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CLIENT PLATEAU
PROJECT CHANNEL RECLAMATION
FEATURE VOLUMES
PROJECT NO. 2-7-5

HANSEN ALLEN & LUCE inc

(CLAYS)

SHEET NO. 12

CHANNEL NO.	STATION	AREA RIPRAP (FT^2)	AVG. AREA RIPRAP (FT^2)	LENGTH (FT)	VOLUME (YD^3) / Σ VOLUME (YD^3)	AREA FILTER (FT^2)	AVG. AREA FILTER (FT^2)	VOLUME (YD^3) / Σ VOLUME (YD^3)
82								
			0	0	0 / 0			
TOP BACK OF CLAY INLET D=0 W=5.0	0-20	0						
			6.69	2				
END OF INLET TRANSISION D=0.8 W=5.0	0-18	13.38						
			17.18	3				
END OF $5D_{50}$ (1.0) D=2.0 W=5.0	0-15	20.97						
			20.97	15				
END INLET SECTION D=2.0 W=5.0	0+00	20.97						
			20.97	760.59				
FILTER STARTS START CLAY LINER DEPTH TRANSISION 1:1 D=2.0 W=5.0	7+60.59	20.97						
			30.46	1.41				
END DEPTH TRANSISION D=5.0 W=5.0	7+63.59	39.95						
			39.95	546.41				
END CLAY LINER	13+10	39.95						
			19.98	1.41				
TOP BACK OF CLAY D=4.0 W=5.0	13+11.41	0						

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HANSEN ALLEN & LUCE inc

SHEET NO. 13

CHANNEL NO. 82 CONT	STATION	AREA RIPRAP (FT.²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³)	ΣVOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³)	ΣVOLUME (YD³)
TOP BACK OF FILTER D=2.0 W=5.0	7+60.59						0	0	0	0
TOP BACK OF RIPRAP D50 (1.25) RIPRAP (0) 1:1 D=2.0 W=5.0	7+62	0	0	1.41	0	0	20.97	10.49	0.55	
END INLET TRANSISION RIPRAP (2.0) 1:1 D=2.0 W=5.0	7+64	48.60	23.30	2	1.73	1.73	34.27	27.62	2.05	2.59
START CHANNEL DEPTH & WIDTH TRANSISION D=2.0 W=5.0	7+72	48.60	48.60	8	14.40	16.13	34.27	34.27	10.15	12.75
END TRANSISION/GRADE CHANGE D=1.0 W=10.0	7+82	45.95	47.27	10	17.51	33.63	32.95	33.61	12.45	25.20
START CHANNEL WIDTH & DEPTH TRANSISION D=1.0 W=10.0	13+10	45.95	45.95	528	898.58	932.21	32.95	32.95	644.36	669.55
RIPRAP CHANGE START RIPRAP DEPTH TRANSISION END TRANSISION D=1.0 W=5.0	13+30	42.27	44.11	20	32.67	964.89	31.11	32.03	23.73	693.28
END TRANSISION D50 (1.0) D=1.5 W=5.0	13+35	35.53	38.90	5	7.20	972.09	29.45	30.28	5.61	698.88
START CHANNEL DEPTH TRANSISION D=1.5 W=5.0	15+00	35.53	35.53	165	217.13	1189.22	29.45	29.45	179.97	878.86
END TRANSISION END CHANNEL D=2.0 W=5.0	15+10	41.07	38.30	10	14.19	1203.40	32.61	31.03	11.49	890.35

HANSEN ALLEN & LUCE INC

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PROJECT: CHANNEL RECLAMATION
FEATURE: VOLUMES
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SHEET NO. 14

CHANNEL NO.	STATION	AREA RIPRAP (FT.²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³) / Σ VOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³) / Σ VOLUME (YD³)
81								
START CHANNEL D50 ( ) D=2.0 W=5.0	0+00	41.07	41.07	0	0 / 0	32.61	32.61	0 / 0
RIPRAP CHANGE START RIPRAP DEPTH TRANSISION D50 (0.5) D=2.0 W=5.0	0+20	41.07	41.07	20	30.42 / 30.42	23.61	32.61	24.16 / 24.16
END DEPTH TRANSISION D=2.0 W=5.0	0+25	20.97	31.02	5	5.74 / 36.17	27.62	25.62	4.74 / 28.90
GRADE CHANGE RIPRAP CHANGE D50 (1.25) D=1.75 W=5.0	5+65	20.97	20.97	540	419.40 / 455.57	27.62	27.62	552.40 / 581.30
START CHANNEL DEPTH TRANSISION D=1.75 W=5.0	20+40	52.98	52.98	1475	2894.28 / 3349.84	34.35	34.35	1876.53 / 2457.83
END DEPTH TRANSISION D=4.0 W=5.0	20+50	85.00	68.99	10	25.55 / 3375.40	48.58	41.47	15.36 / 2473.19
CULVERT ENTRANCE D=4.0 W=5.0	21+12.5	85.00	85.00	62.5	197.[illegible] / 3572.2	48.58	48.58	112.5 / 2585.6
AREA BEHIND CULVERT ENTRANCE DETAIL M					27.9 / 3600.05			12.9 / 2598.5
AREA BEHIND CULVERT OUTLET DETAIL N					65.4 / 3665.45			16.2 / 2614.7

DETAIL M $t = 2.25'$

Riprap Vol

Bottom: $2.5 \times 2.5 \times t$ = 14

SIDES $= 2\left[\left(\frac{\sqrt{(2.5^2)2} + \sqrt{2(2.5+12)^2}}{2} \times 8.94\right] t\right.$ = 484

wedge $= 2\left[20.51 * t^2 + \left(\sqrt{2t^2+t^2}\right) t^2\right]$

$= 41.02 t^2 + 2\sqrt{3}\, t^3 = 247\ ft^3$

Edge $= 2\,(3.53) \times .236\, t^2 = 8.45\ ft^3$

Total Riprap Vol = **753 ft³** = 27.9 cy

Gravel Vol

Bottom: $(2.5 + .236\, t)^2 \times 1$ = 9.2

sides: $2\left[\frac{\sqrt{(2.5^2)2} + \sqrt{2(2.5+12)^2}}{2} * (8.94 + .236\, t)\right](1)$ = 228

wedge: $1\,(20.51)(2t) + 20\,(1)$ = 112

Vol gravel = 350 ft³ = **12.9 cy**

DETAIL N $t = 4'$

Bottom $= 2.5^2 \times t$ = 25.0

SIDES $= 2\left[\left(\frac{\sqrt{(2.5^2)2} + \sqrt{2(2.5+12)^2}}{2} \times 8.94\right] t\right.$ = 860.

wedge $= 2\left[20.51 \times t^2 + \sqrt{2t^2+t^2}\; t^2\right.$

$= 41.02 t^2 + 2\sqrt{3}\, t^3$ = 878

Edge $= 2(3.53) \times .236\, t^2$ = 3.8

Total Riprap 1767 CF

65.4 CY

Gravel: $(2.5 + .236\, t)^2$ = 11.9
Sides 242
Edge 184

438 CF = **16.2 cy**

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SHEET NO. 16

CHANNEL NO.	STATION	AREA RIPRAP (FT²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³) / Σ VOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³) / Σ VOLUME (YD³)
CULVERT OUTLET D50(2.5) START DEPTH TRANSISION D=4.0 W=5	22+40	174.39			/ 3665.45	60.22		/ 2614.7
RIPRAP CHANGE D50 (1.75) END DEPTH & WIDTH TRANSISION D=1.5 W=10.0	22+60	131.14	152.77	20	113.16 /	49.41	54.81	40.60 / 2655.3
END RIPRAP DEPTH TRANSISION D=1.5 W=10.0	22+80	88.38	109.76	20	81.30 /	42.76	46.08	34.13 / 2689.5
START END SECTION RIPRAP DEPTH TRANSISION D=1.5 W=10.0	22+95.25	88.38	88.38	15.25	49.92 /	42.76	42.76	24.15 / 2713.6
END DEPTH TRANSISION D=1.5 W=10.0	23+01.25	236.60	162.49	6	36.11 /	62.71	52.73	11.72 / 2725.3
END CHANNEL START END CHANNEL SLOPE D=1.5 W=10.0	23+10	236.60	236.60	8.75	76.68 /	62.71	62.71	20.32 / 2745.60
TOP BACK OF RIPRAP D=0 W=10.0	23+22	0	118.30	12	52.58 / 4,075.2	13.32	38.02	16.90 / 2762.56
TOP BACK OF FILTER D=0 W=10.0	23+24.2			2.2		0	6.66	0.54 / 2763.10

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SHEET NO. 17

CHANNEL NO.	STATION	AREA RIPRAP (FT^2)	AVG. AREA RIPRAP (FT^2)	LENGTH (FT)	VOLUME (YD^3)	Σ VOLUME (YD^3)	AREA FILTER (FT^2)	AVG. AREA FILTER (FT^2)	VOLUME (YD^3)	Σ VOLUME (YD^3)
25D										
TOP BACK OF FILTER INLET D=0 W=10.0	0-2.2						0			
								0	0	0
			0	2.2	0	0		6.66	0.54	0.54
TOP BACK OF RIPRAP INLET D=0 W=10.0	0+00	0					13.32			
			18.71	3.5	2.43	2.43		21.92	2.84	3.38
END OF INLET TRANSISION D=0.88 W=10.0	0+3.5	37.42					30.53			
			39.47	1.5	2.19	4.62		31.70	1.76	5.14
END OF $5D_{50}$ (1.0) TRANSISION D=1.25 W=10.0	0+5	41.52					32.87			
			41.52	15	23.07	27.68		32.87	18.26	23.4
END INLET SECTION D=1.25 W=10.0	0+20	41.52					32.87			
			41.52	363	558.21	585.90		32.87	441.92	465.3
RIPRAP DEPTH TRANSISION D=1.25 W=10.0	3+83	41.52					32.87			
			53.53	5	9.91	595.81		35.36	6.55	471.8
END DEPTH TRANSISION RIPRAP CHANGE D_{50}=1.5 D=1.25 W=10.0	3+87	65.54					37.85			
			65.54	33	80.10	675.91		37.85	46.26	518.1
RIPRAP CHANGE D_{50}=1.0 RIPRAP DEPTH TRANSISION D=1.25 W=10.0	4+20	65.54					37.85			
			53.53	5	9.91	685.83		35.36	6.55	524.6
END DEPTH TRANSISION D=1.25 W=10.0	4+25	41.52					32.87			

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SHEET NO. 18

CHANNEL NO. 25D CONT	STATION	AREA RIPRAP (FT²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³)	Σ VOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³)	Σ VOLUME (YD³)
START CHANNEL DEPTH TRANSISION D=1.25 W=10.0	5+48	41.52				874.97	32.87			674.42
			41.52	123	189.15			32.87	149.74	
END DEPTH TRANSISION D=3.25 W=10.0	5+52	63.65				882.76	45.52			680.
			52.59	4	7.79			39.19	5.81	
END CHANNEL	5+85	63.65				960.56	45.52			735.8
			63.65	33	77.79			45.52	55.64	

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SHEET NO. 19

CHANNEL NO.	STATION	AREA RIPRAP (FT²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³) / Σ VOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³) / Σ VOLUME (YD³)
25E								
TOP BACK OF FILTER INLET D=0 W=20.0	0-02.2					0	0	0 / 0
TOP BACK OF RIPRAP INLET D=0 W=20.0	0+00	0	0	2.2	0 / 0	23.32	11.66	0.95 / 0.95
END OF INLET TRANSISION D=0.67 W=17.5	0+05	75.12	37.56	5	6.96 / 6.96	41.68	32.50	6.02 / 6.97
END OF 5D50 (1.5) TRANSISION D=1.0 W=16.25	0+07.5	77.21	76.17	2.5	7.05 / 14.01	42.52	42.10	3.90 / 10.87
END INLET SECTION D=1.0 W=10.0	0+20	61.59	69.40	12.5	32.13 / 46.14	36.27	39.40	18.24 / 29.11
END CHANNEL D=1.0 W=10.0	0+50	61.59	61.59	30	68.43 / 114.57	36.27	36.27	40.30 / 69.41

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SHEET NO. 20

CHANNEL NO.	STATION	AREA RIPRAP (FT²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³) / Σ VOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³) / Σ VOLUME (YD³)
83								
							0	0 / 0
TOP BACK OF FILTER D=0 W=6.0	0-22.2					0		
			0	2.2	0 / 0		4.66	0.38 / 0.38
TOP BACK OF RIPRAP D=0 W=6.0	0-20	0				9.32		
			25.79	5	4.78 / 4.78		20.80	3.85 / 4.23
END OF INLET TRANSISION D=1.0 W=6.0	0-15	51.59				32.27		
			55.54	2.5	5.14 / 9.92		33.85	3.13 / 7.37
END OF 5D50 (1.5) D=1.5' W=6.0	0-12.5	59.50				35.43		
			59.50	12.5	27.55 / 37.46		35.43	16.40 / 23.77
END INLET SECTION D=1.5 W=6.0	0+00	59.50				35.43		
			59.50	367.5	809.86 / 847.33		35.43	482.24 / 506.01
START END SECTION RIPRAP DEPTH TRANSISION D=1.5 W=6.0	3+67.5	59.50				35.43		
			110.02	5	20.37 / 867.70		43.74	8.10 / 514.11
END RIPRAP DEPTH TRANSISION D=1.5 W=6.0	3+72.5	160.55				52.06		
			160.55	7.5	44.60 / 912.30		52.06	14.46 / 528.57
START END CHANNEL SLOPE D=1.5 W=6.0	3+80	160.55				52.06		
			80.28	10	29.73 / 942.03		30.69	11.37 / 539.94
TOP BACK OF RIPRAP D=0 W=6.0	3+90	0				9.32		

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SHEET NO. 21

CHANNEL NO. 83 CONT	STATION	AREA RIPRAP (FT^2)	AVG. AREA RIPRAP (FT^2)	LENGTH (FT)	VOLUME (YD^3) / Σ VOLUME (YD^3)	AREA FILTER (FT^2)	AVG. AREA FILTER (FT^2)	VOLUME (YD^3) / Σ VOLUME (YD^3)
TOP BACK OF FILTER D=0 W=6.0	3+92.2			2.2		0	4.66	0.38 / 540.32
6								
TOP BACK OF FILTER D=0 W=8.0	0-22.2					0	0	0 / 0
TOP BACK OF RIPRAP D=0 W=8.0	0-20	0	0	2.2	0 / 0	11.32	5.66	0.46 / 0.46
END OF INLET TRANSISION D=1.78 W=8.0	0-12	130.22	65.11	8	19.29 / 19.29	49.18	30.25	8.96 / 9.42
END OF $5D_{50}$ (2.25) D=2.5 W=8.0	0-8.75	148.44	139.33	3.25	16.77 / 36.06	53.73	51.46	6.19 / 15.62
END INLET SECTION D=2.5 W=8.0	0+00	148.44	148.44	8.75	48.11 / 84.17	53.73	53.73	17.41 / 33.03
START END SECTION RIPRAP DEPTH TRANSISION D=2.5 W=8.0	3+04.75	148.44	148.44	304.75	1675.45 / 1759.62	53.73	53.73	606.45 / 639.48

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SHEET NO. 22

CHANNEL NO. 6 CONT	STATION	AREA RIPRAP (FT²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³) / Σ VOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³) / Σ VOLUME (YD³)
			275.85	8	81.73 / 1841.35		67.03	19.86 / 659.34
END RIPRAP DEPTH TRANSISION D=2.5 W=8.0	3+12.75	403.26				80.33		
			403.26	11.25	168.03 / 2009.37		80.33	33.47 / 692.81
START END CHANNEL SLOPE D=2.5 W=8.0	3+24	403.26				80.33		
			201.63	16	119.48 / 2128.86		45.83	27.16 / 719.97
TOP BACK OF RIPRAP D=0 W=8.0	3+40	0				11.33		
				2.2			5.66	0.46 / 720.43
TOP BACK OF FILTER D=0 W=8.0	3+42.2					0		
7								
							0	0 / 0
TOP BACK OF FILTER D=0 W=5.0	0-22.2					0		
			0	2.2	0 / 0		4.16	0.34 / 0.34
TOP BACK OF RIPRAP D=0 W=5.0	0-20	0				8.32		
			16.27	3.5	2.11 / 2.11		18.03	2.34 / 2.68
END OF INLET TRANSISION D=1.23 W=5.0	0-16.5	32.55				27.74		

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SHEET NO. 23

CHANNEL NO. 7 CONT	STATION	AREA RIPRAP (FT²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³)	Σ VOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³)	Σ VOLUME (YD³)
			35.43	1.5	1.97	4.08		29.38	1.63	4.31
END OF 5D50 (1.0) D=1.75 W=5.0	0-15	38.30					31.03			
			38.30	15	21.28	25.36		31.03	17.24	21.55
END OF INLET SECTION D=1.75 W=5.0	0+00	38.30					31.03			
			38.30	354.5	502.86	528.22		31.03	407.41	428.96
START END SECTION RIPRAP DEPTH TRANSISION D=1.75 W=5.0	3+54.5	38.30					31.03			
			67.63	3.5	8.77	536.99		36.84	4.78	433.74
END RIPRAP DEPTH TRANSISION D=1.75 W=5.0	3+58	96.96					42.66			
			96.96	5	17.96	554.95		42.66	7.90	441.64
START END CHANNEL SLOPE D=1.75 W=5.0	3+63	96.96					42.66			
			48.48	7	12.57	567.52		25.49	6.61	448.24
TOP BACK OF RIPRAP D=0 W=5.0	3+70	0					8.32			
				2.2				4.16	0.34	448.58
TOP BACK OF FILTER D=0 W=5.0	3+72.2						0			

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SHEET NO. 24

CHANNEL NO.	STATION	AREA RIPRAP (FT^2)	AVG. AREA RIPRAP (FT^2)	LENGTH (FT)	VOLUME (YD^3) / Σ VOLUME (YD^3)	AREA FILTER (FT^2)	AVG. AREA FILTER (FT^2)	VOLUME (YD^3) / Σ VOLUME (YD^3)
51								
TOP BACK OF FILTER D=0 W=2.0	0-22.2					0	0	0 / 0
TOP BACK OF RIPRAP D=0 W=2.0	0-20	0	0	2.2	0 / 0	5.32	2.66	0.22 / 0.22
END OF INLET TRANSISION D=1.17 W=2.0	0-17.5	16.94	8.47	2.5	0.78 / 0.78	21.04	13.18	1.22 / 1.44
END OF D_{50} (0.75) D=1.75 W=2.0	0-16.25	21.53	19.23	1.25	0.89 / 1.67	24.70	22.87	1.06 / 2.50
END OF INLET SECTION D=1.75 W=2.0	0+00	21.53	21.53	16.25	12.96 / 14.63	24.70	24.70	14.87 / 17.36
START END SECTION RIPRAP DEPTH TRANSISION D=1.75 W=2.0	2+38.75	21.53	21.53	238.75	190.38 / 205.01	24.70	24.70	218.41 / 235.77
END RIPRAP DEPTH TRANSISION D=1.75 W=2.0	2+41.25	53.45	37.49	2.5	3.47 / 208.48	33.02	28.86	2.67 / 238.45
START END CHANNEL SLOPE D=1.75 W=2.0	2+45	53.45	53.45	3.75	7.42 / 215.91	33.02	33.02	4.59 / 243.03
TOP BACK OF RIPRAP D=0 W=2.0	2+50	0	26.73	5	4.95 / 220.86	5.32	19.17	3.55 / 246.58

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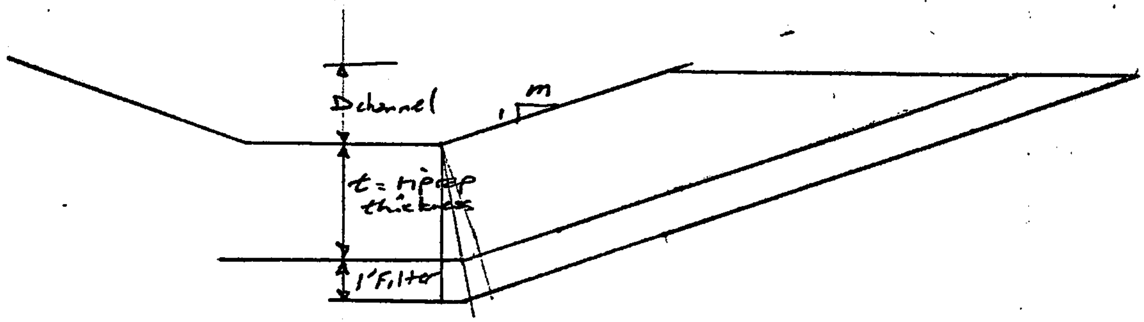
SHEET NO. 25

CHANNEL NO. 51 CONT	STATION	AREA RIPRAP (FT²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT)	VOLUME (YD³) / Σ VOLUME (YD³)		AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³) / Σ VOLUME (YD³)
TOP BACK OF FILTER D=0 W=2.0	2+52.2			2.2			0	2.66	0.22 / 246.8



Channel 4A

0+00 to 3+50 D = 1' w = 6' t = 3.5' m = 2

Riprap $\Delta w = 2\tan\left(\frac{\tan^{-1} 1/m}{2}\right) \times t = 1.65$

$A_{ch} = bY + mY^2 = 6(1) + 2 = 8$

$A_{riprap} = (6 + 1.65)(1 + 3.5) + 2(4.5)^2 - A_{ch} = 66.94$ o.k.

350 × 66.936 ⇒ 867 cy OK

Gravel $\Delta w = 2\tan\left(\frac{\tan^{-1} 1/m}{2}\right) \times (t+1) = 2.12$

$A_G = (6 + 2.12)(4.5 + 1) + 2(5.5)^2 - 66.94 - 8 =$

$A_G = 30.22$ ⇒ 391 cy OK

Channel 25B 0+00 to 2+80

D = 2', w = 13', t = 4', m = 3

Riprap $\Delta w = 1.3$ Gravel $\Delta w = 1.62$

$A_{ch} = 38 ft^2$

$A_{riprap} = (13 + 1.3)(2 + 4) + 3(6)^2 - A_{ch} = 155.8$ ✓

$A_G = (13 + 1.62)(7) + 3(7)^2 - 155.8 - 38 = 55.6$ ✓

Channel 25C 0+00 to 6+80

m = 3, D = 2.5, t = 4.5', w = 25

Riprap $\Delta w = 1.46$ gravel $\Delta w = 1.79$

$A_{ch} = 81.25$

$A_{riprap} = (4.5 + 2.5)(25 + 1.46) + 3(7)^2 - 81.25 = 250.97$ ✓

$A_G = (7 + 1)(25 + 1.79) + 3(8)^2 - 81.25 - 250.97 = 74.1$ ✓

CLIENT PLATEAU
PROJECT CHANNEL RECLAMATION
FEATURE VOLUMES
PROJECT NO. 2-7-5

HANSEN ALLEN & LUCE INC

SHEET NO. 9

CHANNEL NO. 25F CONT	STATION	AREA RIPRAP (FT²)	AVG. AREA RIPRAP (FT²)	LENGTH (FT.)	VOLUME (YD³) / Σ VOLUME (YD³)	AREA FILTER (FT²)	AVG. AREA FILTER (FT²)	VOLUME (YD³) / Σ VOLUME (YD³)
AREA BEHIND CULVERT ENTRANCE DETAIL J		993 ft³			36.78 / 3683.25	458 ft³		16.96 / 2449.78
AREA BEHIND CULVERT OUTLET DETAIL K		1123 ft³			41.59 / 3724.84	3448 ft³		127.70 / 2577.48
ADDITIONAL FILTER DETAIL J						358.32 ft³		13.27 / 2590.75
ADDITIONAL FILTER DETAIL K						354.02 ft³		13.11 / 2603.86
START DEPTH TRANSISION CULVERT OUTLET D50(1.75) D=3.0 W=10.0	19+20	116.84				52.25		
END DEPTH TRANSISION RIPRAP CHANGE D50(1.25) D=1.25 W=10.0	19+50	83.64	100.24	30	111.38 / 3836.21	41.18	46.71	51.90 / 2655.76
END RIPRAP DEPTH TRANSISION D=1.25 W=10.0	19+55	57.12	70.38	5	13.03 / 3849.25	36.19	38.69	7.16 / 2662.9
RIPRAP CHANGE D50(2.0) D=1.25 W=10.0	21+85	57.12	57.12	235	497.16 / 4346.40	36.19	36.19	314.99 / 2977.9
END CHANNEL D=1.25 W=10.0	22+10	103.40	103.40	25	95.74 / 4442.14	44.50	44.50	41.20 / 3019.11

DETAIL J: STA 18+40 to 18+40+5+ 11.31 = 1856.31

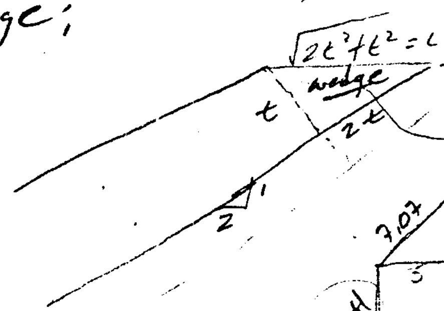
Riprap Vol t = thickness of riprap

bottom = 5' x 5' x t = 25 t

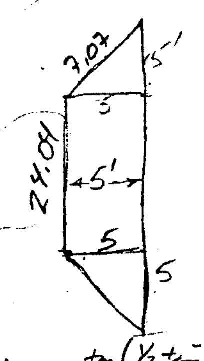
$$\text{sides} = 2\left[\left(\frac{\sqrt{5^2+5^2} + \sqrt{2(5+12)^2}}{2}\right) \times 8.944\right] t = 278.27\,t$$

(slope dist.)

wedge;



t = 3 ⇒ L = 6.71'
t = 2.25' L = 5.03'
$A = \frac{1}{2} 2t^2 = t^2$



Vol one side = $24.04 \times t^2 + 2\left(\frac{t^2 \cdot 10}{2}\right) \times 5$

$= 24.04\,t^2 + 5t^2$

Both sides = $2(29.04\,t^2)$

$\tan(\frac{1}{2}\tan^{-1}\frac{1}{2})$

edge ; $2(7.07) \times 0.236\,t^2 = 3.33$

∴ riprap Vol = $25t + 278.27t + 58.08t^2 + 3.33t^2$

riprap vol = $303.27\,t + 61.41\,t^2$

t = 2.25' ⇒ vol = **993 ft³**

$D_{50} = 1.25'$

Gravel Vol - 1' thick STA 18+40 to 18+56.31

bottom = $(5 + .236\,t)^2 \times 1'$ t = 2.25' → 30.6 ft²

sides = $2\left[\frac{\sqrt{5^2+5^2} + \sqrt{2(5+12)^2}}{2}\right] * (8.944 + .236t) | = 295\ ft^2$

wedge = $24.04(\frac{1}{2}t) + \bar{2}4$ = .132

Vol gravel = 30.6 + 295 ft² + 26.3 + 3.7 = **458 ft³**

ADDITIONAL FILTER 8.94 * 20.04 * 2 = **358.32 ft³**

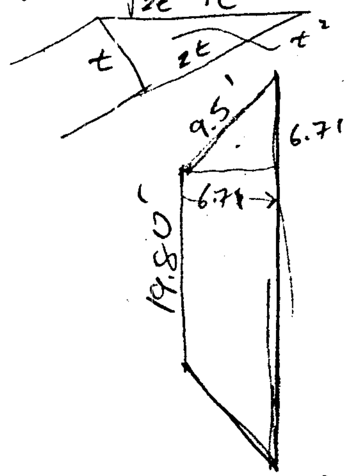
Detail K: STA 19+06.5 to 19+20

Riprap Vol: t = thickness of riprap = 3'

bottom := 5' x 5' x t = 25 t

sides = 2 $\left[\left(\frac{\sqrt{5^2+5^2} + \sqrt{2(5+9)^2}}{2}\right) 6.708\right] t$

wedge: $\sqrt{2t^2+t^2} = L$ t = 3' ⇒ L = 6.71'



Vol = 2 (sides) $[19.80 \times t^2 + 6.71 t^2]$

Vol = $53.0 t^2$

Edge: 2 (7.07) x .236 t^2 = $3.33 t^2$

∴ Riprap Vol = 25t + 180.2t + $53.0 t^2$ + $3.33 t^2$

w/ t = 3'
Riprap Vol = **1123 ft³**

Gravel Vol - 1' thick STA 19+06.5 to 19+20

bottom := $(5 + .236t)^2 \times 1$ = 32.6

sides = 2 $\left[\frac{\sqrt{5^2+5^2} + \sqrt{2(5+9)^2}}{2} * (6.708 + .236t)\right](1)$ = 199.3

wedge = (1)(19.8)(2t) + 20(1) = = 138.8

TOTAL Gravel = **344 ft³**

ADDITIONAL FILTER 8.94 * 19.80 * 2 = **354.02 ft³**

Post Mining Culvert Reclamation Plan

POST MINING CULVERT RECLAMATION PLAN

Culvert No.	Culvert to be removed	Comments	Post Mining Conditions at Existing Culvert Location
1A	Yes	Area at culvert entrance to be reclaimed	N/A - Connected to Culvert 2B
2A	Yes	Area at culvert entrance to be reclaimed	N/A - Connected to Culvert 2B
2B	Yes	Area at culvert entrance to be reclaimed	N/A - Connected to Culvert 2D
2C	Yes	Area at culvert entrance to be reclaimed	N/A - Connected to Culvert 2D
2D	Yes	Area at culvert entrance to be reclaimed	Natural hillside
4A	Yes	Reclamation Channel 4A to be installed	Reclamation channel
5A	Yes	Hillside to be regraded	Natural hillside
5B	Yes	Need for diversion of water eliminated	Natural hillside
6A	Yes	Culvert lies on ground surface, no physical ground restoration required	Natural hillside
7A	Yes	Existing access road to be reclaimed	Reclaimed/Vegetated area
7B	Yes	Existing access road to be reclaimed	Reclaimed/Vegetated area
7E	Yes	Area to be filled in and regraded as part of Pond 5 Reclamation	Reclaimed/Vegetated area
7F	Yes	Area to be covered by coal refuse pile	N/A - Buried
8A	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
9A	Yes	To be replaced by Reclamation Channel 25C	Reclamation channel
10A	Yes	Tributary area to be regraded	Natural hillside
10B	Yes	Tributary sediment trap to be removed and area regraded	Will become part of reclamation channel
10C	Yes	Tributary ditch to be removed	Reclamation channel
10D	Yes	Tributary ditch to be removed	Reclamation channel
10E	Yes	To be replaced by Reclamation Channel 25C	Reclamation channel
12A	Yes	To be replaced by Reclamation Channel 25D	Reclamation channel
12B	Yes	To be replaced by Reclamation Channel 25D	Reclamation channel
15A	Yes	Tributary ditch to be removed	County owned roadside ditch
15B	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
16A	Yes	To be replaced by Reclamation Channel 81	County owned roadside ditch
16B	Yes	To be replaced by Reclamation Channel 81	County owned roadside ditch
16C	Yes	To be replaced by Reclamation Channel 81	County owned roadside ditch
16D	Yes	To be replaced by Reclamation Channel 81	County owned roadside ditch
16E	Yes	To be replaced by Reclamation Channel 81	County owned roadside ditch
16F	Yes	Tributary ditch and Sediment Trap to be removed	County owned roadside ditch
16G	Yes	Tributary ditch and Sediment Trap to be Removed	Natural hillside
UT16A	Yes	To be plugged upon reclamation	Railroad fill material
UT16B	Yes	Roadway over culvert to be removed	Railroad fill material
UT16C	No	To be plugged upon reclamation	Railroad fill material
UT16D	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
17A	No	To remain a part of ranchers access to property north of existing Pond 4	County owned roadside ditch
17B	Yes	Tributary ditches and Sediment Trap to be Removed	Natural hillside

TABLE 1 Grading of Test Samples

Sieve Size, mm (in.) (Square Openings)		Weights of Indicated Sizes, g		
		Grading[A]		
Passing	Retained on	1	2	3
75 (3)	63 (2½)	2 500 ± 50	...	...
63 (2½)	50 (2)	2 500 ± 50	...	...
50 (2)	37.5 (1½)	5 000 ± 50	5 000 ± 50	...
37.5 (1½)	25.0 (1)	...	5 000 ± 25	5 000 ± 25
25.0 (1)	19.0 (¾)	...	...	5 000 ± 25
Total		10 000 ± 100	10 000 ± 75	10 000 ± 50

[A] Gradings 1, 2, and 3 correspond, respectively, in their size distribution to Gradings E, F, and G in the superseded ASTM Method C 131 – 55, Test for Abrasion of Coarse Aggregate by Use of the Los Angeles Machine, which appears in the 1961 *Book of ASTM Standards*, Part 4.

APPENDIX

X1. MAINTENANCE OF SHELF

X1.1 The shelf of the Los Angeles machine is subject to severe surface wear and impact. With use, the working surface of the shelf is peened by the balls and tends to develop a ridge of metal parallel to and about 1¼ in. (32 mm) from the junction of the shelf and the inner surface of the cylinder. If the shelf is made from a section of rolled angle, not only may this ridge develop but the shelf itself may be bent longitudinally or transversely from its proper position.

X1.2 The shelf should be inspected periodically to determine that it is not bent either lengthwise or from its normal radial position with respect to the cylinder. If either condition is found, the shelf should be repaired or replaced before further tests are made. The influence on the test result of the ridge developed by peening of the working face of the shelf is not known. However, for uniform test conditions, it is recommended that the ridge be ground off if its height exceeds 0.1 in. (2 mm).

Standard Test Method for
TOTAL MOISTURE CONTENT OF AGGREGATE BY DRYING[1]

This standard is issued under the fixed designation C 566; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements, see 4.3, 7.2, and 7.2.1.

1.3 The values stated in SI units are to be regarded as the standard.

2. Applicable Documents

2.1 *ASTM Standards:*

C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate[2]

C 128 Test Method for Specific Gravity and Absorption of Fine Aggregate[2]

D 75 Practice for Sampling Aggregates[2]

3. Significance and Use

3.1 This test method is sufficiently accurate for usual purposes such as adjusting batch weights of ingredients for concrete. It will generally measure the moisture in the test sample more reliably than the sample can be made to represent the aggregate supply. In cases where the aggregate itself is altered by heat, or where more refined measurement is required, the test should be conducted using a ventilated, controlled-temperature oven.

3.2 Large particles of coarse aggregate, especially those larger than 50 mm (2 in.), will require greater time for the moisture to travel from the interior of the particle to the surface. The user of this test method should determine by trial if rapid drying methods provide sufficient accuracy for the intended use when drying large size particles.

4. Apparatus

4.1 *Balance*—A balance or scale accurate, readable, and sensitive to within 0.1 % of the test load at any point within the range of use. Within any interval equal to 10 % of the capacity of the weighing device, the load indication shall be accurate within 0.1 % of the difference in weights.

4.2 *Source of Heat*—A suitable source of heat such as an electric or gas hot plate, electric heat lamps, or a ventilated oven capable of maintaining the temperature surrounding the sample at 110 ± 5°C (230 ± 9°F), or a ventilated microwave oven.

4.3 *Sample Container*—A container not affected by the heat, and of sufficient volume to contain the sample without danger of spilling, and of such shape that the depth of sample will not exceed one fifth of the least lateral dimension. **Caution:** When a microwave oven is used, the container shall be nonmetallic.

NOTE 1—Except for testing large samples, an ordinary frying pan is suitable for use with a hot plate, or any shallow flat-bottomed metal pan with heat lamps or oven.

4.4 *Stirrer*—A metal spoon or spatula of convenient size.

[1] This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved May 25, 1984. Published July 1984. Originally issued as C 566 – 65 T. Last previous edition C 566 – 78.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

POST MINING CULVERT RECLAMATION PLAN (Continued)

Culvert No.	Culvert to be removed	Comments	Post Mining Conditions at Existing Culvert Location
18A	No	Part of Railroad drainage system	Railroad fill material
18B	Yes	Need for diversion of waters eliminated	Reclaimed/Vegetated hillside
18C	Yes	Tributary ditch to be removed and regraded	Reclaimed/Vegetated hillside
18D	Yes	Tributary ditch and sediment trap to be removed and regraded	Natural channel
18E	Yes	Tributary ditch and sediment trap to be removed and regraded	Natural channel
21A	Yes	Tributary ditch to be removed and regraded	Natural hillside
22A	Yes	Tributary ditch to be removed and regraded	Reclaimed/Vegetated hillside
23A	Yes	Roadway over culvert to be removed	Reclaimed/Vegetated hillside
23B	No	Culvert to remain as part of roadway drainage	Riprap/Rubble pile at outlet
25A	Yes	Tributary ditch to be removed and regraded	Natural hillside
25B	No	Culvert to remain as part of roadway drainage	Reclamation channel
25C	Yes	To be replaced by Reclamation Channel 25C	Reclamation channel
26A	Yes	Tributary ditch to be removed and regraded	Natural hillside
26B	No	Culvert to remain as part of roadway drainage	Riprap/Rubble pile at outlet
27A	No	Remains as part of Utah Railway spur	Natural channel
28A	No	Remains as part of Utah Railway spur	Natural channel
29A	No	Remains as part of Utah Railway spur	Natural channel
33A	Yes	Tributary ditch to be removed and regraded	Natural hillside
33B	Yes	Roadway over culvert to be removed, channel to be restored to natural grade	Natural channel
34A	Yes	Tributary ditch to be removed and regraded	Natural hillside
35A	Yes	Fill over culvert to be removed and area reclaimed	Reclaimed/Vegetated hillside
37A	Yes	Roadway over culvert to be removed and hillside regraded	Natural channel
38A	Yes	Roadway over culvert to be removed and hillside regraded	Reclaimed/Vegetated hillside
39A	Yes	Roadway over culvert to be removed and hillside regraded	Reclaimed/Vegetated hillside
40A	Yes	Tributary ditch to be removed	Natural hillside
41A	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
42A	Yes	Tributary area to be reclaimed	Reclaimed/Vegetated hillside
42B	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
42C	Yes	Tributary ditch and road over culvert to be removed	Reclaimed/Vegetated hillside
42D	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
42E	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
42F	Yes	Tributary ditch and Sediment Trap to be removed	Reclaimed/Vegetated hillside
46A	No	Remains a part of Carbon County access road	Natural rock draw
46B	No	Remains a part of Carbon County access road	Riprap/Rubble pile at outlet
47A	No	Remains a part of Carbon County access road	Natural rock draw
48A	No	Remains a part of Carbon County access road	Natural rock draw

POST MINING CULVERT RECLAMATION PLAN (Continued)

Culvert No.	Culvert to be removed	Comments	Post Mining Conditions at Existing Culvert Location
52A	Yes	Removed as part of Reclamation Channel 4A Design	Natural hillside
54A	No	Remains a part of Carbon County access road	Natural rock/rubble hillside
55A	No	Remains a part of Carbon County access road	Natural rock/rubble hillside
56A	No	Remains a part of Carbon County access road	Natural rock/rubble hillside
57A	Yes	Tributary Sediment Trap to be removed	County owned roadside ditch
57B	No	Remains a part of Carbon County access road	Natural rock draw
58A	No	Remains a part of Carbon County access road	Natural rock draw
59A	No	Remains a part of Carbon County access road	Natural rock ledge
60A	No	Remains a part of Carbon County access road	Natural rock ledge
61A	No	Remains a part of Carbon County access road	Natural rock ledge
62A	No	Remains a part of Carbon County access road	Rubble pile
63A	No	Remains a part of Carbon County access road	Natural hillside
64A	Yes	Need for diversion of water eliminated	Reclaimed/Vegetated hillside
65A	Yes	Need for diversion of water eliminated	Reclaimed/Vegetated hillside
66A	Yes	Need for diversion of water eliminated	Reclaimed/Vegetated hillside
67A	Yes	Need for diversion of water eliminated	Reclaimed/Vegetated hillside
68A	Yes	Need for diversion of water eliminated	Reclaimed/Vegetated hillside
69A	Yes	Roadway over culvert to be removed	County owned roadside ditch
69B	Yes	Roadway over culvert to be removed	County owned roadside ditch
70A	Yes	Tributary ditch and Sediment Trap to be removed	County owned roadside ditch
70B	Yes	Tributary ditch to be removed	County owned roadside ditch
70C	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
71A	Yes	Tributary ditch and Sediment Trap to be removed	Reclaimed/Vegetated hillside
71B	Yes	Tributary ditch to be removed	County owned roadside ditch
72A	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
72B	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
72C	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
74A	Yes	Tributary ditch to be removed	County owned roadside ditch
74B	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
75A	Yes	Tributary ditch to be removed	County owned roadside ditch
75B	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
80A	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside
80B	Yes	Tributary ditch to be removed	Reclaimed/Vegetated hillside

* Culverts remaining will be a part of the runoff conveyance system used by Carbon County to convey water across the existing mine roads and are not part of the reclamation plan.

Riprap Special Provisions and Testing Procedures

SPECIAL PROVISIONS - TECHNICAL

SECTION 611 - LOOSE RIPRAP

611.01 Description: This item shall consist of furnishing and placing the granular filters and furnishing and placing loose riprap in accordance with these specifications at the locations indicated, and in conformity with the lines, grades, and dimensions shown on the plans or as directed by the Engineer.

611.02 Materials: Riprap shall consist of quarry stone which is sound and durable against disintegration under conditions to be met in handling and placing, and is hard and tenacious and otherwise of a suitable quality to insure permanency in the specified kind of work.

All stone shall be angular (no rounded rock will be permitted), each piece having its greatest dimensions not greater than three times its least dimensions. All stone to be used to line channels and the emergency spillway shall conform to the following test requirements of the American Society for Testing and Materials Standards:

	Requirements	ASTM Standard
Specific gravity, minimum	2.65	C-127-84
Los Angelos Abrasion, maximum percent	40	C-535-81

It should be noted that rock (gypsum anhydride), obtained from quarries near the site, has been tested and found to not meet the test requirements indicated above. Therefore, nearby rock containing gypsum shall not be used as stone for the channel lining. However, nearby rock containing gypsum may be used to provide stone for the slope protective cover as long as it conforms to the following test requirements of the American Society for Testing and Materials Standards:

	Requirements	ASTM Standard
Magnesium Sulphate Soundness, maximum percent	25	ASTM C88-83
Los Angelos Abrasion, maxium percent	55	ASTM C535-81

The contractor shall provide independent laboratory test results indicating that the material meets the project requirements indicated above.

SECTION 611 (CONT.)

Riprap sources shall be approved by the Engineer prior to use. Concrete masonry or concrete pavement may not be used for riprap. Riprap shall be well graded with additional grading requirements for riprap as follows:

Riprap Designation	% Smaller Than Given Size By Weight	Intermediate Rock Dimension (Inches)	Mean Rock Diameter D_{50} (Inches)
Type VL	70-100	8	
	50-70	6	
	35-50	4	4
	2-10	2	
Type VL	70-100	12	
	50-70	9	
	35-50	6	6
	2-10	2	
Type L	70-100	14	
	50-70	12	
	35-50	9	9
	2-10	3	
Type M	70-100	21	
	50-70	18	
	35-50	12	12
	2-10	4	
Type H	70-100	30	
	50-70	24	
	35-50	18	18
	2-10	6	
Type VH	100	42	
	50-70	33	
	35-50	24	24
	2-10	9	

SECTION 611 (CONT.)

