MODERN MINING AND RECLAMATION PROCEDURES FOR REDUCED COSTS AND IMPROVED LAND RESOURCES

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INTRODUCTION

Research over the last decade has repeatedly emphasized the potentials for improvement of our land resource through surface mining techniques which allow construction of landscapes and minesoils with desirable properties for the intended land use. Although scientific and industry leaders may agree to this concept, such potentials often are neglected in the planning of mining operations, allowing improved landscape and soil features to be lost. Directly or indirectly, economic constraints associated with increased permit costs in addition to assumptions of increased mining costs, are often cited as the basis for neglecting these principles.

The T&P Construction Company surface mine is a truck and loader contour surface mine operating under steep topographic conditions. Using technical data and engineering criteria required to obtain a surface mining permit in the State of West Virginia (WV), detailed preplanning of the 86 acre site was conducted in order to accomplish two objectives: (1) Establish least cost mining and reclamation procedures founded on the concept of controlled placement, and (2) at the request of the landowner, maximize the construction of gently sloping landforms containing minesoils with desirable properties conducive to higher land use alternatives than existed before mining. Relative to conventional mining and reclamation practices used in the Appalachian Coal Region, the above procedures have resulted in decreased earthmoving costs, and therefore increased mining efficiency. Additionally, minesoils are physically and chemcially superior to the native soil properties, which, together with improved landscape, increase the post mining land use alternatives. The following paper will discuss site conditions influencing mine design, soil and overburden characterization, engineering criteria and design, and factors influencing improved short-term and long-term economics.

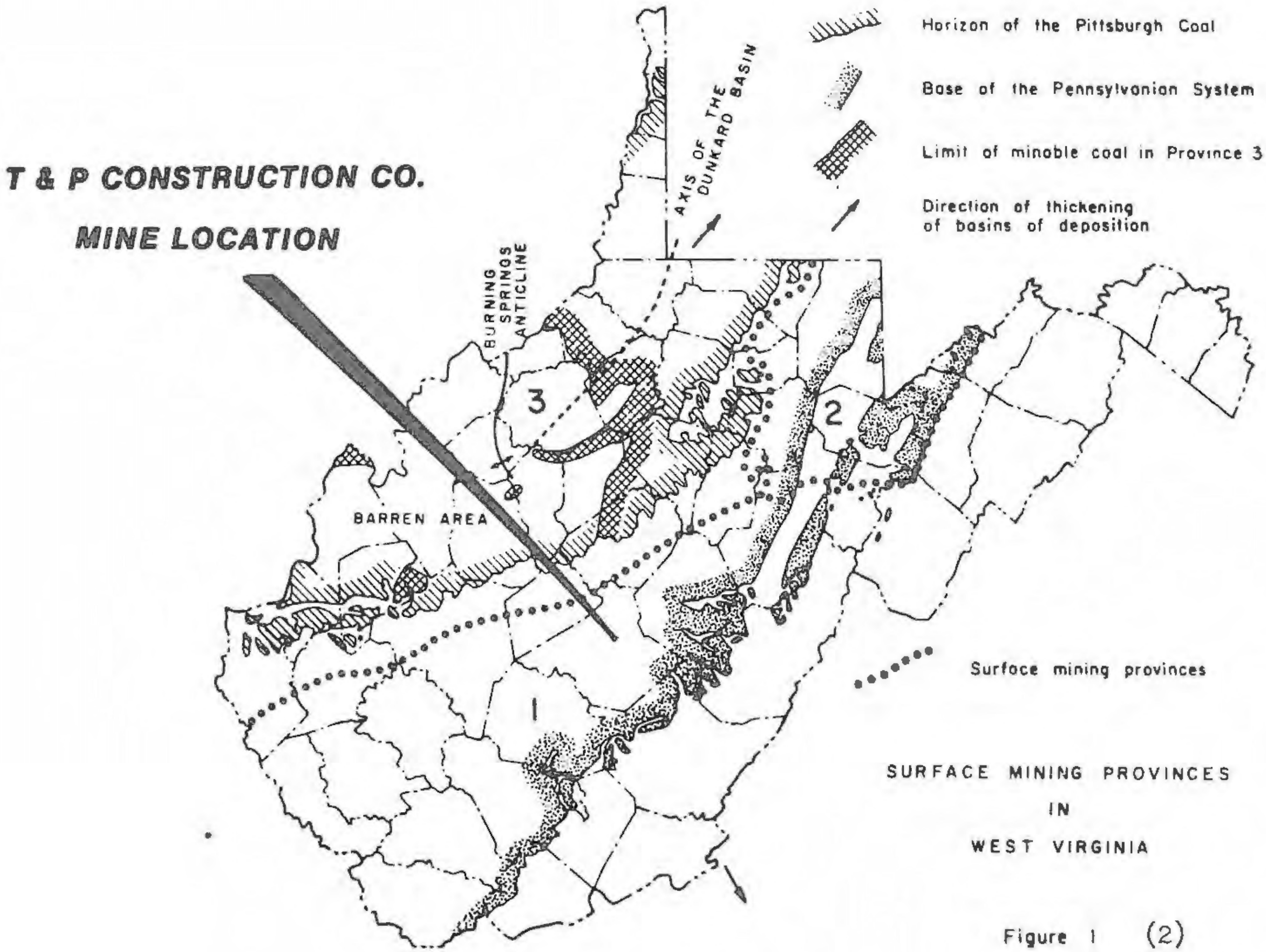
SITE CONDITIONS INFLUENCING MINE DESIGN

Planning and engineering of the T&P Construction Company surface mine was founded on predictions of maximum economic feasibility to attain a favorable return on the investment. Considerations influencing such decisions include, but are not limited to, the topography and geology of the mine site in combination with physical and chemical characteristics of the coals to be mined at the maximum economical stripping ratio. The T&P Construction Company mine site is located in Central West Virginia (Figure 1) and is included in Surface Mining Province I, as defined by Arkle (1). The physiography of Surface Mining Province I is characterized by steep to very steep slopes extending from narrow winding valleys to rugged inaccessible ridges, and ranging in relief from 600 feet to as much as 1400 feet. The coals responsible for much of the coal production are low-sulfur, medium volatile, high Btu.

TOPOGRAPHY AND GEOLOGY OF THE MINE SITE

As illustrated in Figure 2, the topography of the mine site is characterized by steep to very steep slopes ranging from 30% on the narrow ridge points to 75% within the side slopes of the hollows and near the ridge summits. The slope gradient of the upper half of the contour is predominantly greater than 50%.

