJECT Cheney Reservoir - Grand Junction

CLIENT M.K. Ferguson

SAMPLE LOCATION Test Pile #5

SOIL TYPE Sample scalped on #4 sieve

TEST NO. [illegible]-I #5

DATE 12-1-89

TEST BY CMB

TYPE TEST ASTM-D-698-A

MAX. DRY DENSITY 117.3 pcf

OPTIMUM MOISTURE 14.6 %

FRACTION -4

MOLD 0.33 cu. ft.

SIEVE SIZE	% PASSING Total Sample
1½"	
1"	100
3/4"	97.2
1/2"	92.8
3/8"	83.9
4	81.0
10	72.0
20	64.[illegible]
40	56.5
100	36.7
200	29.3
.0200	
.005	

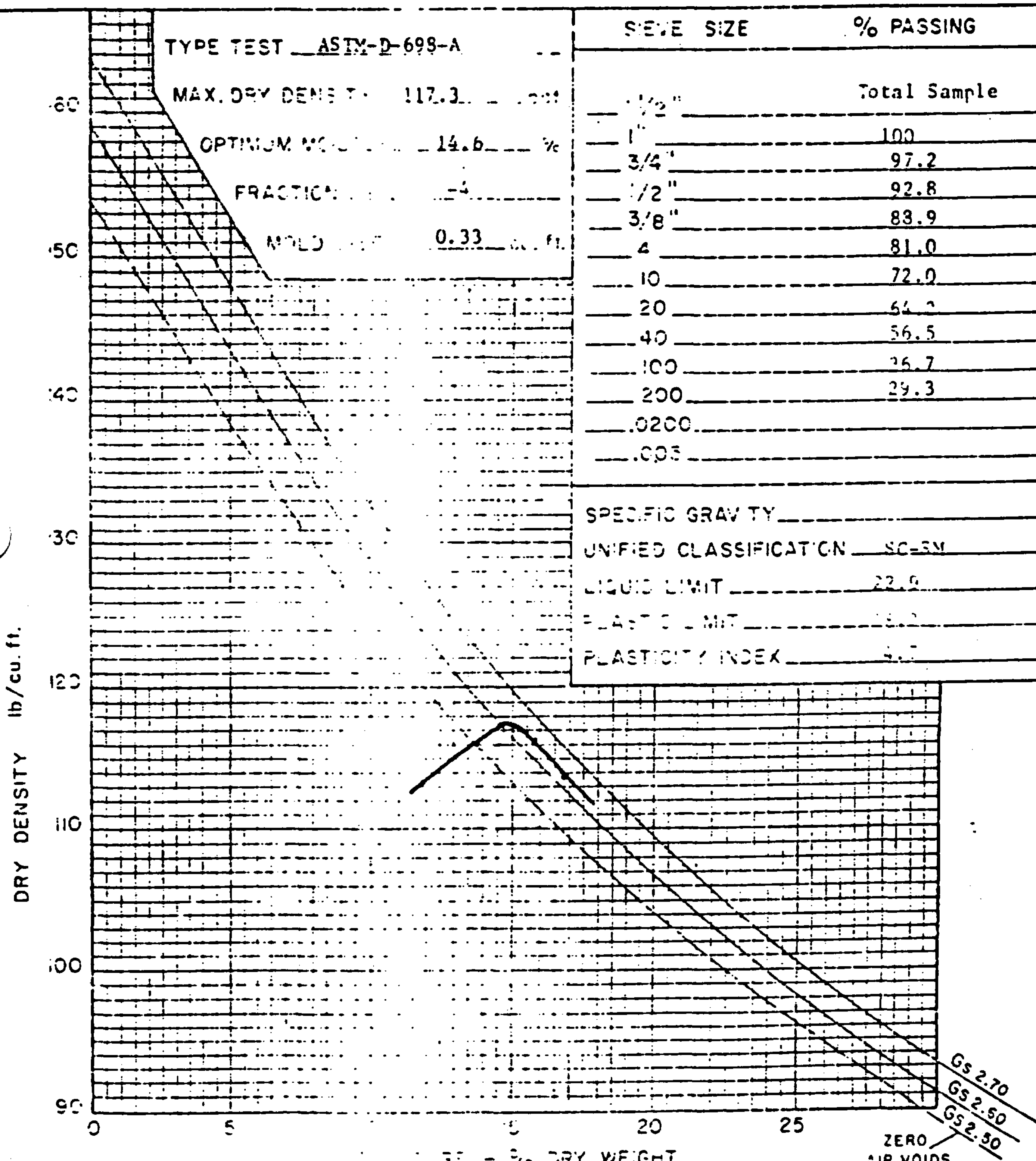
SPECIFIC GRAVITY

UNIFIED CLASSIFICATION SC-SM

LIQUID LIMIT 22.9

PLASTIC LIMIT [illegible]

PLASTICITY INDEX [illegible]



MOISTURE — DENSITY RELATION

LINCOLN DeVORE ENGINEERS · GEOLOGISTS

COLORADO: COLORADO SPRINGS, GRAND JUNCTION, PUEBLO, GLENWOOD SPRINGS
WYOMING: EVANSTON

1-19-90

PROJECT Cheney Reservoir - Grand Junction

CLIENT M.K. Ferguson

SAMPLE LOCATION Test Pile #2

SOIL TYPE Sample scalped on #4 sieve

TEST NO. 71177-1 #7

DATE 12-1-89

TEST BY DPW

TYPE TEST ASTM-D-689-C

MAX. DRY DENSITY 124.6 pcf

OPTIMUM MOISTURE 11.3 %

FRACTION [illegible] -3/4

MOLD SIZE .075 cu. ft.

SIEVE SIZE	% PASSING
1 1/2"	Total sample
1"	100
3/4"	99.2
1/2"	95.7
3/8"	92.5
4	85.4
10	73.6
20	65.8
40	59.5
100	43.8
200	28.3
.0200	
.005	

