APPENDIX 3.4L

RECLAMATION HYDROLOGY STRUCTURES CALCULATIONS

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CASTLEGATE AREA PREPARATION PLANT

GENERAL ASSUMPTIONS FOR RECLAMATION CHANNEL DESIGN

1. MANNINGS n VALUE CALCULATED BASED ON THE FOLLOWING EQUATION:

$$n = 0.0395\ D_{50}^{(1/6)} \quad \text{(BARFIELD, et. al., 1981)}$$

2. FOR CHANNELS WITH MILD SLOPES (< 10%) OR Q_{MAX} < 10 CFS, RIPRAP SIZING IS BASED ON A METHOD DEVELOPED BY SEARCY (1978) FOR THE U.S. DEPARTMENT OF TRANSPORTATION. SEE ATTACHED FIGURES 3.4L-1 & 3.4L-2, RIPRAP THICKNESS IS CALCULATED AS $2.0 \times D_{50}$, PER BARFIELD ET AL. (1983).

3. DESIGN CAPACITY OF CHANNEL BASED ON THE 100-YEAR, 6-HOUR STORM AND THE MINIMUM CHANNEL SLOPE FOR AN INTERMITTENT STREAM CHANNEL, AND THE 10-YEAR, 6-HOUR STORM EVENT AND THE MINIMUM CHANNEL SLOPE FOR AN EPHEMERAL STREAM CHANNEL. REFERENCE (R645-301-742.323 AND 742.333)

4. DESIGN RIPRAP D_{50} (MAX. FLOW VELOCITY) BASED ON THE 100-YEAR, 6-HOUR STORM AND THE MAXIMUM CHANNEL SLOPE FOR AN INTERMITTENT STREAM CHANNEL, AND THE 10-YEAR, 6-HOUR STORM EVENT AND THE MAXIMUM CHANNEL SLOPE FOR AN EPHEMERAL STREAM CHANNEL. REFERENCE (R645-301-742.323 AND 742.333)

5) FOR RECLAMATION CHANNELS WITH STEEP SLOPES ($S \geq 10\%$), THE D50 RIPRAP WAS SIZED BASED ON A METHOD DEVELOPED BY SIMONS, LI & ASSOCIATES (1982) FOR DSM. THE THICKNESS OF THE RIPRAP IS SET AT $1.25 \times D_{50}$.

6) THE THICKNESS OF THE FILTER BLANKET IS SET AT 1/2 THE RIPRAP THICKNESS, BUT NO LESS THAN 6 INCHES (BARFIELD ET AL., 1983)

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CASTLE GATE PREP. PLANT AREA

RECLAMATION CHANNEL SUBWATERSHED AREAS

WATERSHED ID	AREA (AC)
CGRWS - U1	20.48
CGRWS - U2	5.96
CGRWS - U3	50.68
CGRWS - U4	9.18
CGRWS - U5	83.32
CGRWS - U6	174.58
CGRWS - U7	1054.58
CGRWS - U8	4.04
CGRWS - U9	29.38
CGRWS - U10	3.95
CGRWS - R1	7.05
CGRWS - R2	21.89
CGRWS - R3	11.58
CGRWS - R4	1.56
TOTAL UNDISTURBED AREA	1436.15
TOTAL RECLAIMED AREA	42.08
ENTIRE WATERSHED AREA	1478.23

* NOTES:
CGRWS — CASTLEGATE WATERSHED
CGRWS-U1 — UNDISTURBED AREA NO. 1
CGRWS-R1 — RECLAIMED AREA NO. 1
SEE APPENDIX 3.4J FOR CGRWS-U5 SUBWATERSHEDS.
SEE EXHIBITS 3.4-3, 3.4-8 FOR WATERSHED BOUNDARIES.

DETERMINE AVERAGE WATERSHED SLOPES:

$$WS = 0.25\,(EM - EN)(LC_{25} + LC_{50} + LC_{75}) / AREA.$$

EM = MAX. ELEV.
EN = MIN. ELEV.
LC = CONTOUR LENGTH @ 25, 50 + 75 % OF EM-EN
WS = WATERSHED SLOPE

WATERSHED	EM	EN	LC_{25}	LC_{50}	LC_{75}	AREA (AC)	WS (%)
CGRWS-U1	7200'	6086'	800'	700'	425'	20.48	60.0
CGRWS-U2	6635'	6070	350'	200'	140'	5.96	37.5
CGRWS-U3	7700'	6100'	1500'	1250'	1000'	50.68	67.9
CGRWS-U4	6690'	6152	600'	500'	200'	9.18	43.9
CGRWS-U5	7740'	6194'	3375'	1650	1000'	83.32	64.2
CGRWS-U6	8170'	6550'	3375'	4000'	3825	174.82	59.6
CGRWS-U7	8455'	6140'	12375'	18000'	14650'	1054.58	56.8
CGRWS-U8	6500'	6200'	400'	400'	300'	4.04	46.9
CGRWS-U9	7350'	6170'	1200'	900'	900'	29.38	69.2
CGRWS-U10	6370'	6150'	600'	450'	350'	3.95	44.8
CGRWS-R1	6150'	6086'	800'	1050'	1000'	7.05	14.8
CGRWS-R2	6500'	6110'	1150'	750'	400'	21.89	23.5
CGRWS-R3	6230'	6144'	600'	550'	100'	11.58	5.3
CGRWS-R4	6230'	6100'	250'	150'	50'	1.56	21.5

REF = CHANG, M., S.P. WATTERS AND A.K. SAYOK, 1989. A COMPARISON OF METHODS OF ESTIMATING MEAN WATERSHED SLOPE. WATER RESOURCES BULLETIN. VOL 25, NO. 2.

CURVE NUMBERS.

- CURVE NUMBERS TAKEN FROM EARTHFAX REPORT "HYDROLOGIC CALCULATIONS FOR THE CASTLE GATE AREA", FEBRUARY 22, 1991 FOR UNDISTURBED AREAS.
- CURVE NUMBERS ASSUMED TO EQUAL 80 FOR ALL RECLAIMED AREAS.

WATERSHED	CURVE NUMBER
CGRWS- U1	78
CGRWS- U2	78
CGRWS- U3	78
CGRWS- U4	78
CGRWS- U5	80
CGRWS- U6	75
CGRWS- U7	75
CGRWS- U8	75
CGRWS- U9	75
CGRWS- U10	78
CGRWS- R1	80
CGRWS- R2	80
CGRWS- R3	80
CGRWS- R4	80

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CASTLEGATE COAL COMPANY.
PREP. PLANT AREA - FINAL RECLAMATION PLAN
WATERSHED CHARACTERISTICS.

WATERSHED I.D.	HYDRAULIC LENGTH (FT.)	CURVE NUMBER (CN)	SLOPE (%)	AREA (AC)	LAG TIME (HR)	TIME OF CONCENTRATION (HR)
CGRWS-U1	1750	78	60.0	20.48	0.068	0.114
CGRWS-U2	1100	78	37.5	5.96	0.059	0.099
CGRWS-U3	3500	78	67.9	50.68	0.111	0.186
CGRWS-U4	800	78	43.9	9.18	0.043	0.072
CGRWS-U5	5100	80	64.2	83.32	0.146	0.243
CGRWS-U6	6250	75	59.6	174.58	0.207	0.346
CGRWS-U7	14500	75	56.8	1054.58	0.416	0.694
CGRWS-U8	900	75	46.9	4.04	0.050	0.083
CGRWS-U9	1500	75	69.2	29.38	0.061	0.102
CGRWS-U10	500	78	44.8	3.95	0.029	0.048
CGRWS-R1	350	80	14.8	7.05	0.036	0.060
CGRWS-R2	900	80	23.5	21.89	0.060	0.100
CGRWS-R3	1400	80	5.3	11.58	0.180	0.301
CGRWS-R4	200	80	21.5	1.56	0.019	0.031

CASTLE GATE AREA

PREP. PLANT RECLAMATION

PEAK DISCHARGE VALUES

100 -YR, 6-HR STORM EVENT = 2.1 INCHES
10 - YR, 6 - HR STORM EVENT = 1.4 INCHES
SCS TYPE II DISTRIBUTION

WATERSHED	CN	AREA (AC.)	TIME OF CONC (HR)	Q (a) 100-6 (CFS)	Q (b) 10-6 (CFS)
CGRWS-U1	78	20.48	0.114	—	2.70
CGRWS-U2	78	5.96	0.099	2.92	—
CGRWS-U3	78	50.68	0.186	—	5.62
CGRWS-U4	78	9.18	0.072	—	1.35
CGRWS-U5	80	83.32	0.243	40.2	—
CGRWS-U6	75	174.58	0.346	—	7.56
CGRWS-U7	75	1054.58	0.694	179.78	—
CGRWS-U8	75	4.04	0.083	1.54	—
CGRWS-U9	75	29.38	0.102	10.82	—
CGRWS-U10	75	3.95	0.048	1.60	—
CGRWS-R1	80	7.05	0.060	4.24	—
CGRWS-R2	80	21.89	0.100	12.59	—
CGRWS-R3	80	11.58	0.301	5.18	—
CGRWS-R4	80	1.56	0.031	—	0.35

(a) DISCHARGE BASED ON INTERMITTENT STREAM CHANNEL

(b) DISCHARGE BASED ON EPHEMERAL STREAM CHANNEL.

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGRWS-U1

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 20.48 acres
Depth = 1.40 inches	CN = 78.00
Duration = 6.00 hrs	Time conc.= 0.114 hrs

OUTPUT SUMMARY

Runoff depth	0.19110	inches	
Initial abstr	0.56410	inches	
Peak flow =	2.70	cfs	(0.13087 iph)
at time	2.538	hrs	

INPUT FOR: CGRWS-U2

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 5.96 acres
Depth = 2.10 inches	CN = 78.00
Duration = 6.00 hrs	Time conc.= 0.099 hrs

OUTPUT SUMMARY

Runoff depth	0.54150	inches	
Initial abstr	0.56410	inches	
Peak flow =	2.92	cfs	(0.48565 iph)
at time	2.521	hrs	

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGRWS-U3

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 50.68 acres
Depth = 1.40 inches	CN = 78.00
Duration = 6.00 hrs	Time conc.= 0.186 hrs

OUTPUT SUMMARY

Runoff depth	0.19110	inches	
Initial abstr	0.56410	inches	
Peak flow =	5.62	cfs	(0.11007 iph)
at time	2.604	hrs	

INPUT FOR: CGRWS-U4

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 9.18 acres
Depth = 1.40 inches	CN = 78.00
Duration = 6.00 hrs	Time conc.= 0.072 hrs

OUTPUT SUMMARY

Runoff depth	0.19110	inches	
Initial abstr	0.56410	inches	
Peak flow =	1.35	cfs	(0.14565 iph)
at time	2.515	hrs	

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGRWS-U5

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 83.32 acres
Depth = 2.10 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.243 hrs

OUTPUT SUMMARY

Runoff depth	0.62439	inches		
Initial abstr	0.50000	inches		
Peak flow =	40.20	cfs	(0.47851	iph)
at time	2.592	hrs		

INPUT FOR: CGRWS-U6

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 174.58 acres
Depth = 1.40 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.346 hrs

OUTPUT SUMMARY

Runoff depth	0.13224	inches		
Initial abstr	0.66667	inches		
Peak flow =	7.56	cfs	(0.04293	iph)
at time	3.598	hrs		

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGRWS-U7

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 1054.58 acres
Depth = 2.10 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.694 hrs

OUTPUT SUMMARY

Runoff depth	0.43100	inches	
Initial abstr	0.66667	inches	
Peak flow =	179.78	cfs	(0.16906 iph)
at time	3.146	hrs	

INPUT FOR: CGRWS-U8

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 4.04 acres
Depth = 2.10 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.083 hrs

OUTPUT SUMMARY

Runoff depth	0.43100	inches	
Initial abstr	0.66667	inches	
Peak flow =	1.54	cfs	(0.37714 iph)
at time	2.512	hrs	

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGRWS-U9

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 29.38 acres
Depth = 2.10 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.102 hrs

OUTPUT SUMMARY

Runoff depth	0.43100	inches	
Initial abstr	0.66667	inches	
Peak flow =	10.82	cfs	(0.36535 iph)
at time	2.530	hrs	

INPUT FOR: CGRWS-U10

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 3.95 acres
Depth = 2.10 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.048 hrs

OUTPUT SUMMARY

Runoff depth	0.43100	inches	
Initial abstr	0.66667	inches	
Peak flow =	1.60	cfs	(0.40080 iph)
at time	2.509	hrs	

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGRWS-R1

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 7.05 acres
Depth = 2.10 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.060 hrs

OUTPUT SUMMARY

Runoff depth	0.62439	inches		
Initial abstr	0.50000	inches		
Peak flow =	4.24	cfs	(0.59712	iph)
at time	2.512	hrs		

INPUT FOR: CGRWS-R2

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 21.89 acres
Depth = 2.10 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.100 hrs

OUTPUT SUMMARY

Runoff depth	0.62439	inches		
Initial abstr	0.50000	inches		
Peak flow =	12.59	cfs	(0.57062	iph)
at time	2.520	hrs		

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGRWS-R3

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 11.58 acres
Depth = 2.10 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.301 hrs

OUTPUT SUMMARY

Runoff depth	0.62439	inches	
Initial abstr	0.50000	inches	
Peak flow =	5.18	cfs	(0.44321 iph)
at time	2.649	hrs	

INPUT FOR: CGRWS-R4

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 1.56 acres
Depth = 1.40 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.031 hrs

OUTPUT SUMMARY

Runoff depth	0.23824	inches	
Initial abstr	0.50000	inches	
Peak flow =	0.35	cfs	(0.21938 iph)
at time	2.505	hrs	

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TABLE 3.4-12

CASTLE GATE PREPARATION PLANT AREA RECLAMATION CHANNEL DISCHARGE SUMMARY

DIVERSION DITCH	CONTRIBUTORY WATERSHED	TOTAL DRAINAGE AREA (Acres)	DESIGN DISCHARGE (cfs)
CGRD-1	CGRWS-U1	20.48	2.70
CGRD-2	CGRWS-U3	50.68	5.62
CGRD-3b	CGRWS-U4,U5	92.5	41.55
CGRD-3c	CGRWS-U4,U5,R4	94.06	41.90
~~CGRD-4~~	~~CGRWS-U6~~	~~174.58~~	~~7.56~~
CGRD-5	CGRWS-U6,U7	1229.16	222.90
CGRD-6	CGRWS-U6,U7	1229.16	222.90
CGRD-10	CGRWS-U9.R3	40.96	3.43

Note: See Table ~~3.4-~~ 3A-20 for information on diversion ditches 3a, 7, 8 and 9.
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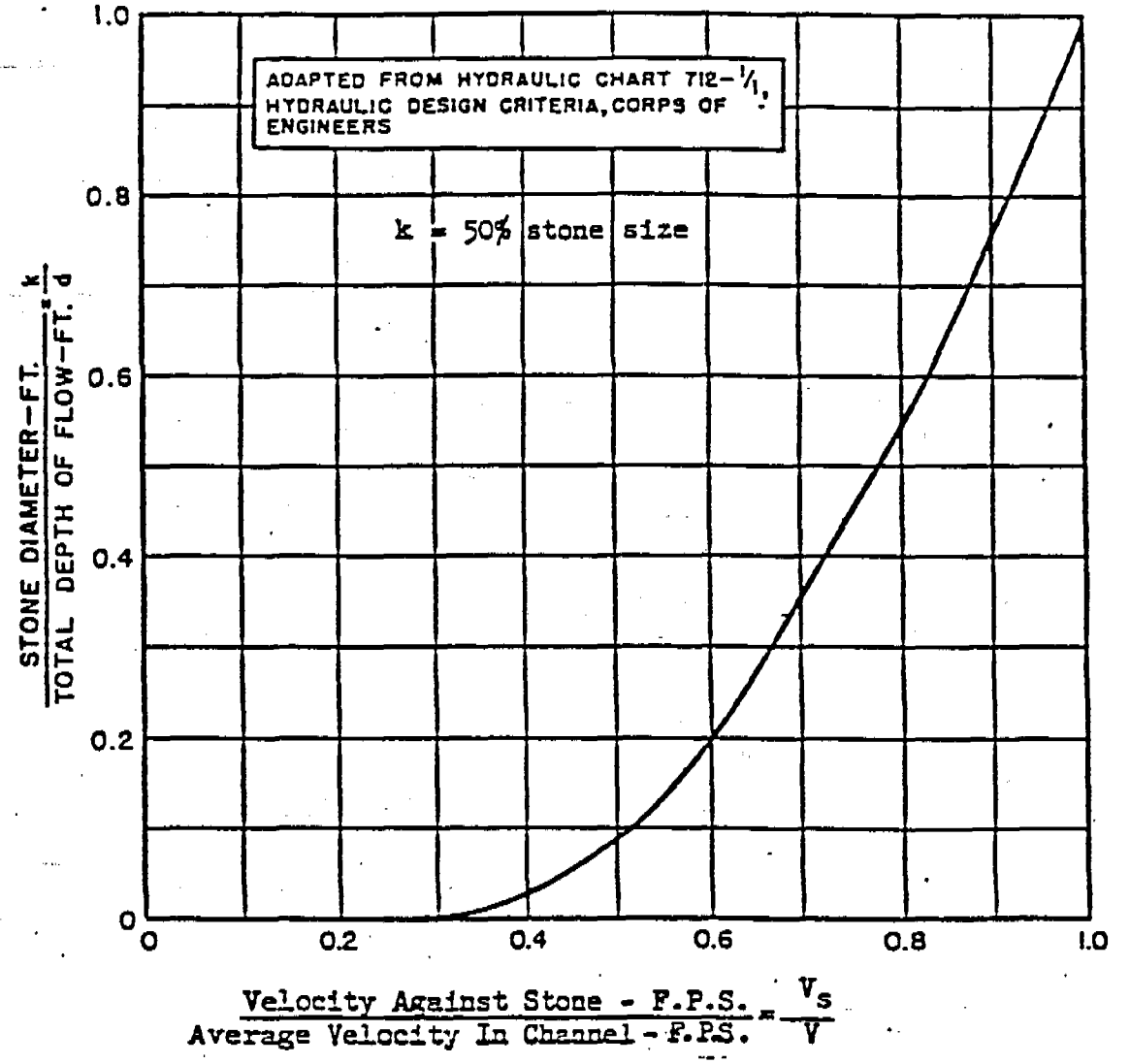
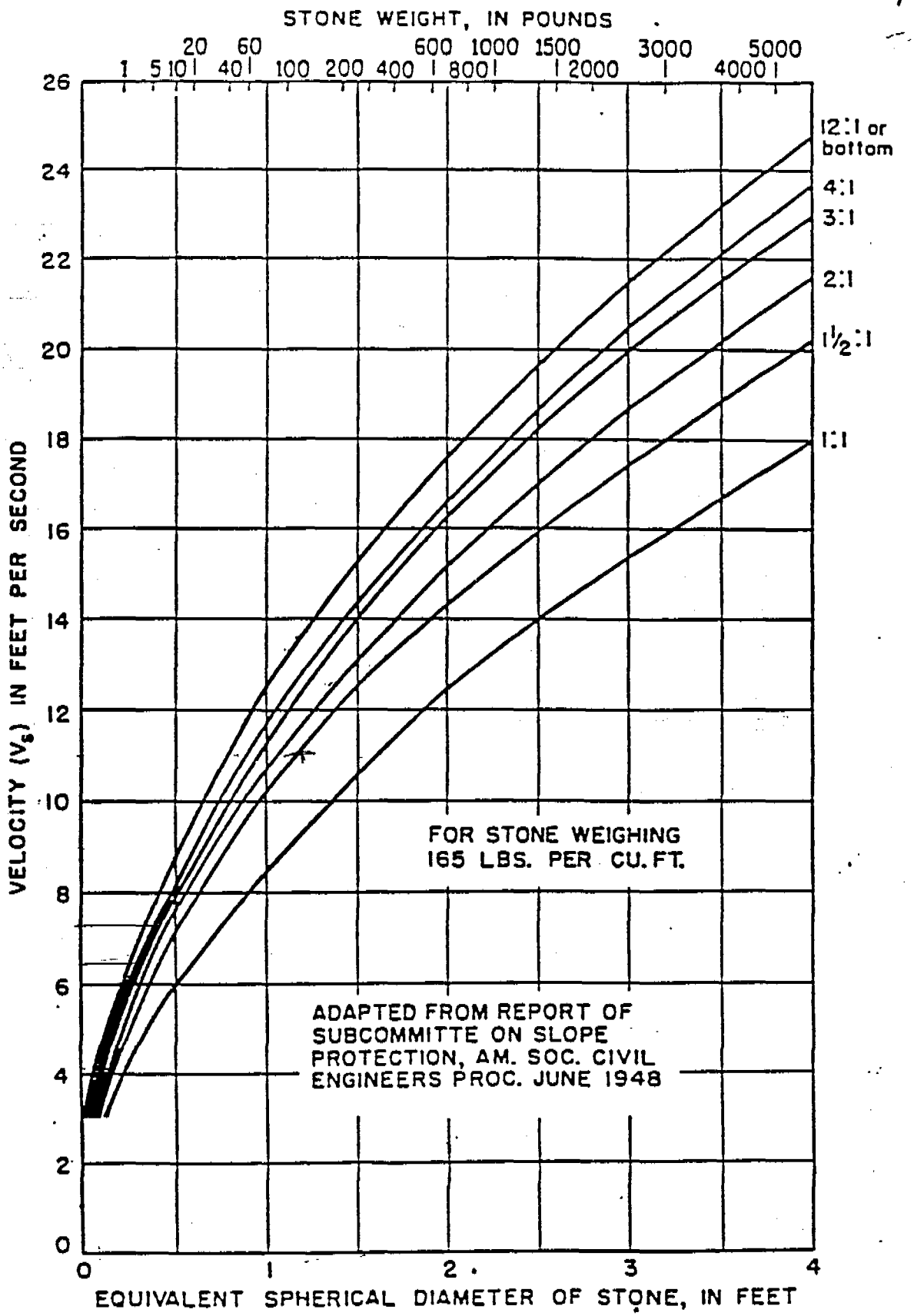
FIGURE 3.4L-1



Velocity Against Stone on Channel Bottom (U.S. Department of Transportation, 1978).

FIGURE 3.4L-2



Size of Stone that will Resist Displacement for Various Velocities and Side Slopes (U.S. Department of Transportation, 1978).

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLSGATE AREA

Comment: CGRD-1

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.2700 ft/ft
Discharge.....	2.70 cfs

MAX. CHANNEL SLOPE.

Computed Results:

Depth.....	0.14 ft
Velocity.....	5.52 fps
Flow Area.....	0.49 sf
Flow Top Width...	3.86 ft
Wetted Perimeter.	3.90 ft
Critical Depth...	0.27 ft
Critical Slope...	0.0303 ft/ft
Froude Number....	2.73 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLSGATE AREA

Comment: CGRD-1

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.1100 ft/ft ← MIN CHANNEL SLOPE.
Discharge.....	2.70 cfs

Computed Results:

Depth.....	0.18 ft
Velocity.....	4.11 fps
Flow Area.....	0.66 sf
Flow Top Width...	4.11 ft
Wetted Perimeter.	4.17 ft
Critical Depth...	0.27 ft
Critical Slope...	0.0303 ft/ft
Froude Number....	1.81 (flow is Supercritical)

CGRD-1 (MINIMUM CHANNEL + RIPRAP SIZING)

D = 0.18 FT. (BASED ON MINIMUM CHANNEL SLOPE)
V = 5.52 FPS. (BASED ON MAXIMUM CHANNEL SLOPE, D=0.14 FT)
Q_{MAX} = 2.7 CFS, SO USE SEARCY METHOD TO DESIGN RIPRAP.

ASSUME: $K = 0.25'$ ∴ $\frac{K}{D} = \frac{0.25'}{0.14'}$ ∴ $\frac{K}{D} > 1$

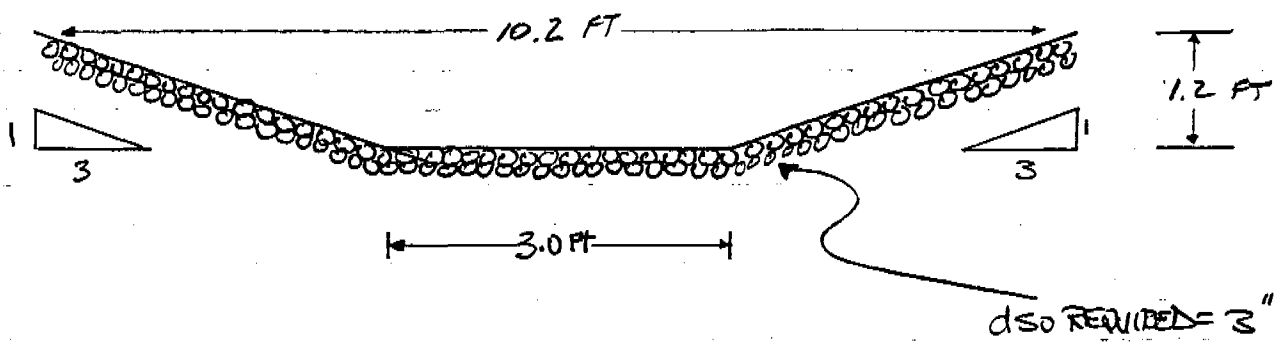
SIDE SLOPES ARE 3H:1V FOR THIS CALCULATION.
FROM FIG 3.4L-1,

∴ $\frac{V_s}{V} = 1$, $V_s = (1)(5.52)$, $V_s = 5.52$ FPS

FROM FIG 3.4L-2,

∴ $\boxed{d_{50} \text{ REQUIRED} = 0.25' = 3 \text{ INCH RIPRAP.}}$

CROSS-SECTION CGRD-1



WATER FLOW DEPTH = 0.2 FT.
FREEBOARD = 1.0 FT.
TOTAL DEPTH = 1.2 FT
CHANNEL SLOPE ⇒ MAX = 0.27 FT/FT
MIN = 0.11 FT/FT.

n = 0.035
PERIMETER = 10.6 FT
FILTER THICKNESS = 6"

* HOWEVER RIPRAP SHOULD BE PLACED TO A DEPTH OF 6 INCHES.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: RECLAMATION CHANNEL CGRD-2

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.3000 ft/ft ← MAXIMUM SLOPE
Discharge.....	5.60 cfs

Computed Results:

Depth.....	0.21 ft
Velocity.....	7.32 fps
Flow Area.....	0.77 sf
Flow Top Width...	4.26 ft
Wetted Perimeter.	4.33 ft
Critical Depth...	0.41 ft
Critical Slope...	0.0270 ft/ft
Froude Number....	3.05 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLSGATE AREA

Comment: CGRD-2

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.0400 ft/ft
Discharge.....	5.62 cfs

MINIMUM CHANNEL SLOPE

Computed Results:

Depth.....	0.37 ft
Velocity.....	3.68 fps
Flow Area.....	1.53 sf
Flow Top Width...	5.23 ft
Wetted Perimeter.	5.35 ft
Critical Depth...	0.41 ft
Critical Slope...	0.0270 ft/ft
Froude Number....	1.20 (flow is Supercritical)

CGRD-2 (MINIMUM CHANNEL + RIPRAP SIZING)

D = 0.37 FT. (BASED ON MINIMUM CHANNEL SLOPE)
V = 7.32 FPS. (BASED ON MAXIMUM CHANNEL SLOPE, D = 0.21')
Q_{MAX} = 5.6 CFS, SO USE SEARCY METHOD TO DESIGN RIPRAP

ASSUME K = 0.33' ∴ $\frac{K}{D} = \frac{0.33}{0.21} > 1$ SO $\frac{V_s}{V} \approx 1.0$
(FIG 3.4L-1)

SIDE SLOPES ARE 3H:1V FOR THIS CALCULATION

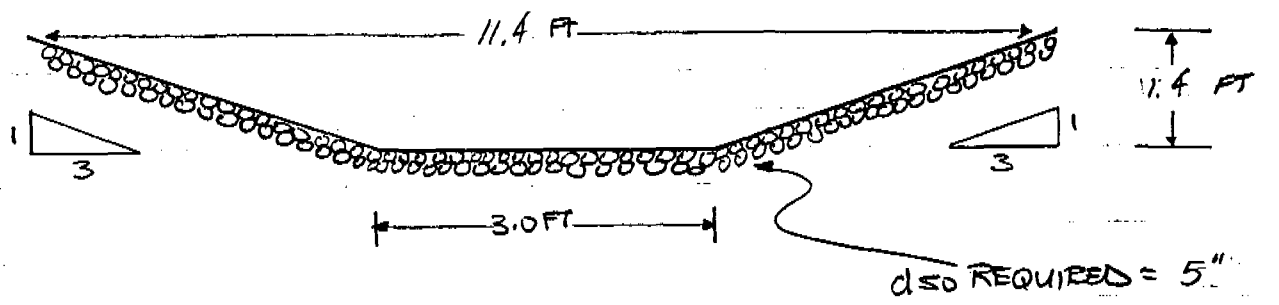
$\frac{V_s}{V} = 1.0 \Rightarrow V_s = (1)(7.3) = 7.32$ FPS

FROM FIG 3.4L-2,

∴ $\boxed{d_{50} \text{ REQUIRED} = 5 \text{ INCH RIPRAP}}$

THICKNESS = 2.0 × D_{50} = (2)(5) = 10"

CROSS-SECTION:



WATER FLOW DEPTH = 0.4 FT
FREEBOARD = 1.0 FT.
TOTAL DEPTH = 1.4 FT.
CHANNEL SLOPE ⇒ MAX = 0.30 FT/FT
MIN = 0.04 FT/FT.

RIPRAP THICKNESS = 10"
FILTER THICKNESS = 6"

PERIMETER = 11.9 FT

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLSGATE AREA

Comment: CGRD-3b

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.0500 ft/ft ← MIN. CHANNEL SLOPE
Discharge.....	41.55 cfs

Computed Results:

Depth.....	0.99 ft ← MAX. FLOW DEPTH
Velocity.....	7.04 fps
Flow Area.....	5.91 sf
Flow Top Width...	8.94 ft
Wetted Perimeter.	9.26 ft
Critical Depth...	1.23 ft
Critical Slope...	0.0203 ft/ft
Froude Number....	1.53 (flow is Supercritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: RECLAMATION CHANNEL CGRD-3b

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.1000 ft/ft ← MAX SLOPE FOR
Discharge.....	41.55 cfs SEARCY RIPRAP SIZING METHOD.

Computed Results:

Depth.....	0.83 ft
Velocity.....	9.06 fps ←
Flow Area.....	4.59 sf
Flow Top Width...	8.00 ft
Wetted Perimeter.	8.27 ft
Critical Depth...	1.23 ft
Critical Slope...	0.0203 ft/ft
Froude Number....	2.11 (flow is Supercritical)

CGRD-3D (MS) (MINIMUM CHANNEL + RIPRAP SIZING)

D = 1.0 FT (BASED ON MINIMUM CHANNEL SLOPE)
V_{MAX} = 9.06 FPS (BASED ON MAXIMUM CHANNEL SLOPE, D = 0.75 FT)

USE SEARCY (US DOT) METHOD FOR RIPRAP DESIGN FOR 200' LENGTH OF CHANNEL WHERE SLOPE < 10%. (MILD SLOPE DESIGN)

ASSUME K = 0.75 FT $\frac{K}{D} = \frac{0.75}{0.83} = 0.9$

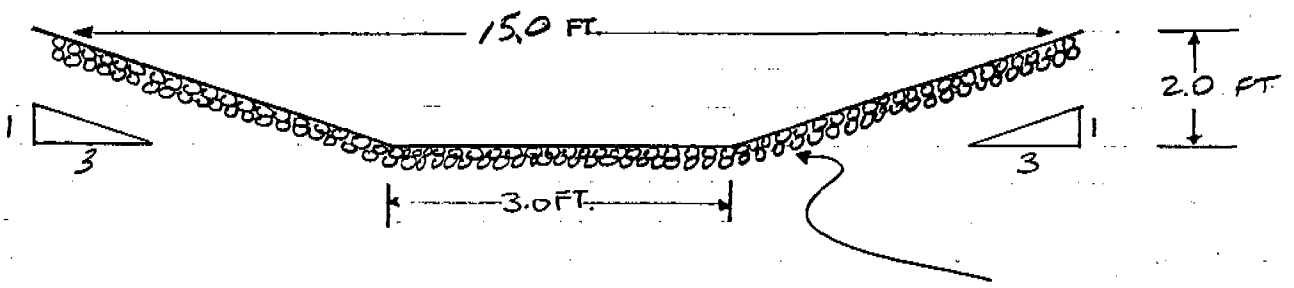
SO $\frac{V_s}{V_v} = 0.98$, $V_s = (0.98)(9.06)$ V_s = 8.88 FPS

WITH 3:1 SIDE SLOPES,

∴ $\boxed{d_{50} \text{ REQUIRED} = 7 \text{ INCH}}$

THICKNESS = $2 * D_{50}$ = 2(7) = 14"

CROSS-SECTION



d_{50} REQUIRED = 7 INCH.

WATER FLOW DEPTH = 1.0 FT
FREEBOARD = 1.0 FT.
TOTAL DEPTH = 2.0 FT.
CHANNEL SLOPE ⇒ MAX = 0.10 FT/FT.
MIN = 0.05 FT/FT.

RIPRAP THICKNESS = 14"

FILTER THICKNESS = 7"

η = 0.035

PERIMETER = 15.6 FT

CGRD - 3b (STEEP SECTIONS) RIPRAP DESIGN

CHANNEL GEOMETRY - TRAPAZOIDAL

BOTTOM WIDTH = 3. FT
SIDE SLOPES = 3:1
DEPTH = 2.0 FT
MAX. SLOPE = 16% APPLY TO 10% - 16% SECTIONS
Q_{MAX} = 42 CFS

REFERENCE: SIMONS, LI AND ASSOCIATES, 1982. SURFACE MINING WATER DIVERSION DESIGN MANUAL. OSM/TR - 82/2. PREPARED FOR THE OFFICE OF SURFACE MINING. WASHINGTON, D.C..

PROCEDURE: FOLLOW STEEP SLOPE CHANNEL DESIGN METHODOLOGY PRESENTED BY SIMONS ET AL. TO CALCULATE RIPRAP D50 SIZE AND THICKNESS. USE THE GRAPHS TO DETERMINE D50 KNOWING BOTTOM WIDTH, SIDE SLOPES, MAXIMUM FLOW, AND CHANNEL SLOPE. (GRAPHS ARE INCLUDED AT THE END OF THIS APPENDIX)
USE GRAPHS DEVELOPED FOR 2:1 SIDE SLOPES EVEN THOUGH THE CASTLE GATE RECLAMATION DIVERSIONS ARE PROPOSED WITH 3:1 SIDE SLOPES. THIS IS A CONSERVATIVE ASSUMPTION BASED ON THE Q = VA PRINCIPLE

SET RIPRAP THICKNESS EQUAL TO 1.25 D_{50} (SIMONS)

SET FILTER THICKNESS EQUAL TO 0.5 X RIPRAP THICKNESS, BUT NOT LESS THAN 6" (BARFIELD)

FOR CGRD-3b,

FROM FIG. 5.4 WITH BW = 6 FT
Q = 42 CFS
S = 16%

D50 = 0.95 FT

FROM TABLE 5.2 WITH

$0.76 < D_{50} \leq 1.0 \Rightarrow D_{50} = 1.0$ FT

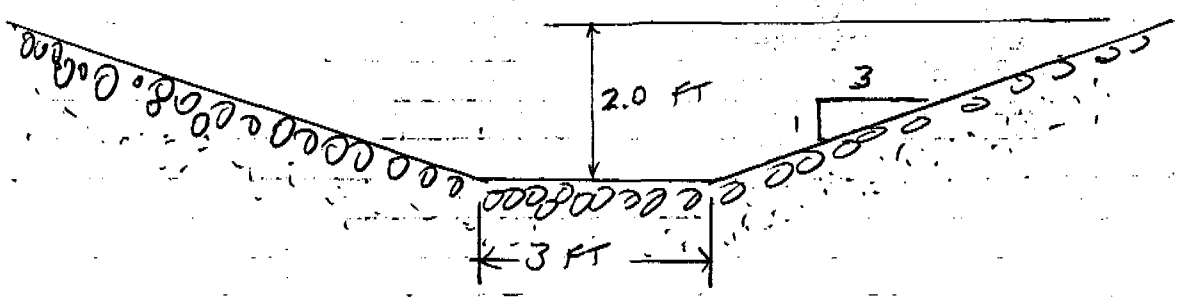
SO D_{50} = 12 INCHES

CGRD -3b STEEP SECTION (CONT.)

RIPRAP THICKNESS = 1.25 D_{50}
= 1.25 (12)
= 15"

FILTER THICKNESS = 0.5 (RIPRAP THICKNESS)
= 0.5 (15)
= 7.5" SAY 7" TO MATCH MILD SLOPE DESIGN.

CROSS - SECTION CGRD - 3b (STEEP)



RIPRAP D50 = 12 INCH

RIPRAP THICKNESS = 15 INCH

FILTER THICKNESS = 7 INCH

PERIMETER = 15.6 FT

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGRD-3c

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.1400 ft/ft ← MIN. CHANNEL SLOPE.
Discharge.....	41.90 cfs

Computed Results:

Depth.....	0.82 ft ← MAX. FLOW DEPTH
Velocity.....	9.31 fps
Flow Area.....	4.50 sf
Flow Top Width...	7.94 ft
Wetted Perimeter.	8.20 ft
Critical Depth...	1.23 ft
Critical Slope...	0.0265 ft/ft
Froude Number....	2.18 (flow is Supercritical)

CGRD - 3C RIPRAP DESIGN

SLOPE VARIES FROM 14% TO 24%. LENGTH IS ONLY 300 FEET, SO BASE DESIGN ON SLOPE EQUAL TO 24%.

CHANNEL GEOMETRY - TRAPAZOIDAL

BOTTOM WIDTH = 3.0 FT
SIDESLOPES = 3:1
DEPTH = 2.0 FT
SLOPE = 24%
Q_{MAX} = 42 CFS

FROM FIGURE 5.4,

D_{50} = 1.3 FT

FROM TABLE 5.2 WITH

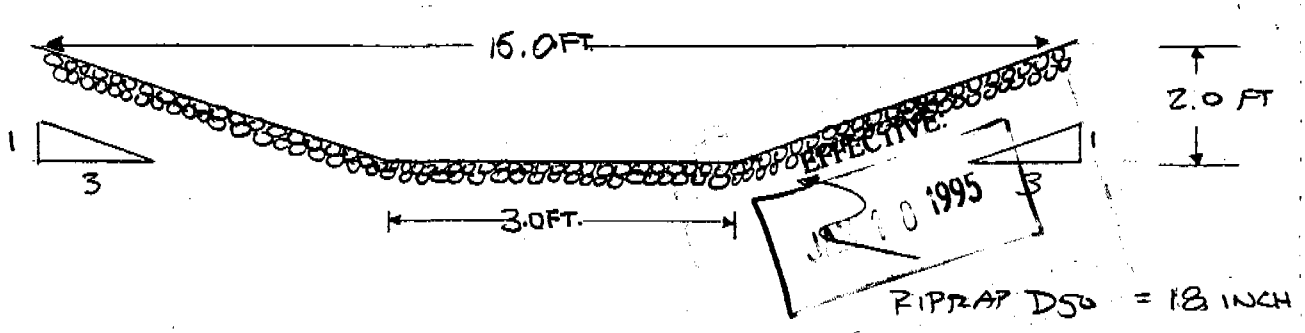
$1.26 \leq D_{50} \leq 1.50 \Rightarrow 1.50$ FT

SO D_{50} = 18"

RIPRAP THICKNESS = 1.25 x 18"
= 22.5" SAY 23"

FILTER THICKNESS = 0.5 (22.5)
= 11"

CROSS - SECTION CGRD-3C



RIPRAP D50 = 18 INCH

WATER FLOW DEPTH = 0.8 FT.
FREEBOARD = 1.2 FT
TOTAL DEPTH = 2.0 FT
CHANNEL SLOPE ⇒ MAX = 0.24 FT/FT.
MIN = 0.14 FT/FT.

RIPRAP THICKNESS = 23"
FILTER
THICKNESS = 11"

PERIMETER = 15.6'

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

DELETED

Worksheet Name: CASTLEGATE AREA

Comment: CGRD-4

Solve For Depth

Given Input Data:

Bottom Width.....	14.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0300 ft/ft ← MIN CHANNEL SLOPE.
Discharge.....	7.56 cfs

Computed Results:

Depth.....	0.19 ft ← MAX. FLOW DEPTH
Velocity.....	2.80 fps
Flow Area.....	2.70 sf
Flow Top Width...	14.38 ft
Wetted Perimeter.	14.54 ft
Critical Depth...	0.21 ft
Critical Slope...	0.0226 ft/ft
Froude Number....	1.14 (flow is Supercritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGRD-4

Solve For Depth

DELETED

Given Input Data:

Bottom Width.....	14.00 ft
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.2100 ft/ft
Discharge.....	7.56 cfs

MAX. CHANNEL SLOPE.

