SOILS OF THE TRACT 2
MINE PLAN AREA OF THE
TRAIL MOUNTAIN COAL MINE

Chapter 8

Prepared by

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SOILS OF THE TRACT 2 MINE PLAN AREA OF THE TRAIL MOUNTAIN COAL MINE

INTRODUCTION

No surface disturbance is planned on the Tract 2 Mine Plan Area of the Trail Mountain Coal Mine in Emery County, Utah. Therefore, no additional fieldwork was done to describe and classify the soils of the Tract 2 Area. The soil descriptions from which this report is based were taken from several available sources, published and unpublished. The sources were: 1) the approved Mine Plan of the Trail Mountain Coal Mine (ACT/015/009), 2) Soil Conservation Service, Price, Utah, 3) U.S. Forest Service, Price, Utah, and 4) Soil Survey: Carbon-Emery Area, Utah (1970).

More detail on the methodologies used by the above references will be given in the following text.

The soils of the Mine Plan Area were described by Allan and Anderson, 1981 (in ACT/015/009) using the older soil taxonomic classification system probably because most of the soil information at that time was based on this system. Since most of the soils of the entire mine area have already been described using this system, the Tract 2 Mine Plan soils will be mapped and compared to the approved Mine Plan soils. This will facilitate cross-referencing between the two reports.

STUDY AREA

As mentioned above, most of the mine area's soils have been previously mapped and described in the approved Mine Plan (ACT/015/009, Chapter 8). However, a portion of the Tract 2 Area was not included the in approved Mine Plan application. These and other soils located in the Tract 2 Area will be described in this report. For a description of the Mine Plan Area soils, refer to the reference mentioned above.

There are two mine boundaries marked on the Soils Map (Fig. 8-1): the Mine Plan Area and the Tract 2 Mine Plan Area. The Mine Plan Boundary is that section of the mine area that has been previously approved (ACT/015/009). The Tract 2 Mine Plan Area Boundary is the area in which the soils will be described in this report.

APPROVED MINE PLAN AREA SOILS

There were four main soil types found to occur in the Mine Plan Area, plus various thin soils among rocky outcrops and on talus slopes which were designated as rockland (map symbols RoG and RY, Approved Mine Plan, ACT/015/009, Fig. 8-1). The main soil types described in the approved plan were map symbols: AbG (very stoney sandy loam complex), CoG (stony sandy loam complex), SN (shaley colluvial land) and RI (riparian soils). For further information, refer to the approved Mine Plan of the Trail

Mountain Coal Mine.

TRACT 2 MINE PLAN AREA SOILS

Three of the above four soils that were found in the approved Mine Plan were also found on the Tract 2 Mine Plan Area. They were RoG (rocklands), CoG (stony sandy loam complex), and AbG (very stony sandy loam complex).

In addition, five other soil types were found within the boundaries of the Tract 2 Mine Plan Area (data taken from the Soil Conservation Service and U.S. Forest Service, Price, Utah). The map symbols and soil types are: AC1 (Argic Pachic Cryoborolls), TU (Typic Ustorthents), TC (Typic Cryorthents), AC3 (Argic Pachic Cryoborolls), and AC2 (Argic Pachic Cryoborolls). Refer to Soils Map 8-1 for locations of these soil types.

All of the soil types found in the Tract 2 Mine Plan Area will be described in this report. Descriptions of the soil types that were also found in the approved Mine Plan Area were taken from that mine plan (ACT/015/009, Chapter 8, Allan and Anderson, 1981). Soil descriptions of the Tract 2 Area that were not found in the approved Mine Plan Area were taken from current available sources using the more recent taxonomic system of classification.

The soil types and descriptions found in the Tract 2 Area are given below. The map symbols given correspond to those on the Soils Map (Fig. 8-1).

Map Symbol	Description
RoG	Rock Outcrops - Soil Complex (Bb-Aa). Thin soils on rocky outcrops and talus slopes (see CoG).
CoG	Stony, sandy loam complex. Soil Complex (Dd-De). Dry stony soils of steep mountain slopes. A soil pit was dug in the Grassland-Shrub Community that was represented by RoG and CoG soils for the approved Mine Plan Area (ACT/015/009). Results from the textural and chemical analyses are shown on Tables 8-1 and 8-2, respectively. This soil was relatively shallow with bedrock at the depth of 19 inches. The A-horizon was 5 inches deep and consisted of 71.5% fine soil and 28% larger rock fragments by weight. The fine soil fraction was a loam soil of 40% sand, 35% silt, and 25% clay. Deeper layers increased rapidly in rocky material, silt, and clay fractions. The pH ranged from 8.2 to 8.7 and the salinity from .3 to .4 mmho/cm2 (ACT/015/009, Chapter 8). For laboratory methods of the chemical and textural analyses, refer to ACT/015/009, Chapter 8, pages 8.3 and 8.4.

AbG Very stony sandy loam complex. Aa-Bb Complex. Dry, stony slopes of steep, mountain slopes.

AC1 USFS Map Unit 411. Argic Pachic Cryoborolls fine-loamy, mixed, light surface color, loam, 4% to 30% slopes--Argic Pachic Cryoborolls fine, montmorillonite, light surface color, 8% to 30% slopes.

This mapping unit occupies low rolling hills. Average annual air temperature is near 50 degrees F. Average annual precipitation is 25 to 30 inches. The freeze-free period is 20 to 40 days. The soils are deep, well drained, clay loams of clays. They developed in alluvium and colluvium from sandstone and shale. Slopes are 4% to 30%.

The first soil is about 55% of the unit. The second soil is about 30% of the unit. 15% of the unit is other soils.

Included areas are: Lithic Cryoborolls loamy-skeletal, mixed, 2% to 15% slopes; Lithic Cryorthents clayey, montmorillonitic, (nonacid), 5% to 30% slopes; Argic Pachic Cryoborolls loamy-skeleton, mixed; and small areas of extremely stony soil on slopes of 40% to 60% (see also "Soil Unit Description #411", Appendix 8A).

AC2 USFS Map Unit 561. Argic Pachic Cryoborolls fine-loamy, mixed, loam, 5% to 40% slopes-Argic Pachic Cryoborolls fine, montmorillonitic, loam, 5% to 20% slopes-Pachic Cryoborolls loamy-skeleton, mixed, loam, 10% to 30% slopes.

This map unit is on ridges and the adjacent mountain slopes, on all exposures. Average annual precipitation is 25 to 30 inches. The freeze-free periods 20 to 40 days. The soils are deep, well-drained clays, clay loams and very cobblely loams. They developed in alluvium, colluvium and residuum from shale and sandstone. Vegetation is aspen, grasses, western coneflower, elderberry, etc.

The first soil is 55% of the unit. The second soil is 20% of the unit. The third soil is 15% of the unit. The remaining 10% is inclusions.

Included are: Lithic Cryoborolls loamy-skeletal, mixed; Rock outcrop; and Typic Cryoboralfs (see "Soil Unit Description

#561", Appendix 8 A).

AC3 USFS Map Unit 41. Argic Pachic Cryoborolls clayey-skeletal, montmorillonitic, clay loam, 4% to 20% slopes.

This map unit occurs on broad ridges and the adjacent side slopes. The average annual air temperature is 34 to 38 degrees F. Average annual precipitation is 25 to 30 inches. Freeze-free season is about 20 days. The soils are moderately deep, well drained and are developed in residuum from shale, limestone and sandstone. Slopes are 4% to 20%. Vegetation is dominantly grasses and forbs, with scattered patches of mountain big sagebrush. Included are Argic Lithic Cryoborolls clays, montmorillonitic, 2% to 5% slopes and Lithic Cryoborolls clayey-skeletal, montmorillonitic, extremely stony clay loam, 30% to 60% slopes (see "Soil Unit Description #41", Appendix 8A).

TU Typic Ustorthents loamy-skeletal, mixed, frigid - Typic Ustochrepts loam-skeletal, mixed, frigid.

This is a steeply sloping escarpment. Soils are shallow to moderately deep and stony. Slopes are 40% to 65%. Vegetation includes pinyon-juniper and mountain brush. The site is dry, due to steep, south-facing slopes and rapid runoff. Runoff from this soil unit contributes to soil erosion downslope.

TC — USFS Map Unit 8. This map unit consists of 30% Typic Cryorthents fine loamy, mixed, shallow; 25% Lithic Cryoboralfs loamy-skeletal, mixed; and 10% Rock Outcrop. Slopes range from 40% to 80%.

The descriptions above of the five additional soil types of the Tract 2 Mine Plan Area were taken directly from description sheets supplied by the U.S.D.A. Soil Conservation Service, Price, Utah (personal correspondence with Robert Fish, S.C.S. Soil Scientist).

TABLE 8-1

GRASSLAND-SHRUB SOIL TEXTURAL ANALYSIS

	Horizons				
	1	2	3	4	5
Thickness (cm)	13	15	5	4	11
Color	reddish-brown	yellowish-gray	gray	yellowish-gray	gray
Structure	none	gravelly	caked hard-pan	clay	clay
Weight Percents of Bulk Soil					
% Rock > 2 mm*	28.5%	46.4%	49.7%	40.3%	66.3%
% Soil < 2 mm	71.5%	53.6%	50.3%	59.7%	33.4%
Weight Percents of Soil Fractions < 2 mm					
"Old Method" (2nd Hydrometer Reading at 1 Hour)					
% Sand	40.2%	17.0%	10.8%	12.0%	14.2%
% Silt	35.2%	47.2%	46.0%	50.0%	52.0%
% Clay	24.6%	25.8%	43.2%	38.0%	33.8%
Texture Class	loam	silty clay loam	silty clay	silty clay loam	silty clay loam
"New Method" (2nd Hydrometer Reading at 2 Hours)					
% Sand	40.2%	17.0%	10.8%	12.0%	14.2%
% Silt	38.8%	61.4%	51.8%	57.6%	56.8%
% Clay	21.0%	21.6%	37.4%	30.4%	29.0%
Texture Class	loam	silt loam	silty clay loam	silty clay loam	silty clay loam

*Tyler Screen, #10 mesh = 1.981 mm openings

TABLE 8-2

SOIL CHEMISTRY: Grassland-Shrub Reference Area

Horizon	Depth (cm)	Soil Texture Class	Acidity (pH)	Salinity (mmho/cm^2)	Soil Fertility P(ppm)	Soil Fertility K(ppm)	Soil Fertility Lime*	CEC† (meq./100g)
1	0-13	loam	8.2	.4	.9	95	++	9.0
2	13-28	silty clay loam	8.3	.4	.9	63	++	8.2
3	28-33	silty clay	8.5	.3	.6	80	++	7.6
4	33-39	silty clay loam	8.7	.3	.4	53	++	4.5
5	39-50	silty clay loam	8.7	.4	.6	75	++	6.3

Horizon	Ammonium Acetate Extractable Ions (meq./100g) Na	K	Ca	Mg	Saturation Percentage	Water Soluble Ions (meq./100g Na	K	Ca	Mg	meq/L in Sat. Ext. Chloride	Bi carbonate	SAR†
1	.33	.26	36.6	2.3	32.4	.02	.01	.1	.03	.3	3.2	.08
2	.44	.32	34.7	3.6	38.6	.02	.01	.1	.06	<.1	3.5	.07
3	.33	.26	36.1	5.7	42.7	.03	.01	<.1	.07	.2	2.5	---
4	.33	.19	36.7	4.9	48.0	.02	.01	<.1	.07	<.1	2.5	---
5	.33	.26	37.0	6.4	49.4	.03	.01	<.1	.10	.6	2.9	---

* Lime is indicated relatively. Here, ++ means lime is high.

† CEC = Cation Exchange Capacity, SAR = Sodium Adsorption Ratio

APPENDIX 8A

Selected Soil Map Description Sheets

SOIL MAP UNIT DESCRIPTION #411

5.00 CHARACTERISTICS AND ESTIMATED PROPERTIES OF MAJOR SOILS AND/OR LAND AREAS

5.10 MAJOR COMPONENT NAME: Argic Pachic Cryoboroll, fine-loamy, mixed light surface color.

DEPTH (INS.)	USDA TEXTURE	>3 IN (% BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK-SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.
0-17	L	-	0-10	6.1-6.5	0.6-2.0	Low	.16-.18	5-10	25-35
17-60	CL	-	-	6.1-6.5	0.2-6.0	Medium	.18-.19	10-15	30-35

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T	EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS
0-17	A-6	ML-CL	.32	4	60	Well	
17-60	A-6	CL	.28				

POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind
Moderate	C	Slow	Mod.	Low

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"	0-10	5
Cobble 3-10"	-	-
Stone 10-24"	-	-
Boulder >24"	-	-
Vegetation	60-90	75
Litter	10-30	10
Bare	0-10	10

FLOODING Frequency	Duration	Months	HIGH WATER TABLE Depth (Ft.)	Kind	Months
None	-	-	None	-	-

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness
	4	.9	-	60	-	Soft

5.11 SIMILAR INCLUDED SOILS WITH 5.10: Argic Pachic Cryoboroll, loamy-skeletal, mixed.

5.20 MAJOR COMPONENT NAME: Argic Pachic Cryoboroll, fine, montmorillonitic.

DEPTH (INS.)	USDA TEXTURE	>3 IN (% BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK-SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.
0-21	CL	-	0-5	6.6-7.3	0.2-0.6	Medium	.17-.18	10-20	30-40
21-44	C	-	-	6.6-7.3	0.6-0.2	High	.17-.18	15-25	40-50
44-60	CL	5-10	5-10	7.4-8.4	0.2-0.6	Medium	.14-.16	10-20	30-40

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T	EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS
0-21	A-4	CL-ML	.32				
21-44	A-6,A-7	CL-CH		4	60	Well	
44-60	A-4	CL-ML					

POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind
Moderate	D	V. Slow	Mod.	Low

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"	0-5	3
Cobble 3-10"	0-5	2
Stone 10-24"	-	-
Boulder >24"	-	-
Vegetation	60-90	70
Litter	10-30	15
Bare	0-5	10

FLOODING Frequency	Duration	Months	HIGH WATER TABLE Depth (Ft.)	Kind	Months
None	-	-	None	-	-

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness
-	4	1.27	-	None	-	-

5.21 SIMILAR INCLUDED SOILS WITH 5.20:

5.30 MAJOR COMPONENT NAME:

DEPTH (INS.)	USDA TEXTURE	>3 IN (% BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK-SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T	EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS

POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"		
Cobble 3-10"		
Stone 10-24"		
Boulder >24"		
Vegetation		
Litter		
Bare		

FLOODING Frequency	Duration	Months	HIGH WATER TABLE Depth (Ft.)	Kind	Months

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness

5.31 SIMILAR INCLUDED SOILS WITH 5.30:

SOIL MAP UNIT DESCRIPTION #561 561

5.00 CHARACTERISTICS AND ESTIMATED PROPERTIES OF MAJOR SOILS AND/OR LAND AREAS

5.10 MAJOR COMPONENT NAME: Argic Pachic Cryoboroll, fine-loamy, mixed.

DEPTH (INS.)	USDA TEXTURE	>3 IN (%BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.
0-17	L	-	0-10	6.1-6.5	0.6-2.0	Low	.16-.18	5-10	25.3[illegible]
17-60	CL	-	-	6.1-6.5	0.2-6.0	Medium	.18-.19	10-15	30-3[illegible]

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T
0-17	A-6	ML-CL	.32	4
17-60	A-6	CL		

EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS	POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind
40	Well		Moderate	C	Slow	Mod.	Low

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"	0-10	5
Cobble 3-10"	-	-
Stone 10-24"	-	-
Boulder >24"	-	-
Vegetation	60-90	75
Litter	10-30	10
Bare	0-10	10

FLOODING Frequency	FLOODING Duration	FLOODING Months	HIGH WATER TABLE Depth (Ft.)	HIGH WATER TABLE Kind	HIGH WATER TABLE Months
None	-	-	None	-	-

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness
	4	.9	-	60	-	Soft

5.11 SIMILAR INCLUDED SOILS WITH 5.10:

5.20 MAJOR COMPONENT NAME: Argic Pachic Cryoboroll, fine, montmorillonitic.

DEPTH (INS.)	USDA TEXTURE	>3 IN (%BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK-SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.
0-12	L	-	-	6.6-7.3	.6-2.0	Medium	.16-.18	10-15	25-35
12-26	CL,C	-	-	6.6-7.3	.20-.60	High	.18-.19	15-25	40-50
26-36	C	-	-	6.6-7.3	.06-.20	High	.18-.19	15-25	40-50
36	WB								

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T
0-12	A-4,A-6	CL	.32	3
12-36	A-7	CL-CH		
26-36	A-7	CL-CH		

EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS	POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind
40	Well		Moderate	C	Slow	Low	Low

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"	-	-
Cobble 3-10"	-	-
Stone 10-24"	-	-
Boulder >24"	-	-
Vegetation	60-90	75
Litter	10-30	20
Bare	0-10	5

FLOODING Frequency	FLOODING Duration	FLOODING Months	HIGH WATER TABLE Depth (Ft.)	HIGH WATER TABLE Kind	HIGH WATER TABLE Months
None	-	-	None	-	-

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness
	3	.5	-	36	-	Soft

5.21 SIMILAR INCLUDED SOILS WITH 5.20:

5.30 MAJOR COMPONENT NAME: Pachic Cryoboroll, loamy-skeletal, mixed.

DEPTH (INS.)	USDA TEXTURE	>3 IN (%BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK-SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.
0-13	L	-	-	6.6-7.3	.6-2.0	Low	.17-.18	5-10	20-35
13-25	STV-L	45-50	5	6.6-7.3	2.0-6.0	Low	.09-.11	5-10	20-35
25-45	STX-L,CL	60-70	-	6.6-7.9	2.0-6.0	Low	.08-.10	10-15	25-40
45	WB								

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T
0-13	A-4	CL-ML	.32	4
13-25	A-4	CL		
25-45	A-6	CL		
45				

EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS	POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind
45"	Well		Moderate	B	Moderate	Low	Low

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"	0-10	5
Cobble 3-10"	-	-
Stone 10-24"	-	-
Boulder >24"	-	-
Vegetation	60-90	75
Litter	10-20	15
Bare	0-10	5

FLOODING Frequency	FLOODING Duration	FLOODING Months	HIGH WATER TABLE Depth (Ft.)	HIGH WATER TABLE Kind	HIGH WATER TABLE Months
None	-	-	None	-	-

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness
	4	1.5	-	45	-	Soft

5.31 SIMILAR INCLUDED SOILS WITH 5.30:

SOIL MAP UNIT DESCRIPTION #41

5.00 CHARACTERISTICS AND ESTIMATED PROPERTIES OF MAJOR SOILS AND/OR LAND AREAS

5.10 MAJOR COMPONENT NAME: Argic Pachic Cryoboroll, clayey-skeletal montmorillonitic.

DEPTH (INS.)	USDA TEXTURE	>3 IN (% BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK-SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.
0-3	CL	-	-	6.6-7.3	0.2-0.6	Medium	.17-.19	10-15	30-40
3-11	CL	-	-	6.6-7.3	0.2-0.6	Medium	.17-.19	15-20	35-45
11-21	STX-C	55-65	5-10	6.6-7.3	0.06-0.2	Low	.08-.09	15-25	40-55
21-30	STX-C	55-65	5-10	7.4-7.8	0.06-.02	Low	.08-.09	25-30	45-55
30									

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T
0-3	A-6	CL	.32	3
3-11	A-6	CL	.28	
11-21	A-7	CL, CH		
21-40	A-7	CL, CH		
40	WB			

EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS	POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind
40	Well		Moderate	C	Slow	Low	Low

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"	0-5	4
Cobble 3-10"	0-5	2
Stone 10-24"	0-5	0
Boulder >24"	-	-
Vegetation	60-80	70
Litter	20-30	20
Bare	5-10	4

FLOODING Frequency	Duration	Months	HIGH WATER TABLE Depth (Ft.)	Kind	Months
None	-	-	None	-	-

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness
	3	.35	3	40-60		Hard

5.11 SIMILAR INCLUDED SOILS WITH 5.10:

5.20 MAJOR COMPONENT NAME:

DEPTH (INS.)	USDA TEXTURE	>3 IN (% BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK-SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T	EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS	POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"		
Cobble 3-10"		
Stone 10-24"		
Boulder >24"		
Vegetation		
Litter		
Bare		

FLOODING Frequency	Duration	Months	HIGH WATER TABLE Depth (Ft.)	Kind	Months

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness

5.21 SIMILAR INCLUDED SOILS WITH 5.20:

5.30 MAJOR COMPONENT NAME:

DEPTH (INS.)	USDA TEXTURE	>3 IN (% BY VOL)	2MM-3 IN. (% BY VOL)	REACTION (pH)	PERMEABILITY (INS./HR.)	SHRINK-SWELL POTENTIAL	A.W.C. (IN./IN.)	P.I.	L.L.