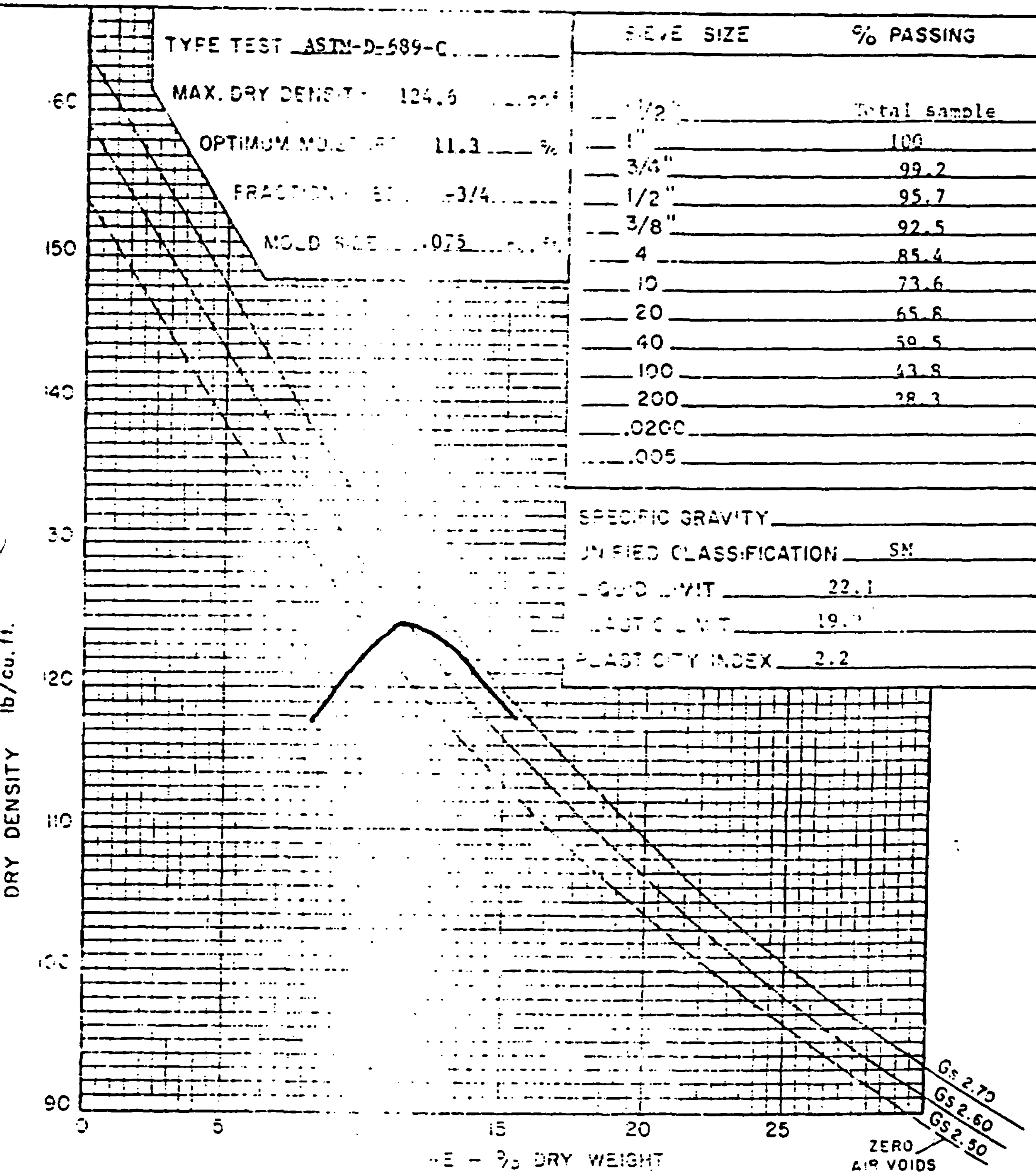
SPECIFIC GRAVITY

UNIFIED CLASSIFICATION SM

LIQUID LIMIT 22.1

PLASTIC LIMIT 19.[illegible]

PLASTICITY INDEX 2.2



MOISTURE — DENSITY RELATION

LINCOLN DeVORE ENGINEERS · GEOLOGISTS

COLORADO: COLORADO SPRINGS, GRAND JUNCTION, PUEBLO, GLENWOOD SPRINGS
WYOMING: EVANSTON

4.L 1-19-90

PROJECT Cheney Reservoir - Grand Junction

CLIENT M.K. Ferguson

SAMPLE LOCATION Test Pile #4

SOIL TYPE Sample scalped on #4 sieve

TEST NO. 71177-I

DATE 12-1-89

TEST BY CMP

TYPE TEST ASTM-D-698-C

MAX. DRY DENSITY 123.4

OPTIMUM MOIST. 11.4

FRACTION -3/4

MOLD SIZE .075 cu. ft.

SIEVE SIZE	% PASSING
	Total sample
1"	100
3/4"	99.1
1/2"	94.3
3/8"	89.5
4	77.7
10	64.9
20	55.6
40	49.7
100	34.1
200	24.9
.0200	
.005	