Computed Results:

Depth.....	0.11 ft
Velocity.....	5.05 fps
Flow Area.....	1.50 sf
Flow Top Width...	14.21 ft
Wetted Perimeter.	14.30 ft
Critical Depth...	0.21 ft
Critical Slope...	0.0226 ft/ft
Froude Number....	2.74 (flow is Supercritical)

EFFECTIVE: JAN 10 1995

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CGRD - 4 (MINIMUM CHANNEL + RIPRAP SIZING)
(EXISTING DIVERSION)

D = 0.19 FT (BASED ON MINIMUM CHANNEL SLOPE)
V = 5.05 FPS (BASED ON MAXIMUM CHANNEL SLOPE, D = 0.11 FT)
Q_{MAX} = 7.4 CFS, SO USE SEARCY METHOD TO DESIGN RIPRAP.

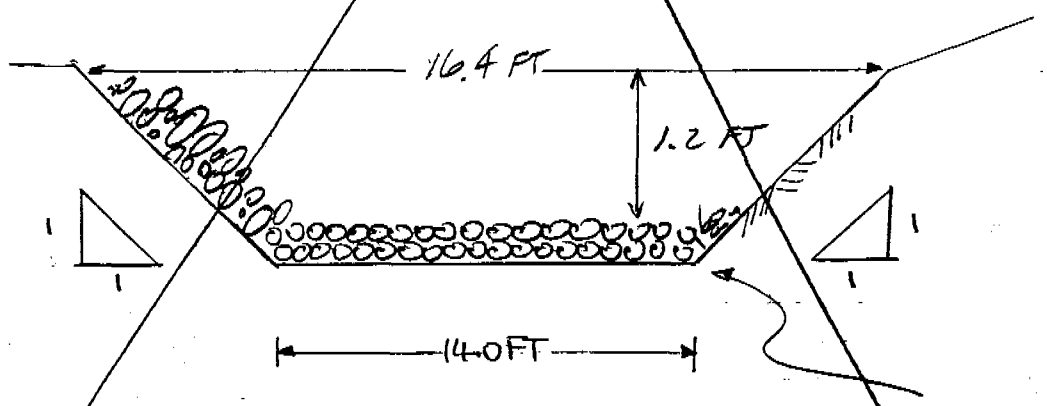
ASSUME K = 0.15' ∴ $\frac{K}{D} = \frac{0.15'}{0.11'}$ ∴ $\frac{K}{D} > 1$

SIDE SLOPES ARE 12H : 1V FOR THIS CALCULATION.

∴ $\frac{V_s}{V} = 1$, $V_s = (1)(5.05)$, $V_s = 5.05$ FPS

$$\boxed{d_{50} = 0.15' = 2 \text{ INCH RIPRAP.}}$$

CROSS-SECTION - CGRD - 4 (MINIMUM REQUIREMENTS)



RIPRAP D50 = 2 IN

RIPRAP THICKNESS = 6 IN

FILTER THICKNESS = 6 IN

BOTTOM WIDTH = 14 FT.
TOTAL DEPTH = 1.2 FT
SIDE SLOPES = 1H : 1V (EXISTING DIVERSION)
TOP WIDTH = 16.4 FT

NORTHWEST SIDE OF CHANNEL IS EXCAVATED INTO SANDSTONE, SO NO RIPRAP NEEDED. FOR VOLUME CALCULATIONS, USE A PERIMETER EQUAL TO 15.7 FT.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE AREA

Comment: CGRD-5 (EXISTING)

Solve For Depth

Given Input Data:

Bottom Width.....	18.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.0200 ft/ft ← MINIMUM SLOPE
Discharge.....	222.90 cfs *

Computed Results:

Depth.....	1.65 ft ← MAXIMUM FLOW DEPTH
Velocity.....	6.60 fps
Flow Area.....	33.75 sf
Flow Top Width...	22.95 ft
Wetted Perimeter.	23.94 ft
Critical Depth...	1.61 ft
Critical Slope...	0.0219 ft/ft
Froude Number....	0.96 (flow is Subcritical)

*	Q
CGWS - U6	43.12
CGWS - U7	179.78

Q_{TOTAL} = 222.90 cfs

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE AREA

Comment: CGRD-5 (EXISTING)

Solve For Depth

Given Input Data:

Bottom Width.....	18.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.1000 ft/ft ← MAXIMUM SLOPE FOR SEAMCY RIPRAP DESIGN
Discharge.....	222.90 cfs

Computed Results:

Depth.....	1.02 ft
Velocity.....	11.13 fps
Flow Area.....	20.02 sf
Flow Top Width...	21.07 ft
Wetted Perimeter.	21.69 ft
Critical Depth...	1.61 ft
Critical Slope...	0.0219 ft/ft
Froude Number....	2.01 (flow is Supercritical)

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CGRD - 5 (EXISTING) RIPRAP & CHANNEL DESIGN

MINIMUM SLOPE = 2% ⟹ FLOW DEPTH = 1.7 FT
USE SEARLY METHOD TO DESIGN RIPRAP FOR CHANNEL SLOPES < 10%.

@ S = 10%, VELOCITY = 11.13 FPS, DEPTH = 1.02 FT

ASSUME K = D_{50} = 1.25' $\frac{K}{d} = \frac{1.25}{1.02} > 1.50$

$\frac{V_s}{V} = 1 \Rightarrow V_s = (1)(11.13) = 11.13$ FPS (FIG 3.4L-1)

FROM FIG 3.4L-2 WITH 1.5 : 1 SIDE SLOPES, V_s = 11.1 FPS,

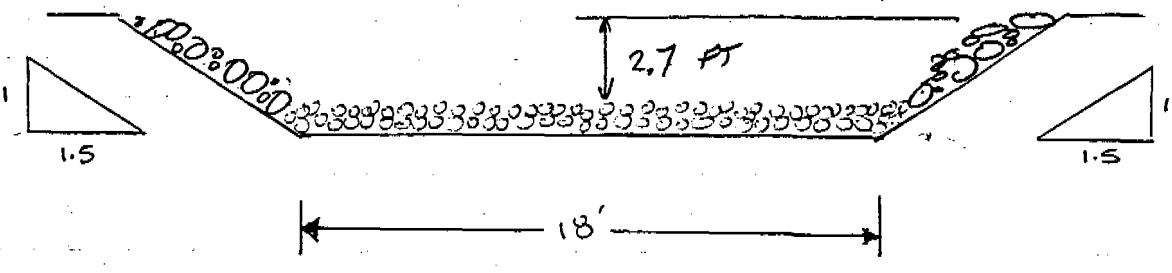
D_{50} = 14"

THICKNESS = (14)(2.0) = 28"

FILTER = 1/2 (28)" = 14"

NOTE: CGRD-5 IS AN EXISTING DIVERSION OF VARYING DEPTH UP TO 20'. MANY SECTIONS HAVE EXISTING RIPRAP BUT IT IS NOT CONTINUOUS. D_{50} RANGES UP TO 24", PER RICH WHITE SITE VISIT FEB 8, 1990. ASSUME 50% OF THE RIPRAP CAN BE REUSED.

MINIMUM CHANNEL CROSS-SECTION : CGRD-5



d = 1.65'
FREEBOARD = 18.35'
TOTAL DEPTH = 20'
n = 0.040
MAX SLOPE = 0.10 FT/FT.
MIN SLOPE = 0.020 FT/FT.

RIPRAP D50 = 14"

RIPRAP THICKNESS = 28"

FILTER THICKNESS = 14"

PERIMETER = 27.7 (REUSE 50% OF EXISTING RIPRAP)

CGRD - 5 (EXISTING) STEEP SLOPE RIPRAP DESIGN

SINCE MAX SLOPE = 14% USE SIMONS ET AL. METHOD TO DESIGN RIPRAP FOR CHANNEL SECTIONS WHOSE SLOPE IS ≥ 10%.

CHANNEL GEOMETRY — TRAPEZOIDAL

BOTTOM WIDTH = 18 FT
SIDE SLOPES = 1.5 : 1
DEPTH (MIN) = 2.7 FT
SLOPE = 14%
Q_{MAX} = 223 CFS

FROM FIG. 5.6 (BW = 14 FT), WITH

Q = 223 CFS
SLOPE = 14%
YIELDS,

D_{50} = 1.40 FT

FROM FIG 5.7 (BW = 20 FT) WITH

Q = 223 CFS
SLOPE = 14%
YIELDS,

D_{50} = 1.2 FT

INTERPOLATE

BW	D50
14	1.40
18	
20	1.20

$$\frac{4}{6} = \frac{x}{.20}$$

x = -0.13
+ 1.40
1.27

FROM TABLE 5.2 WITH

$1.26 \le D_{50} \le 1.50$ USE $D_{50} = 1.50$ FT

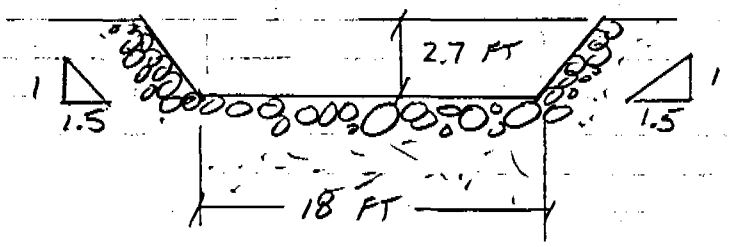
SO $D_{50} = 18''$

RIPRAP THICKNESS $= (1.25)(18) = 23''$

FILTER THICKNESS $= (0.5)(23'') = 11''$

CGRD-5 STEEP SLOPE CROSS-SECTION

(MINIMUM REQUIREMENTS)



RIPRAP D50 = 18 IN

RIPRAP THICKNESS = 23 IN

FILTER THICKNESS = 11 IN

SINCE CGRD-5 IS AN EXISTING CHANNEL, ASSUME 50% OF THE EXISTING RIPRAP CAN BE REUSED. (FIELD VERIFY)

PERIMETER = 27.7 FT

ASSUME NEW FILTER MATERIAL IS REQUIRED ALONG ONLY 50% OF THE CHANNEL. (FIELD VERIFY)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE AREA

Comment: CGRD-6

Solve For Depth

Given Input Data:

Bottom Width.....	18.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.0200 ft/ft ← MINIMUM SLOPE
Discharge.....	222.90 cfs

Computed Results:

Depth.....	1.47 ft ← MAXIMUM FLOW DEPTH
Velocity.....	6.79 fps
Flow Area.....	32.81 sf
Flow Top Width...	26.79 ft
Wetted Perimeter.	27.27 ft
Critical Depth...	1.54 ft
Critical Slope...	0.0169 ft/ft
Froude Number....	1.08 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE AREA

Comment: CGRD-6

Solve For Depth

Given Input Data:

Bottom Width.....	18.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.0600 ft/ft ← MAXIMUM SLOPE
Discharge.....	222.90 cfs (USE SEARCH METHOD)

Computed Results:

Depth.....	1.07 ft
Velocity.....	9.81 fps ← MAXIMUM VELOCITY
Flow Area.....	22.71 sf
Flow Top Width...	24.42 ft
Wetted Perimeter.	24.77 ft
Critical Depth...	1.54 ft
Critical Slope...	0.0169 ft/ft
Froude Number....	1.79 (flow is Supercritical)

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CGRD-6 : (MINIMUM CHANNEL + RIPRAP SIZING)

AT MINIMUM SLOPE OF 2%, FLOW DEPTH = 1.47 FT
AT MAXIMUM SLOPE OF 6%, FLOW DEPTH = 1.07 FT
VELOCITY = 9.81 FPS

ASSUME $K = 0.25'$ $\therefore \frac{K}{d} = \frac{0.25'}{1.07} = 0.23$

SIDE SLOPES ARE 3:1 FOR THIS CALCULATION.

FROM FIG 3.4L-1, WITH $K/d = 0.23$

$\therefore \frac{V_s}{V} = 0.65$

$V_s = (0.65)(9.81)$

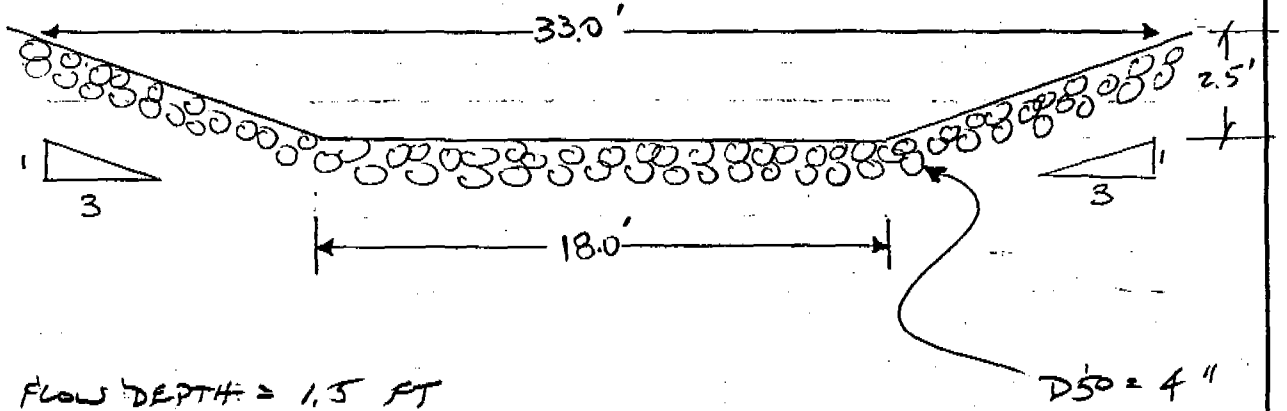
$V_s = 6.4$ FPS

FROM FIG 3.4L-2,

$\therefore$ D50 = 4"

RIPRAP THICKNESS = (2)(D50) = 2(4") = 8"

CROSS-SECTION: CGRD-6



FLOW DEPTH = 1.5 FT
FREEBOARD = 1.0 FT
TOTAL DEPTH = 2.5 FT

PERIMETER = 33.8'

RIPRAP THICKNESS = 8"

FILTER THICKNESS = 6"

3.4 L

SEE APPENDIX 3.4 J FOR

CALCULATIONS FOR SCHOOLHOUSE CANYON

RECLAMATION DIVERSIONS CGRD-4, 7, 8 AND 9

EFFECTIVE:
JAN 10 1995

CGRWS -U4 (UPSLOPE AND EAST OF CGRD-10)
(CONTRIBUTING TO CGRD-10)
(POND 013 SPILLWAY)

DETERMINE AVERAGE WATERSHED SLOPE :

$$WS = 0.25\,(EM - EN)(LC_{25} + LC_{50} + LC_{75}) / AREA.$$

EM = MAX. ELEVATION
EN = MIN. ELEVATION
LC = CONTOUR LENGTH @ 25, 50 + 75 % OF EM - EN
WS = WATERSHED SLOPE

WATERSHED	EM	EN	LC_{25}	LC_{50}	LC_{75}	AREA (AC)	WS (%)
CGRWS-U4	6690	6152	500	450	275	6.2	60.8

REF = CHANG, M., S.P. WATTERS, AND A.K. SAYOK. 1989 A COMPARISON OF METHODS OF ESTIMATING MEAN WATERSHED SLOPE. WATER RESOURCES BULLETIN. VOL 25, NO. 2.

CN = 78
AREA = 6.2 AC
$S = 1000/CN - 10 = 2.82$
$\ell = 1200$ FT.

$$\text{LAG TIME} = \frac{(\ell)^{0.8}\,(S+1)^{0.7}}{1900\,(WS)^{1/2}} = \frac{(1200)^{0.8}\,(3.82)^{0.7}}{1900\,(60.8)^{.5}} = 0.050$$

$$\text{TIME OF CONCENTRATION} = (1.67)(0.050) = 0.084 \text{ HR}$$

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGRWS-U4 (UPSLOPE AND EAST OF CGRD-10)

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 6.20 acres
Depth = 1.40 inches	CN = 78.00
Duration = 6.00 hrs	Time conc.= 0.084 hrs

OUTPUT SUMMARY

Runoff depth	0.19110	inches	
Initial abstr	0.56410	inches	
Peak flow =	0.88	cfs	(0.14123 iph)
at time	2.520	hrs	

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGRD-10

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.20:1 (H:V)
Right Side Slope.	1.20:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1000 ft/ft
Discharge.....	0.88 cfs

Computed Results:

Depth.....	0.09 ft
Velocity.....	3.08 fps
Flow Area.....	0.29 sf
Flow Top Width...	3.22 ft
Wetted Perimeter.	3.29 ft
Critical Depth...	0.14 ft
Critical Slope...	0.0270 ft/ft
Froude Number....	1.82 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGRD-10

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.20:1 (H:V)
Right Side Slope.	1.20:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0100 ft/ft
Discharge.....	0.88 cfs

Computed Results:

Depth.....	0.18 ft
Velocity.....	1.49 fps
Flow Area.....	0.59 sf
Flow Top Width...	3.44 ft
Wetted Perimeter.	3.57 ft
Critical Depth...	0.14 ft
Critical Slope...	0.0270 ft/ft
Froude Number....	0.63 (flow is Subcritical)

CGRD-10 (MINIMUM CHANNEL & RIPRAP SIZING)

D = 0.18 FT (BASED ON MINIMUM CHANNEL SLOPE, V = 1.49 FPS)
V = 3.08 FPS (BASED ON MAXIMUM CHANNEL SLOPE, D = 0.09 FT)

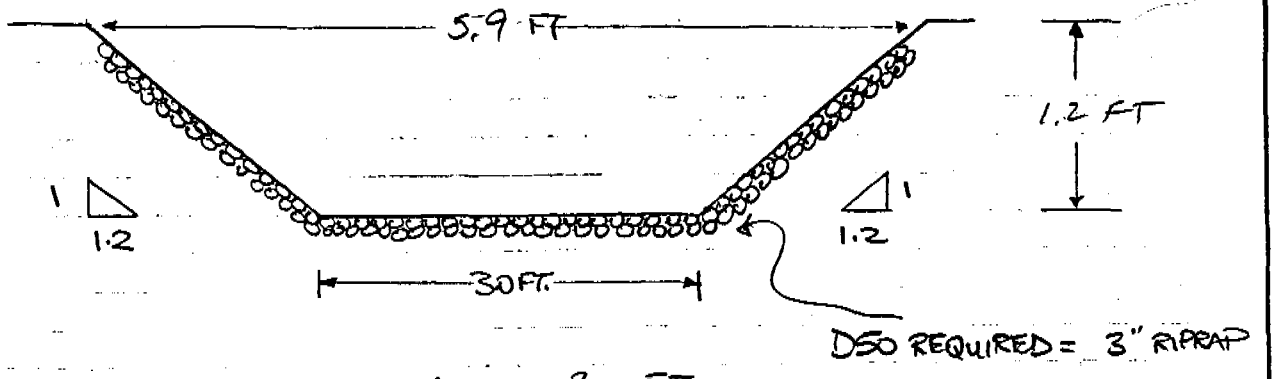
ASSUME K = 0.25' ∴ $\frac{K}{D} = \frac{0.25'}{0.18'}$ ∴ $\frac{K}{D} > 1$

SIDE SLOPES ARE 1.2 H : 1 V FOR THIS CALCULATION.

∴ $\frac{V_s}{V} = 1$, $V_s = (1)(3.08)$, $V_s = 3.08$ FPS

∴ $\boxed{d_{50} \text{ REQUIRED} = 0.25' = 3 \text{ INCH RIPRAP.}}$

CROSS-SECTION: CGRD-10



WATER FLOW DEPTH = 0.2 FT
FREEBOARD = 1.0 FT.
TOTAL DEPTH = 1.2 FT.
CHANNEL SLOPE ⇒ MAX = 0.10 FT/FT.
MIN = 0.01 FT/FT.

$\eta = 0.03$

* RIPRAP SHOULD BE PLACED TO A DEPTH OF 6"

* CGRD-10 (OPERATIONAL HYDROLOGY CGD-8) IS AN EXISTING ADEQUATELY DESIGNED DITCH.

CASTLE GATE PREPARATION PLANT AREA
RECLAMATION CHANNEL SUMMARY

Reclamation Channel	Minimum Bottom Width (ft)[a]	Side Slopes (H:V)	Minimum Channel Depth (ft)	Maximum Bottom Slope (%)	Minimum Bottom Slope (%)	Maximum Flow Depth (ft)	Freeboard (ft)	Maximum Velocity (ft/s)	Minimum Riprap D50 (in)
CGRD-1	3	3:1	1.2	27	11	0.2	1.0	5.52	3[c]
CGRD-2	3	3:1	1.4	30	4	0.4	1.0	7.32	5[c]
CGRD-3b(MS)[b]	3	3:1	2.0	10	5	1.0	1.0	9.06	7[c]
CGRD-3b(SS)[b]	3	3:1	2.0	16	10	< 1.0	> 1.0	-	12[d]
CGRD-3c	3	3:1	2.0	24	14	0.8	1.2	-	18[d]
CGRD-4	14	1:1	1.2	21	3	0.2	1.0	5.05	2[c]
CGRD-5(MS)	18	1.5:1	2.7	10	2	1.7	1.0	11.13	14[c]
CGRD-5(SS)	18	1.5:1	2.7	14	10	< 1.7	> 1.0	-	18[d]
CGRD-6	18	3:1	2.5	6	2	1.5	1.0	9.81	4[c]
CGRD-10[e]	3	1.2:1	1.2	10	1	0.2	1.0	3.08	3[c]

[a] Minimum bottom width measured at minimum depth from top of channel.
[b] MS = mild slope. SS = steep slope.
[c] Riprap D50 calculated by using the Searcy method developed for the U.S. D.O.T..
[d] Riprap D50 calculated by using the Simons et al./OSM steep slope design methodology.
[e] Temporary Reclamation channel (Phase I only).

Note: See Table 3.4-21 for information on reclamation diversions 3a, 7, 8 and 9.

46B

CASTLE GATE PREPARATION PLANT AREA RECLAMATION CHANNELS
RIPRAP AND FILTER BLANKET VOLUMES

CHANNEL	RIPRAP D50 (in.)	LENGTH (ft.)	PERIMETER (ft.)	RIPRAP THICKNESS (in.)	RIPRAP VOLUME (ft^3)	FILTER THICKNESS (in.)	FILTER VOLUME (ft^3)
CGRD-1	3	275	10.6	6	1,458	6	1,458
CGRD-2	5	200	11.9	10	1,983	6	1,190
CGRD-3b(SS)	7	200	15.6	14	3,640	7	1,820
CGRD-3b(MS)	12	250	15.6	15	4,875	7	2,275
CGRD-3c	18	300	15.6	23	8,970	11	4,290
CGRD-4	2	1,400	15.7	6	10,990	6	10,990
CGRD-5(MS)	14	250	27.7	28	8,079[a]	14	4,040[b]
CGRD-5(SS)	18	1,050	27.7	23	27,873[a]	11	13,331[b]
CGRD-6	4	300	33.8	8	6,760	6	5,070
CGRD-10	Riprap in place						
TOTALS					74,628 (5,224 tons)[c]		44,464 (2,890 tons)[d]

(a) Assumes that 50% of the riprap currently lining the existing channel can be reused.
(b) Assumes that new filter material will be required along only 50% of the existing channel.
(c) Assumes a riprap in-place density of 140 pcf.
(d) Assumes a filter in-place density of 130 pcf.

Notes:
1. See Table 3.4-22 for School House Canyon riprap and filter blanket volumes.
2. Riprap at the base of culverts is neglected for the volume calculations.

46c

Rectangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGRC-1

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Manning's n.....	0.024
Channel Slope....	0.0100 ft/ft
Discharge.....	8.64 cfs

Computed Results:

Depth.....	0.50 ft
Velocity.....	3.45 fps
Flow Area.....	2.50 sf
Flow Top Width...	5.00 ft
Wetted Perimeter.	6.00 ft
Critical Depth...	0.45 ft
Critical Slope...	0.0137 ft/ft
Froude Number....	0.86 (flow is Subcritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

CGRC - 1

WIDTH x LENGTH = 60" x 120" BOX = 5' x 10' BOX

η = 0.014 (CONCRETE)

DISCHARGE = 8.64 CFS

SLOPE = 0.010 FT/FT.

∴ USE INLET CONTROL NOMOGRAPH FOR BOX CULVERT TO DETERMINE IF CULVERT IS ADEQUATELY SIZED.

∴ USING D = 60" = 5'
Q = 8.64 CFS

∴ HEADWATER DEPTH < 0.4 DIAMETERS

∴ CGRC-1 IS ADEQUATELY DESIGNED FOR FINAL RECLAMATION HYDROLOGY.

RIPRAP SIZING FOR CGRC-1

V = 3.45 FPS (BASED ON AVERAGE SLOPE.)
D = 0.50 FT

ASSUME K = 0.1' ∴ $\frac{K}{D} = \frac{0.1'}{0.5'}$ ∴ $\frac{K}{D} = 0.2$

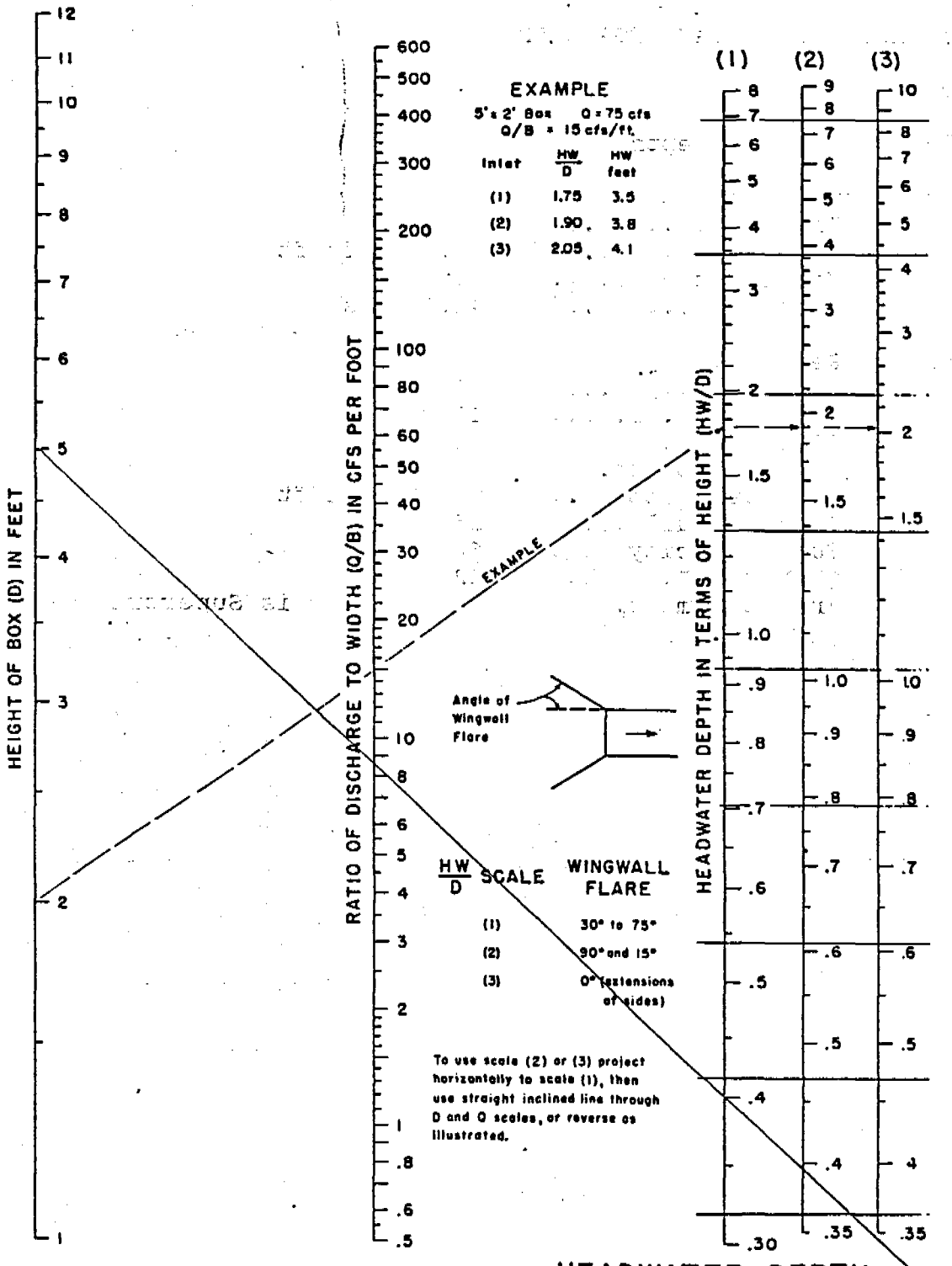
SIDE SLOPES ARE 3H : 1V FOR THIS CALCULATION

∴ $\frac{V_s}{V} = 0.6$ ∴ $V_s = (0.6)(3.45)$ $V_s = 2.07$ FPS

∴ d50 REQUIRED = 0.1' = 1 INCH RIPRAP

* RIPRAP SHOULD BE PLACED 6 INCHES DEEP.

CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGRC-2

Solve For Actual Depth

Given Input Data:

Diameter.....	5.00 ft
Slope.....	0.1000 ft/ft
Manning's n.....	0.014
Discharge.....	41.90 cfs

Computed Results:

Depth.....	0.79 ft
Velocity.....	20.86 fps
Flow Area.....	2.01 sf
Critical Depth....	1.81 ft
Critical Slope....	0.0038 ft/ft
Percent Full.....	15.90 %
Full Capacity.....	764.76 cfs
QMAX @.94D.....	822.66 cfs
Froude Number.....	4.96 (flow is Supercritical)

CGRC-2

DIAMETER = 60" = 5'

η = 0.0140 (CONCRETE)

DISCHARGE = 41.90 cfs

SLOPE = 0.100 FT/FT.

∴ USING INLET CONTROL NOMOGRAPH TO DETERMINE HEADWATER DEPTH FOR CONCRETE CULVERTS WITH INLET CONTROL.

∴ USING D = 60"
Q = 41.90 cfs

∴ HEADWATER DEPTH = 0.51 DIAMETERS

∴ CGRC-2 IS ADEQUATELY DESIGNED FOR RECLAMATION HYDROLOGY.

RIPRAP SIZING FOR CGRC-2

D = 0.79 FT. (BASED ON AVERAGE CHANNEL SLOPE)
V = 20.86 FPS.

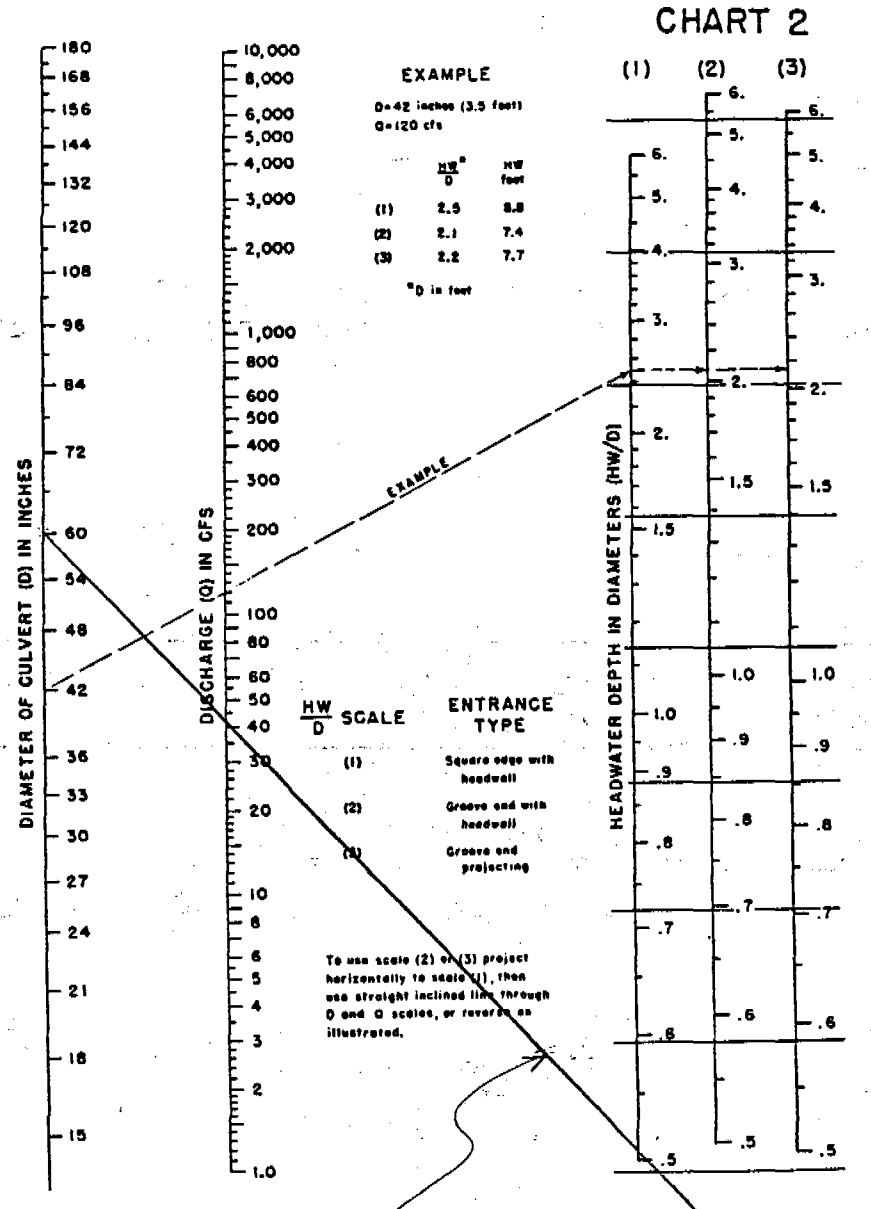
ASSUME K = 3.25' ∴ $\frac{K}{D} = \frac{3.25'}{0.79'}$ ∴ $\frac{K}{D} > 1$

SIDE SLOPES ARE 3H:1V FOR THIS CALCULATION.

∴ $\frac{V_S}{V} = 1$. $V_S = (1)(20.86)$. V_S = 20.86 FPS

∴ d50 REQUIRED = 3.25' = 39 INCH RIPRAP

* RIPRAP SHOULD BE PLACED TO A DEPTH OF 60 INCHES



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

CGRC-2

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGRC-3

Solve For Actual Depth

Given Input Data:

Diameter.....	7.00 ft
Slope.....	0.0500 ft/ft
Manning's n.....	0.024
Discharge.....	222.90 cfs

Computed Results:

Depth.....	2.57 ft
Velocity.....	17.38 fps
Flow Area.....	12.82 sf
Critical Depth....	3.90 ft
Critical Slope....	0.0116 ft/ft
Percent Full.....	36.75 %
Full Capacity.....	773.76 cfs
QMAX @.94D.....	832.33 cfs
Froude Number.....	2.22 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
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CGRC-3

DIAMETER = 2 x 84" CMP = 2 x 7'

n = 0.0240

DISCHARGE = 222.90 cfs

SLOPE = 0.050 FT/FT

∴ USING INLET CONTROL NOMOGRAPH TO DETERMINE HEADWATER DEPTH FOR CMP CULVERTS WITH INLET CONTROL.

∴ USING D = 84"
Q = 222.90 cfs

∴ HEADWALL DEPTH = 0.82 DIAMETERS

∴ CGRC-3 IS ADEQUATELY DESIGNED FOR FINAL RECLAMATION HYDROLOGY.

RIPRAP SIZING : (FOR CGRC-3)

V = 17.38 FPS
d = 2.57 FT.

ASSUME K = 2.57 FT ∴ $\frac{K}{d} = \frac{2.57'}{2.57'}$ ∴ $\frac{K}{d} = 1$

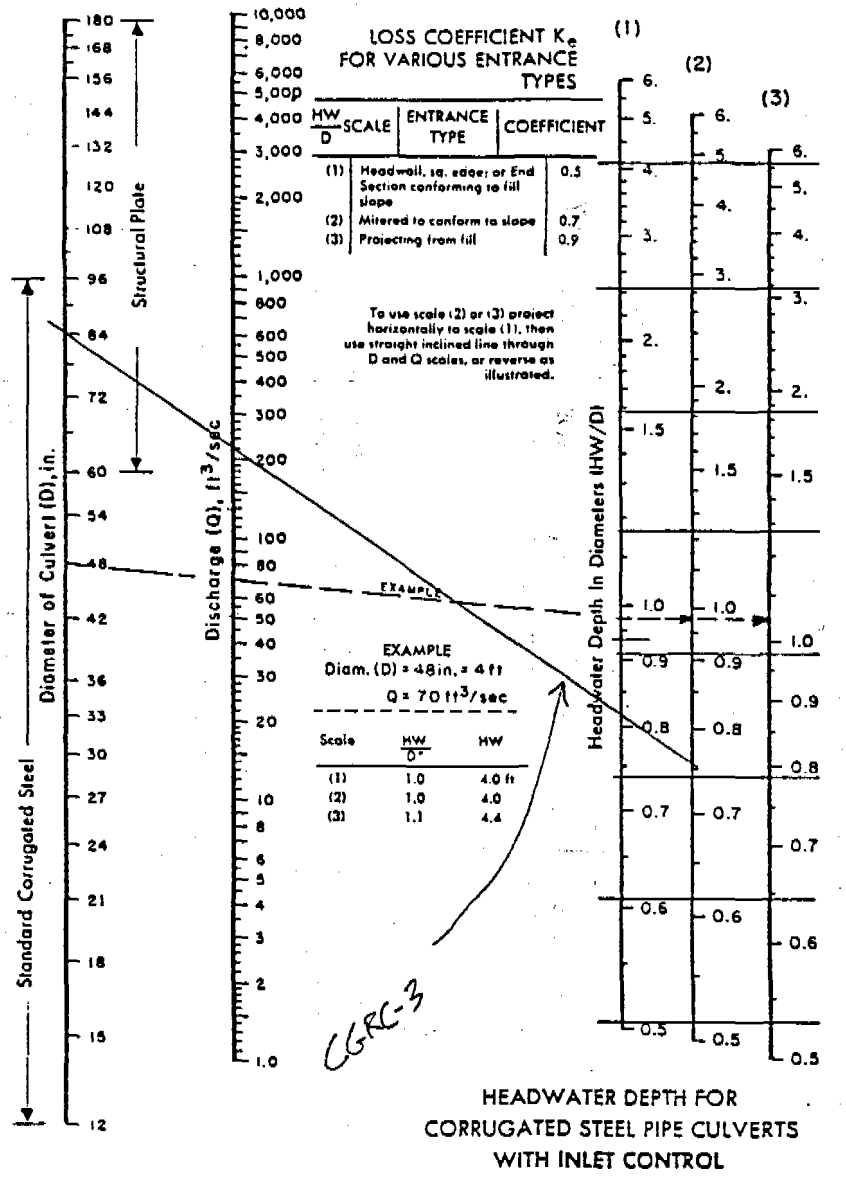
SIDE SLOPES ARE 3:1 FOR THIS CALCULATION.

∴ $\frac{V_s}{V} = 1$

$V_s = (1)(17.38) = 17.38$ FPS

∴ d50 = 2.5' = 30" RIPRAP

* RIPRAP SHOULD BE AT LEAST 45" THICK



HEADWATER DEPTH FOR CORRUGATED STEEL PIPE CULVERTS WITH INLET CONTROL

FHWA HEC 5

Figure 4-28 *Inlet control* nomograph for corrugated steel *pipe* culverts. The manufacturers recommended keeping *HW/D* to a maximum of 1.5 and preferably to no more than 1.0.

CASTLEGATE AREA - FINAL RECLAMATION PLAN.

CULVERT CAPACITY.

CULVERT IDENTIFICATION	SIZE	INLET TYPE	INLET CONTROL CAPACITY (a) (CFS)	CONTRIBUTING WATERSHED (b)	PEAK FLOW (c) (CFS)
CGRC- 1	60"x120" BOX	HEADWALL	280	CGWS- U2, U3	8.64
CGRC- 2	60" CONCRETE	48" x 64" DROP INLET.	128	CGWS- U4, U5, R4	41.90
CGRC- 3	2-84" CMP	MITERED	2x 295 = 590	CGWS- U6, U7	222.90

a) SEE NOMOGRAPH ON PG 34 OF THIS CALC. CAPACITY BASED ON HW/D = 1.0

b) CGWS- R2 USED IN CGRC-1 CALC. FOR INITIAL STAGE OF RECLAMATION HYDROLOGY. CGWS- R2 - USED IN CGRC-2 CALC. FOR FINAL STAGE OF RECLAMATION HYDROLOGY.

c) SEE RUNOFF CALCS. MULTIPLE WATERSHEDS ADDED NUMERICALLY (ie, ASSUMES ALL PEAK FLOWS ARE TEMPORALLY CONCURRENT.