DEPTH (INS.)	AASHTO	UNIFIED	EROS. FACTORS K	EROS. FACTORS T	EFFECTIVE ROOTING DEPTH	DRAINAGE CLASS	WATER YIELD CLASS	POTENTIAL FROST ACTION	SOIL HYDROLOGIC GROUP	INFILTRATION	EROSION HAZARD Water	EROSION HAZARD Wind

GROUND COVER (%)	RANGE	AVERAGE
Gravel 2MM-3"		
Cobble 3-10"		
Stone 10-24"		
Boulder >24"		
Vegetation		
Litter		
Bare		

FLOODING Frequency	Duration	Months	HIGH WATER TABLE Depth (Ft.)	Kind	Months

SHEET AND RILL EROSION TONS/AC/YR Potential	Allowable	Current	Natural	CEMENTED PAN OR BEDROCK Depth (Ins.)	Cemented Pan Thickness	Bedrock Hardness

5.31 SIMILAR INCLUDED SOILS WITH 5.30:

VEGETATION OF THE TRACT 2
MINE PLAN AREA OF THE
TRAIL MOUNTAIN COAL MINE

Chapter 9

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VEGETATION OF THE TRACT 2 MINE PLAN AREA OF THE TRAIL MOUNTAIN COAL MINE

INTRODUCTION

The following is a descriptive discussion of the vegetation within the boundaries of the Tract 2 Mine Plan Area of the Trail Mountain Coal Mine in Utah. This discussion was based on field surveys, aerial photography and previously submitted quantitative data (from the approved Permit Application, ACT/015/009) of the entire area. Quantitative data was not taken within the boundaries of the Tract 2 Mine Plan Area because no surface disturbance by future mining activities is expected in this area.

PLANT COMMUNITIES

There were four major plant communities in the Tract 2 Mine Plan Area. They were the Grassland-Shrub, Pinyon-Juniper, Conifer, and Aspen communities. Three of these communities were quantified and described in the approved Mine Permit Application of the Trail Mountain Coal Mine because they also occur in the mine area. The Aspen communities have not been described in detail by previous Mine Permit Application because they only occur in the higher elevations and therefore have not been affected by current mining activities. Species composition of the Tract 2 Mine Plan Area plant communities may be somewhat different than the approved Mine Permit communities due to physiogonomic changes, however, the quantitative data reported from the application gives the reviewer a general conception of the plant communities of the entire mine area. A vegetation map of the Mine Area, Tract 2 Mine Plan Area and adjacent areas is included. Moreover, a smaller scale map (1":1000') with appropriate boundaries marked is also included to provide an overview of the area.

Grassland-Shrub Community

The Grassland-Shrub Community is common throughout the entire Mine Plan Area and Tract 2 Mine Plan Area of the Trail Mountain Coal Mine. The Grassland-Shrub Community that was described in the approved Mine Permit Plan (ACT/015/009, Chapter 9) was similar to some of those on the Tract 2 Mine Plan Area. A total of 37 plant species were recorded in the approved Mine Permit Plan: 3 tree, 11 shrub, 6 grass and sedge, and 17 forb species. No extensive tree canopy existed, but there were a few isolated trees. Cover by lifeform reported was 2.54% trees, 8.50% shrubs, 33.36% grasses and sedges, 6.49% forbs, and 3.54% cryptograms (Table 9-2). The most important plant species by cover were slender wheatgrass (*Agropyron trachycaulum*), shadscale (*Atriplex confertifolia*), bedstraw (*Galium multiflorum*), low rabbitbrush (*Chysothamnus viscidiflorus*), and Sandberg bluegrass (*Poa secunda*).

Productivity of this community was reported as 910 (air dry) pounds per acre (see approved Mine Plan, ACT/015-/009, Chapter 9). Cover, frequency and density data for the Grassland-Shrub Community taken from the approved Mine Permit are shown on Table 9-2).

As previously mentioned, species composition of the communities may change somewhat in the different areas due to physiognomic changes. For example, the communities on the upper elevations of the properties have a variety of environmental changes when compared to the lower communities. These factors can greatly influence species and composition. Some of the obvious changes that could affect the communities are slope, aspect, moisture, edaphic, grazing, and etc. This was true for the Grassland-Shrub Community. In some of the upper Grassland-Shrub communities, big sagebrush (*Artemisia tridentata var. vaseyana*) becomes much more important and frequent. Moreover, mountain brome (*Bromus carinatus*), mountain timothy (*Phleum alpinum*) and smooth brome becomes the dominate grass species. There are also isolated patches and/or individuals of limber pine (*Pinus flexilis*) scattered among the Grassland-Shrub and Aspen communities of the higher elevations. However, the quantitative data reported gives one a general conception of the plant communities. For a list of the species present in this community refer to

Table 9-1.

Pinyon-Juniper Community

The Pinyon-Juniper Community is another important plant community of the approved Mine Area and the Tract 2 Mine Plan Area (see Vegetation Map I). Because this community was described in the approved Mine Plan (ACT-/015/009), some of the quantitative data of the plan was also used as an aid for the description of the Tract 2 Permit Application.

Grass species dominate the understory vegetation of the Pinyon-Juniper Community with a total cover for this lifeform of 12.99% (or 55.51% of the total living cover). Slender wheatgrass (*Agropyron trachycaulum*) was reported as the most important plant species of the understory cover with a mean value of 11.27% (or 48.16% of the total living cover). The next most important species of the understory were Utah serviceberry (*Amelanchier utahensis*), Hood's phlox (*Phlox hoodii*), Sandberg's bluegrass (*Poa secunda*) and lichens. For cover, frequency, and density values of all the species reported in this community refer to Table 9.5. For a species presence list, refer to Table 9-3.

Conifer Community

The Conifer Community is another important plant community that occurs in both the approved Mine Area and the Tract 2 Mine Plan Area of the Trail Mountain Mine.

Refer to the Vegetation Map I for the boundaries of this community. Six trees, 9 shrubs, 6 grasses and sedges, and 22 forbs have been reported for this community in the approved Mine Plan (ACT/015/009). For a species list refer to Table 9-6.

Douglas fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) are the dominant conifers of the community. Grass and sedge species were the most important understory species with a mean cover value of 9.01%. The most common grass was slender wheatgrass (*Argopyron trachycaulum*). Dominant shrub species of the understory were Utah serviceberry (*Amelanchier utahensis*) and Oregon grape (*Mohonia repens*) with mean covers of 2.35% and 1.30%, respectively. Bedstraw (*Galium multiflorum*) with a mean cover of 1.44% and Hood's phlox (*Phlox hoodii*) at 1.28% represented the dominate forb species. A summary of the understory data is shown on Table 9-8 .

Table 9-7 summarizes the tree data for the conifer stand. Douglas fir had the greatest amount of basal area, but white fir contributed the greater amount of canopy cover and was 10% more frequent. Total density of trees was about 74 per acre, with Douglas fir and white fir even, although Douglas fir had almost twice as many seedlings and saplings. Both trees are reproducing themselves so this stand can be considered a climax community for this exposure, elevation, and other static factors of soil, etc. Mountain red juniper (*Juniperus scopulorum*) showed good reproduction, but there were few tree-size individuals in the samples (ACT/015/009, Chapter 9).

Aspen Community

As can be noted on the Vegetation Map, Aspen communities are established at the upper elevations of the properties. On the basis of area, the Aspen Community is relatively less important the previously described communities. These communities were not however described in the approved Mine Permit because no surface disturbance was expected at that time. As previously stated, no surface disturbance is expected to any of the plant communities of the Tract 2 Mine Plan Area.

TABLE 9-1

SPECIES PRESENCE LIST: GRASSLAND-SHRUB COMMUNITY

Species (Total = 37)	Common Name
TREES (3)	
Abies concolor (Gord. & Glend.) Lindl.	White Fir
Juniperus scopulorum Sarg.	Rocky Mountain Juniper
Pseudotsuga menziesii (Mirb.) Franco	Douglas Fir
SHRUBS (11)	
Amelanchier utahensis (Nutt.) Nutt.	Utah Serviceberry
Artemisia tridentata Nutt.	Big Sage
Atriplex confertifolia (Torr. & Frem.) S. Wats.	Shadscale
Cercocarpus ledifolius Nutt.	Curlleaf Mountain Mahogany
Chrysothamnus viscidiflorus (Hook.) Nutt.	Douglas or Yellowbrush Rabbitbrush
Ephedra viridis Cov.	Green Ephedra, Mormon Tea, Joint Fir
Gutierrezia sarothrae (Pursh) Britton	Broom Snakeweed
Holodiscus dumosus (Hook.) Heller	Bush Oceanspray
Physocarpus malvaceus (Greene) Kuntze	Mallow Ninebark
Rosa woodsii Lindl.	Wild Rose
Symphoricarpos oreophilus A. Gray	Mountain Snowberry
GRASSES AND SEDGES (6)	
Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch Wheatgrass
Agropyron trachycaulum (Link) Malte	Slender Wheatgrass
Carex geyeri Boott	Elk Sedge
Oryzopsis hymenoides (Roem. & Schult.) Ricker	Indian Ricegrass
Poa pratensis L.	Kentucky Bluegrass
Poa secunda Presl	Sandberg's Bluegrass
FORBS (17)	
Arabis drummondii A. Gray	Drummond's Rock Cress
Aster chilensis Nees	Aster
Cirsium undulatum (Nutt.) Spreng	Wavyleaf Thistle
Coryphantha vivipara Britton & Brown	Mammillaria
Cryptantha humilis (Greene) Payson	Cryptantha, Dwarf Catseye
Eriogonum corymbosum Benth.	Buckwheat
Galium multiflorum Kellogg	Shrubby Bedstraw
Haplopappus nuttallii Torr. & Gray	Golden Weed
Heuchera parvifolia Nutt.	Common Alumroot
Hymenoxys richardsonii (Hook.) Cockerell	Hymenoxys
(a) *Lappula redowskii* (Hornem.) Greene	Stickseed
Lepidium montanum Nutt.	Mountain Pepperweed
Penstemon humilis Nutt.	Low Penstemon
Penstemon thompsoniae (A. Gray) Rydb.	Thompson's Penstemon
Phlox hoodii Rich.	Hood's Phlox
Sisymbrium linifolium Nutt.	Tumblemustard
Stanleya pinnata (Pursh) Britton	Desert Prince's Plume

(a) annual

TABLE 9-2

GRASSLAND-SHRUB UNDERSTORY VEGETATION DATA: Cover, Frequency and Density Data from Quadrats

Species	Average % Cover per Quadrat	Absolute Frequency	Number of Stems in 50 Quadrats	Relative % of Cover	% of ΣF	% Density	Importance Value	% Importance	C x F Index
Trees*									
Abies concolor	1.10	2	1	2.02	.48	.20	2.70	.98	.97
Juniperus scopulorum	.80	2	1	1.47	.48	.20	2.15	.78	.71
Pseudotsuga menziesii	.64	4	3	1.18	.97	.59	2.74	.99	1.14
Subtotal	2.54	8	5	4.67	1.93	.99	7.59	2.76	2.82
Shrubs									
Amelanchier utahensis	1.24	10	4	2.28	2.42	.79	5.49	1.99	5.52
Artemisia tridentata	.20	2	1	.37	.48	.20	1.05	.38	.18
Atriplex confertifolia	4.93	32	14	9.06	7.73	2.77	19.56	7.10	70.03
Chrysothamnus viscidiflorus	1.60	14	8	2.94	3.38	1.58	9.90	2.87	9.94
Gutierrezia sarothrae	.51	14	26	.94	3.38	5.14	9.46	3.43	3.18
Rosa woodsii	.02	2	1	.04	.48	.20	.72	.26	.02
Subtotal	8.50	74	54	15.62	17.87	10.67	44.18	16.04	88.86
Grasses and Sedges									
Agropyron spicatum	.20	4	2	.37	.97	.40	1.74	.63	.36
Agropyron trachycaulum	31.18	100	251	57.28	24.15	49.60	131.03	47.57	1383.31
Carex geyeri	.30	4	3	.55	.97	.59	2.11	.77	.53
Oryzopsis hymenoides	.10	2	1	.18	.48	.20	.86	.31	.09
Poa pratensis	.04	2	1	.07	.48	.20	.75	.27	.03
Poa secunda	1.54	14	16	2.83	3.38	3.16	9.37	3.40	9.57
Subtotal	33.36	126	274	61.29	30.43	54.15	145.86	52.95	1393.89

Continued on next page...

*Understory data measured by quadrats.

TABLE 9-CONTINUED

Species	Average % Cover per Quadrat	Absolute Frequency	Number of Stems in 50 Quadrats	Relative % of Cover	% of ΣF	% Density	Importance Value	% Importance	C x F Index
Forbs									
Arabis drummondii	.10	8	7	.18	1.93	1.38	3.49	1.27	.35
Aster chilensis	.04	2	2	.07	.48	.40	.95	.34	.03
Cryptantha humilis	.12	10	6	.22	2.42	1.19	3.83	1.39	.53
Coryphantha vivipara	.40	2	1	.73	.48	.20	1.41	.51	.35
Eriogonum corymbosum	1.3	14	13	2.39	3.38	2.57	8.34	3.03	8.08
Galium multiflorum	2.96	40	85	5.42	9.66	16.80	31.88	11.57	52.36
Haplopappus nuttallii	.56	16	14	1.03	3.86	2.77	7.66	2.78	3.98
Hymenoxys richardsonii	.20	4	4	.37	.97	.79	2.13	.77	.36
Lepidium montanum	.02	2	1	.04	.48	.20	.72	.26	.02
Phlox hoodii	.52	18	25	.96	4.35	4.94	10.25	3.72	4.18
Penstemon humilis	.02	2	1	.04	.48	.20	.72	.26	.02
Sisymbrium linifolium	.13	10	12	.24	2.42	2.37	4.85	1.76	.58
Stanleya pinnata	.12	4	2	.22	.97	.40	1.59	.58	.21
Subtotal	6.49	132	173	11.92	31.88	34.19	77.82	28.25	74.08
Cryptogams									
Moss	.44	16		.81	3.86		4.67		
Lichens	3.10	58		5.70	14.01		19.71		
Subtotal	3.54	74		6.51	17.87		24.38		
Total Living Cover	54.43	414	506	100.00	100.00	100.00			
Non-Living Cover									
Litter	8.72								
Rock	20.46								
Soil	16.39								

TABLE 9-3

SPECIES PRESENCE LIST: PINYON-JUNIPER PLANT COMMUNITY

Species (Total = 62)	Common Name
TREES (6)	
Abies concolor (Gord. & Glend.) Lindl.	White Fir
Juniperus osteosperma (Torr.) Little	Utah Juniper
Juniperus scopulorum Sarg.	Rocky Mountain Juniper
Pinus edulis Engelm.	Pinyon Pine
Pinus flexilis James	Limber Pine
Pseudotsuga menziesii (Mirb.) Franco	Douglas Fir
SHRUBS (13)	
Amelanchier utahensis (Nutt.) Nutt.	Utah Serviceberry
Artemisia tridentata Nutt.	Big Sage
Atriplex confertifolia (Torr.& Frem.) S. Wats.	Shadscale
Cercocarpus ledifolius Nutt.	Curlleaf Mountain Mahogany
Chrysothamnus nauseosus (Pall.) Britton	Rubber Rabbitbrush
Chrysothamnus viscidiflorus (Hook.) Nutt.	Douglas or Yellowbrush Rabbitbrush
Ephedra viridis Cov.	Green Ephedra, Mormon Tea, Joint Fir
Gutierrezia sarothrae (Pursh) Britton	Broom Snakeweed
Holodiscus dumosus (Hook.) Heller	Bush Oceanspray
Mahonia repens G. Don	Oregon Grape, Creeping Barberry
Pachistima myrsinites (Pursh) Raf.	Mountain Lover
Physocarpus malvaceus (Greene) Kuntze	Mallow Ninebark
Symphoricarpos oreophilus A. Gray	Mountain Snowberry
GRASSES (7)	
Agropyron spicatum (Pursh) Scrib. & Smith	Bluebunch Wheatgrass
Agropyron trachycaulum (Link) Malte	Slender Wheatgrass
Bromus inermis Leyss.	Smooth Brome
Bromus tectorum L.	Cheatgrass
Oryzopsis hymenoides (Roem. & Schult.) Ricker	Indian Ricegrass
Poa secunda Presl	Sandberg's Bluegrass
Poa sp.	an unidentified bluegrass species

Continued on next page...