The coals being mined, in descending order with seam thickness, are as follows: Cedar Grove (15" to 24"), Alma (20" to 24"), Peerless (24" to 30"), Eagle Rider (8" to 10"), and Eagle (30" to 54"). The Cedar Grove coal, because of it's position on the steepest part of the landscape, is only mined



SURFACE MINING PROVINCES IN WEST VIRGINIA

Figure 1 (2)

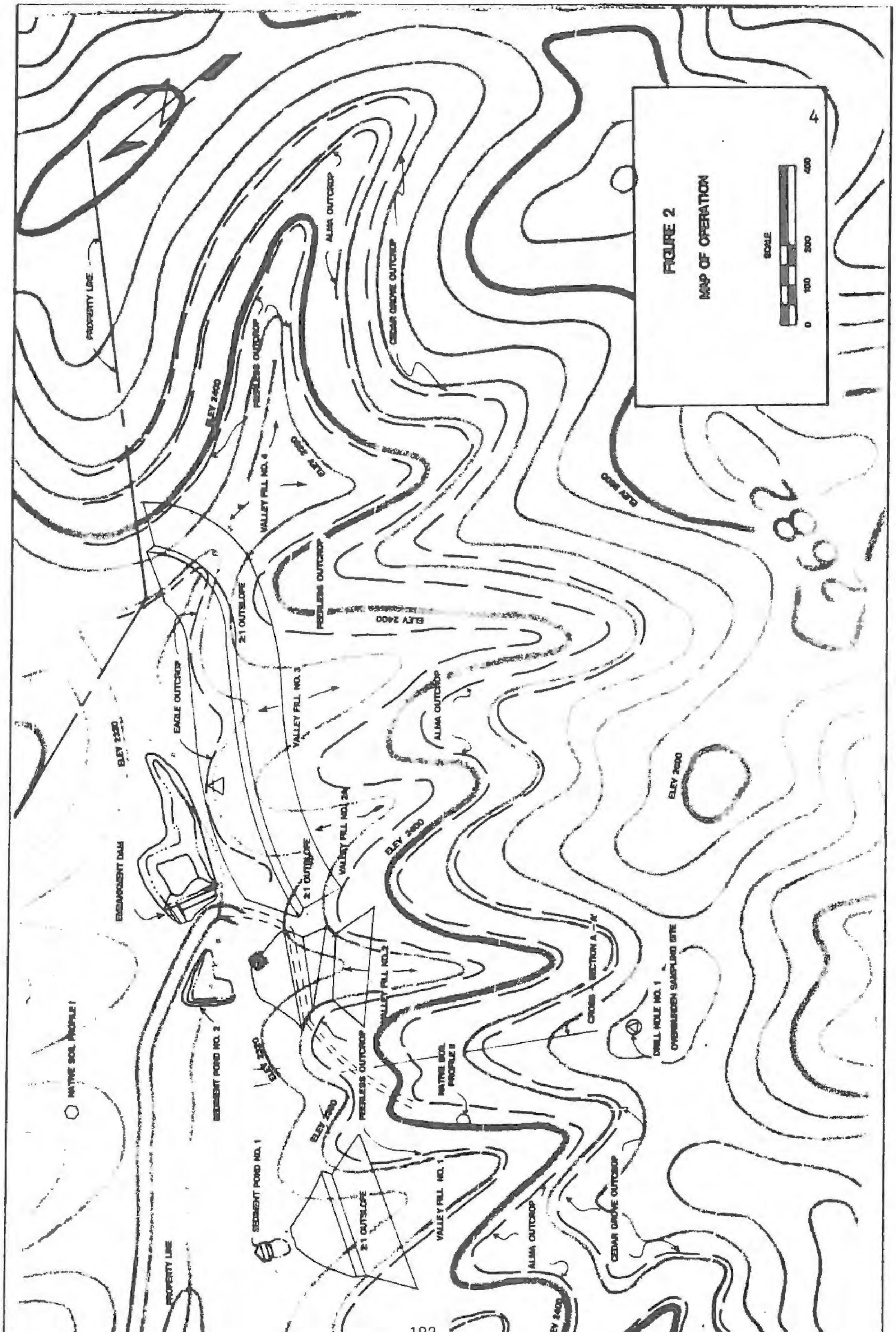


FIGURE 2
MAP OF OPERATION
SCALE
0 100 200 400
PROPERTY LINE
ELEV 2400
PEERLESS OUTCROP
ALMA OUTCROP
CEDAR GROVE OUTCROP
VALLEY FILL NO. 4
2:1 OUTSLOPE
EAGLE OUTCROP
VALLEY FILL NO. 3
EMBANKMENT DAM
VALLEY FILL NO. 2A
SEDIMENT POND NO. 2
NATIVE SOIL PROFILE I
VALLEY FILL NO. 2
CROSS SECTION A — A'
DRILL HOLE NO. 1
OVERBURDEN SAMPLING SITE
NATIVE SOIL PROFILE II
SEDIMENT POND NO. 1
VALLEY FILL NO. 1

to a 35 foot highwall consisting of weathered sandstone and intercalated sandstone/mudstone. The Cedar Grove to Alma interval ranges from 30 to 40 feet and is comprised of mudstone and shale, with minor thicknesses of fine-grained, medium-strength sandstone. The Alma to Peerless interval of 35 to 42 feet ranges from 30 to 80% mudstone and 20 to 70% fine-grained, strongly-cemented sandstone. The Peerless to Eagle Rider interval of 67 to 73 feet is predominantly fine-grained sandstone. The Eagle Rider to Eagle interval of 12 to 20 feet is predominantly loam-textured mudstone. These geologic materials will be identified in more detail in the discussion on soil and overburden characterization.

COAL CHARACTERISTICS AND STRIPPING RATIO

The main coal seams supporting the economics of the mining operation are the Alma, Peerless, and Eagle seams. The Eagle, however, "pinched out" near the center of the permit area and was not available for mining in the southwestern half of the mine (Figure 2). Only a minor cut 60 to 70 feet wide is feasible on the thin Cedar Grove coal because of steep slopes; an the total volume is of lower quality, as a result of weathered outcrop conditions. The seam is therefore blended with higher quality underlying coals in accordance with specific orders. The underlying Alma, Peerless, Eagle Rider, and Eagle seams are predominantly less than 1% sulfur, less than 6% ash, and 13,000 to 14,000 Btu "as received" basis, which commonly exceed specifications for steam coals.

Overall variations in landslope and topography were taken into account in order to arrive at contour cut widths resulting in a maximum stripping ratio (SR) of 12 bank cubic yards (BCY) to 1 ton coal (12:1) at 90% recovery. Stripping ratios approaching 20:1 were experienced on additional 60 foot cuts of the interburden separating the Alma and Peerless coals. The average SR of 12:1

was maintained, however by taking 20:1 cuts at locations coinciding with 6:1 and 8:1 ratio cuts.