RIPRAP ADEQUACY.

CULVERT I.D.	SIZE	SLOPE %	PEAK (a) FLOW (CFS)	VELOCITY (FPS) (b)	RIPRAP d50 (in) (c)
CGRC- 1	60"x120" BOX	.1	8.64	3.45	1
CGRC- 2	60" CONCRETE	10	41.90	20.86	39
CGRC- 3	2-84" CMP	5	222.90	17.38	30

a) SEE RUNOFF CALCS.
b) SEE ATTACHED CALCS. ASSUMES n = 0.024 FOR CMP. / n=0.014 FOR CONCRETE
c) SEE NOMOGRAPH ON PG 8. OF THIS CALC.
ASSUMES K/d > 1 ∴ $V_s = V$. USE CURVE FOR "BOTTOM".

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PROJECT UC-150 PAGE 56 OF
COMPUTED TIC DATE 8-31-92
CHECKED DATE

TYPICAL PLUNGE POOL DESIGN.

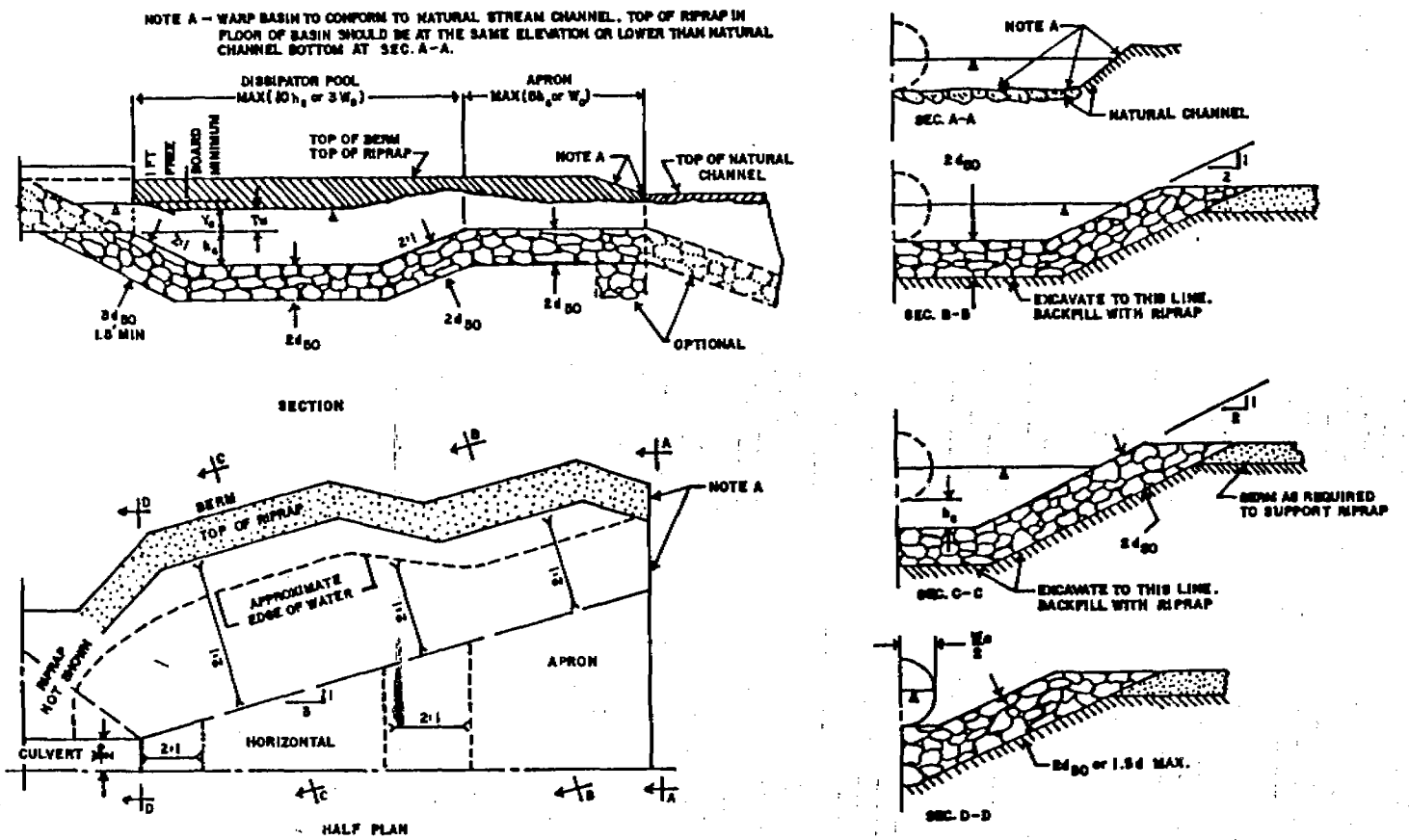


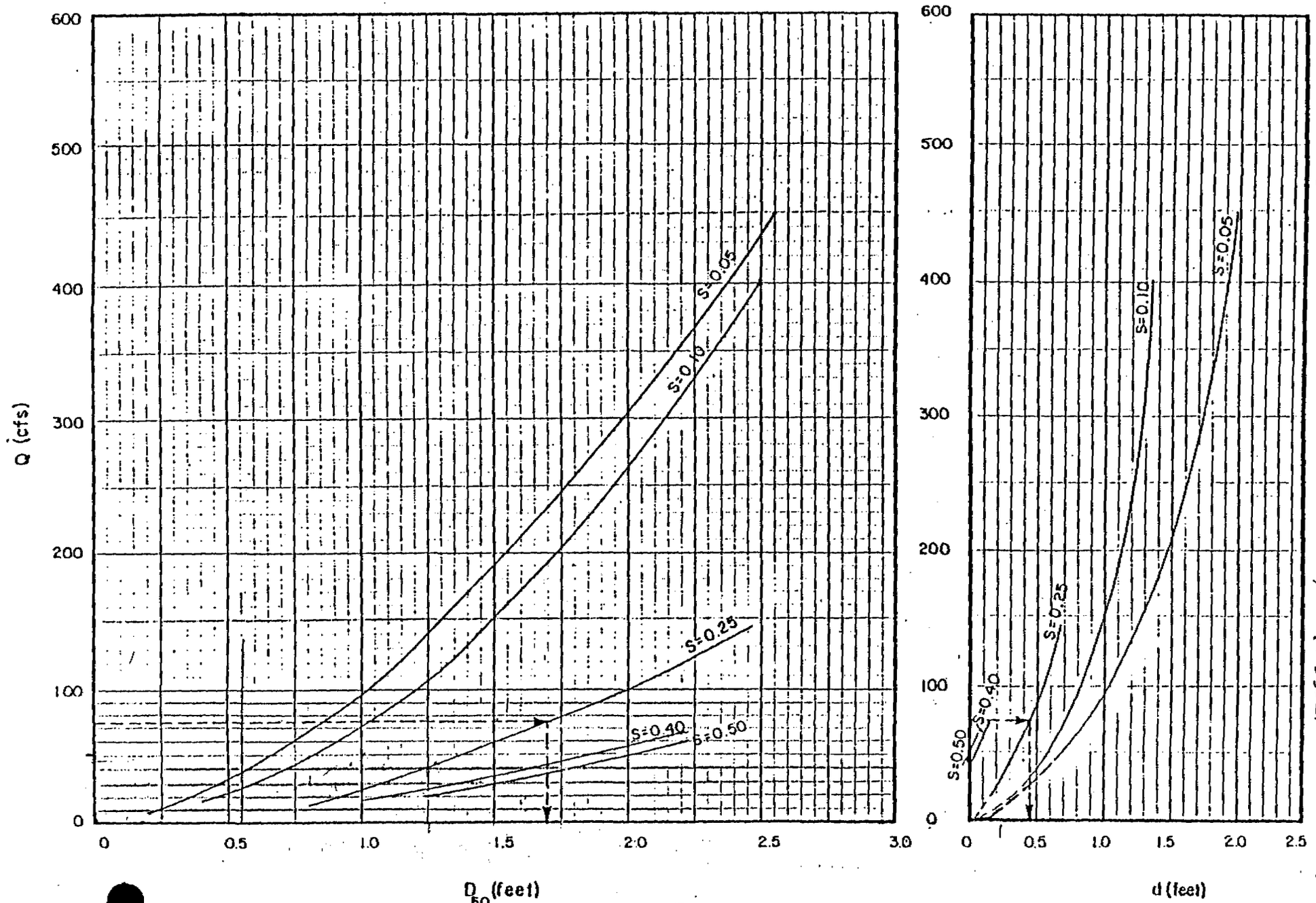
Figure 7.22. Schematic of rip-rapped culvert energy basin. (adapted from FHA, 1975b)

FIGURE 3.4 L-3

(BARFIELD et al, 1981)

* PLEASE NOTE: RIPRAPED ENERGY DISSIPATORS (PLUNGE POOLS) WILL BE PLACED IN CHANNELS GREATER THAN 20 % CHANNEL SLOPE.

* WHERE h_s = DEPTH OF FLOW (FT)



REF: USM/TR-82-2. SURFACE MINING WATER DIVERSION DESIGN MANUAL. PREPARED 5.17 BY SIMONS, LI & ASSOC. SEPT. 1982.

Figure 5.4. Steep slope riprap design, trapezoidal channels, 2:1 sideslopes, 6 ft base width.

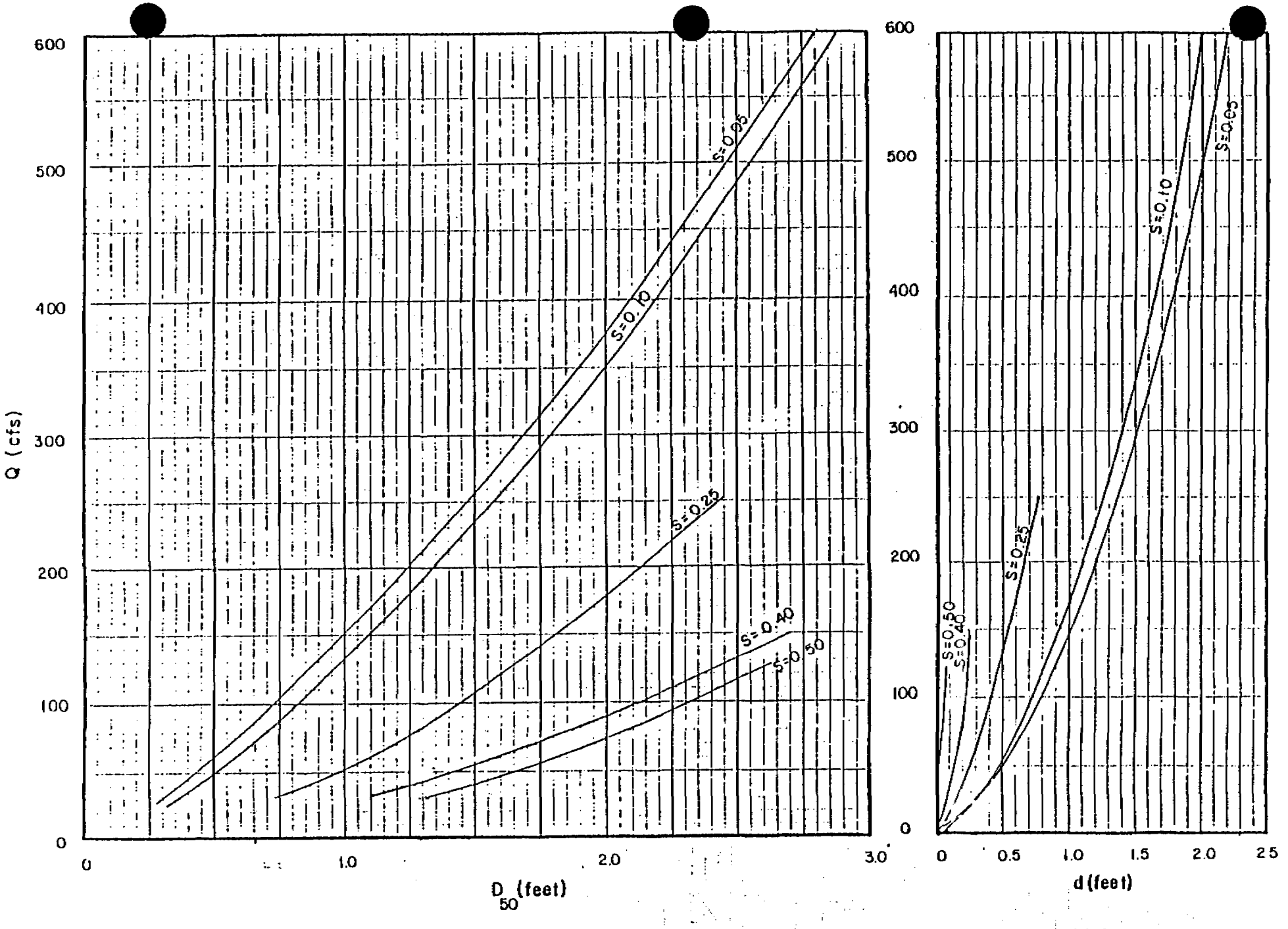


Figure 5.5. Steep slope riprap design, trapezoidal channel, 2:1 sideslopes, 10 ft base width.

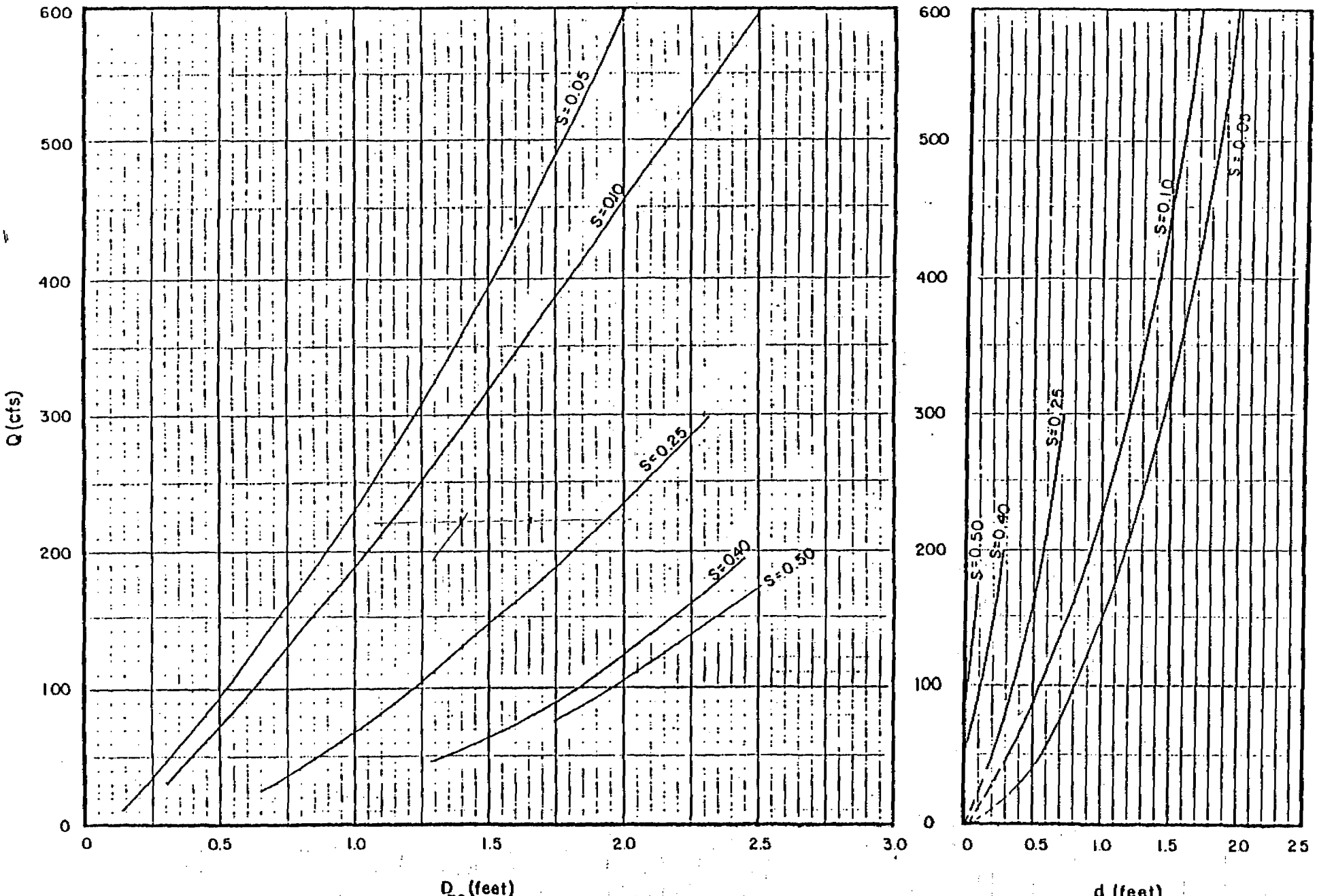


Figure 5.6. Steep slope riprap design, trapezoidal channels, 2:1 sideslopes, 14 ft base width.

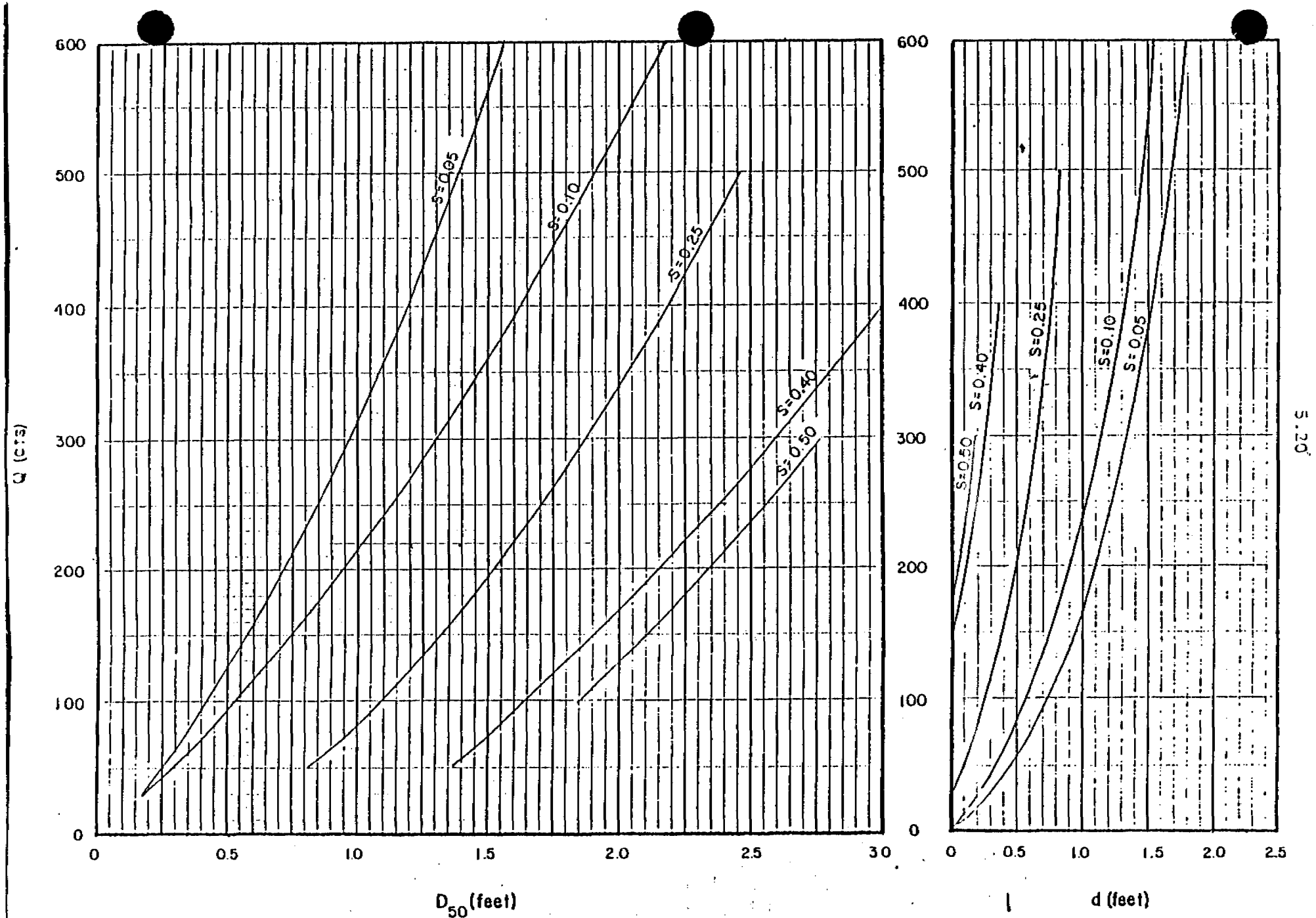


Figure 5.7. Steep slope riprap design, trapezoidal channels, 2:1 sideslopes, 20 ft base width.

Table 5.2. Design D_{50} Values.

D_{50} Determined From Design Curve (ft)	Design D_{50} (ft)
< 0.25	0.25
0.26 - 0.50	0.50
0.51 - 0.75	0.75
0.76 - 1.00	1.00
1.01 - 1.25	1.25
1.26 - 1.50	1.50
1.51 - 1.75	1.75
1.76 - 2.00	2.00
2.01 - 2.25	2.25
2.26 - 2.50	2.50
2.51 - 2.75	2.75
2.76 - 3.00	3.00

APPENDIX 3.4M

RECLAMATION SEDIMENT PONDS CALCULATIONS

REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH

2/2/94

SOIL EROSION TO POND 011

– USE MODIFIED UNIVERSAL SOIL LOSS EQUATION:

$A = R \cdot K \cdot LS \cdot VM$ (ISRAELSEN, et al., 1984)

A = SOIL LOSS PER UNIT AREA.
R = RAINFALL FACTOR
K = SOIL ERODIBILITY FACTOR
LS = TOPOGRAPHIC FACTOR
VM = EROSION CONTROL FACTOR.

R = 11 (MEAN ANNUAL R VALUE FROM FIGURE 1, ISRAELSEN, et, al., 1984)

K = 0.15 (ISRAELSEN, et, al., 1984)

SUB AREA CGWS-R3 (NORTH OF POND 011 AREA)

$$LS = \left(\frac{650 + 450S + 65S^2}{10{,}000 + S^2}\right)\left(\frac{\ell}{72.6}\right)^m$$ (Clyde, et al, 1984)

S = SLOPE = 5.0%

ℓ = SLOPE LENGTH = 450' ok

m = 0.5 (FOR SLOPES : >5%) (ISRAELSEN, et al., 1984)

$$LS = \left(\frac{650 + 450(5.0) + 65(5.0)^2}{10000 + (5.0)^2}\right)\left(\frac{450}{72.6}\right)^{0.5}$$

LS = 1.12

VM = 0.54 (TABLE 3, ISRAELSEN, et al, 1984)

↳ BASED ON BARE SOIL CONDITIONS, SEED + FERTILIZER AFTER SIX MONTHS

A = R · K · LS · VM.

A = (11)(0.15)(1.12)(0.54) = 1.0 TONS/AC/YR.

FOR AREA = 7.36 ACRES
UNIT WEIGHT OF SOIL = 90 PCF

$A = 1.0 \frac{\text{TONS}}{\text{ACRE} \cdot \text{YR}} \times 7.36 \text{ ACRES} \times \frac{2000 \text{ lbs}}{1 \text{ TON}} \times \frac{\text{FT}^3}{90 \text{ lbs}}$

$\boxed{A = 164 \text{ FT}^3/\text{yr}}$

SUB AREA CGWS - R3 (SOUTH + EAST OF POND 011 AREA)

R = 11
K = 0.15

LS : SLOPE = $\frac{6228 - 6150}{1100'}$ = 7.6%

ℓ = 1000' ✓

m = 0.5 (Clyde, et al., 1978)

$LS = \left(\frac{650 + 450(8.0) + 65(8.0)^2}{10{,}000 + (8.0)^2}\right)\left(\frac{1000}{72.6}\right)^{0.5} = 3.10$

VM = 0.54 (TABLE 3, ISRAELSEN et. al, 1984)

A = R · K · LS · VM

A = (11)(0.15)(3.10)(0.54) = 2.76 TONS/ACRE/YEAR

AREA = 4.2 ACRES

UNIT WT OF SOIL ≅ 90 #/FT³

$A = 2.76 \frac{\text{TONS}}{\text{ACRE} \cdot \text{YR}} \times 4.2 \text{ ACRES} \times \frac{2000 \text{ lbs}}{\text{TON}} \times \frac{\text{FT}^3}{90 \text{ lbs}}$

$\boxed{A = 258 \frac{\text{FT}^3}{\text{YR}}}$

CGWS - U8

$R = 11$ $S = 60\%$ $\ell = 500'$

$K = 0.15$ $m = 0.5$

$$LS = \left(\frac{650 + 450(60.0) + 65(60.0)^2}{10{,}000 + (60)^2}\right)\left(\frac{500}{72.6}\right)^{0.5}$$

$LS = 50.5$

$VM = 0.01$ → BASED ON SEEDLINGS ; PERMANENT, AFTER 12 MONTHS (TABLE 3, ISRAELSEN et al, 1984)

$A = R \cdot K \cdot LS \cdot VM$

$A = (11)(0.15)(50.5)(0.01) = 0.83$ TONS/ACRE/YEAR

AREA = 4.04 ACRES

UNIT WT OF SOIL ≅ 90 #/ft³

$$A = 0.83 \frac{\text{TONS}}{\text{ACRE} \cdot \text{YR}} \times \frac{2000 \text{ lbs}}{\text{TON}} \times \frac{\text{ft}^3}{90 \text{ lbs}} \times 4.04 \text{ ACRES}$$

$$\boxed{A = 75 \text{ ft}^3/\text{YEAR.}}$$

CGWS-U9

R = 11 FT TONS / ACRE / 1HR.

K = 0.15

LS: SLOPE = 83%

ℓ = 1000

m = 0.5 (ISRAELSEN, et al., 1984)

$$LS = \left(\frac{650 + 450(83) + 65(83)^2}{10{,}000 + (83)^2}\right)\left(\frac{1000}{72.6}\right)^{0.5}$$

LS = 107

VM = 0.01 (TABLE 3, ISRAELSEN, et al., 1984)

A = R. K. LS. VM.

A = (11) (0.15) (107) (0.01) = 1.77 TONS/ACRE/YR.

AREA = 29.38 ACRES

UNIT WT OF SOIL ≅ 90 #/ft³

$$A = 1.77 \times 29.38 \times \frac{2000^{\#}}{TON} \times \frac{1}{90\ pcf}$$

$$\boxed{A = 1156\ ft^3/YEAR}$$

TOTAL SEDIMENT TO POND 011

$= R3_D + R3_L + U8 + U9$

$= 164 + 258 + 75 + 1156$

$= 1653$

3 YEAR SEDIMENT STORAGE = 4959 FT^3

RUNOFF VOLUME - POND 011

10-YR, 24-HOUR STORM = 1.8 in

CN = 75 FOR UNDISTURBED AREA

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad P > 0.2S$$ (BARFIELD et al, 1983)

$$S = \frac{1000}{CN} - 10 = \frac{1000}{75} - 10 = 3.33$$

P = 1.8 in

$$Q = \frac{(1.8 - 0.2(3.33))^2}{(1.8 + 0.8(3.33))} = 0.288 \text{ in} = 0.024 \text{ FT.}$$

UNDISTURBED AREA = 33.42 ACRES. (U8, U9)

RUNOFF VOLUME = (0.024 FT) (33.42 ACRES) $\left(43560 \frac{FT^2}{ACRE}\right)$

$\boxed{\text{UNDISTURBED AREA RUNOFF VOLUME} = 34{,}939 \text{ FT}^3}$

CN = 80 FOR RECLAIMED (DISTURBED AREA)

$$S = \frac{1000}{CN} - 10 = \frac{1000}{80} - 10 = 2.5$$

$$Q = \frac{(1.8 - 0.2(2.5))^2}{1.8 + 0.8(2.5)} = 0.44 \text{ in} = 0.037 \text{ FT.}$$

RECLAIMED (DISTURBED AREA) = 11.58 ACRES

V = (.037)(11.58)(43560)

$\boxed{\text{RECLAIMED AREA RUNOFF VOLUME} = 18{,}664 \text{ FT}^3}$

TOTAL RUNOFF :

FROM { UNDISTURBED AREA : 34939 FT^3
RECLAIMED AREA : 18664 FT^3

TOTAL RUNOFF = 53,603 FT^3

TOTAL SEDIMENT + RUNOFF = 4959 FT^3 (Sed)
+ 53,603 FT^3 (Runoff)
58,562 FT^3

POND 011
TOTAL SEDIMENT + RUNOFF = 58,562 FT^3

TOTAL REQUIRED SEDIMENT + RUNOFF VOLUME FOR POND 011 IS 58,562 CUBIC FEET. THE ACTUAL VOLUME OF POND 011 WAS PREVIOUSLY DETERMINED TO BE 44,505. THUS POND 011 MUST BE ENLARGED.

SOIL EROSION TO POND 012

SUB AREA COWS-U2

$R = 11$
$K = 0.15$ } (ISRAELSEN, et al., 1984)

$$LS = \frac{(650 + 450\,S + 65\,(S)^2)}{10000 + S^2}\left(\frac{l}{72.6}\right)^m$$

$S = 42$ %

$l = 1100$ FT

$m = 0.5$

$$LS = \left(\frac{650 + 450\,(42) + 65\,(42)^2}{10000 + (42)^2}\right)\left(\frac{1100}{72.6}\right)^{0.5}$$

$LS = 44.5$

$Um = 0.01$ (TABLE 3, ISRAELSEN. et al., 1984)

$A = R \cdot K \cdot LS \cdot Um$

$A = (11)(0.15)(44.5)(0.01) = 0.73$ TONS/ACRE/YEAR

AREA = 5.96 ACRES

UNIT WT OF SOIL ≈ 90 # / ft³

$A = 0.73 \times 5.96 \times 2000 \times 1/90$

$A = 97$ ft³ / YEAR

SUB AREA CGWS-U1D

R = 11
K = 0.15

LS : S = 52.0 %
ℓ = 350 FT
m = 0.5

$$LS = \left(\frac{650 + 450(52.0) + 65(52.0)^2}{10000 + (52.0)^2}\right)\left(\frac{350}{72.6}\right)^{0.5}$$

LS = 34.5

Vm = 0.01 (TABLE 3, ISRAELSEN et al., 1984)

A = R.K.LS.Vm

A = (11)(0.15)(34.5)(0.01) = 0.57 TONS/ACRE/YEAR.

AREA = 3.95 ACRES
UNIT WT OF SOIL = 90 # /ft³
A = 0.57 x 3.95 x 2000 x 1/90

A = 50 ft³/YR

SUB AREA CGWS-R1

R = 11 S = 14.7 % m = 0.5
K = 0.15 ℓ = 900 FT

$$LS = \left(\frac{650 + 450(4.7) + 65(4.7)^2}{10000 + (4.7)^2}\right)\left(\frac{900}{72.6}\right)^{0.5}$$

LS = 1.48

Vm = 0.54 (TABLE 3, ISRAELSEN et al., 1984)

A = R.K.LS.Vm
A = (11)(0.15)(1.48)(0.54) = 1.31 TONS/ACRE/YEAR.

AREA = 7.05 ACRES
UNIT WT OF SOIL ≃ 90 # / ft³

A = 205 ft³/YEAR

SUB-AREA CGWS-R2 - (SECTION HIGHER THAN HAUL ROAD)

R = 11 LS: S = 55.8 %
K = 0.15 ℓ = 300 FT
m = 0.5

$$LS = \left(\frac{650 + 450(55.8) + 65(55.8)^2}{10000 + (55.8)^2}\right)\left(\frac{300}{72.6}\right)^{0.5} = 35.4$$

Vm = 0.01 (TABLE 3, ISRAELSEN et al., 1984)

A = R·K·LS·Vm
A = (11)(0.15)(35.4)(0.01) = 0.58 TONS/ACRE/YEAR

AREA = 4.78 ACRES
UNIT WT OF SOIL = 90 # / ft³

$\boxed{A = 62 \text{ ft}^3/\text{YEAR}}$

SUB AREA CGWS-R2 - (SECTION LOWER THAN + INCLUDING HAUL ROAD)

R = 11 LS: S = 13.7 %
K = 0.15 ℓ = 1400 FT
m = 0.5

$$LS = \left(\frac{650 + 450(13.7) + 65(13.7)^2}{10000 + (13.7)^2}\right)\left(\frac{1400}{72.6}\right)^{0.5} = 8.20$$

Vm = 0.54 (TABLE 3, ISRAELSEN et al., 1984)

A = R·K·LS·Vm
A = (11)(0.15)(8.20)(0.54) = 7.30 TONS/ACRE/YEAR.

AREA = 17.11 ACRES
UNIT WT OF SOIL = 90 # / ft³

$\boxed{A = 2777 \text{ ft}^3/\text{YEAR.}}$

TOTAL SEDIMENT :

CGWS-U2	=	97	FT³/YEAR
CGWS-U10	=	50	FT³/YEAR
CGWS-R1	=	205	FT³/YEAR
CGWS-R2 (UPPER)	=	62	FT³/YEAR
CGWS-R2 (LOWER)	=	2777	FT³/YEAR
COMBINED TOTAL	=	3191	FT³/YEAR

$\boxed{\text{3 YEAR SEDIMENT STORAGE} = 9573 \text{ FT}^3}$

RUNOFF VOLUME - POND 012

10-YR, 24-HOUR STORM = 1.8 in

CN = 78 FOR UNDISTURBED AREA.

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad P > 0.2S$$ (BARFIELD et al, 1983)

$$S = \frac{1000}{CN} - 10 = \frac{1000}{78} - 10 = 2.82$$

P = 1.8 in

$$Q = \frac{(1.8 - 0.2(2.82))^2}{1.8 + 0.8(2.82)} = 0.38 \text{ in} = 0.031 \text{ FT.}$$

UNDISTURBED AREA = CGWS-U2 = 5.96 AC
CGWS-U10 = 3.95 AC
= 9.91 AC

RUNOFF VOLUME = (0.031 FT)(9.91 AC)(43560 FT²/ACRE)

UNDISTURBED AREA RUNOFF VOLUME = 13,382 FT³

CN = 80 FOR RECLAIMED (DISTURBED AREA)

$$S = \frac{1000}{CN} - 10 = \frac{1000}{80} - 10 = 2.5$$

$$Q = \frac{(1.8 - 0.2(2.5))^2}{1.8 + 0.8(2.5)} = 0.44 \text{ in} = 0.037 \text{ FT.}$$

RECLAIMED (DISTURBED AREA) =

CGWS-R1 = 7.05 AC
CGWS-R2 = 21.89 AC
TOTAL = 28.94 AC

RUNOFF VOLUME = (0.037 FT)(28.94 AC)(43560 FT²/AC)

RECLAIMED AREA RUNOFF VOLUME = 46,643 FT³

TOTAL RUNOFF :

FROM { UNDISTURBED AREA : 13,382 FT^3
RECLAIMED AREA : 46,643 FT^3

TOTAL RUNOFF = 60025 FT^3

TOTAL SEDIMENT + RUNOFF :

SEDIMENT = 9 573 FT^3
RUNOFF = 60,025 FT^3
69598 FT^3

POND 012B
TOTAL SEDIMENT + RUNOFF = 69,600 FT^3

RUNOFF VOLUME - POND 013

10-YR, 24-HR = 1.8 in

CN = 75 FOR UNDISTURBED AREA

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad P > 0.2S \text{ (TSCHEFFIELD et al., 1983)}$$

$$S = \frac{1000}{CN} - 10 = \frac{1000}{75} - 10 = 3.33$$

P = 1.8 in

$$Q = \frac{(1.8 - 0.2(3.33))^2}{(1.8 + 0.8(3.33))} = 0.288 \text{ in} = 0.024 \text{ FT}$$

UNDISTURBED AREA = 59.6 AC

RUNOFF VOLUME = (0.024 FT)(59.6 AC)(43560 FT²/AC)

UNDISTURBED AREA RUNOFF VOLUME = 62,300 FT³

CN = 80 FOR RECLAIMED AREAS

$$S = \frac{1000}{CN} - 10 = \frac{1000}{80} - 10 = 2.5$$

$$Q = \frac{(1.8 - 0.2(2.5))^2}{1.8 + 0.8(2.5)} = 0.44 \text{ in} = 0.037 \text{ FT.}$$

RECLAIMED (DISTURBED AREA) = 24.12 AC.

RUNOFF VOLUME = (0.037 FT)(24.12 AC)(43560 FT²/AC)

RECLAIMED AREA RUNOFF VOLUME = 38900 FT³

TOTAL RUNOFF:

UNDISTURBED AREA = 62,300 FT³
RECLAIMED AREA = 38,900 FT³

TOTAL RUNOFF = 101,200 FT³

RE-DESIGN OF POND 011 FOR RECLAMATION CONDITIONS

Stage-Area-Capacity Data (Proposed Structure)

	Elev. (ft)	Stage (ft)	Area (ft^2)	Δ Vol. (ft^3)	Cum. Vol. (ft^3)
	81	0	684		0
				894	
	82	1	1100		894
				2700	
	84	3	1600		3594
				3920	
	86	5	2320		7514
				5332	
	88	7	3012		12,846
				6872	
	90	9	3860		19,718
				8432	
	92	11	4572		28,150
				10,252	
spillway crest	94	13	5680		38,402
				12,512	
	96	15	6832		50,914
				7292	
→	97	16	7752		58,206
				8284	
Primary	98	17	8816		66,490
				9408	
	99	18	10,000		75,898

Note: Elev. relative to 100.0 on top of embankment (see As-Built Drawing)

See drawing on page 2 of this calc.

Stage-Capacity Curve → See pg 3 of this calc.

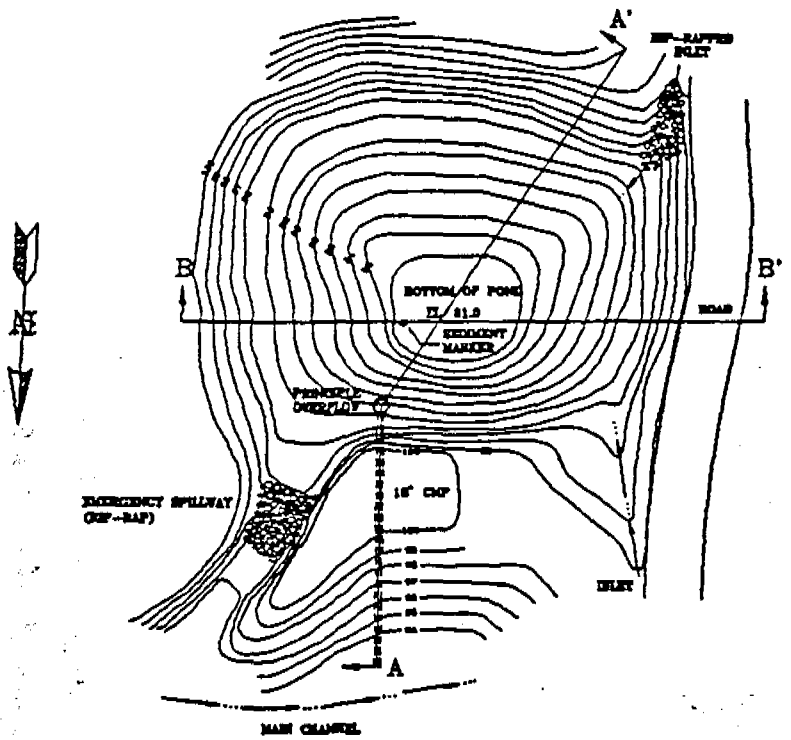
Required Storage Volume (see previous calcs. in this appendix)

Runoff = 53,603 ft^3
3-yr Sed. = 4959 ft^3
Total 58,562

Adequate since 3-yr sed. storage is not a requirement.

POND 011

NOTE: POND 011 WILL BE DEWATERED TO THE MAXIMUM SEDIMENT LEVEL USING A PORTABLE PUMP SYSTEM.