TABLE 9-3 CONTINUED

Species	Common Name
FORBS (36)	
Antennaria rosea Greene	Rose Pussytoes, Everlasting
Arabis drummondii A. Gray	Drummond's Rock Cress
Arabis holboellii Hornem.	Rockcress
Arabis pendulina Greene	Rockcress
Artemisia ludoviciana Nutt.	Louisiana Sage, Wormwood
Chenopodium fremontii S. Watts	Fremont's Goosefoot, Pigweed
Cirsium undulatum (Nutt.) Spreng	Wavyleaf Thistle
Coryphantha vivipara Britton & Brown	Mammillaria
Cryptantha humilis (Greene) Payson	Cryptantha, Dwarf Catseye
**Cryptogramma stelleri* (Gmel.) Prantl	Rockbrake
(a) *Descurainia pinnata* (Walt.) Britton	Tansymustard
Descurainia richardsonii (Sweet) O.E. Schulz	Tansymustard
Erigeron engelmannii A. Nels.	Engelmann's Fleabane
Eriogonum corymbosum Benth.	Buckwheat
Galium aparine L.	Catchweed Bedstraw
Galium multiflorum Kellogg	Shrubby Bedstraw
Haplopappus nuttallii Torr. & Gray	Golden Weed
Heterotheca villosa Welsch & Moore	Golden Aster
Hymenopappus filifolius Hook.	Fineleaf Hymenopappus
Ipomopsis aggregata V. Grant	Skyrocket Gilia, Scarlet Gilia
) *Lappula redowskii* (Hornem.) Greene	Stickseed
Lepidium montanum Nutt.	Mountain Pepperweed
Leptodactylon pungens (Torr.) Nutt.	Prickly Phlox
Leucelene ericoides (Torr.) Greene	Fleabane
(a) *Lithospermum arvense* L.	Stoneseed
Opuntia polyacantha Haw.	Plains Prickly Pear
Penstemon eatonii A. Gray	Eaton's Penstemon
Penstemon thompsoniae (A. Gray) Rydb.	Thompson's Penstemon
Petradoria pumila (Nutt.) Greene	Rock Goldenrod
Phlox hoodii Rich.	Hood's Phlox
Senecio integerrimus Nutt.	Groundsel, Old Man
Senecio multilobatus Torr. & Gray	Lobeleaf Groundsel
Sisymbrium linifolium Nutt.	Tumblemustard
Solidago canadensis L.	Goldenrod
Stanleya pinnata (Pursh) Britton	Desert Prince's Plume
Townsendia incana Nutt.	Hoary Townsendia

* Fern

(a) annuals

TABLE 9-4

PINYON-JUNIPER TREE DATA*

Species	No. of Individuals	Density Trees/Acre	Relative Density	Basal Area	Relative % Dominance	% Cover	Relative % Cover	% Frequency	% ΣF	Importance Value	Relative Importance	C x F Index
Trees												
Juniperus scopulorum	6	14.9	15.0	433.5	10.9	3.1	14.9	60	30	70.8	17.7	447.0
Pinus edulis	27	66.9	67.5	2960.4	74.2	11.0	52.9	90	45	239.6	59.9	2380.5
Pinus flexilis	1	2.5	2.5	103.8	2.6	4.2	20.2	10	5	30.3	7.6	101.0
Pseudotsuga menziesii	6	14.9	15.0	490.6	12.3	2.5	12.0	40	20	59.3	14.8	240.0
Totals	40	99.2	100.0	3988.3	100.0	20.8	100.0	200	100	400.0	100.0	3168.5
Seedlings and Saplings												
Juniperus scopulorum	8	26.8	20.0					50	23.8	43.8	21.9	
Pinus edulis	19	63.6	47.5					80	38.1	85.6	42.8	
Pinus flexilis	2	6.7	5.0					20	9.5	14.5	7.2	
Pseudotsuga menziesii	11	36.8	27.5					60	28.6	56.1	28.1	
Totals	40	133.9	100.0					210	100.0	200.0	100.0	
Trees plus Saplings and Seedlings												
Juniperus scopulorum	14	41.7	17.5									
Pinus edulis	46	130.5	57.5									
Pinus flexilis	3	9.2	3.8									
Pseudotsuga menziesii	17	51.7	21.2									
Totals	80	233.1	100.0									

*Tree density, dominance, and frequency by the quarter method and cover by line intercept method.

TABLE 9-5

PINYON-JUNIPER UNDERSTORY VEGETATION DATA:
Cover, Frequency and Density Data from Quadrats

Species	Average % Cover per Quadrat	Absolute Frequency	Number of Stems in 51 Quadrats	Relative % of Cover	% of ΣF	% Density	Importance Value	% Importance	C x F Index
Tree Seedlings and Saplings*									
Juniperus scopulorum	.12	3.92	2	.51	1.03	.34	1.88	.63	.53
Pinus edulis	.29	1.96	0	1.24	.52	0	1.76	.59	.64
Pseudotsuga mensiesii	.53	3.92	5	2.26	1.03	.85	4.14	1.38	2.33
Subtotal	.94	9.80	7	4.01	2.58	1.19	7.78	2.60	3.50
Shrubs									
Amelanchier utahensis	4.00	23.51	7	17.09	6.18	1.19	24.46	8.15	105.62
Artemisia tridentata	.08	1.96	1	0.34	.52	.17	1.03	.34	.18
Gutierrezia sarothrae	.01	1.96	1	0.04	.52	.17	.73	.24	.02
Symphoricarpos oreophilus	.02	3.92	1	0.09	1.03	.17	1.29	.43	.09
Subtotal	4.11	31.35	10	17.56	8.24	1.70	27.51	9.17	105.91
Grasses									
Agropyron spicatum	.59	7.84	21	2.52	2.06	3.58	8.16	2.72	5.19
Agropyron trachycaulum	11.27	84.31	363	48.16	22.17	61.95	132.28	44.09	1067.71
Oryzopsis hymenoides	.12	3.92	1	0.51	1.03	.17	1.17	.57	.53
Poa secunda	1.01	27.45	22	4.32	7.22	3.75	15.29	5.10	31.19
Subtotal	12.99	123.52	407	55.51	32.48	69.46	157.44	52.48	1104.61

Continued on next page...

*Understory data measured by quadrats. See Tree Tables for canopy data measured by point-quarter and line intercept methods.

TABLE 9-5 CONTINUED

Species	Average Cover per Quadrat	Absolute Frequency	Number of Stems in 51 Quadrats	Relative % of Cover	% of ΣF	% Density	Importance Value	% Importance	C x F Index
Forbs									
Antennaria rosea	.10	5.88	8	.43	1.55	1.37	3.35	1.12	.67
Arabis drummondii	.04	7.84	5	.17	2.06	.85	3.08	1.03	.35
Arabis pendulina	.04	1.96	10	.17	0.52	1.71	2.40	.80	.09
Aster chilensis	.07	3.92	4	.30	1.03	.68	2.01	.67	.31
Chenopodium fremontii	.02	3.92	2	.09	1.03	.34	1.46	.49	.09
Cirsium undulatum	.10	1.96	1	.43	.52	.17	1.12	.37	.22
Cryptantha humilis	.01	1.96	1	.04	0.52	.17	.73	.24	.02
(Fern) *Cryptogramma stelleri*	.02	1.96	1	.09	.52	.17	.78	.26	.05
Descurainia richardsonii	.07	5.88	37	.30	1.55	6.31	8.16	2.72	.47
Erigeron engelmannii	.03	5.88	3	.13	1.55	.51	2.19	.73	.20
Galium multiflorum	.11	7.84	23	.47	2.06	3.92	6.45	2.15	.97
Haplopappus nuttallii	.29	17.64	17	1.24	4.64	2.90	8.78	2.93	5.64
Lappula redowskii	.01	1.96	2	.04	.52	.34	.90	.30	.02
Lepidium montanum	.16	3.92	5	.68	1.03	.85	2.56	.85	.70
Penstemon eatoni	.02	1.96	2	.09	.52	.34	.95	.32	.05
Phlox hoodii	.92	31.37	31	3.93	8.25	5.29	17.47	5.82	32.42
Senecio integerremus	.04	5.88	4	.17	1.55	.68	2.40	.80	.26
Senecio multilobatus	.09	7.84	6	.38	2.06	1.02	3.46	1.15	.78
Subtotal	2.14	119.57	162	9.15	31.44	27.65	68.25	22.75	42.64
Cryptogams									
Moss	.57	23.53		2.44	6.19		8.63	2.88	15.10
Lichens	2.65	72.55		11.32	19.09		30.40	10.13	215.99
Subtotal	3.22	96.08		13.76	25.26		39.03	13.01	231.09
TOTALS: Living Plants	23.40	380.32	586	100.00	100.00	100.00	300.01	100.01	1487.75
Non-living Cover									
Litter	26.02								
Rock	27.27								
Soil	22.57								
Total	75.86								

TABLE 9-6

SPECIES PRESENCE LIST: CONIFER PLANT COMMUNITY

Species (Total = 42)	Common Name
TREES (6)	
Abies concolor (Gord. & Glend.) Lindl.	White Fir
Acer glabrum Torr.	Rocky Mountain Maple, Smooth Maple
Juniperus scopulorum Sarg.	Rocky Mountain Juniper
Pinus edulis Engelm.	Pinyon Pine
Pinus flexilis James	Limber Pine
Pseudotsuga menziesii (Mirb.) Franco	Douglas Fir
SHRUBS (9)	
Amelanchier utahensis Koehne	Utah Serviceberry
Artemisia tridentata Nutt.	Big Sage
Cercocarpus ledifolius Nutt.	Curlleaf Mountain Mahogany
Chrysothamnus viscidiflorus (Hook.) Nutt.	Douglas or Yellowbrush Rabbitbrush
Holodiscus dumosus (Hook.) Heller	Bush Oceanspray
Mahonia repens G. Don	Oregon Grape, Creeping Barberry
Physocarpus malvaceus (Greene) Kuntze	Mallow Ninebark
Ribes cereum Dougl.	Wax Currant
Symphoricarpos oreophilus A. Gray	Mountain Snowberry
GRASSES AND SEDGES (6)	
Agropyron trachycaulum (Link) Malte	Slender Wheatgrass
Carex geyeri Boott	Elk Sedge
Dactylis glomerata L.	Orchard Grass
Elymus glauca Buckl.	Blue Wildrye
Elymus salina E. Jones	Salina Wildrye
Poa secunda Presl	Sandberg's Bluegrass
FORBS (22)	
Antennaria parvifolia Nutt.	Pussytoes, Everlasting
Arabis drummondii A. Gray	Drummond's Rock Cress
Arabis pendulina Greene	Rock Cress
Arabis pulchra M.E. Jones	Rock Cress
Aster chilensis Nees	Aster
Castilleja linariaefolia Benth.	Wyoming Painted Cup, Indian Paintbrush
Chamaechaenactis scaposa (Eastw.) Rydb.	False Yarrow
Clematis pseudoalpina (Kuntze) A. Nels.	Rocky Mountain Clematis
Cryptantha humilis (Greene) Payson	Cryptantha, Dwarf Catseye
Erigeron engelmannii A. Nels.	Engelmann's Fleabane
Erysimum wheeleri (Rothr.) Rydb.	Wallflower
Galium multiflorum Kellogg	Shrubby Bedstraw
Haplopappus nuttallii Torr. & Gray	Golden Weed
Heuchera parvifolia Nutt.	Common Alumroot
Hymenoxys acaulis (Pursh) Parker	Hymenoxys
Malcolmia africana (L.) R. Br.	African Mustard
Penstemon eatoni A. Gray	Eaton's Penstemon
Penstemon thompsoniae (A. Gray) Rydb.	Thompson's Penstemon
Phlox hoodii Rich.	Hood's Phlox
Senecio multilobatus Torr. & Gray	Lobeleaf Groundsel
Sisymbrium altissimum L.	Tumblemustard
Stellaria jamesiana Torr.	Tuber Starwort

TABLE 9-7

CONIFER COMMUNITY TREE DATA

Species	No. of Individuals	Density Trees/ Acre	Relative % Density	Basal Area	Relative % Dominance	% Cover	Relative % Cover	% Frequency	% ΣF	Importance Value	Relative Importance	C x F Index
Trees												
Abies concolor	16	29.5	40	843.52	35.41	34.6	57.4	80	36.4	169.2	42.3	2089.4
Juniperus scopulorum	1	1.8	2.5	23.75	1.00	2.2	3.6	10	4.5	11.5	2.9	16.2
Pinus edulis	7	12.9	17.5	380.88	15.99	0	0	40	18.2	51.7	12.9	0
Pinus flexilis						3.4	5.6		0	5.6	1.4	0
Pseudotsuga menziesii	16	29.5	40	1133.98	47.60	20.2	33.4	90	40.9	161.9	40.5	1366.1
Totals	40	73.7	100.0	2382.13	100.00	60.4	100.0	220	100.0	400.0	100.0	3471.7
Saplings and Seedlings												
Abies concolor	10	125.9	25					70	26.9	51.9		
Juniperus scopulorum	7	90.7	18					60	23.1	41.1		
Pinus edulis	2	25.2	5					10	3.8	8.8		
Pinus flexilis	2	25.2	5					20	7.7	12.7		
Pseudotsuga menziesii	19	236.7	47					100	38.5	85.5		
Totals	40	503.7	100.0					260	100.0	200.0		
Trees and Saplings and Seedlings												
Abies concolor	26	155.4	32.5									
Juniperus scopulorum	8	92.5	10.0									
Pinus edulis	9	38.1	11.3									
Pinus flexilis	2	25.2	2.5									
Pseudotsuga menziesii	35	266.2	43.8									
Totals	80	577.4	100.0									

TABLE 9-8

CONIFER UNDERSTORY VEGETATION DATA: Cover, Frequency and Density Data from Quadrats

Species	Average % Cover per Quadrat	Absolute Frequency	Number of Stems in 30 Quadrats	Relative % of Cover	% of ΣF	% Density	Importance Value	% Importance	C x F Index
Trees*									
Abies concolor	.70	16.6	2	3.0	3.39	.15	6.54	2.18	10.17
Juniperus scopulorum	.76	16.6	5	3.31	3.39	.38	7.08	2.36	11.22
Pinus flexilis	2.00	3.3	2	8.72	.67	.15	9.54	3.18	5.84
Pseudotsuga menziesii	2.73	10.6	3	11.90	2.16	.23	14.29	4.76	25.70
Subtotal	6.19	47.1	12	26.98	9.61	.91	37.45	12.49	52.94
Shrubs									
Amelanchier utahensis	2.35	16.6	4	10.24	3.39	.30	13.93	4.64	34.71
Chrysothamnus viscidiflorus	.03	3.3	1	.13	.67	.08	.88	.29	.09
Mahonia repens	1.30	20.0	66	5.67	4.08	4.95	14.70	4.90	23.13
Symphoricarpos oreophilus	.13	6.7	2	.57	1.37	.15	2.09	.70	.78
Subtotal	3.81	46.6	73	16.61	9.51	5.47	31.60	10.54	58.72
Grasses and Sedges									
Agropyron trachycaulum	6.27	80.0	833	27.33	16.32	62.54	106.19	35.40	446.03
Carex geyeri	1.18	33.3	37	5.14	6.79	2.78	14.71	4.90	34.90
Dactylis glomerata	.23	10.0	7	1.00	2.04	.53	3.57	1.19	2.04
Elymus glauca	1.13	33.3	128	4.93	6.79	9.61	21.33	7.11	33.47
Elymus salina	.20	6.7	5	.87	1.37	.38	2.62	.87	1.19
Subtotal	9.01	163.3	1010	39.28	33.32	75.83	148.42	49.48	517.63

Continued on next page...

*Understory data measured by quadrats. See Tree Tables for canopy data measured by point-quarter and line intercept methods

TABLE 9-8 CONTINUED

Species	Average % Cover per Quadrat	Absolute Frequency	Number of Stems in 30 Quadrats	Relative % of Cover	% of ΣF	% Density	Importance Value	% Importance	C x F Index
Forbs									
Castilleja linariaefolia	.01	6.7	2	.04	1.37	.15	1.51	.50	.05
Chamaechaenactis scaposa	.10	3.3	2	.44	.67	.15	1.26	.42	.29
Cryptantha humilis	.01	3.3	1	.04	.67	.08	.79	.26	.03
Erigeron engelmannii	.12	3.3	3	.52	.67	.23	1.42	.47	.35
Galium multiflorum	1.44	60.0	130	6.28	12.24	9.76	28.28	9.43	76.87
Haplopappus nuttallii	.03	3.3	1	.13	.67	.08	.88	.29	.09
Hymenoxys acaulis	.44	10.0	6	1.92	2.04	.45	4.41	1.47	3.92
Malcolmia africana	.01	3.3	2	.04	.67	.15	.86	.29	.03
Penstemon thompsoniae	.05	13.3	6	.22	2.71	.45	3.38	1.13	.60
Phlox hoodii	1.28	80.0	76	5.58	16.32	5.26	27.16	9.06	91.07
Senecio multilobatus	.27	13.3	10	1.18	2.71	.75	4.64	1.55	3.20
Sisymbrium altissimum	.01	3.3	1	.04	.67	.08	.79	.26	.03
Stellaria jamesiana	.01	10.0	3	.04	2.04	.23	2.31	.77	.08
Subtotal	3.78	213.1	237	16.48	43.45	17.79	77.69	25.90	176.59
Cryptogams									
Moss	.07	10.0		.35	2.04		2.39	.80	.71
Lichens	.08	10.0		.35	2.04		2.39	.80	.71
Subtotal	.15	20.0		.70	4.08		4.78	1.60	1.43
Total Living Cover	22.94	490.1	1332	100.00	100.00	100.00	299.94	100.00	807.30
Non-Living Cover									
Litter	23.37								
Rock	19.23								
Soil	34.40								
Total Non-Living Cover:	77.00								

CHAPTER XI

CLIMATOLOGY

Prepared for

TRAIL MOUNTAIN COAL COMPANY

Orangeville, Utah

By

ENGINEERING DEPT.

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11.1 Scope

This chapter describes the climatology of the Trail Mountain mine plan area Tract 2, and contains description of the air quality control measures. The first discussion centers on three main areas: the methodology, the existing environment, and the air quality control measures.

11.2 Methodology

The information presented in this chapter consists of a review of publist literature regarding the existing climatology environment and referencing approved Trail Mountain Coal Permit No. ACT/015/009.