The Type I granular filter shall consist of natural sand or other approved inert material conforming to the following gradation:

U.S. Standard Sieve Size	Percent Passing by Weight
3/8"	100
No. 4	95-100
No. 16	45-80
No. 50	10-30
No. 100	2-10
No. 200	0-2

The Type II granular filter shall consist of hard, durable, and rough angular fragments of screened or broken stone, gravel, or slag conforming to the following gradation:

U.S. Standard Sieve Size	Percent Passing By Weight
3"	90-100
3/4"	35-90
No. 4	0-30
No. 16	0-15
No. 200	0-3

611.03 Construction Method: Prior to placement of the granular filter on the sideslopes of the cells, the embankment shall be subjected to at least one pass of the sheeps foot roller.

The riprap shall be dumped into place so as to secure a rock mass with a minimum thickness at least equal to the maximum rock size as designated by the gradation requirements of Section 611.02 and to the height as specified on the plans. The rock shall be manipulated to secure a regular surface of graded sizes and mass stability.

611.04 Measurement and Payment: The granular filters and loose riprap shall be measured and paid for by the cubic yard for the sizes specified and accepted in-place, computed from the specified thicknesses as designated in the specifications and on the plans and from the measured surface area. The accepted quantities of these items shall be paid for at the contract unit

SECTION 611 (CONT.)

price per cubic yard for granular filter and loose riprap for the individual types specified. Payment shall be full compensation for all labor, equipment, materials, and incidentals necessary to complete this item, including channel excavation, furnishing, hauling, stockpiling, and placing.

SPECIAL PROVISIONS - TECHNICAL

SECTION 612 - GROUTED RIPRAP

612.01 Description: This item shall consist of furnishing and placing the granular filter and furnishing, placing, and grouting riprap in accordance with these specifications, at the locations indicated and in conformity with the lines, grades, and dimensions shown on the plans or as directed by the Engineer.

612.02 Stone: The stone and granular filter shall meet the requirements specified in Section 611.02 of these specifications for loose riprap and granular filter. Gradations of the stone and granular filter as specified by type shall likewise meet the gradation requirements of Section 611.02 of these specifications; except that the smallest rock fraction (smaller than the 10 percent passing size) shall be eliminated.

612.03 Grout: The grout shall consist of a mixture of Type V Portland Cement, fine and coarse aggregates and water. The coarse and fine aggregates shall be uniformly graded within the limits specified below.

Fine aggregate shall consist of natural sand or other approved inert material. Fine aggregate shall be graded as follows (ASTM C33):

Sieve Size	Percent Passing By Weight
3/8 inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

Coarse aggregate shall consist of clean gravel with no particle exceeding the gradation below. Soft fragments, coal, clay and other deleterious substances shall not exceed four percent by weight. Coarse aggregate shall be graded as follows (ASTM C33):

Sieve Size	Percent Passing By Weight
1 inch	100
3/4 inch	90-100
3/8 inch	20-55
No. 4	0-10
No. 8	0-5

Coarse and fine aggregates shall have no more than two percent passing the No. 200 sieve. Proof of gradation will be provided to Engineer by the Contractor.

SECTION 612 (CONT.)

The Contractor shall be responsible for establishing the mix design. The Contractor shall comply with the following design criteria in establishing the proportions of cement, aggregate, and water to be used:

1.	Water/cement (gals/sack)	6.0 max.
2.	Minimum cement content (sacks/C.Y.)	5.0 min.
3.	Coarse and fine aggregates uniformly graded as indicated above.	

The mixture shall include a high range water reducing admixture. Prior to placing concrete, the Contractor shall furnish the Engineer a mix design and information based on trial batch test results to verify the concrete mix design strength. Changes in the mix design may be made only with written approval from the Engineer. The proportioning and mixing of concrete shall be subject to inspection by the Engineer.

Concrete used on the project shall conform to the following requirements:

Slump (inches)	5-7
Air Content (%)	5 ± 1
Required Mix Design Strength (PSI)	3910
Moving Average Strength (Average of 3) (PSI)	3410
Minimum Strength (PSI)	3000

Batching and mixing; sampling, testing, and acceptance; and temperature control shall meet the requirements specified in Section 505 of these specifications.

612.04 Construction Method: The riprap shall be carefully dumped into place on the granular filter (which covers a graded sub base) and manipulated only enough to approximate the line and the grade shown on the plans. It is desirable to have a rough irregular surface with projecting stones. The grout shall be placed on wetted stones and mechanically vibrated into the riprap to its full depth, filling all the voids, and producing a dense solid mass. Rodding and/or pumping may also be used to assist in the grouting operation. Grouted riprap shall have exposed stones in the finished surface, clean of concrete grout. The surface stones shall be exposed for 1/3 of their height or four inches whichever is less. The grouted riprap shall be kept wet by sprinkling or covering with wet material for at least six days after the grout is placed. The grouted riprap channel shall be protected from stream water or any other disturbance during the curing period.

Weep holes shall be provided at the toe of channel slopes at a spacing not to exceed five feet. The weep holes shall be formed using 1-1/2 inch PVC pipe extended through the entire thickness of the riprap into the granular filter.

612.05 Measurement and Payment: The granular filter and grouted riprap shall be measured and paid for by the cubic yard computed from the specified thickness as designated on the plans and the measured surface area.

SECTION 612 (CONT.)

The accepted quantities for these items shall be paid for at the contract unit price per cubic yard for granular filter and grouted riprap for the individual types as specified. Payment shall be full compensation for all labor, equipment, materials, and incidentals necessary to complete this item, including channel excavation, furnishing, hauling, stockpiling, placing, grouting, and finishing.

each other by more than 15.3 % (Note 5) of their average. The maximum range (difference between highest and lowest) of the three individual ratios used in calculating the average should not exceed 17 % (Note 6).

NOTE 5—These numbers represent respectively the (1S %) and (D2S %) limits as described in Practice C 670.

NOTE 6—Calculated as described in 5.2.2 of Practice C 670.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

Standard Test Method for SOUNDNESS OF AGGREGATES BY USE OF SODIUM SULFATE OR MAGNESIUM SULFATE[1]

This standard is issued under the fixed designation C 88; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This test method covers the testing of aggregates to estimate their soundness when subjected to weathering action in concrete or other applications. This is accomplished by repeated immersion in saturated solutions of sodium or magnesium sulfate followed by oven drying to partially or completely dehydrate the salt precipitated in permeable pore spaces. The internal expansive force, derived from the rehydration of the salt upon re-immersion, simulates the expansion of water on freezing. This test method furnishes information helpful in judging the soundness of aggregates when adequate information is not available from service records of the material exposed to actual weathering conditions.

1.2 The values given in parentheses are provided for information purposes only.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Applicable Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[2]
C 670 Practice for Preparing Precision Statements for Test Methods for Construction Materials[2]
C 702 Methods for Reducing Field Samples of Aggregate to Testing Size[2]
D 75 Practice for Sampling Aggregates[3]
D 3665 Practice for Random Sampling of Construction Materials[3]
E 11 Specification for Wire Cloth Sieves for Testing Purposes[4]
E 100 Specification for ASTM Hydrometers[5]
E 323 Specification for Perforated-Plate Sieves for Testing Purposes[4]

3. Significance and Use

3.1 This test method provides a procedure for making a preliminary estimate of the soundness of aggregates for use in concrete and other purposes. The values obtained may be compared with specifications, for example Specification C 33, that are designed to indicate the suitability of aggregate proposed for use. Since the precision of this test method is poor (Section 12), it may not be suitable for outright rejection of aggregates without confirmation from other tests more closely related to the specific service intended.

3.2 Values for the permitted-loss percentage by this test method are usually different for fine and coarse aggregates, and attention is called to the fact that test results by use of the two salts differ considerably and care must be exercised in fixing proper limits in any specifications that include requirements for these tests. The test is

[1] This method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.
[3] *Annual Book of ASTM Standards*, Vol 04.03.
[4] *Annual Book of ASTM Standards*, Vol 14.02.
[5] *Annual Book of ASTM Standards*, Vol 14.01.

each other by more than 15.3 % (Note 5) of their average. The maximum range (difference between highest and lowest) of the three individual ratios used in calculating the average should not exceed 17 % (Note 6).

NOTE 5—These numbers represent respectively the (1S %) and (D2S %) limits as described in Practice C 670.

NOTE 6—Calculated as described in 5.2.2 of Practice C 670.

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This method has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This test method covers the testing of aggregates to estimate their soundness when subjected to weathering action in concrete or other applications. This is accomplished by repeated immersion in saturated solutions of sodium or magnesium sulfate followed by oven drying to partially or completely dehydrate the salt precipitated in permeable pore spaces. The internal expansive force, derived from the rehydration of the salt upon re-immersion, simulates the expansion of water on freezing. This test method furnishes information helpful in judging the soundness of aggregates when adequate information is not available from service records of the material exposed to actual weathering conditions.

1.2 The values given in parentheses are provided for information purposes only.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

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D 75 Practice for Sampling Aggregates[3]

D 3665 Practice for Random Sampling of Construction Materials[3]

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E 100 Specification for ASTM Hydrometers[5]

E 323 Specification for Perforated-Plate Sieves for Testing Purposes[4]

3. Significance and Use

3.1 This test method provides a procedure for making a preliminary estimate of the soundness of aggregates for use in concrete and other purposes. The values obtained may be compared with specifications, for example Specification C 33, that are designed to indicate the suitability of aggregate proposed for use. Since the precision of this test method is poor (Section 12), it may not be suitable for outright rejection of aggregates without confirmation from other tests more closely related to the specific service intended.

3.2 Values for the permitted-loss percentage by this test method are usually different for fine and coarse aggregates, and attention is called to the fact that test results by use of the two salts differ considerably and care must be exercised in fixing proper limits in any specifications that include requirements for these tests. The test is

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[5] *Annual Book of ASTM Standards*, Vol 14.01.

usually more severe when magnesium sulfate is used; accordingly, limits for percent loss allowed when magnesium sulfate is used are normally higher than limits when sodium sulfate is used.

NOTE 1—Refer to the appropriate sections in Specification C 33 establishing conditions for acceptance of coarse and fine aggregates which fail to meet requirements based on this test.

4. Apparatus

4.1 *Sieves*—with square openings of the following sizes conforming to Specifications E 11 or E 323, for sieving the samples in accordance with Sections 6, 7, and 9:

150 µm (No. 100)	8.0 mm (5/16 in.)
	9.5 mm (3/8 in.)
300 µm (No. 50)	12.5 mm (1/2 in.)
	16.0 mm (5/8 in.)
600 µm (No. 30)	19.0 mm (3/4 in.)
	25.0 mm (1 in.)
1.18 mm (No. 16)	31.5 mm (1 1/4 in.)
2.36 mm (No. 8)	37.5 mm (1 1/2 in.)
	50 mm (2 in.)
4.00 mm (No. 5)	63 mm (2 1/2 in.)
	larger sizes by
4.75 mm (No. 4)	12.5-mm (1/2-in.)
	spread

4.2 *Containers*—Containers for immersing the samples of aggregate in the solution, in accordance with the procedure described in this test method, shall be perforated in such a manner as to permit free access of the solution to the sample and drainage of the solution from the sample without loss of aggregate.

NOTE 2—Baskets made of suitable wire mesh or sieves with suitable openings are satisfactory containers for the samples.

4.3 *Temperature Regulation*—Suitable means for regulating the temperature of the samples during immersion in the sodium sulfate or magnesium sulfate solution shall be provided.

4.4 *Balances*—For fine aggregate, a balance or scale accurate within 0.1 g over the range required for this test; for coarse aggregate, a balance or scale accurate within 0.1 % or 1 g, whichever is greater, over the range required for this test.

4.5 *Drying Oven*—The oven shall be capable of being heated continuously at 230 ±9°F (110 ±5°C) and the rate of evaporation, at this range of temperature, shall be at least 25 g/h for 4 h, during which period the doors of the oven shall be kept closed. This rate shall be determined by the loss of water from 1-L Griffin low-form beakers, each initially containing 500 g of water at a temperature of 70 ±3°F (21 ±2°C), placed at each corner and the center of each shelf of the oven. The evaporation requirement is to apply to all test locations when the oven is empty except for the beakers of water.

4.6 *Specific Gravity Measurement*—Hydrometers conforming to the requirements of Specification E 100, or a suitable combination of graduated glassware and balance, capable of measuring the solution specific gravity within ±0.001.

5. Special Solutions Required

5.1 Prepare the solution for immersion of test samples from either sodium or magnesium sulfate in accordance with 5.1.1 or 5.1.2 (Note 3). The volume of the solution shall be at least five times the solid volume of all samples immersed at any one time.

NOTE 3—Some aggregates containing carbonates of calcium or magnesium are attacked chemically by fresh sulfate solution, resulting in erroneously high measured losses. If this condition is encountered or is suspected, repeat the test using a filtered solution that has been used previously to test the same type of carbonate rock, provided that the solution meets the requirements of 5.1 and 5.2 for specific gravity.

5.1.1 *Sodium Sulfate Solution*—Prepare a saturated solution of sodium sulfate by dissolving a USP or equal grade of the salt in water at a temperature of 77 to 86°F (25 to 30°C). Add sufficient salt (Note 4), of either the anhydrous (Na_2SO_4) or the crystalline ($Na_2SO_4 \cdot 10H_2O$) form,[6] to ensure not only saturation but also the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to 70 ±2°F (21 ±1°C). Again stir, and allow the solution to remain at the designated temperature for at least 48 h before use. Prior to each use, break up the salt cake, if any, in the container, stir the solution thoroughly, and determine the specific gravity of the solution. When used, the solution shall have a specific gravity not less than 1.151 nor more than 1.174. Discard a discolored solution, or filter it and check for specific gravity.

[6] Experience with the test method indicates that a grade of sodium sulfate designated by the trade as dried powder, which may be considered as approximately anhydrous, is the most practical for use. That grade is more economically available than the anhydrous form. The decahydrate sodium sulfate presents difficulties in compounding the required solution on account of its cooling effect on the solution.

NOTE 4—For the solution, 215 g of anhydrous salt or 700 g of the decahydrate per litre of water are sufficient for saturation at 71.6°F (22°C). However, since these salts are not completely stable and since it is desirable that an excess of crystals be present, the use of not less than 350 g of the anhydrous salt or 750 g of the decahydrate salt per litre of water is recommended.

5.1.2 *Magnesium Sulfate Solution*—Prepare a saturated solution of magnesium sulfate by dissolving a USP or equal grade of the salt in water at a temperature of 77 to 86°F (25 to 30°C). Add sufficient salt (Note 5), of either the anhydrous ($MgSO_4$) or the crystalline ($MgSO_4 \cdot 7H_2O$) (Epsom salt) form, to ensure saturation and the presence of excess crystals when the solution is ready for use in the tests. Thoroughly stir the mixture during the addition of the salt and stir the solution at frequent intervals until used. To reduce evaporation and prevent contamination, keep the solution covered at all times when access is not needed. Allow the solution to cool to 70 ±2°F (21 ±1°C). Again stir, and allow the solution to remain at the designated temperature for at least 48 h before use. Prior to each use, break up the salt cake, if any, in the container, stir the solution thoroughly, and determine the specific gravity of the solution. When used, the solution shall have a specific gravity not less than 1.295 nor more than 1.308. Discard a discolored solution, or filter it and check for specific gravity.

NOTE 5—For the solution, 350 g of anhydrous salt or 1230 g of the heptahydrate per litre of water are sufficient for saturation at 73.4°F (23°C). However, since these salts are not completely stable, with the hydrous salt being the more stable of the two, and since it is desirable that an excess of crystals be present, it is recommended that the heptahydrate salt be used and in an amount of not less than 1400 g/litre of water.

6. Samples

6.1 The sample shall be obtained in general accordance with Practice D 75 and reduced to test portion size in accordance with Methods C 702.

6.2 *Fine Aggregate*—Fine aggregate for the test shall be passed through a 9.5-mm (3/8-in.) sieve. The sample shall be of such size that it will yield not less than 100 g of each of the following sizes, which shall be available in amounts of 5 % or more, expressed in terms of the following sieves:

Passing Sieve	Retained on Sieve
600 µm (No. 30)	300 µm (No. 50)
1.18 mm (No. 16)	600 µm (No. 30)
2.36 mm (No. 8)	1.18 mm (No. 16)
4.75 mm (No. 4)	2.36 mm (No. 8)
9.5 mm (3/8 in.)	4.75 mm (No. 4)

6.3 *Coarse Aggregate*—Coarse aggregate for the test shall consist of material from which the sizes finer than the No. 4 sieve have been removed. The sample shall be of such a size that it will yield the following amounts of the indicated sizes that are available in amounts of 5 % or more:

Size (Square-Opening Sieves)	Weight, g
9.5 mm (3/8 in.) to 4.75 mm (No. 4)	300 ± 5
19.0 mm (3/4 in.) to 9.5 mm (3/8 in.)	1000 ± 10
Consisting of:	
12.5-mm (1/2-in.) to 9.5-mm (3/8-in.) material	330 ± 5
19.0-mm (3/4-in.) to 12.5-mm (1/2-in.) material	670 ± 10
37.5-mm (1 1/2-in.) to 19.0-mm (3/4 in.)	1500 ± 50
Consisting of:	
25.0-mm (1-in.) to 19.0-mm (3/4-in.) material	500 ± 30
37.5-mm (1 1/2-in.) to 25.0-mm (1-in.) material	1000 ± 50
63-mm (2 1/2 in.) to 37.5-mm (1 1/2 in.)	5000 ± 300
Consisting of:	
50-mm (2 in.) to 37.5-mm (1 1/2-in.) material	2000 ± 200
63-mm (2 1/2-in.) to 50-mm (2-in.) material	3000 ± 300
Larger sizes by 25-mm (1-in.) spread in sieve size, each fraction	7000 ± 1000

6.4 When an aggregate to be tested contains appreciable amounts of both fine and coarse material, having a grading with more than 10 weight % coarser than the 9.5-mm (3/8-in.) sieve and, also, more than 10 weight % finer than the 4.75-mm (No. 4) sieve, test separate samples of the minus No. 4 fraction and the plus No. 4 fraction in accordance with the procedures for fine aggregate and coarse aggregate, respectively. Report the results separately for the fine-aggregate fraction and the coarse-aggregate fraction, giving the percentages of the coarse- and fine-size fractions in the initial grading.

7. Preparation of Test Sample

7.1 *Fine Aggregate*—Thoroughly wash the sample of fine aggregate on a 300-µm (No. 50) sieve, dry to constant weight at 230 ±9°F (110 ±5°C), and separate into the different sizes by sieving, as follows: Make a rough separation of the graded sample by means of a nest of the standard sieves specified in 6.2. From the fractions obtained in this manner, select samples of sufficient size to yield 100 g after sieving to refusal. (In general, a 110 g sample will be sufficient.) Do not use fine aggregate sticking in the meshes of the sieves in preparing the samples. Weigh samples consisting of 100 ±0.1 g out of each of the separated fractions after final sieving and place in separate containers for the test.

7.2 *Coarse Aggregate*—Thoroughly wash and dry the sample of coarse aggregate to constant weight at 230 ±9°F (110 ±5°C) and separate it into the different sizes shown in 6.3 by sieving to refusal. Weigh out quantities of the different sizes within the tolerances of 6.3 and, where the test portion consists of two sizes, combine them to the designated total weight. Record the weights of the test samples and their fractional components. In the case of sizes larger than 19.0 mm (¾ in.), record the number of particles in the test samples.

8. Procedure

8.1 *Storage of Samples in Solution*—Immerse the samples in the prepared solution of sodium sulfate or magnesium sulfate for not less than 16 h nor more than 18 h in such a manner that the solution covers them to a depth of at least ½ in. (Note 6). Cover the containers to reduce evaporation and prevent the accidental addition of extraneous substances. Maintain the samples immersed in the solution at a temperature of 70 ±2°F (21 ±1°C) for the immersion period.

NOTE 6—Suitably weighted wire grids placed over the sample in the containers will permit this coverage to be achieved with very lightweight aggregates.

8.2 *Drying Samples After Immersion*—After the immersion period, remove the aggregate sample from the solution, permit it to drain for 15 ±5 min, and place in the drying oven. The temperature of the oven shall have been brought previously to 230 ±9°F (110 ±5°C). Dry the samples at the specified temperature until constant weight has been achieved. Establish the time required to attain constant weight as follows: with the oven containing the maximum sample load expected, check the weight losses of test samples by removing and weighing them, without cooling, at intervals of 2 to 4 h; make enough checks to establish required drying time for the least favorable oven location (see 4.5) and sample condition (Note 7). Constant weight will be considered to have been achieved when weight loss is less than 0.1 % of sample weight in 4 h of drying. After constant weight has been achieved, allow the samples to cool to room temperature, when they shall again be immersed in the prepared solution as described in 8.1.

NOTE 7—Drying time required to reach constant weight may vary considerably for several reasons. Efficiency of drying will be reduced as cycles accumulate because of salt adhering to particles and, in some cases, because of increase in surface area due to breakdown. The different size fractions of aggregate will have differing drying rates. The smaller sizes will tend to dry more slowly because of their larger surface area and restricted interparticle voids, but this tendency may be altered by the effects of container size and shape.

8.3 *Number of Cycles*—Repeat the process of alternate immersion and drying until the required number of cycles is obtained.

9. Quantitative Examination

9.1 Make the quantitative examination as follows:

9.1.1 After the completion of the final cycle and after the sample has cooled, wash the sample free from the sodium sulfate or magnesium sulfate as determined by the reaction of the wash water with barium chloride ($BaCl_2$). Wash by circulating water at 110 ±10°F (43 ±6°C) through the samples in their containers. This may be done by placing them in a tank into which the hot water can be introduced near the bottom and allowed to overflow. In the washing operation, the samples shall not be subjected to impact or abrasion that may tend to break up particles.

9.1.2 After the sodium sulfate or magnesium sulfate has been removed, dry each fraction of the sample to constant weight at 230 ±9°F (110 ±5°C). Sieve the fine aggregate over the same sieve on which it was retained before the test, and sieve the coarse aggregate over the sieve shown below for the appropriate size of particle. For fine aggregate, the method and duration of sieving shall be the same as were used in preparing the test samples. For coarse aggregate, sieving shall be by hand, with agitation sufficient only to assure that all undersize material passes the designated sieve. No extra manipulation shall be employed to break up particles or cause them to pass the sieves. Weigh the material retained on each sieve and record each amount. The difference between each of these amounts and the initial weight of the fraction of the sample tested is the loss in the test and is to be expressed as a percentage of the initial weight for use in Table 1.

Size of Aggregate	Sieve Used to Determine Loss
63 mm (2½ in.) to 37.5 mm (1½ in.)	31.5 mm (1¼ in.)
37.5 mm (1½ in.) to 19.0 mm (¾ in.)	16.0 mm (⅝ in.)
19 mm (¾ in.) to 9.5 mm (⅜ in.)	8.0 mm (5⁄16 in.)
9.5 mm (⅜ in.) to 4.75 mm (No. 4)	4.0 mm (No. 5)

10. Qualitative Examination

10.1 Make a qualitative examination of test samples coarser than 19.0 mm (¾ in.) as follows (Note 8):

10.1.1 Separate the particles of each test sample into groups according to the action produced by the test (Note 8).

10.1.2 Record the number of particles showing each type of distress.

NOTE 8—Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking, etc. While only particles larger than ¾ in. in size are required to be examined qualitatively, it is recommended that examination of the smaller sizes be made in order to determine whether there is any evidence of excessive splitting.

11. Report

11.1 The report shall include the following data (Note 9):

11.1.1 Weight of each fraction of each sample before test.

11.1.2 Material from each fraction of the sample finer than the sieve designated in 9.1.2 for sieving after test, expressed as a percentage of the original weight of the fraction.

11.1.3 Weighted average calculated from the percentage of loss for each fraction, based on the grading of the sample as received for examination or, preferably, on the average grading of the material from that portion of the supply of which the sample is representative except that:

11.1.3.1 For fine aggregates (with less than 10 % coarser than the 9.5-mm (⅜-in.) sieve), assume sizes finer than the 300-µm (No. 50) sieve to have 0 % loss and sizes coarser than the 9.5-mm (⅜-in.) sieve to have the same loss as the next smaller size for which test data are available.

11.1.3.2 For coarse aggregate (with less than 10 % finer than the 4.75-mm (No. 4) sieve), assume sizes finer than the 4.75-mm (No. 4) sieve to have the same loss as the next larger size for which test data are available.

11.1.3.3 For an aggregate containing appreciable amounts of both fine and coarse material tested as two separate samples as required in 6.4, compute the weighted average losses separately for the minus No. 4 and plus No. 4 fractions based on recomputed gradings considering the fine fraction as 100 % and the coarse fraction as 100 %. Report the results separately giving the percentage of the minus No. 4 and plus No. 4 material in the initial grading.

11.1.3.4 For the purpose of calculating the weighted average, consider any sizes in 6.2 or 6.3 that contain less than 5 % of the sample to have the same loss as the average of the next smaller and the next larger size, or if one of these sizes is absent, to have the same loss as the next larger or next smaller size, whichever is present.

11.1.4 In the case of particles coarser than 19.0 mm (¾ in.) before test: (*1*) The number of particles in each fraction before test, and (*2*) the number of particles affected, classified as to number disintegrating, splitting, crumbling, cracking, flaking, etc., as shown in Table 2.

11.1.5 Kind of solution (sodium or magnesium sulfate) and whether the solution was freshly prepared or previously used.

NOTE 9—Table 1, shown with test values inserted for purpose of illustration, is a suggested form for recording test data. The test values shown might be appropriate for either salt, depending on the quality of the aggregate.

12. Precision

12.1 For coarse aggregate with weighted average sulfate soundness losses in the ranges of 6 to 16 % for sodium and 9 to 20 % for magnesium, the precision indexes are as follows:

	Coefficient of Variation (1S %), %[A]	Difference Between Two Tests (D2S %), % of Average[A]
Multilaboratory:		
Sodium sulfate	41	116
Magnesium sulfate	25	71
Single-Operator:		
Sodium sulfate	24	68
Magnesium sulfate	11	31

[A] These numbers represent, respectively, the (1S %) and (D2S %) limits as described in Practice C 670.

TABLE 1 Suggested Form for Recording Test Data (with Illustrative Test Values)

Sieve Size			Grading of Original Sample, %	Weight of Test Fractions Before Test, g	Percentage Passing Designated Sieve After Test	Weighted Percentage Loss
Soundness Test of Fine Aggregate						
Minus 150 µm (No. 100)			5.0	...	...	...
300 µm (No. 50) to No. 100			11.4	...	...	...
600 µm (No. 30) to No. 50			26.0	100	4.2	1.09
1.18 mm (No. 16) to No. 30			25.2	100	4.8	1.21
2.36 mm (No. 8) to No. 16			17.0	100	8.0	1.36
4.75 mm (No. 4) to No. 8			10.8	100	11.2	1.21
9.5 mm (⅜ in.) to No. 4			4.6	...	11.2[A]	0.52
Totals			100.0	...	...	5.4
Soundness Test of Coarse Aggregate						
63 mm (2½ in.) to 50 mm (2 in.)	2825 g	2½ to 1½ in.	20.0	4783	4.8	0.96
50 mm (2 in.) to 37.5 mm (1½ in.)	1958 g					
37.5 mm (1½ in.) to 25.0 mm (1 in.)	1012 g	1½ to ¾ in.	45.0	1525	8.0	3.60
25 mm (1 in.) to 19.0 mm (¾ in.)	513g					
19.0 mm (¾ in.) to 12.5 mm (½ in.)	675 g	¾ to ⅜ in.	23.0	1008	9.6	2.20
12.5 mm (½ in.) to 9.5 mm (⅜ in.)	333 g					
9.5 mm (⅜ in.) to 4.75 mm (No. 4)	298 g		12.0	298	11.2	1.34
Totals			100.0	...	...	8.1

[A] The percentage loss (11.2 %) of the next smaller size is used as the percentage loss for this size, since this size contains less than 5 % of the original sample as received. See 11.1.3.4.

TABLE 2 Suggested Form for Qualitative Examination (with Illustrative Test Values)

Qualitative Examination of Coarse Sizes									
Sieve Size	Particles Exhibiting Distress								Total No. of Particles Before Test
	Splitting		Crumbling		Cracking		Flaking		
	No.	%	No.	%	No.	%	No.	%	
63 mm (2½ in.) to 37.5 mm (1½ in.)	2	7	...	...	2	7	...	...	29
37.5 mm (1½ in.) to 19.0 mm (¾ in.)	5	...	...	2	...	...	...	...	50

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

Designation: C 94 – 84

Standard Specification for READY-MIXED CONCRETE[1]

This standard is issued under the fixed designation C 94; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This specification has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This specification covers ready-mixed concrete manufactured and delivered to a purchaser in a freshly mixed and unhardened state as hereinafter specified. Requirements for quality of concrete shall be either as hereinafter specified or as specified by the purchaser. In any case where the requirements of the purchaser differ from these in this specification, the purchaser's specification shall govern. This specification does not cover the placement, consolidation, curing, or protection of the concrete after delivery to the purchaser.

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 As used throughout this specification the manufacturer shall be the contractor, subcontractor, supplier, or producer who furnishes the ready-mixed concrete. The purchaser shall be the owner or representative thereof.

2. Applicable Documents

2.1 *ASTM Standards:*

C 31 Method of Making and Curing Concrete Test Specimens in the Field[2]

C 33 Specification for Concrete Aggregates[2]

C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]

C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[3]

C 138 Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete[2]

C 143 Test Method for Slump of Portland Cement Concrete[2]

C 150 Specification for Portland Cement[2]

C 172 Method of Sampling Freshly Mixed Concrete[2]

C 173 Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method[2]

C 191 Test Method for Time of Setting of Hydraulic Cement by Vicat Needle[3]

C 231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method[2]

C 260 Specification for Air Entraining Admixtures for Concrete[2]

C 330 Specification for Lightweight Aggregates for Structural Concrete[2]

C 494 Specification for Chemical Admixtures for Concrete[2]

C 567 Test Method for Unit Weight of Structural Lightweight Concrete[2]

C 595 Specification for Blended Hydraulic Cements[2]

C 618 Specification for Fly Ash and Raw or Calcined Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete[2]

D 512 Test Methods for Chloride Ion in Water[4]

D 516 Test Methods for Sulfate Ion in Water[4]

E 329 Recommended Practice for Inspection and Testing Agencies for Concrete, Steel, and Bituminous Materials as Used in Construction[5]

2.2 *American Concrete Institute Standards:*[6]

211.1 Recommended Practice for Selecting Proportions for Normal and Heavyweight

[1] This specification under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.09 on Methods of Testing and Specifications for Ready-Mixed Concrete.

Current edition approved Aug. 20, 1984. Published October 1984. Originally published as C 94 – 33 T. Last previous edition C 94 – 83.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 11.01.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] Available from American Concrete Institute, P.O. Box 19150, Detroit, MI 48219.

Standard Test Method for
SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE[1]

This standard is issued under the fixed designation C 127; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This test method has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This test method covers the determination of specific gravity and absorption of coarse aggregate. The specific gravity may be expressed as bulk specific gravity, bulk specific gravity (SSD) (saturated-surface-dry), or apparent specific gravity. The bulk specific gravity (SSD) and absorption are based on aggregate after 24 h soaking in water. This test method is not intended to be used with lightweight aggregates.

1.2 The values stated in acceptable metric unit (SI units and units specifically approved in ASTM E 380 for use with SI units) are to be regarded as the standard.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Applicable Documents

2.1 *ASTM Standards:*

C 29 Test Method for Unit Weight and Voids in Aggregate[2]

C 125 Definitions of Terms Relating to Concrete and Concrete Aggregates[2]

C 128 Test Method for Specific Gravity and Absorption of Fine Aggregate[2]

C 136 Method for Sieve Analysis of Fine and Coarse Aggregates[2]

C 566 Test Method for Total Moisture Content of Aggregate by Drying[2]

C 670 Practice for Preparing Precision Statements for Test Methods for Construction Materials[2]

C 702 Methods for Reducing Field Samples of Aggregate to Testing Size[2]

D 75 Practice for Sampling Aggregates[2]

D 448 Specification for Standard Sizes of Coarse Aggregate for Highway Construction[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

E 12 Definitions of Terms Relating to Density and Specific Gravity of Solids, Liquids, and Gases[2]

E 380 Metric Practice[3]

2.2 *American Association of State Highway and Transportation Officials Standard:*[4]

AASHTO No. T 85 Specific Gravity and Absorption of Coarse Aggregate

3. Summary of Method

3.1 A sample of aggregate is immersed in water for approximately 24 h to essentially fill the pores. It is then removed from the water, the water dried from the surface of the particles, and weighed. Subsequently the sample is weighed while submerged in water. Finally the sample is oven-dried and weighed a third time. Using the weights thus obtained and formulas in this test method, it is possible to calculate three types of specific gravity and absorption.

4. Significance and Use

4.1 Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate, including portland cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Bulk specific gravity is also used in the computation of voids in aggregate in Test Method C 29. Bulk specific gravity (SSD) is used if the aggregate is wet, that is, if its absorption has been satisfied. Conversely, the bulk specific gravity (oven-dry) is used for computations when the aggregate is dry or assumed to be dry.

4.2 Apparent specific gravity pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles which is accessible to water.

4.3 Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregate for approximately 24 h in water. Aggregates mined from below the water table may have a higher absorption, when used, if not allowed to dry. Conversely, some aggregates when used may contain an amount of absorbed moisture less than the 24-h soaked condition. For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture can be determined by deducting the absorption from the total moisture content determined by Test Method C 566.

4.4 The general procedures described in this test method are suitable for determining the absorption of aggregates that have had conditioning other than the 24-h soak, such as boiling water or vacuum saturation. The values obtained for absorption by other methods will be different than the values obtained by the prescribed 24-h soak, as will the bulk specific gravity (SSD).

4.5 The pores in lightweight aggregates may or may not become essentially filled with water after immersion for 24 h. In fact, many such aggregates can remain immersed in water for several days without satisfying most of the aggregates' absorption potential. Therefore, this test method is not intended for use with lightweight aggregate.

5. Definitions

5.1 *specific gravity*—the ratio of the mass (or weight in air) of a unit volume of a material to the mass of the same volume of water at stated temperatures. Values are dimensionless.

5.1.1 *bulk specific gravity*—the ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

5.1.2 *bulk specific gravity (SSD)*—the ratio of the weight in air of a unit volume of aggregate, including the weight of water within the voids filled to the extent achieved by submerging in water for approximately 24 h (but not including the voids between particles) at a stated temperature, compared to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

5.1.3 *apparent specific gravity*—the ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

5.2 *absorption*—the increase in the weight of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry weight. The aggregate is considered "dry" when it has been maintained at a temperature of 110 ± 5°C for sufficient time to remove all uncombined water.

NOTE 1—The terminology for specific gravity is based on terms in Definitions E 12, and that for absorption is based on that term in Definitions C 125.

6. Apparatus

6.1 *Balance*—A weighing device that is sensitive, readable, and accurate to 0.05 % of the sample weight at any point within the range used for this test, or 0.5 g, whichever is greater. The balance shall be equipped with suitable apparatus for suspending the sample container in water from the center of the weighing platform or pan of the weighing device.

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[1] This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved April 27, 1984. Published June 1984. Originally published as C 127 – 36 T. Last previous edition C 127 – 81.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 14.02. Excerpts in all volumes.

[4] Available from American Association of State Highway and Transportation Officials, 444 North Capitol St. N.W., Suite 225, Washington, D.C. 20001.

6.2 *Sample Container*—A wire basket of 3.35 mm (No. 6) or finer mesh, or a bucket of approximately equal breadth and height, with a capacity of 4 to 7 L for 37.5-mm (1½-in.) nominal maximum size aggregate or smaller, and a larger container as needed for testing larger maximum size aggregate. The container shall be constructed so as to prevent trapping air when the container is submerged.

6.3 *Water Tank*—A watertight tank into which the sample container may be placed while suspended below the balance.

6.4 *Sieves*—A 4.75-mm (No. 4) sieve or other sizes as needed (see 7.2, 7.3, and 7.4), conforming to Specification E 11.

7. Sampling

7.1 Sample the aggregate in accordance with Practice D 75.

7.2 Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed using the applicable procedures in Methods C 702. Reject all material passing a 4.75-mm (No. 4) sieve by dry sieving and thoroughly washing to remove dust or other coatings from the surface. If the coarse aggregate contains a substantial quantity of material finer than the 4.75-mm sieve (such as for Size No. 8 and 9 aggregates in Specification D 448), use the 2.36-mm (No. 8) sieve in place of the 4.75-mm sieve. Alternatively, separate the material finer than the 4.75-mm sieve and test the finer material according to Test Method C 128.

7.3 The minimum weight of test sample to be used is given below. In many instances it may be desirable to test a coarse aggregate in several separate size fractions; and if the sample contains more than 15 % retained on the 37.5-mm (1½-in.) sieve, test the material larger than 37.5 mm in one or more size fractions separately from the smaller size fractions. When an aggregate is tested in separate size fractions, the minimum weight of test sample for each fraction shall be the difference between the weights prescribed for the maximum and minimum sizes of the fraction.

Nominal Maximum Size, mm (in.)	Minimum Weight of Test Sample, kg (lb)
12.5 (½) or less	2 (4.4)
19.0 (¾)	3 (6.6)
25.0 (1)	4 (8.8)
37.5 (1½)	5 (11)
50 (2)	8 (18)
63 (2½)	12 (26)
75 (3)	18 (40)
90 (3½)	25 (55)
100 (4)	40 (88)
112 (4½)	50 (110)
125 (5)	75 (165)
150 (6)	125 (276)

7.4 If the sample is tested in two or more size fractions, determine the grading of the sample in accordance with Method C 136, including the sieves used for separating the size fractions for the determinations in this method. In calculating the percentage of material in each size fraction, ignore the quantity of material finer than the 4.75-mm (No. 4) sieve (or 2.36-mm (No. 8) sieve when that sieve is used in accordance with 7.2).

8. Procedure

8.1 Dry the test sample to constant weight at a temperature of 110 ± 5°C (230 ± 9°F), cool in air at room temperature for 1 to 3 h for test samples of 37.5-mm (1½-in.) nominal maximum size, or longer for larger sizes until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50°C). Subsequently immerse the aggregate in water at room temperature for a period of 24 ± 4 h.

NOTE 2—When testing coarse aggregate of large nominal maximum size requiring large test samples, it may be more convenient to perform the test on two or more subsamples, and the values obtained combined for the computations described in Section 9.

8.2 Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated, and, if the surfaces of the particles in the sample have been kept continuously wet until test, the 24-h soaking may also be eliminated.

NOTE 3—Values for absorption and bulk specific gravity (SSD) may be significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in accordance with 8.1. This is especially true of particles larger than 75 mm (3 in.) since the water may not be able to penetrate the pores to the center of the particle in the prescribed soaking period.

8.3 Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. A moving stream of air may be used to assist in the drying operation. Take care to avoid evaporation of water from aggregate pores during the operation of surface-drying. Weigh the test sample in the saturated surface-dry condition. Record this and all subsequent weights to the nearest 0.5 g or 0.05 % of the sample weight, whichever is greater.

8.4 After weighing, immediately place the saturated-surface-dry test sample in the sample container and determine its weight in water at 23 ± 1.7°C (73.4 ± 3°F), having a density of 997 ± 2 kg/m³. Take care to remove all entrapped air before weighing by shaking the container while immersed.

NOTE 4—The container should be immersed to a depth sufficient to cover it and the test sample during weighing. Wire suspending the container should be of the smallest practical size to minimize any possible effects of a variable immersed length.

8.5 Dry the test sample to constant weight at a temperature of 110 ± 5°C (230 ± 9°F), cool in air at room temperature 1 to 3 h, or until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50°C), and weigh.

9. Calculations

9.1 *Specific Gravity:*

9.1.1 *Bulk Specific Gravity*—Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), as follows:

$$\text{Bulk sp gr} = A/(B - C)$$

where:

A = weight of oven-dry test sample in air, g,
B = weight of saturated-surface-dry test sample in air, g, and
C = weight of saturated test sample in water, g.

9.1.2 *Bulk Specific Gravity (Saturated-Surface-Dry)*—Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), on the basis of weight of saturated-surface-dry aggregate as follows:

$$\text{Bulk sp gr (saturated-surface-dry)} = B/(B - C)$$

9.1.3 *Apparent Specific Gravity*—Calculate the apparent specific gravity, 23/23°C (73.4/73.4°F), as follows:

$$\text{Apparent sp gr} = A/(A - C)$$

9.2 *Average Specific Gravity Values*—When the sample is tested in separate size fractions the average value for bulk specific gravity, bulk specific gravity (SSD), or apparent specific gravity can be computed as the weighted average of the values as computed in accordance with 9.1 using the following equation:

$$G = \frac{1}{\frac{P_1}{100\,G_1} + \frac{P_2}{100\,G_2} + \dots \frac{P_n}{100\,G_n}}$$

(see Appendix X1)

where:

G = average specific gravity. All forms of expression of specific gravity can be averaged in this manner.
G_1, $G_2 \dots G_n$ = appropriate specific gravity values for each size fraction depending on the type of specific gravity being averaged.
P_1, $P_2 \dots P_n$ = weight percentages of each size fraction present in the original sample.

NOTE 5—Some users of this test method may wish to express the results in terms of density. Density may be determined by multiplying the bulk specific gravity, bulk specific gravity (SSD), or apparent specific gravity by the weight of water (997.5 kg/m³ or 0.9975 Mg/m³ or 62.27 lb/ft³ at 23°C). Some authorities recommend using the density of water at 4°C (1000 kg/m³ or 1.000 Mg/m³ or 62.43 lb/ft³) as being sufficiently accurate. Results should be expressed to three significant figures. The density terminology corresponding to bulk specific gravity, bulk specific gravity (SSD), and apparent specific gravity has not been standardized.

9.3 *Absorption*—Calculate the percentage of absorption, as follows:

$$\text{Absorption, \%} = [(B - A)/A] \times 100$$

9.4 *Average Absorption Value*—When the sample is tested in separate size fractions, the average absorption value is the average of the values as computed in 9.3, weighted in proportion to the weight percentages of the size fractions in the original sample as follows:

$$A = (P_1A_1/100) + (P_2A_2/100) + \dots (P_nA_n/100)$$

where:

A = average absorption, %,
A_1, $A_2 \dots A_n$ = absorption percentages for each size fraction, and
P_1, $P_2 \dots P_n$ = weight percentages of each size fraction present in the original sample.

10. Report

10.1 Report specific gravity results to the nearest 0.01, and indicate the type of specific gravity, whether bulk, bulk (saturated-surface-dry), or apparent.

10.2 Report the absorption result to the nearest 0.1 %.

10.3 If the specific gravity and absorption values were determined without first drying the aggregate, as permitted in 8.2, it shall be noted in the report.

11. Precision

11.1 The estimates of precision of this test method listed in Table 1 are based on results from the AASHTO Materials Reference Laboratory Reference Sample Program, with testing conducted by this test method and AASHTO Method T 85. The significant difference between the methods is that Test Method C 127 requires a saturation period of 24 ± 4 h, while Method T 85 requires a saturation period of 15 h minimum. This difference has been found to have an insignificant effect on the precision indices. The data are based on the analyses of more than 100 paired test results from 40 to 100 laboratories.

TABLE 1 Precision

	Standard Deviation (1S)[A]	Acceptable Range of Two Results (D2S)[A]
Single-Operator Precision:		
Bulk specific gravity (dry)	0.009	0.025
Bulk specific gravity (SSD)	0.007	0.020
~~Apparent specific gravity~~	~~0.007~~	~~0.020~~
Absorption[B], %	0.088	0.25
Multilaboratory Precision:		
Bulk specific gravity (dry)	0.013	0.038
Bulk specific gravity (SSD)	0.011	0.032
Apparent specific gravity	0.011	0.032
Absorption[B], %	0.145	0.41

[A] These numbers represent, respectively, the (1S) and (D2S) limits as described in Practice C 670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory reference sample data from laboratories using 15 h minimum saturation times and other laboratories using 24 ± 4 h saturation times. Testing was performed on normal-weight aggregates, and started with aggregates in the oven-dry condition.