SOIL AND OVERBURDEN CHARACTERIZATION

Soil and overburden characterization involved identification of the physical and chemical properties of the overburden materials as a means of establishing operational procedures designed to assure quality drainage and successful revegetation for the agricultural post-mining land use. Overburden characterization by Acid-Base Accounting has long been recognized as a dependable method for delineating potentially acid-producing materials which require attentive placement, while simultaneously designating fertile geologic materials that are superior for use as the plant growth medium.

Overburden characterization was accomplished in accordance with standard procedures outlined by Sobek et. al.(3). Overburden sampling of the Cedar Grove to Peerless interval was performed by sampling rotary air-blast drill chips in one foot increments, which were combined into larger sampling intervals based on physical properties after completion of drilling. The geologic materials of the Peerless to Eagle geologic interval were sampled by hand from a freshly exposed highwall. Sampling and analytical costs were funded by the West Virginia Small Operators Assistance Program (SOAP). Sampling was conducted by P.C. Park, M. Dickinson, and C.S. Sturey of WV SOAP, and T.A. Keeney. Sample preparation and analyses were performed by Sturm Environmental Services of Bridgeport, West Virginia.

CHARACTERIZATION OF NATIVE SOILS

Characterization of native soils was accomplished by sampling and describing two soil profiles, the locations of which are illustrated in Figure 2.

Laboratory analyses consisted of sodium bicarbonate extractable phosphrous (P), double-acid extractable potassium (K), calcium (C), and magnesium (Mg), 1:1 pH, and lime requirement (LR). The data are presented in Table 1. The soils were classified as Gilpin, a fine-loamy, mixed, mesic Typic Hapludult.

Both soils were extremely acid to acid in reaction (pH 4.7 to 5.1), and contained medium levels of K, dominantly very low levels of Ca, low to medium levels of Mg, and low levels of P (Table 1). The average lime requirement was 9.2 tons/acre. As will be discussed later, the underlying geologic matrials were characterized by very high levels of K, Ca, and Mg, in addition to superior levels of P, with zero lime requirement. Lime requirement was determined in accordance with Mehliche (4).

CHARACTERIZATION OF GEOLOGIC MATERIALS

Two drill holes were sampled and analyzed on the Cedar Grove to Peerless interval. However, due to space limitations, only the data for Drill Hole #1 will be presented here, in addition to analyses for the Peerless to Eagle interval. Acid-Base Accounting and available plant nutrients and lime requirement analyses were performed on Drill Hole #1 (Tables 2 and 3). In addition, sulfur fractionation was performed on those samples appearing to be potentially-toxic based on total % sulfur. Acid-Base Accounting data for the Peerless to Eagle interval are presented in Table 4. Available plant nutrients and lime requirement were performed on selected samples of this interval and are presented in Table 5.

The Acid-Base Accounting data for Drill Hole #1 (Table 2) illustrate an overwhelming dominance of excess bases ranging from as low as 3.1 to as high as 75.9 tons/1000 tons, $CaCO_3$ equivalent. Excess $CaCO_3$ equivalent values are

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Ratings (Smith et al., 1976)

VL = very low
L = low
M = medium
H = high
VH = very high

COMPANY: T&P Construction Company
SITE: WV S.O.A.P. #037, Native Soil Profile I
DATE: 10/16/81

TABLE 1

AVAILABLE PLANT NUTRIENTS

Sample No.	Phosphorus* P	Potassium* K	Calcium* Ca	Magnesium* Mg	1:1 pH	Lime Req.**
$1(A_1)$	9.7 M	239 VH	2040 H	185 M	4.8	8.4
$2(B_2)$	2.3 L	146 M	343 VL	67 L	4.9	9.2
$3(B_{21t})$	<1.0 L	81 M	95 VL	57 L	4.7	10.4
$4(B_{22t})$	<1.0 L	94 M	200 VL	158 M	5.0	8.4
$5(B_3)$	<1.0 L	104 M	201 VL	153 M	5.1	8.0

TOTAL DEPTH = 38"

COMPANY: T&P Construction Company
SITE: WV S.O.A.P. #037, Native Soil Profile II
DATE: 10/16/81

Sample No.	Phosphorus* P	Potassium* K	Calcium* Ca	Magnesium* Mg	1:1 pH	Lime Req.**
$1(A_1)$	4.6 L	151 M	870 M	196 M	4.8	9.2
$2(B2)$	2.2 L	88 M	199 VL	94 L	4.9	9.6
$3(B_{21t})$	<1.0 L	76 M	135 VL	86 L	5.0	10.0
$4(B_{22t})$	<1.0 L	84 M	141 VL	100 M	5.0	9.6

TOTAL DEPTH = 50"

Company: T & P Construction Company
Site: Regraded Minesoil Samples
Date: 4/30/84

Sample No.	Phosphorus* P	Potassium* K	Calcium* Ca	Magnesium* Mg	1:1 pH	Lime Req.**
1	1.0 L	366 VH	5310 VH	1520 VH	7.9	0
2	6.3 L	204 H	3610 H	910 VH	7.3	0
3	1.3 L	261 VH	4680 VH	1360 VH	7.9	0

Note: Sample depth = 0 to 4"

*Pounds per acre **Tons per acre

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COMPANY: T & P Construction Co., Inc.

SITE: WV S.O.A.P. #037, Drill Hole #1

DATE: 10/9/81

Table 2

ACID—BASE ACCOUNT

Latitude: 38° 19' 27"
Longitude: 80° 42' 30"
Surface Elev.: 2512'