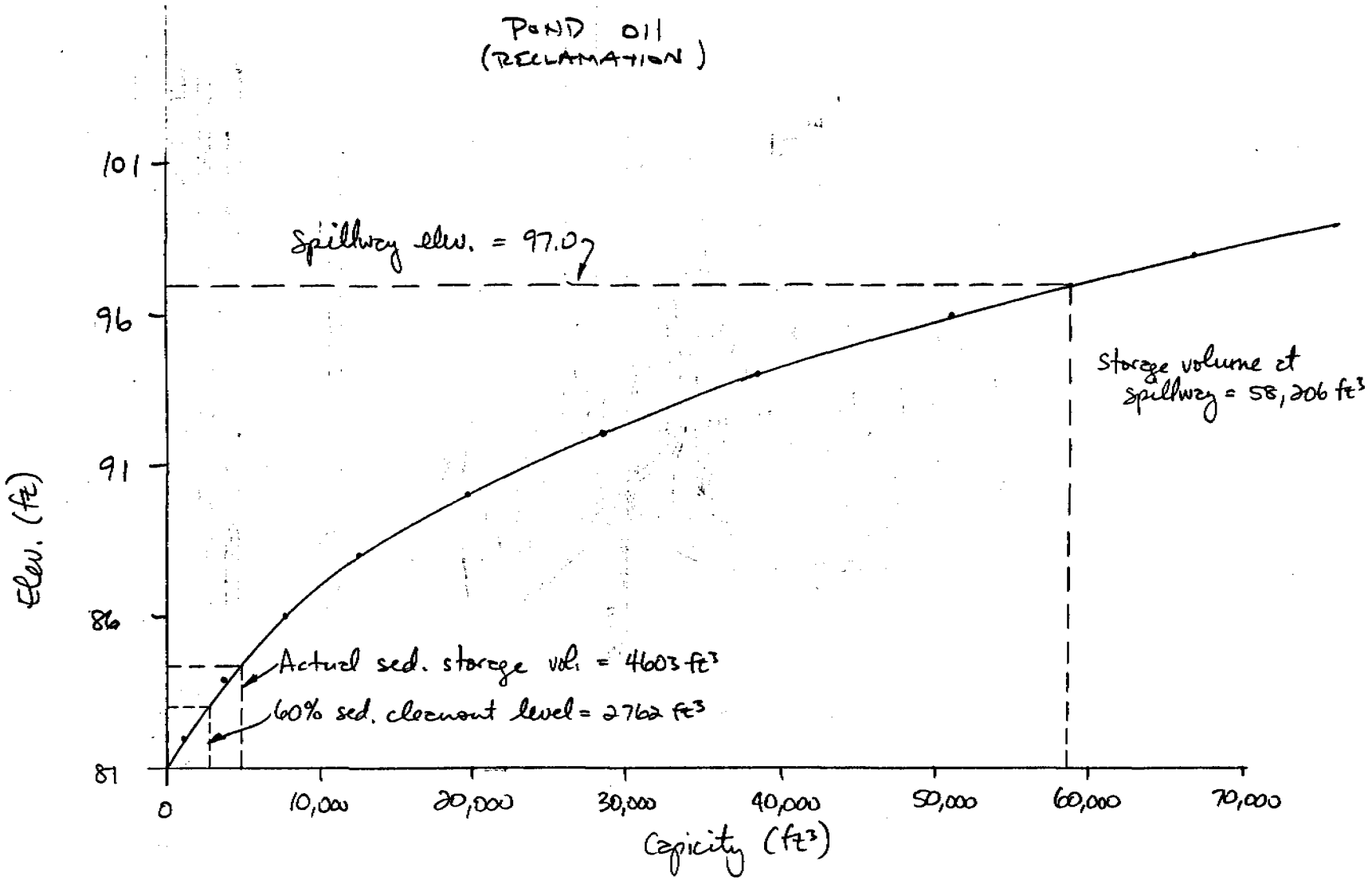
NOTE: ELEVATIONS ARE RELATIVE TO 100.0

MAXIMUM SEDIMENT CAPACITY:	4,603 CUBIC FEET
CAPACITY AT PRINCIPLE OVERFLOW:	58,206 CUBIC FEET
MAXIMUM POND CAPACITY AT SPILLWAY:	66,500 CUBIC FEET

PLAN VIEW

STAGE- CAPACITY CURVE
PREPARATION PLANT

POND 011
(RECLAMATION)



EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT UC-150-18 PAGE 16 OF 60
COMPUTED [illegible] DATE 1 May 92
CHECKED _____ DATE _____

Spillway Adequacy

Methodology → SEDIMOT II

Design storm → 25-yr, 6-hr event (P = 1.6 in)

Storm distribution → SCS Type II

Time increment of outflow hydrograph = 0.1 hr

No. of junctions = 1

No. of branches = 1

Computation mode → hydr. and sed. (to allow flow routing through the pond). Suppress the sed. calcs.

Specific gravity of the eroded sed. = 2.5

Coef. for distributing sed. load = 1.5

Submerged bulk gravity = 1.25

Grain-size distribution:

Size (mm)	% Finer
0.25	100
0.10	50
0.05	35
0.01	19
0.005	15
0.001	6
0.0001	0

Assumed distribution to allow prog. operation only, sed calcs not of interest.

No. of structures → 1 sed. pond

Between structures routing parameters → All Ø

No. of subwatersheds → 2 (reclaimed + undisturbed)

CGWS-R3 ↗ ↖ CGWS-U8 and U9

(see previous calcs in this appendix)

Data for Subwatershed 1 (reclaimed) — CGWS - R3

Area = 11.58 ac

CN = 80

T_c = 0.301 hr

Sed. yield calcs → All ∅

Data for Subwatershed 2 (undisturbed) — CGWS-U8 and CGWS-U9

Area = 33.42 ac

CN = 75

T_c → use T_c for CGWS-U9 + travel time from outlet of U9 to pond

$(T_c)_{U9}$ = 0.102 hr

U9 to pond → 1500 ft @ 1.7% slope ⇒ V = 2.6 ft/s (see pg 6 of this calc.)

$$\frac{1500 \text{ ft}}{2.6 \text{ ft/s}} = 577 \text{ sec}$$
$$= 0.160 \text{ hr}$$

$$T_c = 0.102 \text{ hr} + 0.160 \text{ hr}$$
$$= \underline{\underline{0.262 \text{ hr}}}$$

Sed. yield calcs. → all parameters = ∅

Pond parameters:

Dead space → Assume = 20%

Outflow withdrawal → surface

Inflow → mixed (completely)

Stage-area data → see pg 1 of this calc. Program assumes pond full to spillway crest prior to storm.

No. of cont. stirred reactors → 2

19/60

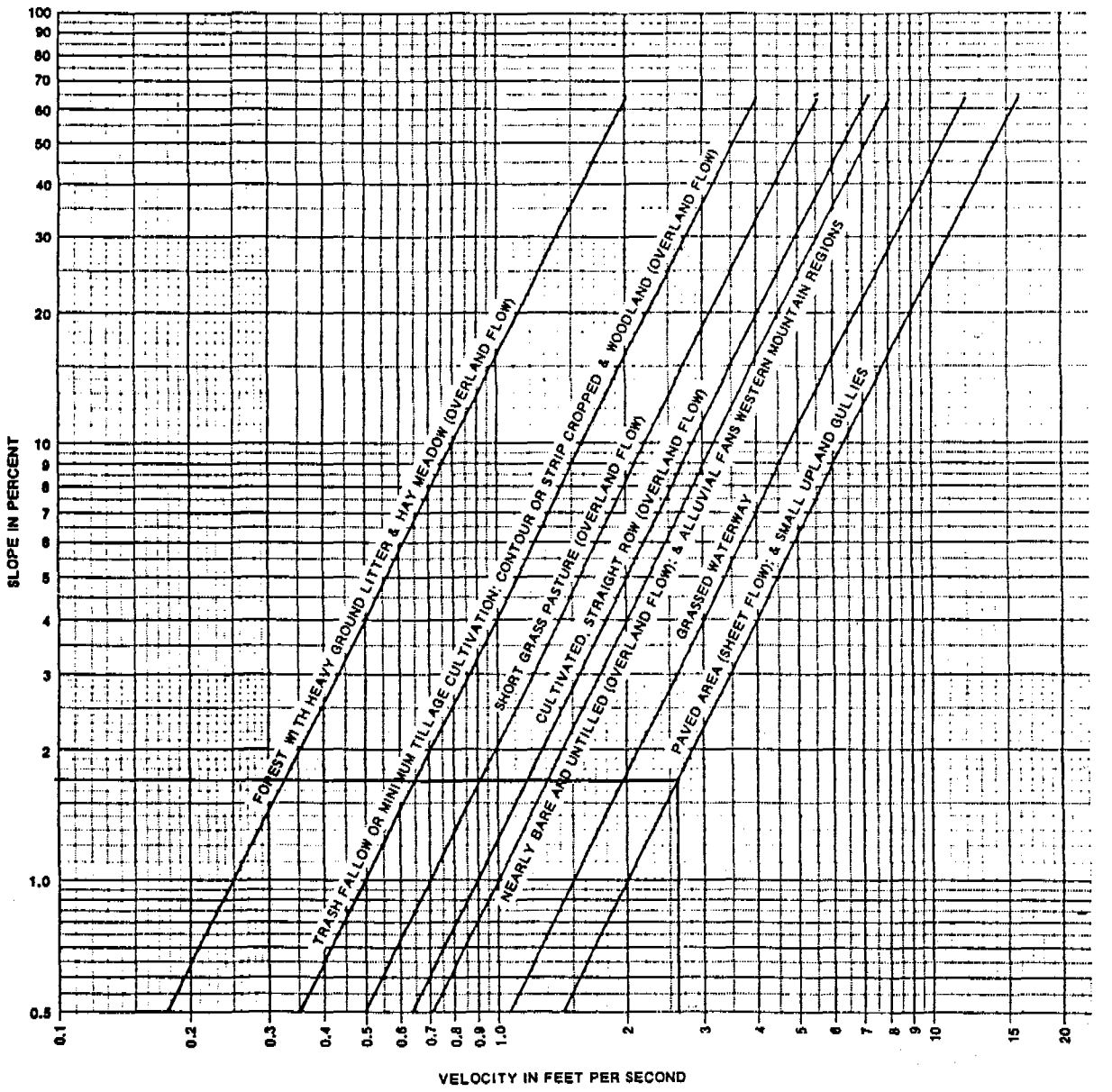


Figure 15.2.--Velocities for upland method of estimating T_c

Source → NEH-4

```
*****************************************************************
                        -- SEDPC --
              SEDIMOT II MODEL FOR THE IBM PC/XT
              CONVERTED BY TECH ENGINEERING INC.
                 VERSION 1.10 NOVEMBER 17,1983
*****************************************************************
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UNIVERSITY OF KENTUCKY COMPUTER MODEL
OF SURFACE MINE HYDROLOGY AND SEDIMENTOLOGY
FOR MORE INFORMATION CONTACT THE AGRICULTURAL
ENGINEERING DEPARTMENT

THE UK MODEL IS A DESIGN MODEL DEVELOPED TO PREDICT
THE HYDRAULIC AND SEDIMENT RESPONSE FROM SURFACE
MINED LANDS FOR A SPECIFIED RAINFALL EVENT (SINGLE STORM)

VERSION DATE 9-23-83

DISCLAIMER: NEITHER THE UNIVERSITY NOR ANY OF ITS EMPLOYEES
ACCEPT ANY RESPONSIBILITY OR LEGAL LIABILITY FOR THE
CONCLUSIONS DRAWN FROM THE RESULTS OF THIS MODEL

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*****************************************************************
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*****************************************************************
*                                                               *
*     THE FOLLOWING VALUES ARE NOW PREDICTED BY SEDIMOT II.     *
*     THEY CAN BE FOUND IN SUMMARY TABLES.                      *
*      1. PERIOD OF SIGNIFICANT CONCENTRATION                   *
*      2. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      3. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PEAK 24 HOUR PERIOD                            *
*      4. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      5. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PEAK 24 HOUR PERIOD                            *
*                                                               *
*     ALL CONCENTRATIONS ARE IN ML/L.                           *
*                                                               *
*****************************************************************
```

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****

WATERSHED IDENTIFICATION CODE

POND 011, 25-YEAR, 6-HOUR STORM

****

********** INPUT RAINFALL PATTERN **********

VALUE	DEPTH	TIME
1	.00	.00
2	.06	.50
3	.13	1.00
4	.22	1.50
5	.37	2.00
6	.96	2.50
7	1.12	3.00
8	1.25	3.50
9	1.34	4.00
10	1.42	4.50
11	1.48	5.00
12	1.54	5.50
13	1.60	6.00

INPUT PARTICLE SIZE-PERCENT FINER DISTRIBUTIONS

SIZE,MM	.250	.100	.050	.010	.005	.001
	.000					
PCT FINER NO. 1	100.000	50.000	35.000	19.000	15.000	6.000
	.000					

**********INPUT VALUES**********

STORM DURATION	-	6.00	HOURS
PRECIPATION DEPTH	-	1.60	INCHES
SPECIFIC GRAVITY	-	2.50	
LOAD RATE EXPONENT FACTOR	-	1.50	
SUBMERGED BULK SPECIFIC GRAVITY	-	1.25	

* *
JUNCTION 1, BRANCH 1, STRUCTURE 1
* *

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	11.58	80.00	.301	.000	.000	.00	2.0
2	33.42	75.00	.262	.000	.000	.00	3.0

*** SEDIMENT INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	SEG NUM	SOIL K	LENGTH FEET	SLOPE PCT	CP VALUE	PART OPT	SURF COND
1	1	.00	.0	.00	.000	1.0	.0
2	1	.00	.0	.00	.000	1.0	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)	SEDIMENT TONS	DIAM (MM)	DELIVERY RATIO 1	DELIVERY RATIO 2
1	1.81	.34	.00	.042	.664	1.000
2	1.78	.20	.00	.021	.525	1.000

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.8930	ACRE-FT
PEAK DISCHARGE	=	3.0451	CFS
AREA	=	45.0000	ACRES
TIME OF PEAK DISCHARGE	=	2.70	HRS
BETA	=	1.0000	
RAINFALL EROSITIVITY FACTOR	=	7.34	EI UNIT
PEAK CONCENTRATION	=	.00	MG/L
PEAK SETTLEABLE CONCENTRATION	=	.00	ML/L
PEAK SETTLEABLE CONCENTRATION	=	.00	MG/L
TOTAL SEDIMENT YIELD	=	.0000	TONS
REPRESENTATIVE PARTICLE SIZE	=	.0001	MM
TIME OF PEAK CONCENTRATION	=	.00	HRS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-9.30	HRS

VOLUME WEIGHTED AVERAGE SETTLEABLE
CONCENTRATION DURING PERIOD OF

SIGNIFICANT CONCENTRATION	-	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	-	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	-	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	-	.00	ML/L

* *

POND RESULTS

* *

***** CONTROL VARIABLES OPTIONS *****

FLOW	FRACTN	ISDO	NRHP	NSP	NCSTR
3	0	2	500	12	2

***** DROP SPILLWAY INPUTS *****

ENTRANCE LOSS COEFFICIENT	-	1.0000	
BEND LOSS COEFFICIENT	-	.5000	
WEIR COEFFICIENT	-	3.1000	
ORIFICE COEFFICIENT	-	.6000	
MANNING COEFFICIENT	-	.0240	
BARREL DIAMATER	-	15.00	INCHES
RISER DIAMETER	-	15.00	INCHES
LENGTH OF PIPE	-	58.30	FEET
VERTICAL HEAD DROP	-	3.90	FEET

***** BASIN GEOMETRY *****

STAGE (FT)	AREA (ACRES)	AVERAGE DEPTH (FT)	DISCHARGE (CFS)	CAPACITY (ACRES-FT)
.00	.016	.00	.00	.00
1.00	.025	.89	.00	.02
3.00	.037	2.57	.00	.08
5.00	.053	4.09	.00	.17
7.00	.069	5.52	.00	.29
9.00	.089	6.85	.00	.45
11.00	.105	8.17	.00	.65
13.00	.130	9.43	.00	.88
15.00	.157	10.60	.00	1.17
16.00	.178	11.14	.00	1.34
17.00	.202	11.62	5.91	1.53
18.00	.230	12.06	8.36	1.74

***** STORM EVENT SUMMARY *****

TURBULENCE FACTOR	=	1.00	
PERMANENT POOL CAPACITY	=	1.336	ACRE-FT
DEAD STORAGE	=	20.00	PERCENT
TIME INCREMENT OUTFLOW	=	.10	HRS
VISCOSITY	=	.009	CM**2/SEC
INFLOW RUNOFF VOLUME	=	.893	ACRE-FT
OUTFLOW ROUTED VOLUME	=	.893	ACRE-FT
STORM VOLUME DISCHARGED (PLUG FLOW)	=	.893	ACRE-FT
POND VOLUME AT PEAK STAGE	=	1.427	ACRE-FT
PEAK STAGE	=	16.476	FT
PEAK INFLOW RATE	=	3.045	CFS
PEAK DISCHARGE RATE	=	2.815	CFS
PEAK INFLOW SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.0000	ML/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.00	MG/L
STORM AVERAGE EFFLUENT CONCENTRATION	=	.00	MG/L
AVERAGE EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
BASIN TRAP EFFICIENCY	=**********		PERCENT
DETENTION TIME OF FLOW WITH SEDIMENT	=	.39	HRS
DETENTION TIME FROM HYDROGRAPH CENTERS	=	.39	HRS
DETENTION TIME INCLUDING STORED FLOW	=	.39	HRS
SEDIMENT LOAD DISCHARGED	=	.00	TONS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-10.90	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR			

PERIOD	-	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	-	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	-	.00	ML/L

*** RUN COMPLETED ****

SEDIMOT II results → Peak inflow = 3.04 cfs
Peak outflow = 2.82 cfs
Peak stage = 16.48 ft
= 0.48 ft above spillway crest.

Stage of emergency spillway = 17. Thus, emerg. spillway will not flow during the design event.

Freeboard = 18.00 - 16.48
= 1.52 ft (adequate)

RE-DESIGN OF POND 012 FOR RECLAMATION CONDITIONS

Stage - Area - Capacity Data (Proposed Structure)

Elev (ft)	(Stage)	Area (ft²)	Δ vol (ft³)	cum. vol (ft³)
6090	0.0	3696		0
			11,069	
6092	2.0	7373		11,069
			18,855	
6094	4.0	11,482		29,924
			26,711	
6096	6.0	15,229		56,635
			16,382	
6097	7.0	17,534		73,017
			18,687	
6098	8.0	19,840		91,704
			20,993	
6099	9.0	22,145		112,697

(See drawing on pg 2 of this calc.)

Stage - Capacity Curve

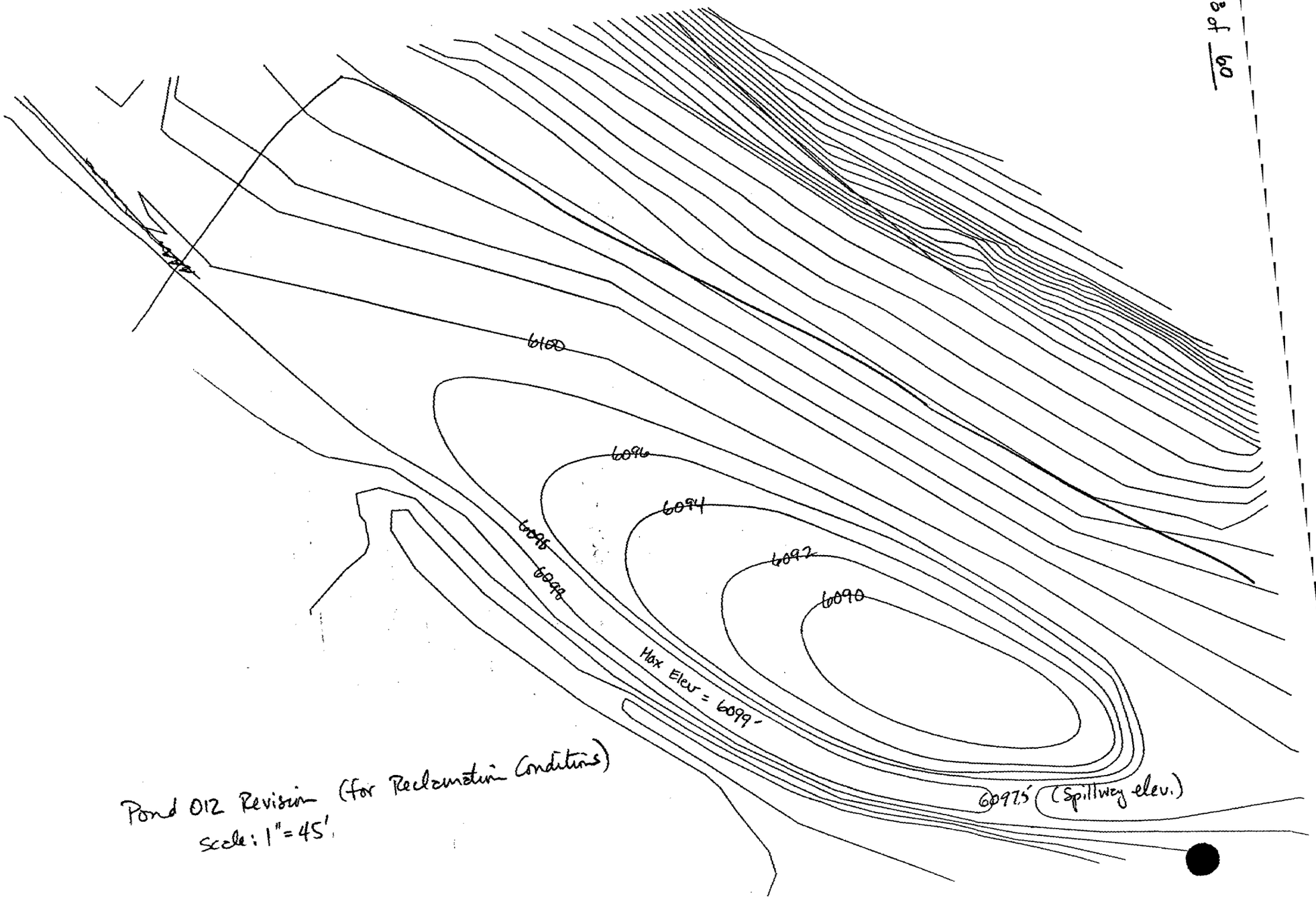
See pg 3 of this calc.

Required Storage Volume

Runoff volume = 60,025 ft³

Sediment volume = 9,573 ft³

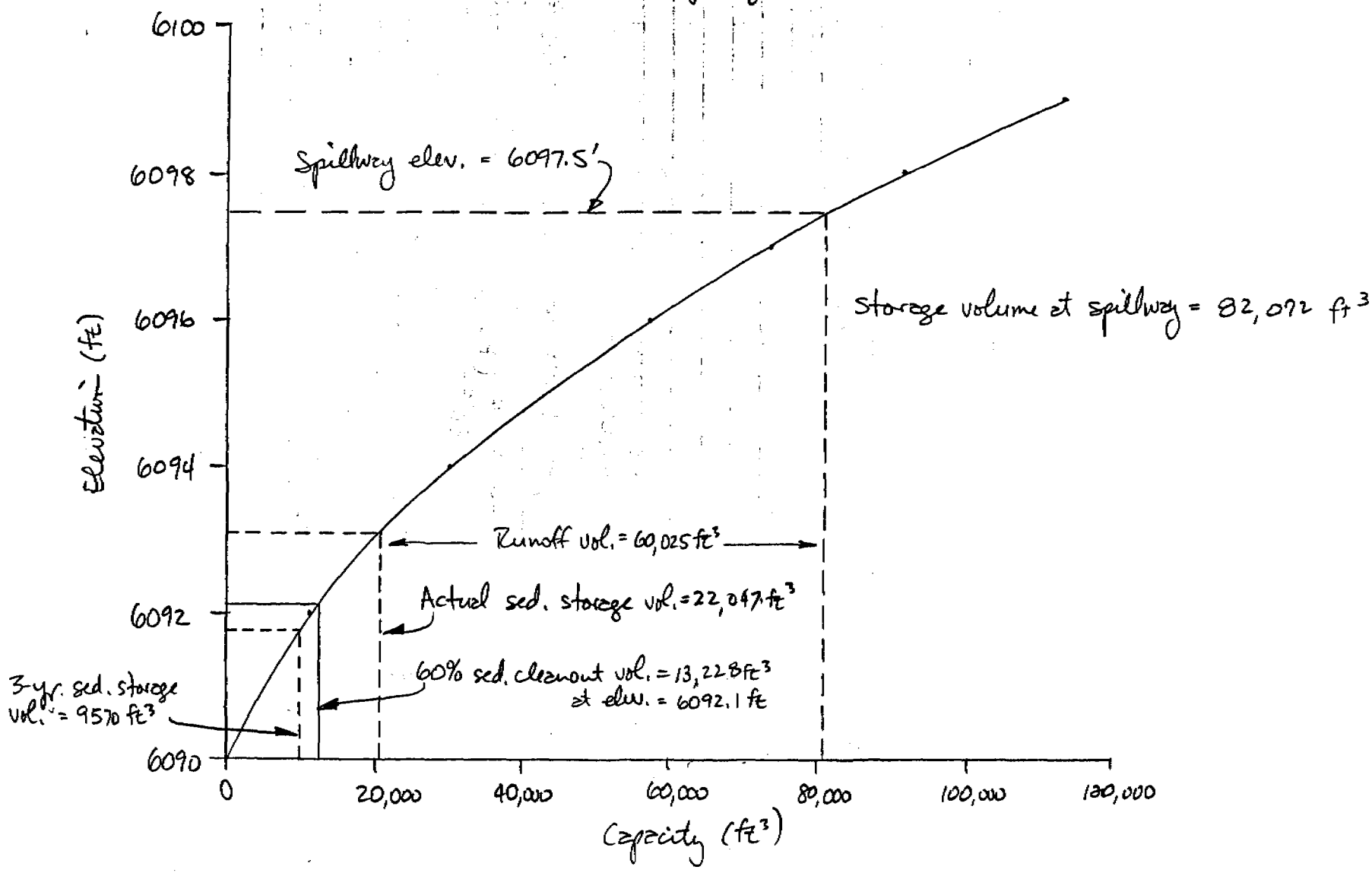
Total ≈ 69,600 ft³ (see previous calcs. in this appendix)



Pond 012 Revision (for Reclamation Conditions)
Scale: 1" = 45'

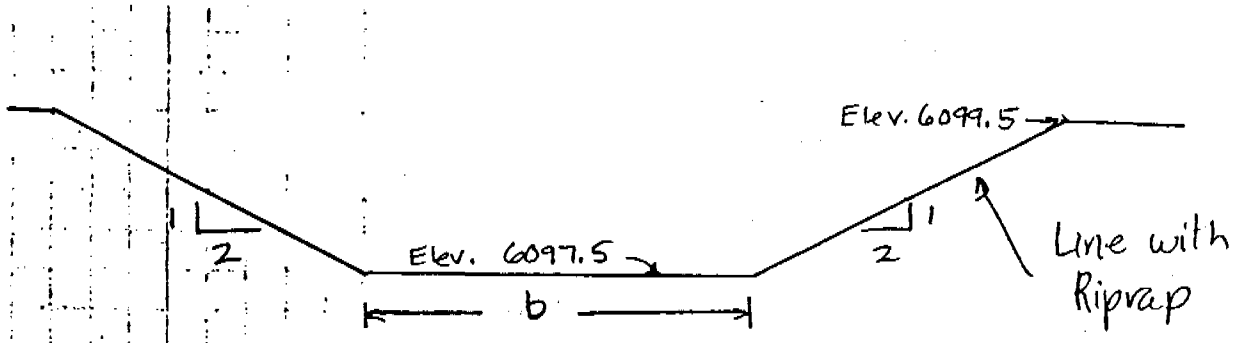
Pond 012 (Revised)

Stage - Capacity Curve



Spillway Capacity

Pond will be constructed to retain existing Pond 012B spillway. From the Pond 012B calcs dated February 1991:



Assume $D_{50} \sim 12''$ to calculate manning's $n \Rightarrow$

$n = .0395\, D_{50}^{1/6}$ (Barfield et al, 1983)

$n = .0395\,(1)^{1/6} = .0395$

Calculate a stage-discharge curve for the spillway channel:

Based on a 100-foot wide rectangular section $\Rightarrow$

$q_r = (.544)\, g^{1/2} (H_{ec})^{1.5} (100)$ (Barfield et al, 1983)

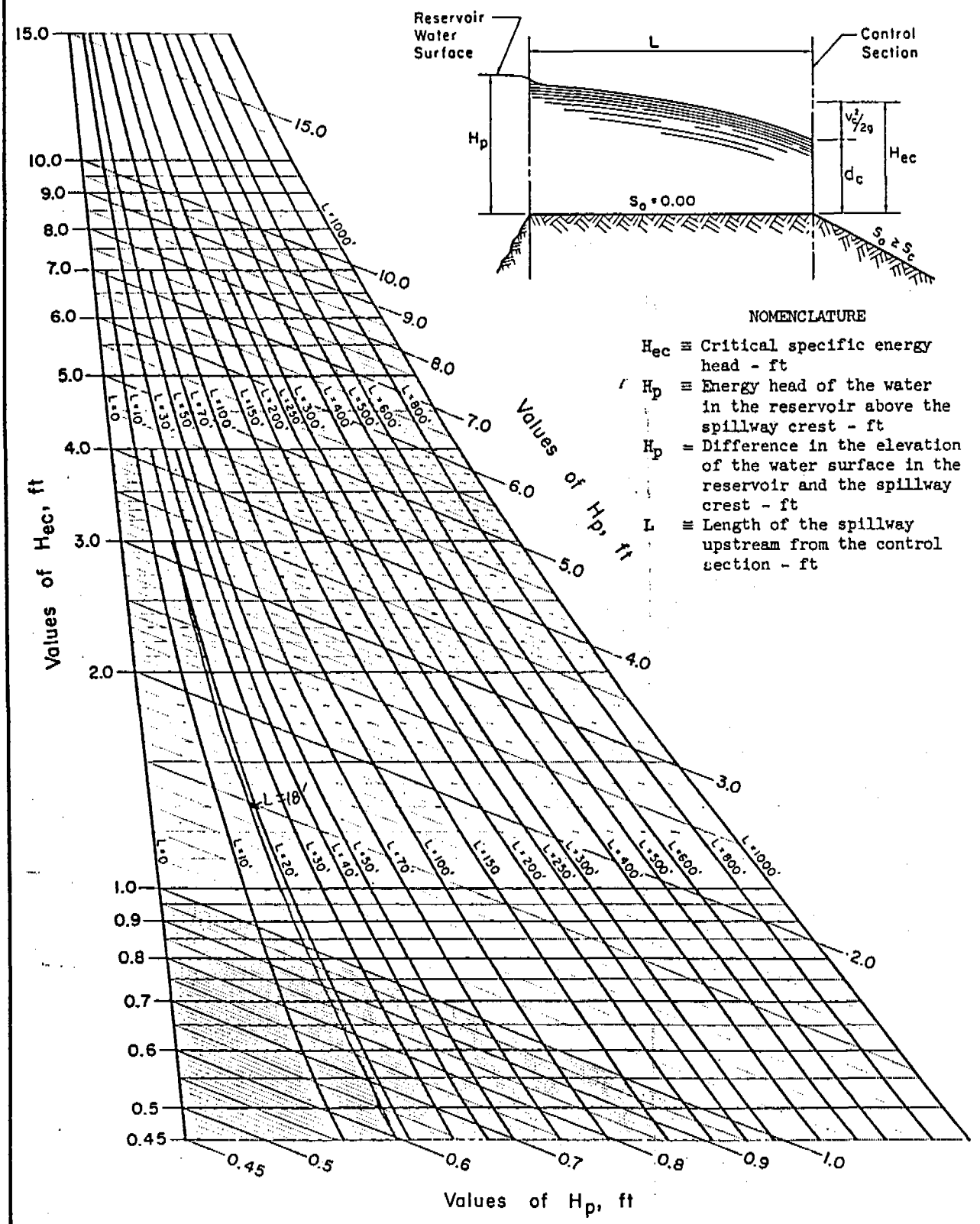
$= 308.69\, H_{ec}^{1.5}$

Using Attached Figure: (pg 5 of this calc.) $L = 18'$

H_p (ft)	H_{ec} (ft)	q_r (ft^3/s)
.6	.45	93.2
.8	.64	158.0
1.0	.83	233.4
1.2	1.04	327.4
1.4	1.28	447.1
1.5	1.32	468.1
2.0	1.80	745.5

31/60

SPILLWAYS: H_{ec} vs H_p for Various Lengths, L	b = 100 ft z = 2 n = 0.04	Case 1



NOMENCLATURE

H_{ec} ≡ Critical specific energy head - ft

H_p ≡ Energy head of the water in the reservoir above the spillway crest - ft

H_p = Difference in the elevation of the water surface in the reservoir and the spillway crest - ft

L ≡ Length of the spillway upstream from the control section - ft

REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION - DESIGN UNIT	STANDARD DWG. NO. ES- 171 SHEET 1 OF 10 DATE 2-67

Convert to a trapezoidal section using the equation

$$q_{trap} = \left[(1.5b + zH_{ec})/150\right](q_r)$$

where $b = 8'$

$z = 2:1 = 2$

(Stage)	Elev. (ft)	H_{ec} (ft)	q_r (ft^3/s)	q_{trap} (ft^3/s)
7.5	6097.5	0	0	0
8.1	6098.1	0.45	93.2	5.2
8.3	6098.3	0.64	158.0	9.2
8.5	6098.5	0.83	233.4	14.2
8.7	6098.7	1.04	327.4	20.9
8.9	6098.9	1.28	447.1	30.0
9.0	6099.0	1.32	468.1	31.6

Adequacy of Spillway Design

Methodology → Use Sedimot II

Design storm → 25-yr, 6-hr storm = 1.6 in (Miller et al., 1973)

Storm distribution → SCS Type B (see distribution on pg 7 of this calc.)

Time increment of outflow hydrograph = 0.1 hr

No. of junctions = 1

No. of branches = 1

Computation mode → hydro. & sed (to allow flow routing – only hydro. output is of concern). Suppress the sed. calcs.

Specific gravity of the eroded sediment = 2.5

Coef. for distributing sed. load = 1.5

Submerged bulk gravity = 1.25

Grain-size distribution:

Size (mm)	% Finer
0.25	100
0.10	50
0.05	35
0.01	19
0.005	15
0.001	6
0.0001	0

Assumed distribution to allow program operation. Sed. calcs not of interest.

RAINFALL DISTRIBUTION - SCS TYPE B - 6 hr

TIME (%)	DEPTH (%)	TIME (hrs)	DEPTH (in)	30 min INTENSITY
0	0	0	0	
				.06
8.33	3.5	0.5	0.06	
				.07
16.67	8.0	1.0	0.13	
				.09
25.0	13.5	1.5	0.22	
				.15
33.33	23.0	2.0	0.37	
				.59
41.67	60.0	2.5	0.96	
				.16
50.0	70.0	3.0	1.12	
				.13
58.33	78.0	3.5	1.25	
				.09
66.67	83.5	4.0	1.34	
				.08
75.0	88.5	4.5	1.42	
				.06
83.33	92.5	5.0	1.48	
				.06
91.67	96.5	5.5	1.54	
				.06
100.0	100.0	6.0	1.60	

No. of structures = 1 (sed. pond)

Between structures routing parameters → All ∅ (no upstream structures or junctions)

No. of subwatersheds = 2 (reclaimed and undisturbed)
CGWS-R1 & CGWS-R2 (See previous calcs in this appendix) CGWS-U10

Data for subwatershed 1 (reclaimed) — CGWS-R1 & CGWS-R2

Area = 28.9 ac

CN = 80

T_c → Use T_c for CGWS-R2 + travel time from outlet of R2 to pond

$(T_c)_{R2} = 0.100$ hr

R2 to pond distance = 700 ft
R2 to pond slope = 1.6%
} V = 2.5 ft/s (see pg 9 of this calc.)
(Paved area equivalent)

$\frac{700 \text{ ft}}{2.5 \text{ ft/s}} = 280$ sec
$= 0.078$ hr

$T_c = 0.100 + 0.078$
$= \underline{\underline{0.178}}$ hr

Subwatershed 2 (CGWS-U10) (Undisturbed)
A = 3.95 ac
CN = 78
$T_c = 0.048$ hr

Sed. yield calcs. → All parameters = ∅ (to suppress output)

Pond parameters:

Dead space → Assume 20%
Outflow withdrawal → surface
Inflow → completely mixed
Stage-area data → see pg 10 of this calc. Program assumes pond full to spillway crest prior to storm.
No. of continuous stirred reactors → 2
Stage-discharge curve → see pg 6 of this calc.