11.3 Existing Environment

The Tract 2 mine permit area is situated on the eastern slope of the Wasatch Plateau and lies approximately 12 miles to the northwest of Orangeville, Utah, on Trail Mountain at an elevation of approximately 21,000 ft. The nearest stations reporting climate data are Utah Power and Lights' Hunter Plant, Castle Dale , Utah; Uah Power and Lights' Huntington Plant, approximately 12 miles west of Huntington, Utah; and Utah Power and Lights' Electric Lake station, approximately 22 miles west of Huntington, Utah.

11.3.1 Precipitation

Precipitation in Emery county during 1984 was similar to other intermountain areas. Mountains in the San Rafael Basin received extremely high snowfall during the 1983, 1984 winter. April 1, 1984, snow surverys indicated snow cover at 168 percent of normal. May 1 snow cover was 184 percent of normal. The resulting 1984 runoff was one of the highest in the past 60 years. Precipitation amounts recorded at the Utah

Power and Light Hunter Plant. Huntington Plant. Electric Lake, and East Mountain for the 1984 water year, Oct. 1983-Sept. 1984, will be presented since the sights included low elevation, intermediate elevation, and two high elevation observation sights in the immediate vacinity of the Trail Mountain Tract 2 Permit Area. The values are shown in Table 1.

11.3.2 Temperatures

To a great extent, daily temperature ranges are controlled by elevation and local topography. During the 1984 water year, temperatures within Emery county at the lower elevations were generally higher than normal while the higher elevations were generally cooler than normal. At the Hunter Plant station, Nov.-Feb., temperatures were below normal and the rest of the year were above normal. The Huntington Plant station was cooler than normal during the months of Dec., Feb., Mar., Apr. and June, while the rest of the year was above normal. The Electric Lake station was cooler than normal every month except for Oct., Dec., May., and Aug., resulting in a yearly average temperature 0.5 degrees below normal (see Table 6). The monthly temperatures which were recorded at the East Mountain station in 1984 were generally higher than the four year average. A comparison of temperatures recorded 1981, 1982. 1983, and 1984 is shown in figure 3. See Appendix 1.

11.3.3 Surface Winds

Although no meteorological measurements have been taken in the Tract 2 Permit Area, Data acquire by Utah Power and Light between 1969 and 1976 in Huntington Canyon indicate that the local circulation in the area is dominated by a mountain-valley wind regime. A well-developed mountain wind regime predominates thoughout the year in the Wasatch Plateau area. During the mid-morning and afternoon periods an up-canyon flow develops in response to differential heating between the canyon air and the air in Castle Valley. This process is reversed during the evening and early morning periods. In addition, along the slopes within the canyon, a smaller scale thermally driven slope flow occurs.

Superimposed upon this local circulation are larger scale patterns of gradient flow. Seasonal variation of the mountain valley wind regime shows stronger winds occurring during the summer. During the winter period there is a higher frequency of light winds and calm conditions. Wind direction also shows a greater variability during the winter.

On an annual basis down-canyon flow is associated with the highest average wind speeds and accounts for the largest percentage of daily flow. The frequency of up-canyon flow increases during the summer with maximum surface heating.

Wind measurements taken at nearby Meetinghouse Ridge indicate that a similar flow pattern occurs in Meetinghouse Canyon. These general patterns can also be expected to occur near the Tract 2 mining area. (see approved mine plan ACT/015/009 Appendix 11 for additional information regarding average wind velocity)

11.3.4 Winds Aloft

The general flow aloft over the central Utah area is a zonal west to east flow which predominates through the year except during the summer period when the flow is generally from the southwest. Winds aloft in the Tract 2 Permit area will tend to be lighter and remain nearly constant.

11.4 Air Quality Control Practices

No surface disturbance will be associated with Tract 2. All permits for air quality requirements have been obtained in the approved mine plan ACT/015/009. These permits will be maintained for the life of the property. No additional air pollution sources will be associated with the mining of the Tract 2 Permit area.

11.5 Bibliography

Utah Power and Light Company East Mountain hydrologic monitoring program annual report for 1984.

Appendix 1 A Comparison of Temperatures Recorded 1981-1984

FIGURE 3

EAST MOUNTAIN

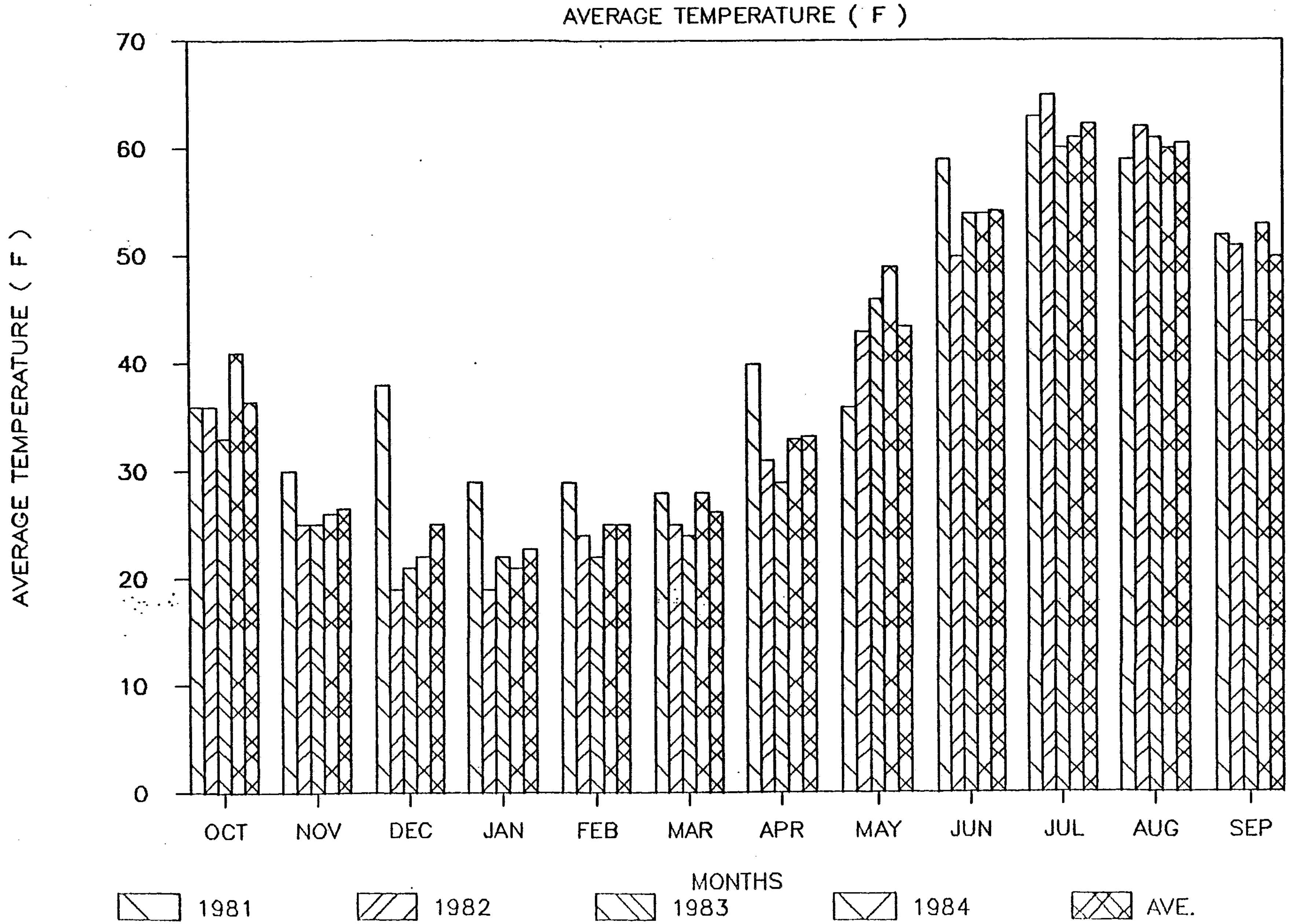

TABLE 1: PRECIPITATION IN EMERY COUNTY, UTAH (1984 Water Year)

Month	Hunter Plant (Elev. 5800') Precip. (in.)	Hunter Plant % Of Normal	Huntington Plant (Elev. 6500') Precip. (in.)	Huntington Plant % Of Normal	Electric Lake (Elev. 8350') Precip. (in.)	Electric Lake % Of Normal	East Mountain (Elev. 8985') Precip. (in.)	East Mountain % Of Normal*
1983								
Oct.	.53	68	.76	61	2.15	101	0.80	NA
Nov.	.66	129	.76	129	4.81	259	2.40	NA
Dec.	1.07	198	2.13	453	7.43	256	2.35	NA
1984								
Jan.	.03	7	.10	19	1.27	63	0.29	NA
Feb.	.39	85	.15	44	1.56	90	0.65	NA
Mar.	.34	81	1.18	190	2.77	145	1.38	NA
Apr.	.34	79	.72	131	3.23	192	0.52	NA
May	.10	17	.17	30	1.73	116	0.22	NA
June	1.09	237	104	254	3.41	421	1.18	NA
July	1.80	310	.74	78	2.55	218	1.88	NA
Aug.	1.89	187	1.39	204	2.26	266	2.10	NA
Sept.	2.35	294	.46	87	1.47	140	0.55	NA
TOTALS	10.55	152	9.68	128	34.64	177	14.32	NA
Mean Monthly	.88	--	.80	--	2.89	--	1.19	--

*Historical data not sufficient for the East Mountain weather station to make comparison.

TABLE-1

TABLE 6: TEMPERATURES IN EMERY COUNTY, UTAH (1984 WATER YEAR)

	Hunter Plant		Huntington Plant		Electric Lake	
Month	Average Temp. (°F)	Departure From Normal	Average Temp. (°F)	Departure From Normal	Average Temp. (°F)	Departure From Normal
1983						
Oct.	52.7	+4.3	54.9	+5.5	40.7	+3.2
Nov.	34.8	-0.4	38.2	+2.2	25.7	0.0
Dec.	23.5	-3.2	27.1	-0.3	16.7	+0.9
1984						
Jan.	16.5	-7.6	26.4	+2.8	10.8	-3.8
Feb.	21.1	-7.3	29.9	-0.3	13.9	-5.4
Mar.	37.2	+1.4	37.6	-0.1	19.8	-1.0
Apr.	46.1	+1.5	43.3	-1.8	24.2	-4.5
May	63.3	+11.2	58.9	+4.0	42.1	+3.1
June	65.3	+3.9	62.0	-3.8	47.0	-1.6
July	73.8	+5.4	74.4	+2.7	55.5	-0.2
Aug.	72.2	+5.8	70.2	+0.8	57.0	+3.1
Sept	64.9	+6.2	61.6	+1.2	47.2	-0.3
TOTALS	47.6	+1.8	48.7	+1.1	33.4	-0.5

A comparison of 1983 and 1984 temperatures for the three stations is addressed since temperatures also influence water supplies from year to year. Table 7 depicts the variation and 1983 to 1984.

TABLE 7: COMPARISON OF 1983 AND 1984 TEMPERATURES

	1983		1984		1984
Station	Average Temp. (°F)	Departure From Normal	Average Temp. (°F)	Departure From Normal	Departure From 1983
Hunter Plant	48.2	+2.4	47.6	+1.8	-0.6
Huntington Plant	49.0	+1.4	48.7	+1.1	-0.3
Electric Lake	30.8	-3.1	33.4	-0.5	+2.6
Average Departure From Normal		+0.2		+0.8	+.6

TABLE-6

CHAPTER XII

GEOTECHNICAL DATA

Prepared for

TRAIL MOUNTAIN COAL COMPANY

Orangeville, Utah

By

JBR CONSULTANTS GROUP

Salt Lake City, Utah

January, 1986

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APPENDIX 6 Locations Within the Tract 1 Mine Plan Area and Their Verticle Dispalcement and Naritive Comparison to Tract 2**

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12.1 Scope

This chapter describes the geotechnical basis of the mine design and the anticipated subsidence which could result from the chosen mining method. The recommended subsidence monitoring plan is also proposed.

12.2 Methodology

Standard methods of pillar design discussed in the SME Mining Engineering Handbook were utilized. Calculations of the maximum potential subsidence values are based upon methods found in the NCB Subsidence Engineer's Handbook, modified by experience gained via actual subsidence measurements in Utah and Colorado.

12.3 Underground Mine Design

12.3.1 Geotechnical Tests and Analyses

Site-specific rock-strength data is not available for the Trail Mountain Mine. The design of pillars and roof spans are based upon prior experience at the Trail Mountain Mine and nearby mine of UP&L.

12.3.2 Coal Pillar Design

Six entry headings, 18-20 feet wide, are driven on 100-foot centers. The main entry pillars are 80 by 80-foot size and have been shown to be adequate in resisting the effects of pressure in the ACT/015/009 permit area. Barrier pillars were designed according to the Holland Formula using depths of 1400, 1700, and 2000 feet (see the ACT/015/009 geotechnical chapter, appended to this chapter). These barrier pillars will protect the east-west and north-south main headings and will be removed as part of the retreat phase of the mining operation.

12.3.3 Roof Span Design

Entry widths of 18-20-feet have been the standard practice in the Trail Mountain in the ACT/015/009 permit area. Development panels up to 2600 feet long will be driven from the main entries. On the retreat, rooms are driven and then the pillars are removed except for those required for a bleeder system. Pillars not completely removed are shot and allowed to crush, relieving any potential high-stress zones in the roof or adjacent pillars. This system, along with roof bolting and timbering has been sufficient in maintaining the top.

12.4 Surface Subsidence Effects of Mining

12.4.1 Subsidence Mechanisms

The causal mechanisms of subsidence at Trail Mountain will be the same as previously discussed in the Tract 1 PAP geotechnical report, appended to this chapter.

12.4.2 Projected Subsidence Effects

The surface overlying the ACT/015/009 and Tract 2 mine plan areas does not contain any structures that could be materially damaged by subsidence.

The surface use of the land for wildlife and grazing could possible be impacted through alteration of the surface configuration or the drainage of three ephemeral ponds which overly the west boundary of the mine plan area.

The method and style of mining proposed for the Tract 2 is the same as that currently in use in the Trail Mountain Mine in the ACT/015/009 permit area. With the exception of the barrier pillars protecting the main entries, the development panels will be allowed to cave following retreat mining. Each new panel will be developed adjacent to the last panel and tied to the old works. The end result will be a uniform supercritical subsidence profile spread over a large area of the mine plan which will minimize stress concentrations and limit them only to the unmined boundaries and those barrier and permanent chain pillars which are not likely to crush.

The overburden depth for most of the Tract 2 area varies, as Figure 6-5 shows, from approximately 1,400 feet to 2,000 feet. Referring to the ACT/015/009 PAP subsidence predictions (Appendix 1, herein) the maximum subsidence factors for this range of depths are 0.35 to 0.247. Utilizing an average extracted thickness of 6.5 feet, the maximum subsidence values for the range should be 2.3 (0.35 x 6.5' = 2.28') to 1.6 (0.247 x 6.5' = 1.61') feet. An angle of draw of 15 degrees can be assumed for this type and thickness of cover which, when combined with the seam dip of 4 degrees west and the maximum overburden thichness of 2,200 feet, would place the western limit of subsidence at a point some 760 feet west of the caved area [2,200' x tan (15^0 + 4^0dip) = 757.5']. The present mine plan includes a north-south set of entries along the west boundary of Tract 2 which are not expected to cave. Because this protected zone is 750 feet wide, the limit of subsidence should remain within the boundaries of Tract 2 on the west. On the north and south sides of the tract the subsidence could extend out a maximum of about 565 feet (2,100' x tan 15^0 = 562.7'). Along the eastern boundary, under the cliffs facing Cottonwood Canyon, subsidence will be controlled by reducing extraction to first mining(see Figure 12-5, Appendix 1). Subsidence will gradually increase toward the west (up the canyon walls) with the result that the cliffs will be tilted toward the west slightly. This should reduce any effects of subsidence on the canyon walls to minor rockfalls.

The impact of the subsidence on the majority of the mine area should be a gradual and uniform lowering of the ground elevation. No faults have been mapped in the mine

area so local concentrations of subsidence along weak zones are not expected.
Fractures which do occur should not pose a safety problem for the low-intensity land uses of the affected surface. There are no bedrock aquifer springs or seeps within the limits of subsidence that might be impacted by fracturing. Two springs with a total 1985 flow rate of 2 gpm (springs TM-10 and TM-14) produce from a colluvial deposit which may be altered by subdisence.
There are no structures, wells, pipelines, utility lines, or through roads within the anticipated limits of subsidence. Timber, wildlife, and grazing are the renewable resources which occur within the area and these should not be materially affected.

12.4.3 Subsidence Control and Mitigation Measures

Subsidence control will be practiced by the uniform extraction of the coal to reduce strain concentrations in the overburden. Extraction will be reduced close to the outcrop to prevent the creation of any mass-slippage zones in the cliffs facing Cottonwood Canyon. In addition, if the subsidence effects on the cliffs become damaging, caving operations will be further reduced under those areas. Any trails or roads which are damaged by subsidence will be repaired to their pre-existing condition. Only two minor springs may be impacted and because the water is apparently produced from colluvium, the impacts of subsidence could be slight. One of these springs will be monitored to determine the nature of any impacts.

Trail Mountain Coal Company commits to restore areas inpacted by subsidence-caused surface cracks which are of a size or nature that could, in the division's opinion, either injure or kill grazing livestock or wildlife.

Restoration will encompass backfilling cracks and recontouring the affected land surface. Restoration shall be undertaken after the review of annual subsidence surface has stabilized. All areas of needed restoration will be completed prior to bond release.

Surface owners will be compensated for lands that could not be safely grazed due to any hazards caused by the surface effects of potential subsidence. Livestock owners will be compensated at fair market value for any livestock which are injured or killed as a direct result of surface hazards caused by subsidence.**

12.4.4 Subsidence Monitoring Plan

Subsidence is being monitored by aerial photograhpy and by conventional survey control. The photographic control allows rapid preparation of contour maps of the entire mine plan area to theoretical accuracies of 0.5 feet (see Figure 12-4, Appendix 1). The conventional monitoring consists of surveying a pattern of rebar observation points placed on the surface over all areas of mining (Figure 12-5, Appendix 12-A). The surveys of the rebar observation points are tied into off-site control points that have been accurately surveyed for horizontal and vertical control.
In addition to the formal surveying and photographic techniques, visual inspections will be conducted to identify any evidence of subsidence. See Appendix 2 and see also Appendix 3.

All subsidence data collected during a calendar year will be sumerized and submitted to the Division of Oil, Gas and Mining on an annual basis. Included in the annual report will be results and data from annual aerial photography, conventional field survey and visual field inspections.**

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12.5 References

Cummins, Arthur B. and Given, Ivan A., eds. 1973. Mining Engineering Handbook. Society of Mining Engineers of AIME. New York, New York.