Sample Number	Depth (Feet)	Strata Thick.	Rock Type	Fiz	Color	% S	Calcium Carbonate Equivalent Tons/1000 Tons of Material: Max. From % S	N.P. $CaCO_3$ Equiv.	Max. Needed (pH-7)	Excess $CaCO_3$	Paste pH
1	8-11'	3'	MS	0	10 YR 7/3	.008	.25	4.22		3.97	5.0
2	11-15'	4'	MS	0	10 YR 6/4	.009	.28	6.00		5.72	5.1
	15-17'	Lost in Coring									
3	17-18'	1'	MS	0	10 YR 6/3	.045	1.41	6.12		4.71	4.9
4	18-22'	4'	MS	0	10 YR 6/4	.036	1.13	4.36		3.23	5.4
5	22-24'	2'	SS/MS	0	10 YR 6/4	.076	2.38	9.68		7.30	5.3
6	24-26'	2'	SS	0	10 YR 7/3	.030	.94	7.26		6.32	5.8
7	26-28'	2'	SS	0	10 YR 6/3	.082	2.56	5.77		3.21	5.7
8	28-32'	4'	SS/MS	0	10 YR 6/4	.005	.16	7.40		7.24	5.9
9	32-37'	5'	MS	0	10 YR 6/4	<.005	.16	8.17		8.01	5.9
10	37-40'	3'	MS	0	10 YR 6/4	.005	.16	9.74		9.58	6.2
11	40-42'	2'	MS	0	10 YR 6/3	.020	.62	8.88		8.26	6.6
12	42-46'	4'	MS	0	10 YR 6/2	.061	1.91	18.92		17.01	7.2
13	46-50'	4'	SS	0	10 YR 6/1	.080	2.50	36.56		34.06	7.7
14	50-54'	4'	SS	0	10 YR 6/2	.086	2.69	18.97		16.28	7.6
15	54-56'	2'	SS	0	10 YR 6/6	.018	.56	8.54		7.98	7.4
16	56-59'	3'	SS	1	10 YR 8/2	.023	.72	28.01		27.29	8.0
17	59-61'	2'	SS	1	10 YR 7/4	.014	.44	16.50		16.06	8.1
18	61-63'	2'	SS	1	10 YR 6/4	.021	.66	33.95		33.29	8.1
19	63-66'	3'	SS/MS	0	10 YR 6/4	.182	5.69	22.01		16.32	7.5
20	66-70'	4'	MS	1	10 YR 7/1	.136	4.25	32.87		28.62	7.7
21	70-73'	3'	SS/MS	1	10 YR 6/1	.079	2.47	23.71		21.24	8.0
22	73'-75'	2'	SS	1	10 YR 5/1	.414	12.94	34.71		21.77	7.9
23	75-78'	3'	MS	1	10 YR 6/1	.659	20.59	38.10		17.51	7.9
24	78-80'	2'	MS/SS	1	10 YR 5/1	.589	18.41	30.85		12.44	7.3
25	80-82'	2'	MS/SS/Carb	0	10 YR 4/1	.225	7.03	26.75		19.72	7.7
26	82-83'	1'	MS/Carb	0	10 YR 3/1	.393	12.28	31.92		19.64	7.4
27	83-84'	1'	Coal	0	10 YR 2/1	.665	20.78	13.51	7.27		7.7
28	84-85'	1'	MS/Coal	0	10 YR 4/1	.228	7.13	3.23	3.90		7.9
29	85-88'	3'	MS	0	10 YR 6/1	.063	1.97	5.08		3.11	8.1
30	88-91'	3'	MS	0	10 YR 7/1	.033	1.03	8.22		7.19	8.3
31	91-93'	2'	MS	0	10 YR 6/1	.029	.91	11.43		10.52	8.3
32	93-97'	4'	MS	0	10 YR 5/1	.064	2.00	14.91		12.91	8.1
33	97-100'	3'	MS	0	10 YR 6/1	.072	2.25	26.90		24.65	8.1
34	100-103'	3'	MS	0	10 YR 6/1	.053	1.66	24.87		23.21	8.1
35	103-106'	3'	MS	0	10 YR 6/1	.060	1.88	21.98		20.10	8.0
36	106-107'	1'	MS	0	10 YR 6/1	.065	2.03	16.03		14.00	8.0
37	107-108'	1'	Coal	0	10 YR 3/1	.367	11.47	3.18	8.29		7.4
38	108-109'	1'	Coal	0	10 YR 2/1	.945	29.53	.90	28.63		6.5
39	109-110'	1'	MS Carb	0	10 YR 5/1	.191	5.97	3.99	1.98		7.4
40	110-112'	2'	MS	0	10 YR 6/1	.120	3.75	4.82		1.07	7.1
41	112-116'	4'	MS	0	10 YR 6/1	.062	1.94	20.05		18.11	8.0
42	116-120'	4'	MS/SS	3	10 YR 7/1	.018	.56	76.49		75.93	8.6
43	120-122'	2'	SS/MS	1	10 YR 6/1	.037	2.19	28.70		26.51	8.5
44	122-126'	4'	MS	0	10 YR 6/1	.048	1.50	17.68		16.18	8.3
45	126-129'	3'	MS	0	10 YR 7/1	.044	1.38	14.91		13.53	8.3
46	129-132'	3'	MS	0	10 YR 6/1	.071	2.22	30.48		28.26	8.4
47	132-136'	4'	MS	1	10 YR 7/1	.078	2.44	28.48		26.04	8.3
48	136-140'	4'	MS	1	10 YR 7/1	.088	2.75	25.15		22.40	8.3
49	140-143'	3'	MS	0	10 YR 7/1	.070	2.19	24.95		22.76	8.3
50	143-144'	1'	MS	0	10 YR 6/1	.054	1.69	17.66		15.97	8.2
51	144-145'	1'	MS-Carb	0	10 YR 4/1	.205	6.41	8.93		2.52	8.1
52	145-147'	2'	Coal	0	10 YR 5/1	.322	10.06	11.85		1.79	8.1
53	147-148'	1'	MS/SS	0	10 YR 4/1	.168	5.25	6.64		1.39	8.3
54	148-152'	4'	MS	0	10 YR 6/1	.068	2.13	18.08		15.95	8.2
55	152-157'	5'	MS	0	10 YR 6/1	.063	1.97	22.95		20.98	8.4

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Table 3

COMPANY: T & P Construction Co., Inc.

SITE: WV S.O.A.P. #037, Drill hole #1

DATE: 11/9/81

Ratings (Smith et al., 1976)

VL = very low
L = low
M = medium
H = high
VH = very high

AVAILABLE PLANT NUTRIENTS

Latitude: 38° 19' 27"
Longitude: 80° 42' 30"
Surface Elev.: 2512'