35/60

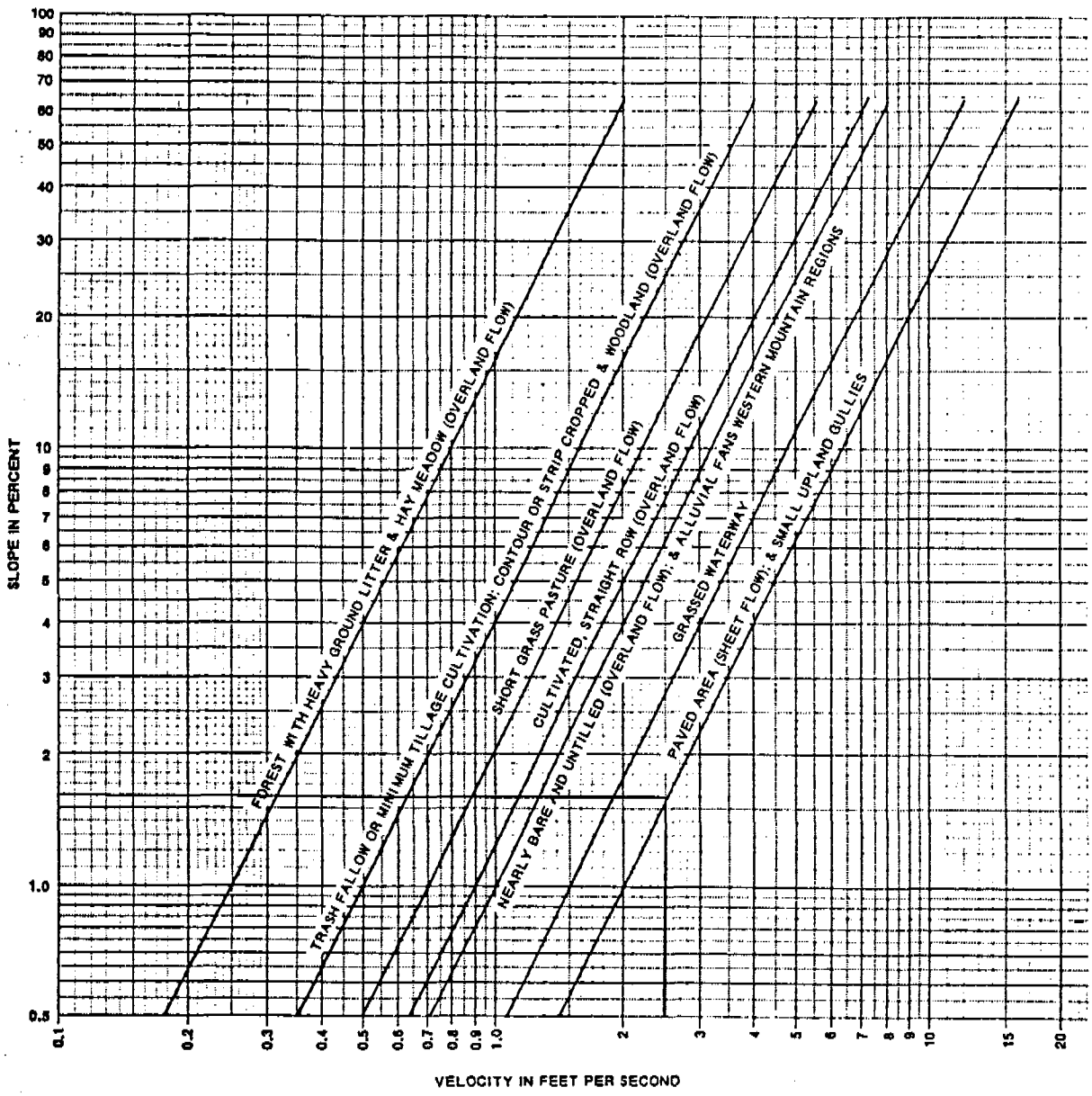


Figure 15.2.—Velocities for upland method of estimating T_c

Source → NEH-4

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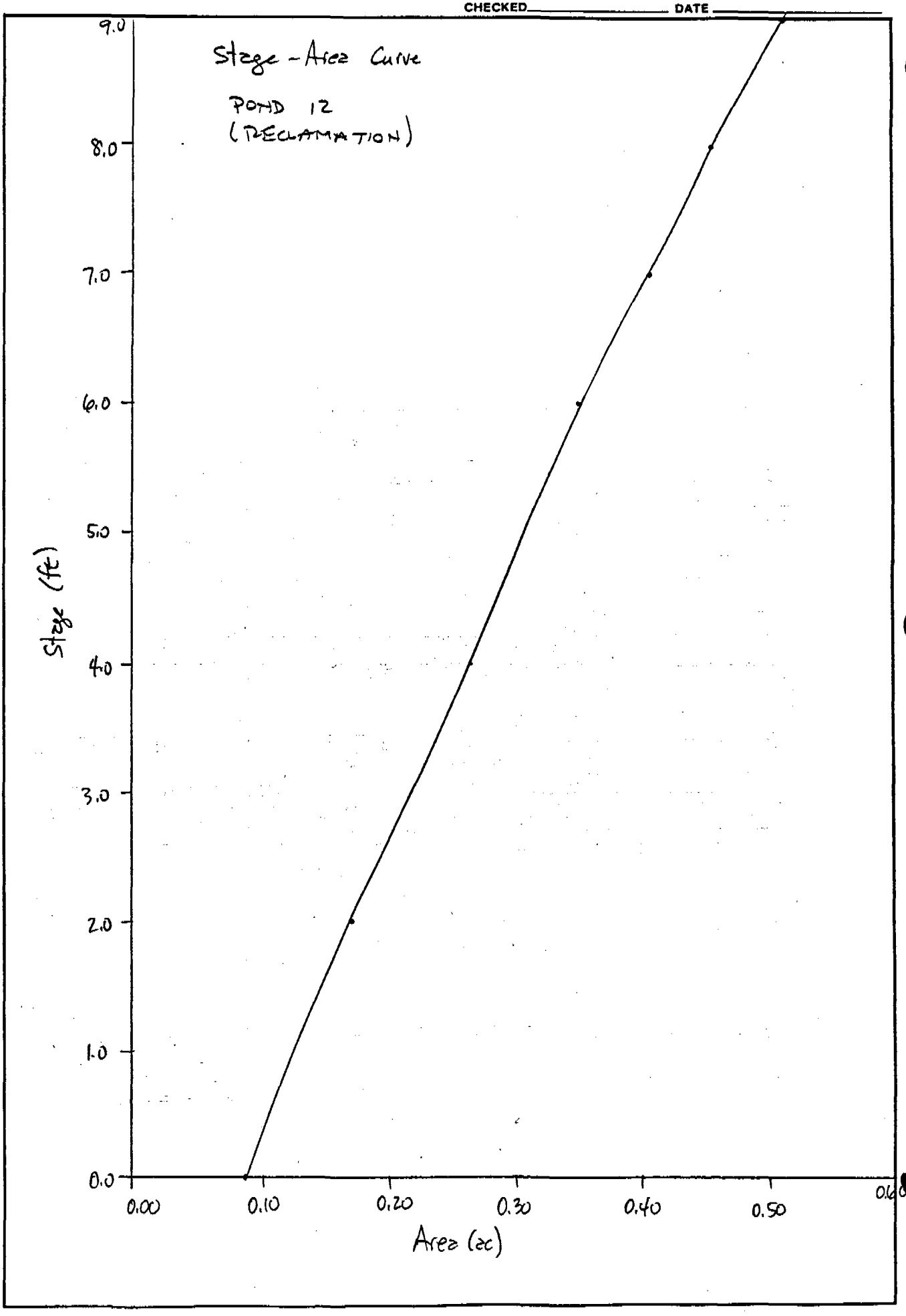
ENGINEERS / SCIENTISTS

PROJECT UC-150-18 PAGE 36 OF 60
COMPUTED RDW DATE 30 Apr 92
CHECKED DATE



```
*****************************************************************
                        -- SEDPC --
              SEDIMOT II MODEL FOR THE IBM PC/XT
              CONVERTED BY TECH ENGINEERING INC.
                 VERSION 1.10 NOVEMBER 17,1983
*****************************************************************


*****************************************************************
*****************************************************************

      UNIVERSITY OF KENTUCKY COMPUTER MODEL
      OF SURFACE MINE HYDROLOGY AND SEDIMENTOLOGY
      FOR MORE INFORMATION CONTACT THE AGRICULTURAL
      ENGINEERING DEPARTMENT

      THE UK MODEL IS A DESIGN MODEL DEVELOPED TO PREDICT
      THE HYDRAULIC AND SEDIMENT RESPONSE FROM SURFACE
      MINED LANDS FOR A SPECIFIED RAINFALL EVENT (SINGLE STORM)

      VERSION DATE 9-23-83

      DISCLAIMER: NEITHER THE UNIVERSITY NOR ANY OF ITS EMPLOYEES
      ACCEPT ANY RESPONSIBILITY OR LEGAL LIABILITY FOR THE
      CONCLUSIONS DRAWN FROM THE RESULTS OF THIS MODEL

*****************************************************************
*****************************************************************


*****************************************************************
*                                                               *
*     THE FOLLOWING VALUES ARE NOW PREDICTED BY SEDIMOT II.     *
*     THEY CAN BE FOUND IN SUMMARY TABLES.                      *
*      1. PERIOD OF SIGNIFICANT CONCENTRATION                   *
*      2. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      3. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PEAK 24 HOUR PERIOD                            *
*      4. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      5. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PEAK 24 HOUR PERIOD                            *
*                                                               *
*     ALL CONCENTRATIONS ARE IN ML/L.                           *
*                                                               *
*****************************************************************


            ********************************************

                 WATERSHED IDENTIFICATION CODE
                 -----------------------------
 POND 012, 25-YEAR, 6-HOUR STORM

            ********************************************
```

********** INPUT RAINFALL PATTERN **********

VALUE	DEPTH	TIME
1	.00	.00
2	.06	.50
3	.13	1.00
4	.22	1.50
5	.37	2.00
6	.96	2.50
7	1.12	3.00
8	1.25	3.50
9	1.34	4.00
10	1.42	4.50
11	1.48	5.00
12	1.54	5.50
13	1.60	6.00

INPUT PARTICLE SIZE-PERCENT FINER DISTRIBUTIONS

SIZE,MM	.250	.100	.050	.010	.005	.001
	.000					
PCT FINER NO. 1	100.000	50.000	35.000	19.000	15.000	6.000
	.000					

**********INPUT VALUES**********

STORM DURATION	=	6.00	HOURS
PRECIPATION DEPTH	=	1.60	INCHES
SPECIFIC GRAVITY	=	2.50	
LOAD RATE EXPONENT FACTOR	=	1.50	
SUBMERGED BULK SPECIFIC GRAVITY	=	1.25	

* *
JUNCTION 1, BRANCH 1, STRUCTURE 1
* *

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	28.94	80.00	.178	.000	.000	.00	2.0
2	3.95	78.00	.048	.000	.000	.00	3.0

*** SEDIMENT INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	SEG NUM	SOIL K	LENGTH FEET	SLOPE PCT	CP VALUE	PART OPT	SURF COND
1	1	.00	.0	.00	.000	1.0	.0
2	1	.00	.0	.00	.000	1.0	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)	SEDIMENT TONS	DIAM (MM)	DELIVERY RATIO 1	DELIVERY RATIO 2
1	5.64	.34	.00	.056	.752	1.000
2	.95	.28	.00	.100	1.000	1.000

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	.9022	ACRE-FT
PEAK DISCHARGE	=	5.9437	CFS
AREA	=	32.8900	ACRES
TIME OF PEAK DISCHARGE	=	2.60	HRS
BETA	=	1.0000	
RAINFALL EROSITIVITY FACTOR	=	7.34	EI UNIT
PEAK CONCENTRATION	=	.00	MG/L
PEAK SETTLEABLE CONCENTRATION	=	.00	ML/L
PEAK SETTLEABLE CONCENTRATION	=	.00	MG/L
TOTAL SEDIMENT YIELD	=	.0000	TONS
REPRESENTATIVE PARTICLE SIZE	=	.0001	MM
TIME OF PEAK CONCENTRATION	=	.00	HRS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-7.00	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

* *

POND RESULTS

* *

***** CONTROL VARIABLES OPTIONS *****

FLOW	FRACTN	ISDO	NRHP	NSP	NCSTR
3	0	1	500	12	2

***** BASIN GEOMETRY *****

STAGE (FT)	AREA (ACRES)	AVERAGE DEPTH (FT)	DISCHARGE (CFS)	CAPACITY (ACRES-FT)
.00	.085	.00	.00	.00
2.00	.169	1.67	.00	.25
4.00	.264	3.22	.00	.69
6.00	.350	4.69	.00	1.30
7.00	.403	5.40	.00	1.68
7.50	.430	5.75	.00	1.89
8.10	.460	6.16	5.20	2.15
8.30	.470	6.30	9.20	2.25
8.50	.484	6.43	14.20	2.34
8.70	.493	6.57	20.90	2.44
8.90	.505	6.70	30.00	2.54
9.00	.508	6.77	31.60	2.59

***** STORM EVENT SUMMARY *****

TURBULENCE FACTOR	=	1.00	
PERMANENT POOL CAPACITY	=	1.886	ACRE-FT
DEAD STORAGE	=	20.00	PERCENT
TIME INCREMENT OUTFLOW	=	.10	HRS
VISCOSITY	=	.009	CM**2/SEC
INFLOW RUNOFF VOLUME	=	.902	ACRE-FT
OUTFLOW ROUTED VOLUME	=	.902	ACRE-FT
STORM VOLUME DISCHARGED (PLUG FLOW)	=	.902	ACRE-FT
POND VOLUME AT PEAK STAGE	=	2.053	ACRE-FT
PEAK STAGE	=	7.876	FT
PEAK INFLOW RATE	=	5.944	CFS
PEAK DISCHARGE RATE	=	3.255	CFS
PEAK INFLOW SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.0000	ML/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.00	MG/L
STORM AVERAGE EFFLUENT CONCENTRATION	=	.00	MG/L
AVERAGE EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
BASIN TRAP EFFICIENCY	=	******	PERCENT
DETENTION TIME OF FLOW WITH SEDIMENT	=	.62	HRS
DETENTION TIME FROM HYDROGRAPH CENTERS	=	.62	HRS
DETENTION TIME INCLUDING STORED FLOW	=	.62	HRS
SEDIMENT LOAD DISCHARGED	=	.00	TONS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-11.30	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

*** RUN COMPLETED ****

Sedimot II results → Peak inflow = 5.94 cfs
Peak outflow = 3.26 cfs
Peak stage = 7.88 ft
= 0.38 ft above spillway crest

Freeboard during design event = 9.00 - 7.88
= 1.12 ft (adequate)

44/60

CASTLEGATE
PREP PLANT
RECLAMATION PHASE I
POND 011

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

POND 011 - EMERGENCY SPILLWAY ONLY

by

Name: ANTHONY MAGLIOCCHINO

Company Name: EarthFax Engineering INC.
File Name: D:\UC150\P011ESON

Date: 08-27-1992

Civil Software Design -- SEDCAD+ Version 3.1
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Company Name: EarthFax Engineering INC.
Filename: D:\UC150\P011ESON User: ANTHONY MAGLIOCCHINO
Date: 08-27-1992 Time: 10:32:32
POND 011 - EMERGENCY SPILLWAY ONLY
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	11.58	80	M	0.301	0.000	0.000	0.0	0.32	1.81
111	2	33.42	75	S	0.262	0.000	0.000	0.0	0.57	1.77
		Type: Pond			Label: POND 011					
111	Structure	45.00							0.89	
111	Total IN	45.00							0.89	3.10
111	Total OUT								0.89	2.96

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Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

POND INPUT/OUTPUT TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 45.0 acres
Total Contributing Drainage Area: 45.0 acres

DISCHARGE OPTIONS:

	Emergency Spillway
Riser Diameter (in)	----
Riser Height (ft)	----
Barrel Diameter (in)	----
Barrel Length (ft)	----
Barrel Slope (%)	----
Manning's n of Pipe	----
Spillway Elevation	----
Lowest Elevation of Holes	----
# of Holes/Elevation	----
Entrance Loss Coefficient	----
Tailwater Depth (ft)	----
Notch Angle (degrees)	----
Weir Width (ft)	----
Siphon Crest Elevation	----
Siphon Tube Diameter (in)	----
Siphon Tube Length (ft)	----
Manning's n of Siphon	----
Siphon Inlet Elevation	----
Siphon Outlet Elevation	----
Emergency Spillway Elevation	98.0
Crest Length (ft)	10.0
Z:1 (Left and Right)	2 2
Bottom Width (ft)	6.0

POND RESULTS:

Permanent Pool (ac-ft)
1.5

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	0.89	3.10
OUT	0.89	2.96

Peak Elevation	Hydrograph Detention Time (hrs)
98.3	0.00

****

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Filename: D:\UC150\P011ESON User: ANTHONY MAGLIOCCHINO
Date: 08-27-1992 Time: 10:32:32
POND 011 - EMERGENCY SPILLWAY ONLY
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-DISCHARGE TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 45.0 acres
Total Contributing Drainage Area: 45.0 acres

Elevation	Emergency Spillway (cfs)	Total Discharge (cfs)
81.00	0.0	0.0
81.50	0.0	0.0
82.00	0.0	0.0
82.50	0.0	0.0
83.00	0.0	0.0
83.50	0.0	0.0
84.00	0.0	0.0
84.50	0.0	0.0
85.00	0.0	0.0
85.50	0.0	0.0
86.00	0.0	0.0
86.50	0.0	0.0
87.00	0.0	0.0
87.50	0.0	0.0
88.00	0.0	0.0
88.50	0.0	0.0
89.00	0.0	0.0
89.50	0.0	0.0
90.00	0.0	0.0
90.50	0.0	0.0
91.00	0.0	0.0
91.50	0.0	0.0
92.00	0.0	0.0
92.50	0.0	0.0
93.00	0.0	0.0
93.50	0.0	0.0
94.00	0.0	0.0
94.50	0.0	0.0
95.00	0.0	0.0
95.50	0.0	0.0
96.00	0.0	0.0
96.50	0.0	0.0
97.00	0.0	0.0
97.50	0.0	0.0
98.00	0.0	0.0

98.50	5.9	5.9
98.60	7.1	7.1
98.70	9.5	9.5
98.80	12.3	12.3
98.90	15.4	15.4
99.00	18.4	18.4

****

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Company Name: EarthFax Engineering INC.
Filename: D:\UC150\P011ESON User: ANTHONY MAGLIOCCHINO
Date: 08-27-1992 Time: 10:32:32
POND 011 - EMERGENCY SPILLWAY ONLY
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-AREA-CAPACITY-DISCHARGE TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 45.0 acres
Total Contributing Drainage Area: 45.0 acres

SW#1: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
81.00	0.00	0.02	0.00	0.00	
81.50	0.50	0.02	0.01	0.00	
82.00	1.00	0.03	0.02	0.00	
82.50	1.50	0.03	0.03	0.00	
83.00	2.00	0.03	0.05	0.00	
83.50	2.50	0.03	0.06	0.00	
84.00	3.00	0.04	0.08	0.00	
84.50	3.50	0.04	0.10	0.00	
85.00	4.00	0.04	0.12	0.00	
85.50	4.50	0.05	0.15	0.00	
86.00	5.00	0.05	0.17	0.00	
86.50	5.50	0.06	0.20	0.00	
87.00	6.00	0.06	0.23	0.00	
87.50	6.50	0.06	0.26	0.00	
88.00	7.00	0.07	0.29	0.00	
88.50	7.50	0.07	0.33	0.00	
89.00	8.00	0.08	0.37	0.00	
89.50	8.50	0.08	0.41	0.00	
90.00	9.00	0.09	0.45	0.00	
90.50	9.50	0.09	0.50	0.00	
91.00	10.00	0.10	0.54	0.00	
91.50	10.50	0.10	0.59	0.00	
92.00	11.00	0.10	0.64	0.00	
92.50	11.50	0.11	0.70	0.00	
93.00	12.00	0.12	0.76	0.00	
93.50	12.50	0.12	0.82	0.00	
94.00	13.00	0.13	0.88	0.00	
94.50	13.50	0.14	0.95	0.00	
95.00	14.00	0.14	1.02	0.00	
95.50	14.50	0.15	1.09	0.00	
96.00	15.00	0.16	1.17	0.00	
96.50	15.50	0.17	1.25	0.00	
97.00	16.00	0.18	1.33	0.00	
97.50	16.50	0.19	1.42	0.00	
98.00	17.00	0.20	1.52	0.00	Stage of SW#1

98.25	17.25	0.20	1.58	2.96	Peak Stage
98.50	17.50	0.22	1.63	5.88	
98.60	17.60	0.22	1.65	7.06	
98.70	17.70	0.22	1.67	9.52	
[illegible].80	17.80	0.22	1.69	12.29	
[illegible].90	17.90	0.23	1.72	15.35	
99.00	18.00	0.23	1.74	18.37	

****

RECLAMATION POND INLETS / OUTLETS
(25-YEAR 6-HOUR STORM EVENT)

	DEPTH (FT)	BOTTOM WIDTH (FT)	SIDE SLOPES H:V	FLOW (CFS)	SLOPE (FT/FT)	DEPTH OF FLOW (FT)	FLOW VELOCITY (FPS)	REQ'D RIPRAP D50 (IN)	EXIST RIPRAP D50 (IN)
POND 011									
N. INLET	2	2.5	2:1	1.8	0.26	0.13	5.1	3"	6
S. INLET	0.83	2	1.2:1	1.7	0.43	0.12	6.4	4"	8
PRINCIPLE OVERFLOW	1.5 ø	–	–	2.82	0.015	0.63	4.0	2"	18 (END OF PIPE)
EMERGENCY SPILLWAY	1.5	6	2:1	2.96	0.33	0.1	5.0	3"	6
POND 012									
N. INLET	1.4	3	3:1	5.94	0.05	0.36	4.1	2"	–
S. INLET									
SPILLWAY	1.0	6	2:1	3.26	0.50	0.09	5.9	4"	9"

n = 0.035 FOR ALL CHANNELS
n = 0.022 FOR POND 011 PRINCIPLE OVERFLOW CULVERT (CMP)

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT LK-150-15 PAGE 52 OF 60
COMPUTED KJH DATE 8/27/92
CHECKED ____ DATE ____

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND 011 - N. INLET

Comment: RECLAMATION POND 011 - NORTH INLET

Solve For Depth

Given Input Data:

Bottom Width.....	2.50 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.2600 ft/ft
Discharge.....	1.80 cfs

Computed Results:

Depth.....	0.13 ft
Velocity.....	5.11 fps
Flow Area.....	0.35 sf
Flow Top Width...	3.01 ft
Wetted Perimeter.	3.07 ft
Critical Depth...	0.24 ft
Critical Slope...	0.0317 ft/ft
Froude Number....	2.63 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND 011 - S. INLET

Comment: RECLAMATION POND 011 - SOUTH INLET

Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	1.20:1 (H:V)
Right Side Slope.	1.20:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.4300 ft/ft
Discharge.....	1.70 cfs

Computed Results:

Depth.....	0.12 ft
Velocity.....	6.43 fps
Flow Area.....	0.26 sf
Flow Top Width...	2.30 ft
Wetted Perimeter.	2.38 ft
Critical Depth...	0.27 ft
Critical Slope...	0.0318 ft/ft
Froude Number....	3.34 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: POND 011 - OUTLET

Comment: RECLAMATION POND 011 - PRINCIPLE OVERFLOW

Solve For Actual Depth

Given Input Data:

Diameter.....	1.50 ft
Slope.....	0.0150 ft/ft
Manning's n.....	0.022
Discharge.....	2.82 cfs

Computed Results:

Depth.....	0.63 ft
Velocity.....	3.98 fps
Flow Area.....	0.71 sf
Critical Depth....	0.64 ft
Critical Slope....	0.0146 ft/ft
Percent Full.....	42.17 %
Full Capacity.....	7.60 cfs
QMAX @.94D.....	8.18 cfs
Froude Number.....	1.02 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND 011 - SPILLWAY

Comment: RECLAMATION POND 011 - EMERGENCY SPILLWAY

Solve For Depth

Given Input Data:

Bottom Width.....	6.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.3300 ft/ft
Discharge.....	2.96 cfs

Computed Results:

Depth.....	0.10 ft
Velocity.....	4.98 fps
Flow Area.....	0.59 sf
Flow Top Width...	6.38 ft
Wetted Perimeter.	6.43 ft
Critical Depth...	0.19 ft
Critical Slope...	0.0321 ft/ft
Froude Number....	2.88 (flow is Supercritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND012 INLET

Comment: RECLAMATION POND 012 - INLET

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.0500 ft/ft
Discharge.....	5.94 cfs

Computed Results:

Depth.....	0.36 ft
Velocity.....	4.05 fps
Flow Area.....	1.47 sf
Flow Top Width...	5.16 ft
Wetted Perimeter.	5.28 ft
Critical Depth...	0.43 ft
Critical Slope...	0.0268 ft/ft
Froude Number....	1.34 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND012 SPILLWAY

Comment: RECLAMATION POND 012 - SPILLWAY OUTLET

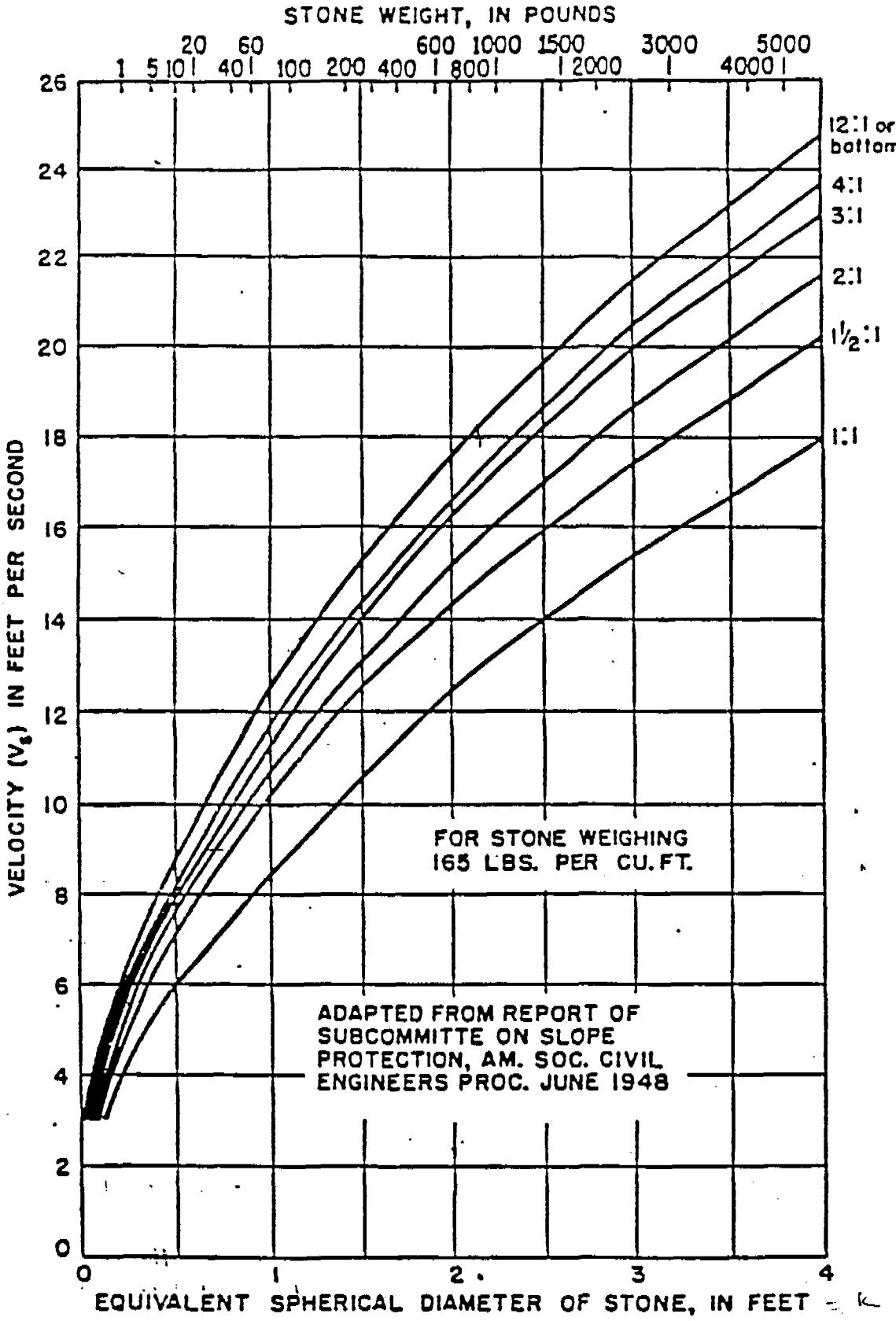
Solve For Depth

Given Input Data:

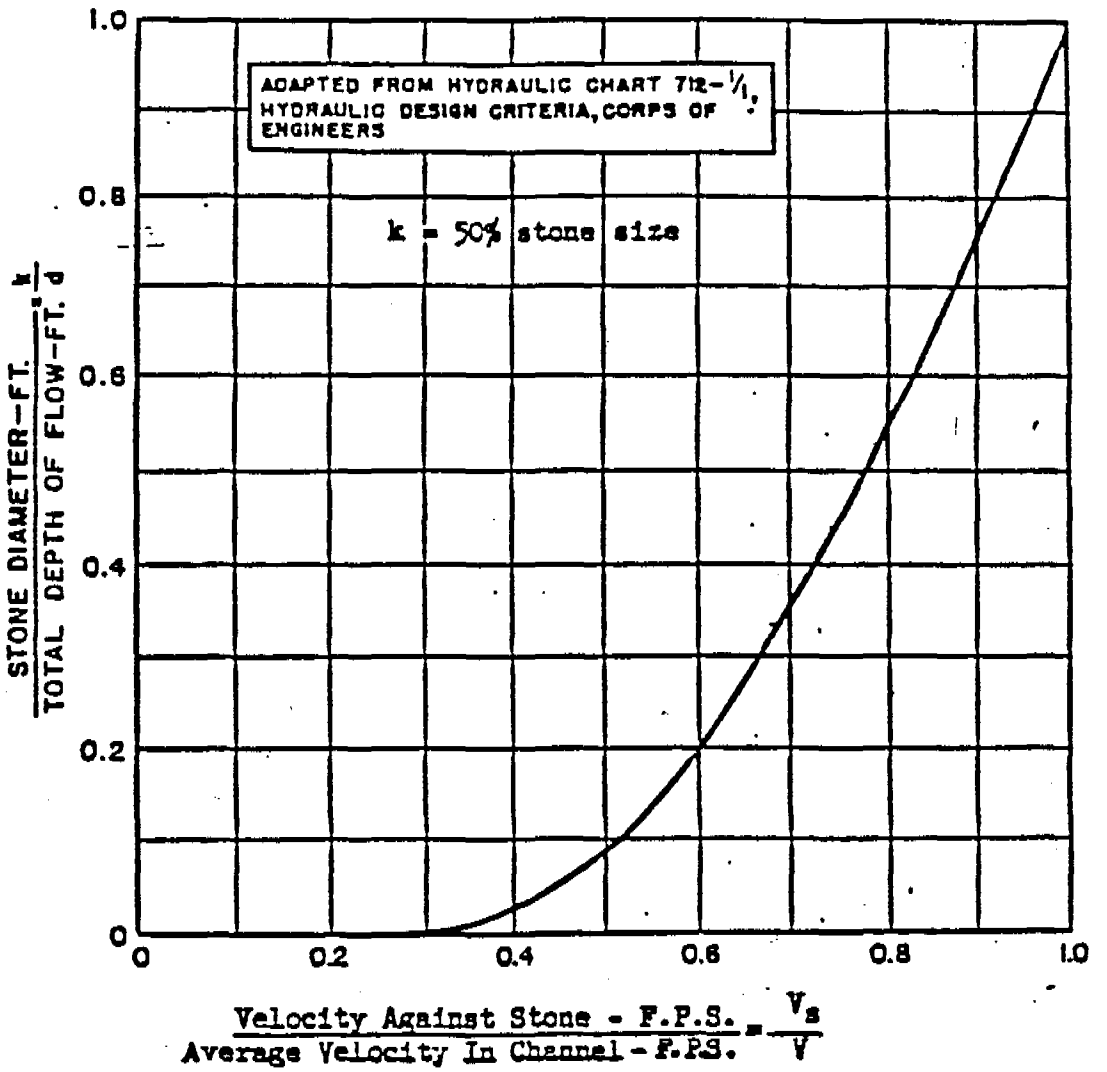
Bottom Width.....	6.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.5000 ft/ft
Discharge.....	3.26 cfs

Computed Results:

Depth.....	0.09 ft
Velocity.....	5.88 fps
Flow Area.....	0.55 sf
Flow Top Width...	6.36 ft
Wetted Perimeter.	6.40 ft
Critical Depth...	0.20 ft
Critical Slope...	0.0315 ft/ft
Froude Number....	3.51 (flow is Supercritical)



SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES



VELOCITY AGAINST STONE ON CHANNEL BOTTOM

TYPICAL DIVERSION/BERM DESIGN.

- DESIGN A DITCH/BERM SYSTEM TO CONVEY THE RUNOFF TO SEDIMENT POND 012
- RUNOFF FROM CGRWS-U9, R3 → 10-YR, 6-HOUR STORM.

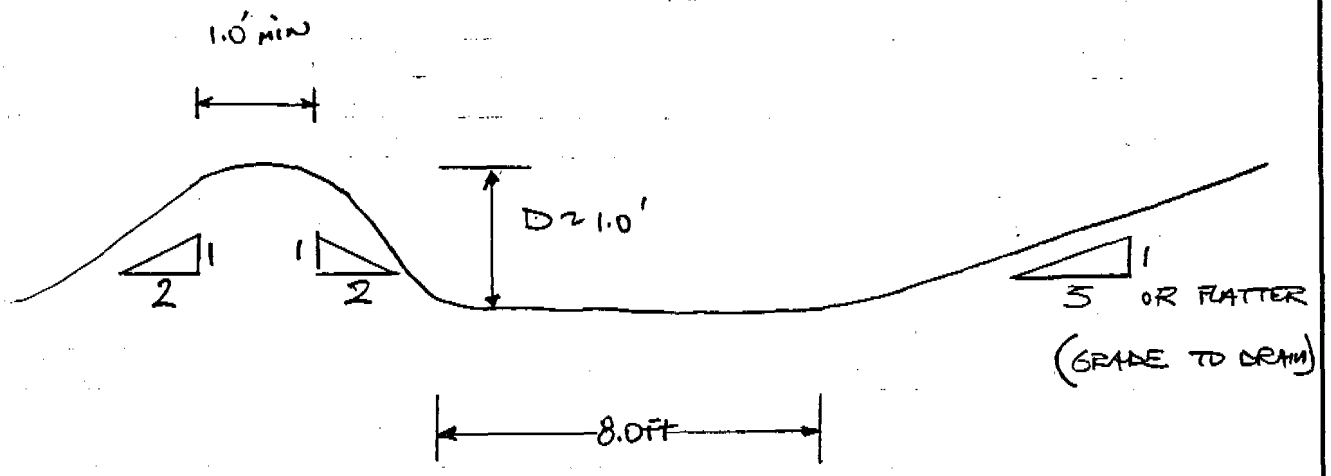
CGRWS-U9
CN = 75
AREA = 29.38 AC
T_c = 0.102 HR

Q = 1.92 CFS

CGRWS-R3
CN = 80
AREA = 11.58 AC
T_c = 0.301 HR

Q = 1.51 CFS

DIVERSION/BERM GEOMETRY.



CONSTRUCT A BERM WITH 1.0' TOPWIDTH AND A HEIGHT OF 1.0', SIDE SLOPES 2H:1V. ADJACENT TO THE BERM, GRADE A BROAD SWALE TO CONVEY THE RUNOFF.

BOTTOM WIDTH = 8.0 FT.
CHANNEL SLOPE ⇒ MAX = 3%
MIN = 1%
MAX. FLOW DEPTH = 0.23 FT.
MAX. VELOCITY = 2.45 FPS

NO RIPRAP REQUIRED FOR V = 2.45 FPS.

60c/6

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: TYPICAL DIVERSION/BERM DESIGN

Solve For Depth

Given Input Data:

Bottom Width.....	8.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	5.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0100 ft/ft
Discharge.....	3.43 cfs

Computed Results:

Depth.....	0.23 ft
Velocity.....	1.73 fps
Flow Area.....	1.99 sf
Flow Top Width...	9.58 ft
Wetted Perimeter.	9.66 ft
Critical Depth...	0.17 ft
Critical Slope...	0.0242 ft/ft
Froude Number....	0.67 (flow is Subcritical)

Open Channel Flow Module, Version 3.2 (c) 1990
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60D/6

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: TYPICAL DIVERSION/BERM DESIGN

Solve For Depth

Given Input Data:

Bottom Width.....	8.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	5.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0300 ft/ft
Discharge.....	3.43 cfs

Computed Results:

Depth.....	0.16 ft
Velocity.....	2.45 fps
Flow Area.....	1.40 sf
Flow Top Width...	9.14 ft
Wetted Perimeter.	9.20 ft
Critical Depth...	0.17 ft
Critical Slope...	0.0242 ft/ft
Froude Number....	1.10 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

APPENDIX 3.4N

ALTERNATIVE SEDIMENT CONTROL MEASURES CALCULATIONS

REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH
2/2/94

RECLAMATION ALTERNATIVE SEDIMENT CONTROL MEASURES SUMMARY AND CALCULATIONS

CASTLE GATE PREPARATION PLANT
CARBON COUNTY, UTAH

Prepared for

AMAX COAL COMPANY
Castle Gate Mine
Carbon County, Utah

Prepared by

EARTHFAX ENGINEERING, INC.
Midvale, Utah

September 4, 1992

RECLAMATION ALTERNATIVE SEDIMENT CONTROL MEASURES - SUMMARY

Three sedimentation ponds will be used within the disturbed area of the Preparation Plant during reclamation. However, it is not feasible to route the storm runoff from the entire reclaimed area to those three ponds (011, 012 and 013). Therefore, silt fences will be used as alternative sediment control (ASC) structures, along with other ASC measures to protect reaches of streams/channels whose precipitation runoff crosses reclaimed areas but does not flow to one of the ponds. ASC measures involving soil preparation and seeding will be used throughout the reclaimed area. An explanation of all the ASC measures is included in section 3.4-4(4). Calculations were performed using the Universal Soil Loss Equation to quantify the benefits of implementing the various ASC measures. Those calculations form the majority of this appendix.

The Universal Soil Loss Equation (A = RKLSCP), combined with the concept of delivery ratio (Y = A * D), was developed under specific limitations. Although its application to the Preparation Plant area stresses those limitations in regard to area, slope, and land use, this evaluation method is widely accepted for the purposes of evaluating potential sheet flow and rill sediment erosion. Erosion within natural stream channels and the reclaimed channels was not considered in this analysis. It is assumed that the structure of the undisturbed channels and the riprap in the reclamation channels will prevent appreciable scour during a 10-year 6-hour storm event. The goal of this analysis was not to quantify the total sediment loads to the reclamation channels, but only to asses the relative benefit of implementing the various ASC options.

Two stream reaches were selected as being representative in terms of the sediment load from both undisturbed and reclaimed areas that can be expected along channels in the Preparation Plant area. A 700 foot reach along the upper section of CGRD-5 in Barn Canyon was evaluated. The south side of reclamation channel CGRD-3C was also analyzed to

ascertain relative sediment loads to the stream. Only erosion from a portion of watershed CGRWS-R4 travels to the south side of the channel, with no undisturbed contributing watershed areas (See Exhibit 3.A-3A).

Two sets of comparisons were performed to evaluate the ASC measures. Sediment erosion was calculated for a discrete storm event of six hour duration and a return period of ten years, and also on an annual basis. The rainfall 'R' factors selected were 17 (Barfield et. al., 1983, Fig.5.11) and 11 (Israelson et. al., 1984) respectively. A summary of these comparisons comprises Table 3.4N - A1.

The erodibility factor, 'K', was determined from a map entitled "State of Utah Soil Erodibility Index (K)". A value of 0.15 corresponds to the location of the Preparation Plant. The LS factor was calculated using the following formula from Barfield et. al. (1983, Eq. 5.10):

$$LS = (l/72.6)^m * ((430x^2 + 30x + 0.43)/6.613)$$

where x = sin(slope angle)

l = length of the slope along which deposition will not occur

m = 0.5 for slopes greater than or equal to 5%

The following cover factors, 'C', were chosen to reflect the characteristics of each sediment control measure:

- Bare soil, C = 1.3 (Barfield et. al., 1983, Table 5.8)
- Ripped soil, C = 0.8 (Barfield et. al., 1983, Table 5A)
- Wood fiber mulch slurry, C = 0.05 (Barfield et. al., 1983, Table 5.8)
- Undisturbed native soil, C = 0.07 (SCS, 1977)

An efficiency of 75% was assumed for filter fabric (silt) fences (Mirafi, Inc., Product #100x).

TABLE 3.4N-A1

CASTLE GATE PREPARATION PLANT RECLAMATION ALTERNATIVE SEDIMENT CONTROL MEASURES

WATERSHED	Area (Ac)	Height of Rise (ft)	Horiz. Proj. of Slope Length (ft)	Slope Angle (%)	Slope Angle (deg)	Field Slope Length (ft)	Slope Factor m	LS Factor	K Factor	Undisturbed Sed. Prod.	Silt to stream – Bare ground (Tons)	Silt to stream – Ripped (Tons)	Silt to stream – Mulched (Tons)	Silt to stream – Silt fence (Tons)	Silt trapped by silt fence (Tons)	Silt trapped by silt fence (Cu Ft)
10–YEAR 6–HOUR STORM																
PREPARATION PLANT																
EAST SIDE OF UPPER CGRD–5																
RECLAIMED AREA	2.10	40.0	220.0	18.2	10.3	224	0.5	5.2	0.15	1.9	36.1	22.2	1.4	0.3	1.0	22
UNDISTURBED AREA (U7)	7.30	290.0	450.0	64.4	32.8	535	0.5	58.7	0.15	76.4	76.4	76.4	76.4	19.1	57.3	1273
TOTAL										78.4	112.6	98.7	77.8	19.4	58.3	1296
CGRD–3C – SOUTH SIDE																
RECLAIMED AREA	0.73	50.0	300.0	16.7	9.5	304	0.5	5.3	0.15	0.7	12.7	7.8	0.5	0.1	0.4	9
ANNUAL EROSION																
PREPARATION PLANT																
EAST SIDE OF UPPER CGRD–5																
RECLAIMED AREA	2.10	40.0	220.0	18.2	10.3	224	0.5	5.2	0.15	1.3	23.4	14.4	0.9	0.2	0.7	16
UNDISTURBED AREA (U7)	7.30	290.0	450.0	64.4	32.8	535	0.5	58.7	0.15	49.5	49.5	49.5	49.5	12.4	37.1	824
TOTAL										50.7	72.8	63.8	50.4	12.6	37.8	840
CGRD–3C – SOUTH SIDE																
RECLAIMED AREA	0.73	50.0	300.0	16.7	9.5	304	0.5	5.3	0.15	0.4	8.2	5.1	0.3	0.1	0.2	4

SOIL CONDITION	'C' FACTOR	'P' FACTOR
BARE	1.3	1.0
RIPPED	0.8	
MULCHED	0.05	
UNDISTURBED	0.07	

	DELIVERY RATIO
UNDISTURBED AREA	1.0
RECLAIMED AREA	1.0

ERODIBILITY FACTOR, K	0.15

RAINFALL FACTORS	
10–YR 6–HR STORM	17
ANNUAL	11

007/004

The control practice factor, 'P', was assumed equal to 1.0 since the land use is not for crops (SCS, 1977). A conservative sediment delivery ratio, 'D', of 1.0 was assumed for all undisturbed and reclaimed areas, since they are smaller than ten acres in area.

Conclusions

Table 3.4N-A1 summarizes the results of the above described calculations. The implementation of each sediment control measure substantially reduces the amount of sediment erosion from the reclaimed areas, to the point that the mulch theoretically inhibits soil loss more effectively than the undisturbed ground cover. The silt fences provide additional protection to the streams by trapping an additional 75% of sediment. In general, the undisturbed areas contributing sediment to the stream channels through silt fences are larger than the reclaimed areas. Accordingly, most of the sediment erosion will occur from the undisturbed area. In the case of the upper reach of CGRD-5, approximately 98% of the sediment loss trapped by the silt fences is from the undisturbed areas. Thus, the background sediment loss overshadows the sediment loss from the reclaimed areas once the wood fiber mulch is in place. It should be noted that the combination of the surface sediment controls on the reclaimed areas and the silt fences along the channels reduces the silt load from the reclaimed areas to the streams by 84% from what it would naturally be if the same reclaimed areas were undisturbed and in their natural state.

Calculations to determine the adequacy of a single layer fence system were performed. The results indicate that a single layer system will be adequate. The spacing of the fences will have to vary depending on location and the grade of the reclaimed ground surface adjacent to the channel. In all cases, the silt fences shall generally be constructed in accordance with Figures 3.4-1 and 3.4-2 with the fences parallel to the contours. Additionally, the fences should be constructed with sufficient projected overlap, and the length of the fence segments should correspond to the spacing and orientation of those segments along the channel.