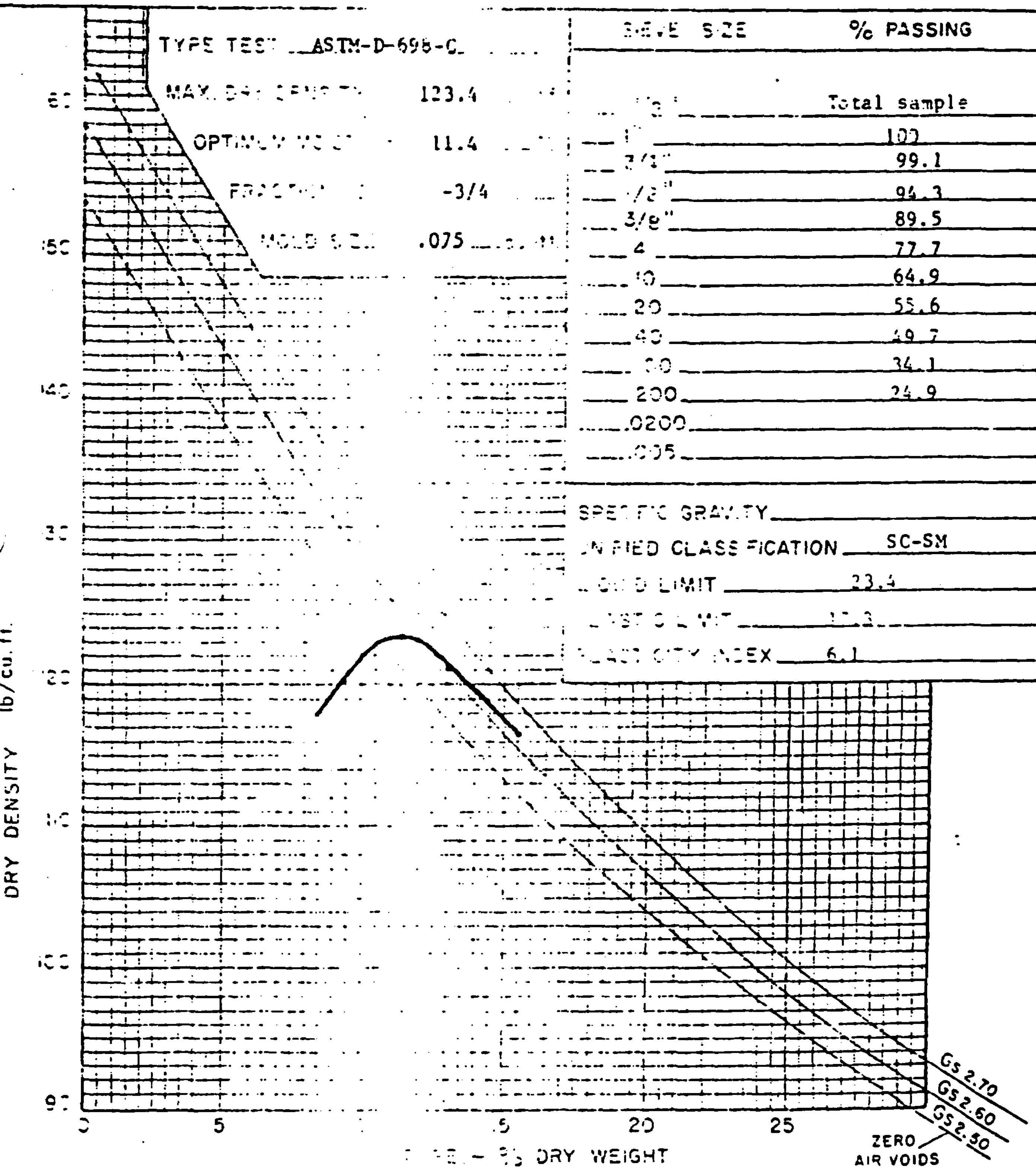
SPECIFIC GRAVITY

UNIFIED CLASSIFICATION SC-SM

LIQUID LIMIT 23.4

PLASTIC LIMIT 17.3

PLASTICITY INDEX 6.1



MOISTURE — DENSITY RELATION

LINCOLN DeVORE ENGINEERS · GEOLOGISTS

COLORADO: COLORADO SPRINGS, GRAND JUNCTION, PUEBLO, GLENWOOD SPRINGS
WYOMING: EVANSTON

P 50
H L. 1-19-90
JAe - 1-31-90

INTRODUCTION

Five 1 3/4" long by 2" diameter core samples of basalt were shipped to this laboratory for petrographic analysis. It is understood that the rock is to be used for riprap. The characteristics of the samples are requested for evaluation of the rocks' use as aggregate in concrete (ASTM-C295).

METHOD

One thin section was cut from each of the five specimens. The sections were studied microscopically according to the methods given in ASTM-C295 and L. Dolar-Mantuani, Handbook of Concrete Aggregates, 1983. Percentages are estimated.

RESULTS

Detailed descriptions of the basalts are given under PETROGRAPHIC DESCRIPTIONS at the end of this report.

1) Shape

Though there is some alignment of the plagioclase in S-3, there are no internal microscopic structures which will significantly affect the shape of particles crushed from the basalts - at least not on a small scale of millimeters to a foot.