[B] Precision estimates are based on aggregates with absorptions of less than 2 %.

APPENDIXES

(Nonmandatory Information)

X1. DEVELOPMENT OF EQUATIONS

X1.1 The derivation of the equation is apparent from the following simplified cases using two solids. Solid 1 has a weight W_1 in grams and a volume V_1 in millilitres; its specific gravity (G_1) is therefore W_1/V_1. Solid 2 has a weight W_2 and volume V_2, and $G_2 = W_2/V_2$. If the two solids are considered together, the specific gravity of the combination is the total weight in grams divided by the total volume in millilitres:

$$G = (W_1 + W_2)/(V_1 + V_2)$$

Manipulation of this equation yields the following:

$$G = \frac{1}{\frac{V_1 + V_2}{W_1 + W_2}} = \frac{1}{\frac{V_1}{W_1 + W_2} + \frac{V_2}{W_1 + W_2}}$$

$$G = \frac{1}{\frac{W_1}{W_1 + W_2}\left(\frac{V_1}{W_1}\right) + \frac{W_2}{W_1 + W_2}\left(\frac{V_2}{W_2}\right)}$$

However, the weight fractions of the two solids are:

$W_1/(W_1 + W_2) = P_1/100$ and $W_2/(W_1 + W_2) = P_2/100$

and,

$$1/G_1 = V_1/W_1 \text{ and } 1/G_2 = V_2/W_2$$

Therefore,

$$G = 1/[(P_1/100)(1/G_1) + (P_2/100)(1/G_2)]$$

An example of the computation is given in Table X1.1.

TABLE X1.1 Example of Calculation of Average Values of Specific Gravity and Absorption for a Coarse Aggregate Tested in Separate Sizes

Size Fraction, mm (in.)	% in Original Sample	Sample Weight Used in Test, g	Bulk Specific Gravity (SSD)	Absorption, %
4.75 to 12.5 (No. 4 to ½)	44	2213.0	2.72	0.4
12.5 to 37.5 (½ to 1½)	35	5462.5	2.56	2.5
37.5 to 63 (1½ to 2½)	21	12593.0	2.54	3.0

Average Specific Gravity (SSD)

$$G_{SSD} = \frac{1}{\frac{0.44}{2.72} + \frac{0.35}{2.56} + \frac{0.21}{2.54}} = 2.62$$

Average Absorption

$$A = (0.44)(0.4) + (0.35)(2.5) + (0.21)(3.0) = 1.7\ \%$$

X2. INTERRELATIONSHIPS BETWEEN SPECIFIC GRAVITIES AND ABSORPTION AS DEFINED IN TEST METHODS C 127 AND C 128

X2.1 Let:

S_d = bulk specific gravity (dry basis),
S_s = bulk specific gravity (SSD basis),
S_a = apparent specific gravity, and
A = absorption in %.

X2.2 Then,

$$S_s = (1 + A/100)S_d \quad (1)$$

$$S_a = \frac{1}{\frac{1}{S_d} - \frac{A}{100}} = \frac{S_d}{1 - \frac{AS_d}{100}} \quad (2)$$

$$S_a = \frac{1}{\frac{1 + A/100}{S_s} - \frac{A}{100}} = \frac{S_s}{1 - \left[\frac{A}{100}(S_s - 1)\right]} \quad (2a)$$

$$A = \left(\frac{S_s}{S_d} - 1\right)100 \quad (3)$$

$$A = \left(\frac{S_a - S_s}{S_a(S_s - 1)}\right)100 \quad (4)$$

Standard Test Method for

RESISTANCE TO DEGRADATION OF LARGE-SIZE COARSE AGGREGATE BY ABRASION AND IMPACT IN THE LOS ANGELES MACHINE[1]

This standard is issued under the fixed designation C 535; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This method covers testing sizes of coarse aggregate larger than ¾ in. (19 mm) for resistance to degradation using the Los Angeles testing machine.

NOTE 1—A procedure for testing coarse aggregate smaller than 1½ in. (37.5 mm) is covered in Method C 131.

2. Applicable Documents

2.1 *ASTM Standards:*

C 131 Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine[2]

C 136 Method for Sieve Analysis of Fine and Coarse Aggregates[2]

C 670 Practice for Preparing Precision Statements for Test Methods for Construction Materials[2]

C 702 Methods for Reducing Field Samples of Aggregate to Testing Size[3]

D 75 Practice for Sampling Aggregates[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[4]

3. Summary of Method

3.1 The Los Angeles test is a measure of degradation of mineral aggregates of standard gradings resulting from a combination of ac- [illegible] and grinding in a [illegible] drum [illegible] number depending upon the grading of the test [illegible] carrying them around until they are dropped to the opposite side of the drum, creating an impact-crushing effect. The contents then roll within the drum with an abrading and grinding action until the shelf plate impacts and the cycle is repeated. After the prescribed number of revolutions, the contents are removed from the drum and the aggregate portion is sieved to measure the degradation as percent loss.

4. Significance and Use

4.1 The Los Angeles test has been widely used as an indicator of the relative quality or competence of various sources of aggregate having similar mineral compositions. The results do not automatically permit valid comparisons to be made between sources distinctly different in origin, composition, or structure. Specification limits based on this test should be assigned with extreme care in consideration of available aggregate types and their performance history in specific end uses.

5. Apparatus

5.1 *Los Angeles Machine* conforming to the requirements of Test Method C 131.

5.1.1 The machine shall be so driven and so counterbalanced as to maintain a substantially uniform peripheral speed (Note 2). If an angle is used as the shelf, the direction of rotation shall be such that the charge is caught on the outside surface of the angle.

NOTE 2—Backlash or slip in the driving mechanism is very likely to furnish test results that are not duplicated by other Los Angeles machines producing constant peripheral speed.

5.2 *Sieves*, conforming to Specification E 11.

5.3 *Balance*—A balance or scale accurate within 0.1 % of test load over the range required for this test

5.4 *Charge*—The charge shall consist of 12 steel spheres averaging approximately 1²⁷⁄₃₂ in. (46.8 mm) in diameter, each weighing between 390 and 445 g, and having a total weight of 5000 ± 25 g.

NOTE 3—Steel ball bearings 1¹³⁄₁₆ in. (46.038 mm) and 1⅞ in. (47.625 mm) in diameter, weighing approximately 400 and 440 g each, respectively, are readily available. Steel spheres 1²⁷⁄₃₂ in. (46.8 mm) in diameter weighing approximately 420 g may also be obtainable. The charge may consist of a mixture of these sizes.

6. Sampling

6.1 The field sample shall be obtained in accordance with Practice D 75 and reduced to test portion in accordance with Method C 702.

7. Test Sample

7.1 The test sample shall be washed and oven-dried at 221 to 230°F (105 to 110°C) to substantially constant weight (Note 4), separated into individual size fractions, and recombined to the grading of Table 1 most nearly corresponding to the range of sizes in the aggregate as furnished for the work. The weight of the sample prior to test shall be recorded to the nearest 1 g.

NOTE 4—If the aggregate is essentially free of adherent coatings and dust, the requirement for washing before and after test may be waived. Elimination of washing after test will seldom reduce the measured loss by more than about 0.2 % of the original sample weight.

8. Procedure

8.1 Place the test sample and charge in the Los Angeles testing machine and rotate the machine at 30 to 33 rpm for 1000 revolutions. After the prescribed number of revolutions, discharge the material from the machine and make a preliminary separation of the sample on a sieve coarser than the 1.70-mm (No. 12). The finer portion shall then be sieved on a 1.70-mm sieve in a manner conforming to Method C 136. The material coarser than the 1.70-mm sieve shall be washed (Note 4), oven-dried at 221 to 230°F (105 to 110°C) to substantially constant weight, and weighed to the nearest 5 g (Note 5).

NOTE 5—Valuable information concerning the uniformity of the sample under test may be obtained by determining the loss after 200 revolutions. This loss should be determined without washing the material coarser than the 1.70-mm (No. 12) sieve. The ratio of the loss after 200 revolutions to the loss after 1000 revolutions should not greatly exceed 0.20 for material of uniform hardness. When this determination is made, take care to avoid losing any part of the sample; return the entire sample, including the dust of fracture, to the testing machine for the final 800 revolutions required to complete the test.

9. Calculation

9.1 Express the loss (difference between the original weight and the final weight of the test sample) as a percentage of the original weight of the test sample. Report this value as the percent loss.

NOTE 6—The percent loss determined by this method has no known consistent relationship to the percent loss for the same material when tested by Test Method C 131.

10. Precision

10.1 The precision of this method has not been determined. It is expected to be comparable to that of Test Method C 131.

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[1] This method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.03.05 on Methods of Testing and Specifications for Physical Characteristics of Concrete Aggregates.

Current edition approved April 24, 1981. Published June 1981. Originally published as C 535 – 64 T. Last previous edition C 535 – 69 (1975).

[2] *Annual Book of ASTM Standards*, Vols 04.02 and 04.03.

[3] *Annual Book of ASTM Standards*, Vol 04.02.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

EXHIBIT 52

RESPONSE TO INITIAL COMPLETENESS REVIEW COMMENT UMC 784.14(a)(1)
PERMIT RENEWAL - AUGUST 1987

ICR UMC 784.14
(a)(1) "The applicant must provide a description of the potential for water infiltration into the waste rock pile following reclamation and attendant impacts to the quality of surface and ground water within the proposed mine plan and adjacent area."

RESPONSE:

Presented in this response will be the following sections: previous investigations of the waste rock pile (referred to herein as the refuse pile), a description of existing site and geologic conditions in the vicinity of the refuse pile, uses of ground and surface waters in the vicinity of the refuse pile, and conclusions with regard to potential impacts from the refuse pile to the quality of surface and ground water within the proposed mine plan and adjacent area based on data available at this point in time.

PREVIOUS INVESTIGATIONS

Several geotechnical investigations have been conducted on the refuse pile itself or in the vicinity of the refuse pile which provide information as to the subsurface conditions within and beneath the coal refuse pile. These previous investigations and the scopes of these investigations were as follows:

1. An investigation of the refuse pile conducted in 1976 by Dames and Moore of Salt Lake City, Utah entitled "Report of Engineering Studies - Stability and Construction Method Study Active Coal Refuse Pile." The purpose of this study was to conduct a stability analysis on the then active portion of the refuse pile, which comprises the Phase I portion of the present refuse pile, and to determine the minimum construction requirements for the refuse pile to maintain an acceptable factor of safety against instability.

2. An investigation of the refuse pile conducted in 1981 by Rollins, Brown and Gunnell, Inc. of Provo, Utah entitled "Slope Stability Studies for the Plateau Mine Refuse Dumps Phases II and III." The purpose of this study was to conduct a stability analysis for the Phase II and Phase III areas of the refuse pile, located on the west side of the Phase I area of the refuse pile studied by Dames and Moore.

3. An investigation conducted in 1983 by Rollins, Brown and Gunnell, Inc. entitled "Soil and Foundation Investigation Plateau Mine Expansion Wattis, Utah." This study was conducted to define the characteristics of the subsurface materials throughout the then proposed development area for facilities associated with the conveyor to the unit train load-out area as well as the facilities of the unit train load-out itself.

4. An investigation conducted in 1984 by Rollins, Brown and Gunnell, Inc. entitled "Soil and Foundation Investigation Plateau Mine Expansion Phase II Wattis, Utah." This study was performed to investigate subsurface foundation conditions for proposed modifications to the coal handling facilities which were investigated during their 1983 investigation.

5. An investigation conducted in 1984 by Chen and Associates, Inc. of Salt Lake City, Utah entitled "Geotechnical Investigation Thickener Underflow Treatment Ponds Plateau Mine Wattis, Utah." This study was conducted to determine the geotechnical engineering aspects of the design and construction of the Thickener Underflow Treatment Ponds at the site.

6. An investigation conducted in 1985 by Chen and Associates, Inc. entitled "Coal Refuse Pile Study Plateau Mining Company Price, Utah." This study involved a subsurface exploration program, laboratory testing, and engineering analyses for the purpose of determining the condition and stability of the refuse pile as of June 1985.

The above referenced reports summarizing the results of these investigations have previously been submitted to the agency as part of the documentation for design and construction of the various facilities for which the reports were prepared. Therefore, reference will be made to information provided in these reports without reproducing all of the documentation contained therein.

EXISTING SITE AND GEOLOGIC CONDITIONS

Plateau Mining Company disposes of the coal processing waste materials, materials separated from the coal product in the coal preparation, in a stock pile located primarily in Section 10 T. 15 S., R. 8 E., on the south side of the mine access road to the facility (see Figure 1). In a report entitled, "Coal

Processing Waste Pile Extension Plan and Feasibility Study," prepared by Vaughn Hansen Associates, Inc. in 1981, the expansion to the refuse pile was divided and referred to as being constructed in phases, with Phase I being the then existing pile, Phase II being a separate pile constructed immediately to the west of the Phase I pile, and Phase III being the placement of refuse between the Phase I pile and the Phase II pile such that the refuse pile would be one continuous deposit.

The refuse pile is located on a bench along the foothills on the east side of the Wasatch Plateau. This bench is dissected on both the immediate north and south sides of the site of the refuse pile by ephemeral drainage channels, running in an easterly-northeasterly direction. These channels have eroded downward some 50 to 70 feet below the elevation of the bench.

Doelling (1972) identifies the surface geologic formation in the vicinity of the refuse pile to be the Masuk member of the Mancos Shale Formation. Doelling also identifies the presence of a thin veneer of gravel deposits beneath the north and northeasterly portion of the refuse pile. Doelling indicates that these gravel deposits are "partly consolidated poorly sorted and stratified deposits of rock fragments of local origin, pediments or terrace, up to 75 feet thick." Dames and Moore identified these gravel deposits beneath the Phase I area of the refuse pile, indicating that the "underlying natural soils encountered in the borings...consist of brown to brown silty fine to coarse sand with fine and coarse gravel and occasional cobbles." Dames and Moore also indicated that "this natural soil is probably alluvial or colluvial in origin" and that "although bedrock was not definitely encountered in any of the borings or test pits, it is anticipated to be at very shallow depths beneath the surface at the refuse pile location." A line of demarkation could be drawn from the borings at the site for the surface interface between these gravel deposits and the Mancos Shale Formation. The borings indicate that much of the Phase II and Phase III segments of the refuse pile will be located directly above the Mancos Shale Formation, with the near surface soils being primarily clays or silty clays, whereas the Phase I area of the refuse pile is located above the gravel deposits.

GROUND WATER CONDITIONS

The exact depth to ground water beneath the refuse pile is not known at this time. However, the borings drilled to date as well as the surface conditions of the ephemeral channels located on the north and south sides of the refuse pile indicate that the ground water table beneath the site is at least greater and probably much greater than 40 feet deep.

Ground water was not encountered in any of the borings drilled as part of the investigations previously referenced. Borings No. 1 through No. 7 (see Figure 1), drilled by Rollins, Brown, and Gunnel, Inc. during their 1981 investigation of the Phase II and Phase III areas of the refuse pile expansion, were drilled to depths ranging from nearly 36 feet to 41 feet below the natural ground surface. Borings DH-6 through DH-9, drilled by Rollins, Brown, and Gunnell during their January 1983 investigation, were drilled through the fill and refuse material placed in the ephemeral channel on the north side of the refuse pile, on top of which are currently located the raw coal stacking tube and conveyor and the clean coal stacking tube and conveyor. These borings were drilled to a depth of between 21 to 22 feet below original ground surface. Boring DH-7 was drilled down to elevation 7316 feet without encountering ground water, which is some 104 feet below the original ground surface elevation at boring No. 2 (approximate elevation 7420 feet) which was centered, with reference to the north south direction, in the Phase II and III areas of the refuse pile (see Figure 1) roughly due south of boring DH-7.

The geotechnical investigations of the refuse pile have also indicated that saturated conditions within the pile itself are apparently not present, although very moist conditions in limited areas were encountered. In the original investigation conducted by Dames and Moore, Dames and Moore indicated that saturated conditions in the coal refuse material were not encountered, however, "some small layers and zones of nearly saturated coal refuse were encountered. These perched zones are related to variations in the permeability of the coal refuse material. The primary source of water is the coal refuse which is placed at the site in a very moist condition." In the 1985 investigation of the coal refuse pile conducted by Chen and Associates, Chen and Associates indicated that although the "moisture content of the coal refuse ranged from slightly moist to very moist,...no free water was encountered within the test pits, borings or dozer cuts, at the time of the investigation."

In addition to the geotechnical investigations referenced above, four piezometers have been installed in the refuse pile to monitor whether or not the refuse pile material is becoming saturated (see Figure 1 for location of piezometers). These piezometers have been monitored on a regular basis and to date have indicated that a saturated condition within the refuse pile material itself is not occurring.

There is also no evidence of a shallow ground water table in either the ephemeral drainage on the north side or the ephemeral drainage on the south side of the refuse pile. There are no seeps and springs that have been identified in either of these drainages and water loving vegetation is not found along the channels, which would indicate that the ground-water table beneath the refuse pile and adjacent area is probably well below the bottom of these ephemeral drainages. In fact, there are no known springs within several miles to the east of the refuse pile area which would presumably be down gradient (with regard to the direction of ground-water movement) from the refuse pile.

USE OF GROUND AND SURFACE WATER

The use of ground or surface water in the vicinity or adjacent area of the refuse pile is extremely limited. As indicated previously, the drainage channels on both the north and south sides of the refuse pile are ephemeral drainage channels which are generally dry except during the early spring or snowmelt period of the year or except during a rainfall event. There are apparently no surface or ground water rights associated with either of these drainage channels downstream of the refuse pile. In fact, the closest surface or ground water rights located in an eastward direction from the refuse pile (the anticipated direction of ground water movement in the vicinity of the refuse pile) are some 3.5 miles to the east southeast. These water rights are actually located on or within the Miller Creek drainage area. The only other water rights in the near vicinity of the refuse pile are located in drainage channels to the north of the mine plan area. These rights are located in a position and at an elevation that would not be down gradient from ground water beneath the refuse pile.

Also as indicated previously, there is no evidence of a shallow ground water table in either the ephemeral drainage on the north side or the ephemeral drainage on the south side of the refuse pile. There are no seeps and springs that have been identified in either of these drainages and water loving vegetation is not found along the channels, which would indicate that the ground water beneath the refuse pile is not used as a supply for wildlife or for vegetation in the adjacent area to the refuse pile.

POTENTIAL IMPACTS TO QUALITY OF SURFACE AND GROUND WATERS

There is not sufficient data to provide a quantitative assessment of potential impacts to the quality of surface and ground waters due to infiltration through the refuse pile upon reclamation. Therefore, impacts are assessed qualitatively herein.

As indicated by the information presented above, the refuse pile has been located in an area such that the refuse material will be placed entirely above the original ground surface, which will place the refuse material at least 40 feet and probably on the order of greater than 100 feet above the ground-water table beneath the site. Therefore, potential impacts to the ground-water quality due to the free flow of saturated fluids through the refuse material will be non existent. This is of course one of the principal techniques recommended for use in minimizing potential impacts to the ground water system from potentially toxic or acid forming materials, i.e. to locate toxic or acid forming refuse in a position within the refuse storage area that would be above the ground water table in the area.

It should also be noted that with the two ephemeral channels on the north and south sides of the refuse pile, the bench on which the refuse pile is located is a small ridge extending eastward from the base of the plateau. As a result, the surface area from which surface water runoff would be tributary to the refuse pile is primarily from the refuse pile itself. In addition, surface water runoff in the vicinity of the refuse pile is controlled by the surface drainage control facilities of the mine to prevent erosion along the toe of the refuse pile.

Infiltration and deep percolation through the refuse pile upon reclamation will occur primarily from direct precipitation on the pile. Once surface runoff and evapotranspiration are subtracted from direct precipitation on the refuse pile after reclamation, actual deep percolation down through the refuse pile to the ground-water system is anticipated to be nominal and therefore, impacts to the quality of ground water beneath the site are anticipated to be likewise nominal. Jeppson et. al. (1968) indicate that the normal annual precipitation at the location of the refuse pile is approximately 16 inches. Price and Arnow (1974) and the U.S. Geological Survey (1979) estimated that the percentage of annual precipitation that recharges the ground water system along the Wasatch Plateau is probably less than 5 percent. As reported in the mine permit application, from streamflow gaging records on Tie Fork, the percentage of annual precipitation that recharges the ground-water system within the mine permit area was estimated to be on the order of 4 percent. It is anticipated that this percentage would be even less in the vicinity of the refuse pile. Based on this percentage and the normal annual precipitation of 16 inches, estimated deep percolation due to precipitation on the refuse pile would be less than 0.6 of an inch per year.

The ground water beneath the site or in the adjacent area is placed to no known beneficial use as evidenced by the lack of water rights within a distance of 3.5 miles to the east of the site. The lack of any indication of water loving vegetation in the vicinity of the site is an indication that the ground water beneath the refuse pile is not used as a source of supply for even vegetation in the vicinity of the site. Any use of ground water from beneath the refuse pile area by vegetation is assumed to be miles from the site. Therefore, even if the ground water quality were impacted by the minimal quantity of water that might percolate through the refuse pile material, by the time this water reaches a point of use dilution through mixing with ground water which receives recharge from a significantly larger area than area of the refuse pile will probably negate any potential impacts to the ground water quality. In addition and as indicated in the report entitled "An Evaluation of the Toxic and Acid Forming Properties of Overburden and Coal Refuse Materials" prepared in response to the DOGM completeness review comments related to UMC 783.14, 817.71, 817.72, and 817.103, analyses of quality data of refuse pile material, overburden materials, and natural soils in the area "demonstrates the underground development and coal processing wastes are, using the Division's regulations and guidelines, non-toxic and non-acid forming materials." It is also indicated in this report that "it is Plateau's opinion that these materials pose no potential problems to either plant or animal life or water quality."

EXHIBIT 51

REVISION TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining

by pgl date 1/30/89

AN EVALUATION OF THE TOXIC AND ACID FORMING PROPERTIES OF OVERBURDEN AND COAL REFUSE MATERIALS

Prepared for Plateau Mining Company

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INTRODUCTION

During the permit review process of Plateau Mining Company's (PMC) permit renewal application, the Utah Division of Oil, Gas and Mining (UDOGM) expressed concerns relative to the adequacy of information submitted under Sections UMC 783.14 and UMC 817.48. These concerns were conveyed to Plateau in a letter dated November 20, 1986. The purpose of this report is to provide a discussion of the acid or toxic forming properties of overburden and coal refuse materials as they might affect long term reclamation of Plateau's properties. Since these are two somewhat separate issues, this discussion will address each one of these areas separately as outlined in the Division's adequacy review letter.

Overburden

The Division expressed the following concern:

UMC 783.14 - Geology Description (RVS)

(a)(1)(iii) Chemical analyses presented in Table 3 for overburden/interburden/underburden are pertinent to processed (burned) development waste rock. Inasmuch as development waste rock will not be burned prior to final disposal, these chemical data are inappropriate for the purposes of identifying whether those horizons to be removed contain potential acid-forming toxic-forming or alkalinity producing materials.

The Division recommends that the applicant provide the below-listed data (and sampling locations) for non-coal bearing horizons that may be extracted during the permit renewal term:

1. pH
2. EC mmhos/cm 25°C
3. Saturation %
4. Texture
5. SAR
6. Selenium
7. Boron
8. Acid/Base Potential

RESPONSE:

In accordance with Division concerns, Plateau submitted 35 additional samples of roof, floor and split materials to Bockcliffs Laboratories in Steamboat Springs, Colorado for analysis. These samples were sampled for the parameters suggested by the Division. The laboratory data sheets for these samples are contained as an appendix to this report entitled, Appendix 1, Bookcliffs Laboratory Data Sheets. The sampling locations of each sample are identified on the lab sheets and can be correlated with the appropriate drill hole locations found on permit Map 4, Mine Plan Hiaw Seam; Map 5, Mine Plan Third Seam; and Map 6, Mine Plan Wattis Seam.

Potential Acid or Toxic Forming Properties

In order to evaluate the potential acid or toxic forming properties of these 35 overburden samples, they were evaluated according to the Division's proposed overburden suitability guidelines presented in Table 4 of the Division's proposed "Guidelines for Management of Topsoil and Overburden for Underground Coal Mining".

In conducting this evaluation, the following definitions from UMC 700.5 were used:

Overburden means material of any nature, consolidated or unconsolidated, that overlies a coal deposit, excluding topsoil.

Acid-forming materials means earth materials that contain sulfide minerals or other materials which, if exposed to air, water, or weathering processes, form acids that may create acid drainage.

Acid drainage means water with a pH of less than 6.0 and in which total acidity exceeds total alkalinity, discharged from active, inactive or abandoned underground coal mining activities or from an area affected by underground coal mining activities.

Toxic-forming materials means earth materials or wastes which, if acted upon by air, water, weathering, or microbiological processes, are likely to produce chemical or physical conditions in soils or water that are detrimental to biota or uses of water.

In addition to the 35 samples analyzed in the current evaluation another sample, previously collected by Plateau, named the Graben Crossing Sample, was included in this evaluation. In total, 36 overburden samples were available for evaluation of their reclamation suitability. In order to facilitate the review, statistical summaries were made comparing means, ranges, and frequencies of each parameter identified as being of concern by the Division. These comparisons allow for the overburden, refuse and undisturbed soils properties to be compared. The comparisons are based on the data from the 35 above mentioned overburden samples, 46 refuse samples and approximately 84 undisturbed soil samples submitted in the permit application on Table 58, Star Point Mine No. 1 Soil Properties; Table 59, Refuse Area Soil Analysis; Table 60, Lion Deck Access Road Soil Samples; Table 61, Chemical and Physical Analysis of Cut and Fill Areas; Table 62 Corner Canyon Fan Site Soil Properties and Table 63, Unit Train Loadout Topsoil Analysis. These values were used to represent native soils since these are indicative of soil types that have been disturbed by previous mining activities. This section will compare overburden and native soil properties only.

pH

Using the Division's proposed suitability classes (Table 1, Percentage of pH Samples by Suitability Classes) suggests 69% of the overburden samples are rated "good" as compared to only 38% of the soil samples. One pH sample (Lab No. 87-0281) had a pH value of 4.4 or in the unacceptable category. Since this sample is a portion of bone or split in the coal seam, it will be mixed with the roof and floor material during mining. This mixing and removal of the coal during treatment will dilute the adverse properties of this boney split. Mixing of these three materials will yield a weighted average pH from this area of approximately 6.5. According to the Division's proposed guidelines, the overall average pH of these mixed materials would be "good". As are shown in Table 2, Means Comparison of Materials by Chemical and Physical Parameters.

The average pH of the overburden equals 7.30 while the average pH of the soil is 7.82. This translates into a proposed average pH suitability of "good" for the overburden and "good/fair" for the undisturbed soil. Given the standard references on the availability of plant nutrients as affected by pH, an average pH of 7.3 is more optimum for normal plant growth than is an average pH of 7.82. According to USGS (1979) available nitrogen, phosphorus, iron, manganese, boron, copper and zinc are all less available at pH values near 7.8 as compared to values near 7.3. In order to compare the overall reclamation suitability of the various plant growth mediums, Plateau transferred the individual observations into the four suitability classes proposed in the Division's "Guidelines". A good class was assigned a numeral value of 1, while an unacceptable class was assigned a value of 4. Thus, a lower value denotes a more desirable suitability ranking. Table 3, Statistical Mean Comparison by Reclamation Suitability Class; documents that with respect to pH, overburden has a significantly more desirable suitability ranking than do the native soils found in the area.

According to the mine spoil classification developed in Ohio (Arora et. al., 1981) which uses pH as the sole criteria for classifying mine spoil acidity, this material would be classified as calcareous since the pH values of more than half of the samples is more than 7.0. Given these analyses, Plateau submits that based upon pH, the overburden material cannot be considered as "acidic". In fact, evidence suggests the overburden material constitutes a more suitable plant growth medium with respect to pH than do the undisturbed native soils.

Electrical Conductivity (EC)

Table 4, Percentage of Electrical Conductivity Samples by Suitability Class documents that 97% of the overburden and 96% of the undisturbed soils have a "good" suitability as a reclamation medium.

The average EC value for overburden is 1.47 mmhos while the average EC value of the undisturbed soil is 1.16 mmhos, (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters). The means are not significantly different. When statistically evaluated according to reclamation suitability classes, (Table 3, Statistical Mean Comparison by Reclamation Suitability Classes) the mean suitability class was 1.02

for the overburden and 1.04 for the native soils. The EC data for the overburden suggest this material cannot be considered to be "toxic" nor will inhibit plant growth any more than the native soils in the area.

Saturation Percentage (SP)

According to the proposed Division "Guidelines", all 35 overburden samples and all 13 soil samples would be ranked "good" with respect to saturation percentage. Table 2, Mean Comparison of Materials by Chemical and Physical parameters shows the average saturation percentage of the overburden samples is significantly higher than those of the soil samples. Since the higher value is more optimum, Plateau concludes that no "toxic" properties with respect to saturation percentage exist with respect to the overburden analyzed. When evaluated according to overall suitability (Table 3, Statistical Mean Comparison by Reclamation Suitability Class) no differences exist between the overburden or native soils as plant growth medium.

Texture

On a frequency basis, 89 percent of the overburden samples and 76 percent of the native soil samples fall into the "good" reclamation suitability class (Table 5, Percentage of Texture Samples by Suitability Classes). Table 2, Mean Comparison of Materials by Chemical and Physical parameters shows that based on particle size, the average texture of the overburden is a loam, which has a good suitability as compared to an average clay loam for the native soil. The Division's "Guidelines" omit a suitability class for clay loam, but Wyoming ranks a clay loam a "fair" material. Since the proposed "Guidelines" list clay as both a fair and a poor class, it is likely the fair clay is supposed to denote a clay loam material.

Table 3, Statistical Mean Comparison by Reclamation Suitability Classes; shows the overburden materials to be a significantly more desirable plant growth medium, from a textural stand point than with the native soils. Given this analysis, Plateau submits that the overburden material cannot be considered to be "toxic" with respect to texture.

Clay

The Division has no proposed suitability standard for clay in its proposed "Guidelines". Since this parameter has long been utilized by the State of Montana and plays an important role in evaluating the suitability of materials, it is included in this analysis. Simply, whenever the clay percentage exceeds 40%, Montana considers this to be a suspect level. In this analysis, values having a clay content of greater than 40% were considered unacceptable as a plant growth medium. Values greater than 40% clay were assigned a numeric value of 4 (unsuitable) while values less than 40% clay were assigned a numeric value of 1 in the suitability class analysis.

The frequency distributions revealed (Table 6, Percentage of Clay Samples by Suitability Class) that all of the overburden samples and 94% of the soil samples possessed "good" suitability for reclamation. When compared by suitability class rankings (Table 3, Statistical Mean Comparison by Reclamation Suitability Class), the mean suitability values of the overburden samples were found to be significantly higher than those for the native soils. In this comparison, it appears the overburden materials are slightly more suited for reclamation with respect to clay content than are the native soils.

Sand

The Division has no proposed standard for percent sand. As for clay, the Montana standard was used in the same manner as previously described. A frequency comparison (Table 7, Percentage of Sand Samples by Suitability Classes) reveals that 86% of the overburden samples and 98% of the soil samples are ranked "good". Examination of the five values ranked unsuitable reveals that 4 of the 5 suspect values are floor samples (86-18-1C Wattis Floor, W-20-C Hiaw Floor, 86-107-TU-C, Third Roof, 86-119-WD-C, Hiaw Floor and 86-129-WD-C Hiaw Floor). Since these samples will largely remain in place and not be removed from the mine as a result of mining, the potential problems are reduced in comparison to the other zones. Plateau submits the mixing of material during mining will produce sand percentages lower than these extremes. Analysis of the refuse material supports this mixing phenomenon. Plateau believes based upon these considerations, high sand contents do not pose a potential hazard or toxicity problem with respect to reclamation suitability.

Sodium Adsorption Ratio (SAR)

Examination of the 36 overburden samples, 50 undisturbed soils samples and 35 Refuse samples reveals (Table 3, Statistical Mean Comparison by Reclamation Suitability Class) indicates that all of the samples are ranked "good" with respect to sodium adsorption ratio. A mean comparison of values (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters) documents that the mean sodium adsorption ratio for the overburden samples is significantly lower than the levels found in native soils. Plateau submits that this demonstration provides ample evidence that the overburden materials cannot be considered to be "toxic" with respect to sodium adsorption ratio.

Selenium (Se)

The Division has proposed a suitability value of 0.1 mg/kg or ppm as the standard for selenium. This is the same standard utilized by Montana. New Mexico uses a suitability standard of 0.5 and Wyoming and OSM have no proposed standard.

A frequency analysis of the 35 overburden samples (Table 8, Percentage of Selenium by Suitability Class) reveals that 71% of the samples have values less than 0.1 mg/kg while in the soil, all 10 of the native soil samples had selenium values less than 0.10 mg/kg.

The 10 overburden values having suspect selenium values include: CVR-1-C, Wattis Floor; 84-23-1-C, Wattis Floor; W-4-C, Hiaw Floor; W-8-C, Wattis Floor; 82-55-TD-C, Third Floor; 85-103-TU=C, Wattis Floor; 85-103-TU-C, Wattis Roof; 86-119-WD-C, Wattis Floor; 86-129-WD-C, Third Roof; and 86-129-WD-C, Hiaw Roof. Four of the samples correspond to the Wattis Floor, 2 samples to the Wattis Roof and one sample each to the Hiaw Floor, Hiaw Roof, Third Floor and Third Roof.

The mean comparison of all individual observations (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters) suggest the overall mean of the overburden selenium values is significantly higher than corresponding selenium values in the undisturbed soils of the immediate site. While these values seem somewhat elevated when compared to the apparent standard, they are significantly lower than the regional values for Emery County, Utah reported by Boon et. al., (1987).

The proposed values are also within the guidelines proposed by various researchers in the field of reclamation. Schafer (1979) proposed a suspect level of 2.0 ppm, or the value 0.5 ppm currently utilized by New Mexico (OTA, 1986). Wyoming and Montana both used the value of 2.0 ppm until recently. Munshower (1983) presented a detailed discussion of this element as it relates to reclamation planning. He reported the concern over selenium toxicity is not relative to plant toxicity but due to possible adverse effects on the grazing animals diet. He reported that "neither total or water-soluble selenium has any direct relationship to plant selenium levels". This is also the opinion of Barth et. al. (1981). Munshower reported: "The use of water soluble selenium extracts to identify potential excesses of selenium in mine soils and overburden is inadequate and expensive." He reported that analysis of overburden samples gives highly inaccurate results. This same concern was also shared by OTA (1986). Barth (1981) summarized the technical literature on soil selenium and concluded: "Based on the information available from the literature, available selenium in material to be used as a plant growth medium should average somewhat less than 100 ppb and materials exceeding approximately 2,000 ppb should be considered suspect until growth testing confirms otherwise. Munshower (1983) reports that most recent researchers in the selenium field recommend using plant selenium levels as a basis for defining potential plant toxicities. Boon et. al., (1987) recently proposed that given the poor correlation of soil selenium to plant selenium "monitoring plant quality on the reclaimed surface may be more effective than baseline studies of overburden trace metal content". Given this background, Plateau suggests that numerous options are available to quantify the apparent selenium levels apparent in the overburden samples will be sufficiently mixed through mixing and plant analysis.

Evaluation of the selenium values by overburden type revealed that overburden type had no measurable effect on selenium values. The average selenium content of the roof was .074 mg/kg; floor .082 mg/kg; tunnel material .049 mg/kg; and split 0.061 mg/kg. A statistical comparison of the values revealed no significant differences between means. A weighted average mean of roof selenium values was 0.068 mg/kg while the weighted mean average of the floor materials was 0.084 mg/kg. A t-test revealed no significant difference in these means.

Boron (B)

An analysis of Table 9, Percentage of Boron Samples by Suitability Class; reveals that 94% of the overburden samples are ranked "good" with respect to boron. The two samples that exceed the suspect level are from drill hole 86-18-1-C. Since such a small number of samples appear suspect and the overall average boron content of overburden is lower (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters) than either the native soils or refuse pile samples, Plateau is of the opinion that mixing of the overburden materials during mining will effectively alleviate the problem of any potential boron toxicities being manifest from the small number of samples above the suspect level.

Acid Base Potential (ABP)

Of the 35 overburden samples analyzed for acid base potential using percent total sulfur. Ninety one percent of the samples were classified as a "good" plant growth medium. The three samples below the suspect level were 86-18-1-C - Wattis Floor, 85-103-TU-C - Wattis Split and 86-129-WD-C - Third Roof. Plateau submits the potential problems associated with sample 86-18-1-C - Wattis Floor will largely be nonexistent because between 95 and 98 percent of the waste rock removed from the mine originates in the roof and split segments of the overburden. Due to the poor coal quality associated with the split, Plateau avoids mining this coal whenever possible. This avoidance significantly reduces the potential contamination of waste rock originating from this area.

Examination of these three samples with respect to sulfur forms and lithologies (Appendix Table 1, Bookcliffs Laboratory Results and Table

12, Overburden lithologic Descriptions) document that in sample 18-1-C is a carbonatious mudstone with 80% of the total sulfur in the sulfate sulfur form. Sample 103-TU-C is a portion of the Wattis Split which contains approximately 50% coal. Since this material will be processed through the coal processing plant, it is expected the coal and rock fragments will be separated. This operational benefication process will also produce a refuse material without the current high coal content which will be significantly less adverse with respect to acid base potential. The average acid base potential of all the overburden samples analyzed yielded a mean value of 76.54 tons $CaCO_3$ per 1,000 tons.

Overburden material appeared to have some influence on acid base potential. The roof material averaged 84.07 tons $CaCO_3$ per 1,000 tons, the floor material averaged 61.65 tons $CaCO_3$ per 1,000 tons, the split material samples was -50 tons $CaCO_3$ per 1,000 tons, while the tunnel material averaged 168 tons $CaCO_3$ per 1,000 tons. Although the mean acid base potential value of the roof materials was somewhat higher than the floor materials with the existing sample size, the means were not statistically different.

Plateau believes examination of the existing acid base potential data from the overburden suggests little, if any potential for toxicity exists with respect to the acid base account of these overburden samples.

Division Concern:

In addition, a calculated volume of waste rock for each seam to be mined during the term of the permit renewal must be provided.

RESPONSE:

It is difficult for Plateau to understand why the Division is requesting this information. Plateau's examination of UMC 783.14 (a)(1)(iii) reveals no regulatory basis for this request. It is our interpretation of this section that the only information required is a chemical and physical description and interpretation of the overburden materials with respect to their "acid-forming, toxic-forming, or alkalinity-producing" potentials.

If the Division inserted this request on the assumption that such materials were present, Plateau submits they were making an assumption unsupported by the geochemical information available.

The evaluation of the overburden on a parameter by parameter comparison previously presented, documents (Table 4, Percentage of Electrical Conductivity Samples by Suitability Class; Table 5, Percentage of Texture Samples by Suitability Class; Table 6, Percentage of Clay Samples by Suitability Class; Table 7, Percentage of Sand Samples by Suitability Class; Table 8, Percentage of Selenium Samples by Suitability Class; Table 9, Percentage of Boron Samples by Suitability Class; Table 10, Percentage of Acid Base Potential Values by Suitability Class and summarized in Table 3, Statistical Mean Comparison by Reclamation Suitability Class) that the overburden with a few minor exceptions, according to the Division's proposed suitability "Guidelines" is no more adverse with respect to the reclamation suitability than is topsoil. The Division's request apparently originates on the erroneous assumption that these materials might potentially contain inimical substances that could potentially require selective handling to isolate these inhibitory materials. Examination of the cited Tables documents the overburden is a "cleaner" plant growth medium than is the native topsoils with respect to pH, EC, texture and percent clay, and equal to topsoil in suitability with respect to SP and SAR. Only with respect to the parameters of sand, selenium, boron and acid base potential does the overburden possess a lower reclamation suitability than the "control" native soils.

A comparison of these four parameters (Table 11, Seam Comparison of Selected Chemical and Physical Properties) reveals that significant differences exist between seams only with respect to sand and boron. Percent sand in the Hiawatha Seam is elevated with respect to corresponding values in the Wattis and Third Seam overburden materials. Since approximately 5% of the floor materials are anticipated being removed from the mine as waste, this mean is disproportionally high. Accounting for this factor and mixing that will occur during the mining process, Plateau anticipates the overall sand content of the Hiawatha Seam as waste material will be closer to a weighted mean for all seams of approximately 48.9%. Comparison of this value with the mean sand content of the existing Refuse Material (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters) which has an average of 55.68%.

Two additional factors preclude, in Plateau's opinion, the likelihood of elevated sand levels in the Hiawatha Floor posing any potential problem. At the present time and during the remainder of the mining operations, the Hiawatha Seam will contain only approximately 11% of the reserves proposed for mining. However, when this material is mined, the likelihood of this material ending up as waste rock are extremely small. Examination of the lithologic descriptions of the overburden materials (Table 12, Overburden Lithologic Descriptions) show the Hiawatha Floor to be a discrete grey colored medium grained massive marine sandstone. Past experience has shown this material is very resistant to breakage during mining and due to it's massive state, can only be broken with considerable difficulty with the currently utilized mining equipment. Wear and tear on the equipment working this material is prohibitive and for these reasons, Plateau submits that these potentially high sand values in reality pose no potential problem with respect to potential toxicities.

Two samples from drill hole 86-18-1-C for the Wattis Seam possess boron values above the proposed suspect value of 5 mg/kg. A comparison of boron values by seam (Table 11, Seam Comparison of Selected Chemical and Physical Properties) reveal that overall, the boron values for these materials are well below proposed standards. Although the means of the Wattis and Third Seam overburden materials are significantly statistically higher than boron values in the Hiawatha seam, Plateau submits since approximately 52% of the life of mine coal will originate from the Wattis Seam, 37% from the third seam and only 11% from the Hiawatha Seam will be mined, these differences are entirely academic. From an operational standpoint, the mixing of the potentially toxic sample zones with the predominately inert zones will cause sufficient dilution to render the overall boron levels all within the "good" suitability class. The overall mean boron value from the overburden samples (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters) with these two elevated boron values is lower than corresponding values found in native soils in the permit area. Plateau believes these considerations effectively preclude the possibility of elevated boron levels in the overburden posing a likely revegetation problem.

In summary, Plateau believes since there is no basis to believe the overburden materials as a whole or by individual seams can be considered to be toxic or acid forming, and are in the majority of instances equal to or better in overall suitability than are the native soils, there is insufficient basis for the Division to require a more detailed breakdown of estimated waste rock materials than is presently presented in the existing permit application. If the Division has additional concerns relating to this need, Plateau would welcome documentation on this subject.

Division Concern:

The Division also recommends that the permittee develop and provide a plan for systematically deriving overburden/interburden/underburden quality and volume data as part of the operational phase of monitoring activities.

RESPONSE:

As explained in the response to the Division's previous request for volumetric calculations of waste rock materials, it is difficult for Plateau to understand the value or application of the level of detail requested by the Division with regard to waste rock volume data. It is Plateau's opinion, based on the available laboratory data, that the overburden materials in question cannot be considered by the Division's suitability criteria to be toxic or acid forming. The material is as good or better in suitability than the native topsoils in the permit area. Given the similarities of the two materials and since none of the Utah coal operations to our knowledge are required to routinely report waste rock volumes to the Division whenever new material is removed and stockpiled, Plateau sees no justification or regulatory basis for the information being requested and fails to understand exactly how this information will be utilized in the permitting process. Plateau therefore requests if the present response is not adequate, the Division provide documentation on how the information being requested relates to the determination of the reclamation suitability or protection of the environmental resources of the area.