REFERENCES

U.S. Department of Agriculture. Soil Conservation Service. July 1977. Preliminary Guidance for Estimating Erosion on Areas Disturbed by Surface Mining Activities in the Interior Western United States.

Barfield, B.J., Warner, R.C., and Hann, C.T.. 1983. Applied Hydrology and Sedimentology for Disturbed Areas. Oklahoma Technical Press. Stillwater, Oklahoma.

Simons, Li and Associates, Inc. May 1983. Design of Sediment Control Measures for Small Areas in Surface Coal Mining. Office of Surface Mining.

Israelson, C. Earl, Fletcher, Joel E., Haws, Frank W., and Israelson, Eugene K.. Erosion and Sedimentation in Utah: A Guide for Control. February 1984. Utah State University. Logan, Utah.

Mirafi Civil Engineering Fabrics. Mirafi, Inc. Charlotte, N.C..

CASTLE GATE
PREPARATION PLANT

RECLAMATION PLAN - ALTERNATIVE SEDIMENT CONTROL

A TYPICAL AREA CONTRIBUTING TO A STREAM CHANNEL PROTECTED BY SILT FENCES IS ON THE SOUTHEAST SIDE OF THE UPPER SECTION OF CGRD-5, BOTH RECLAIMED AND UNDISTURBED AREA RUNOFF CONTRIBUTE TO THIS REACH OF CHANNEL. A SECOND TYPICAL REACH IS THE SOUTH SIDE OF CGRD-3C, WHICH ONLY RECEIVES FLOW FROM A RECLAIMED AREA. EVALUATE THESE TWO STREAM REACHES TO DETERMINE RELATIVE SEDIMENT LOADS WITH VARIOUS BSCM'S IN PLACE. CONSIDER BOTH A DISCRETE STORM EVENT AND EROSION ON A YEARLY BASIS.

NOTE: THERE ARE SEVERAL LOCATIONS WHERE RUNOFF FROM PRIMARILY UNDISTURBED AREAS FLOWS THROUGH SILT FENCES, WITH VERY LITTLE RECLAIMED AREA RUNOFF CONTRIBUTING. SINCE THE PURPOSE OF THE FENCES IS TO COLLECT ERODED SEDIMENTS FROM RECLAIMED AREAS, THE REACHES JUST MENTIONED WERE NOT EVALUATED.

REFERENCE EXHIBIT 3.4-3A.

A SAMPLE CALCULATION FOLLOWS WITH ALL ASSUMPTIONS LISTED. THE RESULTS OF THE BALANCE OF THE CALCULATIONS IS CONTAINED IN TABLE 1 OF THIS APPENDIX.

USE UNIVERSAL SOIL LOSS EQUATION.

$A = RKLSCP$

$Y = D \cdot A$

Y = SEDIMENT YIELD
D = DELIVERY RATIO

A = COMPUTED SOIL LOSS PER UNIT AREA (TONS/ACRE)
R = RAINFALL FACTOR
K = ERODIBILITY FACTOR
LS = LENGTH SLOPE FACTOR
C = COVER FACTOR
P = CONTROL PRACTICE FACTOR

ASSUME EROSION IS NOT RESTRAINED BY SEDIMENT TRANSPORT CAPACITY. THUS, THERE IS NO INTERMEDIATE DEPOSITION AND DELIVER RATIO = 1.0 SO $Y = A$.

REFERENCE FOR USE:

BARFIELD ET AL, 1983 APPLIED HYDROLOGY AND SEDIMENTOLOGY FOR DISTURBED AREAS, OKLAHOMA TECHNICAL PRESS, OKLAHOMA.

R: FOR DISCRETE STORM EVENT 10-YR 6-HR: ACCORDING TO MILLER ET AL,

PRECIPITATION-FREQUENCY ATLAS OF THE WESTERN UNITED STATES, NOAA, 1973.

10-YEAR 6-HOUR EVENT IN THE PREP PLANT AREA

P = 1.4"

USING BARFIELD ET AL, 1983 FIG 5.11

WITH P = 1.4" AND H_R = 6 HOURS

$R_{10-6} \doteq 17$ (THIS COULD BE READ AS 18, BUT CONSIDERING A LOW ANNUAL 'R' FACTOR COMPARED TO SURROUNDING AREA, R=17 WAS SELECTED.)

FOR ANNUAL BASIS:

REFERENCE: ISRAELSON ET AL, 1984, PRICE AREA MAP ENTITLED "MEAN ANNUAL 150-EROSIVITY 'R' VALUE"

R_A = 11 FOR PREP PLANT

K: PER ISRAELSON ET AL, 1984, MAP ENTITLED "STATE OF UTAH SOIL ERODIBILITY INDEX (K)"

K = 0.15 FOR PREP PLANT

CONSIDER THE EAST SIDE OF THE UPPER REACH OF CGRD-5. SEE EXHIBIT 3.4-3A

RECLAIMED AREA = 2.1 ACRES

UNDISTURBED AREA (CGRWS-W7) = 7.3 ACRES

LS:

$$LS = \left(\frac{\lambda}{72.6}\right)^m \left(\frac{430x^2 + 30x + 0.43}{6.613}\right)$$

λ = FIELD SLOPE LENGTH (FT) (LENGTH OF SLOPE FROM POINT OF ORIGIN OF OVERLAND FLOW UNTIL SLOPE DECREASES SUCH THAT DEPOSITION OCCURS OR UNTIL FLOW ENTERS A DEFINED CHANNEL)

$x = \sin\theta$

θ = ANGLE OF SLOPE (°)

$m = 0.5$ IF $\theta \geq 5$ %

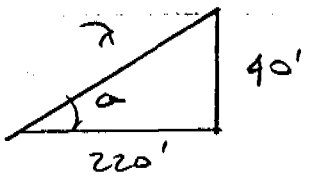
RECLAIMED:

USING EXHIBIT 3.4-3A

THE ~~HORIZ~~ PROJECTED AREA OF THE LONGEST RECLAIMED SLOPE IS 220'.

$\Delta ELEV = 6240 - 6200 = 40'$

$\tan\theta = \frac{40}{220}$ $\theta = 10.3°$



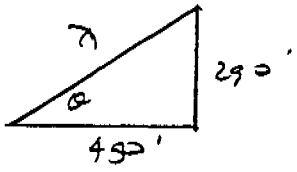
$\sin 10.3° = \frac{40}{\lambda}$ $\lambda = 224'$

LS CONT:

FOR THE UNDISTURBED AREA

$x = 450'$

$\Delta ELEV = 6530 - 6240$
$= 290'$



$\tan \theta = \frac{290}{450}$ $\theta = 32.8°$

$\sin 32.8° = \frac{290}{r}$ $r = 535'$ (AGREES WITH TABLE 1)

OK

RECLAIMED:

$$LS = \left(\frac{224'}{72.6}\right)^{0.5}\left(\frac{430(\sin 10.3)^2 + 30(\sin 10.3) + .43}{6.613}\right)$$

$LS = 5.2$

UNDIST:

$$LS = \left(\frac{535}{72.6}\right)^{0.5}\left(\frac{430(\sin 32.8)^2 - 30(\sin 32.8) + 0.43}{6.613}\right)$$

$= 58.6$ (TABLE 1 ⇒ 58.7 OK)

'C' FACTOR:

BARE SOIL (DOZED UP & DOWN) $C = 1.3$ BARFIELD ET AL, 1983, TABLE 5.8

RIPPED SOIL $C = 0.8$ BARFIELD ET AL, 1983, TABLE 5.A.1

WOOD FIBER SLURRY MULCH $C = 0.05$ BARFIELD, 1983 TABLE 5.8

(ALSO NOTE: TEMPORARY SEEDINGS AFTER 60 DAYS, $C = 0.05$ PER BARFIELD TABLE 5.A.1)

SILT FENCE EFFICIENCY 75% (MIRAFI, PRODUCT 100 X)

'C' FACTOR CONT:

UNDISTURBED AREA: C = 0.07 SCS, 1977. TABLE 4 *

* THIS IS BASED ON TYPE AND DENSITY OF CANOPY AND GROUND COVER VEGETATION. SAGE, LOW BRUSH AND GRASSES ARE SIMILAR TO THOSE FOUND IN HANDSCRAPBLE CANYON WHERE A C = 0.07 WAS USED. REFERENCE APPENDIX 3.3-E.

'P' FACTOR:

SINCE LAND IS NOT USED FOR CROPS,

P = 1

REFERENCE: SCS, 1977.

CALCULATE 'A' FOR A DISCRETE STORM EVENT OF 10 YR 6 HR.

RECLAIMED:

A = RKLSCP

= (17)(0.15)(5.2) C (1.0)

= 13.26 C

A_{TOTAL} = (A) (AREA)

= (13.26C)(2.1 ACRES)

= 27.8 C

FOR C = 1.3 → A_{TOTAL} = (27.8)(1.3) = 36.2 TONS/EVENT

FOR C = 0.8 → A_{TOTAL} = (27.8)(0.8) = 22.2 TONS/EVENT

FOR C = 0.05 → A_{TOTAL} = (27.8)(0.05) = 1.4 TONS/EVENT

UNDISTURBED AREA

A_{TOTAL} = RKLSCP (AREA)

= (17)(0.15)(58.6)(0.07)(1)(7.3 ACRES)

= 76.4 TONS/EVENT

TOTAL LOAD TO EAST SIDE OF CERD-5 (UPPER REACH)

$A_{TOTAL(UNDIST)} + A_{TOTAL(REC)}$ = 1.4 + 76.4 = 77.8 TONS

WITH MULCH IN PLACE

WITH SILT FENCE IN PLACE:

TRAPPED SEDIMENT = (0.75)(77.8) = 58.4 TONS

SILT TO STREAM = (0.25)(77.8) = 19.4 TONS

77.8 TONS ✓

FOR THAT REACH OF STREAM,

TRAPPED VOLUME OF SEDIMENT = 58.4 TONS × 2000 lbs / 1 TON × CF / 90 lbs

= 1298 CF SAY 1300 CF

TO PLACE SILT FENCES PARALLEL TO CONTOURS, THEY WILL HAVE TO BE AT AN ANGLE OF APPROXIMATELY 45° TO THE CHANNEL CENTERLINE. USING 50' FENCE SEGMENTS AND 10' OF PROJECTED OVERLAP,

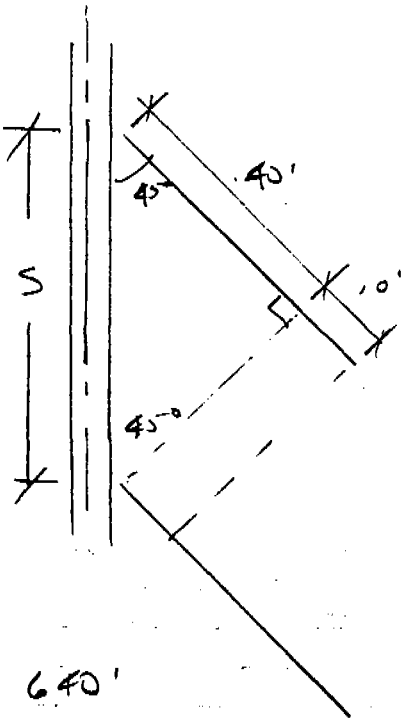
CALCULATE SPACING OF SEGMENTS.

$\cos 45° = \frac{40}{S}$

$S = 56.6$ FT

SAY 55'

USE 50' OF FENCE FOR EVERY 55' OF CHANNEL (ONE SIDE ONLY)



TOTAL LENGTH OF FENCE =

REACH LENGTH $\times \frac{50'}{55'}$

$700 \times \frac{50}{55} = 636$ SAY 640'

TOTAL VOLUME TO FENCE = 1300 CF (FROM PG 6)

$\frac{1300 \text{ CF}}{640 \text{ FT}} = 2.0$ SF

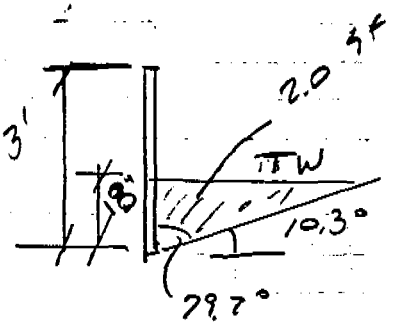
ALLOWING SILT TO BUILD UP TO 18";

MAX CAPACITY OF FENCE:

$A = \frac{1}{2}(1.5')(8.25')$

$= 6.18$ SF >> 2.0 SF

↑ ALLOWABLE ↑ ACTUAL



$\tan 79.7° = \frac{TW}{1.5'}$

TW = 8.25'

OK

FENCE WILL NOT OVERLOAD AFTER 1 10 YR 6 HR STORM.

USING VALUES FROM TABLE 1 OF THIS APPENDIX,

RECLAIMED AREA:

$\frac{1.9 - 0.3}{1.9}$ = 84 % REDUCTION FROM BASELINE LEVEL WITH MULCH AND SILT FENCE IN PLACE.

TOTAL AREA.

$\frac{0.3}{19.4}$ = 2 % OF SEDIMENT IS FROM RECLAIMED AREA

CONCLUSION:

THE IMPLEMENTATION OF VARIOUS ALTERNATIVE SEDIMENT CONTROL MEASURES ON THE RECLAIMED AREAS SIGNIFICANTLY REDUCES THE SILT LOAD TO THE CHANNELS. IN FACT, THERE IS AN 84% REDUCTION IN SEDIMENT LOAD TO THE STREAMS FROM THE RECLAIMED AREAS, COMPARED TO THOSE SAME AREAS IN THEIR NATURAL STATE.

ALSO, FOR THOSE CHANNEL REACHES THAT RECEIVE EROSION FROM UNDISTURBED AREAS, THE SEDIMENT FROM THE RECLAIMED AREAS (WITH MULCH AND FENCES IN PLACE) CONSTITUTES < 10 % OF THE TOTAL SEDIMENT TO THE STREAM CHANNEL.

CASTLE GATE PREPARATION PLANT RECLAMATION ALTERNATIVE SEDIMENT CONTROL MEASURES

WATERSHED	Area (Ac)	Height of Rise (ft)	Horiz. Proj. of Slope Length (ft)	Slope Angle (%)	Slope Angle (deg)	Field Slope Length (ft)	Slope Factor m	LS Factor	K Factor	Undisturbed Sed. Prod.	Silt to stream – Bare ground (Tons)	Silt to stream – Ripped (Tons)	Silt to stream – Mulched (Tons)	Silt to stream – Silt fence (Tons)	Silt trapped by silt fence (Tons)	Silt trapped by silt fence (Cu Ft)
10–YEAR 6–HOUR STORM																
PREPARATION PLANT																
EAST SIDE OF UPPER CGRD–5																
RECLAIMED AREA	2.10	40.0	220.0	18.2	10.3	224	0.5	5.2	0.15	1.9	36.1	22.2	1.4	0.3	1.0	22
UNDISTURBED AREA (U7)	7.30	290.0	450.0	64.4	32.8	535	0.5	58.7	0.15	76.4	76.4	76.4	76.4	19.1	57.3	1273
TOTAL										78.4	112.6	98.7	77.8	19.4	58.3	1296
CGRD–3C – SOUTH SIDE																
RECLAIMED AREA	0.73	50.0	300.0	16.7	9.5	304	0.5	5.3	0.15	0.7	12.7	7.8	0.5	0.1	0.4	9
ANNUAL EROSION																
PREPARATION PLANT																
EAST SIDE OF UPPER CGRD–5																
RECLAIMED AREA	2.10	40.0	220.0	18.2	10.3	224	0.5	5.2	0.15	1.3	23.4	14.4	0.9	0.2	0.7	16
UNDISTURBED AREA (U7)	7.30	290.0	450.0	64.4	32.8	535	0.5	58.7	0.15	49.5	49.5	49.5	49.5	12.4	37.1	824
TOTAL										50.7	72.8	63.8	50.4	12.6	37.8	840
CGRD–3C – SOUTH SIDE																
RECLAIMED AREA	0.73	50.0	300.0	16.7	9.5	304	0.5	5.3	0.15	0.4	8.2	5.1	0.3	0.1	0.2	4

SOIL CONDITION	'C' FACTOR	'P' FACTOR
BARE	1.3	1.0
RIPPED	0.8	
MULCHED	0.05	
UNDISTURBED	0.07	

	DELIVERY RATIO
UNDISTURBED AREA	1.0
RECLAIMED AREA	1.0

ERODIBILITY FACTOR, K 0.15

RAINFALL FACTORS

10–YR 6–HR STORM	17
ANNUAL	11

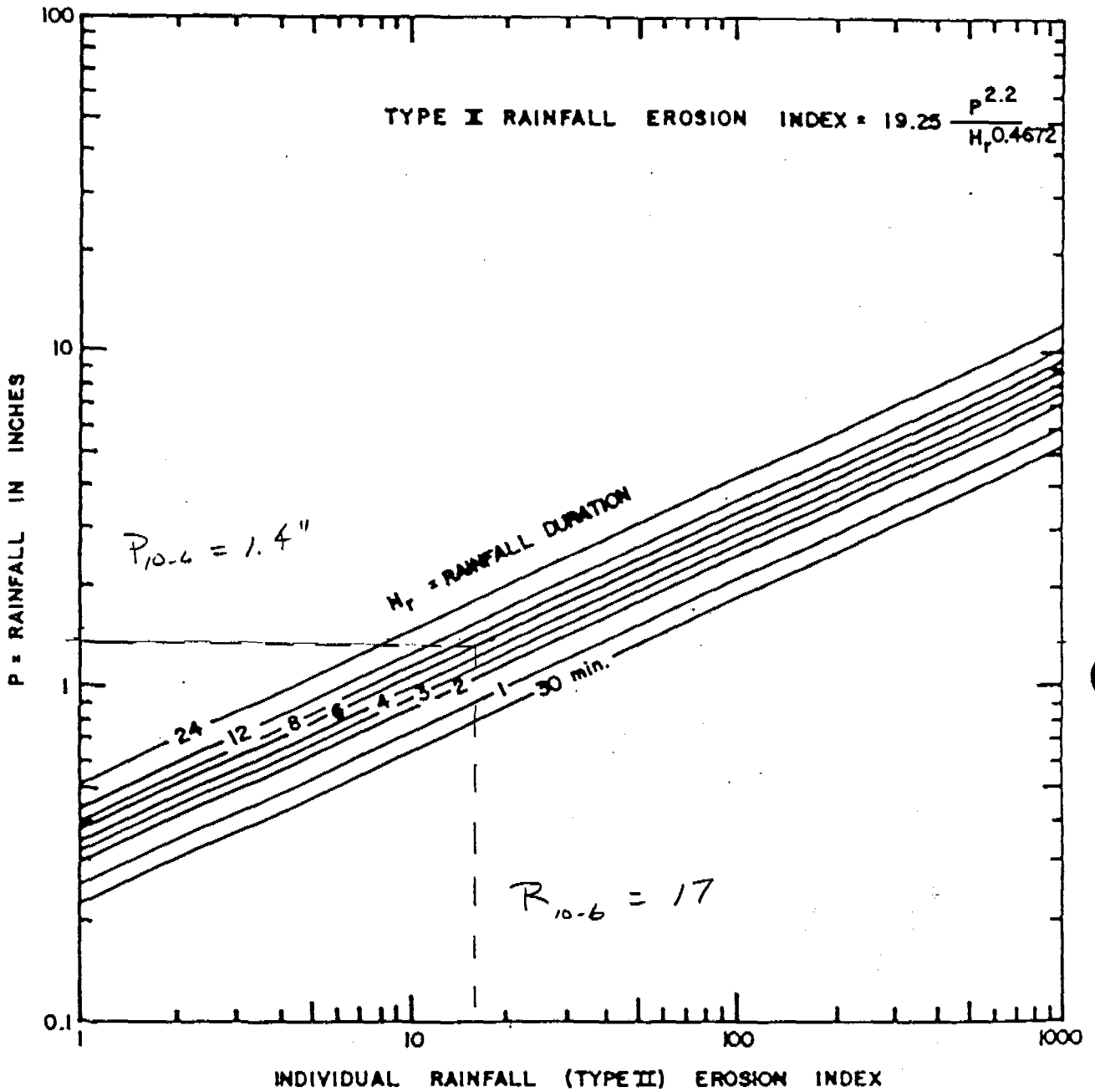


Figure 5.11. Relation between depths and duration of Type II rainfall and single storm erosion index. (Hotes et al., 1973)

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SOIL ERODIBILITY INDEX (K)

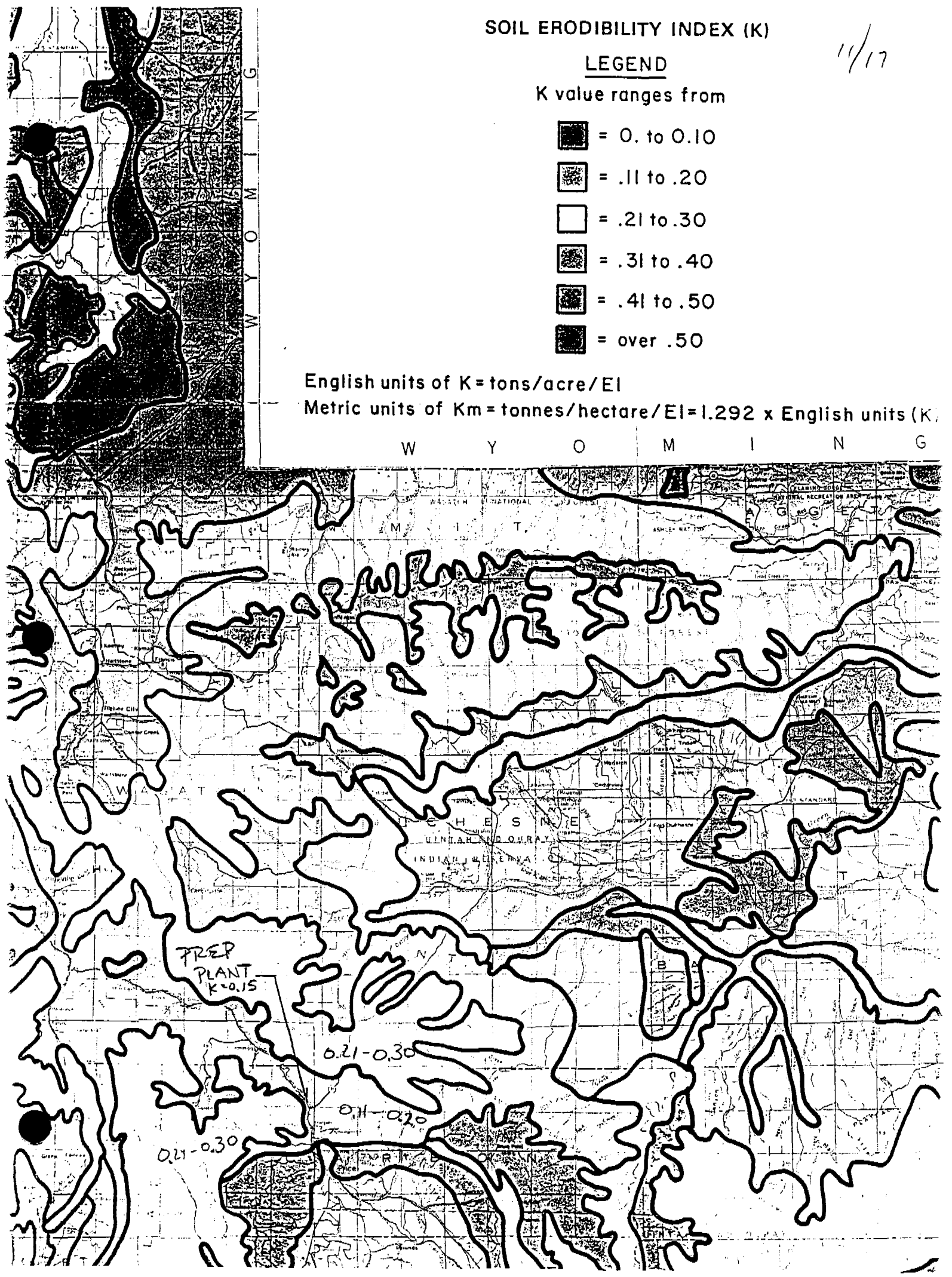
LEGEND

K value ranges from

- = 0. to 0.10
- = .11 to .20
- = .21 to .30
- = .31 to .40
- = .41 to .50
- = over .50

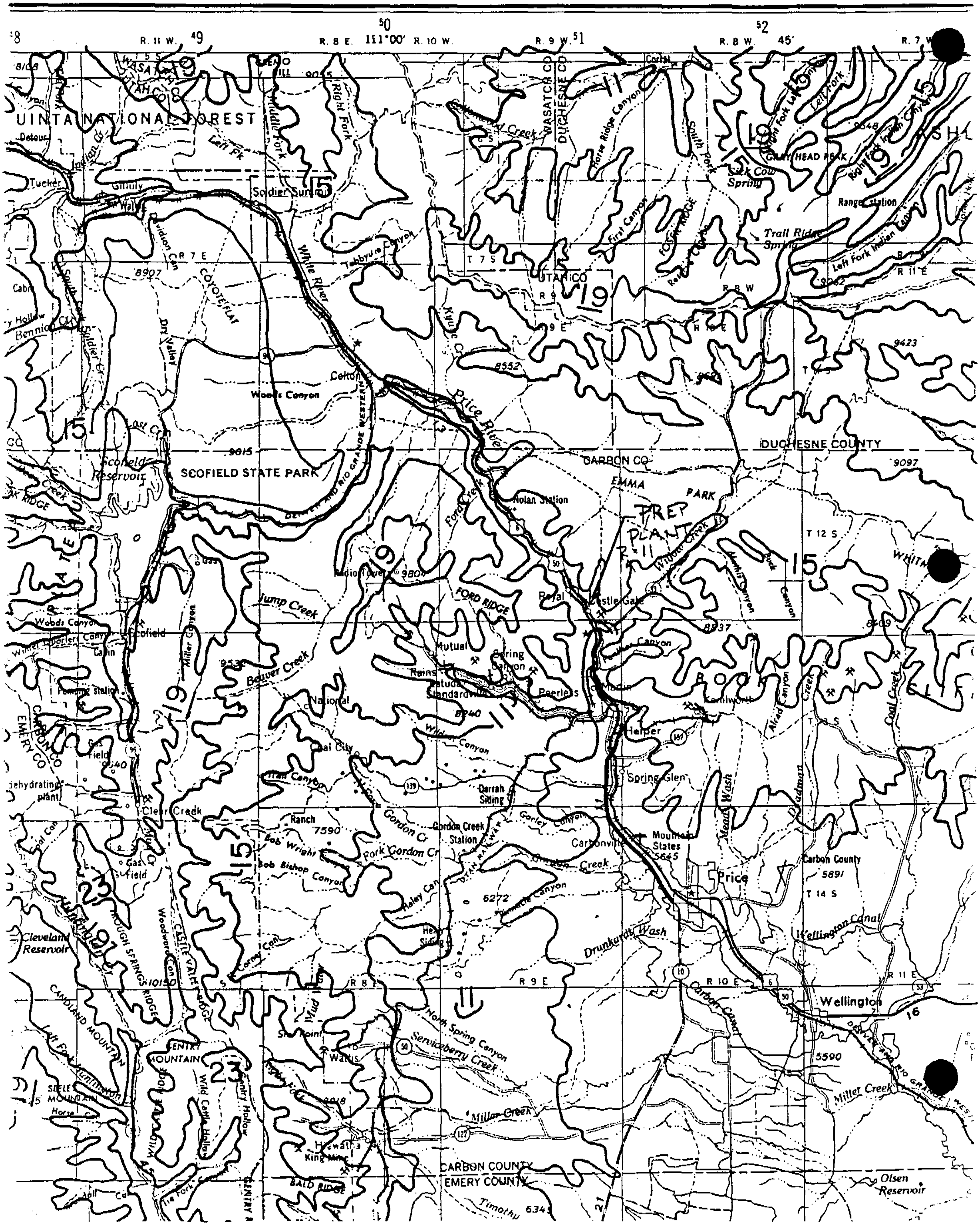
English units of K = tons/acre/EI

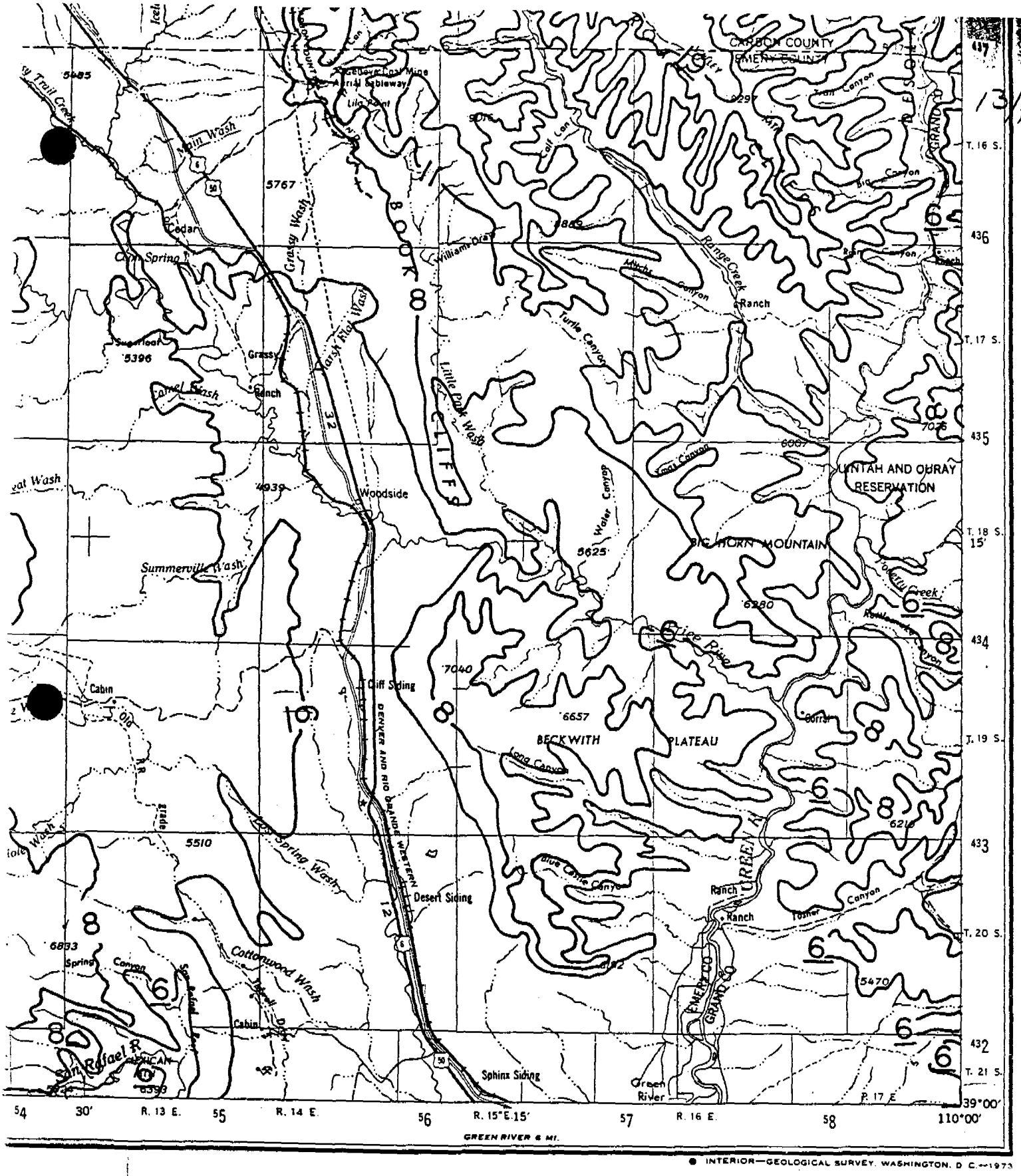
Metric units of Km = tonnes/hectare/EI = 1.292 x English units (K)



PRICE

12/17


UINTA NATIONAL FOREST
Soldier Summit
White River
SCOFIELD STATE PARK
Scofield Reservoir
Price River
DUCHESNE COUNTY
CARBON CO
EMMA PARK
PREP PLANT
Castle Gate
Helper
Kenilworth
Spring Glen
Price
Wellington
Carbon County
CARBON COUNTY
EMERY COUNTY
Olsen Reservoir
Cleveland Reservoir
Scofield
Clear Creek
Coal City
National
Standardville
Peerless
Mutual
Spring Canyon
Colton
Tucker
Woods Canyon
Jump Creek
FORD RIDGE
Beaver Creek
Gordon Creek
Drunkards Wash
Miller Creek
Serviceberry Creek
North Spring Canyon
Hiawatha
Wattis
GRAY HEAD PEAK
Ranger station
Trail Ridge Spring
Left Fork Indian Canyon
Tabbyune Canyon
Dry Valley
COYOTE FLAT
Wellington Canal
Carbon Canal
Deadman Wash
Coal Creek
CASTLE VALLEY RIDGE
GENTRY MOUNTAIN
CANDLAND MOUNTAIN
Nolan Station
Royal
Mountain States
Carbonville
Gordon Creek Station
Darrah Siding
Radio Tower
Gas Field
Dehydrating plant
Pumping station
15
19
11
23



● INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1973

e:
alues shown are for rain and
lt together. R value for
elt alone = R_s = 0.23881 R
.34328.

MEAN ANNUAL ISO-ERODENT (R) VALUES

Units of R
English R = foot tons/acre/hour
Metric Rm = meter tonnes/hectare/hour
Rm = 1.735 x R

AH WATER RESEARCH LABORATORY UTAH STATE UNIVERSITY LOGAN, UTAH 1983

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Appendix 5A

Table 5.A.1 Typical C Factor Values Reported in the Literature.*

	Condition	C 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 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, unprepared seedbed	0.64
	same after six months	0.54
	seed, fertilize and 12 months chemical	0.38
	not tilled algae crusted	0.01
	tilled algae crusted	0.02
	undisturbed except scraped	0.66 - 1.30
	scarified only	0.76 - 1.31
	sawdust 2 inches deep, disked in	0.61
2.	Asphalt emulsion	
	1210 gallons/acre	0.01 - 0.019
	605 gallons/acre	0.14 - 0.57
	302 gallons/acre	0.28 - 0.60
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/acre	0.01 - 0.05
	Aquatain	0.68
	Aerospray 70, 10 percent cover	0.94
	Curasol AE	0.30 - 0.48
	PVA	0.71 - 0.90
	Terra-Tack	0.66
	wood fiber slurry, 1400 lb/acre fresh	0.01 - 0.02
	wood fiber slurry, 3500 lb/acre fresh	0.10
5.	Seedings[1]	
	temporary, 0 to 60 days[2]	0.40
	temporary, after 60 days	0.05
	permanent, 2 to 12 months	0.05
6.	Brush	0.35

1. If plantings are used with mulches, use the minimum C values.
2. If dry weather occurs at planting and emergence is a problem, extend the 0-60 days to a period when rainfall normally occurs.

* National Cooperative Highway Research Program, 1976.

BARFIELD ET AL, 1981.

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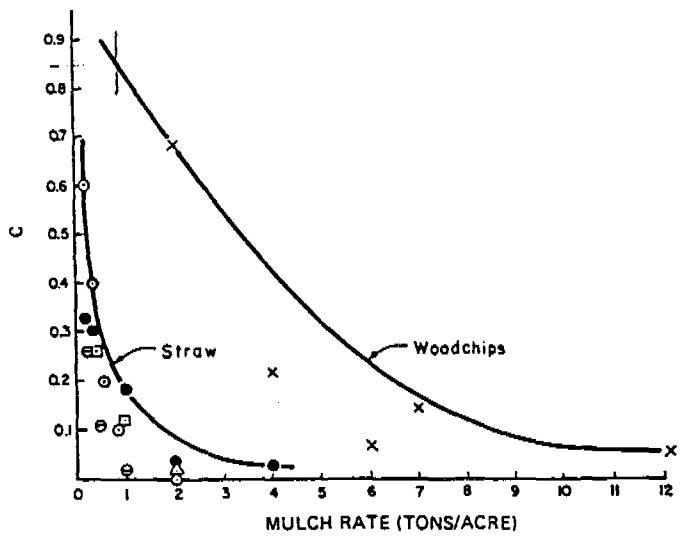

Figure 5.16b. Control factor, C, of surface mulching. (Chen, 1974)

Chemicals are also available for stabilizing the soil surface. C values for selected chemicals are tabulated in Table 5.8. A more complete listing can be found in Table 5.A.1.

Table 5.8 Selected C Values reported in the literature. A comprehensive list is given in Appendix 5A.

Condition	C factor
1. Bare soil conditions	
compacted bulldozer scraped up and down	1.30
compacted fill	1.24 – 1.71
2. Asphalt emulsion	
1250 gallons/acre	0.02
151 gallons/acre	0.65 – 0.70
3. Other chemicals	
Petroset SB	0.40 – 0.66
wood fiber slurry, 1000 lb/acre fresh	0.05
4. Seedings[1]	
permanent, 0 to 60 days[2]	0.40
permanent, after 12 months	0.01
5. Excelsior blanket with plastic net	0.04 – 0.10

1. If plantings are used with mulches, use the minimum C values.
2. If dry weather occurs at planting and emergence is a problem, extend the 0-60 days to a period when rainfall normally occurs.

BARFIELD ET AL, 1981.

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Table 4. "C" Factors for Permanent Pasture and Rangeland

Vegetative Canopy			Cover That Contacts the Surface 1/						
Type and Height of Raised Canopy 2/	Canopy Cover 3/	Type 4/	Percent Ground Cover						
			0	10	20	40	60	80	95-1
No appreciable canopy		G	1.0	.45	.20	.10	.042	.013	.0
		W	1.0	.45	.24	.15	.090	.043	.0
Canopy of tall forbs or short brush (0.5 m fall ht.)	25	G	1.0	.36	.17	.09	.038	.012	.0
		W	1.0	.36	.20	.13	.082	.041	.0
	50	G	1.0	.26	.13	.07	.035	.012	.0
		W	1.0	.26	.16	.11	.075	.039	.0
	75	G	1.0	.17	.10	.06	.031	.011	.0
		W	1.0	.17	.12	.07	.067	.038	.0
Appreciable brush or brushes (2 m fall ht.)	25	G	1.0	.40	.18	.09	.040	.013	.0
		W	1.0	.40	.22	.14	.085	.042	.0
	50	G	1.0	.34	.16	.085	.038	.012	.0
		W	1.0	.34	.19	.13	.081	.041	.0
	75	G	1.0	.28	.14	.08	.036	.012	.0
		W	1.0	.28	.17	.12	.077	.040	.01
Trees but no appreciable low brush (4 m fall ht.)	25	G	1.0	.42	.19	.10	.041	.013	.0
		W	1.0	.42	.23	.14	.087	.042	.0
	50	G	1.0	.39	.18	.09	.040	.013	.0
		W	1.0	.39	.21	.14	.085	.042	
	75	G	1.0	.36	.17	.09	.039	.012	

1/ All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists

2/ Average fall height of waterdrops from canopy to soil surface: m=meters.

3/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (a bird's-eye view).

4/ G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter.

W: Cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface, and/ undecayed residue.)

Table 5. Factor "C" for Various Quantities of Mulch

Mulch—adequately crimped into soil	"C" Factor
bare areas	1.0
¼ ton straw mulch per acre	.52
½ " " " " "	.35
¾ " " " " "	.24
1 " " " " "	.18
1½ " " " " "	.10
2 " " " " "	.06
3 " " " " "	.03
4 " " " " "	.02

SCS, 1977

MIRAFI®

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TABLE 1: GUIDE SPECIFICATION FOR SILT FENCE FABRIC

General Description: The fabric shall be a woven or nonwoven fabric consisting of synthetic filaments or yarns formed into a stable network such that the filaments or yarns retain their relative position to each other. The fabric shall be inert to commonly encountered chemicals and conform to the properties in the following table.

FABRIC PROPERTY	TEST METHOD*	FABRIC REQUIREMENTS
I. RESISTANCE TO INSTALLATION STRESSES		
a. Grab Tensile Strength, lbs	ASTM-D-1682	90
b. Grab Tensile Elongation, %	ASTM-D-1682	20
c. Mullen Burst Strength, psi	ASTM-D-751	180
d. Trapezoid Tear Strength, lbs	ASTM-D-2263	60
II. PERFORMANCE CRITERIA DURING SERVICE LIFE		
a. Slurry Flow Rate, gal/min/ft^2	VTM-51-79	0.3
b. Retention Efficiency,%	VTM-51-79	75
III. RESISTANCE TO ENVIRONMENT FACTORS		
a. Mildew, Rot Resistance, % Strength Retention	AATCC-30-74	100
b. Insect, Rodent Resistance, % Strength Resistance	AATCC-24-74	100
c. Ultraviolet Resistance, % Strength Retention	ASTM-D-1682 after 500 Xenon Weatherometer Hrs.	80

* TEST METHOD DESIGNATIONS:

ASTM: American Society of Testing and Materials

VTM: Virginia Dept. of Highways & Transportation test method per Reference (3).