Mining Department, National Coal Board. Subsidence Engineer's Handbook. 1975. National Coal Board. London, England.

APPENDIX 1

SELECTED GEOTECHNICAL DATA FROM

ACT/015/009 PAP

GEOTECHNICAL

Scope

The following discussion concerns the underground mine design and subsidence.

Methodology

The method of determination of barrier pillar design and the amount of subsidence are presented below:

Barrier Pillars

The Holland Formula, presented below, was used to determine the barrier pillar width for varying overburden thicknesses and a uniform extracted thickness of seven and one-half feet. Two other formulas, the Ashley and the Pressure Arch Formulas were also considered but were not utilized since neither formula considers the rock strength of the pillar material and the latter formula does not include the extracted thickness. Preliminary calculations using both these formulas, however, when averaged, result in a pillar width comparable to that obtained with the Holland Formula.

Holland Formula:

$$D = (5) \frac{\text{Log } 2 \ (W_2 \ 7.5/7)}{.09 \text{ loge}}$$

where D = pillar width

W_2 = convergence in mm, based on 7-foot seam

7.5/7 = correction factor to 7.5-foot seam

e = 2.7+

Subsidence

Determination of the amount of maximum subsidence that can potentially occur was determined from the following relationship:

$$S = ma$$

where S = subsidence

m = coal seam thickness (extracted height)

a = subsidence factor

Underground Mine Design

Barrier Pillar Design and Roof Span

Barrier pillars are planned for the approximate central portion of the existing lease area, oriented east-west, to maintain access to coal reserves west of the present lease area. These are in addition to the existing barrier pillars along the present north-south main headings. The pillars must be sufficient in size to remain intact to provide access to adjoining properties with a potential life of 15 to 20 years and protect the present and planned main headings. Presently, six entry headings are driven on 100-foot centers with protecting barrier pillars having an estimated life of over 25 years. The main entry pillars are 80 by 80 feet which has been adequate in the Trail Mountain Mine and at Utah Power & Light Company's Wilberg Mine. These show no affects of excessive pressure and have protected the main entries from collapse.

The barrier pillars were designed, as calculated below, according to the Holland Formula (SME Mining Engineering Handbook), using average depths of overburden 1,400, 1,700 and 2,000 feet for the existing and planned mains. Convergence values were obtained from Figure 12-1, (Ref. 4) for coal with a crushing strength of 3,000 psi ± 10 percent (3-inch cube) with a seam thickness of 7 feet.

<u>1,400 feet</u>

$$D = (5)\ \frac{\log 2\ (55 \times 5/7)}{.09\ (.432)} = 266 \text{ feet}$$

<u>1,700 feet</u>

$$D = (5)\ \frac{(\log 2\ (80 \times 5/7)}{.09\ (.432)} = 287 \text{ feet}$$

<u>2,000 feet</u>

$$D = (5)\ \frac{(\log 2\ (120 \times 5/7)}{.09\ (.432)} = 310 \text{ feet}$$

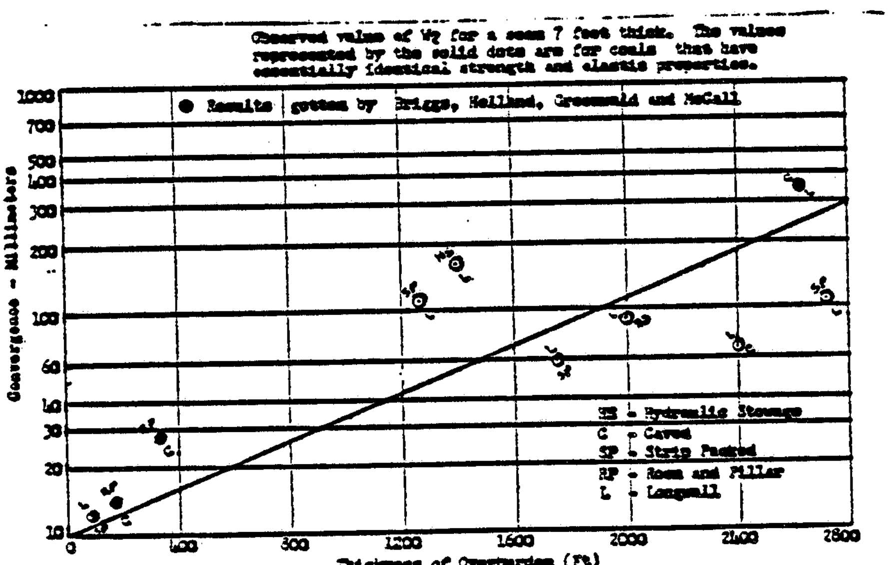


Figure 12-1

The above values are considered conservative since the main pillars (80 by 80 feet) will add support. Entries will be cut to 18 feet and timbered in areas of 50 percent recovery or pillared areas, with pillars left for a bleeder line, will be left adjacent to the barriers to aid in support. from 280 to 330 feet have been successfull. The associated entry widths vary from 18 to 20 feet. Timbering and roof bolting with the pillar sized as stated above, have been sufficiently holding the top.

Subsidence Affects Due to Mining

Surface subsidence affects of the final underground mining plan at the present Trail Mountain lease area are presented below:

Subsidence Mechanism

Surface subsidence occurs as a result of downward strata movement caused by the caving of mine openings and is usually expressed as a percentage of the mining height extracted. Subsidence is considered to involve two stages:

1. The development of a compression or "pressure arch" above and below the opening, and

2. The occurrence of subsurface subsidence caused by the rupture of this compression zone as it progresses upwards to the ground surface.

The subsidence mechanism is affected by the overburden properties, mining dimensions, and rate of mining. The "pressure arch" behavior is determined mainly by panel width. If the panel width does not exceed a certain dimension, usually up to one-third of the mining depth (Ref. 7), the "pressure arch" remains in a static, stable condition and no surface subsidence will occur. The overburden load is transferred onto abutments or barrier pillars through the compression zones of this arch. Distressed zones are encompassed by the "pressure arch" which causes strata deflections. Compressed arching progresses to the surface as the panel width increases where it collapses, causing surface subsidence after a critical panel width is reached.

Subsidence at the Trail Mountain Mine is expected to occur in a gradual manner. Gradual subsidence will allow volume expansion within the overburden, thus reducing the total vertical movements. The limit of subsidence at the surface is defined by the limit angle or angle of draw.

The Subsidence Trough Theory, based on observations and measurements of such subsidence, had been used to develop a concept of tensile and compressive stresses, as shown in Figure 12-2. This concept proposes three stages of subsidence according to the ratio of the panel width to the overburden depth:

1. Subcritical when the second limit plane of influence intersects below the surface (maximum subsidence not achieved);

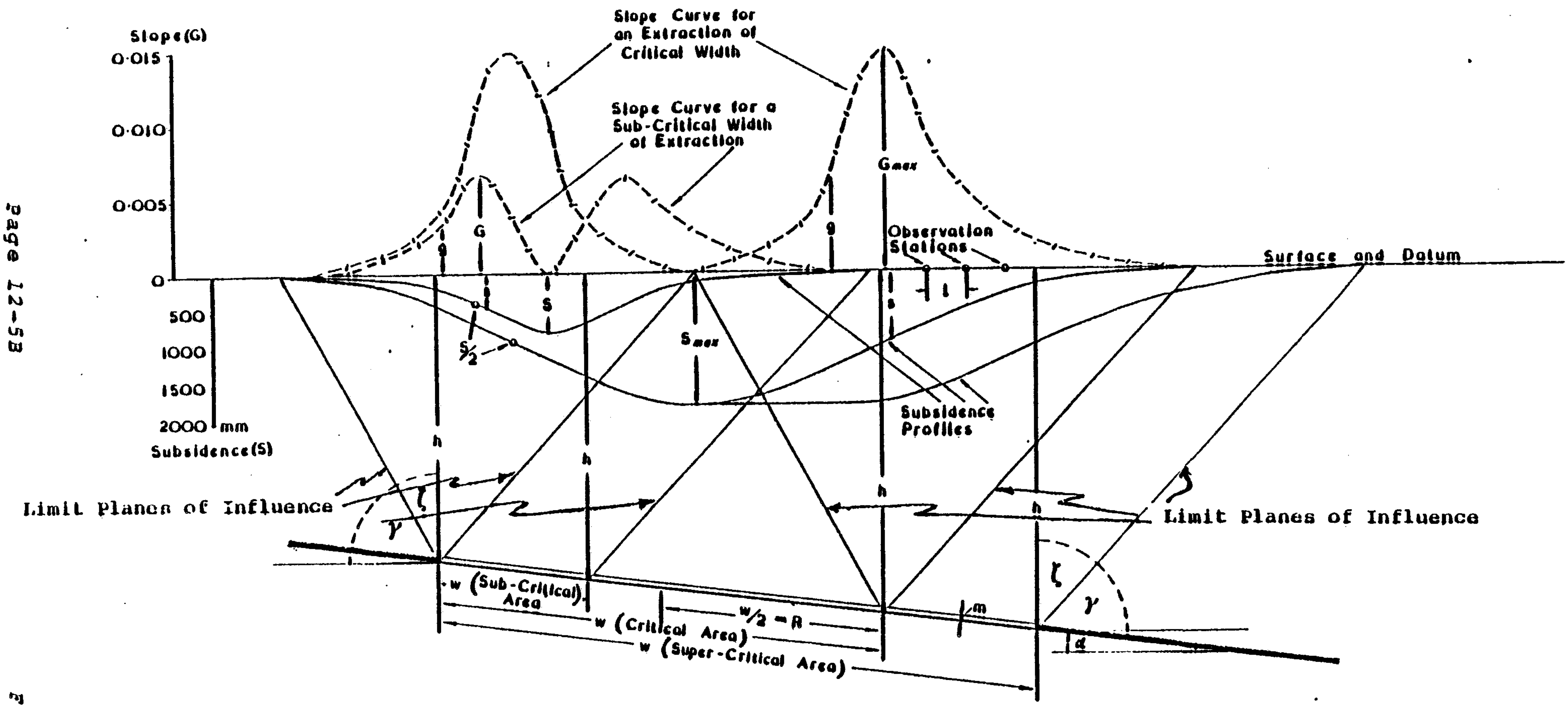
2. Critical when these planes intersect at the surface (maximum subsidence achieved at one surface point):

3. Super critical when no further movement is obtained between intersection of these planes and the surface (maximum subsidence achieved at more than one surface point).

Maximum vertical deformation is obtained in the critical and supercritical stages, that is when the width of the panel is 1.0 to 1.4 of the overburden depth, provided the panel length is at least 1.4 of the depth (Ref. 7). Subcritical subsidence is thus expected to occur at the Trail Mountain Mine.

<u>Subsidence Experience Over Coal Mines</u>

Extensive measurements made in Great Britian show a definite correlation between the amount of subsidence and the thickness, width and depth of mining



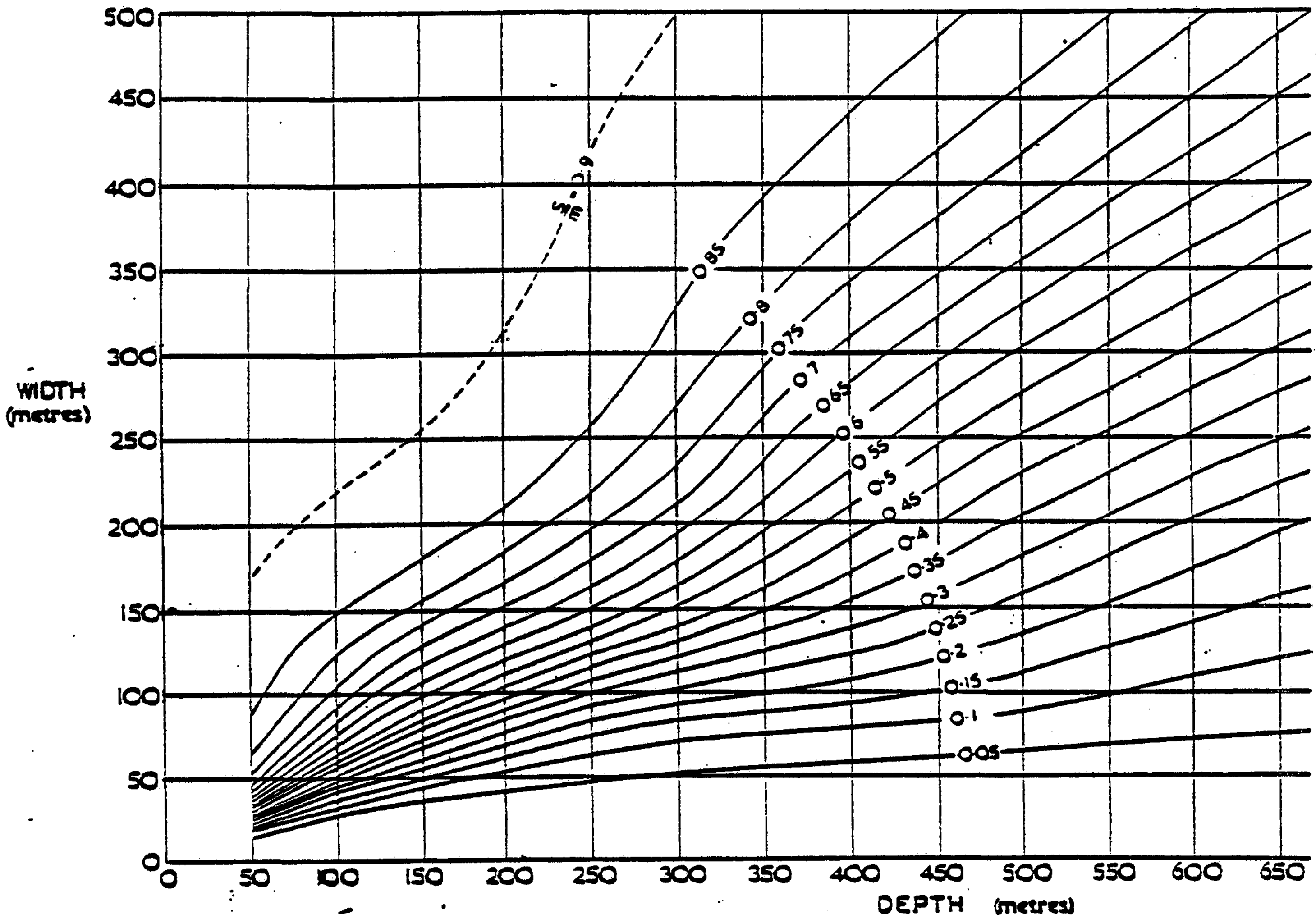
Slope Curve for an Extraction of Critical Width
Slope Curve for a Sub-Critical Width of Extraction
Slope(G)
0.015
0.010
0.005
0
500
1000
1500
2000 mm
Subsidence(S)
G
g
S
S/2
S_{max}
G_{max}
Observation Stations
Surface and Datum
Subsidence Profiles
h
Limit Planes of Influence
Limit Planes of Influence
ζ
γ
w (Sub-Critical) Area
w (Critical Area)
w/2 = R
w (Super-Critical Area)
m
α

Figure 12-2

(Ref. 1). These relationships are summarized in Figure 12-3 (Ref. 5), which shows the mean subsidence over long wall mines without fill. The surface subsidence versus panel width/overburden (W/D) depth ratio is at its maximum once the panel width/overburden ratio of greater than 1.0 is reached. This experience pertains mostly to long wall mining, a system of almost complete extraction. Complete room and pillar mining may induce probably as much subsidence as long wall mining under similar conditions.

The angle of draw, which defines the limit between underground excavations and surface effects of subsidence determines the unmined area that must be left to protect surface features. An angle of draw of 15^{0} is considered acceptable if miner subsidence can be tolerated (Ref. 4).

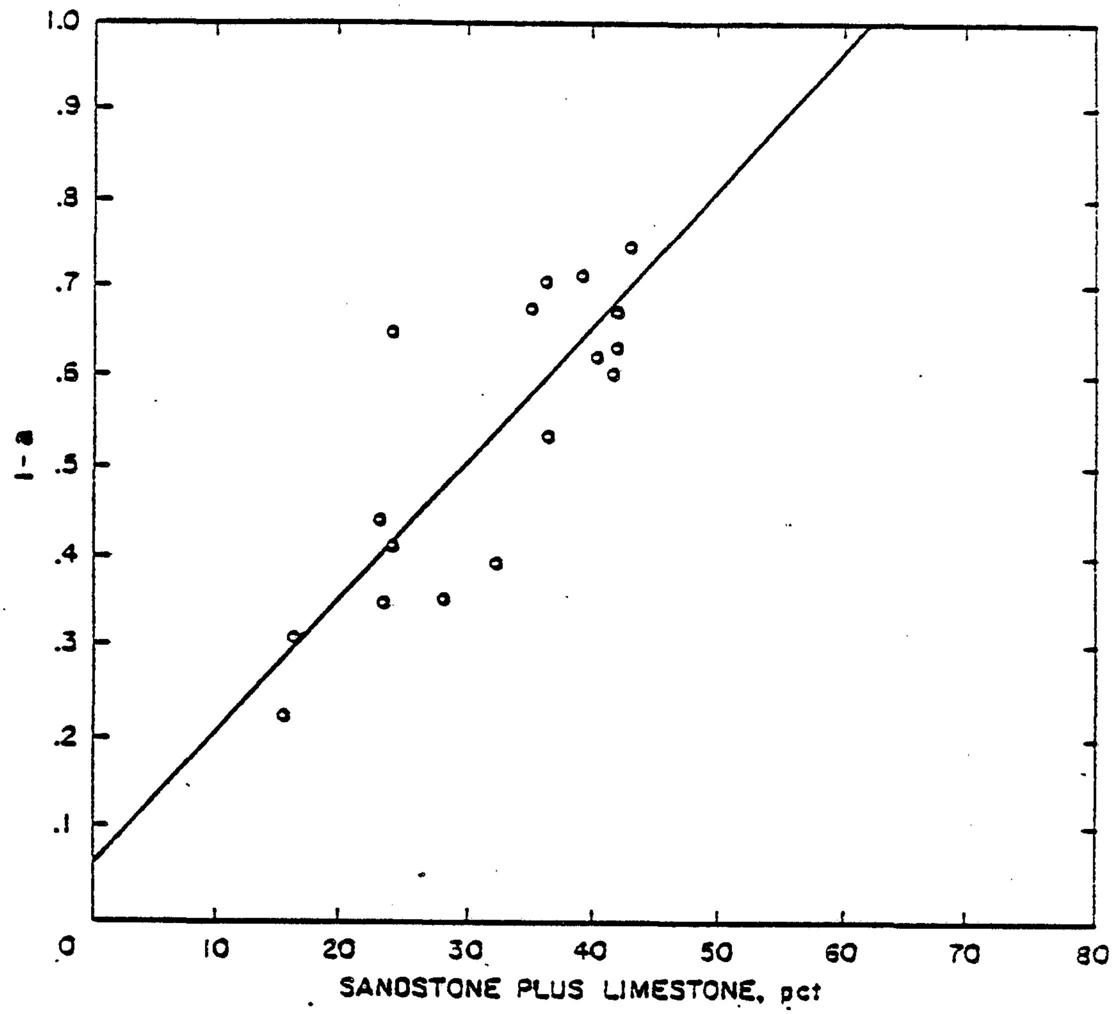
A recent study over coal mines in Utah and Colorado, undertaken by the USGS, indicates draw angles of 20^{0} in mines with weak to moderately strong overburden 650 to 900 feet thick (Ref. 2). This angle tends to steepen to 15^{0} at depths of 900 to 1,000 feet in the Somerset area of Colorado. Experienced maximum subsidence at the site for a panel width to overburden depth ratio of 0.66 was 31 percent, considerably less than the subsidence obtained from Figure 12-3, for a mine without backfill. According to the study, the major reason for this difference is due to remaining compression arching affects. The authors expect that subsidence may approach that shown in Figure 3 as arching mechanisms progresses upward and fail with time. It is noteworthy that this conclusion is based on European data where subsidence factors are appreciably higher (.6 to .9), then factors determined in the United States (.28 to .72 - Ref. 6) for room and pillar mining with full caving. The difference is attributed to overburden lithology. Research studies by the US Bureau of Mines (Ref. 6) indicate a linear relationship between the subsidence factor, a reduction factor based on the mine seam



Relationship of subsidence to panel width and overburden depth thickness used to estimate total subsidence, and the ratio of strong rock (sandstone and limestone), to total overburden thickness (Figure 12-4). These data are not directly in this report due to their preliminary nature but presented to show that a direct relationship exists between the strength characteristics of the overburden and the subsidence factor. At the Trail Mountain Mine area, the ratio of strong rock to total overburden thickness (n) is 54 percent where the Blackhawk Formation comprises the overburden, 71 percent where the Blackhawk and Castlegate Sandstones comprise the overburden and 76 percent where the overburden consists of the Blackhawk, Castlegate and Upper Price River units.