Sample No.	Phosphorus* P	Potassium* K	Calcium* Ca	Magnesium* Mg	1:1 pH	Lime Req.
11	8.5 L	152 M	3,150 H	880 VH	6.8	0
12	5.6 L	190 H	3,290 H	930 VH	7.4	0
13	5.0 L	223 H	4,040 VH	1,290 VH	7.7	0
14	4.3 L	166 H	2,720 H	670 VH	7.7	0
15	19.6 M	88 M	2,110 H	500 VH	7.4	0
16	6.7 L	149 M	7,780 VH	1,640 VH	8.0	0
17	5.6 L	106 M	5,200 VH	1,070 VH	8.1	0
18	6.2 L	113 M	8,580 VH	1,870 VH	8.1	0
19	5.0 L	285 VH	3,350 H	800 VH	7.6	0
20	5.6 L	231 H	6,930 VH	1,900 VH	7.8	0
21	5.0 L	219 H	6,970 VH	1,490 VH	8.0	0
22	4.3 L	197 H	10,270 VH	1,930 VH	7.9	0
23	4.8 L	248 VH	9,250 VH	3,202 VH	7.8	0
24	4.3 L	237 VH	5,120 VH	1,370 VH	7.2	0
25	4.3 L	257 VH	2,340 H	500 VH	7.8	0
26	4.3 L	237 VH	2,070 H	440 H	7.3	0
29	3.7 L	326 VH	1,580 M		8.1	0
30	3.4 L	323 VH	1,690 M	420 H	8.4	0
31	3.4 L	315 VH	1,670 M	380 H	8.4	0
32	3.7 L	275 VH	2,080 H	480 H	8.2	0
33	3.7 L	257 VH	4,410 VH	1,060 VH	8.1	0
34	4.3 L	258 VH	4,280 VH	940 VH	8.1	0
35	4.0 L	229 H	3,240 H	410 H	8.0	0
36	4.3 L	236 VH	2,900 H	390 H	8.1	0
39	4.3 L	255 VH	1,560 H	360 H	7.6	0
40	5.0 L	272 VH	2,280 VH	360 H	7.1	0
41	4.3 L	240 VH	4,470 VH	880 H	7.9	0
42	5.2 L	179 H	8,600 VH	2,110 VH	8.6	0
43	4.3 L	229 H	7,140 VH	1,430 VH	8.5	0
44	5.2 L	436 VH	3,990 H	900 VH	8.4	0
45	4.3 L	328 VH	2,990 H	530 VH	8.4	0
46	4.0 L	350 VH	6,840 VH	2,020 VH	8.4	0
47	4.6 L	411 VH	7,960 VH	2,070 VH	8.3	0
48	5.0 L	318 VH	6,830 VH	1,510 VH	8.4	0
49	4.3 L	351 VH	5,280 VH	1,260 VH	8.3	0
50	3.7 L	344 VH	3,770 H	660 VH	8.0	0

*Pounds per acre **Tons per acre

P. O. Box 650, Bridgeport, WV 26330

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Table 4

Company: T & P Construction Company
Site: Peerless to Eagle Overburden Samples
Date: 4/30/84

ACID-BASE ACCOUNT

							Calcium Carbonate Equivalent Tons/1000 Tons of Material				
Sample Number	Depth (Feet)	Strata Thick. (Feet)	Rock Type	Fiz	Color	% S	Max. From % S	N.P. $CaCO_3$ Equiv.	Max. Needed (pH-7)	Excess $CaCO_3$	Paste pH
1	6'-9.6'	3.6'	MS	0	10 YR 7/3	<.005	.16	7.63		7.47	5.1
2	9.6'-17.6'	8.0'	SS	1	2.5 Y 7/2	.019	.59	9.79		9.20	7.2
3	17.6'-20.1'	2.5'	MS	0	5 Y 6/1	.026	.81	3.95		3.14	7.3
4	20.1'-25.1'	5.0'	MS	0	5 Y 6/1	.070	2.19	4.27		2.08	7.2
5	25.1'-29.6'	4.5'	MS/SS	0	5 Y 5/1	.108	3.38	8.28		4.91	6.8
6	29.6'-35.6'	6.0'	MS/SS	0	5 Y 5/1	.125	3.91	9.34		5.43	6.5
7	35.6'-41.6'	6.0'	MS/SS	0	5 Y 5/1	.190	5.94	9.00		3.06	6.6
8	41.6'-45.6'	4.0'	SS	0	5 Y 5/1	.125	3.91	13.37		9.46	7.5
9	45.6'-51.6'	6.0'	SS	0	5 Y 5/1	.195	6.09	10.30		4.21	7.9
10	51.6'-55.6'	4.0'	SS	1	5 Y 6/1	.177	5.53	18.95		13.42	7.0
11	55.6'-59.6'	4.0'	SS	1	5 Y 6/1	.208	6.50	22.03		15.53	7.5
12	59.6'-63.8'	4.2'	SS	0	10 YR 5/1	.575	17.97	14.94	3.03		7.5
13	63.8'-65.4'	1.6'	MS	0	10 YR 4/1	1.70	53.13	6.89	46.24		6.9
14	65.4'-65.7'	.3'	MS	0	10 YR 4/1	1.54	48.13	4.55	43.58		5.9
15	65.7'-66.5'	.8'	Coal	0	10 YR 2/1	1.19	37.19	.40	36.79		3.9
16	66.5'-67.3'	.8'	MS	0	5 Y 6/1	.080	2.50	6.31		3.81	7.4
17	67.3'-68.1'	.8'	MS	0	5 Y 6/1	.024	.75	7.76		7.01	7.8
18	68.1'-72.1'	4.0'	SS	2	5 Y 6/1	.028	.88	57.33		56.46	8.0
19	72.1'-76.1'	4.0'	MS	1	5 Y 5/1	.080	2.50	35.23		32.73	8.0
20	76.1'-79.1'	3.0'	SS	0	5 Y 6/1	.043	1.34	24.78		23.44	7.8
21	79.1'-83.1'	4.0'	MS	0	10 YR 6/1	.055	1.72	32.38		30.66	7.3
22	83.1'-87.1'	4.0'	MS	0	10 YR 7/1	.029	.91	4.38		3.47	7.2
23	87.1'-91.7'	4.6'	MS	1	5 Y 8/1	.024	.75	33.88		33.13	7.4
24	91.7'-92.1'	.4'	MS	0	10 YR 4/1	.109	3.41	3.05	.36		7.2
25	92.1'-94.6'	2.5'	Coal	0	10 YR 2/1	.595	18.59	1.12	17.47		7.6
26	94.6'-94.8'	.2'	SH	0	10 YR 4/1	1.03	32.19	3.78	28.41		7.4

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Sturm Environmental Services

COMPANY: T & P Construction Company

SITE: Eagle Overburden Samples

DATE: 5/14/84

Ratings (Smith et.al., 1976)
VL = Very Low
L = Low
M = Medium
H = High VH = Very High

TABLE 5

AVAILABLE PLANT NUTRIENTS

Sample No.	Phosphorus* P		Potassium* K		Calcium* Ca		Magnesium* Mg		1:1 pH	Lime Req.**
1	13.4	M	161	H	2010	H	690	VH	5.4	2.0
2	<1.0	L	141	M	1170	M	290	H	7.4	0
3	<1.0	L	375	VH	770	L	650	VH	7.5	0
4	1.4	L	321	VH	790	L	650	VH	7.4	0
5	<1.0	L	312	VH	1080	M	460	H	6.9	0
6	1.6	L	276	VH	1760	M	340	H	6.6	0
7	4.1	L	301	VH	2070	H	340	H	6.7	0
8	1.2	L	319	VH	2130	H	350	H	7.6	0
9	<1.0	L	358	VH	2260	H	380	H	8.0	0
10	1.9	L	285	VH	4070	VH	730	VH	7.1	0
11	<1.0	L	246	VH	5420	VH	1190	VH	7.8	0
12	4.1	L	333	VH	2990	H	570	VH	7.6	0
13	3.8	L	321	VH	1990	M	320	H	6.7	0
16	1.2	L	338	VH	1850	M	290	H	7.4	0
17	<1.0	L	300	VH	2100	H	260	H	7.7	0
18	<1.0	L	208	H	5770	VH	1940	VH	8.1	0
19	1.2	L	280	VH	5260	VH	1910	VH	8.0	0
20	2.8	L	304	VH	2140	H	340	H	7.7	0
21	2.1	L	319	VH	2130	H	380	H	7.6	0
22	2.8	L	325	VH	1150	M	280	H	7.4	0
23	2.4	L	391	VH	1150	M	310	H	7.5	0