AATCC: American Association of Textile Colorist and Chemists

APPENDIX 3.40

AS-BUILT POND SURVEY AND CONSTRUCTION METHOD CERTIFICATIONS

POND CONSTRUCTION METHODS

CASTLE GATE COAL COMPANY

SEDIMENT POND 011

The following is a list of pertinent information concerning the above referenced pond and the procedures used in the reconstruction of the pond by E.I.S. Co.:

(1) The pond is incised - no embankments.

(2) The pond was cleaned out, deepened and widened. The removed material was saturated and stored beneath the plant beltline until dry enough to haul to the refuse pile.

(3) Work to the pond consisted of enlarging the pond, rip-rapping the inlets, lowering the primary overflow, and adding an emergency spillway and channel from the spillway to the natural drainage to the north.

(4) No decant was added to the pond.

(5) Equipment used on the pond reconstruction was:

(a) Poclane 160 Trackhoe.
(b) International 100 Loader.
(c) Gas-powered hand compactor.
(d) International 150 Loader.
(e) Cat D-9 Dozer.
(f) 2 - 10 cu. yd. dump trucks.

REGISTERED PROFESSIONAL ENGINEER
No 4548
DAN W. GUY
STATE OF UTAH

SEDIMENT POND CERTIFICATION

Company Name and Address	CASTLE GATE COAL COMPANY
	P.O. BOX 449
	HELPER, UTAH 84526
Permit Number	ACT/007/004
Pond Location	CASTLE GATE
Pond Identification	011

Certification Statement:

I hereby certify that I am experienced in the construction of impoundments; I am qualified and authorized in the State of Utah to inspect and certify the construction of impoundments in accordance with the certified and approved design for this structure; the materials and conditions required for construction are in accordance with approved design and meet or exceed the minimum design requirements; and, that inspections of the impoundment were made during critical periods of the construction by or under my direction in accordance with the requirements of regulation R645-301-514.300.

REGISTERED PROFESSIONAL ENGINEER
No. 4548
HAN W. GUY
STATE OF UTAH

(Signature)

10/29/91
(Date)

POND INSPECTION REPORT
CASTLE GATE COAL COMPANY
(FINAL INSPECTION)

POND: 011

LOCATION: CASTLE GATE (Upper)

ITEM	REMARKS
(1) Potential Safety Hazards	None noted.
(2) Slope Stability	Slopes appear stable. Steep interior. Pond mostly incised.
(3) Erosion	None evident.
(4) Construction and Maintenance Performance Standards	Pond cleaned and deepened. Emerg. Spillway added.
(5) Recommendations/Comments	Surveyed 10/6/91. Capacity at Principle O.F.- 44,505 cu.ft. Pond appears to meet design requirements.

I have performed the above inspection on this pond and do hereby certify it to be a true and accurate representation of the pond at this time.

(Signature)

10/6/91
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

POND INSPECTION REPORT
CASTLE GATE COAL COMPANY
(CONSTRUCTION INSPECTION)

POND: 011

LOCATION: CASTLE GATE (Upper)

ITEM	REMARKS
(1) Potential Safety Hazards	None noted.
(2) Slope Stability	Pond slopes appear stable. Steep interior.
(3) Erosion	None evident.
(4) Construction and Maintenance Performance Standards	Removing material to deepen pond & install spillway.
(5) Recommendations/Comments	Appears to meet reconstruction design.

I have performed the above inspection on this pond and do hereby certify it to be a true and accurate representation of the pond at this time.

(Signature)

10/3/91
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

POND CONSTRUCTION METHODS

CASTLE GATE COAL COMPANY

SEDIMENT POND 012A

The following is a list of pertinent information concerning the above referenced pond and the procedures used in the reconstruction of the pond by E.I.S. Co.:

(1) The pond is incised - no embankments.

(2) The pond was cleaned. The removed material was saturated and stored beneath the plant beltline until dry enough to haul to the refuse pile.

(3) Work to the pond consisted of cleaning the pond, lowering the principle overflow and adding an emergency spillway on the south end.

(4) The pond had an existing decant.

(5) Equipment used on the pond reconstruction was:

(a) Poclane 160 Trackhoe.
(b) Case 580C Backhoe.
(c) Gas-powered hand compactor.
(d) International 100 Loader.
(e) 2 - 10 cu. yd. dump trucks.

REGISTERED PROFESSIONAL ENGINEER
No 4548
DAN W. GUY
STATE OF UTAH

SEDIMENT POND CERTIFICATION

Company Name and Address	CASTLE GATE COAL COMPANY P.O. BOX 449 HELPER, UTAH 84526
Permit Number	ACT/007/004
Pond Location	CASTLE GATE
Pond Identification	012 A

Certification Statement:

I hereby certify that I am experienced in the construction of impoundments; I am qualified and authorized in the State of Utah to inspect and certify the construction of impoundments in accordance with the certified and approved design for this structure; the materials and conditions required for construction are in accordance with approved design and meet or exceed the minimum design requirements; and, that inspections of the impoundment were made during critical periods of the construction by or under my direction in accordance with the requirements of regulation R645-301-514.300.

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

(Signature)

10/29/91
(Date)

POND INSPECTION REPORT
CASTLE GATE COAL COMPANY
(FINAL INSPECTION)

POND: 012A

LOCATION: CASTLE GATE

ITEM	REMARKS
(1) Potential Safety Hazards	None noted.
(2) Slope Stability	Slopes appear stable. Steep bank from upper road on east side.
(3) Erosion	None evident.
(4) Construction and Maintenance Performance Standards	Open-notch spillway added on south end.
(5) Recommendations/Comments	Surveyed 9/29/91. Capacity at Principle O.F.- 54,203 cu.ft. Meets or exceeds design.

I have performed the above inspection on this pond and do hereby certify it to be a true and accurate representation of the pond at this time.

(Signature)

9/29/91
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

POND INSPECTION REPORT
CASTLE GATE COAL COMPANY
(CONSTRUCTION INSPECTION)

POND: 012A

LOCATION: CASTLE GATE

ITEM	REMARKS
(1) Potential Safety Hazards	None noted.
(2) Slope Stability	Slopes appear stable. Steep bank from upper road on east side.
(3) Erosion	None evident.
(4) Construction and Maintenance Performance Standards	O.K. - Spillway under construction.
(5) Recommendations/Comments	90% complete. Dress up berm.

I have performed the above inspection on this pond and do hereby certify it to be a true and accurate representation of the pond at this time.

(Signature)

9/27/91
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

POND CONSTRUCTION METHODS

CASTLE GATE COAL COMPANY

SEDIMENT POND 012B

The following is a list of pertinent information concerning the above referenced pond and the procedures used in the reconstruction of the pond by E.I.S. Co.:

(1) The pond is incised on east side, with embankments on west and south. Inlet is from north.

(2) The pond was partially cleaned. The removed material was stored beneath the plant beltline until dry enough to haul to the refuse pile.

(3) The pond was widened toward the road side. The embankment was raised on the railroad side and shifted to the west toward the railroad. The embankment was compacted in 12" lifts by running over the placed material with the loader and a full bucket.

(4) The pond was deepened approximately 2' and lenthened by about 1/3. This was due to the presence of 3 separate water lines within the pond construction area which prevented further deepening or widening.

(5) The principle overflow was removed. A decant and emergency spillway were added. All small cut areas were compacted with the hand compactor.

(6) The embankment on the west was later raised again and extended to the north. Native fill material was hauled in to raise embankments. The material was compacted in 12" lifts with a 5-ton roller.

(7) Equipment used on the pond reconstruction was:

(a) Poclane 160 Trackhoe.
(b) Case 580C Backhoe.
(c) Gas-powered hand compactor.
(d) International 100 Loader.
(e) 2 - 10 cu. yd. dump trucks.
(f) Cat D-3 Dozer.
(g) Rex 5-ton roller.

REGISTERED PROFESSIONAL ENGINEER
No 4548
DAN W. GUY
STATE OF UTAH

SEDIMENT POND CERTIFICATION

Company Name and Address	CASTLE GATE COAL COMPANY P.O. BOX 449 HELPER, UTAH 84526
Permit Number	ACT/007/004
Pond Location	CASTLE GATE
Pond Identification	012 B

Certification Statement:

I hereby certify that I am experienced in the construction of impoundments; I am qualified and authorized in the State of Utah to inspect and certify the construction of impoundments in accordance with the certified and approved design for this structure; the materials and conditions required for construction are in accordance with approved design and meet or exceed the minimum design requirements; and, that inspections of the impoundment were made during critical periods of the construction by or under my direction in accordance with the requirements of regulation R645-301-514.300.

(Signature)

5/16/92
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

POND INSPECTION REPORT
CASTLE GATE COAL COMPANY
(FINAL INSPECTION)

POND: 012B

LOCATION: CASTLE GATE

ITEM	REMARKS
(1) Potential Safety Hazards	None noted.
(2) Slope Stability	Slopes appear stable. Near vertical on east side. Mostly incised-shallow pond.
(3) Erosion	None evident.
(4) Construction and Maintenance Performance Standards	Pond completed. Embankment raised approx. 2', and extended to north along inlet.
(5) Recommendations/Comments	Surveyed 5/16/92. Capacity at Spillway - 53,730 cu. ft. Pond appears to meet design.

I have performed the above inspection on this pond and do hereby certify it to be a true and accurate representation of the pond at this time.

(Signature)

5/16/92
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

POND INSPECTION REPORT
CASTLE GATE COAL COMPANY
(CONSTRUCTION INSPECTION)

POND: 012B

LOCATION: CASTLE GATE

ITEM	REMARKS
(1) Potential Safety Hazards	None noted.
(2) Slope Stability	Slopes appear stable. Near vertical on east side. Mostly incised-shallow pond.
(3) Erosion	None evident.
(4) Construction and Maintenance Performance Standards	Embankment being raised and compacted with roller. Bank along inlet also being raised to north.
(5) Recommendations/Comments	Under reconstruction. Compaction looks good. Pond interior not modified.

I have performed the above inspection on this pond and do hereby certify it to be a true and accurate representation of the pond at this time.

(Signature)

4/20/92
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

SEDIMENT POND CERTIFICATION

Company Name and Address	CASTLE GATE COAL COMPANY P.O. BOX 449 HELPER, UTAH 84526
Permit Number	ACT/007/004
Pond Location	CASTLE GATE
Pond Identification	012 B

Certification Statement:

I hereby certify that I am experienced in the construction of impoundments; I am qualified and authorized in the State of Utah to inspect and certify the construction of impoundments in accordance with the certified and approved design for this structure; the materials and conditions required for construction are in accordance with approved design and meet or exceed the minimum design requirements; and, that inspections of the impoundment were made during critical periods of the construction by or under my direction in accordance with the requirements of regulation R645-301-514.300.

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

(Signature)

10/29/91
(Date)

POND INSPECTION REPORT
CASTLE GATE COAL COMPANY
(FINAL INSPECTION)

POND: 012B

LOCATION: CASTLE GATE

ITEM	REMARKS
(1) Potential Safety Hazards	None noted.
(2) Slope Stability	Slopes appear stable. Near vertical on east side. Mostly incised-shallow pond.
(3) Erosion	None evident.
(4) Construction and Maintenance Performance Standards	Pond completed. Emergency spillway and decant added.
(5) Recommendations/Comments	Surveyed 10/6/91. Capacity at Spillway - 53,730 cu. ft. Pond appears to meet design, although it is longer.

I have performed the above inspection on this pond and do hereby certify it to be a true and accurate representation of the pond at this time.

(Signature)

10/6/91
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

POND INSPECTION REPORT
CASTLE GATE COAL COMPANY
(CONSTRUCTION INSPECTION)

POND: 012B

LOCATION: CASTLE GATE

ITEM	REMARKS
(1) Potential Safety Hazards	None noted.
(2) Slope Stability	Slopes appear stable. Near vertical on east side.
(3) Erosion	None evident.
(4) Construction and Maintenance Performance Standards	Pond under reconstruction. Water and sewer lines are limiting enlargement.
(5) Recommendations/Comments	Lengthen pond to compensate for inability to deepen due to lines.

I have performed the above inspection on this pond and do hereby certify it to be a true and accurate representation of the pond at this time.

(Signature)

10/3/91
(Date)

REGISTERED PROFESSIONAL ENGINEER
No. 4548
DAN W. GUY
STATE OF UTAH

APPENDIX 3.4P-1

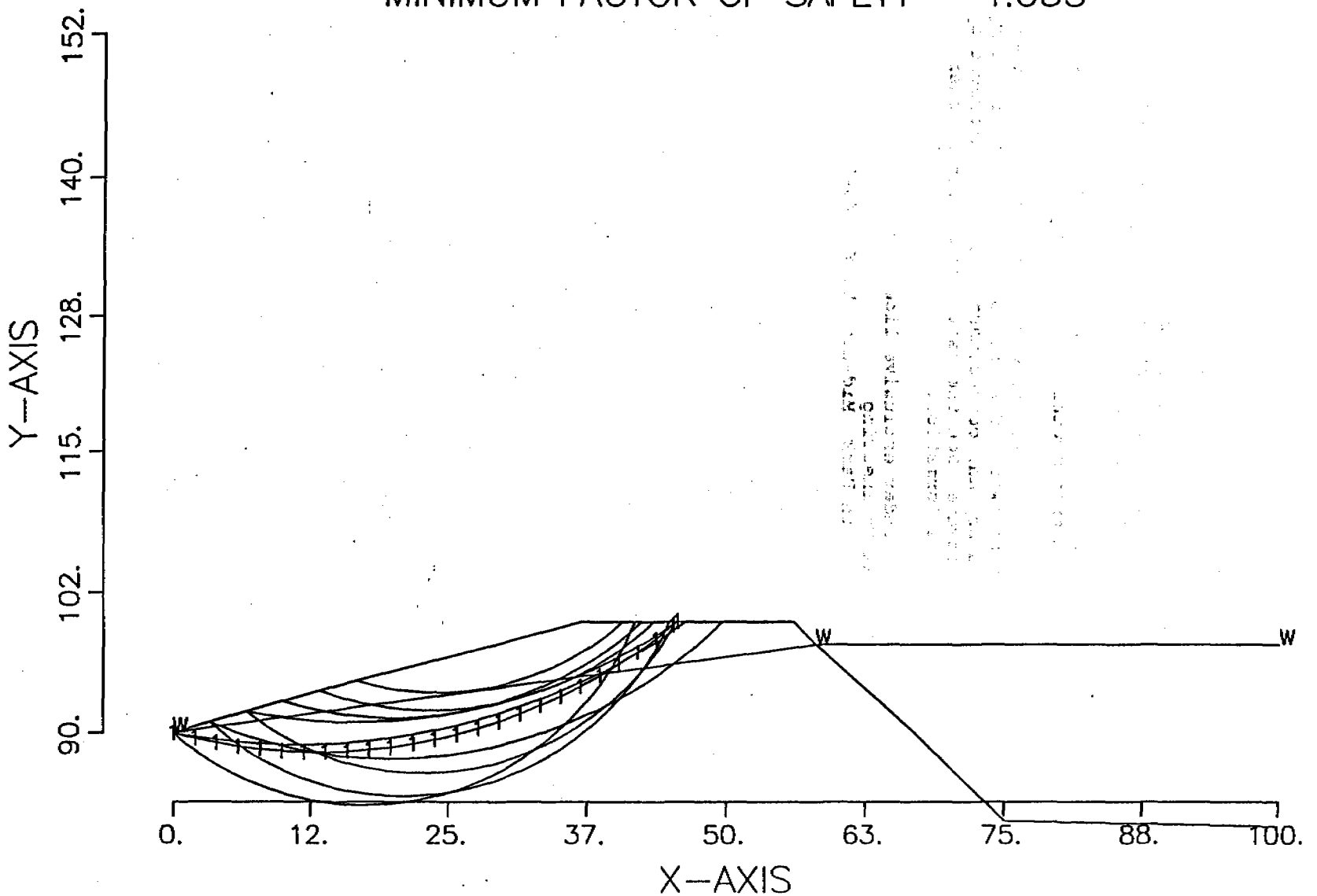
EMBANKMENT STABILITY ANALYSIS FOR POND 011
COMPUTER OUTPUT

REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH

2/2/94

Earth Fax Engineering
732[illegible] S.Union Park Midvale, UTAH 8[illegible]47

CASTLE GATE COAL – PREPARATION PLANT
POND 011 OUTSLOPE C – C'
100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 4.035



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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION CASTLE GATE COAL - PREPARATION PLANT
POND 011 OUTSLOPE C - C'

BOUNDARY COORDINATES

7 TOP BOUNDARIES
7 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	90.00	14.00	94.00	1
2	14.00	94.00	37.00	100.00	1
3	37.00	100.00	56.00	100.00	1
4	56.00	100.00	58.00	98.00	1
5	58.00	98.00	67.00	90.00	1
6	67.00	90.00	75.00	82.00	1
7	75.00	82.00	100.00	81.50	1

ISOTROPIC SOIL PARAMETERS

1 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	115.0	135.0	100.0	34.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNIT WEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	90.00
2	58.00	98.00
3	100.00	98.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = .00
AND X = 30.00

EACH SURFACE TERMINATES BETWEEN X = 40.00

AND X = 65.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

2.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

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FAILURE SURFACE # 1 SPECIFIED BY 26 COORDINATE POINTS

SAFETY FACTOR = 4.035

X-CENTER = 13.17
Y-CENTER = 138.78
RADIUS = 50.53

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	.00	90.00	-13.98
2	1.94	89.52	-11.71
3	3.90	89.11	-9.44
4	5.87	88.78	-7.18
5	7.86	88.53	-4.91
6	9.85	88.36	-2.64
7	11.85	88.27	-.37
8	13.85	88.26	1.90
9	15.85	88.32	4.17
10	17.84	88.47	6.43
11	19.83	88.69	8.70
12	21.81	89.00	10.97
13	23.77	89.38	13.24
14	25.72	89.83	15.51
15	27.64	90.37	17.77
16	29.55	90.98	20.04
17	31.43	91.66	22.31
18	33.28	92.42	24.58
19	35.10	93.26	26.85
20	36.88	94.16	29.11
21	38.63	95.13	31.38
22	40.33	96.17	33.65
23	42.00	97.28	35.92
24	43.62	98.45	38.19
25	45.19	99.69	40.45
26	45.55	100.00	

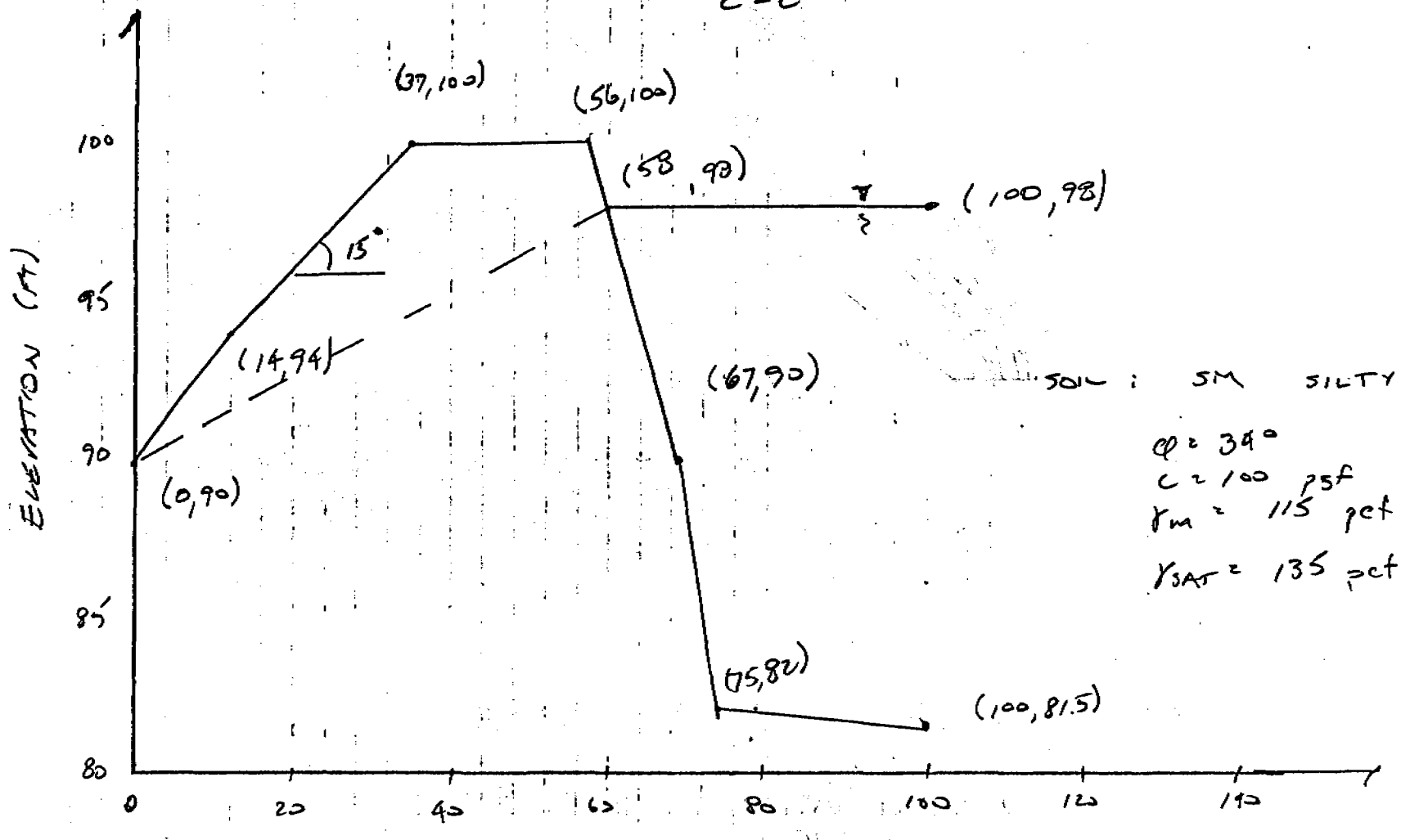
SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	.97	1.94	115.80	.00	.00	137.39	72.53

2	2.92	1.96	342.41	.00	.00	372.89	111.90
3	4.89	1.97	555.65	.00	.00	587.87	147.84
4	6.86	1.98	753.82	.00	.00	782.48	180.37
5	8.85	1.99	935.41	.00	.00	956.83	209.52
6	10.85	2.00	1099.06	.00	.00	1111.07	235.30
7	12.85	2.00	1243.64	.00	.00	1245.33	257.74
8	13.92	.15	100.38	.00	.00	99.75	20.46
9	14.92	1.85	1262.94	.00	.00	1255.16	255.60
10	16.84	1.99	1455.73	.00	.00	1438.46	290.03
11	18.83	1.99	1526.89	.00	.00	1502.66	300.76
12	20.82	1.98	1576.58	.00	.00	1547.75	308.30
13	22.79	1.96	1604.72	.00	.00	1573.98	312.68
14	24.74	1.95	1611.48	.00	.00	1581.61	313.96
15	26.68	1.93	1597.21	.00	.00	1570.93	312.17
16	28.60	1.90	1562.48	.00	.00	1542.26	307.38
17	30.49	1.88	1508.06	.00	.00	1495.96	299.64
18	32.35	1.85	1434.91	.00	.00	1432.42	289.02
19	34.19	1.82	1344.19	.00	.00	1352.07	275.59
20	35.99	1.78	1237.23	.00	.00	1255.38	259.42
21	36.94	.12	80.01	.00	.00	82.05	17.12
22	37.81	1.63	995.81	.00	.00	1019.23	216.54
23	38.84	.42	226.82	.00	.00	234.42	51.26
24	39.69	1.29	626.87	.00	.00	645.59	145.41
25	41.17	1.66	626.63	.00	.00	647.69	157.84
26	42.81	1.62	397.15	.00	.00	405.40	117.34
27	44.41	1.57	167.64	.00	.00	154.04	75.32
28	45.37	.36	6.44	.00	.00	-1.40	11.57

```
PROFIL
CASTLE GATE COAL - PREPARATION PLANT          POND 011  OUTSLOPE  C - C'
7
0.0 90.0 14.0 94.0 1
14.0 94.0 37.0 100.0 1
37.0 100.0 56.0 100.0 1
56.0 100.0 58.0 98.0 1
58.0 98.0 67.0 90.0 1
67.0 90.0 75.0 82.0 1
75.0 82.0 100.0 81.5 1
SOIL
1
115.0 135.0 100.0 34.0 0.0 0.0 0
WATER
1 0.0
3
0.0 90.0
58.0 98.0
100.0 98.0
CIRCL2
10 10
0.0 30.0
40.0 65.0
0.0
2.0
0.0
0.0
```

X-VXII

POND 011
OUTSLOPE
C-C'



SOIL : SM SILTY SAND

$\phi = 34°$
$c = 100$ psf
$\gamma_m = 115$ pcf
$\gamma_{SAT} = 135$ pcf

NOTE: ELEVATIONS ARE RELATIVE

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PROJECT LLC-150-07 PAGE ___ OF ___
COMPUTED KDH DATE 6/92
CHECKED ___ DATE ___

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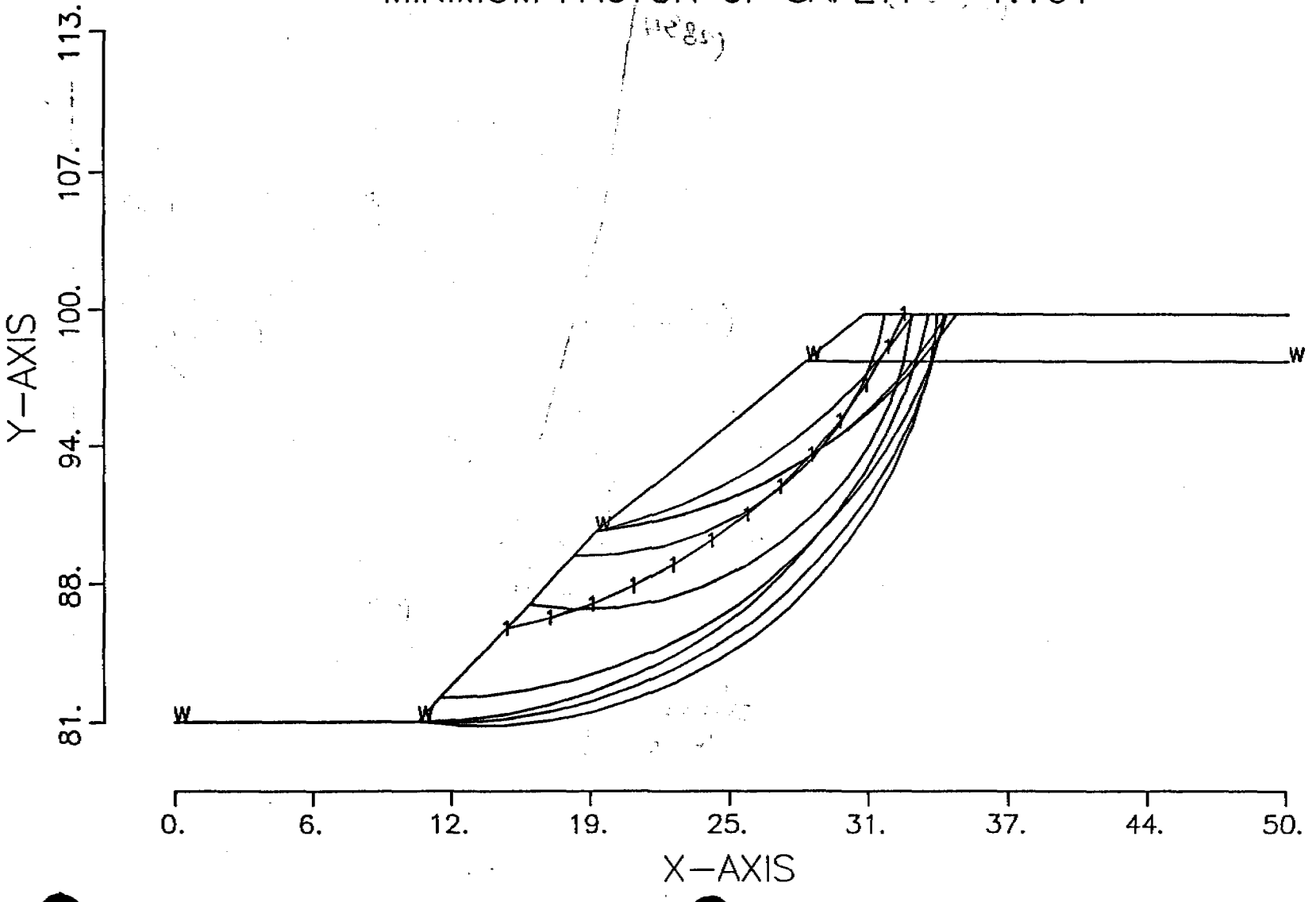
CASTLE GATE COAL – PREPARATION PLANT
POND 011 INSLOPE D – D'
100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.161



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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION CASTLE GATE COAL - PREPARATION PLANT
POND 011 INSLOPE D - D'

BOUNDARY COORDINATES

5 TOP BOUNDARIES
6 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	81.50	11.00	81.50	1
2	11.00	81.50	19.00	90.00	1
3	19.00	90.00	28.40	97.80	1
4	28.40	97.80	31.00	100.00	2
5	31.00	100.00	50.00	100.00	2
6	28.40	97.80	50.00	97.80	1

ISOTROPIC SOIL PARAMETERS

2 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	135.0	135.0	25.0	34.0	.00	.0	0
2	115.0	115.0	200.0	34.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNIT WEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 5 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	81.50
2	11.00	81.50
3	19.00	90.00
4	28.40	97.80
5	50.00	97.80

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED ALONG THE GROUND SURFACE BETWEEN X = 11.00

AND X = 20.00

EACH SURFACE TERMINATES BETWEEN X = 31.00
AND X = 50.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

2.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

RESTRICTIONS HAVE BEEN IMPOSED UPON THE ANGLE OF INITIATION.
THE ANGLE HAS BEEN RESTRICTED BETWEEN THE ANGLES OF -45.0 AND 20.0 DEG.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

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FAILURE SURFACE # 1 SPECIFIED BY 13 COORDINATE POINTS

SAFETY FACTOR = 1.161

X-CENTER = 10.16
Y-CENTER = 110.04
RADIUS = 24.76

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	15.00	85.75	13.58
2	16.94	86.22	18.21
3	18.84	86.85	22.84
4	20.69	87.62	27.47
5	22.46	88.54	32.09
6	24.16	89.61	36.72
7	25.76	90.80	41.35
8	27.26	92.12	45.98
9	28.65	93.56	50.61
10	29.92	95.11	55.24
11	31.06	96.75	59.87
12	32.06	98.48	64.49
13	32.79	100.00	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	15.97	1.94	209.44	.00	.00	179.81	147.59
2	17.89	1.90	588.07	.00	.00	507.81	338.22
3	18.92	.16	63.83	.00	.00	54.41	35.26
4	19.84	1.69	782.46	.00	.00	668.72	428.10
5	21.57	1.77	971.26	.00	.00	823.47	521.67
6	23.31	1.69	1029.53	.00	.00	870.82	549.19