Verbal communications with Chris Shingleton (Mining Enginer, UP&L Co.), indicate that room and pillar mining, with 50 percent extraction, at the Des Bee mine in the general vicinity of the Trail Mountain mine, has resulted in no detectable subsidence of the ground surface over panels 400 feet by 4,000 feet. The panels were separated by chain pillars 200 feet wide and overlain by overburden 1,300 to 1,700 feet thick. Extraction was completed in the 1940's. The lack of subsidence is attributed to the bridging affect of the strong sandstones in the overburden which have apparently modified the compression arch. Overburden sandstones of the Des Bee mine are estimated to be of lesser percent than those at the Trail Mountain mine area.

Extraction of 65 to 70 percent was completed by early to mid 1982 in the southern-most portion of the present Trail Mountain lease area involving two panels 400 feet by 3,000 feet in dimension, separated by a solid coal chain pillar 60 feet wide and with overburden ranging from 1,400 to 2,000 feet thick. Progressing from the east limit to the west limit of the lease area, the overburden consists of the Blackhawk Formation, the Blackhawk Formation and the Castlegate Ss and, at 2,000 feet of overburden, the Blackhawk Forma-



a = subsidence factor = .94 - 1.5 n
where n = ratio of strong rock to overburden thickness

tion, the Castlegate Ss and the Upper Price River Member. No known subsidence has occurred to date over this area although the 60-foot chain pillar is expected to crush, leaving a w/d ratio ranging from 800/1,400 to 800/-2,000, progressing east to west through the lease area. This portion of the mine lease is expected to exhibit the maximum potential subsidence due to it having the widest span between permanent chain pillars. Chain pillars left between panels in the remainder of the lease area range from 110 feet to 170 feet in width and are not expected to yield and will result in appreciably lowr w/d ratios and resultin lower potential subsidence.

As yet unpublished data concerning subsidence at the UP&L Co. Deer Creek Mine, utilizing longwall mining which probably achieves a higher value of subsidence than room and pillar mining, with a seam thickness of 11 feet, overburden of 1,500 feet similar in type to the Trail Mountain area but again with lower sandstone pecentages and with panels up to 2,500 x 2,500, indicate a final, maximum subsidence factor (a) of 0.60.

Subsidence Affects and Control

Based on the preceeding discussions, a conservative value of 0.6 is used as the subsurface factor (a) for determining the maximum potential subsidence for this overburden strata for the Trail Mountain lease area. Referring to Figure 12-3, the subsidence factor (a = S/m = 0.6) for the Trail Mountain area is thus equivalent to a = S/M = 0.9 for the data from the Subsidence Engineer Handbook (Figure 3). For an extracted thickness (m) of seven and one-half feet, an overburden thickness (D) of 1,400 feet (431 m.), 1,700 feet (523 m.) and 2,000 feet (615 m.) and a mined panel width, or W, (worst case for the Trail Mountain property) of 800 feet (246 m.) the following are obtaind from Figure 12-3 where a, the subsidence factor, is equal to S (maximum potential subsidence) divided by m (extended thickness).

W:D = 246 m.: 431 m.

$$S/m \qquad \frac{0.6}{0.9} : \frac{X}{.53};\ X = .35$$

W:D = 246 m.: 523 m.

$$S/m \qquad \frac{0.6}{0.9} : \frac{X}{.41};\ X = .27$$

W:D = 246 m.: 615 m.

$$S/m \qquad \frac{0.6}{0.9} : \frac{X}{.37};\ X = .247$$

where x = subsidence factor adjusted by panel width and overburden depth.

Thus, where S/m = 0.6 for (a) maximum subsidence factor, and for an eight-foot thick extracted thickness (m) the following maximum subsidence for the various overburden depths are determined:

D = 1400 feet

S = am = .35 x 7.5 ft = 2.6 ft

D = 1700 feet

S = am = .27 x 7.5 ft = 2.0 ft

D = 2000 feet

$$S = am = .247 \times 75 \text{ ft} = 1.85 \text{ ft}$$

Fracturing of strata can be minimized or avoided if coal extraction is uniform, complete and rapid. This had been well illustrated in the USA and in Europe.

At the Trail Mountain Mine, gradual subsidence with minimal strata fracturing will be obtain with high pillar extraction and with the cave line following in close proximity of a retreating face.

Continuous miners are used at the Trail Mountain Coal Co. Development panels are driven from the main entries having an average length of 2,400 feet. On the retreat, rooms will be driven and the pillars removed except those required for a bleeder system. Pillars not completely removed by the continuous miner will be shot and allowed to crush, relieving any potential high stress zones within the overburden. The next panel driven in to be next to the previous panel and tied to the old works. The end result of the mining method is required subsidence with areas of higher stress present only along the unmined boundaries, barrier pillars and, in some areas of the mine, along permanent chains pillars. Expected topographic affects to the land surface should be small and subsidence should occur gradually and uniformly over large areas. Fractures, if they occur in the margins of the subsidence troughs, are potentially self healing as has been observed in other locations where well planned caving operations were performed.

The preceeding, calculated subsidence values are assumed to be maximum values since the amount of strong rock in the overburden is appreciable and is expected to have a considerable but unknown affect on the total subsidence at the ground surface. These subsidences assume nearly complete pillar recovery and ultimate panel widths to overburden depth ratios of .4 to .57 with panel lengths of about 3,000 feet. An angle of draw of 15 degrees from the normal to the coal seam is also projected, based on the previous discussions of the affect of extensive strong rock units in the overburden.

Controlled extraction, consisting of secondary mining only, utilizing 60-foot pillars at 80-foot spacings and two barrier pillars will be conducted within 325 feet of boundary outcrops to prevent slumping or ravelling of the outcrop areas along the Cottonwood Creek Canyon wall in this portion of the lease area. No subsidence is expected in this area due to the planned 435 percent extraction, the barrier pillars to be left between the panels to be mined, and the shallow overburden. Subsidence may be quickly halted in any given area by stopping caving operations. This may be used as a control measure, if required.

Several surveys have been conducted of the 775 acres, presently controlled by Trail Mountain Coal Company, which may be affected by the coal mining operations. Timber, wildlife, grazing areas and water seeps are the renewable resources which occur in the lease area. There are no oil and gas wells, pilelines, utility structures or transmission lines that will be affected by ground surface subsidence within the permit area. Timber growth or wildlife is not expected to be affected by any subsidence that may occur. Water seeps and springs within or adjacent to the permit area have been surveyed by others previously and are currently being monitored. The springs occur at the higher elevation west of the permit area and are fed by precipitation on the plateau areas in the near vicinity. Most of the springs dry up during the summer months. Surface percolation of waters is not anticipated to be appreciable due to the low to negligible amount of ground surface cracking expected on final subsidence. In addition, the shale and mudstone strata within the Blackhawk Formation should provide an effective barrier to percolation of the water from the ground surface to appreciable depths and will allow migration of subsurface waters downdip, or to the west.

As previously stated, no structures are present that could be affected by subsidence on Trail Mountain. Any trails or roads that are materially damaged by subsidence will be repaired, regraded and restored to their pre-subsidence usefulness.

In lieu of renewable insurance covering damage to existing structures, Trail Mountain Coal Company, as an alternative, proposes to restore these resources to their pre-subsidence usefulness as mining continues. Since there are no structures or facilities that could be affected by subsidence, except for trails, there is no need for renewable insurance.

By following the preceeding subsidence control plan, Trail Mountain Coal Company will mine coal underground in a manner that will prevent subsidence from causing material damage to the surface. The value of the land will be maintained so that the surface retains its pre-subsidence usefulness.

Public Notice

Any surface owners that may be affected by subsidence will receive a mining schedule which will detail the area in which mining is to take place and the planned date of that activity. This schedule will be included with the annual subsidence monitoring report for completeness.

Subsidence Monitoring Plan

The subsidence monitoring requirements were first imposed by the 211 U.S. Geological Survey regulations. Later, with the formation of the Office of Surface Mining (OSM) and the realignment of the U.S.G.S. responsibilities, subsidence monitoring came under the jurisdiction of OSM. The U.S. Forest Service concurrently generated a resource monitoring program utilizing photogrammetry.

Method

ity noted.

The subsidence patterns at Trail Mountain are anticipated to be similar to those occurring on East Mountain from Utah Power & Light's Deer Creek operation. UP&L has reported no visible detection of surface movement without the use of surveying equipment with a maximum slope of 0.5 feet in 100 on the edge of the subsidence trough. The small magnitude of the slope should not have any effect on vegetation growth.

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APPENDIX 2 Forest Service Plan for Studying the Effects of Underground Coal Mining on Surface and Subsurface Resources

Bill Boley

~~FOREST~~ PLAN FOR STUDYING THE EFFECTS OF UNDERGROUND COAL MINING ON SURFACE AND SUBSURFACE RESOURCES

Bill Boley

~~Manti-LaSal~~ National Forest

Approved by: W. H. Boley
Forest Engineer

6/26/86
Date

Public Law 86-517
86th Congress, H. R. 10572
June 12, 1960

AN ACT

74 STAT. 215.

To authorize and direct that the national forests be managed under principles of multiple use and to produce a sustained yield of products and services, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it is the policy of the Congress that the national forests are established and shall be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes. The purposes of this Act are declared to be supplemental to, but not in derogation of, the purposes for which the national forests were established as set forth in the Act of June 4, 1897 (16 U.S.C. 475). Nothing herein shall be construed as affecting the jurisdiction or responsibilities of the several States with respect to wildlife and fish on the national forests. Nothing herein shall be construed so as to affect the use or administration of the mineral resources of national forest lands or to affect the use or administration of Federal lands not within national forests.

National forests, management.

30 Stat. 34.

SEC. 2. The Secretary of Agriculture is authorized and directed to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield of the several products and services obtained therefrom. In the administration of the national forests due consideration shall be given to the relative values of the various resources in particular areas. The establishment and maintenance of areas of wilderness are consistent with the purposes and provisions of this Act.

Multiple use; sustained yield.

SEC. 3. In the effectuation of this Act the Secretary of Agriculture is authorized to cooperate with interested State and local governmental agencies and others in the development and management of the national forests.

SEC. 4. As used in this Act, the following terms shall have the following meanings:

Definitions.

(a) "Multiple use" means: The management of all the various renewable surface resources of the national forests so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output.

(b) "Sustained yield of the several products and services" means the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land.

Approved June 12, 1960.

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FOREST PLAN FOR STUDYING THE EFFECTS OF UNDERGROUND COAL MINING ON SURFACE AND SUBSURFACE RESOURCES

Manti-LaSal National Forest

I. INTRODUCTION

Minerals are one of the abundant resources of the Manti-LaSal National Forest. The extraction of these minerals is endorsed by the Forest Land Management Plan, except where this action is incompatible with planned surface uses. The Forest, by regulation and law, is committed to multiple use management of all National Forest resources, and must assure that adverse impacts to surface and subsurface resources are minimized whenever any resource is utilized--including minerals and mineral resources.

Data describing the effects of coal mining and mining-related activities is scarce. Current resource protection, mitigation, and reclamation measures are based on this limited data. A resource monitoring program is needed to assess impacts to resources, to evaluate the effectiveness of protection, mitigation, and reclamation measures, and to provide a basis for making--as needed--new protection, mitigation, and reclamation stipulations for mineral leases, and mining and reclamation plans.

Since 1973, the Manti-LaSal National Forest has recommended that a program be established to quantify impacts to surface resources due to underground mining. Certain stipulations have appeared in all Environmental Assessment Reports and Impact Statements dealing with coal programs which are prepared by or had concurrence of the Forest Service.

Two stipulations have been developed that relate to the mining activity. Stipulation Number One requires that baseline data be obtained prior to any disturbance, and Stipulation Number Two requires that a monitoring program be initiated during mining operations. They are as follows:

> Stipulation 1 - The lessee shall perform a study to secure adequate baseline data to quantify the existing surface resources on and adjacent to the lease area. Existing data may be used if such data is adequate for the intended purposes. The study shall be adequate to locate, quantify, and demonstrate the inter-relationship of the geology, topography, surface hydrology, vegetation, and wildlife. Baseline data will be established so that future programs of observation can be incorporated at regular intervals for comparison.

> Stipulation 2 - The lessee shall be required to establish a monitoring system to locate, measure, and quantify the progressive and final affects of underground mining activities on the topographic surface, underground and surface hydrology, and vegetation. The monitoring system shall utilize techniques which will provide a continuing record of change over time and an analytical method for location and measurement of a number of points over the lease area. The monitoring shall incorporate and be an extension of baseline data.

In managing wildlands, information is needed to address all Forest Service resource systems, forest and rangeland, water, wildlife and fish, outdoor recreation and wilderness, etc. To make an assessment of the potential effects of alternative land uses such as underground mining on surface resource systems, requires basic information on resources and their relationship to each other. Local management and planning decisions require mapped and pinpointed information, whereas state, regional and national level decisions may be based on statistical information obtained from much broader samples. This plan requires a high degree of resolution, consequently large scale (low altitude) aerial photographs and large scale maps will be required to facilitate the process.

II. OBJECTIVES

Objectives of the program will include:

A. Establishing baseline surface terrain resource and hydrologic data prior to mining, and for existing mines.

B. Implementing programs of observation at regular intervals, which would generate data for comparison with baseline.

C. Defining impacts of coal mining upon wildlife, range, vegetation, timber, water, topography, geology, other minerals, recreation, and visual resources; all of which are encompassed in the multiple use direction of the Forest Service.

D. Coordinating resource uses and management planning with coal mining, minimize adverse impacts to surface resources on National Forest System lands.

E. Predicting change(s) in the hydrologic cycle that may occur as a result of coal mining so that provisions for relocation of water sources or development of alternative water sources can be made available to facilitate the multiple uses of the Forest.

F. Careful inventorying and monitoring of resources at each mine prior to, during, and after the conclusion of underground mining will help establish and predict the area's response to coal extraction, and expedite technology to minimize the resultant effects.

III. RESOURCE CONSIDERATIONS

The objective of resource monitoring is to quantify and display the progression and final effects of underground mining upon surface resources of National Forest System lands.

The surface and subsurface resources to be considered have been categorized into four resource groups. They are:

A. Recreation and Visual Resources

B. Vegetation (Which Includes Range, Wildlife Habitat, and Timber)

C. Geology and Hydrology

D. Other

The basic data requirements with which these resources will be inventoried and monitored is included with each resource group.

A. Recreation and Visual Resources

Potential effects of mining on recreation and visual resources shall be evaluated - including an inventory to establish a comparison baseline - prior to any mining activity. The recreational uses and scenic values of the area will determine the nature and extent of monitoring requirements.

It is expected that monitoring of recreation resources would include defining of changes in areas of use by recreationists, i.e., fishing, hunting, camping, hiking, etc., as may be affected by mining activities, i.e., coal hauling, mining.

For visual resources, a monitoring program would most generally be visual inspections on a programmed frequency. This would include a photographic record and map at a scale compatible for registration with other data map record layers as well as a written record. It would address such items as the visual change in mine facilities, roads, streams, slopes and escarpments (i.e., rockfalls), slope failures, excessively eroded areas, etc.

B. Vegetation

The effect of undermining upon vegetation is still largely unknown. Range analyses, timber surveys, and wildlife habitat studies will be conducted in areas expected to be affected by mining. The intensity and frequency of these investigations will be determined on a site-by-site basis. Data will be summarized annually, and used to define change.

This monitoring program would rely upon existing data, supplemented where necessary with data from other sources and from field inventories obtained prior to mining. These data would form the base upon which the monitoring program data would be compared for definition of change.

In situations where mining effects become substantial, the mining company would be required to participate in formulation and implementation of mitigation measures.

C. Geology and Hydrology

The geologic structure and stratigraphic nature of an area has a major determining effect upon the ground water regimen, upon the mining, conservation of the resource, mode of subsidence, and surface features such as topography, soils, and slope stability.

Without adequate geologic data--both from surface exposures and drilling and mining--resource conservation planning cannot be done. Also, any impacts to surface resources cannot be identified or mitigated without a knowledge of the geology.

To fulfill the requirements of this monitoring plan, the following is required to establish baseline data.

1. A geologic map at the same scale as other data map layers showing lease location, faults, folds, joint systems, geologic formations, seeps, springs, and other data which are essential for proper identification of the existing geologic and hydrologic conditions. The map would be updated as new information becomes available.