*Pounds per acre **Tons per acre

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dominantly in the range of 10 to 31 tons/1000 tons. In addition, paste pH values were consistently above 7.0, and ranged as high as 8.6. Available plant nutrient, pH, and lime requirement data presented in Table 3 further substantiate the high quality of overburden materials in the Cedar Grove to Peerless geologic interval at this site. Plant available levels of K, Ca, and Mg are consistently high and very high. Although bicarbonate extractable P levels are rated as low, with the exception of sample #15, available levels are consistently above 3 lbs/acre. It appears that a higher amount of P may become available upon weathering based on the very high levels of Ca, which implies that the P may be present in the form of Ca-phosphates. These compounds are known to be relatively insoluble at high pH values (5). Fertilization with acid phosphates are recycling from plant residues will remedy immediate phosphorus deficiencies, which are apparently less severe than in the native soils.

Acid-Base Accounting data for the Peerless to Eagle geologic interval (Table 4) again illustrate an overwhelming dominance of excess $CaCO_3$ equivalent, with neutralization potential (NP) values ranging from 4 to 57 tons/1000 tons. Maximum potential acidity values (Max. From % S) based on total % sulfur indicate that the 6.9 feet of materials overlying the Eagle Rider seam are potentially acid-forming. These materials are currently being blended with the overlying high-base geologic materials high in the fill, but 8 to 10 feet below the surface in order to avoid water quality and revegetation problems. These data, in addition to the available plant nutrient and lime requirement data presented in Table 5, clearly indicate that the Eagle Rider to Eagle interval is superior to the native soil for use as the plant growth medium. Normal earthmoving procedures of this truck-loader operation which results in the Eagle Rider to Eagle interval of mudstone being removed secondary to the Peerless to Eagle Rider interval automatically insures that these loam-textured materials which weather rapidly are available for surface placement. This fundamental concept is the basis of reduced earthmoving costs at the site by eliminating costly storage, rehandling, and distribution of the native soil.

Three samples of the regraded minesoil were analyzed for available plant nutrients and lime requirement. The data are presented in Table 1. The minesoil would be classified under the West Virginia University System of Minesoil Classification (6,7) as the Postoak Family of minesoils. Postoak minesoils contain a dominance of mudstone materials, are neutral in reaction, and have a loamy-skeletal partical-size class. The data illustrate neutral soil reaction (pH 7.3, 7.9, and 7.9), zero lime requirement, high to very high levels of Ca and K, and very high levels of magnesium. Phosphorus values are characteristically low but measurably higher than in the native soils. These data again substantiate the superior fertility of the geologic materials for use as the plant growth medium.

ENGINEERING CRITERIA AND DESIGN

The fundamental engineering criteria for the design of surface mining operations in West Virginia centers around controlled placement of overburden materials and effective sediment control measures. The term "controlled placement" in its original meaning with regard to contour and mountaintop removal surface mining was used to designate the elimination of downslope placement of overburden materials on slopes in excess of 20° (36%). This restriction necessitated technological developments which would maintain the economic feasibility of the mining process while addressing the problem of excess overburden. Such developments include the Haulback Method of mining and the placement of excess overburden in adjacent hollows in "valley fills". These methods are the two fundamental procedures around which the T&P Construction Company mine is designed and operated.

OVERBURDEN VOLUME EVALUATIONS

The total overburden volume in bank cubic yards (BCY) was evaluated in order to establish the total volume, with swell, to be considered in valley fill and backfill configurations. As previously stated, the objective was to develop a design to maximize the construction of level landscape suitable for use as hayland at the request of the surface owner. Due to the high volume of mudstone, net compacted swell volume was estimated at 20%. Observations to date indicate the 20% swell value to be consistent with field conditions. Volume calculations were made from cross-sections using the "average end areas" method (8).

VALLEY FILL DESIGNS AND CONSTRUCTION

The conventional valley fill design requires that overburden materials be compacted in stages, or "lifts", no more than four feet high to meet a predetermined elevation (9). As the fill progresses, a rock core with a minimum width of 15 feet is usually constructed from the natural drainway of the hollow upward with each successive lift to the surface. The "chimney chain" is designed to allow water to filter through, thus minimizing erosion, providing sediment control, and insuring the future stability of the fill (9). However, because of an insufficient volume of sandstone to construct the core upwards through the entire fill, the valley fills (Figure 2) were designed for a minimum rock core cross-section of 16 feet by 20 feet in the natural drainway, from the toe of the fill to the head of the hollow. This further required the design and construction of diversion ditches over the top and along the side of the fill which would pass a 100 year, 24 hour storm event. The rock cores were actually 20 feet by 40 feet, however, after an increased volume of sandstone was encountered. An advantage of the smaller rock core was that it would not pose as much of an obstacle to the agricultural post mining land use as would the conventional, larger rock core. In addition, the 100 year, 24 hour diversion ditches were of parabolic and shallow vee designs (4% side slopes), again to avoid presenting an obstacle to forage harvesting.

REGRADED LANDSCAPE CONFIGURATION

The final regrading backfill configuration which balanced the net cut, swell, and coal removal volume is illustrated in Figure 3. The flat bench, or terrace, coincided roughly with the Alma elevation (Figures 4 and 5). This simplified the coordination with the mine foreman and communication with the equipment operators since it was a simple matter to maintain the terrace at the Alma elevation as mining and backfilling progressed along the cropline.

DRAINAGE AND SEDIMENT CONTROL

Drainage and sediment control was accomplished using two dugout sediment ponds and one embankment dam (Figure 2). In addition, excavated sediment ditches were constructed along the Peerless outcrop on the western end of the job. Upon completion of backfilling of the Cedar Grove to Alma highwall, excavated sediment ditches were constructed at the base of the backfill for sediment control of the 2:1 slope.