With respect to the Division's request that Plateau provide a plan to characterize overburden quality as a routine part of the monitoring program, the detailed response and proposal for monitoring are presented in the response to the Divisions concerns in Section 817.48, Acid and Toxic-Forming Materials.

Division Concern:

(a)(2)(iii) The applicant must provide information about the clay content of the stratum immediately below the coal seam to be mined.

RESPONSE:

The laboratory data sheets presented in Appendix Table 1, Bookcliffs Laboratory Results, contain the clay content on all floor materials likely to be mined. A detailed evaluation of the suitability of the overburden floor materials is presented in the response to Division concerns over permit Section 783.14. Reference to this discussion and data summarized (Table 3, Statistical Mean Comparison by Reclamation Suitability Class and Table 6, Percentage of Clay Samples by Suitability Class) in the previous discussion document the clay content of the floor materials is statistically superior to the native soils with respect to reclamation suitability.

Division Concern:

UMC 784.19 - Underground Development Waste (PGL)

The applicant proposes three alternatives for the development waste. The disposition of the waste must be specified. A sampling program for determining the acidity or toxicity of this waste must be outlined (see 783.14). If the waste is acidic or toxic, provisions must be made for its disposal. How will it be segregated? Where will it be disposed? A waste development plan must be included in the PAP.

RESPONSE:

Plateau proposes to dispose of all underground development waste that cannot be stored in abandoned mine areas in the existing waste refuse pile. The laboratory analyses and evaluation of potential acid and toxic forming properties of all anticipated sources of underground development are presented in the response to the Division's concerns relative to permit Section 784.14. This detailed evaluation identified no potentially acid or toxic forming materials. This determination is based on the commonly used OSM guidelines that dragline mixing of the spoil will mask an inimicable zone containing 15 percent of the overburden volume and truck shovel mining will dilute an inimicable zone containing 20 percent of the overburden volume. Assumptions made in this analysis and comparison of the mixing phenomenon as evidenced by the existing refuse pile fail to demonstrate that any of the materials potentially present as underground development waste meet the criteria of either potentially acid or toxic forming materials. In this light, no provisions for selectively handling this material is necessary. As a result, Plateau believes no additional detail relative to a waste development plan are necessary. Plateau believes the existing waste development plan utilized by Plateau and approved by the Division and the proposed monitoring plan addressed in response to the Division's concerns relative to permit Section 817.48 adequately address these concerns.

Division Concern:

Page 783-132 of the MRP states sufficient evidence is available to quantify that the coal refuse material is not acid or toxic-forming as defined in UMC 700.5, and therefore does not need to have four feet of buffer material applied prior to topsoiling. Given the available data, the applicant requests that Division of Oil, Gas and Mining concur with this position. At this time it is premature for the Division to agree with this position.

Sampling locations of the coal refuse in Table 64 of the MRP need to be located on a map of the coal refuse, and explained if the samples are depth increments or individual surface samples across the refuse pile.

RESPONSE:

The locations of all refuse samples collected on the Plateau properties are depicted on revised permit Map 39, Disturbed Area Soils, Sheet 6.

Division Concern:

Although most parameters appear to be within acceptable limits, EC values are saline for samples WP2 middle, B-2, B-3, and VHA and samples 12058 and 12059 are above suspect concentrations for selenium. Procedures used to analyze refuse and soil parameters need to be submitted to determine if values are total concentrations or plant available concentrations.

RESPONSE:

Permit Table 64, Coal Refuse Analysis has been revised to document the analytical procedures used to obtain the reported values. Consultation with Standard Laboratories which analyzed refuse samples 12058 and 12059 have documented the Selenium and Arsenic values for these samples are in total concentrations, rather than plant available concentrations. A footnote to this effect has been added.

Plateau acknowledges the EC values for samples WP2 Middle, B-2, B-3 and VHA are greater than 4 mmhos/cm and using the criteria for agronomic soils would be classified as saline (Richards, 1969). However, as the reference by Richards (1969) states, this is the value at which "yields of very sensitive crops may be restricted". Examination of the rankings of various plants to salt tolerance presented in this reference graphically document that none of the salt sensitive crops are proposed for planting on the site, nor would the Division likely ever approve their usage. Of the species proposed in the reclamation seed mixtures, according to Richards (1969) all tolerate significantly higher salt levels than the agronomic saline soil level of 4.0 mmhos/cm. In describing the salt tolerance levels of native species Richards (1969) western wheatgrass is tolerant of salts upwards of 18 mmhos/cm and McKell (1978) reviewed the available salt tolerance data of native shrubs and reported big sagebrush was tolerant of electrical conductivities upwards of 28.1 mmhos/cm, rubber rabbitbrush at values of 103 mmhos/cm.

Comparison of native soils in the adjacent area substantiates the salt tolerance of native species referred to above. Permit Table 64, Coal Refuse Analysis suggests 27% of the electrical conductivity values of the coal refuse are considered saline, while permit Table 60, Lion Deck

Access Road Soil Samples document 33% of the samples collected along this road are classified as saline. Given the extensive regulatory background of how this road was constructed and the Division's extensive concerns about the need to salvage all available "saline" topsoil along this road, Plateau has a difficult time understanding why the Division has applied concerns over "saline" soils in such a way as to suggest they are of no problem relative to the stripping of topsoil, but might pose a problem with respect to demonstrating the refuse material is suitable as a plant growth medium. Plateau submits the Division's concerns over the potentially "saline" nature of the refuse pile material ignores the site specific salt levels of soils in this area and the inherent salt tolerance of the native species of the area.

Division Concern:

The test plots on the coal refuse were initiated to determine adequate topsoil depths. Results to date are promising, but are inconclusive for determining long term adequacy. After this study is completed and the refuse sample location and procedures used to analyze the refuse have been submitted, the Division should then have sufficient data to determine if the refuse is non-toxic and acid-forming.

RESPONSE:

Plateau finds no basis for the Division to suggest that the final reclamation plan for the refuse material can only be determined "after the study is completed...". The information submitted in the initial permit application and subsequent submittals fail to document that a potential problem or likelihood of failure prior to the bond release awaits the test plots as are seemingly suggested by the Division. It is Plateau's contention that the proposal seemingly suggested by the Division to make a formal determination on the reclamation suitability at the termination of the current test plot program is unsupported by the available scientific literature on long term reclamation success and existing regulatory requirements. Ample technical literature is available which suggests initial reclamation stand establishment is highly correlated with long term reclamation success. Furthermore, Plateau submits that such a "wait and see" attitude for determining the reclamation success of a given reclamation technique is potentially contrary to existing regulations. UMC 786.19 specifically requires "No permit or revision shall be approved unless the application affirmatively demonstrates and the Division finds in writing...that surface coal mining and reclamation activities as required by the Act, this chapter, and the regulatory program can be feasibly accomplished under the mining and reclamation activities plan contained in the application." Therefore, it is Plateau's intention to demonstrate, as previously proposed, that no justifiable reason exists for covering the refuse pile with 4 feet of cover as implied by the existing regulatory perception. This discussion will serve as the demonstration required by UMC 786.19 to document that reclamation of the refuse pile "can be feasibly accomplished" without the 4 foot cover requirement.

In order to facilitate this demonstration, the following review of the regulations is in order. The regulations of the Division contain the following pertinent definitions and requirements:

<u>Coal processing waste</u> means earth materials which may be combustible, physically unstable, or acid-forming or toxic-forming, and which are wasted or otherwise separated from product coal, and slurried or otherwise transported from coal preparation plants, after physical or chemical processing, cleaning, or concentrating of coal.

<u>Underground development waste</u> means waste rock mixtures of coal, shale, claystone, siltstone, sandstone, limestone, or related materials that are excavated, moved, and disposed of during development and preparation of areas incident to underground coal mining activities.

<u>Combustible material</u> means organic material that is capable of burning, either by fire or through oxidation, accompanied by the evolution of heat and a significant temperature rise.

<u>Acid-forming materials</u> means earth materials that contain sulfide minerals or other minerals which, if exposed to air, water, or weathering processes, form acids that may create acid drainage.

Acid drainage means water with a pH of less than 6.0 and in which total acidity exceeds total alkalinity, discharged from active, inactive or abandoned underground coal mining activities or from an area affected by underground coal mining activities.

Toxic-forming materials means earth materials or wastes which if acted upon by air, water, weathering, or microbiological process, are likely to produce chemical or physical conditions in soils or water that are detrimental to biota or uses of water.

UMC 817.85 - Coal Processing Waste Banks: Construction Requirements

(d) Following grading of the coal processing waste bank, the site shall be covered with a minimum of 4 feet of the best available non-toxic and noncombustible material, in accordance with UMC 817.22(e), and in a manner that does not impede flow from subdrainage systems. The coal processing waste bank shall be revegetated in accordance with UMC 817.111 - 817.117 will be met.

UMC 817.103 Backfilling And Grading: Covering Coal And Acid- And Toxic-Forming Materials

**(a) Cover.

**(1) A person who conducts underground coal mining activities shall insure that all debris, acid-forming materials, toxic materials, or materials constituting a fire hazard are treated or buried and compacted or otherwise disposed of in a manner designed to prevent contamination of ground or surface waters.

(2) If necessary, these materials shall be treated to neutralize toxicity, in order to prevent water pollution and sustained combustion and minimize adverse effects on plant growth and land uses.

(3) Where necessary to protect against upward migration of salts, exposure by erosion, to provide an adequate depth for plant growth, or to otherwise meet local conditions, the Division shall specify thicker amounts of cover using non-toxic material.

RESPONSE:

In order to properly evaluate the potential acid and toxic forming properties of the refuse material, Plateau completed an evaluation of the parameters of concern identified by the Division in response to permit Section 783.14. Each parameter identified as being of concern to the Division is discussed below. The evaluation of each parameter was completed using the methods utilized in the overburden evaluation presented in response to permit Section 783.14. Since the Division deemed the 17 refuse samples submitted in the original permit application as insufficient, Plateau collected another 30 samples of the Refuse in February and May of 1987. Some samples were randomly collected across the refuse pile with respect to age and depth of the refuse, but almost half of these 30 samples were collected form areas suspected as being potentially problematic. Therefore, the sampling program is biased in a deliberate attempt to isolate potential problems. This sample program was discussed with the Division in several meetings in February, 1987 in connection with the permit review process. An additional consideration was given in the sampling to attempt to characterize the refuse material with respect to age and depth.

pH

A total of 46 samples of refuse material were analyzed with respect to pH (Table 1, Percentage of pH Samples by Suitability Class) and 98% were found to have a "good" suitability. The overall numeric mean of these samples (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters) indicates the mean of both the refuse and overburden were significantly lower than the pH values of the native soils. The overall reclamation suitability of these materials (Table 3, Statistical Mean Comparison by Reclamation Suitability Class) demonstrates the overall suitability of the refuse material was significantly better than either the overburden or native soil.

Age of the refuse material had no definable effect on the pH values of the refuse material (Table 13, Comparison of Refuse Material by Age). There is a possible slight decrease in pH during the first three years of weathering, but evidence suggests (using the 3 and 6 year data collected from the adjacent sample points in the refuse test plots) that the pH values increase over time. Analysis of the data by age suggest no trends of acidification or deterioration in the reclamation suitability with respect to age. These pH values are particularly important since they suggest no evidence of acidification of the refuse material over the 18 year period in which wash plant refuse has been deposited. Regardless of the potential problems of acidification, these data suggest 100% of the samples collected cannot be considered to be potentially acid forming materials as measured by pH. In an often quoted report relative to refuse materials in Utah (White et. al., 1982) these authors concluded (based on an extremely small sample size) the pH values in several of the piles studies appeared to decrease as a function of time. They developed a r value of $r = 0.70$ with their rather limited database. A regression analysis of the relationship of refuse age and pH values from this data set yield a value of $r = .056$. This demonstration documents that with the Plateau refuse material, there is no relationship between increasing

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Sample depth within the refuse pile could not be correlated with changes in pH (Table 14, Refuse Material Chemical and Physical Characteristics by Depth). In summary, the pH values of the refuse pile provide no evidence of this material being acidic or toxic forming. In fact, the refuse material pH is statistically superior in reclamation suitability to the control native soil.

Electrical Conductivity (EC)

The overall electrical conductivity values in the refuse material were significantly higher than those of the native soil or overburden as a whole (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters). When compared to all of the soil and overburden samples, the overall suitability of this material was lower than that of the soil or overburden (Table 4, Percentage of Electrical Conductivity Samples by Suitability Class and Table 3, Statistical Comparison by Reclamation Suitability Class). However, this comparison is somewhat biased in its findings. Comparison of the electrical conductivity values with soils along the Lion Deck Portal Access Road as was discussed previously shows this refuse material to be no more adverse with respect to salt content than specific soil types within the permit area.

Electrical conductivities of the refuse samples appear to increase slightly between wet collected samples and dried samples (Table 13, Comparison of Refuse Material by Age). The electrical conductivity values of the wet refuse were lower, apparently due to the presence of the wash plant water. It appears the conductivity of samples increased as the material dried, probably as a result of the evaporation of the added water. No increase or decrease in electrical conductivity could be observed in the data once the materials had dried and through 18 years of weathering. These findings are different than those reported by Schafer et. al. (1979) who reported in new mine soils the soluble salts were rapidly leached from the uppermost portion of the soil profile. Plateau believes this trend is particularly important in substantiating that the rate of weathering of these materials is extremely slow. More will be discussed in connection with the weathering of these materials in connection with the discussion of acid base potential.

Examination of the refuse data with respect to depth (Table 14, Refuse Material Chemical and Physical Characteristics by Depth) show some evidence of salt enrichment in the 0-3" depth as compared to the deeper depths. This is common in undisturbed soils in the area as well. Statistical analysis of the 0-3" and 3-9" layers revealed no significant difference in overall electrical conductivity values.

The results from this analysis were compared to results reported by White et. al. (1982). They stated that older refuse had significantly higher electrical conductivity values than did newer refuse. Their conclusions based on 15 samples also suggested an increase in conductivity with depth. Analysis of the Plateau data based on a site specific data base three times larger than the regional database used by White et. al. (1982) contains no evidence to confirm their findings.

Saturation Percentage (SP)

The 46 saturation percentage values obtained from refuse material are all within the "good" suitability range proposed by the Division (Table 3, Statistical Comparison by Reclamation Suitability Class). Since all of the samples collected from the undisturbed soils and overburden are also rated "good" with respect to saturation percentage, there is little evidence to suggest any potential reclamation problem exists with respect to saturation percentage. Evaluation of the saturation percentage data by age and depth (Table 13, Comparison of Refuse Material by Age and Table 14, Refuse Material Characteristics by Depth) reveal no trends with respect to saturation percentage based on either of these two variables.

Texture

The overall average texture of the Plateau refuse material was found to be of higher suitability as a plant growth medium than the undisturbed soils in the permit area (Table 5, Percentage of Texture Samples by

Suitability Class; Table 2, Mean Comparison of Materials by Chemical and Physical Parameters; and Table 3, Statistical Comparison by Reclamation Suitability Class). Statistical analysis of this data suggest that with respect to texture, the refuse material is superior to either the native soils or overburden. Mixing and the corresponding dilution of the extremely sandy overburden samples probably explains this apparent difference between the refuse and overburden. Due to the mixing and apparent improvement in overall texture, Plateau believes that available documentation contains no evidence to suggest the refuse material texture will inhibit plant growth with respect to soil texture.

Clay content of the refuse material (Table 6, Percentage of Clay Samples by Suitability Class and Table 3, Statistical Comparison by Reclamation Suitability Class) is statistically superior to the native soils in the area. Sand content of the refuse material (Table 7, Percentage of Sand Samples by Suitability Class and Table 3, Statistical Comparison by Reclamation Suitability Class) also document the superiority of the refuse materials as compared to the native soils with respect to sand content.

Sodium Adsorption Ratio (SAR)

The same conclusions previously presented for electrical conductivity also apply to sodium adsorption ratios.

With respect to correlation of these data with the findings of White et. al. (1982). They reported higher SAR's were associated with new refuse as compared to old refuse. Examination of our data (Table 13, Comparison of Refuse Material by Age) suggests such a possible relationship, but no definite conclusions can be drawn.

Calcium content of refuse from this region was reported by White et. al. (1982) to increase with age and depth. Examination of the Plateau data (Table 13, Comparison of Refuse Material by Age) suggest that calcium content increases form fresh refuse, but appears to reach an equilibrium within a three year period, then remains relatively constant.

Magnesium content of the refuse in this region was reported by White et. al. (1982) to be higher in new refuse as compared to the old refuse. Their data also suggest that magnesium content tends to increase with depth. The Plateau data with respect to age show similar, but more dramatic increases in magnesium content in connection with age than those suggested by White (Table 13, Comparison of Refuse Materials by Age). Depth appeared to have no effect on the magnesium content of Plateau's Refuse (Table 14, Refuse Material Characteristics by Depth).

Sodium content of refuse was reported by White et. al. (1982) to be highest in new material and to be relatively unaffected by depth. Examination of the Plateau data (Table 13, Comparison of Refuse Material by Age and Table 14, Refuse Material Characteristics by Depth) do not confirm the generalizations report for this region.

<u>Selenium</u>

A total of 34 samples were analyzed to characterize the selenium content of the refuse material. Five of these samples were found to have values exceeding 0.10 mg/kg (Table 8, Percentage of Selenium Samples by Suitability Class). The overall average selenium content and suitability of the refuse was found to be midway between the soil and overburden materials (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters; and Table 3, Statistical Comparison by Reclamation Suitability Class).

There is the potential for elevated selenium values to exceed the recommended standard, however, examination of the existing data tend to alleviate that possibility. Examination of the field notes taken at the time these samples were collected suggest that operationally, this problem can be readily resolved. When the data are separated based on random samples versus samples collected in potentially problematic areas, the data become considerably more understandable. Previous mention of the selective nature of the sampling was mentioned. This selective sampling was initiated in order to find potentially problematic areas.

Of the 34 selenium samples taken, 19 can be considered as random and 15 were selectively located. The 19 random samples correspond to refuse holes 87-R-1, 87-R-2, 87-R-3, 87-R-4, 87-R-5 and the values in Table 64, Coal Refuse Analysis. Examination of these randomly located samples reveal only one of the 19 samples exceeded the recommended standard (hole 87-4-2, 0-3"). The 15 selectively placed holes correspond to refuse holes 87-R-6, 87-R-7, 87-R-8 and 87-R-9. The samples were specifically placed in areas having a noticeable presence of white colored crusted salt patches at the surface. Four of the five excursions to the recommended standard were associated with these areas. Of these four excursions, (corresponding to refuse holes 87-R-6, 87-R-7, 87-R-8, and 87-R-9) all were located in the 0-3" depth zone. Sample site 87-R-9 is located in the nontopsoiled portion of the refuse test plots being evaluated by Plateau as part of previous Division permitting stipulations. The vegetation growing at this sample site exhibit no adverse physiological responses and do not appear to be adversely affected by the elevated selnium levels. Age did not seem to correlate with selenium content of the refuse (Table 13, Comparison of Refuse Material by Age) once the surface zone was taken into consideration.

Depth of the refuse material (Table 14, Refuse Material Characteristics by Depth) confirmed the observations made above. Fortunately, the potential selenium problem is easily recognized in the field and treatable. Recognizing this potential problem exists, Plateau proposes to mix or cover all exposed coal refuse having evaluated selenium values prior to final reclamation. The specifics of this plan will be based upon the sampling program implemented immediately prior to topsoiling of the refuse material. The presentation of this monitoring plan will be given later in this discussion. Plateau believes since this problem is so localized, it can be readily treated as required by existing regulations.

According to the recent review of this parameter (Fisher et. al., 1987), "the analysis of soil Se provides a poor index of potential toxicity". These records state that "generalizations about toxic soils must be made with caution" due to the complex nature of individual plant species response and weathering potential as it might affect ground water. This paper suggested soil analysis alone is one of the poorest methods available to delineate potential selenium toxicities. They suggest the best currently available technique is plant tissue analysis. Due to the relative poor set of environmental conditions present at this site, relative tolerance of the native plant species present the results of this analytical technique probably exaggerate the potential problem.

Boron

All of the 43 refuse samples analyzed tested below the Division's proposed standard of 5.0 ppm for boron (Table 9, Percentage of Boron Samples by Suitability Class). Statistical analysis of the boron values reveals the boron content and boron suitability of the refuse material is as good as the undisturbed soils in the adjacent area (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters; and Table 3, Statistical Analysis by Reclamation Suitability Class). Plateau believes this evaluation demonstrates no potential problem with respect to boron toxicity exists with respect to the refuse material as a potential plant growth medium. The results from the report by White et. al. (1982) were compared to the results obtained from the Plateau refuse evaluated. The boron technique used in their report appears to have been a total boron analysis. In the report by White, it is reported (based on 5 samples) that boron content increases with age and depth. The Plateau data confirm no such relationship.

Acid Base Potential (ABP)

The evaluation of the potential acid forming properties of overburden, waste and refuse materials are mandated by existing regulations. The Division has proposed to utilize the acid base account procedure developed in West Virginia (Sobek et. al., 1978). This procedure has had wide application in the eastern coal fields, but has proven highly controversial in the west. According to Sobek et. al. (1978) "This method measures the total sulfur in a sample. If all of the total sulfur occurs in pyritic forms, the calculations of maximum potential acidity from sulfur corresponds with actual potential acidity from sulfur, but if part of the sulfur occurs in other forms, the maximum as calculated will be too high." Using this methodology, Sobek suggests in certain instances some forms of sulfur (particular sulfate sulfur) should be raised out prior to determination of the acid potential of the material. Many factors and assumptions are used in connection with this technique. Smith and Sobek (1978) summarize the variables influencing this technique and the prediction of oxidization of pyritic sulfur. These variables include: reactive surface area, ferric iron, partial pressure of oxygen, forms of pyritic sulfur, catalytic agents, pH and biologic organisms. A recent evaluation of overburden testing in the western states (OTA, 1986) suggests the acid base potential test is generally used only in Wyoming although the state regulatory agencies in Colorado, Montana and New Mexico sometimes require this information. The OTA (1986) report is highly critical of utilizing this test in the west due to the complexity of the factors involved. They report that: (1) the relative lack of water; (2) the high percentage or organic sulfur forms; and (3) the typically high buffering capacity of the western overburden limits the potential of acid formation. They are also concerned in the west "where exposure to oxidizing agents is limited, the assumption that all sulfur forms will be oxidized completely is not valid." This report furthermore states that many western coal operators where "overburden material is being erroneously classified as unsuitable and that as a result, they are required to special handle the material needlessly."

Regarding this concern, it must be pointed out that extensive literature is available to document the unnecessary economic burden that has been placed on the coal industry to address perceived acid forming overburden materials. In 1983, in a conference organized by OSM, Andy Sobek the author of the original formula, was asked the following question: "I have a question here, that involves Andy as well, and his research, with this acid-base potential. Andy, with your experience back East and what we see or maybe what you've experienced out west in coal mining, do you feel that the formula that you and Dr. Smith evaluated for acid-base potential is effective in the western states assuming that the pyrite proportion of our sulfur out here is minimal compared to the organic form?" In responding, Sobek effectively dodged the question by stating two important considerations. Eastern rainfall of 26-66 inches per year and differences in overburden mineralogy which produced a situation where "you have shades of gray all of the way through it...".

When asked about the origin of the conversion factor of 31.24, Sobek replied: "The 31.24 is taken from the stoichiometric equation of assuming that all sulfur is pyritic and will oxidize 100%. Now, if you're in an area where you have sulfate build up, you must take this into consideration, whether you want to continue to do it." When asked about his feelings of including organic sulfur in the acid potential calculation, Sobek replied, "I don't want to get behind you on this, but I've talked to Dr. Smith and he suggests that right now the equation for Wyoming is not valid. We should not use either sulfates or organic sulfur as part of the equation, and use only pyritic sulfur," emphasis added. It is interesting to note that since this time, Wyoming and Colorado have revised their formulas to exclude sulfate sulfur from their acid base potential calculations. Texas, which has long had an extensive research program on acid forming mine spoil, bases their calculation totally on pyritic sulfur.

Doug Dollhopf at Montana State University has also done extensive research on acid forming spoils in the Northern Great Plains. Dollhopf and Russell (1984) reported that "overestimation of the total sulfur content results in much overburden being falsely categorized as acid producing. The phenomenon can be attributed to the presence of organic matter in the samples." Based upon another report (Harvey and Dollhopf, 1985) they concluded that the acid base accounting method was not entirely valid in terms of assessing long term acid production because the simple balance of acid and base potential was incorrect. Additional problems with inclusion of organic sulfur as a component were also considered questionable. Based upon a more realistic weathering scheme, these authors reported the acid base account calculations over estimated the acid production by a factor of 4.2 fold as compared to a Manual Laboratory Weathering Method and 3.8 as compared to the Computerized Automated Rapid Weathering Apparatus Method. The discrepancies in results were attributed to measure of the nonreactive (i.e. massive pyrite and organic) sulfur compounds. Examination of sulfur, fraction and acid production suggested organic sulfur accounted for only 1% of the measurable acid produced.

Discrepancies between the acidity of drainage originating from two strip mined areas of Pennsylvania having equal levels of pyrite were reported by Caruccio and Geidel (1978). Although pyrite content was similar, one mine produced acid mine drainage while the other produced nonacid drainage. Pyrite morphology of the two areas was determined to explain the difference in drainage quality. The nonacid producing area contained a massive pyrite, while the acid producing area was dominated by small frambiodal pyrite crystals. The authors recommended acid producing potential be based on the percentages of frambiodal pyrite present in the samples and not total pyrite content to more realistically estimate potentially acid producing materials.

Working on Texas lignite, Arora et. al. (1981) reported organic sulfur "has been shown to remain essentially unaltered throughout artificial oxidation studies in coal." They reported a rapid build up in sulfates in usually associated to the oxidation of pyrite materials.

Summarizing an extensive study on the acid mine spoil of the Dave Johnson Mine in Wyoming, Harvey and Dollhopf (1986) sampled various ages of acid forming spoil, ranging in age of weathering of one week, three years, 12 years and 18 years old. The relative percent pyrite sulfur was calculated to be 22.6%, 15.6%, 13.2% and 7.4%, respectively. The relative percent sulfate sulfur was calculated to be 38.3%, 49.8%, 57.1% and 66.0%, respectively. The relative percent organic sulfur was calculated to be 39.1%, 35.2%, 29.8% and 26.1%, respectively. These data are typical of acid forming spoil in that pyrite content decreases with oxidation resulting in a progressive increase in sulfate sulfur.

Recently, Sobek and Bogner (1985) summarized the merits of the Acid-Base Account technique. They reported: "The total, or pyritic sulfur content accurately quantifies the potential acidity of materials when all sulfur is present as a pyritic material. The presence of gypsum crystals in a sample of highly weathered overburden indicates that part of the total sulfur is non acid-forming. Samples high in organic carbon usually contain organic sulfur. Therefore, the maximum potential acidity as calculated will be too high when these nonacid-forming forms of sulfur are present. This is the reason that such calculations are referred to as maximums." They also stated, "where sulfur in overburden is present exclusively as pyrite, the total sulfur content accurately quantifies the acid-producing potential. Removal of sulfates and organic sulfur naturally present in some overburden or resulting from weathering of pyritic materials allows increased accuracy in predicting the acid-producing potential of materials containing mixed sulfur species," emphasis added. This paper is also valuable because the authors suggest acid base potential values be evaluated in connection with mine discharge waters to correlate the results of the acid-base potential test.

Examination of the Plateau refuse material with respect to the acid base account technique recommended by the Division is presented on Table 10, Percentage of Acid Base Potential Values by Suitability Class. This table along with Table 2, Mean Comparison of Materials by Chemical and Physical Parameters and Table 3, Statistical Comparison by Reclamation Suitability Class, suggest the refuse material is acid forming. Unfortunately, the pH measurements (Table 1, Percentage of pH Samples by Suitability Class, Table 2, Mean Comparison of Materials by Chemical and Physical Parameters), and long term surface water monitoring fail to support the potential acid forming properties of the refuse material.

Plateau's consultant discussed these data with Doctors Doug Dollhopf and Lloyd Hosner, two recognized authorities in the area of acid base potential. They recommended that values less than -5 tons $CaCO_3$ per 1,000 tons be sampled to determine sulfur species. This analysis was completed and the findings were quite amazing. For example, the sulfate sulfur content of some overburden samples was found to approach 80% of the relative sulfur (Appendix Table 1, Bookcliffs Laboratory Results). According to this evaluation and upon recalculating the acid base potential values based upon pyritic sulfur according to the recommendations given to Plateau's consultant, the 24 original excursions of the Division's Standard was reduced to 3. Only one of these samples was refuse material.

It was also suggested to Plateau's consultant that the sulfur species be evaluated to determine whether or not there was any evidence of acidification occurring. Accordingly, sulfur species were evaluated to determine whether there was any evidence of pyrite oxidation and sulfate accumulation, indicative of acidification. An evaluation of the data in this form (Table 15, Relative Percent Sulfur Forms of Refuse Material by Age) reveal no evidence of sulfur oxidation or acid forming conditions. The previous discussion of electrical conductivities confirmed that no definate evidence of salt leaching has occurred and the evaluation of the sulfur data in this same manner provides no evidence of the breakdown and weathering of the sulfur present in the refuse material.

This data was further evaluated with respect to the documented inverse correlation between pH and sulfate (Arora et. al., 1981 and Harvey and Dollhopf, 1986). It has long been recognized that a corresponding decrease in pH was associated with sulfate buildup under conditions of acidification. The data of Arora et. al. (1981) show an R^2 of 0.95 between these two variables, suggesting that 95% of the sulfate could be accounted for by pH. Harvey and Dollhopf (1986) presented data suggesting that 84% of the variability of the sulfates in the soil could be explained on the basis of pH. The Plateau data on sulfate sulfur was therefore correlated with soil pH to determine whether any correlation existed between sulfate sulfur and soil pH as previously suggested. The correlation analysis indicated 6.1% of the sulfate sulfur and 0.08% of the percent relative sulfate sulfur could be accounted for by soil pH. It is Plateau's opinion that the theoretical possibility exists for this material to be acid forming, but environmental conditions and the apparent presence of pyrite being in the massive form appear to preclude such a possibility. Harvey and Dollhopf (1986) reported that based upon their research at the Dave Johnson Mine in Wyoming, the majority of acidity was produced three years after regrading. The pH values of fresh spoil were reported to average 5.5 and after three years of weathering, the pH value was found to average 3.3. At the Kemmerer, Wyoming study sites, researchers at the University of Wyoming early on recognized the acidic forming properties of western mine spoil (May et. al. 1971 and Jacoby, 1969). Precipitation at this site averaged 9.4 inches and spoil banks 3 years old were reported to have pH values as low as 4.1 with some pH values found to be as low as 2.2. These pH values were found on spoil aged 3 years and 15 years respectively. Previous research conducted at Magna, Utah documented that oxidation of pyrites is copper tailings occurred at a relatively fast rate. pH values measured in June 1971 of 7.0 had dropped to 3.0 by September of the same year (Nielson and Peterson, 1972). Acidification of certain tailing ponds reduce the pH to values as low as 1.5. Working in southern Idaho, Richardson and Farmer (1981) reported that reclaimed mine spoils began to reacidify two years following treatment. Plateau is submitting this discussion to substantiate acid production in the arid west proceeds very quickly provided conditions of acid formation are present. Plateau submits since no definable trends exist with respect to changes in pH values over the 18 year period for which refuse has been piled and in light of the available western data, there is little possibility that this material will ever become acid-forming.

Another important factor to be considered with respect to be reclamation suitability of the refuse material is the potential buffering capacity of the topsoil to be respread onto this material. Since essentially all the topsoil has been stockpiled and mixed in the removal and dumping process, the average acid base potential value of this material needs to be considered with respect to the potential acidification of the refuse material which will be covered by the respread topsoil. Using the acid base potential the probability of acidification of the respread topsoil can be calculated. In order to present a worst situation, the lowest refuse material acid base potential value obtained on the basis of total sulfur will be used. Thus, our acid base potential values will be -36 tons $CaCO_3$ per 1,000 tons (acre 6 inch slice) for the refuse material (Appendix Table 1, Bookcliffs Laboratory Results) and the average acid base potential value of 151 tons $CaCO_3$ per 1,000 tons (acre 6 inch slice); Table 2, Mean Comparison of Materials by Chemical and Physical Parameters). The existing reclamation plan commits Plateau to cover the refuse with approximately 17 inches of respread topsoil. This means the reapplication of this thickness of topsoil would be the equivalent of applying 428 tons of $CaCO_3$ per acre. This lime equivalent would correspondingly neutralize the potential acidity in the top 5.9 feet of the refuse material.

However, assuming this assumption should short circuit, Plateau would like to point out that during the excavation of refuse hole 87-R-9, located inside the nontopsoiled refuse test plots, abundant healthy roots from the respread vegetation were observed growing to a depth of 30 inches. Coincidentally, this is the very hole containing a -36 tons $CaCO_3$ per 1,000 tons acid base potential. Plateau submits that this piece of documentation showing apparently health plants growing into a material determined by a dubious laboratory test to be potentially acid and toxic forming, sheds great doubt on the reliability of predicting plant growth response based upon such a questionable test. It is all too obvious that the test is measuring something that the plants haven't yet discovered.

According to the definition of acid and toxic forming materials contained in UMC Section 700.5, the regulatory basis in delineating these materials is that when "acted upon by air, water, weathering, or microbiological processes" may create chemical or physical conditions "that are detrimental to biota or uses of water," or which may "create acid drainage". Plateau respectfully submits the negative response of 18 years of the refuse being "acted upon by air, water, weathering, or microbiological processes" and 5 years of acceptable plant growth in this material are significantly more reliable in predicting the potential acidity or toxic forming properties of the refuse than are application of a test considered by its authors (Sobek, 1983) to not be applicable to the western applications proposed by the Division. Since the acid base potential test creates a scenario totally different than one stipulated by UMC 700.5 regarding definition of acid and toxic materials, Plateau suggests the Division discard or significantly modify how this perceived panacea is applied in determining the acid or toxic forming properties of overburden, waste and refuse materials.

The potential of acid mine drain originating from the refuse material theoretically exists, but in actuality, will be almost impossible to ever occur. The low rainfall, high evaporation demands, small size of the refuse pile in relationship to the water sheds and overall alkalinity of the natural runoff and native soils in the immediate area render such an event extremely unlikely. Using the drainage on the southern edge of the refuse pile which is a much smaller water shed and receives proportionally more runoff from the refuse pile than the drainage from the refuse pile going to the north, it can be determined using the data from this drainage that total alkalinity exceeds that of acidity by a factor of 88 times. Therefore, the proportional amount of water discharging from the refuse pile would have to be increased with respect to the watershed as whole by a factor of at least 88 times, while the runoff from the undisturbed area remained constant to create conditions suitable for acid mine drainage. The potential of such an occurrence is essentially impossible. However, even if such an event did occur, such acid mine drainage would immediately be exposed to shale outcrops upon which the refuse pile site would almost instantly neutralize the acid mine drainage. The exposed shale has pH values often averaging between 8.0 and 8.5 and contains a tremendous buffering capacity with respect to the unlikely event of any acid mine drainage.

Another extremely important consideration with respect to the potential for acid production on the refuse materials deals with the known direction of technology as it relates to coal mining. Out of sheer necessity, it can be assumed the technological advances in mining which increases mining efficiencies and correspondingly lowers operation costs will occur if the industry or Plateau mine is to remain competitive. To the extent that these technological advances add to the probability of enhancing long term reclamation success, they should be addressed. The obvious cause of the potential acidity in the refuse material originates with the amount of coal contained in the refuse material. Examination of the overburden geochemical analyses (Appendix Table 1, Bookcliffs Laboratory Results; Table 2, Mean Comparison of Materials by Chemical and Physical comparison; and permit Table 3, Selected Components of Seam, Roof and Floor Compositions) suggests the waste coal mixed into the refuse is the predominant source of potentially acid forming sulfur in the refuse material.

Using the Wattis Seam and overburden as an example, (since this is the largest database available and represents the majority of coal to be mined) the average percent total sulfur of the roof averages 0.163 percent, the floor 0.445 percent and 0.738 percent for the coal seam. The coal seam mean is significantly different from the roof and floor materials at alpha equals 0.05 level. The roof and floor values are significantly different at the 0.10 level. Since the average percent total sulfur of the refuse averages 0.851 percent (Table 2, Mean Comparison of Materials by Chemical and Physical Parameters) is significantly higher than either the roof or floor overburden materials and is closer to the coal seam value, it is logical to assume any operational improvement that would reduce the amount of refuse coal going into the pile would accordingly reduce the amount of sulfur and potential acidity of the refuse material as well.

Aware that the refuse coal is a valuable unused resource, Plateau has initiated an extensive engineering study to determine how this current waste coal material can be recovered. The detailed engineering studies on the wash plant upgrade are scheduled for 1988, with design and construction scheduled to commence immediately thereafter. The upgraded wash plant is scheduled to be operational in 1989. Using conservative estimates, this upgrading of the wash plant will reduce the amount of refuse coal by at least half. Plateau submits this documentation to demonstrate the current refuse material geochemical data in actuality represents more of a "worst case" scenario, than those that will likely be encountered during the remaining life of this mine.

Another important aspect that must be considered in evaluating the potential geochemical characteristics of the refuse pile at the time of reclamation are the properties that will be used to cap the pile prior to topsoiling. Current mine planning suggests that the last reserves to be mined at the time of mine closure will be from the Third Seam. Specifically, the reserves anticipated to be mined immediately prior to mine closure are those reserves in the immediate vicinity of drill holes 86-103 and 86-107. Examination of the geochemical data for the Third Seam for these two holes reveals no potential problems in regards to either acid base potential or selenium. These materials average 37 tons $CaCO_3$ per 1,000 tons and 0.037 mg/kg, respectively. Since this material will be utilized to cap the top of the refuse pile, which represents the largest portion of the refuse pile, Plateau submits that the potential occurrence of adverse revegetation or hydrologic conditions for the refuse pile are further minimized.

Division Concern:

A plan needs to be submitted which identifies how mine development waste rock will be disposed of in the refuse pile if shown to be toxic as required by UMC 784.14(a)(1)(iii). The plan must propose how the material will be disposed of so it will not be detrimental for vegetation or may adversely affect water quality if not treated or buried.

RESPONSE:

The previous detailed discussion documents the mine development waste rock cannot be considered to be toxic or acid forming as defined by the Division's Guidelines and regulations. Since this evaluation suggests this material is as good, if not better material, than stockpiled topsoil. No additional discussion of special handling considerations of the mine development waste rock is necessary. All available technical literature suggests this material will not adversely affect plant or animal life or water quality.

Division Concern:

UMC 817.71 - .72 - Disposal of Underground Development Waste and Excess Spoil and Non-Acid and Non-Toxic Forming Coal Processing (PGL)

The applicant must incorporate in the narrative the commitments of the operation, maintenance and monitoring of the refuse piles (one of the alternatives for the development waste disposal). There were recommendations by consultants, but commitments are needed by the applicant in the narrative of the PAP. The inspections must be made at least quarterly (817.71 [i]). The material must be demonstrated to be non-toxic and nonacid forming and demonstrated to be consistent with the design stability of the fill (817.71 [j][1]).

RESPONSE:

Plateau previously addressed maintenance and monitoring in responses to DOGM comments on UMC 8784.11(b)(4). The response can be found in the the permit renewal Initial Completeness Review, page 5. This response demonstrates the underground development and coal processing wastes are, using the Division's regulations and guidelines, non-toxic and non-acid forming materials. It is Plateau's opinion that these materials pose no potential problems to either plant or animal life or water quality. Furthermore, Plateau believes the Division's proposed suitability guidelines with respect to acid base potential are technological flawed, contrary to the definitions of acid-forming and toxic forming materials as defined in UMC 700.5, and impossible to support using existing scientific literature. Plateau strongly recommends that the Division proposes standards which at a minimum, produce results consistent with the requirements of UMC 700.5 and are supported by the scientific community, especially the scientists who authored the methods being proposed by the Division.

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TABLE 1
PERCENTAGE OF pH SAMPLES BY SUITABILITY CLASS

MATERIAL	N	GOOD	FAIR	POOR	UNACCEPTABLE
Overburden	36	69	25	3	3
Soil	84	38	50	12	-
Refuse	46	98	2	-	-

TABLE 2
MEAN COMPARISON OF MATERIALS BY CHEMICAL AND PHYSICAL PARAMETERS

PARAMETER	UNITS	OVERBURDEN	SOIL	REFUSE
pH	units	7.30a[1]	7.82b	7.11a
EC	mmhos	1.47a	1.16a	3.64b
SP	%	41.23b	37.62a	56.32c
Ca	meq/l	9.20a	218.58c	27.49b
Mg	meq/l	9.75a	28.56b	25.85b
Na	meq/l	0.94a	3.79b	2.67b
SAR	units	0.36a	0.71b	0.61b
B	mg/kg	1.24a	1.73a	2.14a
Se	mg/kg	.075c	.002a	.005b
$CaCO_3$	%	8.59b	12.66c	2.18a
Total S	%	0.30b	0.11a	0.85c
ABP	tons	77.37b	150.90c	-4.10a
Sand	%	49.40b	42.66a	55.68c
Silt	%	41.30c	34.01b	30.35a
Clay	%	9.25a	23.37c	13.97b

[1]Means within a row followed by a different level are significantly different at the 0.05 level.

TABLE 3

STATISTICAL COMPARISON BY RECLAMATION SUITABILITY CLASS*

PARAMETER	UNITS	MATERIAL		
		OVERBURDEN	SOIL	REFUSE
pH	units	1.38b	1.73c	1.02a
EC	mmhos	1.02a	1.04a	1.27b
SP	%	1.00a	1.00a	1.00a
Texture	classes	1.20b	1.31c	1.03a
Clay	%	1.00a	1.17b	1.00a
Sand	%	1.43b	1.06a	1.08a
SAR	units	1.00a	1.00a	1.00a
Selenium	mg/kg	1.86c	1.00a	1.44b
Boron	mg/kg	1.16b	1.00a	1.00a
Acid Base Potential	tons	1.17b	1.00a	1.17b
Average	---	1.22a	1.13a	1.10a

*Individual parameter suitability classes were based on all observations within that parameter being assigned a numeric rating of 1, 2, 3, 4 based upon the Division's Suitability Guidelines of good, fair, poor and unsuitable, respectively. The overall average suitability was calculated based on the calculated suitability values of each parameter within a plant growth medium.

TABLE 4

PERCENTAGE OF ELECTRICAL CONDUCTIVITY SAMPLES BY SUITABILITY CLASS

MATERIAL	N	GOOD	FAIR	POOR	UNACCEPTABLE
Overburden	36	97	3	-	-
Soil	81	96	4	-	-
Refuse	44	77	18	5	-

TABLE 5

PERCENTAGE OF TEXTURE SAMPLES BY SUITABILITY CLASS

MATERIAL	N	GOOD	FAIR	POOR	UNSUITABLE
Overburden	35	89	3	8	-
Soil	55	76	16	8	-
Refuse	37	97	3	-	-

TABLE 6

PERCENTAGE OF CLAY SAMPLES BY SUITABILITY CLASS

MATERIAL	N	GOOD	UNSUITABLE
Overburden	35	100	-
Soil	51	94	6
Refuse	37	100	-

TABLE 7

PERCENTAGE OF SAND SAMPLES BY SUITABILITY CLASS

MATERIAL	N	GOOD	UNSUITABLE
Overburden	35	86	14
Soil	51	98	2
Refuse	37	97	3

TABLE 8

PERCENTAGE OF SELENIUM SAMPLES BY SUITABILITY CLASS

MATERIAL	N	GOOD	UNSUITABLE
Overburden	35	71	29
Soil	10	100	-
Refuse	34	85	15

TABLE 9

PERCENTAGE OF BORON SAMPLES BY SUITABILITY CLASS

PARAMETER	N	GOOD	UNSUITABLE
Overburden	36	94	6
Soil	12	100	-
Refuse	43	100	-

TABLE 10

PERCENTAGE OF ACID BASE POTENTIAL SAMPLES BY SUITABILITY CLASS

PARAMETER	N	GOOD	UNSUITABLE
Overburden	35	91	9*
Overburden	35	94	6**
Soil	10	100	-
Refuse	35	40	60*
Refuse	35	94	6**

*Based on total sulfur.