2. A narrative description of each of the above items, giving sufficient detail for evaluation. Existing seeps and springs on the lease area and adjacent areas, which would be affected by underground mining, will be inventoried. In most cases, estimates of quantity would be adequate. However, representative springs (springs having current use for wildlife, range, or for municipal use) which are important for the management of the surface resource will be sampled and tested for quality, and flows determined.

The responsibility for these data would be that of the mining company. The Forest Service and the Office of Surface Mining would, however, cooperate in the designation of hydrologic monitoring requirements for each site, and would provide those data which may have been obtained from previous studies.

D. Other

Surface structures, such as power transmission lines, pipelines, oil and gas wells, roads, dams and reservoirs, and other physical improvements could be affected by mining. Mine planning must consider these features, and data must be obtained prior to mining that will identify possible impacts. Those structures that are identified which might be damaged should be photographed before and after mining, together with the documented inspections which establish their condition prior to, during, and after mining.

The mining company would have responsibility for this information. There are, however, considerable data available on these structures which could be made available by the Forest Service, Bureau of Land Management, State, and county.

IV. FOREST SERVICE REQUIREMENTS

The following responsibilities, procedures, resource inventories, and study programs are those which the Manti-LaSal National Forest will require for leasing of National Forest System lands for coal mining, exploration, or for coal mine plan approval. These are, in part, requirements of laws and regulations of the Department of the Interior and, in part, requirements of the Forest Service. Those required by the Department of the Interior are not referenced and may not be included in their entirety or have the same specific requirements. It is not intended that this program plan supersede in whole or in part requirements of the Department of the Interior. The programs are intended to generate the data we have determined essential for responsible multiple resource management. The operator would be responsible for those parts where data are needed to determine the effects of mining upon surface resources.

All programs to monitor the effect of mining on surface and subsurface resources will be applicable to existing leases (in all stages of development) and future leases. Accumulation of data pertinent to coal mining studies will occur at all stages of lease development.

A. Tract Leasing

Prior to leasing of any land on the Manti-LaSal National Forest for coal mining, the preparation of a site specific Environmental Assessment (EA) will be required. This assessment is the process by which the Manti-LaSal National Forest will determine a tract's suitability for leasing. A Decision Notice (DN) and, if appropriate, a Finding of No Significant Impact (FONSI) will be prepared for each lease. The Decision Notice, accompanied by the Environmental Assessment, is the Forest Service approval document for coal land leasing. The Forest Service will be responsible for its preparation. The Technical Examination required to obtain the essential data for the EA will be performed by the Forest Service in cooperation with the Bureau of Land Management. Data would be obtained by the Forest Service, Bureau of Land Management, State, and other agencies as needed.

The Technical Examination will include an inventory and description of surface resources and uses; and will include the requirements given in items 1 through 9 below. These requirements, however, are not intended to be of a detail as to establish baseline data for the requirements of resource monitoring as specified in item C for mine plan approval. They will, however, include sufficient detailed data to make an assessment of the compatibility of a coal lease tract with other resource elements, uses, determining the tract's leasability, an evaluation of probable impacts of mining the tract upon the environment, and for developing of lease stipulations.

The requirements for the Environmental Assessment will include the following information:

1. A description and assessment of the existing environment, including wildlife, vegetation, hydrology, soils, topography, geology, mineral occurrence, recreation, visual quality, historical, archeological, surface structures, and other resources as may be appropriate, will be required. This report also would include an assessment with regard to areas which may not be available for leasing, i.e., wilderness, withdrawals, threatened and endangered species, special uses, oil and gas fields, pipelines, reservoirs, and other surface features as may affect human safety.

2. A preliminary geologic map of an acceptable scale that will include faults, folds, joint systems, geologic formations, and significant surface geologic features, such as landslides and unstable slopes is required.

3. A topographic map. This would properly serve as the base map for 2 and 4. Currently, existing color resource photography would supplement the topographic map for making the inventory and assessments.

4. A preliminary inventory of known ponds, reservoirs, springs, seeps, and significant wet areas will be recorded on a map. Flows will be estimated.

5. a. A preliminary assessment of the surface hydrology that will include climate, precipitation, flooding, and descriptions of the stream(s) and drainage systems.

   b. A preliminary assessment of the ground water geohydrology. This would include item 4 above, with a description as necessary. In addition, it will include an appraisal of the importance of each item listed and described to Forest management and will furnish estimated flow quantities and, where appropriate, the water quality. This would also include a description of the water source (i.e., seeps, springs, wells, etc.) in relation to topography, geologic conditions, vegetation, and other resources as may be appropriate.

6. Existing transportation and utility corridors, and possible future corridors, should be located and recorded on maps. Each should be accompanied by a <u>detailed</u> description.

7. Existing roads, existing mine portals, possible mine sites, oil and gas wells, and the opportunity for relocation of these features should be discussed jointly with the Forest Service and BLM so that any major restrictions to these activities will be brought to light early in the process.

8. An evaluation of the tract for feasibility of mining, in-place tonnage, and expected recoverability will be addressed in a report to the Forest Service by the Bureau of Land Management. A conceptual mine plan, complete with a transportation plan, will accompany this data.

9. Any drilling by the Bureau of Land Management, prior to leasing, should be required to follow exploration regulations (Part B, below).

B. Exploration

Exploration of a coal mining tract is normally performed by the lessee after the lease is obtained. Some exploration for evaluation prior to leasing may be done by private industry or by the Bureau of Land Management as required by 30 CFR 211. Exploration is performed to evaluate the value of the coal seam(s) and the geologic structure; and the lithology of the rock formations for mine planning.

Exploration is most often performed by drilling of holes from the ground surface to the coal seam(s). However, not all lessees will be explored by drilling, nor is it required. New exploration methods are being developed. Presently, drilling is the method used.

When exploration is done by drilling, the following should be required of the operator:

1. A comprehensive plan of operations as required by 30 CFR 211. This plan should include:

   a. A map showing the locations of the proposed activity (drill hole locations) and the proposed access.

   b. A detailed description of drilling plans and procedures. This should include:

      (1) Drill hole locations, T., R., S.

      (2) Expected depths of drill holes.

      (3) Proposed access routes, including a description of the requirements for upgrading, reconstruction, or construction of the access roads.

      (4) The time frame for the drilling program.

      (5) Surface resource protection considerations.

   c. A reclamation plan.

2. A log from each drill hole showing the ground waters encountered. Data will be compiled and submitted by the company giving depths and lithologies where water is encountered. An attempt will be made to quantify amounts of water in the aquifers. Each actual drill hole location will be accurately plotted on the base map or appropriate overlay.

These data, combined with the surface geologic and hydrologic data, will aid to define the ground water system. This will be used to develop the hydrolotic monitoring system required by regulation, as well as to aid in identifying possible impacts to surface water sources from undermining.

Selected holes may be required to be left open for periodic water level measurements and ground water sampling. These drill holes and intervals of monitoring will be designated by the Bureau of Land Management or Office of Surface Mining in consultation with the Forest Service upon the review of the drilling information.

C. Mine Plan Approval

All mining plans for underground coal mines should include, as part of the mining plan, a study and monitoring program to determine what, if any, effects mining will have upon other resource elements and land uses. This plan or study program will necessarily include two phases; (1) establishment of baseline data for existing resource and land use elements from which any change due to mining can be measured (see Stipulation #1), and (2) establishment of study programs to monitor these resource and land use elements for measurement of any change that has occurred because of the mining (see Stipulation #2).

1. Baseline Data Collection

The Forest Service will require of the operator the following specific data:

a. Water - The location and identification, including a detailed description, of water sources. This should include the topography, geology, use, flow, quality, and other data as may be necessary to define each water source. Water sources which will be inventoried include seeps, springs, wet areas, natural ponds, lakes, reservoirs, stock ponds, streams, and water wells, on and within the area of influence of the leasehold. This would include a literature search, compilation of existing data, and a field search, investigation, and description of each.

To aid in the location and identification of these water sources, color infrared aerial photography (CIR) of the proposed mine area and area of influence may be required. The main purpose for the color infrared photography is to aid in: (1) the location identification and description of all water source points, and (2) the detection and monitoring of dead or dying (stressed) vegetation due to subsurface mining activities.

Water sources, surface cracks, property corners, and other points that are not used or tied to basic project control may be photo-identified in the field by direct or precise methods. A description of the procedures using these two methods can be found in the Appendix (VIII. A.).

It is expected that the infrared photography will not be required for all mine plans. The need for this photography is to be determined by the Forest Service in consultation with and concurrence of the Bureau of Land Management or the Office of Surface Mining on a site-by-site basis.

Each water source shall be located and plotted on the base map or appropriate overlay, giving elevation, coordinates, flow (gpm), and date flow was measured. The method used to measure the flow must be described, i.e., weir, flow meter, estimated, etc. See a. above. Measurements ideally should be quarterly for a minimum of two years and preferably longer prior to any significant mining.

It is recognized that some water sources cannot be measured at these frequencies because of heavy snow cover, intermittent flows, or difficulty of access to the area.

It is not a requirement that the targets or ground panels required for the subsidence monitoring photography appear or be visible on the CIR photography. The same scale of photography (or degree of resolution) may not be required for detecting or interpreting images as may be required for accurate terrain measurements. However, there are several advantages in maintaining the ground panels for visibility on the CIR photography and flying all photography at the same altitude or scale. Cross correlation for interpretive comparisons and the transfer of points and data from one set to the other are but a few of these advantages.

If required, the CIR photography will be obtained with an acceptable 9" x 9" format mapping camera with an 8 1/4" or 6" focal length and single-lens-between-the-lens-shutter system. Film will be Kodak Aerochrome Infrared 2443 (or equivalent) and will be exposed with the proper filter and camera setting as to provide the best possible image resolution and print quality. The flight dates of the CIR photography will be scheduled by individual project to obtain the optimum results for water and vegetative detection and analysis. The nominal or mean scale of this photography will not exceed 1:6,000.

b. Geology - A geologic map on which will be shown the rock formations, faults, folds, joint systems, dip and strikes, landslides, and other significant geologic features is required of the operator.

c. Manmade Features - The location of surface and subsurface features that might incur damage by subsidence is required. This would include power transmission lines, property or land corners, pipelines (water, oil and gas, etc.), oil and gas wells, roads, dams, reservoirs, buildings, and other features as may be present. Documented descriptions, along with appropriate photographs, are required. The location of existing major highways and proposed highways should be identified. Unless otherwise specified, this information will be shown on the original topographic and/or planimetric base.

d. Monumentation - A network of monuments is to be established, both over the mine or proposed mine workings and in adjacent areas not expected to be disturbed (reference monuments) by the mining operations (subsidence). Each mine or proposed mine area will require an individual control survey and targeting plan to complement the topography, access, mine layout, aerial photography coverage, and other constraints. The monuments will be constructed as survey control points for the subsidence, hydrologic, vegetative, and other monitoring study programs. The monuments will be located on a coordinate system that is the same for the mine survey and surface survey, so that surface points and the subsurface mine works can be superimposed. It is recommended that the state plane coordinate system be used as primary control for all surveys. Reference the Appendix (VIII. B, Figures 5 and 6) for target or ground panel configuration and dimensions.

e. Surface Terrain - Initial, low altitude color or black and white aerial photography of the proposed mine area will be flown at a scale such that elevations to within one foot vertically and horizontally (± 0.5) can be attained by photogrammetric methods. This photography will be used for constructing the initial baseline surface map upon which potential subsequent surface subsidence will be measured and recorded. It will also provide the master base to assist in documenting changes to vegetation, topography, geology, surface structures, recreational, and land uses on the surface over undermined areas. All other map data layers will be registered to this base which will be constructed at a scale of 1" = 100′.

See attached map specifications for symbols, etc., in the Appendix (VIII. C, Figure 5). This map will contain the following:

(1) Plotted horizontal positions of all control survey monuments and elevations.

(2) Plane coordinate grid 5000′ intervals.

(3) Contours. Interval to be specified on a project by project basis.

(4) Aerial photo centers.

(5) Paneled section and quarter corners.

(6) Planimetry and cultural features.

(7) Legend.

(8) Water sources - streams, springs, marshes, wet areas, reservoirs, and lakes.

(9) Transportation system including all existing travelways, roads, trails, railroads, etc.

(10) Grid ticks showing the horizontal position including coordinates and vertical elevation of all terrain surface points, read photogrammetrically.

f. Vegetation - Vegetative and wildlife inventories are to be conducted in areas subject to potential impacts. The inventories will consist of on-the-ground transects. Data will be presented in the form of a map overlay which will register to the master base. In most cases, the photography will be used for delineation of vegetative types and from which this data will be photogrammetrically transferred to its respective overlay.

The following vegetative analysis studies will be established for areas which may be affected or disturbed and will be measured as:

(1) Permanent photo points and photo studies.

(2) Changes in plant species composition and vegetative trends.

(3) Changes in ground cover density (changes in vegetative and litter cover).

(4) Changes in total forage production.

(5) Quantification by acre of all riparian vegetation.

g. Visual Observation - Visual observation of surface effects. Every monitoring plan will include an on-the-ground observation to document the existing (premining) condition of the ground surface, at the proposed portal, access, and over the proposed mine area (plus angle of draw).

h. Precipitation Gages - Installation of precipitation gages at the mine site. A qualified hydrologist will supervise the site selection and the installation of the gages.

i. Seismic Events - Natural seismic events. All such events that may occur over mine areas shall be documented. It would include a documentation of each event, its magnitude, intensity, epicenter location, date of occurrence, any resulting underground or surface disturbance, and its probable intensity at the mine site.

2. Study Programs for Resource Monitoring

The Forest Service will require of the operator the following specific monitoring plans:

a. Subsidence Monitoring - Aerial photography will be required initially for baseline data collection. Subsequent flights will be annual and will cover the area mined and the area to be mined in the next 18 months (plus the angle of draw) on the entire lease area, as may be appropriate. A 30-percent overlap of flight lines and a 65-percent overlap of photographs will be required. The photography will be flown at a scale that will produce elevations accurate to within one foot (±0.5). Unless otherwise approved, the nominal or mean scale will be 1:4,800 for an 8 1/4" focal length camera and 1:6,600 for a 6" focal length camera. The criteria being that vertical photogrammetric measurements should be obtainable to 1/10,000 of the flying height. Both scales and respective focal lengths theoretically equal .33 feet. The vertical margin should allow for some residual reading errors.

   Aerial photography will be evaluated each year for determining the location and magnitude of subsidence. It will be supplemented by surveys for subsidence evaluation.

   The aerial photography will not only serve for subsidence monitoring, but will aid in interpretating and documenting changes to vegetation, topography, geology, hydrology, recreational uses, wildlife use, range use, and surface structures. Prints of the aerial photography will be furnished to the Forest Service by the operator of the initial flight and of each annual flight as requested. "Pugged" diapositives of the baseline flights will also be furnished, along with control coordinates as requested.

   Monuments established for the initial flight will be properly paneled each year prior to each annual flight. For required dimensions and suggested materials, see Appendix (VIII. B, Figure 3).

   Visual Observation of Surface Effects. An on-the-ground visual inspection will be made each year of the condition of the ground surface above all underground mine workings (plus angle of draw). This survey should attempt to locate, photo-identify and document the presence of tension cracks, fissures, structural offsets, and obvious subsidence damage to buildings, roads, powerlines, pipelines, railroads, dams, reservoirs, or other features. The hydrologic monitoring program will assess changes in spring flows, streams, ground water levels, etc. Photographs, as well as written documentation, will be required.

   An annual field inspection of all unstable areas will be made for evidence of renewed movement. Unstable areas would include landslides, escarpments, etc. These will be documented with photographs, written descriptions, and maps.

A continued documentation of seismic events will be maintained throughout the mine life. These data are available from State and Federal agencies.

b. Hydrologic Monitoring - The monitoring for water quality and quantity will be of representative sources selected from the baseline inventory. Time intervals and methods of monitoring will be determined on a site specific basis. Representative sources and specifics of the requirements for monitoring will be determined by coordination of the operator, Forest Service, and Office of Surface Mining or Bureau of Land Management. Requirements for sampling, measuring of flows, and testing are defined by the Office of Surface Mining and Bureau of Land Management regulations. Those water sources not designated for detailed monitoring within the affected area where subsidence might reasonably be expected to occur will be visually evaluated annually.

Frequent recording and quantification (where possible) of water encountered in the mining operations will be required. Sufficient measurements of major seeps or flows within the mine should be made to determine any trends in flow and quality. Location of the flow should be documented and a description should be made of the geologic structure where such waters are produced. This would include such features as faults, joints, sandstone beds, wet coal, etc.

Mine water discharge must be sampled and analyzed as required by EPA and State regulations. In addition, mine water discharge will be measured for volume, and the moisture content of the coal will be measured.

Infrared aerial photography as required will be repeated once every five years, or more frequently if needed. This will be for the mine area plus the area to be mined in the next five years. Prints of the initial flight will be furnished upon request.

The precipitation gages required by 1.h. will be monitored daily. Data will be furnished the Office of Surface Mining and Forest Service monthly.

c. Vegetative and Wildlife Monitoring - The plots (on-ground transects) established for the baseline inventory will be permanently identified on the ground. They will be reevaluated at 3- to 5-year intervals throughout the mine's life. Shorter intervals may be required at some sites. The data will be presented in the form of a map having a scale of 1:4,800. It would be expected that the aerial photography would be used for this study and would serve as the base map.

d. Visual and Recreation Monitoring - Monitoring of visual resources will include a visual inspection at least annually and more frequently if required. This inspection will include a photographic and map record, as well as written. It will document the visual changes in an area from installation of mine facilities, roads, and traffic of these facilities. It would address such items as portal areas, roads, conveyor lines, streams, slopes, escarpments (i.e., rockfalls), slope failures, excessively eroded areas, etc.

Monitoring of recreation resources will include defining of changes in an area's use by recreationists as is affected by the installation of a coal mine. This would include fishing, hunting, camping, hiking, etc. Of particular importance to this monitoring program would be the affect of the increased truck traffic on the roads.

V. LEASE READJUSTMENT

Rentals, royalties, and other conditions of the lease are subject to readjustment at the end of the primary term of 20 years, and at the end of each following 10-year period. The Bureau of Land Management, in cooperation with the Forest Service, is required to prepare an Environmental Assessment Report/Technical Examination. Stipulations may be added which bring the lease into conformance with surface management planning or other legal requirements. Monitoring programs, because they are part of the mine plans, will be implemented or modified as needs are identified, and will generally not be part of the lease readjustment process.