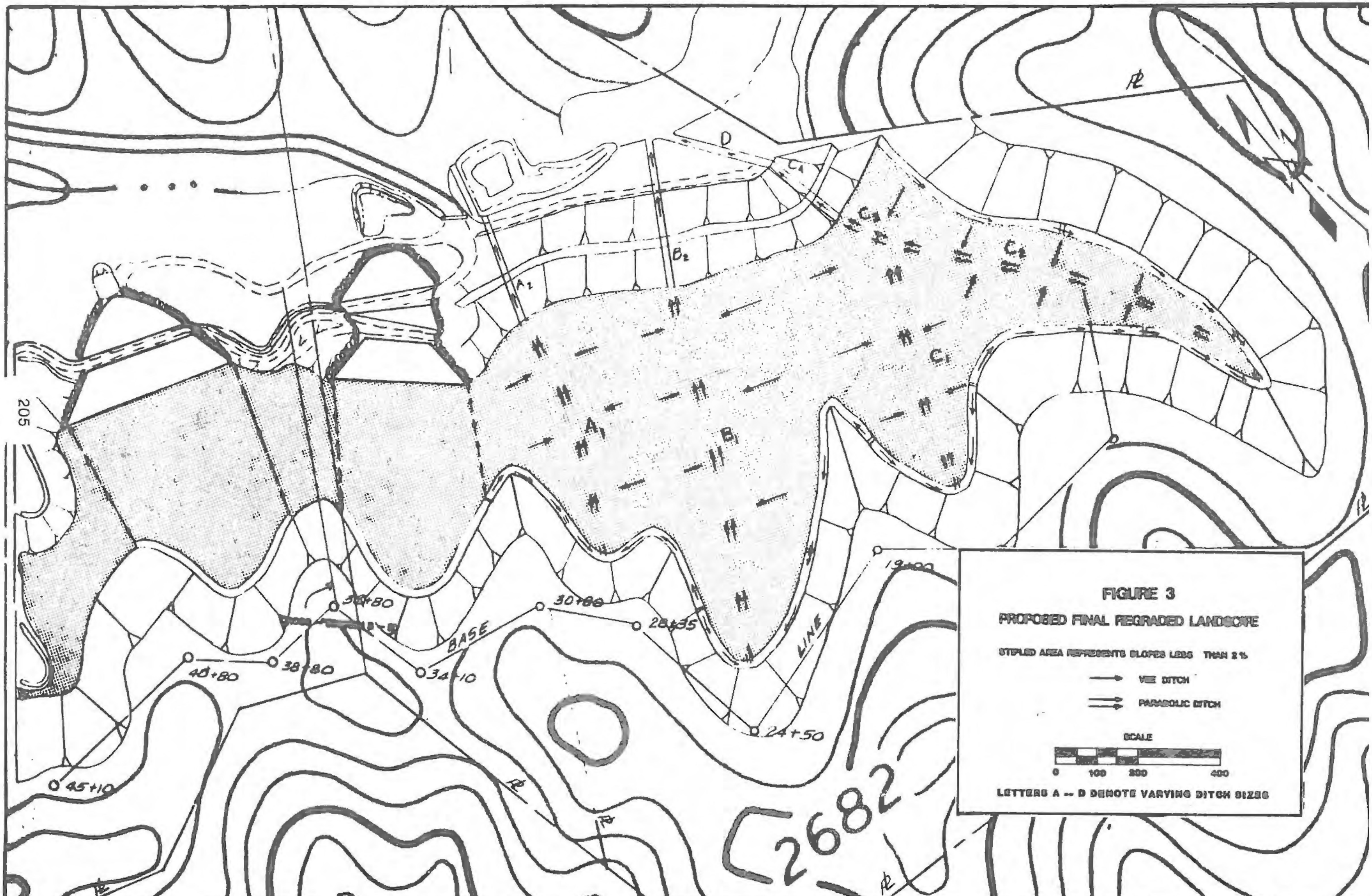


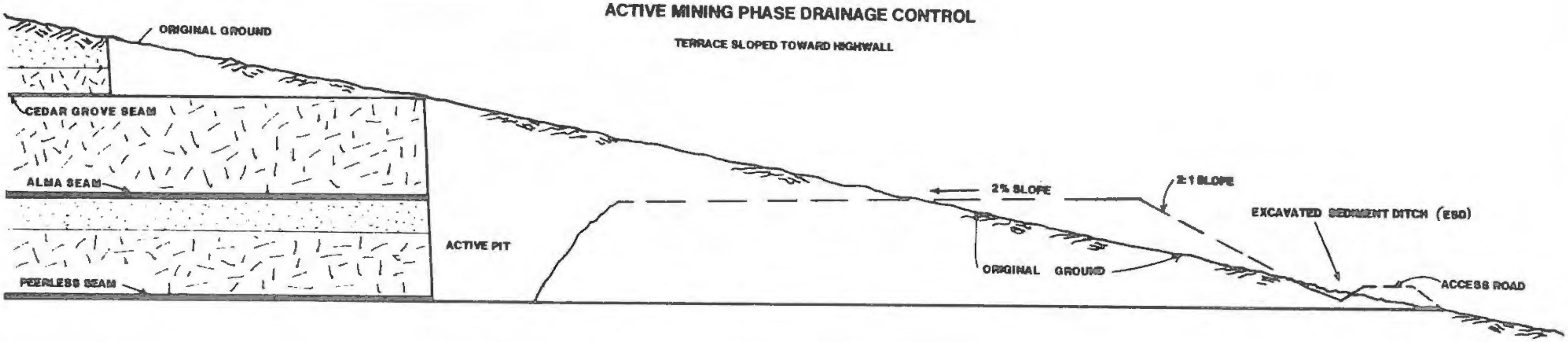
FIGURE 3
PROPOSED FINAL REGRADED LANDSCAPE

CROSS – SECTION A – A'