**Based on total sulfur for all values >-5 and pyritic sulfur for all values >-5.

TABLE 11

SEAM COMPARISON OF SELECTED OVERBURDEN CHEMICAL AND PHYSICAL PROPERTIES

PARAMETER	UNITS	WATTIS	THIRD	HIAWATHA
Se	mg/kg	.087a	.069a	.069a
Sand	%	45.5a	46.1a	64.8b
ABP	tons	70.4a	78.0a	44.2a
B	mg/kg	2.1b	1.0b	0.4a

TABLE 12
OVERBURDEN LITHOLOGIC DESCRIPTIONS

SAMPLE	LITHOLOGIC DESCRIPTION
86-18-1-C, Wattis Roof (1072-1074.1')	Grey sandstone with interbedded mudstone
86-18-1-C, Wattis Floor (1083.0-1084.7')	Grey massive sandstone
86-18-1-C, Third Floor (1128.6-1130.1')	Black carbonaceous mudstone
86-18-2-C, Third Roof (1137.9-1139.8')	Grey massive sandstone
86-18-2-C, Third Floor (1144.0-1145.9')	Black carbonaceous mudstone
CVR-1-C, Wattis Roof (1576.0-1578.0)	Dark grey carbonaceous mudstone
CVR-1-C, Wattis Floor (1588.0-1590.0)	Dark grey sandstone with interbedded mudstone
84-23-1-C, Wattis Roof (1801.0-1802.6)	Massive sandstone
84-23-1-C, Wattis Floor (1812.5-1814.2')	Dark grey claystone
83-14-3-C, Tunnel Zone (1348.7-1350.5')	Massive sandstone
83-14-3-C, Tunnel Zone (1350.5-1352.3')	Massive sandstone
83-14-3-C, Tunnel Zone (1354.1-1355.9')	Massive sandstone
W-4-C, Hiaw Floor (1259.8-1261')	Grey massive sandstone
W-8-C, Wattis Roof (1611.75-1612.35')	Dark grey shaley claystone
W-20-C, Hiaw Floor (1505.5-1506')	Grey massive sandstone
82-55-TU-C, Third Roof (0-2')	Fine grained sandstone with interbedded mudstone
82-55-TD-C, Third Floor (0-2')	Fine grained silty sandstone
85-103-TU-C, Third Roof (0-2')	Fine grained sandstone, mottled and bioturbated
85-103-TU-C, Wattis Floor (32-33.6')	Fine grained sandstone with interbedded mudstone
85-103-TU-C, Wattis Split (Boney) (36.5-38.5')	Coaly fine grained sandstone
85-103-TU-C, Wattis Roof (46.2-48.2')	Siltstone with interbedded fine grained sandstone
86-107-TU-C, Third Roof (0-2')	Massive medium grained sandstone

TABLE 12
CONTINUED

SAMPLE	LITHOLOGIC DESCRIPTION
86-107-TU-C, Wattis Floor (78-79.7')	Dark grey silty mudstone
86-119-WD-C, Wattis Floor (0-1')	Light grey mudstone
86-119-WD-C, Wattis Roof (0-2')	Dark grey silty mudstone
86-119-WD-C, Third Roof (55-56')	Light grey fine sandstone
86-119-WD-C, Third Floor (66-67')	Light grey fine sandstone
86-119-WD-C, Hiaw Roof (115-116.4')	Dull white fine grained sandstone
86-119-WD-C, Hiaw Floor (123-124.2')	Massive medium grained sandstone
86-129-WD-C, Wattis Floor (0-1.5')	Dark grey mudstone
86-129-WD-C, Wattis Roof (0-2')	Clean light grey fine grained sandstone
86-129-WD-C, Third Roof (61-62.2')	Sandstone
86-129-WD-C, Third Floor (83-84')	Sandstone, silty
86-129-WD-C, Hiaw Roof (107.5-108.4')	Mudstone, carbonaceous, rich
86-129-WD-C, Hiaw Floor (114.3-116')	Sandstone, clean

TABLE 13

COMPARISON OF REFUSE MATERIALS BY AGE

AGE	pH	EC	SP	Ca (meq/l)	Mg (meq/l)	Na (meq/l)
0	7.25	1.42	60.5	10.3	5.1	0.7
3	6.68	3.20	45.3	31.4	20.0	2.0
5	7.06	3.31	59.0	19.9	19.9	1.5
6	6.85	3.95	67.0	29.4	40.2	1.5
7	7.17	4.47	62.5	23.5	45.3	0.3
8	7.03	3.34	65.0	28.2	22.8	3.9
12	7.12	3.54	53.7	28.9	22.0	2.0
18	7.03	3.46	52.3	29.0	18.4	3.7

AGE	SAR	mg/kg B	mg/kg Se	% $CaCO_3$	% TS	Tons TS ABP	Tons Pyrite ABP	% SAND	% SILT	% CLAY
0	0.3	0.8	.043	3.1	0.8	5.3	19.5	56	35	9
3	0.4	0.9	<.005	3.4	0.8	7.3	-	-	-	-
5	0.3	3.3	.057	1.0	0.9	-16.6	0.8	58	31	11
6	0.3	4.1	.108	0.8	1.1	-26.5	-2.3	51	36	13
7	0.2	3.6	.080	1.3	0.9	-17.8	1.5	59	31	10
8	0.8	1.5	.017	2.7	0.9	-2.0	2.0	44	38	18
12	0.4	2.6	.058	1.8	0.7	-3.8	5.7	55	31	14
18	0.8	1.4	.019	3.0	0.8	6.0	12.0	55	30	15

TABLE 14
REFUSE MATERIAL CHARACTERISTICS BY DEPTH

DEPTH	units pH	mmhos EC	% SP	meq/l Ca	meq/l Mg	meq/l Na
*surface	7.18	3.87	47.4	37.8	16.3	6.55
0-3"	7.06	4.36	59.7	19.7	48.9	1.45
3-9"	6.88	3.51	58.8	24.5	28.9	1.43
1'	7.17	3.48	54.7	29.4	20.4	2.65
9-18"	7.00	3.18	62.0	28.9	21.5	1.04
18-48"	7.23	3.19	62.8	28.7	18.9	1.81
36-60"	7.50	2.70	65.5	24.3	13.4	2.15
7'	6.80	3.33	52.0	27.4	19.1	2.78
12'	7.10	3.42	59.5	28.8	21.9	3.85
15'	7.10	3.25	58.0	27.6	17.7	4.51
20'	7.10	3.16	59.5	29.9	15.3	2.33

DEPTH	units SAR	mg/kg B	mg/kg Se	% $CaCO_3$	% TS	TS Tons ABP	% SAND	% SILT	% CLAY
*surf.	1.45	0.9	.004	2.99	.89	1.02	58.4	24.4	17.1
0-3"	.27	2.8	.136	1.90	.91	-11.9	55.1	38.9	10.9
3-9"	.28	3.3	.062	1.48	.82	-10.8	54.3	35.0	11.0
1'	.53	1.3	.022	3.67	.74	13.7	46.0	37.7	16.3
9-18"	.21	4.1	.060	.67	.93	-22.7	57.7	28.0	14.3
18-48"	.38	3.7	.033	.93	.83	-16.8	56.3	30.8	13.0
36-60"	.52	3.4	.040	1.05	.87	-16.5	56.5	29.5	14.0
7'	.58	1.8	.008	.70	.87	-20.0	56.0	30.0	14.0
12'	.75	1.9	.020	2.45	.79	0.0	51.0	33.5	15.5
15'	.95	1.0	.015	4.50	.68	24.0	55.0	30.0	15.0
20'	.48	1.5	.015	1.05	.80	-15.0	62.5	28.0	9.5

*These are the surface samples presented in permit Table 64, Coal Refuse Analysis. The exact depth of sampling is not known. They were described as surface samples and it is probable they represent the 0-6" zone.

TABLE 15

RELATIVE PERCENT SULFUR FORMS OF REFUSE MATERIAL BY AGE

AGE	SULFATE	ORGANIC	PYRITIC
0	24	21	55
5	23	42	35
6	34	37	28
7	21	51	28
8	9	22	69
12	15	49	36
13	21	45	34

REVISED PERMIT

TABLE 64

COAL REFUSE ANALYSIS

Sample	pH[1]	EC[1] mmhos/cm	SP %	Ca[1] meq/l	Mg[1] meq/l	Na[1] meq/l	SAR	ESP
WP1 Bottom	7.5	3.3	39.0					0.3
WP2 Middle	7.0	5.2	51.0					1.6
WP3 Top	7.3	3.8	51.0					1.0
A1-A	6.6	3.2	45.0	31.4	20.6	2.44	.48	
A1-B	6.6	3.3	45.0	32.4	20.6	1.65	.32	
A2-A	6.7	3.2	46.0	31.4	20.6	1.74	.34	
A2-B	6.8	3.1	45.0	30.4	18.1	2.31	.47	
B-1	7.6	3.5	45.0				<1	
B-2	7.3	5.8	60.9				<1	
B-3	7.6	5.3	45.6				<1	
New	7.6	1.2						
Old 0-15cm	7.0	2.4						
15-30cm	6.9	2.2						
VHA	-	8.8	-				3.11	5.58
12058	7.2	-	-					
12059	6.8							
57-4205	7.9							
83-4987	7.3	2.1	-	63.5	1.81	24.59	5.04	0.16

[1]Saturated paste extraction

[2]Bicarbonate extraction

[3]Hot water extraction

[4]AB-DTPA extraction

[5]Ammonium oxalate extraction

REVISED PERMIT

TABLE 64

COAL REFUSE ANALYSIS

(Cont'd)

Sample	Arsenic[2] ppm	Boron[3] ppm	Copper[4] ppm	Lead[4] ppm	Mo[5] ppm	NO_3-N[3] ppm	Selenium[3] ppm
A1-A	0.015	0.8	1.56	0.68	<.5	0.5	<.005
A1-B	0.025	0.8	1.64	0.80	<.5	0.6	<.005
A2-A	0.025	0.9	1.80	0.80	<.5	0.6	<.005
A2-B	0.030	0.9	1.60	0.72	<.5	0.6	<.005
VHA	-	-	0.65	-	-	7.4	-
12058	1.6*						1.6*
12059	1.6*						0.6*
57-4205	<.002	-	<.04	-	-	-	.002
83-4987	-	0.7	.013	-	.01	-	-

*Total values

Sample	Sand %	Silt %	Clay %	Texture	Organic Matter %	P[4] ppm	K[4] ppm	CEC	$CaCO_3$ %
WP1 Bottom	59	24	17	SL	25.1	-	-	12.6	4.1
WP2 Middle	66	20	14	SL	52.9	-	-	18.4	0.1
WP3 Top	65	22	13	SL	51.2	-	-	10.7	0.1
A1-A	-	-	-	-	52.0	3.12	60.2	-	-
A1-B	-	-	-	-	51	1.56	55.4	-	-
A2-A	-	-	-	-	48	1.44	67.4	-	-
A2-B	-	-	-	-	52	0.80	63.2	-	-
B-1	50	33	17	L	19.6	-	-	19.9	4.6
B-2	64	25	11	SL	42.6	-	-	46.6	1.8
B-3	42	42	16	L	21.4	-	-	21.4	7.2
New	61	15	24	SCL	-	-	-	-	-
Old 0-15cm	61	14	25	SCL	-	-	-	-	-
15-30cm	61	13	26	SCL	-	-	-	-	-
VHA	-	-	-	-	-	5.4	83.2	39.3	-
83-4987	-	-	-	-	-	1.65	500	-	-

REVISED PERMIT

TABLE 64

COAL REFUSE ANALYSIS

(Cont'd)

Sample	Total Sulfur %	Acid Potential tons/1000 ton	% $CaCO_3$	Neutralization Potential Tons $CaCO_3$/1000 tons	Acid Base Potential Tons $CaCO_3$/ 1000 tons
A1-A	1.05	32.81	3.7	37.00	4.19
A1-B	1.28	40.00	3.8	38.00	-2.00
A2-A	0.97	30.31	2.8	28.00	-2.31
A2-B	0.03	0.94	3.2	32.00	31.06
12058	1.16	36.25	3.1	30.64	-5.61
12059	0.84	26.25	2.5	25.00	-1.23

APPENDIX 1

ACZ INC./LABORATORY DIVISION
SOILS ANALYSES REPORT

Client: Plateau Mining Company
P.O. Drawer PMC
Price, Utah 84501

Report Date: 06/04/87
Date Received: 03/28/87

Attn: Mr. D.C. Spears

LAB NO.	SAMPLE I.D.	SAMPLE DATE	Saturation %	pH 1 (units)	Conductivity 1 mmhos/cm @ 25 C	Calcium 1 meq/l	Magnesium 1 meq/l	Sodium 1 meq/l	SAR	Boron 2 mg/kg	Selenium 2 mg/kg	Neutralization Potenital as CaCO3 %	Sulfur, Total %
87-0246-Soil	87-R-1 (1')	Unknown	47	7.2	3.81	32.0	18.5	3.86	0.77	1.4	0.034	3.7	0.75
87-0247-Soil	87-R-1 (7')	Unknown	52	6.8	3.33	27.4	19.1	2.78	0.58	1.8	0.008	0.7	0.87
87-0248-Soil	87-R-1 (15')	Unknown	58	7.1	3.25	27.6	17.7	4.51	0.95	1.0	0.015	4.5	0.68
87-0495-Soil	87-R-2 (0-3")	05/05/87	54	7.0	4.28	29.2	35.4	2.69	0.47	3.9	0.19	1.7	0.73
87-0496-Soil	87-R-2 (3-9")	05/05/87	53	7.1	3.84	28.7	25.9	2.49	0.48	4.1	0.09	1.4	0.61
87-0497-Soil	87-R-2 (18-48")	05/05/87	55	7.0	3.39	27.0	21.8	2.05	0.42	2.8	0.02	1.1	0.84
87-0249-Soil	87-R-2 (1')	Unknown	51	7.2	3.57	28.4	23.4	1.66	0.33	1.5	0.013	3.8	0.82
87-0250-Soil	87-R-2 (12')	Unknown	52	7.2	3.15	29.5	17.0	1.95	0.40	1.6	0.025	1.3	0.74
87-0251-Soil	87-R-2 (20')	Unknown	57	7.2	3.03	30.9	8.26	1.20	0.27	1.5	0.012	1.2	0.32
87-0252-Soil	87-R-3 (1')	Unknown	66	7.1	3.06	27.7	19.2	2.43	0.50	1.0	0.018	3.5	0.64
87-0253-Soil	87-R-3 (12')	Unknown	67	7.0	3.68	28.0	26.8	5.75	1.10	2.2	0.014	3.6	0.83
87-0254-Soil	87-R-3 (20')	Unknown	62	7.0	3.28	28.8	22.3	3.45	0.68	1.4	0.018	0.9	1.28
87-0255-Soil	87-R-4	Unknown	56	7.4	1.54	11.7	7.03	1.09	0.36	0.7	0.076	5.6	0.60
87-0256-Soil	87-R-5	Unknown	65	7.6	1.30	8.77	3.08	0.39	0.16	0.8	0.009	1.3	0.71
87-0257-Soil	87-R-6 (0-3")	Unknown	55	6.5	4.90	22.1	45.0	0.63	0.11	3.3	0.130	0.6	0.88
87-0258-Soil	87-R-6 (3-9")	Unknown	58	6.7	3.28	24.4	14.9	0.68	0.15	2.4	0.016	1.5	0.67
87-0498-Soil	87-R-6 (9-18")	05/05/87	58	7.0	3.05	28.3	17.8	0.99	0.21	3.9	0.05	0.9	0.96
87-0499-Soil	87-R-6 (18-36")	05/05/87	61	7.5	3.01	28.1	12.9	2.51	0.55	3.2	0.04	0.8	0.88
87-0500-Soil	87-R-6 (36-60")	05/05/87	63	7.6	2.33	18.7	8.84	2.61	0.70	3.6	0.05	1.3	0.87
87-0259-Soil	87-R-7 (0-3")	Unknown	59	7.2	8.68	17.6	153	1.75	0.19	2.5	0.210	1.8	1.12
87-0260-Soil	87-R-7 (3-9")	Unknown	60	7.0	4.29	17.5	31.1	1.13	0.23	2.2	0.051	2.5	0.89
87-0501-Soil	87-R-7 (9-18")	05/05/87	59	7.2	3.14	28.8	18.9	1.08	0.22	4.6	0.02	0.4	0.76
87-0502-Soil	87-R-7 (18-36)	05/05/87	66	7.3	3.08	29.3	18.7	1.00	0.20	4.3	0.05	0.7	0.81
87-0503-Soil	87-R-7 (36-60")	05/05/87	58	7.4	3.06	29.9	18.0	1.68	0.34	3.2	0.03	0.8	0.86
87-0261-Soil	87-R-8 (0-3")	Unknown	63	6.9	4.56	17.9	31.8	1.55	0.31	4.6	0.120	1.5	0.92
87-0504-Soil	87-R-9 (0-3")	05/05/87	66	6.8	5.26	30.3	67.2	2.06	0.30	3.7	0.22	0.8	1.42
87-0505-Soil	87-R-9 (3-9")	05/05/87	64	6.7	3.92	27.4	43.6	1.41	0.24	4.5	0.09	0.5	1.10
87-0506-Soil	87-R-9 (9-18")	05/05/87	69	6.8	3.36	29.5	27.9	1.04	0.19	3.8	0.10	0.7	1.09
87-0507-Soil	87-R-9 (18-48")	05/05/87	69	7.1	3.26	30.2	22.2	1.67	0.33	4.3	0.02	1.1	0.79
87-0262-Soil	86-18-1-C, WATTIS ROOF (1072-1074.1')	Unknown	47	7.5	0.79	3.36	3.06	1.36	0.76	8.2	0.094	13.3	0.12
87-0263-Soil	86-18-1-C, WATTIS FLOOR (1083.0-1084.7')	Unknown	36	5.1	2.26	17.5	8.17	2.99	0.83	13.0	0.012	0.3	[illegible]
87-0264-Soil	86-18-1-C, THIRD FLOOR (1128.6-1130.1')	Unknown	47	6.9	1.80	14.1	8.66	0.87	0.26	3.2	0.093	4.0	0.97
87-0265-Soil	86-18-2-C, THIRD ROOF (1137.9-1139.8')	Unknown	41	7.4	2.43	12.6	19.1	1.44	0.36	0.9	0.014	12.6	0.72

1 Saturated Paste Extraction 2 Hot Water Extraction

Ralph V. Poulsen
Ralph V. Poulsen, Director

ACZ INC./LABORATORY DIVISION
SOILS ANALYSES REPORT

Client: Plateau Mining Company
P.O. Drawer PMC
Price, Utah 84501

Report Date: 06/04/87
Date Received: 03/28/87

Attn: Mr. D.C. Spears

LAB NO.	SAMPLE I.D.	SAMPLE DATE	Acid-Base Potential tons CaCO3/1000 tons	Sand %	Silt %	Clay %	Texture
87-0246-Soil	87-R-1 (1')	Unknown	14	55	30	15	SL
87-0247-Soil	87-R-1 (7')	Unknown	-20	56	30	14	SL
87-0248-Soil	87-R-1 (15')	Unknown	24	55	30	15	SL
87-0495-Soil	87-R-2 (0-3")	05/05/87	-6	53	29	18	SL
87-0496-Soil	87-R-2 (3-9")	05/05/87	-5	51	33	16	L
87-0497-Soil	87-R-2 (18-48")	05/05/87	-15	51	31	18	L
87-0249-Soil	87-R-2 (1')	Unknown	12	40	45	15	L
87-0250-Soil	87-R-2 (12')	Unknown	-10	60	29	11	SL
87-0251-Soil	87-R-2 (20')	Unknown	2	77	18	5	LS
87-0252-Soil	87-R-3 (1')	Unknown	15	43	38	19	L
87-0253-Soil	87-R-3 (12')	Unknown	10	42	38	20	L
87-0254-Soil	87-R-3 (20')	Unknown	-31	48	38	14	L
87-0255-Soil	87-R-4	Unknown	37	45	41	14	L
87-0256-Soil	87-R-5	Unknown	-9	67	28	5	SL
87-0257-Soil	87-R-6 (0-3")	Unknown	-22	56	34	10	SL
87-0258-Soil	87-R-6 (3-9")	Unknown	-6	55	36	9	SL
87-0498-Soil	87-R-6 (9-18")	05/05/87	-21	61	25	14	SL
87-0499-Soil	87-R-6 (18-36")	05/05/87	-20	60	31	9	SL
87-0500-Soil	87-R-6 (36-60")	05/05/87	-14	58	29	13	SL
87-0259-Soil	87-R-7 (0-3")	Unknown	-33	58	33	9	SL
87-0260-Soil	87-R-7 (3-9")	Unknown	-3	61	33	6	SL
87-0501-Soil	87-R-7 (9-18")	05/05/87	-20	60	26	14	SL
87-0502-Soil	87-R-7 (18-36)	05/05/87	-18	58	31	11	SL
87-0503-Soil	87-R-7 (36-60")	05/05/87	-19	55	30	15	SL
87-0261-Soil	87-R-8 (0-3")	Unknown	-14	63	31	6	SL
87-0504-Soil	87-R-9 (0-3")	05/05/87	-36	45	41	14	L
87-0505-Soil	87-R-9 (3-9")	05/05/87	-29	49	38	13	L
87-0506-Soil	87-R-9 (9-18")	05/05/87	-27	52	33	15	SL,L
87-0507-Soil	87-R-9 (18-48")	05/05/87	-14	56	30	14	SL
87-0262-Soil	86-18-1-C, WATTIS ROOF (1072-1074.1')	Unknown	129	34	53	13	SL
87-0263-Soil	86-18-1-C, WATTIS FLOOR (1083.0-1084.7')	Unknown	-9	79	20	1	LS
87-0264-Soil	86-18-1-C, THIRD FLOOR (1128.6-1130.1')	Unknown	10	44	50	6	SL,SiL
87-0265-Soil	86-18-2-C, THIRD ROOF (1137.9-1139.8')	Unknown	104	59	35	6	SL

1 Saturated Paste Extraction 2 Hot Water Extraction

Ralph V. Poulsen

Ralph V. Poulsen, Director

ACZ INC./LABORATORY DIVISION
SOILS ANALYSES REPORT

Client: Plateau Mining Company
P.O. Drawer PMC
Price, Utah 84501

Report Date: 06/04/87
Date Received: 03/28/87

Attn: Mr. D.C. Spears

LAB NO.	SAMPLE I.D.	SAMPLE DATE	Saturation %	pH 1 (units)	Conductivity 1 mmhos/cm @ 25 C	Calcium 1 meq/l	Magnesium 1 meq/l	Sodium 1 meq/l	SAR	Boron 2 mg/kg	Selenium 2 mg/kg	Neutralization Potenital as CaCO3 %	Sulfur, Total %
87-0266-Soil	86-18-2-C, THIRD FLOOR (1144.0-1145.9')	Unknown	33	7.7	0.71	3.35	3.12	0.49	0.27	2.0	0.049	8.6	0.04
87-0267-Soil	CVR-1-C, WATTIS ROOF (1576.0-1578.0')	Unknown	46	7.4	1.06	5.77	4.93	0.66	0.29	1.2	0.069	8.4	0.09
87-0268-Soil	CVR-1-C, WATTIS FLOOR (1588.0-1590.0')	Unknown	43	7.6	1.03	6.43	4.11	0.71	0.31	0.7	0.130	8.9	0.07
87-0269-Soil	84-23-1-C, WATTIS ROOF (1801.0-1802.6')	Unknown	37	7.7	1.58	7.14	12.5	0.80	0.26	0.3	0.047	9.5	0.11
87-0276-Soil	84-23-1-C, WATTIS FLOOR (1812.5-1814.2')	Unknown	50	6.9	3.31	29.8	24.3	1.04	0.20	1.5	0.150	9.7	0.70
87-0270-Soil	83-14-3-C, TUNNEL ZONE (1348.7-1350.5')	Unknown	38	8.0	1.28	5.31	8.09	0.86	0.33	0.4	0.060	17.2	0.02
87-0271-Soil	83-14-3-C, TUNNEL ZONE (1350.5-1352.3')	Unknown	36	7.7	2.76	21.8	22.3	1.20	0.26	0.4	0.075	17.3	0.07
87-0272-Soil	83-14-3-C, TUNNEL ZONE (1354.1-1355.9')	Unknown	33	7.6	2.71	19.8	23.8	1.00	0.21	0.2	0.013	16.6	0.12
87-0273-Soil	W-4-C, HIAW FLOOR (1259.8-1261')	Unknown	44	7.8	1.29	6.83	7.74	0.75	0.28	0.7	0.190	9.7	0.11
87-0274-Soil	W-8-C, WATTIS ROOF (1611.75-1612.35')	Unknown	48	7.3	1.46	11.8	6.17	0.70	0.23	0.6	0.110	9.5	0.21
87-0275-Soil	W-20-C, HIAW FLOOR (1505.5-1506')	Unknown	33	5.0	1.46	10.4	5.92	0.35	0.12	0.1	0.009	0.1	0.05
87-0277-Soil	82-55-TU-C, THIRD ROOF (0-2')	Unknown	44	8.1	1.04	2.52	8.83	0.69	0.29	0.7	0.096	16.7	0.07
87-0278-Soil	82-55-TD-C, THIRD FLOOR (0-2')	Unknown	40	7.8	0.82	3.41	4.22	0.67	0.34	0.7	0.110	9.2	0.03
87-0279-Soil	85-103-TU-C, THIRD FLOOR (0-2')	Unknown	40	7.7	1.06	4.51	6.31	0.75	0.32	0.3	0.067	8.3	0.36
87-0280-Soil	85-103-TU-C, WATTIS FLOOR (32-33.6')	Unknown	43	7.7	1.24	7.23	6.49	0.63	0.24	0.4	0.140	9.6	0.11
87-0281-Soil	85-103-TU-C, WATTIS SPLIT (BONEY) (36.5-38.5')	Unknown	44	4.4	3.85	27.2	31.0	0.95	0.18	-0.1	0.061	0.1	1.64
87-0282-Soil	85-103-TU-C, WATTIS ROOF (46.2-48.2')	Unknown	49	7.6	0.70	4.75	2.83	0.79	0.41	1.0	0.130	9.4	0.15
87-0283-Soil	86-107-TU-C, THIRD ROOF (0-2')	Unknown	32	6.1	4.45	26.3	59.7	0.69	0.11	-0.1	0.006	1.5	0.43
87-0284-Soil	86-107-TU-C, WATTIS FLOOR (78-79.7')	Unknown	51	7.4	1.05	7.16	4.28	0.79	0.33	1.1	0.072	13.0	0.64
87-0285-Soil	86-119-WD-C, WATTIS FLOOR (0-1')	Unknown	45	8.0	0.65	2.60	2.67	0.76	0.47	0.4	0.130	9.5	0.04
87-0286-Soil	86-119-WD-C, WATTIS ROOF (0-2')	Unknown	39	7.7	0.86	3.97	3.39	1.15	0.60	0.7	0.060	9.9	0.05
87-0287-Soil	86-119-WD-C, THIRD ROOF (55-56')	Unknown	29	8.0	2.08	9.87	18.5	2.04	0.54	0.2	0.019	13.2	0.99
87-0288-Soil	86-119-WD-C, THIRD FLOOR (66-67')	Unknown	38	8.3	0.65	1.84	3.56	0.82	0.50	0.2	0.039	16.1	0.04
87-0289-Soil	86-119-WD-C, HIAW ROOF (115-116.4')	Unknown	39	7.7	0.95	6.36	4.06	1.00	0.44	0.1	0.065	9.2	0.06
87-0290-Soil	86-119-WD-C, HIAW FLOOR (123-124.2')	Unknown	37	6.7	0.59	3.74	1.94	0.85	0.50	0.4	0.010	0.1	0.05
87-0291-Soil	86-129-WD-C, WATTIS FLOOR (0-1.5')	Unknown	39	7.6	0.66	4.32	2.28	0.39	0.21	0.4	0.083	0.1	0.10
87-0292-Soil	86-129-WD-C, WATTIS ROOF (0-2')	Unknown	34	7.8	1.50	7.70	7.85	1.61	0.58	0.5	0.020	9.9	0.55
87-0293-Soil	86-129-WD-C, THIRD ROOF (61-62.2')	Unknown	54	6.8	1.09	6.95	4.09	1.09	0.46	1.7	0.180	0.3	0.86
87-0294-Soil	86-129-WD-C, THIRD FLOOR (83-84')	Unknown	48	7.6	0.90	5.19	3.75	0.87	0.41	1.1	0.084	9.5	0.22
87-0295-Soil	86-129-WD-C, HIAW ROOF (107.5-108.4')	Unknown	53	7.4	0.90	5.76	3.52	0.78	0.36	0.8	0.120	9.2	0.34
87-0296-Soil	86-129-WD-C, HIAW FLOOR (114.3-116')	Unknown	33	7.4	0.44	2.05	1.50	0.69	0.52	0.2	0.022	0.2	0.01

1 Saturated Paste Extraction 2 Hot Water Extraction

Ralph V. Poulsen

Ralph V. Poulsen, Director

ACZ INC./LABORATORY DIVISION
SOILS ANALYSES REPORT

Client: Plateau Mining Company
P.O. Drawer PMC
Price, Utah 84501

Report Date: 06/04/87
Date Received: 03/28/87

Attn: Mr. D.C. Spears

LAB NO.	SAMPLE I.D.	SAMPLE DATE	Acid-Base Potential tons CaCO3/1000 tons	Sand %	Silt %	Clay %	Texture
87-0266-Soil	86-18-2-C, THIRD FLOOR (1144.0-1145.9')	Unknown	85	43	49	8	L
87-0267-Soil	CVR-1-C, WATTIS ROOF (1576.0-1578.0')	Unknown	81	36	53	11	SiL
87-0268-Soil	CVR-1-C, WATTIS FLOOR (1588.0-1590.0')	Unknown	87	39	50	11	L,SiL
87-0269-Soil	84-23-1-C, WATTIS ROOF (1801.0-1802.6')	Unknown	92	49	43	8	L,SL
87-0276-Soil	84-23-1-C, WATTIS FLOOR (1812.5-1814.2')	Unknown	75	47	38	15	L
87-0270-Soil	83-14-3-C, TUNNEL ZONE (1348.7-1350.5')	Unknown	171	34	55	11	Si L
87-0271-Soil	83-14-3-C, TUNNEL ZONE (1350.5-1352.3')	Unknown	171	54	41	5	SL
87-0272-Soil	83-14-3-C, TUNNEL ZONE (1354.1-1355.9')	Unknown	162	62	34	4	SL
87-0273-Soil	W-4-C, HIAW FLOOR (1259.8-1261')	Unknown	94	34	55	11	SiL
87-0274-Soil	W-8-C, WATTIS ROOF (1611.75-1612.35')	Unknown	88	49	43	8	L
87-0275-Soil	W-20-C, HIAW FLOOR (1505.5-1506')	Unknown	-1	90	10	0	S
87-0277-Soil	82-55-TU-C, THIRD ROOF (0-2')	Unknown	165	36	49	15	L
87-0278-Soil	82-55-TD-C, THIRD FLOOR (0-2')	Unknown	91	38	46	16	L
87-0279-Soil	85-103-TU-C, THIRD FLOOR (0-2')	Unknown	72	41	50	9	L,SiL
87-0280-Soil	85-103-TU-C, WATTIS FLOOR (32-33.6')	Unknown	93	36	50	14	L,SiL
87-0281-Soil	85-103-TU-C, WATTIS SPLIT (BONEY) (36.5-38.5')	Unknown	-50	50	41	9	L
87-0282-Soil	85-103-TU-C, WATTIS ROOF (46.2-48.2')	Unknown	89	42	40	18	L
87-0283-Soil	86-107-TU-C, THIRD ROOF (0-2')	Unknown	2	72	20	8	SL
87-0284-Soil	86-107-TU-C, WATTIS FLOOR (78-79.7')	Unknown	110	44	38	18	L
87-0285-Soil	86-119-WD-C, WATTIS FLOOR (0-1')	Unknown	94	29	57	14	SiL
87-0286-Soil	86-119-WD-C, WATTIS ROOF (0-2')	Unknown	97	44	45	11	L
87-0287-Soil	86-119-WD-C, THIRD ROOF (55-56')	Unknown	101	64	30	6	SL
87-0288-Soil	86-119-WD-C, THIRD FLOOR (66-67')	Unknown	160	30	57	13	SiL
87-0289-Soil	86-119-WD-C, HIAW ROOF (115-116.4')	Unknown	90	57	35	8	SL
87-0290-Soil	86-119-WD-C, HIAW FLOOR (123-124.2')	Unknown	-1	86	13	1	S
87-0291-Soil	86-129-WD-C, WATTIS FLOOR (0-1.5')	Unknown	-2	39	51	10	SiL
87-0292-Soil	86-129-WD-C, WATTIS ROOF (0-2')	Unknown	82	66	29	5	SL
87-0293-Soil	86-129-WD-C, THIRD ROOF (61-62.2')	Unknown	-24	44	53	3	SiL
87-0294-Soil	86-129-WD-C, THIRD FLOOR (83-84')	Unknown	88	36	53	11	SiL
87-0295-Soil	86-129-WD-C, HIAW ROOF (107.5-108.4')	Unknown	81	33	51	16	SiL
87-0296-Soil	86-129-WD-C, HIAW FLOOR (114.3-116')	Unknown	2	89	10	1	S

1 Saturated Paste Extraction 2 Hot Water Extraction

Ralph V. Poulsen

Ralph V. Poulsen, Director

ACZ INC./LABORATORY DIVISION

SOILS ANALYSES REPORT

Client: Plateau Mining Company
P.O. Drawer PMC
Price, Utah 84501

Report Date: 06/03/87
Date Received: 03/28/87

Attn: Mr. D.C. Spears

LAB NO.	SAMPLE I.D.	Sulfur, Organic %	Sulfur, Pyritic %	Sulfur, Sulfate %	Sulfur, Total %	Neutralization Potential % CaCO3	Acid-Base Potential tons CaCO3/1000 tons
87-0247-Soil	87-R-1 (7')	0.39	0.30	0.18	0.87	0.7	-2
87-0250-Soil	87-R-2 (12')	0.26	0.40	0.08	0.74	1.3	1
87-0254-Soil	87-R-3 (20')	0.28	0.89	0.11	1.28	0.9	-19
87-0256-Soil	87-R-5	0.34	0.35	0.02	0.71	1.3	2
87-0257-Soil	87-R-6 (0-3")	0.33	0.19	0.34	0.88	0.6	0
87-0258-Soil	87-R-6 (3-9")	0.28	0.22	0.17	0.67	1.5	8
87-0259-Soil	87-R-7 (0-3")	0.40	0.22	0.50	1.12	1.8	11
87-0261-Soil	87-R-8 (0-3")	0.35	0.34	0.23	0.92	1.5	4
87-0263-Soil	86-18-1-C, WATTIS FLOOR (1083.0-1084.7')	-0.01	0.08	0.31	0.39	0.3	1
87-0281-Soil	85-103-TU-C, WATTIS SPLIT (BONEY) (36.5-38.5')	0.07	1.32	0.25	1.64	0.1	-40
87-0293-Soil	86-129-WD-C, THIRD ROOF (61-62.2')	0.27	0.59	-0.01	0.86	0.3	-15
87-0495-Soil	87-R-2 (0-3")	0.38	0.21	0.14	0.73	1.7	10
87-0496-Soil	87-R-2 (3-9")	0.30	0.31	-0.01	0.61	1.4	4
87-0497-Soil	87-R-2 (18-48")	0.40	0.18	0.26	0.84	1.1	5
87-0498-Soil	87-R-6 (9-18")	0.34	0.28	0.36	0.96	0.9	0
87-0499-Soil	87-R-6 (18-36")	0.45	0.37	0.06	0.88	0.8	-4
87-0500-Soil	87-R-6 (36-60")	0.39	0.42	0.06	0.87	1.3	0
87-0501-Soil	87-R-7 (9-18")	0.46	0.12	0.18	0.76	0.4	0
87-0502-Soil	87-R-7 (18-36)	0.42	0.22	0.17	0.81	0.7	0
87-0503-Soil	87-R-7 (36-60")	0.40	0.34	0.12	0.86	0.8	-3
87-0504-Soil	87-R-9 (0-3")	0.33	0.48	0.61	1.42	0.8	-7
87-0505-Soil	87-R-9 (3-9")	0.36	0.29	0.45	1.10	0.5	-4
87-0506-Soil	87-R-9 (9-18")	0.40	0.33	0.36	1.09	0.7	-3
87-0507-Soil	87-R-9 (18-48")	0.45	0.18	0.16	0.79	1.1	5

Ralph V. Poulsen

Ralph V. Poulsen, Director

EXHIBIT 53

Removed and put in 1991 permit 4/16/92

NOTE:

Because of the limited availability and/or reproducible quality of this exhibit, it is requested that Exhibit 53 be removed from the 1989 permit revision and be inserted herein.

FILE: 2-5-2-4

State of Utah

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

Norman H. Bangerter
Governor
Dee C. Hansen
Executive Director
Dianne R. Nielson, Ph.D.
Division Director

355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, Utah 84180-1203
801-538-5340

September 23, 1988

Mr. Ben Grimes
Environmental Coordinator
Plateau Mining Company
P. O. Drawer PMC
Price, Utah 84501

Dear Mr. Grimes:

Re: Final Approval, Section 18, Coal Exploration Program, Plateau Mining Company, Starpoint Mine, CEP/007/006-88A, Carbon County, Utah

Division staff Brent Stettler and Pamela Grubaugh-Littig have reviewed your above noted submittal dated September 19, 1988. Plateau Mining Company's exploration program is hereby approved. Please incorporate the recomendations noted in the technical memorandum from Brent Stettler (copy attached) regarding reclamation measures.

Please advise the Division upon completion of the program.

Sincerely,

John J. Whitehead

John J. Whitehead
Permit Supervisor/
Reclamation Hydrologist

djh
cc: B. Stettler
P. Grubaugh-Littig
J. Helfrich
B. Malencik
WP+/46

Norman H. Bangerter
Governor
Dee C. Hansen
Executive Director
Dianne R. Nielson, Ph.D.
Division Director

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, Utah 84180-1203
801-538-5340

September 22, 1988

TO: John Whitehead, Permit Supervisor

FROM: Brent Stettler, Reclamation Biologist Brent

RE: Reclamation Plan for Exploration Permit 88-1, Cyprus-Plateau Mining Company, Starpoint Mine, ACT/007/006, Folder #2, Carbon County, Utah

After review of Exploration Permit 88-1, the Division recommends that:

1. Reclamation take place immediately after completion of exploration activities.
2. Seed be hand-raked into the soil after broadcasting.
3. A mulch cover of alfalfa hay be applied.
4. The seed mix be reduced as shown below:

Common Name	Scientific Name	PLS lbs./acre	PLS/ft^2
Bluebunch Wheatgrass	*Agropyron spicatum*	9	25.7
Slender Wheatgrass	*A. trachycaulum*	8	29.4
Yellow Sweetclover	*Melilotus officinalis*	4	23.9
Wood's Rose	*Rosa woodsii*	2	2.1
		23	81.1

djh
WP+/14

ENV 25-29

G4-1003-901

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

PROSPECTING PERMIT
(Geophysics, Oil and Gas, Geothermal, Acquired Minerals)
(Act of June 4, 1987) (Ref: FSM 2821)

FILE REFERENCE	2820
NAME OF PERMITTEE	Cyprus Plateau Mining Corp.
DATE OF APPLICATION	11/9/89

Permission is hereby granted to Robert Lauman of Cyprus Plateau Mining Corporation - Starpoint Mines to use the following-described lands: Sections 14, 23, and 26, T. 15 S., R. 7 E., SLM, Utah (see attached map) for the purpose of conducting a VLF (very low frequency) geophysical survey totaling approximately 20,250 linear feet (approximately 2,000 feet of which are off Cyprus Plateau's leasehold) to better define the geologic structure of the Gentry Hollow Graben.

This permit is granted subject to all valid claims to the described lands, and to the following conditions:

1. The permittee shall pay to the Forest Service, U.S. Department of Agriculture, the sum of $200.00 for each mile (or portion thereof) of off-lease survey line.

2 The permittee, in exercising the privileges granted by this permit, shall comply with the regulations of the Department of Agriculture and all Federal, State, county, and municipal laws, ordinances, or regulations which are applicable to the area or operations covered by this permit, including, but not limited to, those pertaining to fire, sanitation, fish, and game.

3. This permit is accepted subject to the conditions set forth herein, and to conditions 4 to 41 attached hereto and made a part of this permit.

PERMITTEE	NAME OF PERMITTEE Robert Lauman Cyprus Plateau Mining Corp.	SIGNATURE OF AUTHORIZED OFFICER TITLE: Manager, Tech. Services Robert G. Lauman	DATE 12/14/89
ISSUING OFFICER	NAME AND SIGNATURE Ira W Hatch Ira W. Hatch	TITLE: Forester (Adm) (DFR) Price District Ranger	DATE 12/14/89

R4-2800-1 (8/87)

4. This permit does not grant any exclusive right to the use of the described lands for prospecting, or other purposes; the area herein described shall be subject at all times to any other lawful uses by the United States, its lessees, permittees, licensees, and assigns.
5. This permit does not grant any rights of any kind in minerals; nor does it grant any perference right of any nature whatsoever in the issuance of a permit or lease for the exploration, removal, or development of the mineral resources in the described lands.
6. The permittee shall take all reasonable precaution to prevent and suppress forest fires. Particularly in connection with operations under this permit, fire prevention and fire-fighting equipment as required by the Forest Supervisor shall be provided, and the burning or other disposal of brush and other flammable debris shall be done by the permittee in accordance with written stipulations to be issued by the Forest Supervisor.
7. No national forest timber may be cut or destroyed without first obtaining a permit from the forest officer in charge.
8. The permittee will exercise diligence in protecting from damage the land and property of the United States covered by and used in connection with this permit and will pay the United States for any damage resulting from the violation of the terms of this permit or any law or regulation applicable to the national forests by the permittee, his agents, or employees, or through negligence of the permittee, his agents, or employees, when acting within the scope of their employment.
9. The permittee shall safeguard with fences, barriers, fills, covers or other effective devices, any shafts, pits, tunnels, cuts, and other excavations which otherwise would unduly imperil the lives, safety, or property of other persons.
10. Upon abandonment, termination, or revocation of this permit, the permittee shall remove all structures and facilities which have been placed on the premises by him, and shall restore the site, unless otherwise agreed upon in writing or in this permit.
11. This permit may be revoked by the Forest Supervisor upon determination that permittee's operations have violated any of the terms and conditions set forth in this permit.
12. The permittee shall fully repair all damage, other than ordinary wear and tear, to roads and trails in the national forests caused by the permittee in the exercise of the privilege granted by this permit.
13. In case of change of address, permittee shall immediately notify the Forest Supervisor.
14. No Member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this permit or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this permit if made with a corporation for its general benefit.
15. The conditions of this permit are completely set forth herein and none of its terms can be varied or modified except in writing by the forest officer issuing the permit, his successor, or superior, and in accordance with applicable law and the regulations of the Secretary of Agriculture.
16. Glenn Miller (Name) — Consulting Geologist (Title)

P.O. Drawer PMC (Address) — (801) 637-2875 (Business Phone)

Price, Utah 84501 (ZIP) — ____________ (Home Phone)

is designated as the authorized field representative of the permittee to be in charge and responsible for operations under the permit and for compliance with the terms and conditions thereof.
17. In the event of any conflict between any of the preceding printed clauses or any provision thereof and any of the following clauses or any provision thereof, the following clauses will control.