7	24.96	1.60	1025.76	.00	.00	870.28	548.88
8	26.51	1.50	966.62	.00	.00	826.83	523.63
9	27.83	1.14	709.54	.00	.00	614.78	392.61
10	28.53	.25	151.00	.00	.00	130.67	83.72
11	29.29	1.27	703.16	.00	.00	618.09	402.31
12	30.46	1.08	495.60	.00	.00	441.07	297.14
13	31.03	.06	24.23	.00	.00	21.34	14.69
14	31.37	.61	197.32	.00	.00	173.89	127.21
15	31.87	.39	84.44	.00	.00	-32.60	116.57
16	32.43	.73	63.37	.00	.00	-207.87	169.40

```
PROFIL
CASTLE GATE COAL - PREPARATION PLANT                    POND 011  INSLOPE  D - D'
0.0 81.5 11.0 81.5 1
11.0 81.5 19.0 90.0 1
19.0 90.0 28.4 97.8 1
28.4 97.8 31.0 100.0 2
31.0 100.0 50.0 100.0 2
28.4 97.8 50.0 97.8 1
SOIL
2
135.0 135.0 25.0 34.0 0.0 0.0 0
115.0 115.0 200.0 34.0 0.0 0.0 0
WATER
1 0.0
5
0.0 81.5
11.0 81.5
19.0 90.0
28.4 97.8
50.0 97.8
CIRCL2
10 10
11.0 20.0
31.0 50.0
0.0
2.0
20.0
[illegible].0
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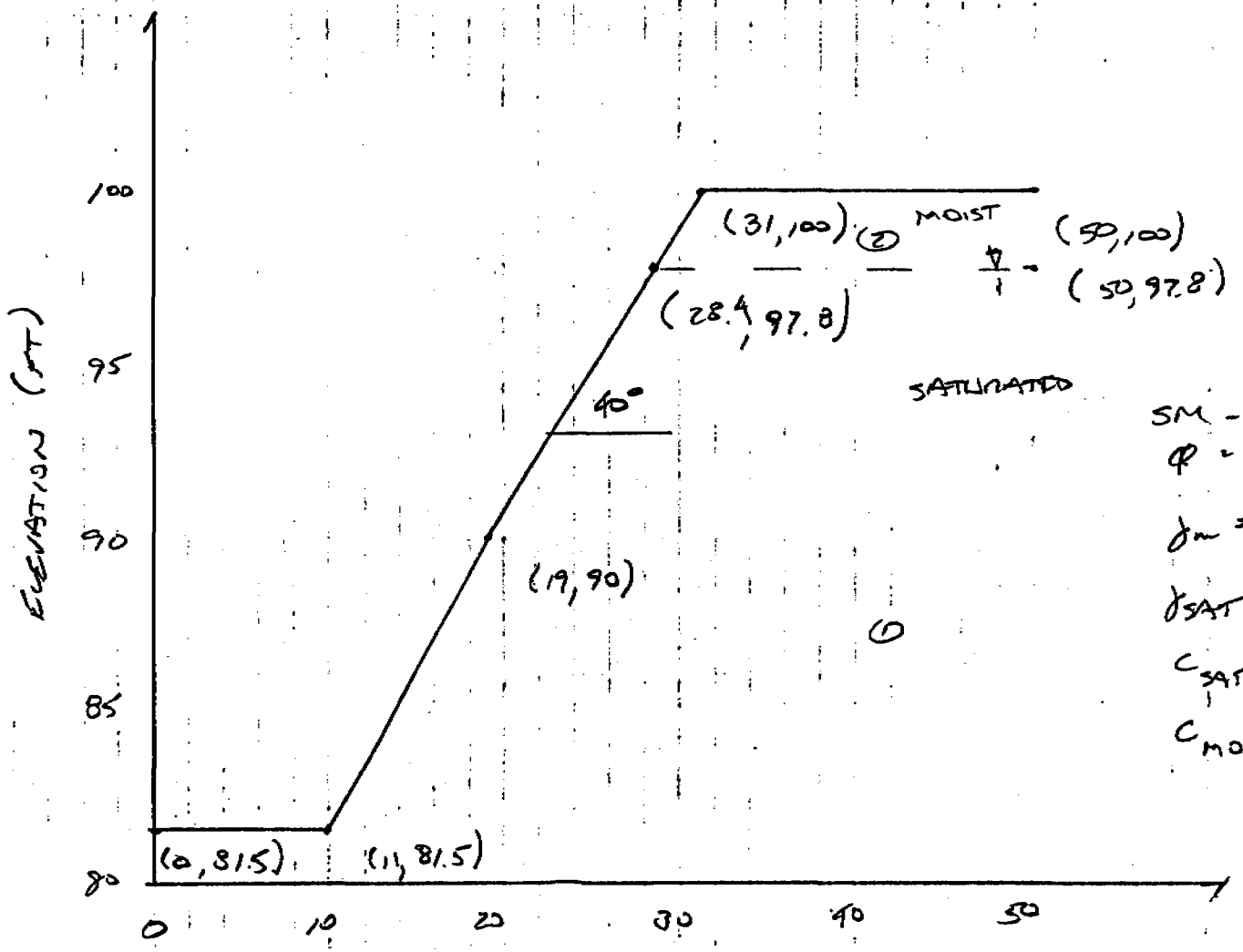
PROJECT AK-130 PAGE
COMPUTED [illegible] DATE 7/2/92 OF
CHECKED DATE

POND. 011 - INSLOPE
D - D'



SM - SILTY SAND, COMPACTED
$\phi = 34°$
$\gamma_m = 115$ PCF
$\gamma_{SAT} = 135$ PCF
$C_{SAT} = 25$ PSF
$C_{MOIST} = 200$ PSF

CASTLE GATE COAL
POND EMBANKMENTS
UNIT WEIGHT CALCULATIONS

REFERENCE: ① NAVFAC DM-7 DESIGN MANUAL SOIL MECHANICS, FOUNDATIONS AND EARTH STRUCTURES, MARCH 1971.

② HOEK, EVERT & BRAY JOHN. ROCK SLOPE ENGINEERING. 1981. THIRD EDITION

SILTY GRAVEL (GM):

SATURATED $\gamma_{SAT} = 120$ pcf ② SAND & GRAVEL MIXED GRAIN (NOT NECESSARILY COMPACTED) TABLE 1

DRY $\gamma_{DRY} = 110$ pcf

DRY: γ_{DRY} 120 - 135 ① TABLE 9-1 COMPACTED MATERIALS

RANGE OF OPTIMUM MOISTURE 8 - 12 %

$$\gamma_{WET} = \gamma_{DRY}(1+w)$$

ASSUME:
$\gamma_{DRY} = 125$ PCF LOW END OF "COMPACTED" RANGE BUT ABOVE HOEK VALUE

ASSUME: $G_s = 2.65$ G_s = SPECIFIC GRAVITY OF SOLIDS

$$w = S\left(\rho_w/\rho_d - 1/G_s\right)$$

$\rho_w = \gamma_w$ = DENSITY OF WATER

$\rho_d = \gamma_d$ = DRY DENSITY OF SOIL

S = DEGREE OF SATURATION

w = WATER CONTENT

IN SATURATED CONDITION

$$w = 1.0\left(\frac{62.4}{125} - \frac{1}{2.65}\right)$$

$$= 0.122 \text{ OR } 12.2\%$$

REFERENCE: CIVIL ENG. REFERENCE MANUAL MICHAEL LINDEBURG 1986. PG 9-7

$\gamma_{WET} = \gamma_{DRY}(1+w)$

@ $w = 12.2$, $\gamma_{DRY} = 125$ $\gamma_{WET} = \gamma_{SAT}$

$\gamma_{SAT} = 125(1+0.122)$

$\gamma_{SAT} = 140.2$ pcf SAY 140 PCF

GM: SILTY GRAVEL	γ_{DRY} = 125 PCF	
	γ_{SAT} = 140 PCF	

SM: SILTY SAND

② HOEK

	γ_{DRY}	γ_{SAT}
LOOSE SAND, MIXED GRAIN	99	125
DENSE SAND, MIXED GRAIN	116	135

① NAVFAC

SILTY SAND, SM, COMPACTED 110-125

OPT MOISTURE 11-16%

USE $\gamma_{DRY} = 115$ PCF

ASSUME $G_s = 2.65$

$w = S\left(\frac{\gamma_w}{\gamma_{DRY}} - \frac{1}{G_s}\right)$ $\gamma_w = \gamma_{WATER}$

$= 1.0\left(\frac{62.4}{115} - \frac{1}{2.65}\right)$

$w = 16.5\%$

$\gamma_{SAT} = \gamma_{WET}$ @ $S = 1$ ($w = 16.5\%$)

$\gamma_{SAT} = \gamma_{DRY}(1+w)$

$= 115(1+.165)$

$\gamma_{SAT} = 134$ PCF SAY 135 PCF

SILTY SAND, SM	$\gamma_{DRY} = 115$ PCF $\gamma_{SAT} = 135$ PCF

GP (SANDY GRAVEL)

(2) HOEK

	γ_{SAT}	γ_{DRY}
GRAVEL, UNIFORM	140	130

(1) NAVFAC

GRAVEL, SAND MIX, GP COMPACTED	115-125

USE $\gamma_{DRY} = 130$ pcf

$G_s = 2.65$

$w = S\left(\frac{\gamma_{WATER}}{\gamma_{DRY}} - \frac{1}{G_s}\right)$

$w_{SAT} = 1.0\left(\frac{62.4}{130} - \frac{1}{2.65}\right)$

$w_{SAT} = 10.32$

$\gamma_{SAT} = 130(1+.103)$

$\gamma_{SAT} = 143.4$

SAY 145 PCF

GP:	$\gamma_{DRY} = 130$ PCF $\gamma_{SAT} = 145$ PCF

Allow. Bearing Values 7-11-12
Prop. of Compacted Mat'ls 7-9-2
FRICTION FACTORS 7-10-7

DESIGN MANUAL

SOIL MECHANICS, FOUNDATIONS, AND EARTH STRUCTURES

NAVFAC DM-7
March 1971

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
200 STOVALL STREET
ALEXANDRIA, VA. 22332

KLEBBA

FROM NAVFAC DM-7

TABLE 9-1
Typical Properties of Compacted Materials

Group symbol	Soil type	Range of maximum dry unit weight, pcf	Range of optimum moisture, percent	Typical value of compression: At 1.4 tsf (20 psi) percent of original height	Typical value of compression: At 3.6 tsf (50 psi) percent of original height	Typical strength characteristics: Cohesion (as compacted) psf	Typical strength characteristics: Cohesion (saturated) psf	Typical strength characteristics: ϕ (Effective stress envelope) degrees	Typical strength characteristics: Tan ϕ	Typical coefficient of permeability ft/min.	Range of CBR values	Range of subgrade modulus k lb/cu in.
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix.	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	5×10^{-5}	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	2×10^{-6}	.....	
SC	Clayey sands, poody graded sand-clay mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	5×10^{-7}	5 - 20	100 - 300
ML	Inorganic silts and clayey silts .	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	10^{-5}	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	5×10^{-7}	.....	
CL	Inorganic clays of low to med. plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	10^{-7}	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	5×10^{-7}	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	10^{-7}	15 or less	50 - 150
OH	Organic clays and silty clays ...	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:
1. All properties are for condition of "standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.

(....) indicates insufficient data available for an estimate.

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Rock Slope Engineering

Revised third edition

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The Institution of Mining and Metallurgy, London
1981

Friction, cohesion and unit weight

The material properties which are most relevant to the discussion on slope stability presented in this book are the angle of friction, the cohesive strength and the unit weight of the rock and soil masses.

Friction and cohesion are best defined in terms of the plot of shear stress versus normal stress given in Figure 9. This plot is a simplified version of the results which would be obtained if a rock specimen containing a geological discontinuity such as a joint is subjected to a loading system which causes sliding along the discontinuity. The shear stress τ required to cause sliding increases with increasing normal stress σ. The slope of the line relating shear to normal stress defines the angle of friction ϕ. If the discontinuity surface is initially cemented or if it is rough, a finite value of shear stress τ will be required to cause sliding when the normal stress level is zero. This initial value of shear strength defines the cohesive strength c of the surface.

The relationship between shear and normal stresses for a typical rock surface or for a soil sample can be expressed as :

$$\tau = c + \sigma \tan \phi \qquad (1)$$

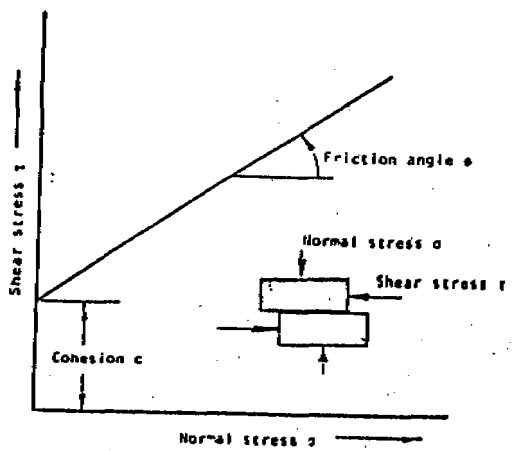


Figure 9 : Relationship between the shear stress τ required to cause sliding along a discontinuity and the normal stress σ acting across it.

HOEK & BRAY, 1981

TABLE 1 - TYPICAL SOIL AND ROCK PROPERTIES

Description			Unit weight (Saturated/dry)		Friction angle	Cohesion	
Type		Material	[illegible]	[illegible]	Degrees	[illegible]	[illegible]
Cohesionless	Sand	Loose sand , uniform grain size	118/90	19/14	28-34[a]		
		Dense sand, uniform grain size	130/109	21/17	32-40[a]		
		Loose sand, mixed grain size	124/99	20/16	34-40[a]		
		Dense sand, mixed grain size	135/116	21/18	38-46[a]		
	Gravel	Gravel, uniform grain size	140/130	22/20	34-37[a]		
		Sand and gravel, mixed grain size	120/110	19/17	48-45[a]		
	Blasted/broken rock	Basalt	140/110	22/17	40-50[a]		
		Chalk	80/62	13/10	30-40[a]		
		Granite	125/110	20/17	45-50[a]		
		Limestone	120/100	19/16	35-40[a]		
		Sandstone	110/80	17/13	35-45[a]		
		Shale	125/100	20/16	30-35[a]		
Cohesive	Clay	Soft bentonite	80/30	13/6	7-13	200-400	10-20
		Very soft organic clay	90/40	14/6	12-16	200-600	10-30
		Soft, slightly organic clay	100/60	16/10	22-27	400-1000	20-50
		Soft glacial clay	110/76	17/12	27-32	600-1500	30-73
		Stiff glacial clay	130/105	20/17	30-32	1500-3000	70-150
		Glacial till, mixed grain size	145/130	23/20	32-35	3000-5000	150-250
	Rock	Hard igneous rocks - granite, basalt, porphyry	[a] 160 to 190	25 to 30	35-45	720000-1150000	35000-55000
		Metamorphic rocks - quartzite, gneiss, slate	160 to 180	25 to 28	30-40	400000-600000	20000-40000
		Hard sedimentary rocks - limestone, dolomite, sandstone	150 to 180	23 to 28	35-45	200000-600000	10000-30000
		Soft sedimentary rock - sandstone, coal, chalk, shale	110 to 150	17 to 23	25-35	20000 - 400000	1000-20000

[a] Higher friction angles in cohesionless materials occur at low confining or normal stresses as discussed in Chapter 5.

[a] For intact rock, the unit weight of the material does not vary significantly between saturated and dry states with the exception of materials such as porous sandstones.

APPENDIX 3.4P-2

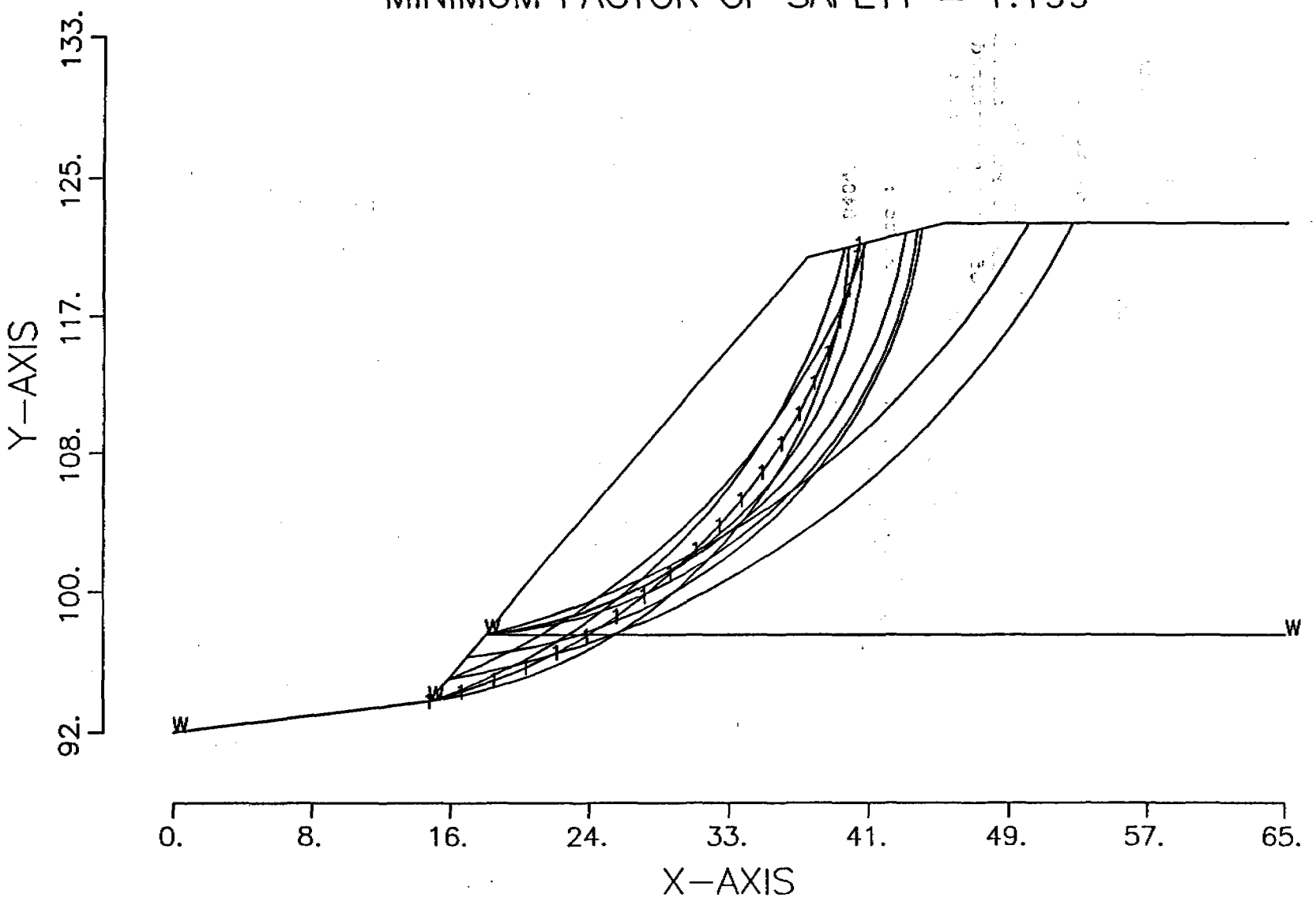
EMBANKMENT STABILITY ANALYSIS FOR POND 012A
COMPUTER OUTPUT

REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH

2/2/94

Earl Fax Engineering
7324 S.Union Park Midvale, UTAH 84047

CASTLE GATE COAL – PREPARATION PLANT
POND 012A INSLOPE G – G'
100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.199



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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION CASTLE GATE COAL - PREPARATION PLANT
POND 012A INSLOPE G - G'

BOUNDARY COORDINATES

6 TOP BOUNDARIES
7 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	92.20	15.00	94.00	1
2	15.00	94.00	18.30	97.90	1
3	18.30	97.90	20.00	100.00	2
4	20.00	100.00	37.00	120.00	2
5	37.00	120.00	45.00	122.00	2
6	45.00	122.00	65.00	122.00	2
7	18.30	97.90	65.00	97.90	1

ISOTROPIC SOIL PARAMETERS

2 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	135.0	135.0	25.0	34.0	.00	.0	0
2	115.0	115.0	200.0	34.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNIT WEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 4 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	92.20
2	15.00	94.00
3	18.30	97.90
4	65.00	97.90

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 15.00
AND X = 25.00

EACH SURFACE TERMINATES BETWEEN X = 35.00
AND X = 65.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00

2.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL
FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL
FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

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FAILURE SURFACE # 1 SPECIFIED BY 21 COORDINATE POINTS

SAFETY FACTOR = 1.199

X-CENTER = 6.68
Y-CENTER = 126.86
RADIUS = 33.90

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	15.00	94.00	15.90
2	16.92	94.55	19.28
3	18.81	95.21	22.66
4	20.66	95.98	26.04
5	22.45	96.86	29.42
6	24.20	97.84	32.80
7	25.88	98.92	36.19
8	27.49	100.10	39.57
9	29.03	101.38	42.95
10	30.50	102.74	46.33
11	31.88	104.19	49.71
12	33.17	105.71	53.09
13	34.37	107.31	56.47
14	35.48	108.98	59.85
15	36.48	110.71	63.23
16	37.38	112.49	66.61
17	38.18	114.33	70.00
18	38.86	116.21	73.38
19	39.43	118.13	76.76
20	39.89	120.07	80.14
21	40.01	120.75	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	15.96	1.92	224.00	.00	.00	190.52	148.84
2	17.61	1.38	426.83	.00	.00	368.97	237.90
3	18.56	.51	210.73	.00	.00	183.25	114.36

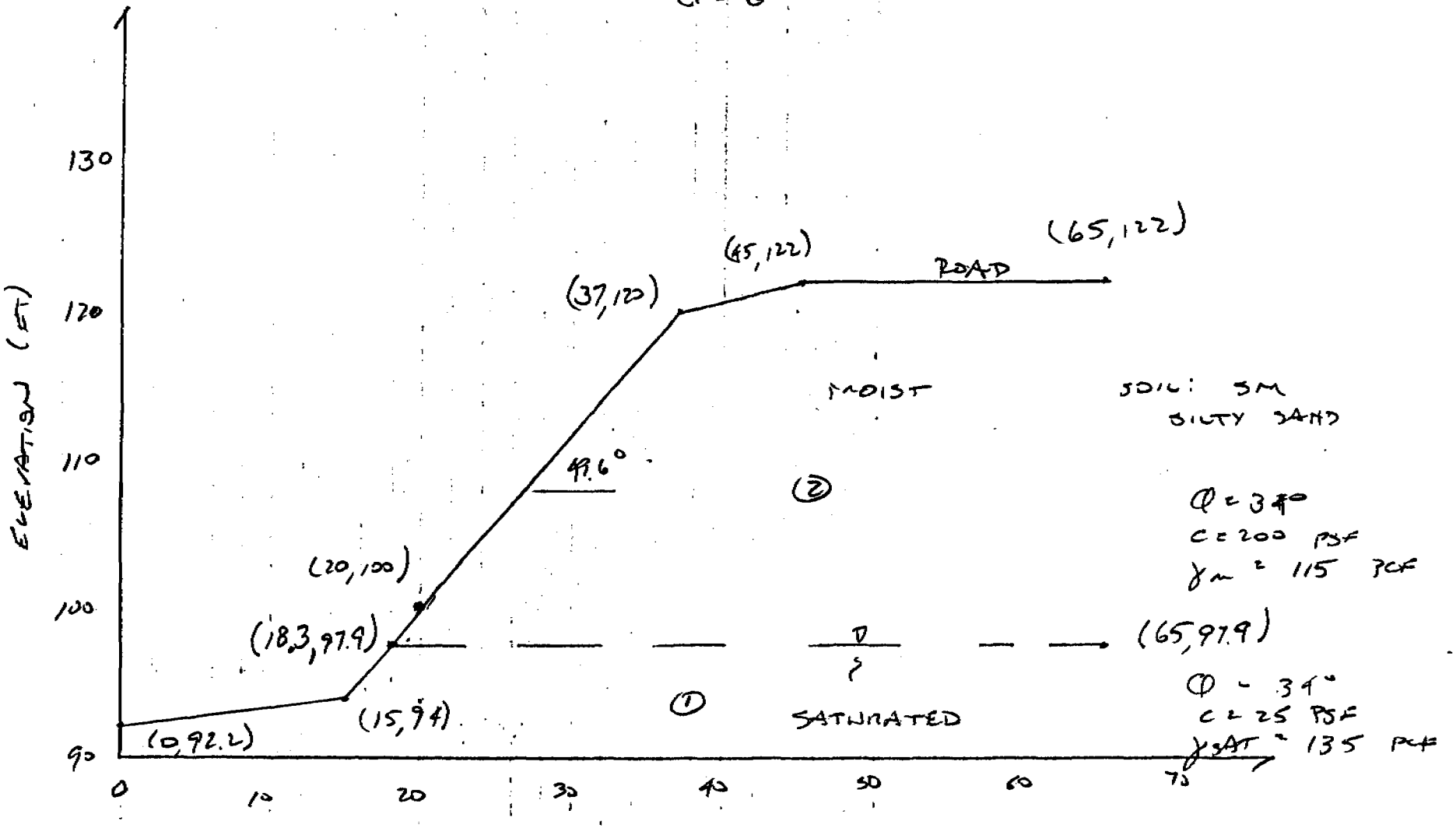
4	19.41	1.19	578.55	.00	.00	498.65	307.29
5	20.33	.66	370.63	.00	.00	320.24	194.95
6	21.56	1.80	1171.61	.00	.00	1006.91	607.99
7	23.33	1.74	1334.06	.00	.00	1144.93	685.61
8	24.24	.09	76.22	.00	.00	65.47	39.13
9	25.08	1.59	1382.23	.00	.00	1057.90	910.04
10	26.68	1.61	1550.08	.00	.00	1187.87	1001.59
11	28.26	1.54	1592.05	.00	.00	1221.83	1020.70
12	29.77	1.46	1587.42	.00	.00	1219.71	1019.51
13	31.19	1.38	1540.23	.00	.00	1183.78	999.29
14	32.53	1.29	1455.35	.00	.00	1116.48	961.44
15	33.77	1.20	1338.45	.00	.00	1020.49	907.46
16	34.93	1.10	1195.86	.00	.00	898.79	839.01
17	35.98	1.00	1034.47	.00	.00	754.69	757.97
18	36.74	.52	504.70	.00	.00	350.08	388.69
19	37.19	.38	349.15	.00	.00	233.71	273.17
20	37.78	.79	619.17	.00	.00	342.82	526.33
21	38.52	.68	402.03	.00	.00	101.81	390.78
22	39.15	.57	221.66	.00	.00	-118.69	266.77
23	39.66	.46	82.51	.00	.00	-311.83	158.15
24	39.95	.12	4.41	.00	.00	-150.09	30.57

```
PROFIL
CASTLE GATE COAL - PREPARATION PLANT                    POND 012A  INSLOPE  G - G'

0.0 92.2 15.0 94.0 1
15.0 94.0 18.3 97.9 1
18.3 97.9 20.0 100.0 2
20.0 100.0 37.0 120.0 2
37.0 120.0 45.0 122.0 2
45.0 122.0 65.0 122.0 2
18.3 97.9 65.0 97.9 1
SOIL
2
135.0 135.0 25.0 34.0 0.0 0.0 0
115.0 115.0 200.0 34.0 0.0 0.0 0
WATER
1 0.0
4
0.0 92.2
15.0 94.0
18.3 97.9
65.0 97.9
CIRCL2
10 10
15.0 25.0
35.0 65.0
0.0
2.0
0.0
```

POND 012A - INSLOPE

G - G'



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PROJECT Lb-190-07 PAGE ___ OF ___
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APPENDIX 3.4P-3

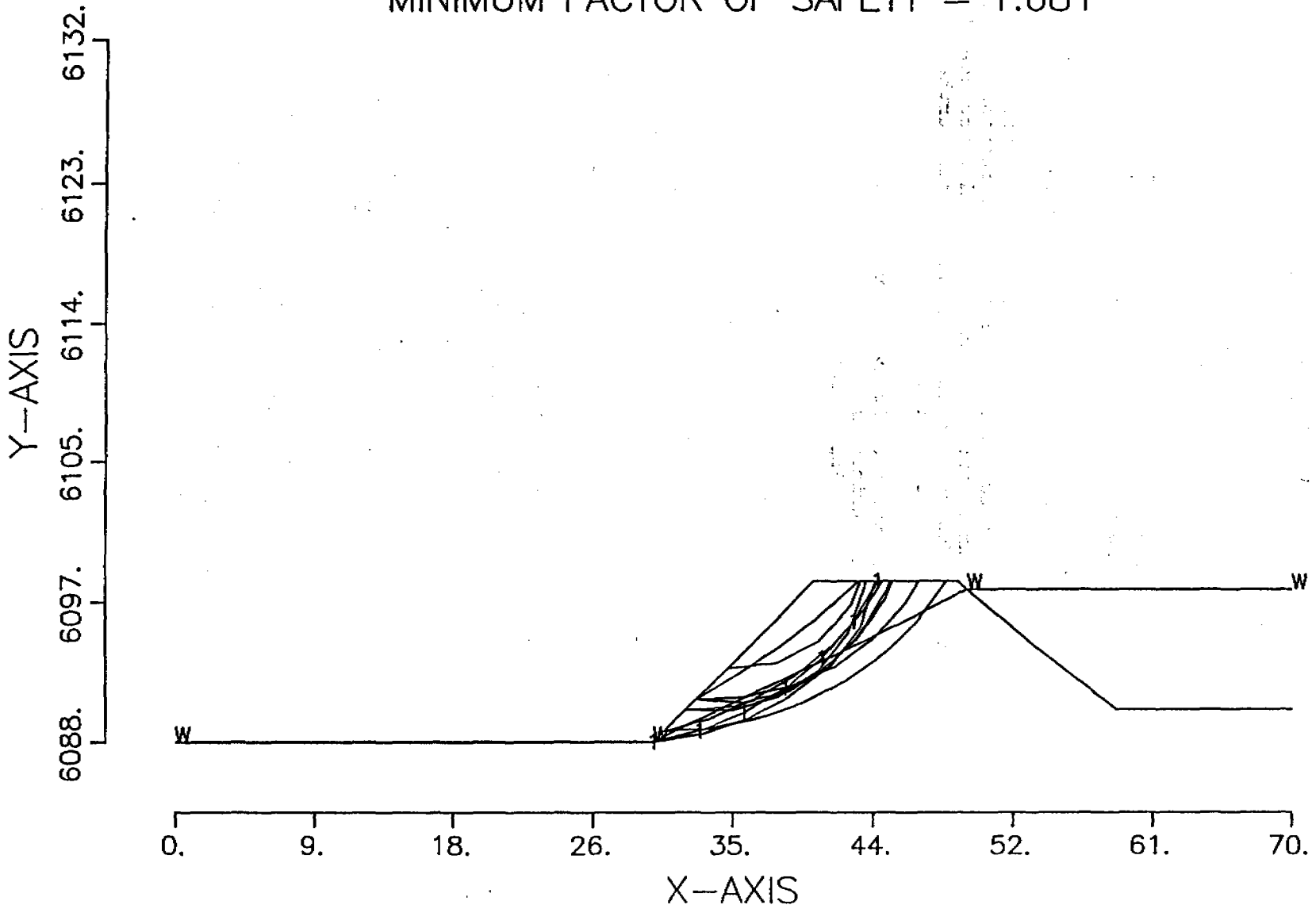
EMBANKMENT STABILITY ANALYSES FOR POND 012B
COMPUTER OUTPUT

REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH

2/2/94

Earl Fax Engineering
7324 S.Union Park Midvale, UTAH 84047

CASTLE GATE COAL – PREPARATION PLANT
POND 012B OUTSLOPE F – F'
100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.681



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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION CASTLE GATE COAL - PREPARATION PLANT
POND 012B OUTSLOPE F - F'

BOUNDARY COORDINATES

6 TOP BOUNDARIES
6 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	6088.00	30.00	6088.00	1
2	30.00	6088.00	40.00	6098.00	1
3	40.00	6098.00	49.00	6098.00	1
4	49.00	6098.00	49.60	6097.50	1
5	49.60	6097.50	59.00	6090.00	1
6	59.00	6090.00	70.00	6090.00	1

ISOTROPIC SOIL PARAMETERS

1 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	115.0	135.0	100.0	34.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNIT WEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 4 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	6088.00
2	30.00	6088.00
3	49.60	6097.50
4	70.00	6097.50

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 30.00
AND X = 36.00

EACH SURFACE TERMINATES BETWEEN X = 42.00

AND X = 59.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

3.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

EarthFax Engineering
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FAILURE SURFACE # 1 SPECIFIED BY 7 COORDINATE POINTS

SAFETY FACTOR = 1.681

X-CENTER = 27.14
Y-CENTER = 6106.81
RADIUS = 19.03

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	30.00	6088.00	13.16
2	32.92	6088.68	22.20
3	35.70	6089.82	31.24
4	38.26	6091.37	40.27
5	40.55	6093.31	49.30
6	42.51	6095.59	58.34
7	44.00	6098.00	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	30.00	.00	.00	.00	.00	-.02	.09
2	31.46	2.92	375.91	.00	.00	314.80	304.71
3	34.31	2.78	977.46	.00	.00	844.55	517.40
4	36.98	2.57	1294.05	.00	.00	1130.14	632.00
5	39.13	1.74	1002.84	.00	.00	895.31	494.61
6	40.01	.01	5.99	.00	.00	5.36	2.94
7	40.28	.54	307.33	.00	.00	273.81	152.24
8	41.53	1.96	798.79	.00	.00	693.78	456.89
9	43.25	1.49	206.53	.00	.00	72.64	197.86

```
PROFIL
CASTLE GATE COAL - PREPARATION PLANT          POND 012B  OUTSLOPE  F - F'
0.0 6088.0 30.0 6088.0 1
30.0 6088.0 40.0 6098.0 1
40.0 6098.0 49.0 6098.0 1
49.0 6098.0 49.6 6097.5 1
49.6 6097.5 59.0 6090.0 1
59.0 6090.0 70.0 6090.0 1
SOIL
1
115.0 135.0 100.0 34.0 0.0 0.0 0
WATER
1 0.0
4
0.0 6088.0
30.0 6088.0
49.6 6097.5
70.0 6097.5
CIRCL2
10 10
30.0 36.0
42.0 59.0
0.0
3.0
0.0
0.0
```

EARTHFAX ENGINEERING, INC.
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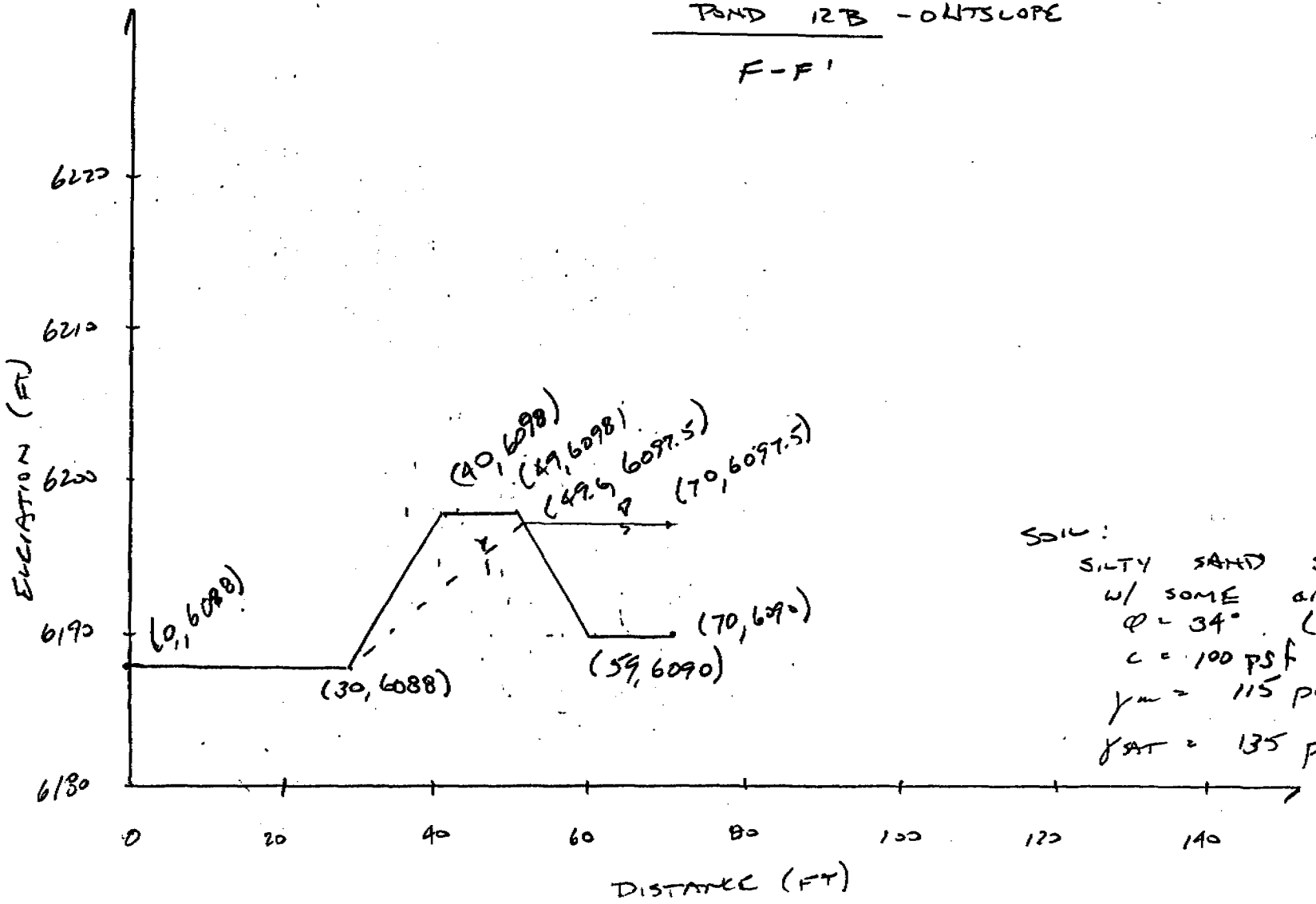
PROJECT LC-150-07 PAGE ___ OF ___
COMPUTED [illegible] DATE 6/92
CHECKED ___ DATE ___

POND 12B - OUTSLOPE

F-F'



SOIL:
SILTY SAND SM
w/ SOME GRAVEL
$\varphi = 34°$ (COMPACTED)
$c = 100$ psf
$\gamma_m = 115$ pcf
$\gamma_{SAT} = 135$ pcf

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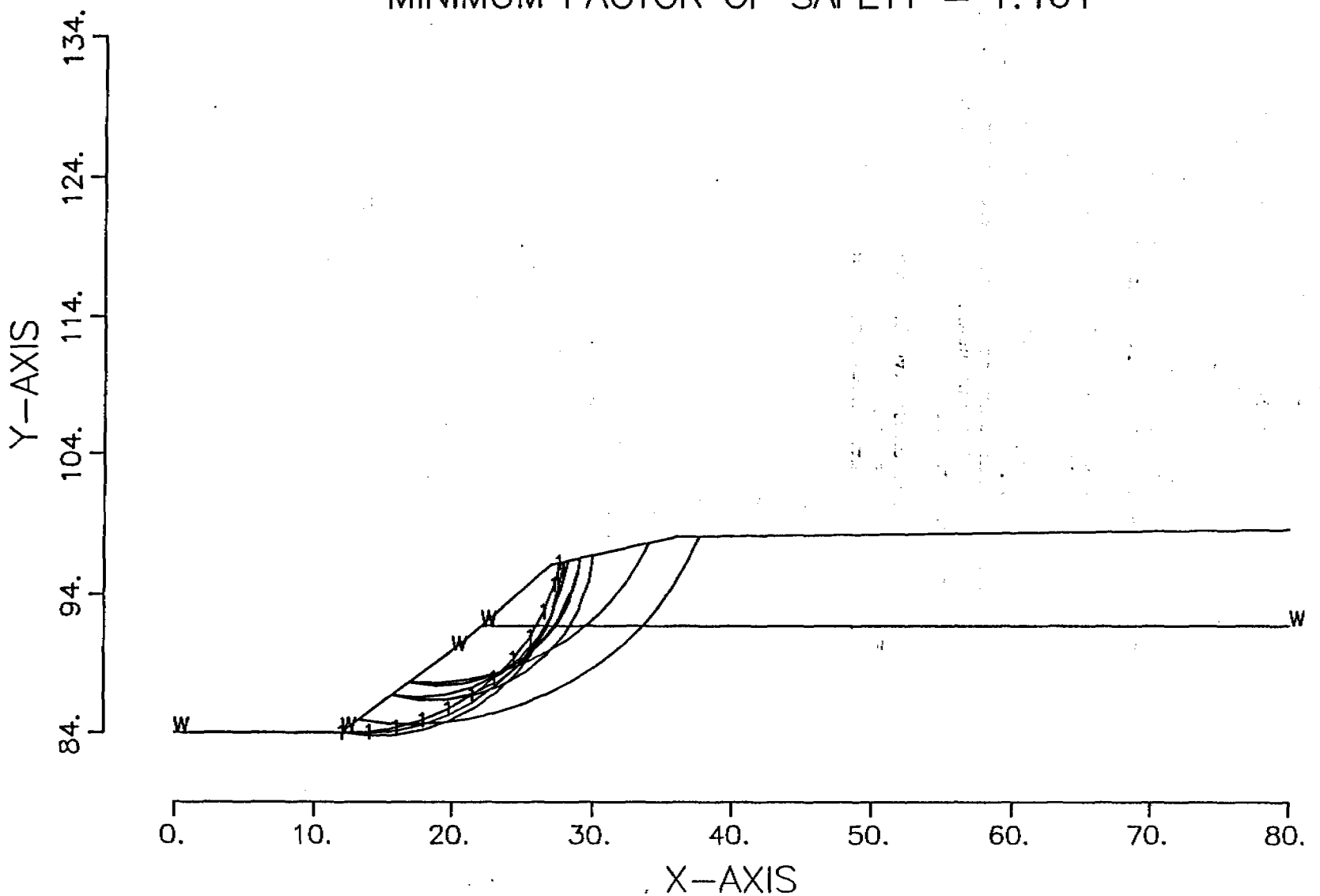
CASTLE GATE COAL – PREPARATION PLANT
POND 012B INSLOPE H – H'
100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.461



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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION CASTLE GATE COAL - PREPARATION PLANT
POND 012B INSLOPE H - H'

BOUNDARY COORDINATES

6 TOP BOUNDARIES
7 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	84.00	12.00	84.00	1
2	12.00	84.00	20.00	90.00	1
3	20.00	90.00	22.10	91.80	1
4	22.10	91.80	27.00	96.00	2
5	27.00	96.00	36.00	98.00	2
6	36.00	98.00	80.00	98.50	2
7	22.10	91.80	80.00	91.80	1

ISOTROPIC SOIL PARAMETERS

2 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	135.0	135.0	25.0	34.0	.00	.0	0
2	115.0	115.0	200.0	34.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNIT WEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 5 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	84.00
2	12.00	84.00
3	20.00	90.00
4	22.10	91.80
5	80.00	91.80

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED

ALONG THE GROUND SURFACE BETWEEN X = 12.00
AND X = 23.00

EACH SURFACE TERMINATES BETWEEN X = 25.00
AND X = 50.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

2.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

RESTRICTIONS HAVE BEEN IMPOSED UPON THE ANGLE OF INITIATION.
THE ANGLE HAS BEEN RESTRICTED BETWEEN THE ANGLES OF -40.0 AND 20.0 DEG.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

EarthFax Engineering
7324 S.Union Park Midvale, UTAH 84047

FAILURE SURFACE # 1 SPECIFIED BY 12 COORDINATE POINTS

SAFETY FACTOR = 1.461

X-CENTER = 12.72
Y-CENTER = 99.28
RADIUS = 15.29

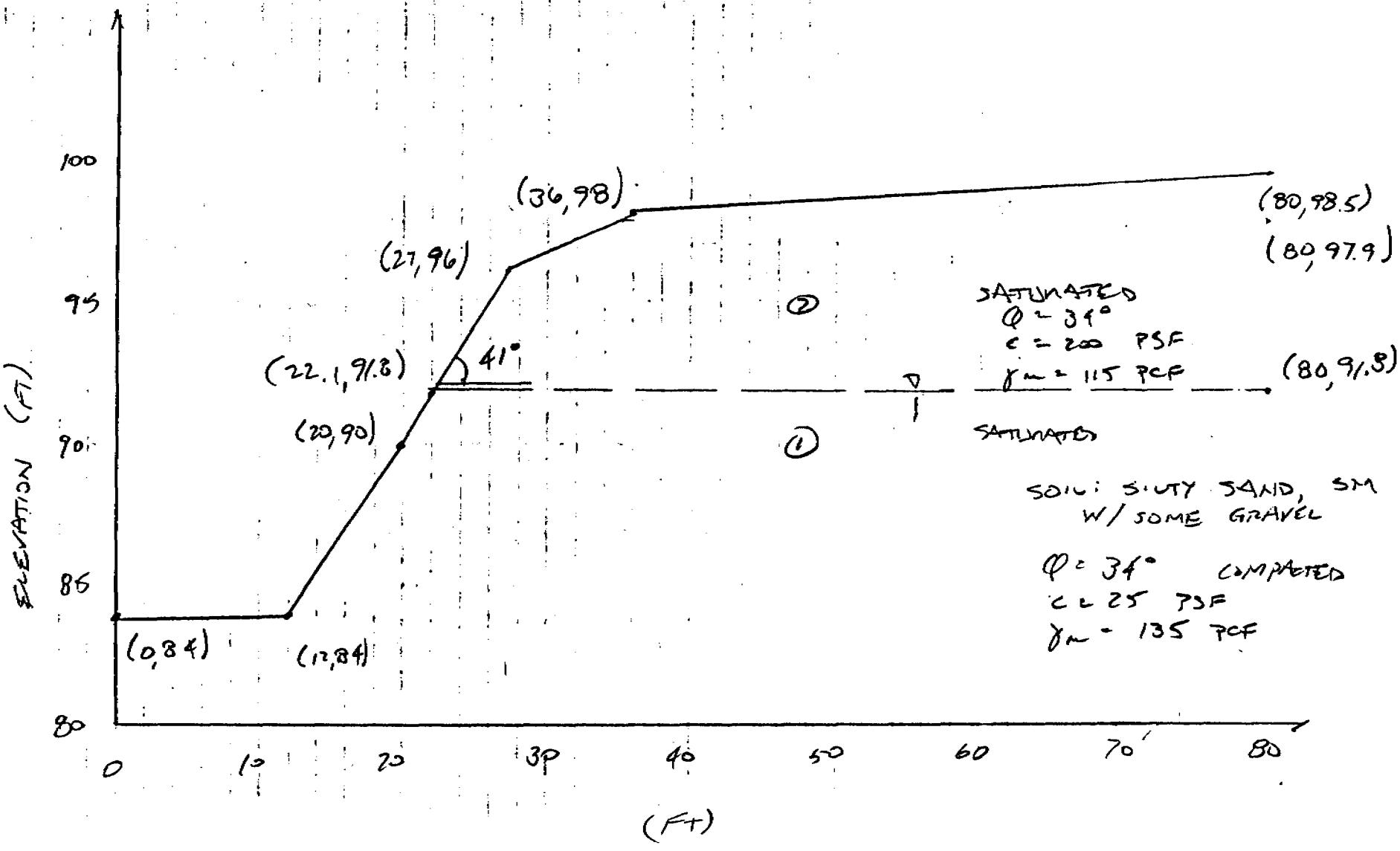
POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	12.00	84.00	1.06
2	14.00	84.04	8.56
3	15.98	84.33	16.06
4	17.90	84.89	23.55
5	19.73	85.69	31.05
6	21.45	86.72	38.55
7	23.01	87.97	46.05
8	24.40	89.41	53.55
9	25.59	91.01	61.04
10	26.56	92.76	68.54
11	27.29	94.63	76.04
12	27.67	96.15	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	13.00	2.00	197.44	.00	.00	195.18	124.30
2	14.99	1.98	548.85	.00	.00	514.17	271.54
3	16.94	1.92	802.46	.00	.00	728.42	370.43
4	18.82	1.83	946.66	.00	.00	847.30	425.30
5	19.87	.27	148.81	.00	.00	133.41	66.91
6	20.72	1.45	846.95	.00	.00	760.01	379.68
7	21.77	.65	400.50	.00	.00	366.07	183.26
8	22.56	.91	557.02	.00	.00	509.11	254.91
9	23.70	1.39	803.29	.00	.00	758.67	384.39

10	24.99	1.19	594.06	.00	.00	586.82	305.07
11	25.80	.44	181.95	.00	.00	189.75	102.96
12	26.29	.53	190.63	.00	.00	66.13	181.27
13	26.78	.44	126.78	.00	.00	-35.19	150.05
14	27.14	.29	58.51	.00	.00	-52.13	83.36
15	27.48	.38	31.31	.00	.00	-256.97	96.14

```
PROFIL
CASTLE GATE COAL - PREPARATION PLANT                    POND 012B  INSLOPE  H - H'
  5
0.0 84.0 12.0 84.0 1
12.0 84.0 20.0 90.0 1
20.0 90.0 22.1 91.8 1
22.1 91.8 27.0 96.0 2
27.0 96.0 36.0 98.0 2
36.0 98.0 80.0 98.5 2
22.1 91.8 80.0 91.8 1
SOIL
2
135.0 135.0 25.0 34.0 0.0 0.0 0
115.0 115.0 200.0 34.0 0.0 0.0 0
WATER
1 0.0
5
0.0 84.0
12.0 84.0
20.0 90.0
22.1 91.8
80.0 91.8
CIRCL2
10 10
12.0 23.0
25.0 50.0
0.0
2 0
  .0
-40.0
```

POND 012B - INSLOPE
H-H'



EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT LE-150.07 PAGE ___ OF ___
COMPUTED KKH DATE 7/2/92
CHECKED ___ DATE ___