FIGURE 4

ACTIVE MINING PHASE DRAINAGE CONTROL

TERRACE SLOPED TOWARD HIGHWALL

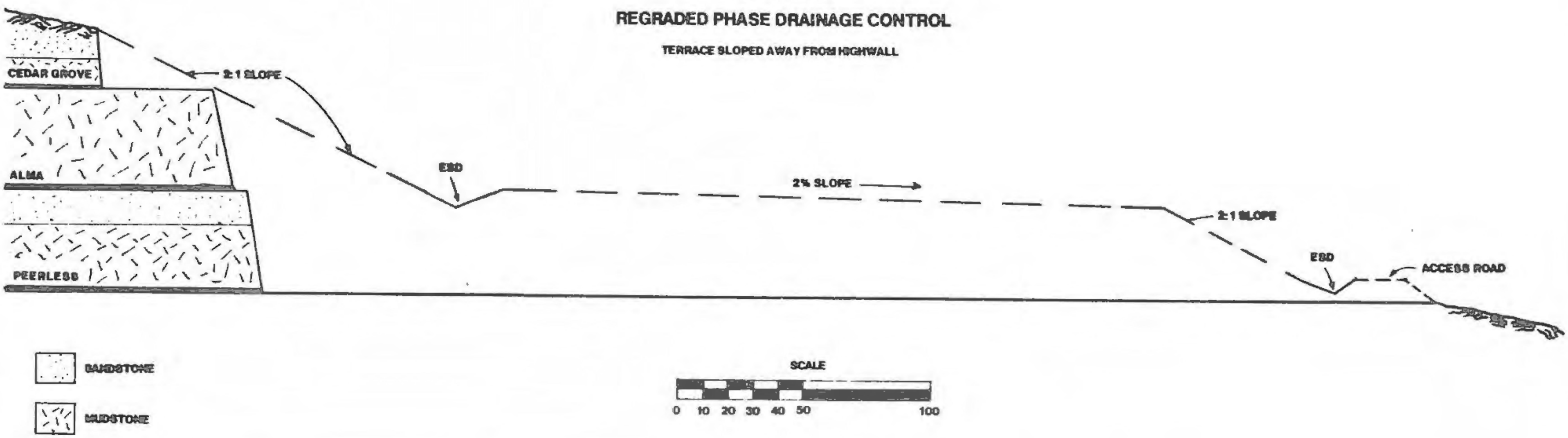


CROSS – SECTION B – B'

FIGURE 5

REGRADED PHASE DRAINAGE CONTROL

TERRACE SLOPED AWAY FROM HIGHWALL



Drainage control for the area above the Peerless outcrop was actually accomplished by a two-phase approach as illustrated in Figures 4 and 5. During the active mining phase on the northwestern end of the operation, the terrace was sloped back toward the highwall, forcing storm runoff to filter through the graded overburden and through the rock cores beneath the valley fills. This resulted in reduced suspended solids problems from the drainage structures. After completion of regrading of the backfilled highwall, the bench was then graded to slope to the outside as required by the regulatory authority.

ECONOMIC EVALUATION

As previously stated, those procedures undertaken with the objective of improved land resources as requested by the landowner resulted in reduced earthmoving costs. Additionally, minesoils with superior fertility were confirmed by additional analyses. Construction of improved landscape and soil features should realistically result in increased land values and higher anticipated returns from the post mining agricultural enterprise.

FACTORS AFFORDING REDUCED EARTHMOVING COSTS

Earthmoving costs are relative to the volume and characteristics of the overburden, the distance and conditions under which the material must be moved, machinery and operator skill, and overall job layout. The point of significance is that least-cost mining is actually attained by attention to fundamental earthmoving principles. It costs less to move materials once instead of two or more times; it costs less to mcve materials short distances rather than long distances; it costs less to move materials on the level rather than vertically; it costs less to move materials down hill rather than uphill (10).

These fundamental principles are the basis for decreased earthmoving costs at the T&P Construction Company mine relative to previously experienced costs associated with designs which simply allow for the post mining topography to be returned to approximate original contour (AOC). Maintaining the terrace, or bench, at the Alma seam, the second seam of the Cedar Grove-Alma-Peerless interval afforded short hauls, minimized hauling up or down long, steep grades, both of which decreased truck cycle time, thereby increasing overall truck-loader time and fuel efficiency.

MINESOIL VALUE COMPARED TO NATIVE SOIL

Minesoil is defined as soil made by mining or mining related activity under the general concept that soils may be modified or even made by man. In considering the value of the Postoak minesoil at this site, it is appropriate to remember that the chemical characteristics of acid pH, low fertility, and high lime requirement of the native soils alone, without regard to the prohibitive slopes, would have precluded management of this site for such high value forage crops as alfalfa-smooth bromegrass. Liming costs in this area currently start at $30/ton. Analyses of the native soil indicated that a lime requirement of as much as 10 tons/acre would have been required to eliminate aluminum toxity and raise the soil reaction of only 6 inches of soil to productive levels for alfalfa. This volume, relative to the 30 acres of hayland to be constructed would have resulted in a capital outlay of $9,000. High fertilization costs would have also had to been incurred. Additionally, the longevity of alfalfa stands on native soils in this area is further decreased by shallowness to bedrock, as well as acidity and nutrient deficiences of the subsoil.

In contrast, the Postoak minesoils at the T&P mine site are neutral in reaction and of high and very high fertility throughout the entire profile, with no bedrock limitations. With continued weathering of larger rock fragments over time, "auto-liming" and "auto-fertilization" (11) of the minesoil can be expected to substantially reduce maintenance costs for the alfalfa-smooth bromegrass forage mixture. These considerations alone indicate a significant superiority in value of the minesoil relative to the native soil.

LAND VALUES AND ANTICIPATED RETURNS

The value of a parcel of land is affected by many factors; some general, some local or regional, and some specific to the particular unit because of its unique characteristics. Additional factors are rising incomes, increasing population, and inflation (10). These factors combined with the essentially fixed supply of land, have resulted in rapidly increasing land values. When land is suitable for conversion to more intensive uses, its value is increased considerably. Such is the case with the T&P mine site. Premining landslope alone would have precluded more intensive land uses above forestry. Although forestry contributes significantly to the overall economy of the County and State as well, the contention of the landowner was that an agricultural enterprise would provide quicker cash flow from the property. After an initial one to two year period of "conditioning", an anticipated modest yield of 4 tons/acre for 30 acres of alfalfa-smooth bromegrass forage, currently selling at $110/ton in the area, would result in a cash flow of $13,200/year. In addition, the sloping areas are to be grazed by beef cattle. Many cases in West Virginia are known where hay yields have exceeded 2 tons per acre on minesoils, from forage mixtures that have lower yield potentials than alfalfa and bromegrass.

SUMMARY AND CONCLUSIONS

In contrast to conventional operational designs used in this steeply sloping area, the T&P Construction Company mine site was designed to result in gently sloping landforms containing fertile minesoils conducive to a hayland/pasture agricultural enterprise favored by local landowners. Making use of innovative engineering designs and controlled overburden placement guided by Acid-Base Accounting and fertility data, overall mining and reclamation costs were reduced below costs experienced on previous operations which required returning the land to the approximate original contour (AOC). Premining soils were strongly acid, infertile, and possessed lime requirements near 10 tons/acre. In contrast, recently sampled minesoils contain high and very high levels of Ca, Mg, and K, with zero lime requirement. Low soil phosphorus levels will be remedied by phosphorus fertilization and nutrient recycling. Improved landscapes (gentle slopes) and high soil fertility will then assure increased land values and higher anticipated returns per acre or per hectare. The organization of this operation is such that precise economic data will become available promptly following mining.

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