18. "This permit does not authorize any operations in conflict with an outstanding Bureau of Land Management mineral lease or permit."

19. "Before beginning any exploration work, including access and work road location and construction the permittee shall prepare a "Prospecting Plan". This plan should be prepared after consultation with the District Ranger or Rangers in whose District the work will be done. The final plan, including maps, shall be submitted, in triplicate, to the Forest Supervisor, Manti-LaSal, National Forest, for final approval, at least 1 week before any operations are to be commenced under the plan. Such approval will be conditioned on reasonable requirements needed to prevent soil erosion, water pollution, and unnecessary damages to the surface vegetation and other resources of the United States and to provide for the restoration of the land surface and vegetation. The plan shall contain all such provisions as the Forest Service may deem necessary to maintain proper management of the lands and resources within the prospecting areas and must be in harmony with the provisions of the National Environmental Policy Act of 1969, as amended, and the Environmental Quality Act of 1970, as amended. Where appropriate, depending upon the location and type of operation, the Forest Supervisor may require the plan to contain, but not be limited to the following items:

    (1) The location, construction specifications, maintenance program, and estimated use by the permittee, his employees, and agents of all access and work roads.

    (2) The exact location and extent of any and all areas on which there will be surface disturbance during the operations including a suitable map or aerial photograph which shows topographic, cultural, and drainage features involved.

    (3) The methods to be used in the operations, including disposal of waste material.

    (4) The size and type of equipment to be used in the operation.

    (5) The name, address, and telephone number of the permittee and of his designated field representative who will be responsible for operations under the permit.

    If later exploration requires departure from or additions to the approved plan, these revisions or amendments, together with justification statement for proposed revisions, will be submitted to the Forest Supervisor at least 1 week before operations under the proposed revision or amendment are to begin.

    If, in the judgment of the Forest Supervisor, later exploration or other developments require modification of an approved plan, the Forest Supervisor may require the operator to make revisions or amendments of the operations thereunder, in accordance with the foregoing principles.

Any and all operations conducted in advance of approval of an original, revised, or amended prospecting plan, or which are not in accord with an approved plan, constitute a violation of the terms of this permit and the Forest Service reserves the right to close down operations until such corrective action as is deemed necessary, is taken by the permittee.

20. "The permittee shall furnish and maintain a reclamation bond in the amount of N/A conditioned upon compliance with the terms and conditions of the permit." (Note: Reclamation does not include fire liability or other actions in connection with the operations.)

21 "Explosives must be stored and handled in compliance with Federal, State, and local rules and regulations governing the use of such items."

22 "Reclamation includes, but is not limited to, cleanup, removal and proper disposal of stakes, flagging, explosive debris, and other materials utilized during exploration."

23 "Upon completion of exploration, all drilled holes will be plugged and abandoned in conformance with applicable Federal and State laws and regulations."

24. "This prospecting permit will expire on December 13,1990, unless an extension of time is authorized in writing by the Forest Supervisor or his designated representative."

25. "Prior to bond release and permit termination, a map will be furnished the Forest Supervisor or his designated representative showing the location and number of holes drilled and information concerning location and depth of underground water encountered during testing, and final inspection of the test sites will be made by the permittee with the Forest Supervisor or his designated representative."

26. All surface disturbing activities conducted under this permit must be supervised by a designated, responsible official or representative of the permittee who is aware of the terms and conditions of this permit.

27. A copy of this permit must be available at the project site during operations and must be presented to any Forest Service official upon request.

28. The Manti-LaSal National Forest reserves the right to suspend all permits during periods of high fire potential.

29. Any and all damages to resources, structures, and improvements which result from the permittee's operations must be repaired as soon as possible. The Forest Service must be notified of such damages. Repairs must meet Forest Service specifications.

30. If cultural or paleontological resources are discovered during operations, all operations which may result in disturbance to the resource must cease and the Forest Service must be notified of the discovery.

31. Section corners claim markers or other survey markers within the project area must be flagged for preservation prior to commencement of surface disturbing operations. The removal, displacement, or disturbance of markers is not permitted.

32. Fire suppression equipment must be available to all personnel on the project site. Equipment must include a minimum of one hand tool per crew member consisting of shovels and pulaskis, and one properly rated fire extinguisher per vehicle and/or internal combustion engine.

33 All gasoline, diesel and steam-powered equipment must be equipped with effective spark arrestors and mufflers. Spark arrestors must meet Forest Service specifications discussed in the USDA Forest Service Spark Arrestor Guide, June 1981. In addition, all electrical equipment must be properly insulated to prevent sparks.

34. The permittee will be held responsible for damage and suppression costs for fires started as a result of operations. Fires must be reported to the Forest Service as soon as possible.

35. Off-road vehicle travel is prohibited unless specifically approved by the Forest Service.

36. All operations must be suspended during inclement weather conditions. Use of Forest roads must be avoided when they are wet and susceptible to rutting. In either case, the Forest Service must be notified as soon as possible when operations are postponed.

37. Harassment of wildlife and livestock is prohibited.

38. All range fence gates which are opened for access must be closed after passing through, unless otherwise noted.

39. All accidents or mishaps resulting in significant resource damage and/or serious personal injury must be reported to the Forest Service.

40. Water needed in support of operations must be properly and legally appropriated according to State water laws. The location of diversions, if on National Forest Systems lands, is subject to Forest Service review and approval.

41. Vehicle operators must observe safe speeds commensurate with road and weather conditions.

42. This permit will become effective immediately.

Ben & Steve

CYPRUS
Plateau Mining

Cyprus Plateau Mining Corporation
P.O. Drawer PMC
Price, Utah 84501
(801) 637-2875

December 14, 1989

Mr. Ira Hatch
Mr. Walt Nowak
USDA Forest Service
Manti-LaSal National Forest
Price Ranger District
599 West Price River Drive
Price, UT 84501

Re: Lease U-13097 Surface Exploration, Geophysical and Pit Prospecting Permits, Prospecting Permit No. G4-1003-891, Special Use Permit

Dear Ira and Walt:

Exploration Pits

As per our previous communication, Cyprus Plateau proposed to excavate exploration pits on anomaly sites demonstrated along the 14 resistivity profiles surveyed in 1989. Due to timing and the approach of the winter season, Cyprus Plateau only pursued excavation of the pits in the northeast of the lease this year. We request that the Forest Service extend the Special Use Permit through 1990 so that the balance of the pits may be completed under reasonable weather conditions. Special use permit will be extended, must be amended for SW pits, will save time.

Resistivity Prospecting Permit

Cyprus Plateau understands that this permit has expired. OK

VLF Prospecting Permit

This permit is to be issued in 1989 contingent upon a $200 fee allowing limited traversing west of the lease line. We request that this permit extend through 1990. Dec 13.

Since these non-disturbing geophysical surveys appear to work especially well on Gentry, Cyprus Plateau will most likely apply for numerous permits in 1990 and 1991 for Castle Valley Ridge.

Sincerely,

Bob Lauman

Robert G. Lauman
Manager, Technical Services

/kam

File: ENV 2-5-2-9

Do VLF & Resistivity on same permit, file theoretical plan provide actuals after survey, amend permit later. Do pit again as a special use permit.

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

BILL FOR COLLECTION

PAYER'S COPY

PLACE OF ISSUE
Price R. D.
Price, Utah 84501

DATE OF ISSUE
12-13-89

TP1003
0011

USFS Collection Officer File 61657
PO Box 60000
San Francisco CA 94160-1657

Cyprus-Plateau Mining Corp.
PO Drawer PMC
Price, Utah 84501

RETAIN IN YOUR RECORDS. RECEIPT WILL NOT BE FURNISHED UNLESS REQUESTED.

FOLD HERE

DATE OR PERIOD	DESCRIPTION	AMOUNT
12-13-89	Prospecting Permit - Geophysical Survey off of Permit area, FY-90 No. G4-1003-901 Paid Cash 12-14-89 Received for USDA Forest Service [illegible]	$200.00

BILL NO.	UNIT NO.	CONTRACT NO.	DATE PAYMENT DUE	AMOUNT DUE →	
	TP-10				$200.00

FS - 6500-89 (8/80)

CYPRUS
Plateau Mining

Cyprus Plateau Mining Corporation
P.O. Drawer PMC
Price, Utah 84501
(801) 637-2875

August 30, 1989

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining

by RVS date 10/2/89

Mr. Ira Hatch
USDA Forest Service
Manti-LaSal National Forest
Price Ranger District
599 West Price River Drive
Price, UT 84501

Re: Prospecting Permit No. G4-1003-891 -
Pit Locations and Pit Excavation Plans

Dear Mr. Hatch:

We have completed the resistivity surveys on the 14 lines included in the subject permit. From those surveys, we have identified 22 potential sites where we would propose digging test pits.

The intent of the test pits is to correlate actual ground features with anomalies identified by the resistivity surveys. By comparing actual ground conditions with the anomaly trace produced by the resistivity process, we may be able to eliminate some of the pits. The number of pits will be kept to the least amount possible.

A copy of the map included in the original permit is attached, showing the locations of the pits. Because the scale of this map is not very clear, a new map is also included which is at a scale of 1" = 400'. The test pits are designated by resistivity line. For example, resistivity line 89-R-8 has three pits proposed -- R8-1, R8-2, and R8-3.

All of the proposed pits are located on resistivity lines 89-R-7 through 89-R-13. All of the pits can be accessed from existing roads, with no disturbance other than the pits themselves. At this time, no pits are proposed on resistivity lines 89-R-1 through 89-R-6, and 89-R-14; pits may be proposed on these lines in the future.

The pits will be excavated with either a rubber-tired backhoe or trackhoe machine. Disturbance will be kept to the smallest possible area; generally an area 10 feet wide by 50 feet long will be required. Topsoil will be removed and stored by the side of each pit for later reclamation. Each pit will remain open only for a short period (one to two days), and will be backfilled immediately upon completion of geologic investigations. Subsoil will be replaced in the pits, after which topsoil will be replaced and left in a rough condition.

Seeding will be done during the first available season following soil replacement. The seed mixture, as shown on Table 1 (enclosed), will be hand-spread and raked into the topsoil. No mulch will be used because the high elevation of the sites will allow adequate moisture retention.

Mr. Ira Hatch
August 30, 1989
Page 2

Archeological investigations of all 14 resistivity lines were made by the Office of Public Archeology from Brigham Young University. No new cultural resources were found during the investigations. A report of findings was sent to Stan McDonald of your office, and to James Dykman of the Utah State Historic Preservation Office. A copy of the report is enclosed with this letter.

Considering the lateness of the season, we are anxious to complete the pits. We would appreciate very much a timely approval of the test pits so we can complete the project and reclaim the sites before snowfall.

If you need anything further, don't hesitate to call.

Sincerely,

Ben Grimes
Sr. Environmental Engineer

/kam

Enclosures

Chrono: BG890806

File: ENV 2-5-2-9

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining

by RUS date 10/2/89

TABLE 1

SEED MIX

SPECIES	SEEDING RATE IN PLS LBS/ACRE
GRASSES	
Bluebunch Wheatgrass	2
Slender Wheatgrass	2
Kentucky Bluegrass	1
Intermediate Wheatgrass	1
Timothy	1.5
Orchardgrass	1.5
Meadow Foxtail	1.5
Manchar Smooth Brome	1.5
Chewings Red Fescue	1.5
FORBS	
Western Yarrow	1.5
Utah Sweet Vetch	1.5
SHRUBS	
Mountain Snowberry	2
Woods Rose	2
TOTAL	20.5

Seed mix based on research conducted at the U.S. Forest Service Research Station at Ephriam and Logan, Utah, for high mountain elevations.

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining

by RUS date 10/2/89

FILE 2-5-3-9

BRIGHAM YOUNG
UNIVERSITY

THE GLORY OF GOD
IS INTELLIGENCE

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining
by RUS date 10/2/89

August 24, 1989

Mr. Ben Grimes
Cyprus Plateau Mining Company
P.O. Drawer PMC
Price, Utah 84501

Dear Mr. Grimes:

On August 23, 1989, a Class III cultural resource inventory of the proposed Cyprus Plateau Mining resistivity lines and excavation locations on Gentry Ridge, Emery County, was performed. The inventory was carried out by Scott Billat and Richard Talbot of the Office of Public Archaeology (OPA), Brigham Young University. No new cultural resources were encountered during the survey, although two previously recorded sites are located near the project area. This letter report summarizes the inventory.

Project: Cyprus Plateau Mining, Gentry Ridge Resistivity Lines and Excavation Locations

Utah State Project Authorization No: U-89-BC-535f

Location: The project area (Figure 1) consists of 14 short (each between 1000-2800 feet) proposed geophysical lines located on top, and on the western slope of Gentry Ridge, in Sections 14, 15, 22, 23, 26 and 27 of T15S R7E (Wattis and Hiawatha Quadrangles). Access will be from existing roads, or by foot only. The project area is located generally between 8800 and 10,000 feet elevation, on terrain dominated by aspen, ponderosa pine, mountain mahogany, low sage and grasses. Deer and smaller mammals are common, as are hawks and other birds.

Land Ownership: Manti-LaSal National Forest

Previous Research: A literature search carried out at the Utah State Historic Preservation Office (USHPO) and at the Manti-LaSal Forest Supervisors Office revealed two previous inventories on Gentry Ridge. Talbot (1983) surveyed some drill pads and access roads, recording a single historic corral (42Em 1758) and some isolated aspen bark carvings.

OFFICE OF PUBLIC ARCHAEOLOGY
105 ALLEN HALL
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH 84602
(801) 378-4783, 378-7123

The corral was determined to be not elible for the National Register of Historic Places (NRHP), and has since been rebuilt and substantially modified. Montgomery and Montgomery (1987) surveyed several large plats on Gentry Ridge, including the entire NE1/4 of Section 14, which encompasses three of the 14 lines covered by the current survey. Only one site and a few isolated finds were recorded. The site is a lithic scatter located well to the north (ca. 1/2 mile) of the current project.

Methodology: Each of the proposed resistivity and excavation locations were surveyed by a single surveyor walking a zig-zag transect within a 50 foot corridor, for the entire length of each line. The centerline of each corridor had been previously staked and flagged, thereby facilitating the survey.

Results: No new historic or prehistoric sites were found within the proposed project areas. One isolated aspen bark carving - "Aug 21 1937 Otterson Hello You"- was noted, but is not considered to be significant. The previously recorded historic corral described above is not eligible for the NRHP and is not within any of the surveyed corridors.

Conclusions: No impact will occur to NRHP-eligible sites within the project area.

For your information, OPA is providing copies of this report to USHPO and to the Manti-LaSal National Forest. If you have any questions or concerns, please feel free to contact us at any time. Thank you for considering OPA/BYU.

Sincerely,

Richard K. Talbot
Senior Archaeologist
OPA/BYU

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining

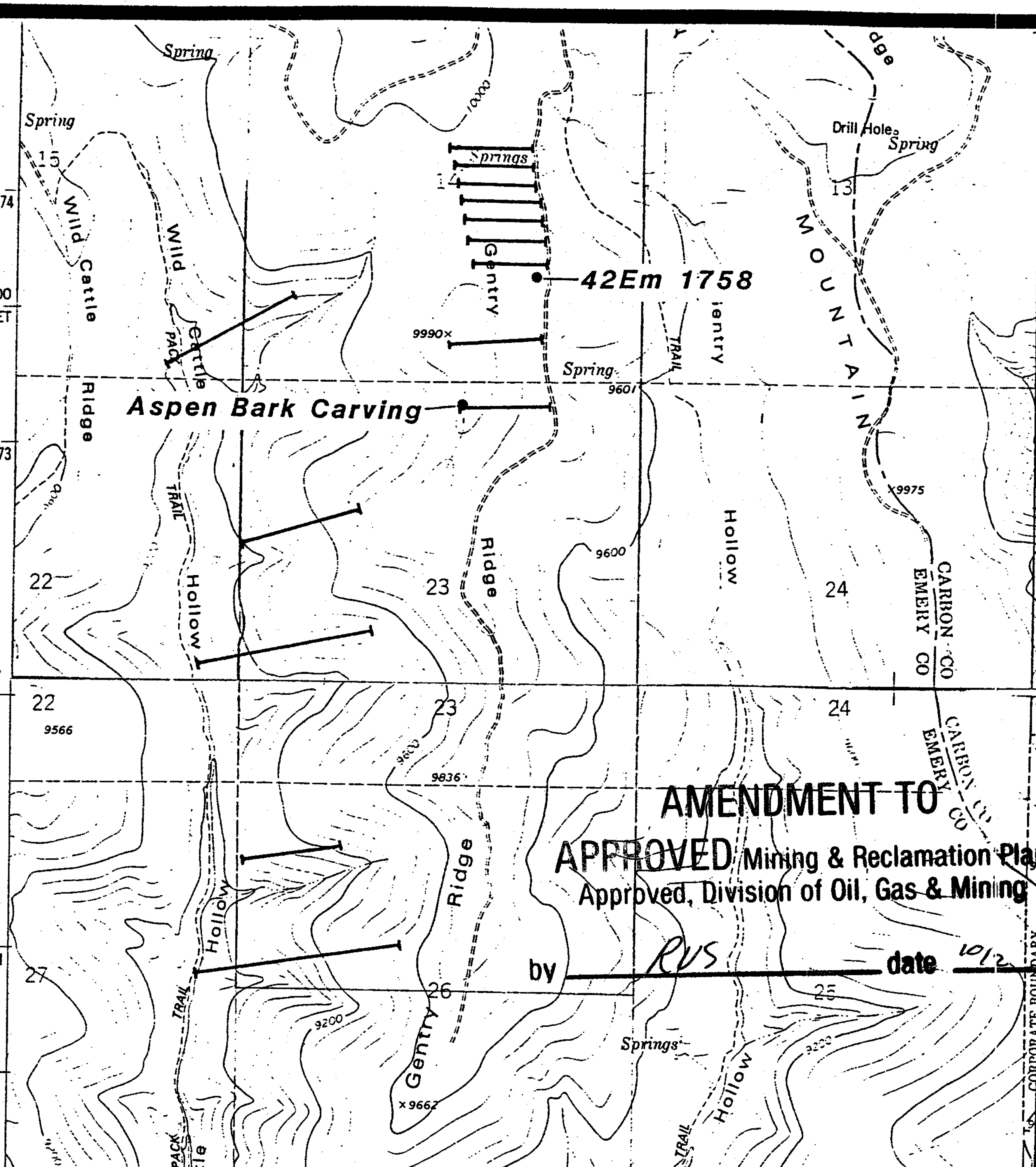
by RUS date 10/2/89

cc: Mr. Stan McDonald - Manti-LaSal N.F.
Mr. James Dykman - USHPO

References Cited:

Montgomery, Keith and Jackie Montgomery
1987 Cultural Resource Inventory of Cyprus Plateau Mining Company Gentry Mountain Coal Properties, Emery and Carbon Counties, Utah. Abajo Archaeology, Bluff.

Talbot, Richard
1983 A Cultural Resource Inventory of Drill Pads and Access Roads on the Skyline Property in Emery, Carbon and Sanpete Counties, Utah. BYU Museum of Peoples and Cultures Technical Series No. 83-36, Provo.



AMENDMENT TO APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining
by RVS date 10/2 89

0 1/2 1 Mile

0 .5 1 Kilometer

LEGEND

- Survey Area
- Archaeological Site/Isolated Find

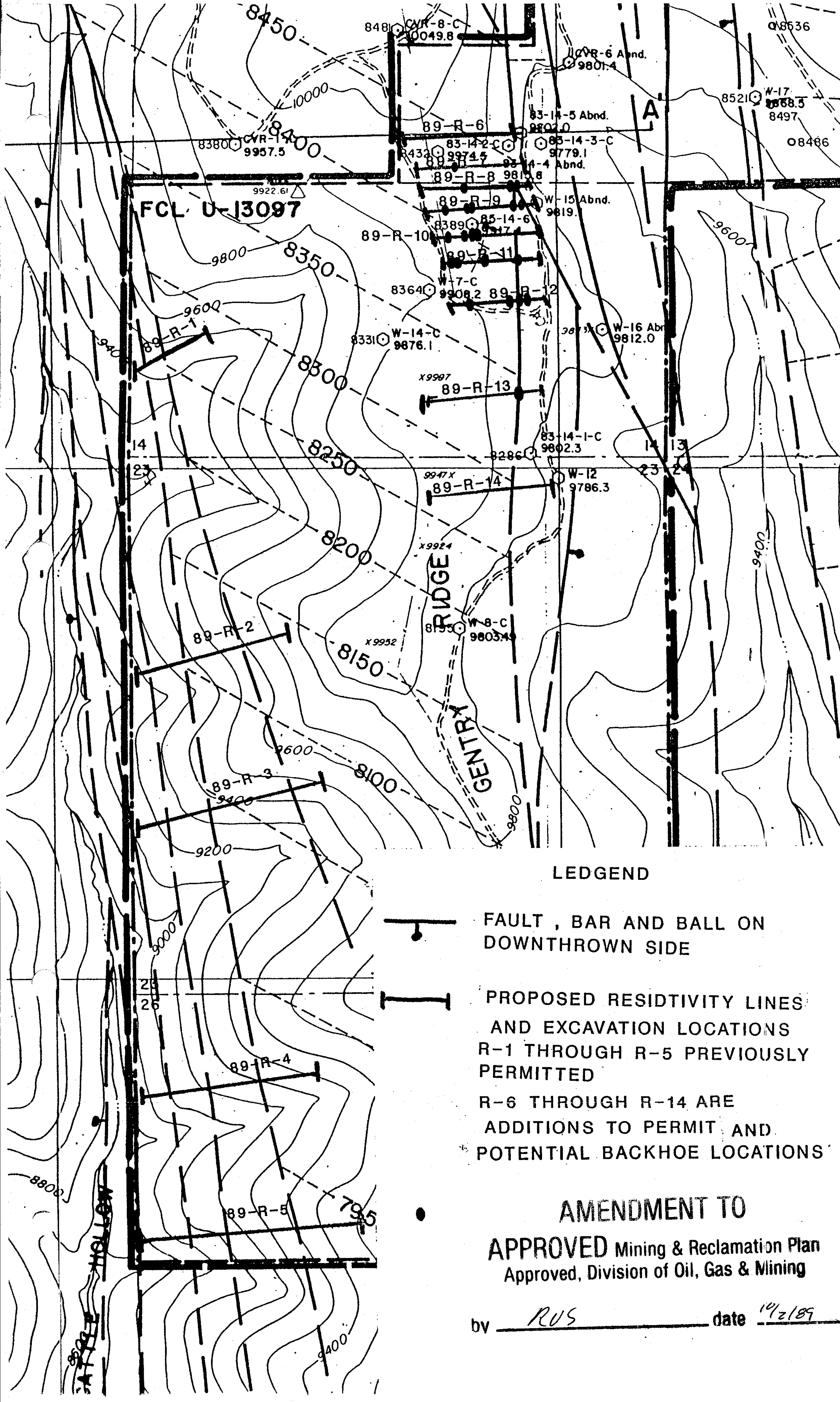
OFFICE of PUBLIC ARCHAEOLOGY
MUSEUM OF PEOPLES AND CULTURES
BRIGHAM YOUNG UNIVERSITY

PROJECT: Cyprus Plateau Mining-Gentry Ridge

COUNTY: Emery

QUAD: Wattis/
Hiawatha
T15S R7E

FIGURE 1



LEDGEND

FAULT , BAR AND BALL ON DOWNTHROWN SIDE

PROPOSED RESIDTIVITY LINES AND EXCAVATION LOCATIONS
R-1 THROUGH R-5 PREVIOUSLY PERMITTED
R-6 THROUGH R-14 ARE ADDITIONS TO PERMIT AND POTENTIAL BACKHOE LOCATIONS

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining

by RVS date 10/2/89

ENV 2-5-2-16-52

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

Norman H. Bangerter
Governor
Dee C. Hansen
Executive Director
Dianne R. Nielson, Ph.D.
Division Director

355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, Utah 84180-1203
801-538-5340

September 28, 1989

Mr. Benjamin Grimes
Environmental Coordinator
Cyprus-Plateau Mining Company
P. O. Drawer P M C
Price, Utah 84501

Dear Mr. Grimes:

Re: Approval of Amendment for Alternate Sediment Control Areas, Cyprus-Plateau Mining Company, Starpoint Mine, ACT/007/006-89H, Folder #3, Carbon County, Utah

This letter will inform you that the above-identified amendment was approved on September 28, 1989.

Sincerely,

Richard V. Smith

Richard V. Smith
Permit Supervisor

djh
cc: J. Helfrich, DOGM
T. Munson, DOGM
AT8/94

CYPRUS
Plateau Mining

Cyprus Plateau Mining Corporation
P.O. Drawer PMC
Price, Utah 84501
(801) 637-2875

September 19, 1989

Mr. Richard Smith
Division of Oil, Gas & Mining
355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, UT 84180-1203

Re: Alternative Sediment Control Areas -
DOGM Letter of August 31, 1989

Dear Mr. Smith:

Enclosed please find six copies of revised text pages, Table 95, and revised Maps 42, 67, 68, and 71, with the SAE's changed to ASCA's.

Respectfully,

Ben Grimes
Sr. Environmental Engineer

/kam

Enclosures

Chrono: BG890903

File: ENV 4-3

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

Norman H. Bangerter
Governor
Dee C. Hansen
Executive Director
Dianne R. Nielson, Ph.D
Division Director

355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, Utah 84180-1203
801-538-5340

August 31, 1989

Mr. Benjamin Grimes
Environmental Coordinator
Cyprus-Plateau Mining Company
P. O. Drawer P M C
Price, Utah 84501

Dear Mr. Grimes:

Re: Review of Proposed Amendment for Alternative Sediment Control Areas, Cyprus-Plateau Mining Company, Starpoint Mines, ACT/007/006-89H, Folder #2, Carbon County, Utah

Attached is a Technical Memorandum that reviews the proposed amendment for alternative sediment control areas at the Starpoint Mines. Please provide six copies, suitable for insertion into the approved Permit Application Package, of appropriately revised text and plates by no later than September 15, 1989.

Sincerely,

Richard V. Smith
Richard V. Smith
Permit Supervisor

djh
Attachment
cc: T. Munson, DOGM
W. Warmack, DOGM, PFO
AT8/104

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

Norman H. Bangerter
Governor
Dee C. Hansen
Executive Director
Dianne R. Nielson, Ph.D.
Division Director

355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, Utah 84180-1203
801-538-5340

August 9, 1989

TO: Richard V. Smith, Permit Supervisor

FROM: Tom Munson, Reclamation Hydrologist RVS for

RE: Review of Proposed Amendment for Alternative Sediment Control Areas, Cyprus-Plateau Mining Company, Starpoint Mines, ACT/007/006-89H, Folder #2, Carbon County, Utah

Synopsis

On July 6, 1989, the Division received a request from Cyprus-Plateau Mining Company regarding Small Area Exemptions (SAE's). Six areas have been identified by the operator as qualifying as small area exemptions. These areas are designated as SAE's One through Six, and are shown on Map 71, Mine Permit Area. This memo reviews this request by the Cyprus-Plateau Mining Company.

Analysis

Table 95 included in this submittal identifies six areas and gives the sediment controls currently in place which are used to treat disturbed runoff. The ability of these structures to effectively treat runoff and meet applicable effluent standards has been field verified by Division Field Specialist Bill Malencik as documented in his memos of September 29, 1988 and July 22, 1989. All areas have been determined to qualify as Alternative Sediment Control Areas (ASCA's) not SAE's. The total disturbed area involved is 3.8 percent of the total disturbed area currently permitted at the Starpoint Mine.

Bill Malencik's memo of July 26, 1989 states that silt fence is needed to supplement the berms, in place, adjacent to the half-round culvert. At the time of his inspection, these berms had not been maintained and it was felt that silt fence would provide additional alternative sediment control treatment.

When an inspection was performed on August 3, 1989, the berms were repaired and appeared to be very effective in trapping all runoff and preventing erosion. Therefore, it was recommended to the operator on site that this ASCA be approved as is and that maintenance of the berms was of utmost importance, regarding approval of this area as an ASCA.

Recommendations

Approval be granted when all six areas identified as ASCA's in the text and on the maps to correspond with current policy requirements. This can be accomplished by substituting the term ASCA for SAE in the text and on the maps. The operator also needs to refer to a maintenance plan in the PAP for all ASCA's. Failure to maintain sediment controls at any ASCA will result in enforcement action.

djh
AT5/26-27

CYPRUS
Plateau Mining

Cyprus Plateau Mining Corporation
P.O. Drawer PMC
Price, Utah 84501
(801) 637-2875

July 3, 1989

Mr. Lowell Braxton
Division of Oil, Gas and Mining
355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, UT 84180-1203

Re: Small Area Exemptions

Dear Mr. Braxton:

It has come to our attention that there are two additional areas that do not drain to sediment ponds at our operation, which should be added as small area exemptions. Enclosed please find a response to UMC 817.42 which should be added to our MRP to cover areas that do not drain to sedimentation ponds. This information was inadvertently left out of the permit renewal document. The response includes revisions to Maps 42, sheet 2 of 3, and 71, and a new Table 95.

We must stress that all of these areas have been previously permitted and approved by the Division in various submittals in the past. This submittal is to include the areas under the Small Area Exemption provisions of UMC 817.42 and to make our MRP document complete. No approvals are required by this action, except as to form and content.

When the Division is satisfied that this information covers the requirements, additional copies will be provided for all MRP sets.

Three sets of new text, maps, and the table are enclosed. If you have questions, please call.

Respectfully,

Ben Grimes
Sr. Environmental Engineer

/kam

Enclosures

cc: Bill Malencik, w/o enclosures

Chrono: BG890701

File: ENV 4-3

CONSULTANTS/ENGINEERS
HANSEN ALLEN & LUCE INC
6771 SOUTH 900 EAST
MIDVALE, UTAH 84047
(801) 566-5599

May 10, 1988

Mr. Ben Grimes
Environmental Coordinator
Plateau Mining Company - PMC 41
Wattis, Utah

RE: Culvert extensions.

Dear Ben:

As requested by phone we have analyzed hydraulic characteristics of four culverts located along the upper mine pad road. Specifically we were asked to:

1. Determine the size of downspout culvert required to convey water from existing Road Culverts 23B, 26B and 46B down the steep embankments, into downstream natural channels. If possible, a reduction in pipe size was desired down the steeper sections.

2. Identify the location where the pipe reduction should be installed. Could the reduction be placed at the existing road culvert outlet, or would it have to be installed on the steeper slope section where adequate heads could be developed.

3. Hydraulically design a new pipe section under the conveyor belt to replace existing Road Culvert 4A which has partially failed. The new location as proposed lies approximately 200 feet east of the existing Culvert 4A. A reduced downspout section was also desired for this location to convey the road culvert flows into the existing channel above existing Culvert 63A.

As requested we have performed culvert capacity calculations for new Culvert 4A, and existing Road Culverts 23B, 26B and 46B, such that they may be extended downslope to the channel bottom. Hydraulic design indicates that a 27 inch CMP culvert may be installed for Culvert 4A at the new location shown in the attached calculation sheets. According to design, the culvert to be placed beneath the conveyor belt and roadway should be placed on a 15 percent grade with an 18 inch CMP extending down the slope to the channel bottom.

The culvert extension to existing Road Culvert 23B must be 18 inches in diameter, however, we recommend using at least a 21 inch CMP to reduce total head required to push the flow through the downstream culvert inlet. Existing Road Culverts 26B and 46B require 18 inch CMP downspouts.

All four contractions discussed herein may be installed at the location of the existing culvert outlets and need not be installed on the steeper slope sections.

One area of concern we have with regards to the culverts is the potential for plugging at the contraction to the smaller diameter pipe. It may be advisable to install and maintain debris grates over the entrances to the culverts to help eliminate passage of potentially clogging materials. It may also be advisable to place the contractions where they can be easily removed and the culverts cleaned should it be necessary. Erosion protection will also be required at the culvert outlets.

Should you have any questions, please call.

Sincerely,

David E. Hansen, Ph.D., P.E.

DEH/dh

As per phone call from Ben Grimes today- PMC needs to extend culverts 4A, 46B, 23B + 26B to bottom of Channel due to hillside Erosion. In Addition, Ben wants to 1) Reduce culvert size down hill and 2) Move #4A approx. 200' East.

CHECK: 1) Req'd size down slope
2) Placement of Reducer
3) Sizing of culvert 4A (New Location)

Culvert No.	Size (in)	Design Q (cfs)	Pipe Length (ft)	Pipe Slope (ft/ft)
4A	30	11.0	216	0.176
23B	30	16.4	225	0.057
26B	30	5.7	209	0.139
46B	30	6.2	211	0.176

Culvert 4A - At New Location ~200' East of Old Location

Area = 24.3 + 1.3 = 25.6 ac
S = 76.5%
H_L = 1710 + 200 = 1910'
CN = 75
P = 2.1 in

} Q = 11.5 cfs

@ HW/D = 1.0 (Dia Req'd = 27") Qcap. inlet = 15.5 cfs > 11.5 OK

Using Mannings: (n = 0.024) S = 15%

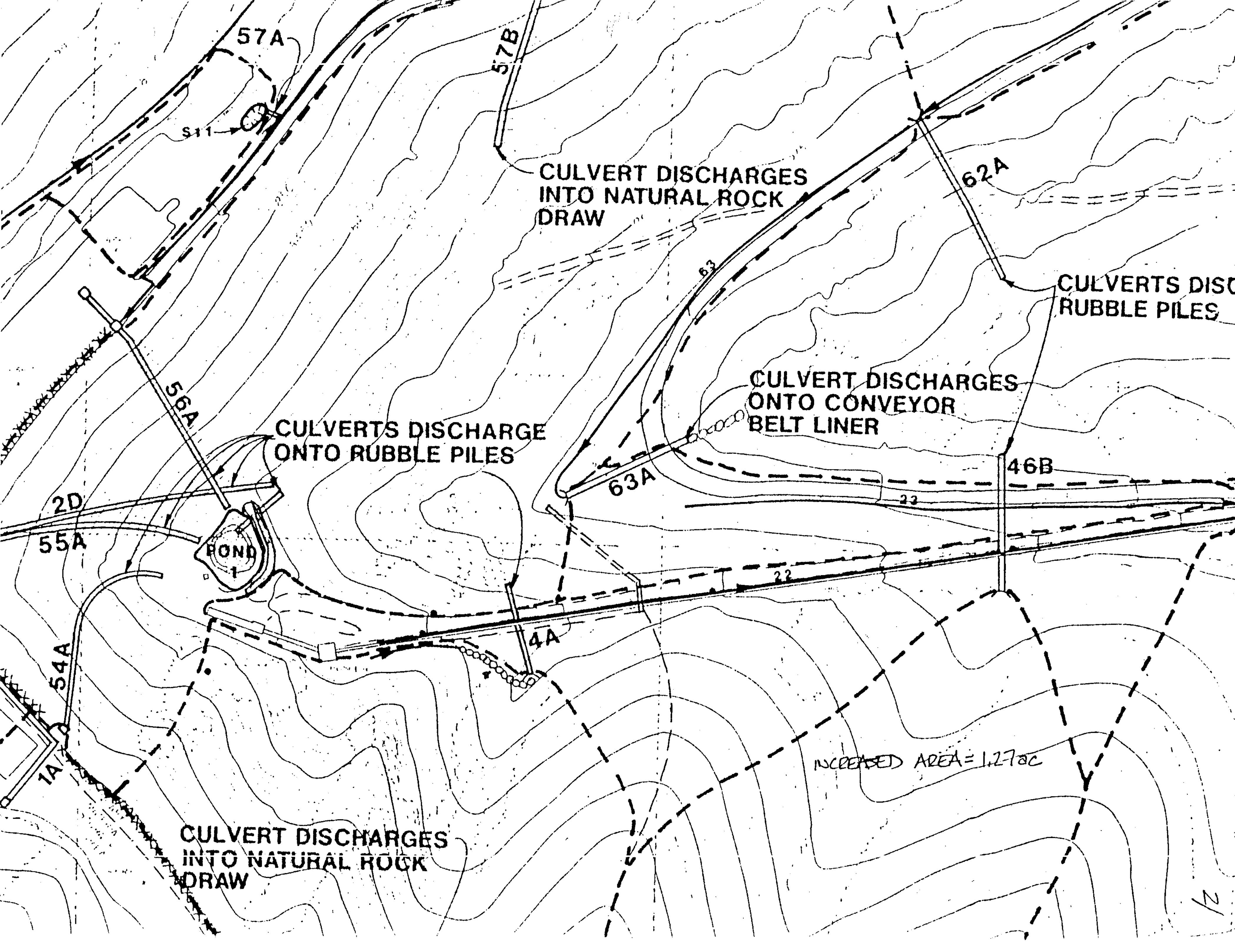
full flow Conditions: Q = 65 cfs >> 11.5 cfs OK

Check size req'd down Slope : S ~ 30%

φ (in)	Q (cfs)
27	92
18	31.2
12	10.6

A = 1.77 P = 4.71 R = 0.38 V = 17.6

Could use 18"



57A
57B
S11
CULVERT DISCHARGES
INTO NATURAL ROCK
DRAW
62A
CULVERTS DISC
RUBBLE PILES
63
CULVERT DISCHARGES
ONTO CONVEYOR
BELT LINER
56A
CULVERTS DISCHARGE
ONTO RUBBLE PILES
2D
55A
POND
1
63A
46B
23
22
4A
54A
1A
INCREASED AREA = 1.27 ac
CULVERT DISCHARGES
INTO NATURAL ROCK
DRAW
N

PROJECT : Plateau Mining Company - Ditch 4A - New Location East 200 feet

AREA= 25.6 ACRES
AVERAGE BASIN SLOPE= 76.5 PERCENT
CURVE NUMBER= 75.0
DESIGN STORM= 2.10 INCHES
STORM DURATION= 24.0 HOURS
HYDRAULIC LENGTH= 1910. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TP= .0787 HOURS   QPCFS= 246.11 CFS   QPIN= 9.5339 INCHES
C3= 46.9926   ITERATIONS= 8   SCS 24-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
11.53	.6456	.0000	.0000	.0	.00
11.55	.6707	.0000	.0000	12.3	.00
11.56	.6958	.0003	.0002	76.4	.00
11.58	.7209	.0009	.0006	163.4	.03
11.60	.7460	.0018	.0010	225.9	.10
11.61	.7711	.0032	.0013	246.1	.25
11.63	.7962	.0048	.0017	230.5	.48
11.64	.8213	.0069	.0020	194.6	.80
11.66	.8464	.0092	.0023	152.2	1.19
11.67	.8715	.0119	.0027	112.3	1.63
11.69	.8967	.0148	.0030	79.2	2.11
11.71	.9218	.0181	.0033	53.8	2.61
11.72	.9469	.0217	.0036	35.4	3.12
11.74	.9720	.0256	.0039	22.7	3.64
11.75	.9971	.0298	.0042	14.3	4.16
11.77	1.0222	.0343	.0045	8.8	4.68
11.78	1.0473	.0390	.0047	5.3	5.18
11.80	1.0724	.0440	.0050	3.2	5.68
11.82	1.0975	.0493	.0053	1.9	6.17
11.83	1.1226	.0549	.0055	1.1	6.65
11.85	1.1477	.0607	.0058	.6	7.12
11.86	1.1729	.0667	.0061	.4	7.59
11.88	1.1980	.0730	.0063	.2	8.04
11.89	1.2231	.0796	.0065	.1	8.48
11.91	1.2482	.0864	.0068	.0	8.92
11.93	1.2733	.0934	.0070	.0	9.34
11.94	1.2984	.1007	.0073	.0	9.76
11.96	1.3235	.1081	.0075	.0	10.17
11.97	1.3486	.1158	.0077	.0	10.57
11.99	1.3737	.1237	.0079	.0	10.97
12.00	1.3935	.1301	.0064	.0	11.33
12.02	1.3983	.1317	.0016	.0	11.52
12.04	1.4031	.1332	.0016	.0	11.22
12.05	1.4078	.1348	.0016	.0	10.35
12.07	1.4126	.1364	.0016	.0	9.09

PROJECT : Plateau Mining Company - Ditch 4A - New Location East 200 feet
(Continued)

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
12.08	1.4173	.1380	.0016	.0	7.71
12.10	1.4221	.1396	.0016	.0	6.42
12.11	1.4268	.1412	.0016	.0	5.33

HYDROGRAPH PEAK= 11.52 cfs
TIME TO PEAK= 12.02 Hours
RUNOFF VOLUME= .92 Acre-Feet

Check Inlet Control on 18" Section

HW/D = 2.4' Required. (3.6') (7.5' drop from Inlet to Bend exists @ 15% pipe grade)

$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$

Calculate Slope friction in 27" Pipe

$\frac{11.5(.024)}{1.49} = AR^{2/3} S^{1/2}$

A = full Pipe = $\pi(2.25)^2/4$ = 3.98 ft^2
P = π D = π(2.25) = 7.07 ft
R = A/P = 0.56

$S_f = \left(\frac{11.5(.024)}{1.49(3.98)(.56)^{2/3}}\right)^2 = 0.0047$ ft/ft

friction Head = 0.23' (Using a 50' Pipe Section)

Available Head = 7.5 - .23 = 7.27' > 3.6' Reqd - OK

(USE 18" Lower Section)

Culvert 23B

Existing Dia = 30" Q = 16.4 cfs

@ HW/D = 1.0 , Dia Reqd = 30"

Calculate Slope friction (Maximum) $S_f = \left(\frac{Q n}{1.49 A R^{2/3}}\right)^2$

A = $\pi D^2/4$ = 4.91 P = πD = 7.85 R = 0.63

$S_f = \left(\frac{16.4 * .024}{1.49(4.91)(.63)^{2/3}}\right)^2 = 0.0054$ ft/ft

Pipe Length = 225' - Use 250' (Conservative)

Friction Head loss ~ 250 * S_f = 1.35'

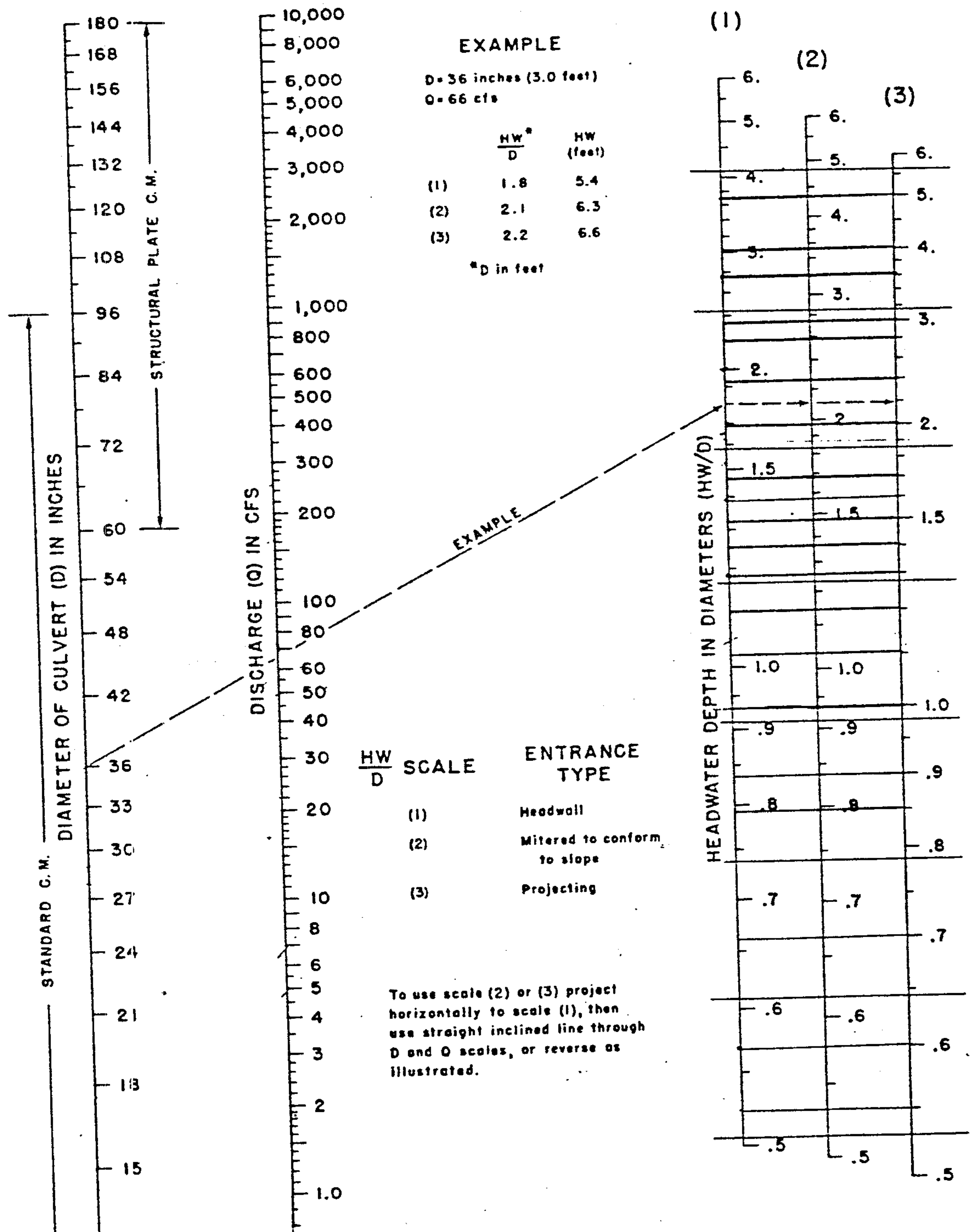
Available Head = 0.057 * 200' = 11.4' (200' used as conservative value)
Pipe Slope

11.4 - 1.35 ~ 10.0' Available for inlet control head.