The shape of particles resulting from crushing will be equant and satisfactory.

2) Roundness

Aggregate broken from the basalts shall be angular but, in some basalts, S-1 and S-1A, edges may tend to abraid if the aggregate is subjected to excessive handling. Roundness should be satisfactory in most cases.

3) Surface Texture

Surface of broken particles is rough and pitted. This will result in good cohesiveness between basalt and cement or basalt and asphalt. Surface texture is satisfactory.

4) Surface Coatings

Under the right circumstances ambient rock dust or soil may stick to some of the basalts such as S-1 and S-1A because of the voids in the rock.

H.L. 1-19-90
JAC 1-31-90

PETROGRAPHIC DESCRIPTIONS

71177, S-1; Porous Olivine Basalt.

Pheonocrysts(5%):		
5% Olivine	0.2-1.2mm	Lightly fractured euhedra. 60% altered to iddingsite from rims inward.
Voids(15%):		
	0.15-0.8mm	Principally as highly irregular cavities interstitial to groundmass crystals. Rarely as round large vesicles on order of 2-8mm in diameter.
Groundmass(80%):		
32% Plagioclase	0.05-0.4mm long	Fresh tabular crystals.
26% Augite	0.03-1.2mm	As small granules and as larger poikilitic prisms containing plagioclase crystals. Titaniferous.
19% Glass	-	Dark brown phase interstitial to crystalline phases.
3% Olivine	0.03-0.12mm	Sparse fresh granules occasionally with iddingsite alteration in core.
tr Hematite	<0.02mm	Deep red plates.
tr Opaques	<0.02mm	Grains scattered in glass. Magnetite and ilmenite(?).

The groundmass voids could be somewhat interconnected and permiability may be high for a basalt.

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H.L. 1-19-90
JAE 1-31-90

71177, S-2A; Olivine Basalt.

Phenocrysts(3%):		
3% Olivine	0.2-1.2mm	Fractured subhedra. Fresh.
Voids(2%):		
	0.04-0.5mm	Irregular rounded voids lined with darker brown glass. Some are filled with calcite.(See calcite in groundmass.)
Groundmass(95%):		
45% Plagioclase (Anorthite= 68%)	0.06-0.5mm long	Fresh unoriented tabular crystals intermixed with olivine and glass and as inclusions in poikilitic augite.
18% Augite	0.05-1.4mm	As equant poikilitic anhedra containing feldspar crystals. Ophitic texture.
14 Olivine	0.03-0.12mm	Equant anhedra dispersed in plagioclase/glass.
13% Glass	-	Light broan phase interstitial to plagioclase and olivine.
3% Opaque	0.01-0.5mm long	Plately mineral. Probably ilmenite.
2% Calcite	0.12mm	Radiate aggregates in 0.4-1mm irregular clusters (filling voids). Commonly Fe-stained.

71177, S-3; Lightly Argillized Olivine Basalt.

Phenocrysts(5%):		
5% Olivine	0.16-2.6mm	Lightly fractured euhedra. Some crystals up to 70% replaced by clay(smectite group). Replacement not uniform in crystals or rock.
Filled voids(5%):		
	0.05-0.4mm	Irregular patches interstitial to groundmass. Filled with orange(Fe-stained) clay (Same as that which replaces olivine). Rarely filled with anhedral calcite crystals. Also rare green clay-filled, 3mm, vesicles.
Groundmass(90%):		
54% Plagioclase	0.05-0.5mm long	Fresh ragged crystals partly intergrown with augite. Crudely aligned in a flow structure.
22% Augite	0.05-0.5mm	Interstitial(to clay) anhedra and elongate poikilitic crystals contain plagioclase.
9% Olivine	0.02-0.15mm	Rounded, scattered, predominately fresh subhedra.
4% Glass	-	Brown patches interstitial to plagioclase and ferromagnesian minerals.
1% Opaque	0.02-0.15mm	Ilmenite plates and equant grains.
tr Hematite	$<$0.01mm	Plates in glass and associated with pyroxene.