An 18" CMP would require HW/D = 4.5 to pass the given flow

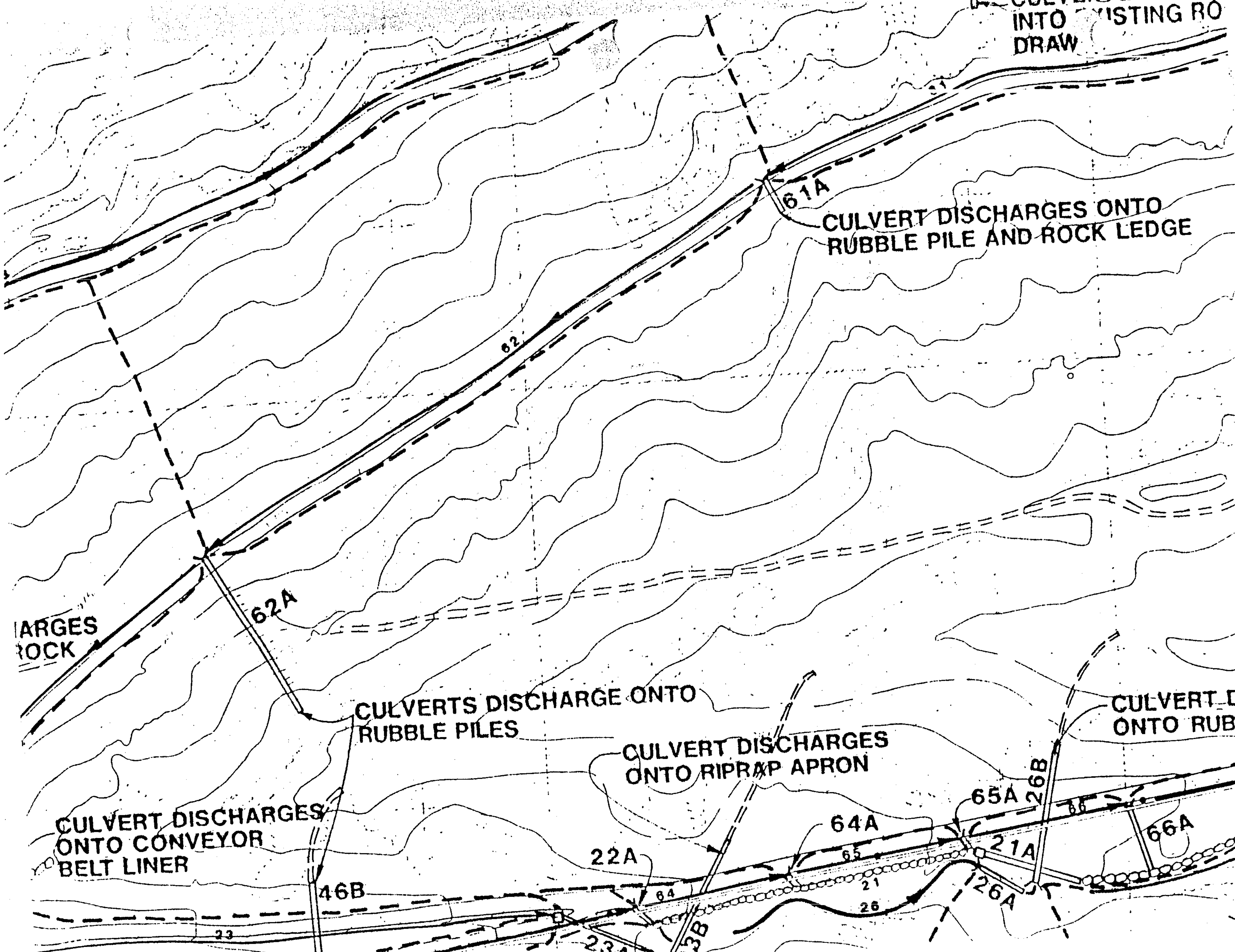
4.5 * 1.5 = 6.75' < 10.0' OK - Would pass

CHART 5



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL



INTO ISTING RO
DRAW
61A
CULVERT DISCHARGES ONTO
RUBBLE PILE AND ROCK LEDGE
62
62A
ARGES
ROCK
CULVERTS DISCHARGE ONTO
RUBBLE PILES
CULVERT DISCHARGES
ONTO RIPRAP APRON
CULVERT D
ONTO RUB
CULVERT DISCHARGES
ONTO CONVEYOR
BELT LINER
46B
22A
64A
65A
26B
66A
21A
26A
65
21
26
64
23
66

Although an 18" CMP would pass the flow, a 21" CMP would reduce the upstream head by approx. 47% and thereby reduce the risk of a pipe separation failure

If a 21" CMP is Used, HW/D = 2.4 and Head = 3.6'

Recommend using a 21" CMP

Culvert 26B

Existing Dia = 30"   Q = 5.7 cfs   Pipe Length = 209'

Max. S_f in 30" ϕ pipe

$$S_f = \left(\frac{Q\,n}{1.49\,A\,R^{2/3}}\right)^2 = \left(\frac{5.7(.024)}{1.49(4.91)(.63)^{2/3}}\right)^2 = 0.00065$$

Pipe Length = 209'

Friction Head Loss = 209(.00065) = 0.14 ft

Available Head = 209 * 0.139 = 29.0'

Available Head for Inlet Control: 29.0 - 0.14 = 28.9'

Using an 18" CMP, HW/D = 1.0' ok

Culvert 46B

Existing Dia = 30"   Q = 6.2 cfs   Pipe Length = 211'   S = 0.176

Max S_f in 30" ϕ Pipe

$$S_f = \left(\frac{6.2(.024)}{1.49(4.91)(.63)^{2/3}}\right)^2 = 0.00077$$

Friction Head Loss = 0.00077 (211) = 0.16'

Available Head = 211 * 0.176 = 37.1 ft

Using an 18" CMP   HW/D = 1.1' ok

NOTE: CARE MUST BE MADE AT REDUCTION JOINTS TO PREVENT SEPARATION FAILURE DUE TO HYDRAULIC HEADS.

EXHIBIT 54

REFUSE PILE DITCH
+ CULVERT CALCS.

CYPRUS
Plateau Mining

Cyprus Plateau Mining Corporation
P.O. Drawer PMC
Price, Utah 84501
(801) 637-2875

July 26, 1989

Mr. Tom Munson
Utah Department of Natural Resources
Division of Oil, Gas and Mining
355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, UT 84180-1203

Re: Inlet Protection Culverts 7F and 6B, Additional Copies of Culvert 6B Design and Ditch 7G and Culvert 7G Designs

Dear Mr. Munson:

In confirmation of our phone conversation today, I am enclosing three additional copies of the designs for Culvert 6B, Ditch 7G, and Culvert 7G.

You said Bob Lauman's letter dated July 21, 1989, was adequate to document inlet protection at Culvert 6B. A similar treatment will be made at Culvert 7F; rock with a mean diameter of 0.5 feet will be placed in the channel at the inlet for a distance of 10 feet upstream. A trash rack constructed of 1/2 inch diameter rebar or 5/8 inch roof bolts will be placed at the inlet end of the culvert.

Construction of the new Ditch 7G and Culvert 7G will be completed within 30 days of receipt of approval of the design from the Division.

I suggest adding these amendments as a new exhibit (Exhibit 54) along with my June 15, 1989, submittal. Six copies of the List of Exhibits page showing this addition are enclosed.

Six copies of this letter are enclosed for insertion in PAP sets. If you need anything further, give me a call.

Respectfully,

Ben Grimes
Sr. Environmental Engineer

/kam

Enclosures

Chrono: BG890703

File: ENV 2-5-2-12

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining
by T. Munson date 7/31/89

CYPRUS
Plateau Mining

Cyprus Plateau Mining Corporation
P.O. Drawer PMC
Price, Utah 84501
(801) 637-2875

July 21, 1989

RECEIVED
JUL 25 1989
DIVISION OF
OIL, GAS & MINING

Mr. Tom Munson, Reclamation Hydrologist
State of Utah Natural Resources
Division of Oil, Gas and Mining
3 Triad Center, Suite 350
Salt Lake City, UT 84180-1203

Re: 1989 Minor Ditch Modifications

Dear Tom:

Following your phone call, I checked on the progress of the downspout to Ditch 6B. The culvert is installed with tension cable and inlet. The berm is about 4 feet high and 3 feet wide on top. The berm slope runs about 30 feet to the east and 6 feet to the inlet side.

The crew is using natural rock to face the berm at the inlet; about 95 percent of the rock ranges from 8 inches to 4 feet on the flat side dimension and greater than 6 inches thick. About 5 percent of the rock is less than 5 inches in diameter. They have used about 3 $yds.^3$ of rock.

The trash rack will be built about 20 feet up the ditch on the outside curve. The rack will consist of 5 foot long, 3/4 inch and 5/8 inch roof bolts driven into the ditch bottom with horizontal bars wired to the uprights. Bar centers will be 6 inches to 8 inches.

The crew expects to be complete on this project by Tuesday afternoon, July 25. The culvert for Ditch #7 will be initiated thereafter, contingent upon other maintenance priorities.

Sincerely,

Bob Lauman

Robert G. Lauman
Manager, Technical Services

/kam

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining
by T. Munson date 7/31/89

cc: Ben Grimes
Bill Warmack, DOGM-Price

File: 2-5-2-16-25

CYPRUS
Plateau Mining

Cyprus Plateau Mining Corporation
P.O. Drawer PMC
Price, Utah 84501
(801) 637-2875

June 15, 1989

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining
by T. Munson date 7/3/89

Mr. Richard Smith
Utah Department of Natural Resources
Division of Oil, Gas and Mining
355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, UT 84180-1203

Re: Add Culvert Downspout at Ditch 6C,
Revised Location and Design for Ditch 7G, and
Revised Design Data for Ditches Surrounding Refuse Pile

Dear Mr. Smith:

Please find enclosed calculations and revised Map 42, Map B, Sheet 2 of 3, showing the location and design details for a new culvert 6B at the south end of ditch 6C (formerly called ditch 6B). This culvert needs to be added to prevent erosion from occurring during runoff events. The culvert will consist of a 24 inch diameter inlet section 20 feet long, and an 18 inch diameter culvert from there to the drainage channel.

Construction of culvert 6B will be completed by July 19, 1989, as stated in a memorandum from Mr. Bob Lauman to Mr. Bill Malencik and Mr. Henry Sauer dated May 19, 1989.

Also find enclosed calculations for ditch 7G and culvert 7F, which replace ditch 7E at the west side of the refuse pile. This new ditch is consistent with the overall refuse pile plan as presented in the MRP. The refuse pile is expanding westward, which requires the new ditch and culvert. Copies of Map 42, Map A, Sheet 2 of 3, and Map 42, Map B, Sheet 2 of 3, are enclosed showing the location of ditch 7G and culvert 7F and design details for both. Culvert 7F will consist of a 12 inch pipe running to ditch 7H.

Also find enclosed calculations for ditches 6C (formerly 6B), 8, 16, 32, 33, and 76, using the 100-year 6-hour storm. As mentioned previously, ditch 7E is being replaced with ditch 7G. These calculations have been made after much consultation with Tom Munson as to design criteria and methodology. It is our understanding that the criteria and methodology used are correct, even though the peak flows and velocities differ from those included in a memorandum from Tom Munson to yourself dated May 17, 1989. Tom's calculations were made using the existing ditches' configurations.

Tom's peak flows are generally higher than ours. Tom indicated that ditch 6B (now 6C) has potentially erosive flows in its steeper reaches, but did not recommend rip rap. Since our flows and velocities are lower, we anticipate no major erosion. We will monitor the steep areas and will initiate erosion protection if a problem arises.

Tom's analysis of ditches 8, 16, 32, 33, and 76 showed that the existing ditches were "within the Division's guidelines for erosion protection and conveyance of the 100-year 6-hour storm." Since our peak flows and velocities are lower, the existing ditch configurations are more than adequate to carry the flows.

Tom analyzed all of the existing culverts associated with these ditches and found them to "be well in excess of design requirements... with the 100-year, 6-hour storm criteria." Since our calculations show less flow than Tom's, the culverts do have excess capacities.

Tables 76A and 76B have been modified to reflect the changes discussed herein and are being sent under separate cover by Hansen, Allen and Luce, Inc.

The section of ditch 7E which has been under a variance issued by the Division on January 8, 1986, has been noted on Map 42, Map A, Sheet 2 of 3, as requested by Tom Munson.

Three copies of the calculations and maps are enclosed. When the Division is satisfied that all is well, additional copies will be provided for distribution to other agencies.

Sincerely,

Ben Grimes
Sr. Environmental Engineer

/kam

Enclosures

Chrono: BG890602

File: ENV 2-5-2-12
NOV File

HANSEN ALLEN & LUCE inc

CLIENT: PLATEAU
PROJECT: 89 MISC
FEATURE: DITCH 6B CULVERT
PROJECT NO.: 002.06.100

COMPUTED: DEH
CHECKED:
DATE: 22 MAY 89

SIZE DOWNSPOUT CULVERT AT END OF DITCH 6B - REQUESTED 5/22/89 BY BEN GRIMES.

FROM 1988 MISC HYDROLOGY FILE: (Hydro Run duplicated for this project - attached)

$Q_{100\,YR-6\,HR} = 16.77$ cfs.

CHECK USING CMP L: 560'

DITCH 6B: depth = 1.5'; B = 2.5', m = 1.3 (Existing design)

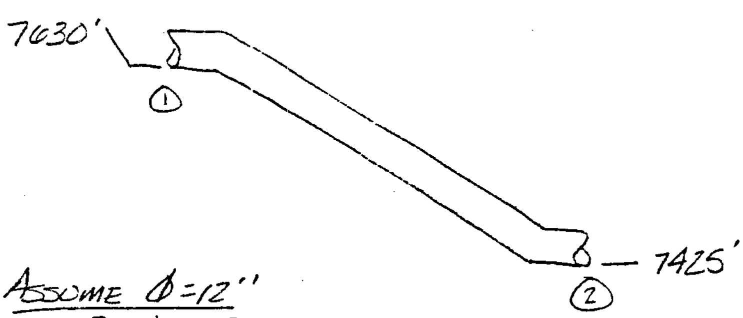
For D = 18", HW/D = 1.0 $Q_{inlet} \sim 5.5$ cfs << 16.7 cfs

Using HW/D = 1.0; D req'd = 30" (Q_{max} = 20 cfs)

Check HW Req'd for Various CMP Sizes

Dia (in)	HW/D	HW (ft)
12	N/A	N/A
18	4.3	6.5
21	2.4	4.2
24	1.4	2.8 *
27	1.1	2.5
30	0.9	2.25

CHECK REQUIRED SIZE DOWN SLOPE



ΔH ~ 205'

APPROVED AMENDMENT TO Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining
by [signature] date 7/31/89

ASSUME Ø = 12"

$E_1 - h_L = E_2$

$E = y + \frac{V^2}{2g} + z$ Assume $V_1 = 0$, $y_1 = 2.5'$ (HW DEPTH) $E_1 = Z_1 = 7632.5$

Entrance loss ~ $0.4\frac{V^2}{2g}$

PROJECT : Plateau Mining Company - Ditch 6R - 100 Year, 6 Hour Storm

AREA= 85.3 ACRES
AVERAGE BASIN SLOPE= 34.0 PERCENT
CURVE NUMBER= 75.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS
HYDRAULIC LENGTH= 6850. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TP= .2601 HOURS   QPCFS= 248.02 CFS   QPIN= 2.8834 INCHES
CJ= 14.2125   ITERATIONS= 8   SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.13	.6565	.0000	.0000	.0	.00
2.18	.7335	.0013	.0013	12.4	.02
2.24	.8105	.0060	.0046	77.0	.16
2.29	.8875	.0137	.0078	164.6	.67
2.34	.9645	.0244	.0107	227.7	1.79
2.39	1.0415	.0379	.0135	248.0	3.65
2.44	1.1185	.0539	.0160	232.3	6.22
2.50	1.1955	.0724	.0185	196.1	9.38
2.55	1.2196	.0787	.0063	153.4	12.78
2.60	1.2404	.0842	.0056	113.2	15.45
2.65	1.2612	.0900	.0057	79.8	16.77
2.71	1.2820	.0959	.0059	54.2	16.77
2.76	1.3028	.1019	.0061	35.7	15.93
2.81	1.3236	.1082	.0062	22.9	14.74
2.86	1.3444	.1145	.0064	14.4	13.55
2.91	1.3652	.1210	.0065	8.9	12.56
2.97	1.3860	.1277	.0067	5.4	11.84
3.02	1.4055	.1340	.0064	3.2	11.36
3.07	1.4221	.1396	.0055	1.9	11.06
3.12	1.4388	.1452	.0056	1.1	10.82
3.17	1.4554	.1509	.0057	.6	10.57
3.23	1.4721	.1567	.0058	.4	10.33
3.28	1.4887	.1626	.0059	.2	10.11
3.33	1.5054	.1686	.0060	.1	9.95
3.38	1.5220	.1747	.0061	.0	9.84

HYDROGRAPH PEAK= 16.77 cfs
TIME TO PEAK= 2.71 Hours
RUNOFF VOLUME= 2.70 Acre-feet

: Friction Loss $= \frac{f l V^2}{2g}$ for CMP $\frac{\epsilon}{D} = \frac{0.5}{12} = 0.04$; $\phi = 12''$

$f \sim 0.065$

$$h_L = 0.065(560)\frac{V^2}{2g} = 36.4\frac{V^2}{2g}$$

Exit Loss: $\frac{V^2}{2g}$

$$7632.5 = \left(0.4\frac{V^2}{2g} + 36.4\frac{V^2}{2g} + \frac{V^2}{2g}\right) + 7425 = 37.8\frac{V^2}{2g} + 7425$$

$V^2 = 353.5$ ∴ $V = 18.8$ fps in a 12" ϕ CMP
∴ $Q = VA = 18.8 \frac{\pi}{4}(1)^2 = 14.8$ cfs

TOO SMALL

Enlarge to 18" $\frac{\epsilon}{D} = \frac{0.5}{18} = 0.03$ ∴ $f \sim 0.058$

$$h_{L\,pipe} = 0.058(560)\frac{V^2}{2g} = 32.48\frac{V^2}{2g}$$

$$7632.5 = \left(1.4\frac{V^2}{2g} + 32.48\frac{V^2}{2g}\right) + 7425$$

$V^2 = 394.4$

$V = 19.9$ fps

$Q = VA = V\left(\frac{\pi(1.5)^2}{4}\right) = 35.1$ cfs

35.1 cfs > 17 cfs OK

Could reduce to 15" CMP?

$f_{15''} \sim 0.061$

$fl \simeq 0.061(560) = 34.16$

$$\frac{(7632.5 - 7425)\,2g}{(1.4 + 34.16)} = V^2$$

$V = 19.4$ fps

$Q = V\frac{\pi(1.25)^2}{4} = 23.8$ cfs > 17 cfs

OK

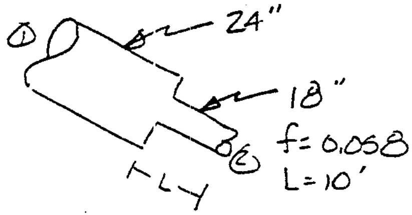
If Transition from 24" to 18" Check Required Head:

RECOMMEND USING 18" DOWNSPOUT

HANSEN ALLEN & LUCE inc

CLIENT: PLATEAU
PROJECT:
FEATURE:
PROJECT NO.: 002.06.100

COMPUTED: DEH
CHECKED:
DATE: 23 MAY 89



$\Delta H = H_L = 1.4\frac{v^2}{2g} + f\frac{L}{d}\frac{v^2}{2g}$

$\Delta H = \frac{v^2}{2g}\left(1.4 + 0.058(10)\right) = 1.98\frac{v^2}{2g}$

$V_{max} = 19.9$ fps (in 18" section)

$V_{des} = 17/\pi(1.5)^2/4 = 9.6$ fps

$\Delta H = 1.98\frac{(9.6)^2}{2g} = 2.85$ ft (Under design flow)

$\Delta H = 1.98\frac{(19.9)^2}{2g} = 12.2$ ft (Under max. pipe flow)

PLACE TRANSITION ~10' DOWNSTREAM (VERTICALLY)

<u>CHECK JOINT FORCE</u> - @ 100 YR - 6 HR STORM

<u>$\Sigma F = \rho Q \Delta V$</u> $Q = 17$ cfs ; $\rho = 1.94$

$A_1 = \pi(2)^2/4 = \pi$; $A_2 = \pi(1.5)^2/4 = 1.77 ft^2$

$V_1 = Q/A_1 = 17/\pi = 5.41$ fps

$V_2 = Q/A_2 = 17/1.77 = 9.62$ fps

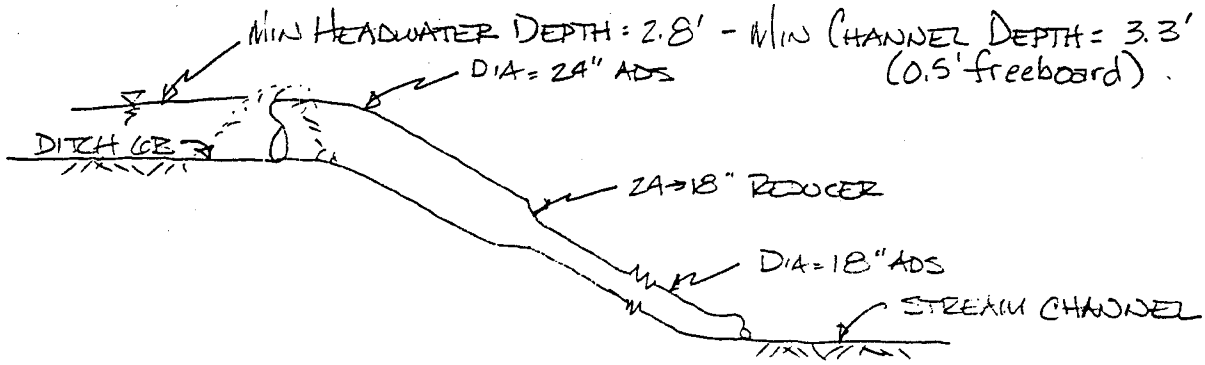
$\Sigma F = 1.94(17)(9.62 - 5.41) = 139$ lb

Pressure = 139 lb / $(\pi - 1.77)$ * 144 = <u>0.7 psi</u>

<u>Check Static Pressure</u> if downstream plugs (Assume 20' upper section is used)

Press = 20' * 62.4 $\frac{lb}{ft^3}$ * $\frac{ft^2}{144 in^2}$ = 8.67 psi

HYDROSTATIC FORCE + WATER PRESSURE = 0.7 + 8.7 = <u>9.4 psi</u>



CONSULTANTS/ENGINEERS
HANSEN ALLEN & LUCE INC
6771 SOUTH 900 EAST
P.O. BOX 21146
SALT LAKE CITY, UTAH 84121-0146
(801) 566-5599

June 13, 1989

Mr. Ben Grimes
Environmental Coordinator
Plateau Mining Company - PMC 41
Wattis, Utah

RE: Ditch 7G Redesign.

Dear Ben:

Please find attached the calculation sheets for Ditch 7G which we have redesigned as requested last week. The modified portion of the upper ditch section has been designed with a one percent slope starting at an elevation of 7560 feet, and ending at the saddle to the south at an elevation of 7545 feet. Based upon the flow calculations attached, a 12 inch CMP pipe is sufficient to carry the design flow to the lower section, however, a larger diameter pipe should perhaps be considered if there is a potential for debris plugging.

Calculations indicate that overall flow rates have been reduced from previous calculations due to 1) the diversion of some of the flow into Pond 9, and 2) the reduction in curve number resulting from an increase in size of the refuse pile. With the modified flow rates, only two ditch sections require riprap. The first is at the outlet of the downspout (requiring a mean riprap size of 0.5 feet) and the other is at the extreme lower section of the ditch where slopes are greater than 7 percent (requiring a mean riprap size of 0.75 feet). As a result of this modified design we have been able to 1) reduce the channel width in the lower section, 2) reduce the size of, or eliminate the riprap in the lower ditch section, and 3) place loose riprap at the outlet to the downspout in lieu of grouted riprap. A summary of design details is shown on the last page of the calculation sheets.

Should you find that the location of surface facilities as shown on the map in the attached calculation sheets, or the assumptions made require modification, please let us know so that appropriate corrections can be made.

Sincerely,

David E. Hansen

David E. Hansen, Ph.D., P.E.

DEH/dh

Enclosures

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining
date ________
by ________

DITCH 7G (Old section 7G Lower named within as 7E)

REDESIGN BASED UPON NEED TO GET ABOVE THE NEW ACCESS ROAD ENTERING FROM N.W. PLACE AT ABOUT THE 7550' CONTOUR. DESIGN ALSO USING SCS 6-HOUR RUNOFF EVENT.

6 HOUR PRECIPITATION = 2.0 inches
AREA = 6.15 ac (Upper); = 23.4 ac (Lower)
HYD. LENGTH = 1720' (Upper); = 2600' (Lower)
CN = 75 (Undisturbed); = 70 (Coal Refuse)
SLOPE:

$$\text{Upper} = \frac{11280 * 10 * 100}{43560 * 6.15} = 42.1\%$$

$$\text{Lower} = \frac{12280 * 10 * 100}{43560 * 23.4} = 12.1\%$$ (Assume pile is flat from 7500' Elev)

Q WEIGHT CN for LOWER SECTION; BASE UPON UNDIST AREA ABOVE 7500' CONTOUR ELEV, AND COAL PILE BELOW.

AREA UNDIST = 12.61 ac
AREA DIST = 23.4 − 12.61 = 10.8 ac

$A_1 = 12.61$ $A_2 = 10.8$
$CN_1 = 75$ $CN_2 = 70$
$P = 2.0$
$Q_1 = 0.38$ $Q_2 = 0.24$ $\bar{Q} = 0.32$

CN = 73

RUNOFF

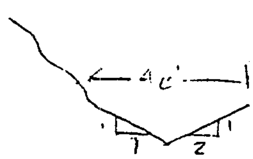
UPPER: 1.8 cfs

LOWER: 3.4 cfs

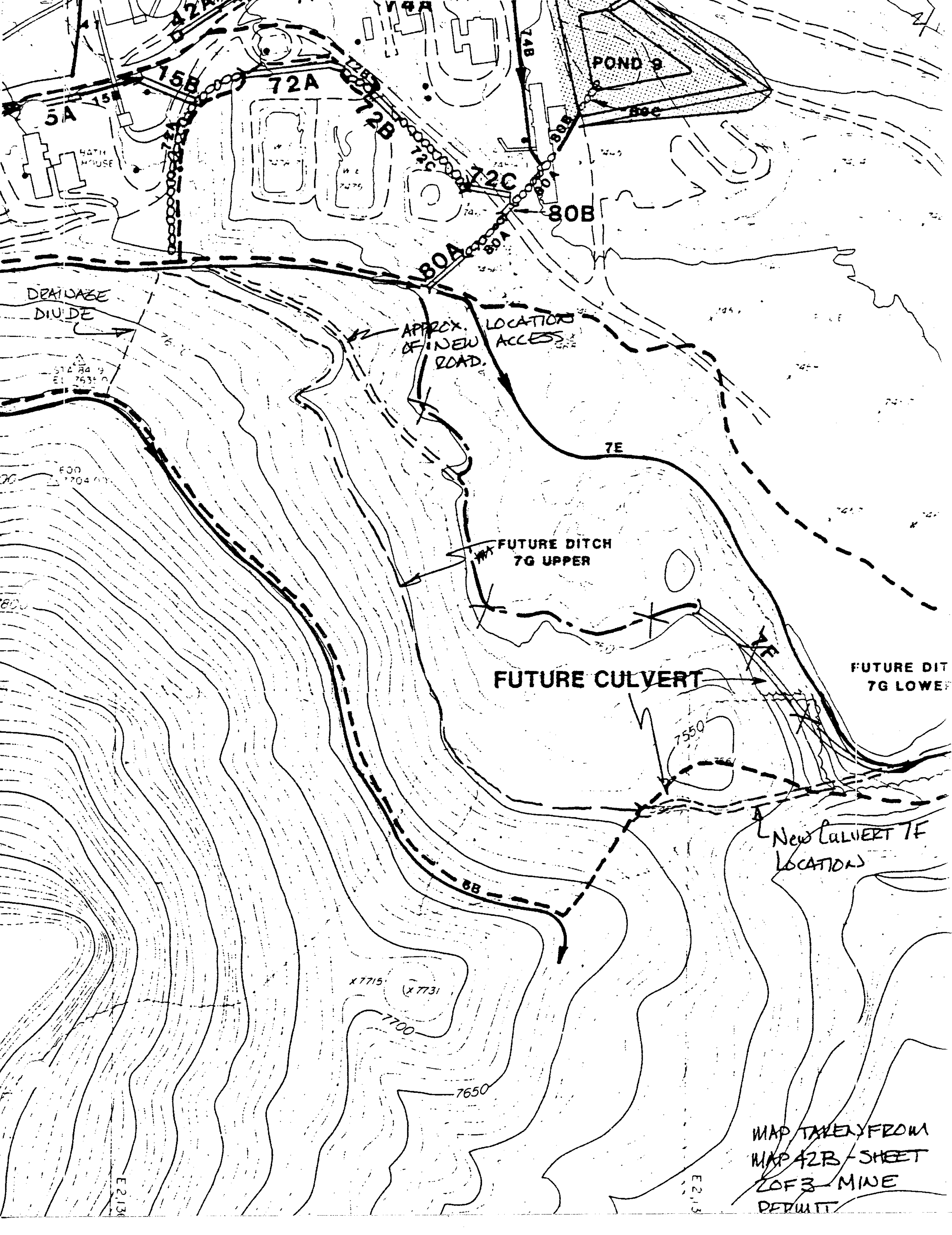
DESIGN OF UPPER SECTION

PLACE ON 1% SLOPE; PRINTOUT INDICATES VEL ~ 2.9 fps @ 2% Slope
∴ RIPRAP NOT NEEDED. (VEL ~ 2.2 fps @ 1% Slope)

MIN DEPTH = 1.25'
SIDE SLOPES = 1:1; 2:1



USE 1:1 (DITCH TO BE CUT W/CAT BLADE)



42A
74B
POND 9
80C
15B
72A
72B
5A
15
BATH HOUSE
72A
72C
72C
80B
80A
80B
80A
80A
DRAINAGE DIVIDE
APPROX. LOCATION OF NEW ACCESS ROAD.
7E
FUTURE DITCH 7G UPPER
7F
FUTURE CULVERT
FUTURE DIT
7G LOWE
7550
New Culvert 7F Location
6B
x 7715
x 7731
7700
7650
MAP TAKEN FROM MAP 42B - SHEET 2 OF 3 - MINE PERMIT

3/12

PROJECT : Plateau Mining Company - Modified Ditch 7G - 06/12/89

AREA= 6.2 ACRES
AVERAGE BASIN SLOPE= 42.2 PERCENT
CURVE NUMBER= 75.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS (100YR-6HR)
HYDRAULIC LENGTH= 1720. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TC= .0975 HOURS QPCFS= 47.72 CFS QPIN= 7.6956 INCHES
CI= 37.9316 ITERATIONS= 8 SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.12	.6443	.0000	.0000	.0	.00
2.14	.6731	.0000	.0000	2.4	.00
2.16	.7020	.0004	.0004	14.8	.00
2.18	.7308	.0012	.0008	31.7	.00
2.20	.7597	.0025	.0013	43.8	.03
2.22	.7885	.0043	.0018	47.7	.07
2.24	.8174	.0065	.0022	44.7	.13
2.26	.8462	.0092	.0027	37.7	.21
2.28	.8751	.0123	.0031	29.5	.31
2.30	.9039	.0158	.0035	21.8	.42
2.32	.9327	.0197	.0039	15.4	.54
2.34	.9616	.0240	.0043	10.4	.67
2.36	.9904	.0287	.0047	6.9	.80
2.38	1.0193	.0337	.0051	4.4	.93
2.40	1.0481	.0392	.0054	2.8	1.06
2.42	1.0770	.0450	.0058	1.7	1.19
2.44	1.1058	.0511	.0062	1.0	1.31
2.46	1.1347	.0576	.0065	.6	1.44
2.48	1.1635	.0645	.0068	.4	1.56
2.49	1.1924	.0716	.0072	.2	1.68
2.51	1.2057	.0750	.0034	.1	1.78
2.53	1.2135	.0771	.0020	.0	1.83
2.55	1.2213	.0791	.0021	.0	1.79
2.57	1.2291	.0812	.0021	.0	1.66
2.59	1.2369	.0833	.0021	.0	1.48
2.61	1.2447	.0854	.0021	.0	1.30
2.63	1.2525	.0876	.0021	.0	1.13
2.65	1.2603	.0897	.0022	.0	1.00

HYDROGRAPH PEAK= 1.83 cfs
TIME TO PEAK= 2.53 Hours
RUNOFF VOLUME= .19 Acre-Feet

[illegible] : Plateau Mining Company - Modified Ditch 70 Lower - 06/12/89

AREA= 23.4 ACRES
AVERAGE BASIN SLOPE= 12.1 PERCENT
CURVE NUMBER= 73.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS (100YR-6HR)
HYDRAULIC LENGTH= 2600. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TC= .2679 HOURS QPCFS= 66.06 CFS QPIN= 2.7995 INCHES
CN= 13.7986 ITERATIONS= 8 SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.14	.6719	.0000	.0000	.0	.00
2.20	.7512	.0000	.0000	3.3	.00
2.25	.8305	.0022	.0021	20.5	.00
2.30	.9098	.0075	.0053	43.9	.06
2.36	.9891	.0158	.0083	60.6	.23
2.41	1.0684	.0268	.0111	66.1	.57
2.46	1.1477	.0405	.0137	61.9	1.10
2.52	1.2073	.0525	.0119	52.2	1.79
2.57	1.2287	.0571	.0046	40.9	2.52
2.63	1.2502	.0619	.0048	30.1	3.07
2.68	1.2716	.0669	.0050	21.2	3.35
2.73	1.2930	.0720	.0051	14.4	3.37
2.79	1.3145	.0773	.0053	9.5	3.24
2.84	1.3359	.0828	.0055	6.1	3.05
2.89	1.3573	.0884	.0056	3.8	2.86
2.95	1.3788	.0941	.0058	2.4	2.71
3.00	1.4001	.1001	.0059	1.4	2.61
3.05	1.4173	.1049	.0049	.9	2.55
3.11	1.4344	.1099	.0049	.5	2.51
3.16	1.4516	.1149	.0050	.3	2.46
3.21	1.4687	.1200	.0051	.2	2.41
3.27	1.4859	.1253	.0052	.0	2.37

HYDROGRAPH PEAK= 3.37 cfs
TIME TO PEAK= 2.73 Hours
RUNOFF VOLUME= .62 Acre-Feet

Trapezoidal Channel Flow Calculations using Mannings Equation

Client:	Plateau Mining Company	Date:	14-Jun-89
Project No.:	002.06.100	Time:	09:37 AM
Channel Section:	Ditch 7B	Computed:	DEH

			UNITS
GENERAL CRITERIA:	Design Flow:	1.83	cfs.
	Bottom Width:	0.0	feet
	Side Slope1:	1.0	1/m1
	Side Slope2:	2.0	1/m2
	Friction Factor:	0.030	
	Min. Bottom Slope:	0.010	ft/ft
	Max. Bottom Slope:	0.020	ft/ft
	Freeboard:	0.50	feet
CALCULATION:	Depth (Min. S):	0.74	feet
(Channel Depth)	Qn/1.49(S)1/2=	0.369	
	A(R)2/3=	0.371	
	Required Depth:	1.24	feet
	Area:	0.82	ft2
	Perimeter:	2.70	feet
	Hydraulic Radius:	0.30	feet
	Velocity:	2.23	ft/sec
	Riprap Ck (V<5?):	Not Needed	
CALCULATION:	Depth (Max. S):	0.65	feet
(Velocity Check)	Qn/1.49(S)1/2=	0.261	
	A(R)2/3=	0.263	
	Required Depth:	1.15	feet
	Area:	0.63	ft2
	Perimeter:	2.37	feet
	Hydraulic Radius:	0.27	feet
	Velocity:	2.89	ft/sec
	Riprap Ck (V<5?):	Not Needed	

DESIGN CRITERIA:	Bottom Width:	0.0	feet
	Side Slope 1:	1.0	1/m1
	Side Slope 2:	2.0	1/m2
	Min. Bottom Slope:	1.0	%
	Max. Bottom Slope:	2.0	%
	Min Channel Depth:	1.24	feet
	Riprap (Min S):	Not Needed	
	Riprap (Max S):	Not Needed	

HANSEN ALLEN & LUCE INC

CLIENT: PLATEAU
PROJECT: DITCH 76 REDESIGN
FEATURE:
PROJECT NO.: 002.06.100

SHEET 6 OF 12
COMPUTED: DEH
CHECKED:
DATE: 6/12/87

CULVERT SIZING

FOR FLOW RATE OF 1.83 cfs - A CULVERT $\phi = 1.0'$ IS ADEQUATE.

$Q_{CAP} = 2.1$ cfs.

BASED UPON THE RELATIVELY SHORT PERIOD OF TIME (~2 YRS) THE CULVERT WILL BE IN BEFORE BEING COVERED BY THE REFUSE PILE, THE 12" PIPE IS PROBABLY ACCEPTABLE, GENERALLY IT WOULD BE MORE DESIREABLE TO INSTALL AN 18" LINE TO PREVENT DEBRIS PLUGGING.

CULVERT INLET ELEV ~ 7545'
" OUTLET " ~ 7450'
" LENGTH ~ 480'

DESIGN OF LOWER SECTION

SLOPES: MIN = 6.7%, MAX = 20.0% } w/ Q = 3.37 cfs, Riprap will be Required. Use Trapezoidal Channel with bottom Width = 3.0'

for Mild Sections (ie: S ~ 6.7%)

No Riprap Required for $M_1 = M_2 = 2.0'$
b = 3.0'
Channel Depth = 1.0'

for Steep Sections (ie: S > 7%)

from Chart 27 US DOT "Design of Stable Channels with Flexible Linings"

$D_{50} = 0.5(1.5) = \underline{0.75'}$

Angle of Repose (Chart 30) ~ 42°

$\frac{\tau_{max}}{\tau_{bottom}}$ (Chart 31)   B/d = 3.0/0.23 = 13.04

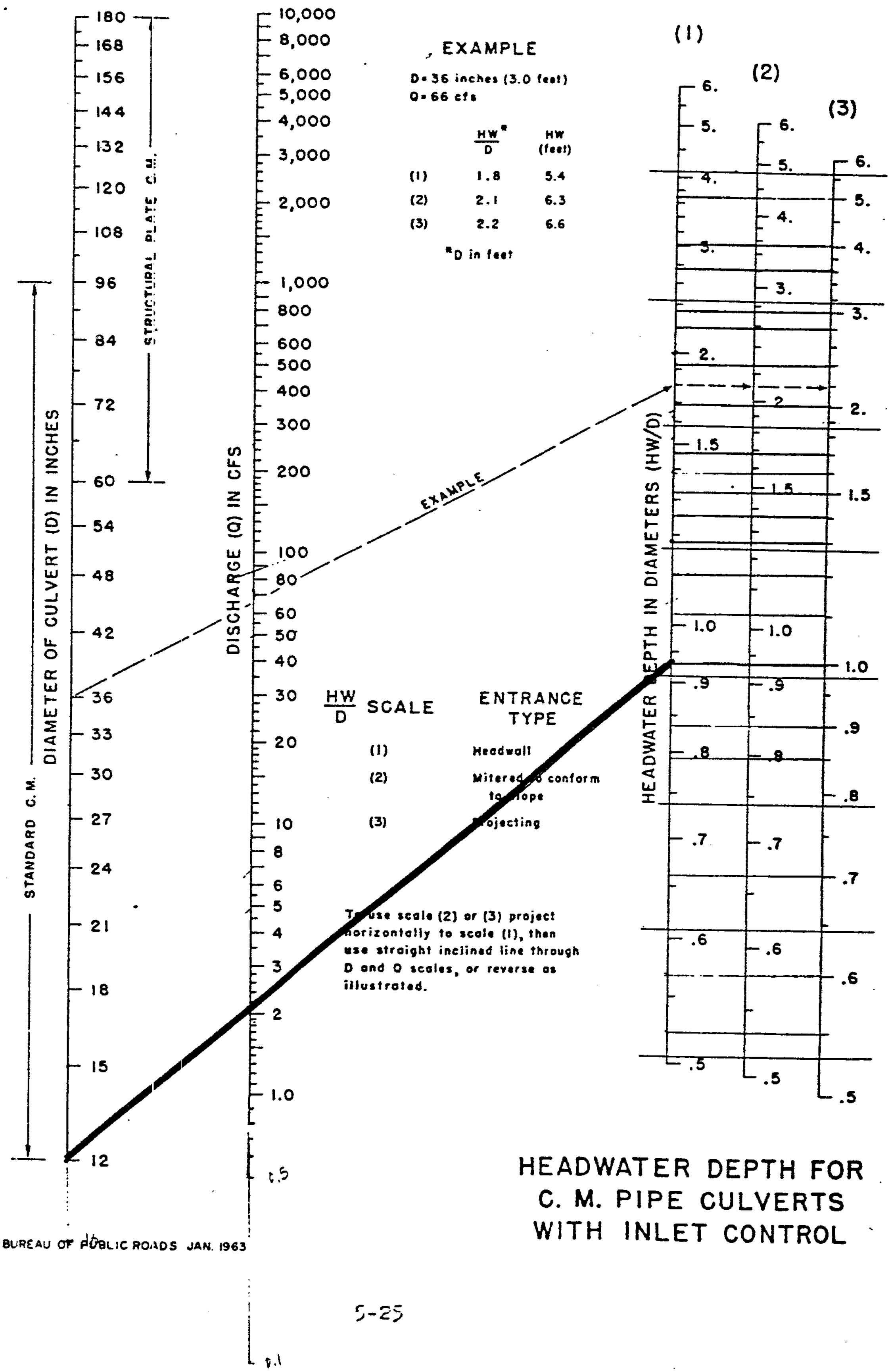
$\underline{K_1 \sim 0.78}$

$\frac{\tau_{critical\ side}}{\tau_{critical\ bottom}}$ (Chart 32) $\underline{K_2 \sim 0.74}$

Side Slope Multiplier = 0.78/0.74 = 1.05   1.05 * 0.75 = 0.79

(STAY WITH 0.75' D50)

CHART 5



HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

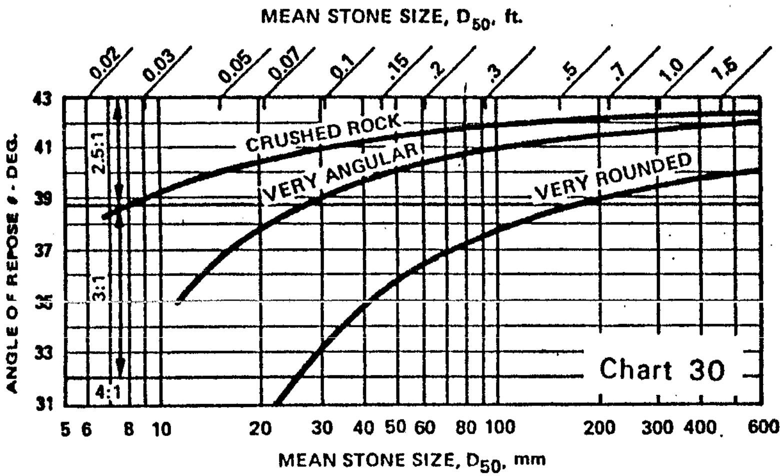
Trapezoidal Channel Flow Calculations using Mannings Eq

Client:	Plateau Mining Company	Date:	
Project No.:	002.06.100	Time:	
Channel Section:	Ditch 7E	Computed:	

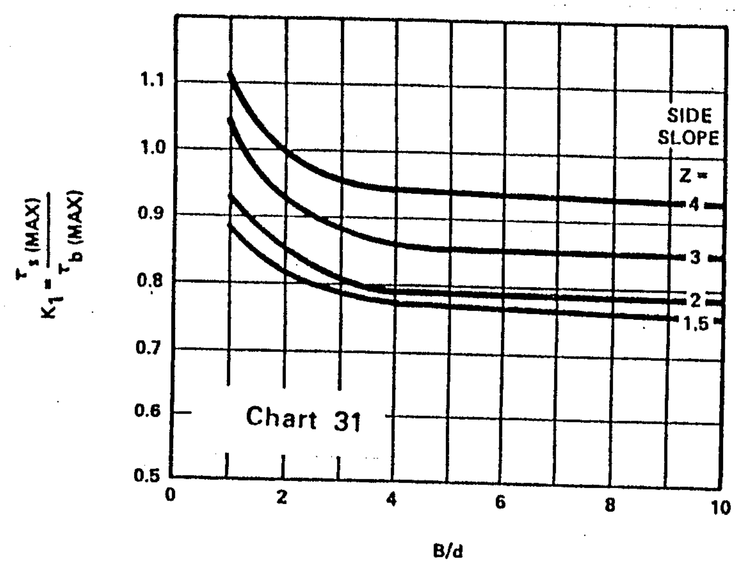
			UNITS
GENERAL CRITERIA:	Design Flow:	3.37	cfs
	Bottom Width:	3.0	feet
	Side Slope1:	2.0	1/m1
	Side Slope2:	2.0	1/m2
	Friction Factor:	0.030	
	Min. Bottom Slope:	0.067	ft/ft
	Max. Bottom Slope:	0.200	ft/ft
	Freeboard:	0.50	feet
CALCULATION: (Channel Depth)	Depth (Min. S):	0.23	feet
	Qn/1.49(S)1/2=	0.263	
	A(R)2/3=	0.270	
	Required Depth:	0.73	feet
	Area:	0.80	ft2
	Perimeter:	4.03	feet
	Hydraulic Radius:	0.20	feet
	Velocity:	4.23	ft/sec
	Riprap Ck (V<5?):	Not Needed	
GENERAL CRITERIA:	Design Flow:	3.37	cfs
	Bottom Width:	3.0	feet
	Side Slope1:	2.0	1/m1
	Side Slope2:	2.0	1/m2
	Friction Factor:	0.038	
	Min. Bottom Slope:	0.067	ft/ft
	Max. Bottom Slope:	0.200	ft/ft
	Freeboard:	0.50	feet
CALCULATION: (Velocity Check)	Depth (Max. S):	0.19	feet
	Qn/1.49(S)1/2=	0.193	
	A(R)2/3=	0.195	
	Required Depth:	0.69	feet
	Area:	0.64	ft2
	Perimeter:	3.85	feet
	Hydraulic Radius:	0.17	feet
	Velocity:	5.25	ft/sec
	Riprap Ck (V<5?):	Required	

DESIGN CRITERIA:	Bottom Width:	3.0	feet
	Side Slope 1:	2.0	1/m1
	Side Slope 2:	2.0	1/m2
	Min. Bottom Slope:	6.7	%
	Max. Bottom Slope:	20.0	%
	Min Channel Depth:	0.73	feet
	Riprap (Min S):	Not Needed	
	Riprap (Max S):	Required	

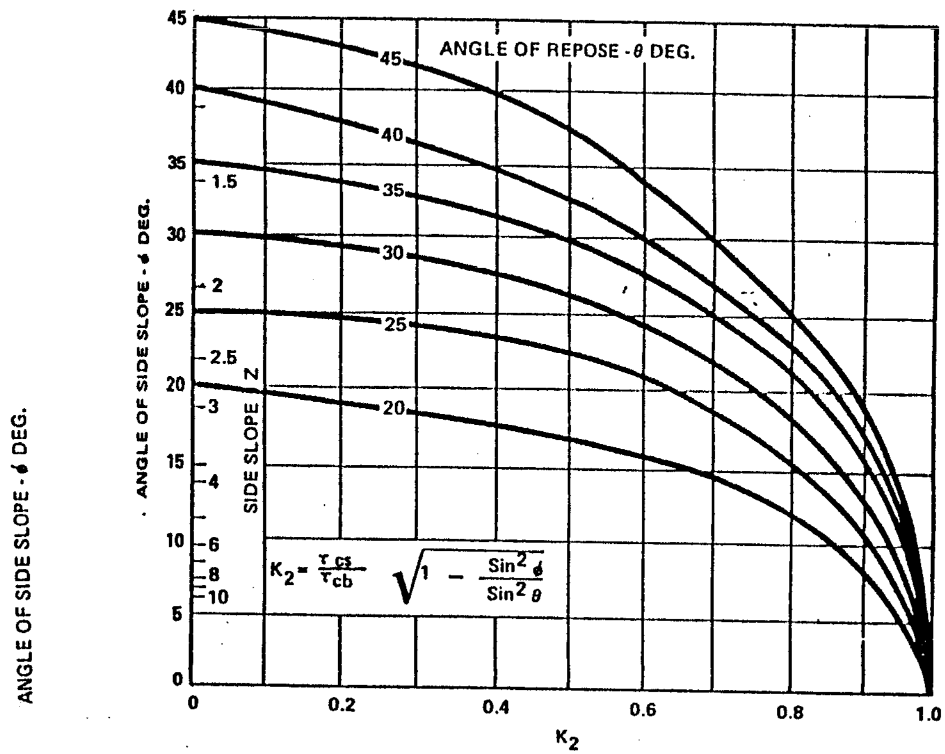
Chart 32



ANGLE OF REPOSE OF RIPRAP IN TERMS OF MEAN SIZE AND SHAPE OF STONE



DISTRIBUTION OF BOUNDARY SHEAR AROUND WETTED PERIMETER OF TRAPEZOIDAL CHANNELS



RATIO OF CRITICAL SHEAR ON SIDES TO CRITICAL SHEAR ON BOTTOM FOR NONCOHESIVE SEDIMENT

HANSEN ALLEN & LUCE INC

CLIENT PLATEAU
PROJECT DITCH 76
FEATURE
PROJECT NO. 002.04.100
SHEET 9 OF 12
COMPUTED DEH
CHECKED
DATE 12 JUN 89

CHECK DOWNSTREAM ENERGY DISSIPATION REQUIREMENTS

$Q_{PIPE} = 1.83\,cfs$ $\quad n = 0.024 \quad S \sim 25\%$ (at bottom end - last 100')
$D = 1.0'$

$Qn/1.49S^{1/2} = 0.059$

Y	$AR^{2/3}$	
0.2	0.027	A = 0.20
0.3	0.061 →	R = 0.17
		V = 9.23 fps

TW ~ 0.3' < 0.5 (D_{10}) use Figure 1-15

"Erosion & Sediment Control" - EPA 1976

According to figure; $d_{50} = 0.5'$

Apron Length ≐ 5.0' Horizontal Section

PLACE HORIZONTAL SECTION OF CMP AT END OF DOWNSPOUT TO 1) REDUCE VELOCITIES AND 2) CHANGE FLOW DIRECTION.

RIPRAP GRADATIONS - From "Urban Storm Drainage Criteria Manual" Wright-McLaughlin Eng's - Denver - 1969 VOL 2

Rock D_{50}	Designation	% Smaller By Weight	Intermediate Rock Size (in)	Comment
0.5'	VL.	70-100	12	FOR PLACEMENT AT END OF DOWNSPOUT
		50-70	9	
		35-50	6	
		2-10	2	
0.75	L	70-100	15	FOR PLACEMENT ON STEEP (S>7%) SECTIONS OF LOWER DITCH 7G
		50-70	12	
		35-50	9	
		2-10	3	

FILTER GRADATION - USE 12" LAYER TYPE II BEDDING

U.S. STD SIEVE SIZE	% PASSING BY WT
3"	90-100
3/4"	20-90
#4	0-20
#200	0-3

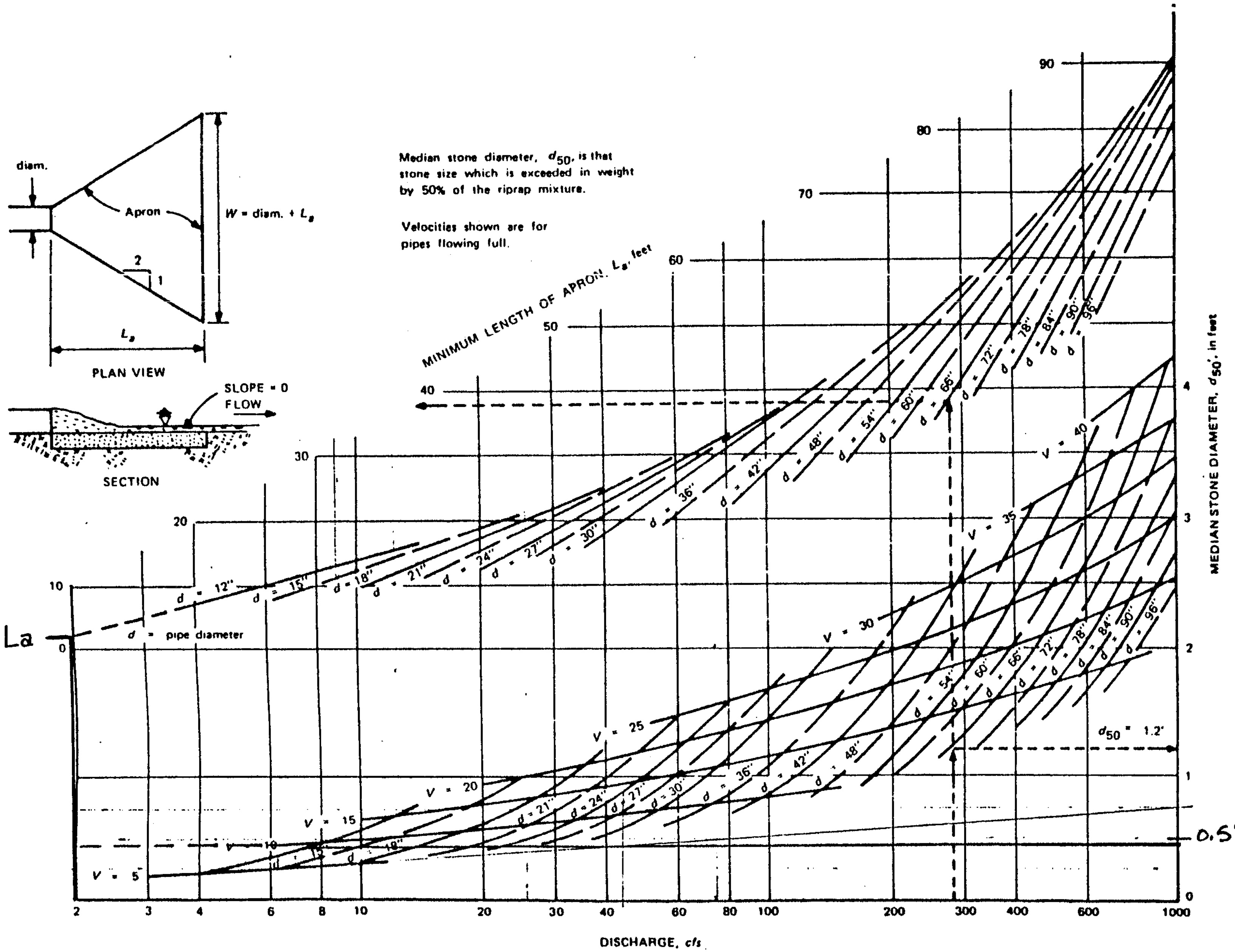


Figure I-15. Design of outlet protection – minimum tailwater condition ($T_W < 0.5$ diam.)[1]

11/12

HANSEN ALLEN & LUCE inc

CLIENT: PLATEAU
PROJECT: Ditch 7 (Revised)
FEATURE:
PROJECT NO. 002.06.100

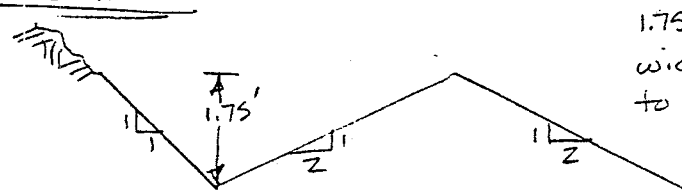
SHEET 12 OF 12
COMPUTED DEH
CHECKED
DATE 12 Jun 89

DITCH SUMMARY - 7G + 7E

Location	Slope(%)	b(ft)	m	D_{50}(ft)	L(ft)	Thickness(ft) Riprap	Thickness(ft) Filter	Depth(ft) Flow	Depth(ft) Ditch
7G	1.0	0	1;2	N/A	1500	N/A	N/A	0.65	1.75
7E	0.0	3.0	2	0.5	8.0*	1.0	1.0	-	1.0
7E	6.7	3.0	2	N/A	300	N/A	N/A	0.23	0.75
7E	20.0	3.0	2	0.75	120	1.5	1.0	0.19	0.75

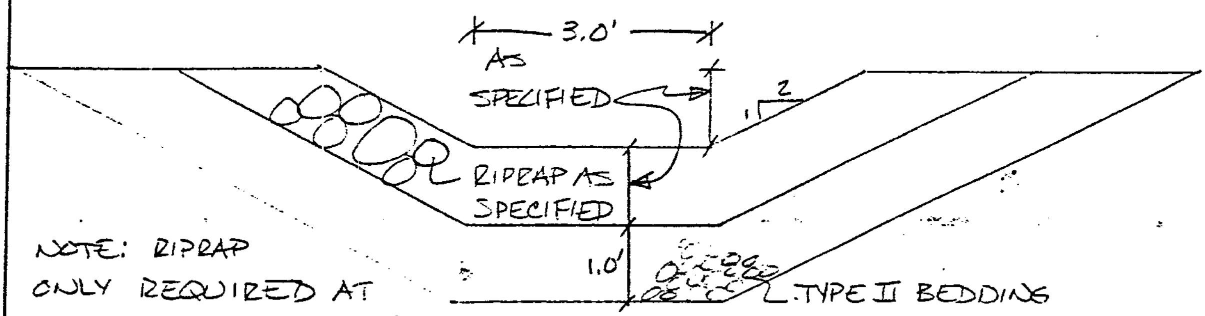
* Place riprap under last 3.0' of CMP, and for 5.0' downstream

TYPICAL SECTIONS



1.75' depth allows for width in outer embankment to prevent seep through

DITCH 7G



NOTE: RIPRAP ONLY REQUIRED AT CULVERT OUTFALL AND IN STEEP CHANNEL SECTION

DITCH 7E

CONSULTANTS/ENGINEERS
HANSEN ALLEN & LUCE INC
6771 SOUTH 900 EAST
P.O. BOX 21146
SALT LAKE CITY, UTAH 84121-0146
(801) 566-5599

June 14, 1989

Mr. Ben Grimes
Environmental Coordinator
Plateau Mining Company - PMC 41
Wattis, Utah

AMENDMENT TO
APPROVED Mining & Reclamation Plan
Approved, Division of Oil, Gas & Mining
by J. Munson date 7/31/89

RE: Refuse Pile Ditches.

Dear Ben:

Please find attached runoff and ditch redesign calculation sheets for the ditches impacting or impacted upon by the coal refuse pile. These ditches have been redesigned based upon the 100 year, 6 hour runoff event as requested earlier today. The first page of the calculations shows a table summary of the design data found in the remaining sheets. Note that the widths and channel side slopes used in the analysis are as shown by DOGM except for the maximum and minimum channel slopes for Ditch 16. The channel slopes for Ditch 16 were taken from prior data shown on the base map because the value shown by DOGM was substantially higher than that shown previously and it is thought to perhaps be in error.

Also note that a new ditch number (6C) has been used for the old ditch 6B located immediately above the coal refuse pile. This new number was assigned because of the confusion which would result between the ~~24~~ 25 year and 100 year runoff design requirements between the upper and lower sections of old Ditch 6B. Technically speaking, the upper section of Ditch 6B should be able to use the old design runoff value (24 hour event) since it is the lower portion (new Ditch 6C) which actually diverts the flow around the refuse pile. We felt that if the ditch sections are not separated, it leaves the door open for DOGM to require a more stringent design on the upper section of old Ditch 6B based upon the 100 year event.

6-15-89 D. HANSEN

We hope that this information provides the clarity required to meet State regulations. Let us know if you find that you need further clarification regarding the design calculations included.

Sincerely,

David E. Hansen

David E. Hansen, Ph.D., P.E.

DEH/dh

DITCH 6C ETC.

100 YR, 6HR EVENT RUN BUT DITCH NEVER DESIGNED. DESIGN ANEW.

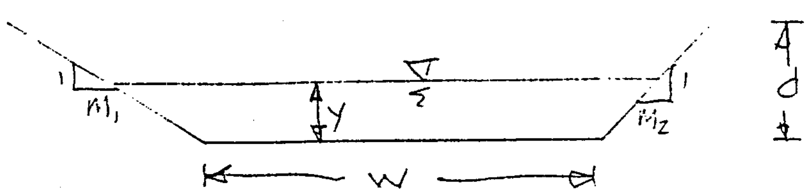
Q_{DESIGN} = 16.77cfs SEE SHEET 2

CHANNEL CRITERIA: SEE SHEET 3 (DESIGNED ACCORDING TO EXISTING DATA –)

BUILD SUMMARY TABLE FOR REFUSE PILE DITCHES BASED UPON 100 YR, 6HR STORM

DITCH NO.	W* (ft)	M_1 1/m	M_2 1/m	S_{min} (ft/ft)	Y (ft)	d (ft)	S_{max} (ft/ft)	V_{max} (fps)	Q (cfs)	SEE SHEET
6C	2.5	2	2	0.01	1.0	1.5	0.02	4.5	16.77	2,3
8	0.1	9.0	1.5	0.08	0.25	0.75	0.12	4.1	1.23	4,5
16(All)	0.1	1.8	6.3	0.045	0.32	0.82	0.095	4.1	1.38	6,7
32	0.6	4.4	0.7	0.10	0.1	0.6	0.10	2.7	0.12	8,9
33	0.6	1.2	6.0	0.06	0.1	0.6	0.06	1.6	0.20	10,11
76	0.1	11.7	0.8	0.12	0.13	0.63	0.12	3.0	0.35	12,13

* As reported by DOGM



PROJECT : Plateau Mining Company - Ditch ~~2R~~ 6C - 100 Year. 6 Hour Storm

AREA= 85.3 ACRES
AVERAGE BASIN SLOPE= 54.0 PERCENT
CURVE NUMBER= 75.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS
HYDRAULIC LENGTH= 6850. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TP= .2601 HOURS QPCFS= 248.02 CFS QPIN= 2.8834 INCHES
CP= 14.2125 ITERATIONS= 8 SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.13	.6565	.0000	.0000	.0	.00
2.18	.7335	.0013	.0013	12.4	.02
2.24	.8105	.0060	.0046	77.0	.16
2.29	.8875	.0137	.0078	164.6	.67
2.34	.9645	.0244	.0107	227.7	1.79
2.39	1.0415	.0379	.0135	248.0	3.65
2.44	1.1185	.0539	.0160	232.3	6.22
2.50	1.1955	.0724	.0185	196.1	9.38
2.55	1.2196	.0787	.0063	153.4	12.78
2.60	1.2404	.0842	.0056	113.2	15.45
2.65	1.2612	.0900	.0057	79.8	16.77
2.71	1.2820	.0959	.0059	54.2	16.77
2.76	1.3028	.1019	.0061	35.7	15.93
2.81	1.3236	.1082	.0062	22.9	14.74
2.86	1.3444	.1145	.0064	14.4	13.55
2.91	1.3652	.1210	.0065	8.9	12.56
2.97	1.3860	.1277	.0067	5.4	11.84
3.02	1.4055	.1340	.0064	3.2	11.36
3.07	1.4221	.1396	.0055	1.9	11.06
3.12	1.4388	.1452	.0056	1.1	10.82
3.17	1.4554	.1509	.0057	.6	10.57
3.23	1.4721	.1567	.0058	.4	10.33
3.28	1.4887	.1626	.0059	.2	10.11
3.33	1.5054	.1686	.0060	.1	9.95
3.38	1.5220	.1747	.0061	.0	9.84

HYDROGRAPH PEAK= 16.77 cfs
TIME TO PEAK= 2.71 Hours
RUNOFF VOLUME= 2.70 Acre-Feet

3/13

Trapezoidal Channel Flow Calculations using Mannings Equation

Client: Plateau Mining Company
Project No.: 002.06.100
Channel Section: ~~6B~~ 6C

Date: 14-Jun-89
Time: 02:34 PM
Computed: DEH

			UNITS
GENERAL CRITERIA:	Design Flow:	16.77	cfs
	Bottom Width:	2.5	feet
	Side Slope1:	2.0	1/m1
	Side Slope2:	2.0	1/m2
	Friction Factor:	0.030	
	Min. Bottom Slope:	0.010	ft/ft
	Max. Bottom Slope:	0.020	ft/ft
	Freeboard:	0.50	feet
CALCULATION: (Channel Depth)	Depth (Min. S):	1.00	feet
	Qn/1.49(S)1/2=	3.386	
	A(R)2/3=	3.361	
	Required Depth:	1.50	feet
	Area:	4.50	ft2
	Perimeter:	6.97	feet
	Hydraulic Radius:	0.65	feet
	Velocity:	3.73	ft/sec
	Riprap Ck (V<5?):	Not Needed	
CALCULATION: (Velocity Check)	Depth (Max. S):	0.84	feet
	Qn/1.49(S)1/2=	2.394	
	A(R)2/3=	2.389	
	Required Depth:	1.34	feet
	Area:	3.51	ft2
	Perimeter:	6.26	feet
	Hydraulic Radius:	0.56	feet
	Velocity:	4.78	ft/sec
	Riprap Ck (V<5?):	Not Needed	

DESIGN CRITERIA:	Bottom Width:	2.5	feet
	Side Slope 1:	2.0	1/m1
	Side Slope 2:	2.0	1/m2
	Min. Bottom Slope:	1.0	%
	Max. Bottom Slope:	2.0	%
	Min Channel Depth:	1.50	feet
	Riprap (Min S):	Not Needed	
	Riprap (Max S):	Not Needed	

PROJECT : Plateau Mining Company - Ditch 8 100Yr-6Hr Runoff

AREA= 12.3 ACRES
AVERAGE BASIN SLOPE= 20.0 PERCENT
CURVE NUMBER= 70.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS
HYDRAULIC LENGTH= 2080. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TP= .1893 HOURS QFCFS= 49.14 CFS QPIN= 3.9622 INCHES
CN= 19.5296 ITERATIONS= 8 SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.23	.8056	.0000	.0000	.0	.00
2.27	.8617	.0000	.0000	2.5	.00
2.31	.9177	.0008	.0008	15.3	.00
2.35	.9737	.0031	.0022	32.6	.02
2.38	1.0298	.0067	.0036	45.1	.07
2.42	1.0858	.0116	.0049	49.1	.18
2.46	1.1418	.0177	.0062	46.0	.35
2.50	1.1978	.0251	.0074	38.9	.58
2.54	1.2146	.0275	.0024	30.4	.85
2.57	1.2297	.0298	.0023	22.4	1.08
2.61	1.2448	.0322	.0024	15.8	1.21
2.65	1.2600	.0346	.0024	10.7	1.23
2.69	1.2751	.0371	.0025	7.1	1.19
2.73	1.2903	.0398	.0026	4.5	1.13
2.76	1.3054	.0424	.0027	2.8	1.05
2.80	1.3206	.0452	.0028	1.8	.99
2.84	1.3357	.0481	.0029	1.1	.95
2.88	1.3508	.0510	.0029	.6	.92
2.91	1.3660	.0540	.0030	.4	.91
2.95	1.3811	.0571	.0031	.2	.92
2.99	1.3963	.0602	.0032	.1	.92
3.03	1.4091	.0630	.0027	.0	.94

HYDROGRAPH PEAK= 1.23 cfs
TIME TO PEAK= 2.65 Hours
RUNOFF VOLUME= .25 Acre-feet

Trapezoidal Channel Flow Calculations using Mannings Equation

Client: Plateau Mining Company
Project No.: 002.06.100
Channel Section: 8

Date: 14-Jun-89
Time: 11:24 AM
Computed: DEH

			UNITS
GENERAL CRITERIA:	Design Flow:	1.23	cfs
	Bottom Width:	0.1	feet
	Side Slope1:	9.0	1/m1
	Side Slope2:	1.5	1/m2
	Friction Factor:	0.030	
	Min. Bottom Slope:	0.080	ft/ft
	Max. Bottom Slope:	0.120	ft/ft
	Freeboard:	0.50	feet
CALCULATION: (Channel Depth)	Depth (Min. S):	0.25	feet
	Qn/1.49(S)1/2=	0.088	
	A(R)2/3=	0.086	
	Required Depth:	0.75	feet
	Area:	0.35	ft2
	Perimeter:	2.81	feet
	Hydraulic Radius:	0.13	feet
	Velocity:	3.48	ft/sec
	Riprap Ck (V<5?):	Not Needed	
CALCULATION: (Velocity Check)	Depth (Max. S):	0.23	feet
	Qn/1.49(S)1/2=	0.072	
	A(R)2/3=	0.071	
	Required Depth:	0.73	feet
	Area:	0.30	ft2
	Perimeter:	2.60	feet
	Hydraulic Radius:	0.12	feet
	Velocity:	4.09	ft/sec
	Riprap Ck (V<5?):	Not Needed	

DESIGN CRITERIA:	Bottom Width:	0.1	feet
	Side Slope 1:	9.0	1/m1
	Side Slope 2:	1.5	1/m2
	Min. Bottom Slope:	8.0	%
	Max. Bottom Slope:	12.0	%
	Min Channel Depth:	0.75	feet
	Riprap (Min S):	Not Needed	
	Riprap (Max S):	Not Needed	

PROJECT : Plateau Mining Company - Ditch 16 (All) 100Yr-6Hr Runoff

AREA= 15.2 ACRES
AVERAGE BASIN SLOPE= 21.0 PERCENT
CURVE NUMBER= 70.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS
HYDRAULIC LENGTH= 2680. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TP= .2262 HOURS QPCFS= 50.81 CFS QPIN= 3.3149 INCHES
C3= 16.3392 ITERATIONS= 8 SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.26	.8484	.0000	.0000	.0	.00
2.31	.9154	.0008	.0008	2.5	.00
2.35	.9823	.0036	.0028	15.8	.02
2.40	1.0493	.0082	.0047	33.7	.08
2.44	1.1163	.0148	.0065	46.6	.22
2.49	1.1832	.0231	.0083	50.8	.45
2.53	1.2136	.0274	.0043	47.6	.76
2.58	1.2317	.0301	.0027	40.2	1.06
2.62	1.2498	.0330	.0029	31.4	1.27
2.67	1.2679	.0359	.0030	23.2	1.37
2.71	1.2860	.0390	.0031	16.3	1.38
2.76	1.3041	.0422	.0032	11.1	1.33
2.81	1.3222	.0455	.0033	7.3	1.27
2.85	1.3403	.0489	.0034	4.7	1.22
2.90	1.3584	.0525	.0035	2.9	1.18
2.94	1.3765	.0561	.0036	1.8	1.16
2.99	1.3946	.0599	.0038	1.1	1.15
3.03	1.4101	.0632	.0033	.7	1.16
3.08	1.4246	.0664	.0032	.4	1.17
3.12	1.4391	.0696	.0032	.2	1.17
3.17	1.4536	.0729	.0033	.1	1.16
3.21	1.4680	.0762	.0034	.0	1.15

HYDROGRAPH PEAK= 1.38 cfs
TIME TO PEAK= 2.71 Hours
RUNOFF VOLUME= .30 Acre-Feet

Trapezoidal Channel Flow Calculations using Mannings Equation

Client: Plateau Mining Company
Project No.: 002.06.100
Channel Section: A16 (A11)

Date: 14-Jun-89
Time: 03:14 PM
Computed: DEH

			UNITS
GENERAL CRITERIA:	Design Flow:	1.38	cfs
	Bottom Width:	0.1	feet
	Side Slope1:	1.8	1/m1
	Side Slope2:	6.3	1/m2
	Friction Factor:	0.030	
	Min. Bottom Slope:	0.045	ft/ft
	Max. Bottom Slope:	0.095	ft/ft
	Freeboard:	0.50	feet
CALCULATION: (Channel Depth)	Depth (Min. S):	0.32	feet
	Qn/1.49(S)1/2=	0.131	
	A(R)2/3=	0.131	
	Required Depth:	0.82	feet
	Area:	0.45	ft2
	Perimeter:	2.80	feet
	Hydraulic Radius:	0.16	feet
	Velocity:	3.09	ft/sec
	Riprap Ck (V<5?):	Not Needed	
CALCULATION: (Velocity Check)	Depth (Max. S):	0.28	feet
	Qn/1.49(S)1/2=	0.090	
	A(R)2/3=	0.093	
	Required Depth:	0.78	feet
	Area:	0.35	ft2
	Perimeter:	2.46	feet
	Hydraulic Radius:	0.14	feet
	Velocity:	3.99	ft/sec
	Riprap Ck (V<5?):	Not Needed	

DESIGN CRITERIA:	Bottom Width:	0.1	feet
	Side Slope 1:	1.8	1/m1
	Side Slope 2:	6.3	1/m2
	Min. Bottom Slope:	4.5	%
	Max. Bottom Slope:	9.5	%
	Min Channel Depth:	0.82	feet
	Riprap (Min S):	Not Needed	
	Riprap (Max S):	Not Needed	

PROJECT : Plateau Mining Company - Ditch 32 100Yr-6Hr Runoff

AREA= . .7 ACRES
AVERAGE BASIN SLOPE= 48.0 PERCENT
CURVE NUMBER= 70.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS
HYDRAULIC LENGTH= 280. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TP= .0246 HOURS QPCFS= 20.63 CFS QPIN=30.5326 INCHES
C3=150.4950 ITERATIONS= 8 SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.26	.8441	.0000	.0000	.0	.00
2.28	.8804	.0001	.0001	20.6	.00
2.31	.9168	.0008	.0007	6.6	.02
2.33	.9531	.0021	.0013	.7	.03
2.36	.9895	.0040	.0019	.0	.05
2.38	1.0258	.0064	.0024	.0	.06
2.41	1.0622	.0094	.0030	.0	.08
2.43	1.0985	.0129	.0035	.0	.09
2.46	1.1349	.0169	.0040	.0	.11
2.48	1.1712	.0214	.0045	.0	.12
2.51	1.2020	.0257	.0042	.0	.12
2.53	1.2119	.0271	.0014	.0	.06
2.55	1.2217	.0286	.0015	.0	.04
2.58	1.2315	.0301	.0015	.0	.04
2.60	1.2413	.0316	.0015	.0	.04
2.63	1.2512	.0332	.0016	.0	.04

HYDROGRAPH PEAK= .12 cfs
TIME TO PEAK= 2.48 Hours
RUNOFF VOLUME= .01 Acre-Feet

Trapezoidal Channel Flow Calculations using Mannings Equation

Client: Plateau Mining Company
Project No.: 002.06.100
Channel Section: 32

Date: 14-Jun-89
Time: 11:27 AM
Computed: DEH

			UNITS
GENERAL CRITERIA:	Design Flow:	0.20	cfs
	Bottom Width:	0.6	feet
	Side Slope1:	4.4	1/m1
	Side Slope2:	0.7	1/m2
	Friction Factor:	0.030	
	Min. Bottom Slope:	0.100	ft/ft
	Max. Bottom Slope:	0.100	ft/ft
	Freeboard:	0.50	feet
CALCULATION: (Channel Depth)	Depth (Min. S):	0.09	feet
	Qn/1.49(S)1/2=	0.013	
	A(R)2/3=	0.012	
	Required Depth:	0.59	feet
	Area:	0.07	ft2
	Perimeter:	1.11	feet
	Hydraulic Radius:	0.07	feet
	Velocity:	2.68	ft/sec
	Riprap Ck (V<5?):	Not Needed	
CALCULATION: (Velocity Check)	Depth (Max. S):	0.09	feet
	Qn/1.49(S)1/2=	0.013	
	A(R)2/3=	0.012	
	Required Depth:	0.59	feet
	Area:	0.07	ft2
	Perimeter:	1.11	feet
	Hydraulic Radius:	0.07	feet
	Velocity:	2.68	ft/sec
	Riprap Ck (V<5?):	Not Needed	
DESIGN CRITERIA:	Bottom Width:	0.6	feet
	Side Slope 1:	4.4	1/m1
	Side Slope 2:	0.7	1/m2
	Min. Bottom Slope:	10.0	%
	Max. Bottom Slope:	10.0	%
	Min Channel Depth:	0.59	feet
	Riprap (Min S):	Not Needed	
	Riprap (Max S):	Not Needed	

PROJECT : Plateau Mining Company - Ditch 33 100Yr-6Hr Runoff

AREA= 1.0 ACRES
AVERAGE BASIN SLOPE= 46.0 PERCENT
CURVE NUMBER= 70.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS
HYDRAULIC LENGTH= 250. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TP= .0229 HOURS QPCFS= 33.00 CFS QPIN=32.7262 INCHES
C3=161.3076 ITERATIONS= 8 SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.27	.8568	.0000	.0000	.0	.00
2.29	.8907	.0003	.0003	33.0	.00
2.31	.9246	.0010	.0008	10.6	.03
2.34	.9585	.0023	.0013	1.2	.05
2.36	.9924	.0041	.0018	.0	.07
2.38	1.0263	.0064	.0023	.0	.10
2.41	1.0602	.0092	.0028	.0	.12
2.43	1.0941	.0124	.0032	.0	.14
2.45	1.1280	.0161	.0037	.0	.16
2.47	1.1619	.0202	.0041	.0	.18
2.50	1.1958	.0248	.0046	.0	.20
2.52	1.2080	.0266	.0017	.0	.11
2.54	1.2172	.0279	.0014	.0	.07
2.57	1.2264	.0293	.0014	.0	.06
2.59	1.2355	.0307	.0014	.0	.06
2.61	1.2447	.0321	.0014	.0	.06
2.63	1.2539	.0336	.0015	.0	.07

HYDROGRAPH PEAK= .20 cfs.
TIME TO PEAK= 2.50 Hours
RUNOFF VOLUME= .02 Acre-Feet

Trapezoidal Channel Flow Calculations using Mannings Equation

Client: Plateau Mining Company
Project No.: 002.06.100
Channel Section: 33

Date: 14-Jun-89
Time: 11:26 AM
Computed: DEH

			UNITS
GENERAL CRITERIA:	Design Flow:	0.12	cfs
	Bottom Width:	0.6	feet
	Side Slope1:	12.1	1/m1
	Side Slope2:	1.2	1/m2
	Friction Factor:	0.030	
	Min. Bottom Slope:	0.060	ft/ft
	Max. Bottom Slope:	0.060	ft/ft
	Freeboard:	0.50	feet
CALCULATION: (Channel Depth)	Depth (Min. S):	0.07	feet
	Qn/1.49(S)1/2=	0.010	
	A(R)2/3=	0.010	
	Required Depth:	0.57	feet
	Area:	0.07	ft2
	Perimeter:	1.56	feet
	Hydraulic Radius:	0.05	feet
	Velocity:	1.61	ft/sec
	Riprap Ck (V<5?):	Not Needed	
CALCULATION: (Velocity Check)	Depth (Max. S):	0.07	feet
	Qn/1.49(S)1/2=	0.010	
	A(R)2/3=	0.010	
	Required Depth:	0.57	feet
	Area:	0.07	ft2
	Perimeter:	1.56	feet
	Hydraulic Radius:	0.05	feet
	Velocity:	1.61	ft/sec
	Riprap Ck (V<5?):	Not Needed	

DESIGN CRITERIA:	Bottom Width:	0.6	feet
	Side Slope 1:	12.1	1/m1
	Side Slope 2:	1.2	1/m2
	Min. Bottom Slope:	6.0	%
	Max. Bottom Slope:	6.0	%
	Min Channel Depth:	0.57	feet
	Riprap (Min S):	Not Needed	
	Riprap (Max S):	Not Needed	

PROJECT : Plateau Mining Company - Ditch 76 100Yr-6Hr Runoff

AREA= 1.0 ACRES
AVERAGE BASIN SLOPE= 36.3 PERCENT
CURVE NUMBER= 75.0
DESIGN STORM= 2.00 INCHES
STORM DURATION= 6.0 HOURS
HYDRAULIC LENGTH= 515. FEET
MINIMUM INFILTRATION RATE= .00 IN/HR

TP= .0400 HOURS QPCFS= 18.90 CFS QPIN=18.7402 INCHES
CN= 92.3703 ITERATIONS= 8 SCS 6-hour

TIME HOURS	ACCUMULATED RAINFALL INCHES	RUNOFF INCHES	RAINFALL EXCESS INCHES	UNIT HYDROGRAPH CFS	OUTFLOW HYDROGRAPH CFS
2.12	.6376	.0000	.0000	.0	.00
2.14	.6672	.0000	.0000	9.2	.00
2.16	.6968	.0003	.0003	18.9	.00
2.18	.7264	.0011	.0008	13.3	.01
2.20	.7560	.0023	.0013	6.1	.03
2.22	.7856	.0041	.0018	2.2	.05
2.24	.8152	.0063	.0022	.7	.08
2.26	.8448	.0090	.0027	.2	.10
2.28	.8744	.0122	.0031	.0	.12
2.30	.9040	.0158	.0036	.0	.15
2.32	.9336	.0198	.0040	.0	.17
2.34	.9632	.0242	.0044	.0	.19
2.36	.9928	.0291	.0048	.0	.21
2.38	1.0224	.0343	.0052	.0	.23
2.40	1.0520	.0399	.0056	.0	.25
2.42	1.0816	.0459	.0060	.0	.27
2.44	1.1112	.0523	.0064	.0	.29
2.46	1.1408	.0590	.0067	.0	.31
2.48	1.1704	.0661	.0071	.0	.33
2.50	1.2000	.0736	.0074	.0	.35
2.52	1.2080	.0756	.0021	.0	.31
2.54	1.2160	.0777	.0021	.0	.22
2.56	1.2240	.0798	.0021	.0	.15
2.58	1.2320	.0820	.0021	.0	.12
2.60	1.2400	.0841	.0022	.0	.11
2.62	1.2480	.0863	.0022	.0	.11

HYDROGRAPH PEAK= .35 cfs
TIME TO PEAK= 2.50 Hours
RUNOFF VOLUME= .03 Acre-Feet

Trapezoidal Channel Flow Calculations using Mannings Equation

Client: Plateau Mining Company
Project No.: 002.06.100
Channel Section: 76

Date: 14-Jun-89
Time: 11:25 AM
Computed: DEH

			UNITS
GENERAL CRITERIA:	Design Flow:	0.35	cfs
	Bottom Width:	0.1	feet
	Side Slope1:	11.7	1/m1
	Side Slope2:	0.8	1/m2
	Friction Factor:	0.030	
	Min. Bottom Slope:	0.120	ft/ft
	Max. Bottom Slope:	0.120	ft/ft
	Freeboard:	0.50	feet
CALCULATION: (Channel Depth)	Depth (Min. S):	0.13	feet
	Qn/1.49(S)1/2=	0.020	
	A(R)2/3=	0.019	
	Required Depth:	0.63	feet
	Area:	0.12	ft2
	Perimeter:	1.79	feet
	Hydraulic Radius:	0.07	feet
	Velocity:	2.96	ft/sec
	Riprap Ck (V<5?):	Not Needed	
CALCULATION: (Velocity Check)	Depth (Max. S):	0.13	feet
	Qn/1.49(S)1/2=	0.020	
	A(R)2/3=	0.019	
	Required Depth:	0.63	feet
	Area:	0.12	ft2
	Perimeter:	1.79	feet
	Hydraulic Radius:	0.07	feet
	Velocity:	2.96	ft/sec
	Riprap Ck (V<5?):	Not Needed	

DESIGN CRITERIA:	Bottom Width:	0.1	feet
	Side Slope 1:	11.7	1/m1
	Side Slope 2:	0.8	1/m2
	Min. Bottom Slope:	12.0	%
	Max. Bottom Slope:	12.0	%
	Min Channel Depth:	0.63	feet
	Riprap (Min S):	Not Needed	
	Riprap (Max S):	Not Needed	