VI. RECLAMATION/MITIGATION

At this point in time, it is difficult to suggest any mitigation of impacts or reclamation of areas that are impacted by undermining, since we can only assume those impacts and their effect. Mitigating measures will be contingent upon the findings of the program. As data is collected, methods of mitigation and reclamation will be formulated. This will be done in cooperation with the Bureau of Land Management, Office of Surface Mining and other agencies as required.

Since significant subsidence is expected to occur after final mining, the Forest Service will require continuance of pertinent programs until such time that it is determined the program is no longer needed. This time period will be a result of data evaluation and information from not only the specific mine involved, but as a result of data from several sources. The time period will be established by the Forest Service, Office of Surface Mining, and the Bureau of Land Management.

VII. LAND MANAGEMENT POLICY

All data accumulated by these monitoring programs will be used to mitigate impacts to resource elements of the National Forest System lands and to update the Forest Land Management Plan, and to provide source information for processing new leases and/or new mining proposals and operations. The programs will be congruous with all present and future management plans. Changes in resource values and emphasis will also have bearing on the intensity of these programs. Flexibility of these programs and their implementation is important in the management of the Forest. The Forest Service will, therefore, recommend modification of the monitoring programs as necessary.

This monitoring plan will be evaluated and updated as frequently as needed by the Forest Service, in cooperation with the Bureau of Land Management and Office of Surface Mining, in response to the data generated and to changes in management policies and direction.

VIII. APPENDIX

A. Direct and Precise Methods for Photo Identification

If size prohibits the direct identification, a small diameter image point readily identifiable on the photography is used for a compass bearing and distance tie to the water source. Small pinholes in the photo emulsion surface are used to identify the image point selected (reference Figure 1).

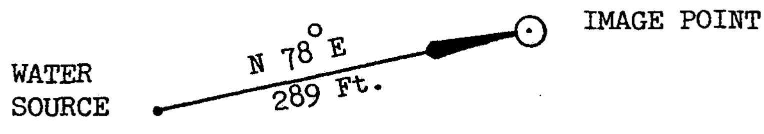


Figure 1 - Compass Bearing and Distance. Note that the bearing is from the property corner to the image point. If horizontal distance exceeds 400 feet, the precise identification procedure should be used (reference Figure 2).

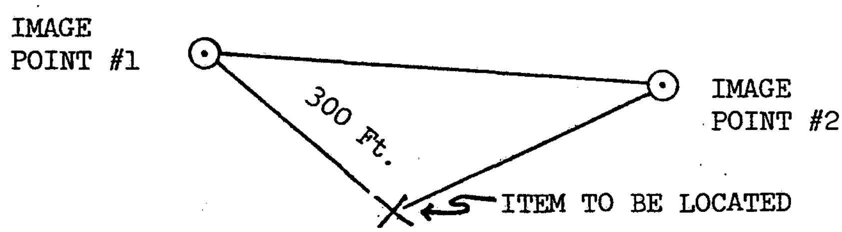


Figure 2 - Precise Identification Tie. Both image points must be pinpricked on the photograph. Horizontal and vertical angles are observed from X to image points 1 and 2. Horizontal and vertical angles are observed from image point #1 to X and image point #2. Horizontal distance is measured between image point 1 and X. Regardless of the method used, a sketch (and description of image points and item being located) on the back of the photograph are essential. Both methods of identification provide for accurate photogrammetric transfer to a base map. If water sources or other items required to be plotted on a base map are tied horizontally to the photo control network, their positions may be scaled on the base map from coordinate values. In the event color infrared photography is not required or available, the photo-identification will apply to existing project photography.

B. Photographic Targets (Ground Panels)

The precision required in large scale mapping projects using photogrammetrics methods, requires an exact correlation between the photography coverage and a significant number of selected points or monuments on the ground for which X, Y, and Z coordinates are accurately measured and established by ground survey methods. These points are usually station markers in the ground in solid rock or on a permanent concrete-type structure where the points, once measured, will be well preserved for recovery and use whenever needed. Placement of a target centered on the monument or station marker so it will appear as a well-defined concentric image on the aerial photographs is essential (see Figures 3 and 4). These targets should also be placed on all supplemental control points required for orientation of the aerial photographs in photogrammetric instruments for forming stereoscopic models to scale and elevation for accomplishing the required measuring and mapping. Targets should also be placed on pertinent survey monuments on the boundaries of all affected properties including Township and Range, Section and quarter corners. Predetermined points on which photogrammetric measurements will be made to establish surface baseline information may also require targeting, however, these will not require permanent monumentation. In this case, capped rebar in the center of each target will be adequate. Property corners not used as basic control may be targeted with only 3 legs of equal spacing using the same dimensions as shown in Figure 3.

Care should be taken where possible to place control and targets in open areas where they will not be obscured by ground cover and/or shadows. In some cases, this may not be possible and clearing will be required. Figure 4 illustrates the approximate clearing criteria. Experience has shown that the darker center of the target provides better contrast for "readability".

C. Photogrammetric Map Compilation

1. Description

This work shall consist of compiling a topographic map and/or "reading" a series of points from aerial photographs in accordance with these specifications, including labor, equipment, materials, and incidentals necessary to complete the work. The initial area to be mapped shall be the area to be mined in the next 18 months (plus angle of draw) on the entire lease area as appropriate.

2. Materials

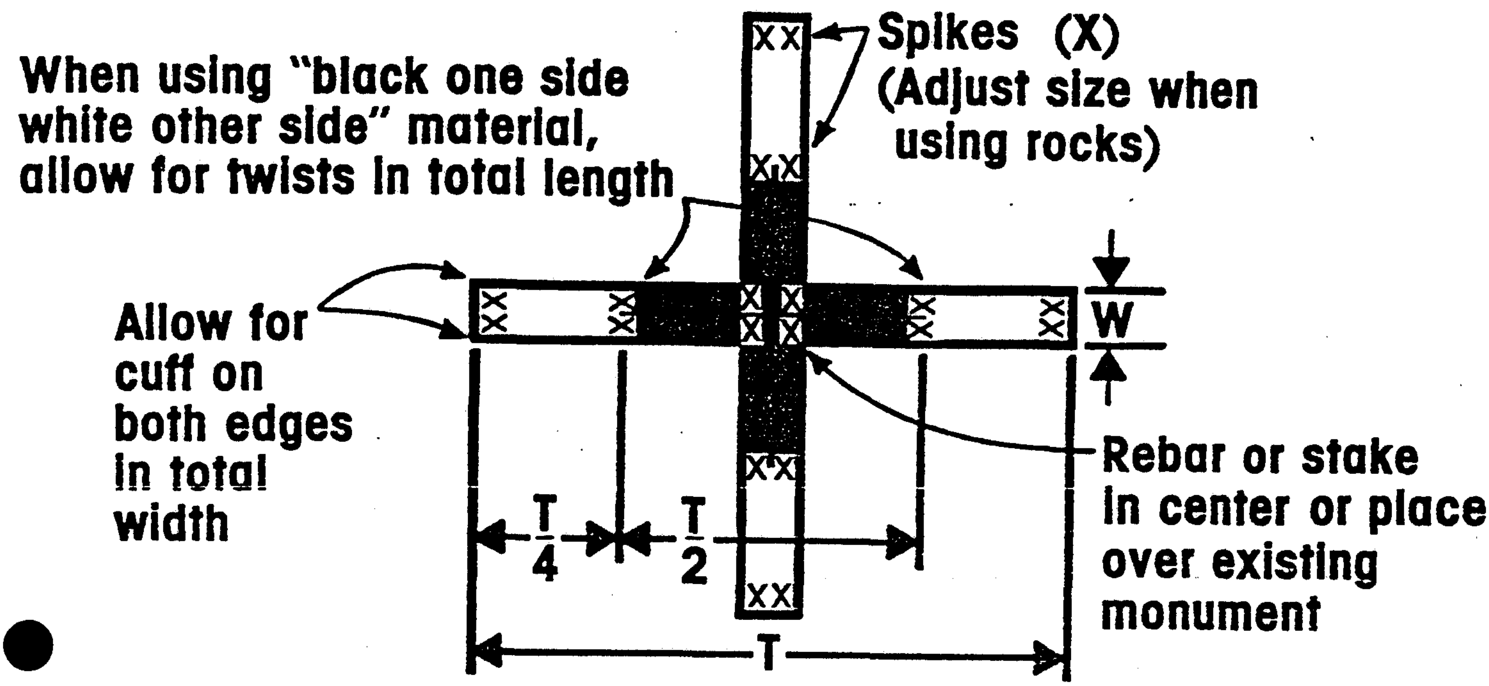
Base sheets for both the original base manuscripts and the overlays shall be polyester base film between 0.004 inch and 0.007 inch in thickness. Paper prints of the final drafted map sheets shall be 16 pounds or heavier stock paper.

3. Requirements

a. Manuscript Map Requirements - Manuscripts shall be compiled as follows:

GROUND TARGETS FOR CONTROL SURVEYS

RECOMMENDED DIMENSIONS



T = Total Length (in feet)
= 1/50 Photo Scale (ft to 1 in)
ie. 1:6000 PSR = 1" = 500' ÷ 50 = 10'-12'

W = Width of Leg (in inches)
= 1/60 Photo Scale (ft to 1 in)
ie. 1:6000 = 1" = 500' ÷ 60 = 8.3"-12"

- Terrain, cover and reflectance characteristics of surface material affect pt. reading accuracy of targeted control station
- Record of location (photo I.D./image pt. tie)
- Maintenance
- Roll stock, pre-cut and/or prefabricated material and targets available from commercial sources

Figure 3

GROUND TARGET PLACEMENT GUIDE

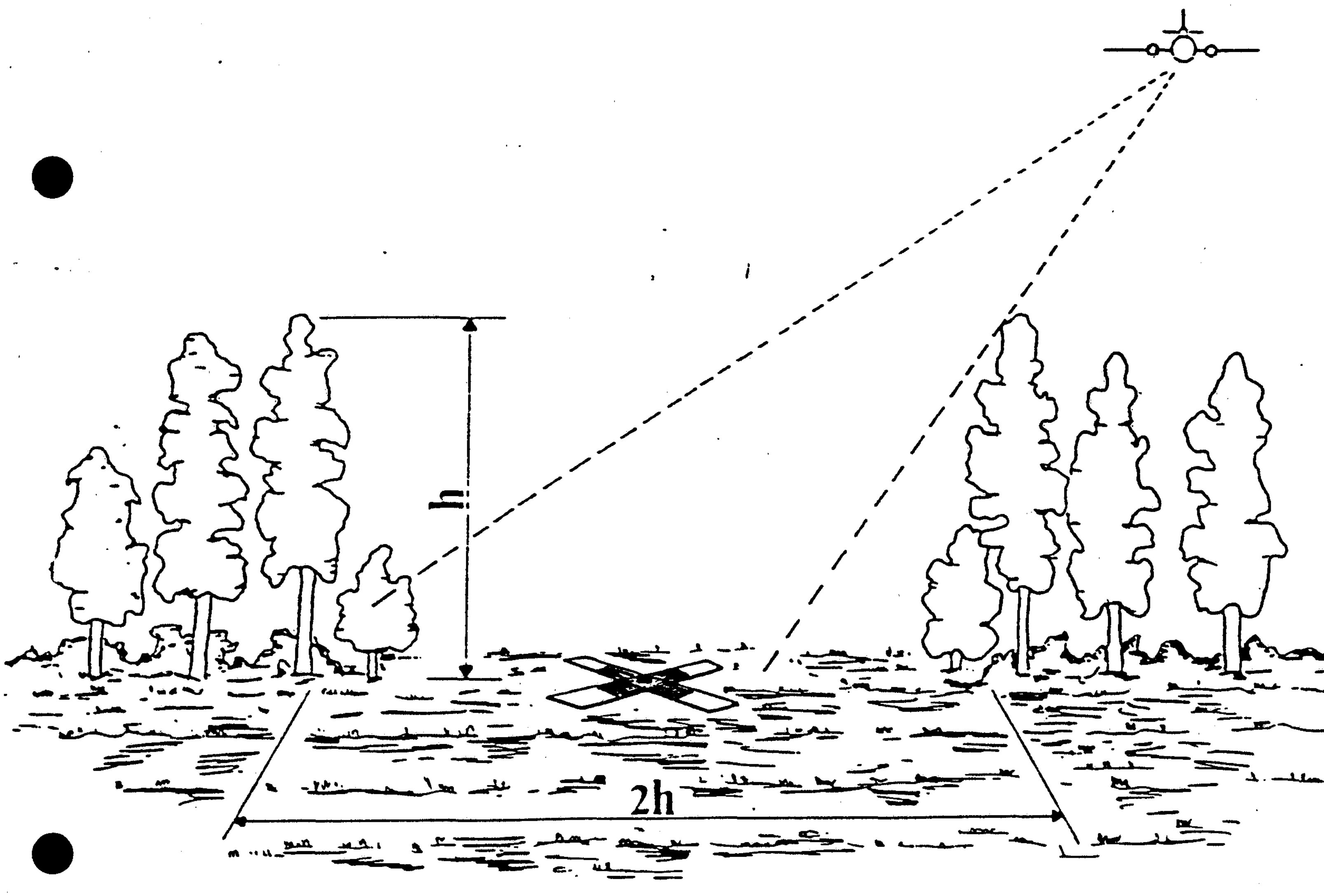


Figure 4

(1) Coordinate Grid Ticks - The plotted positions of each plane coordinate grid tick shall not vary by more than 0.01 inch from the true grid position. Grid ticks shall be plotted at 5 inch intervals. A north arrow indicating grid north shall be shown on each sheet.

(2) Scale and Contour Interval - The scale and contour interval shall be 1" = 100′ and 2′ or as specified by individual project.

(3) Match Lines - Match lines and reference numbers shall be provided so that each map may be accurately joined to those which are adjacent.

(4) Sheet Layout - Each sheet shall be numbered in the border area in each of the four corners. The numbers shall be approximately 0.5 inch high and shall be encircled. A label which includes Forest name, project name, date, and scale shall be placed in the margin at the lower right hand corner of each sheet.

(5) Control Points - All control points shall be plotted and labeled including: horizontal and vertical control points, pass points, tie points, and construction survey control points when required. The principle point of each photo shall also be plotted and labeled.

(6) Planimetric Features - All planimetric features visible and identifiable on the aerial photos shall be shown. Planimetric feature symbols shall conform to Figure 5. Planimetric features not shown on Figure 5 shall be drawn to scale and labeled.

(7) Topographic Features - All contours shown shall be compiled using a stereo plotting instrument. Every fifth contour shall be a heavier weight line. The elevation of every fifth contour shall be shown in tiers approximately 10 inches apart.

Where contours spacing is more than 2 inches apart at final scale, spot elevations shall be shown in a 1-inch grid pattern. Spot elevations shall also be shown at peaks, depressions, saddles, on centerline at each end of a bridge, on centerline at road intersections, and at locations where interpolations from contours will not give true elevations.

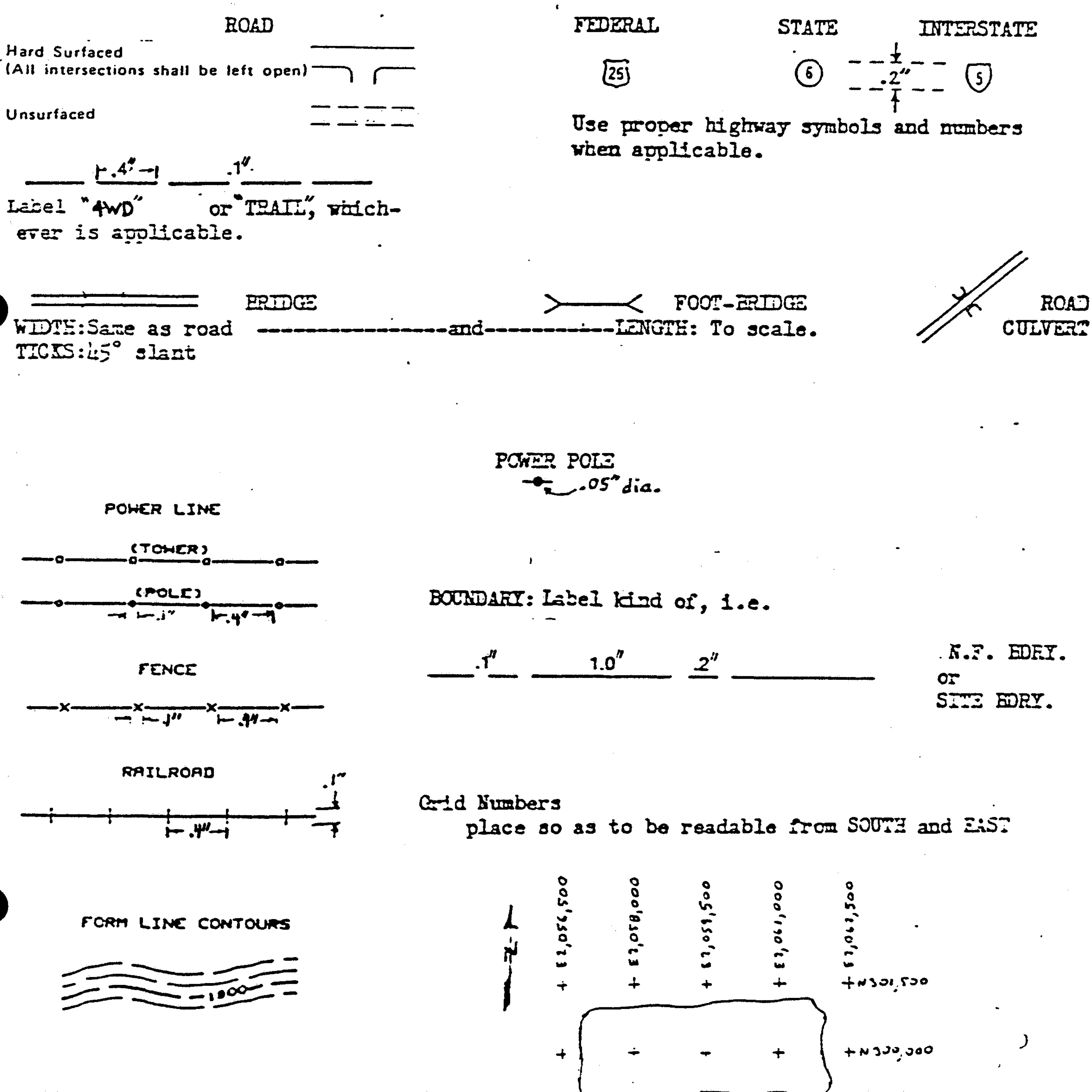
Where contour spacing is less than 10 per inch, the intermediate contours may be dropped and every fifth contour, with heavier line weights, shall be left.

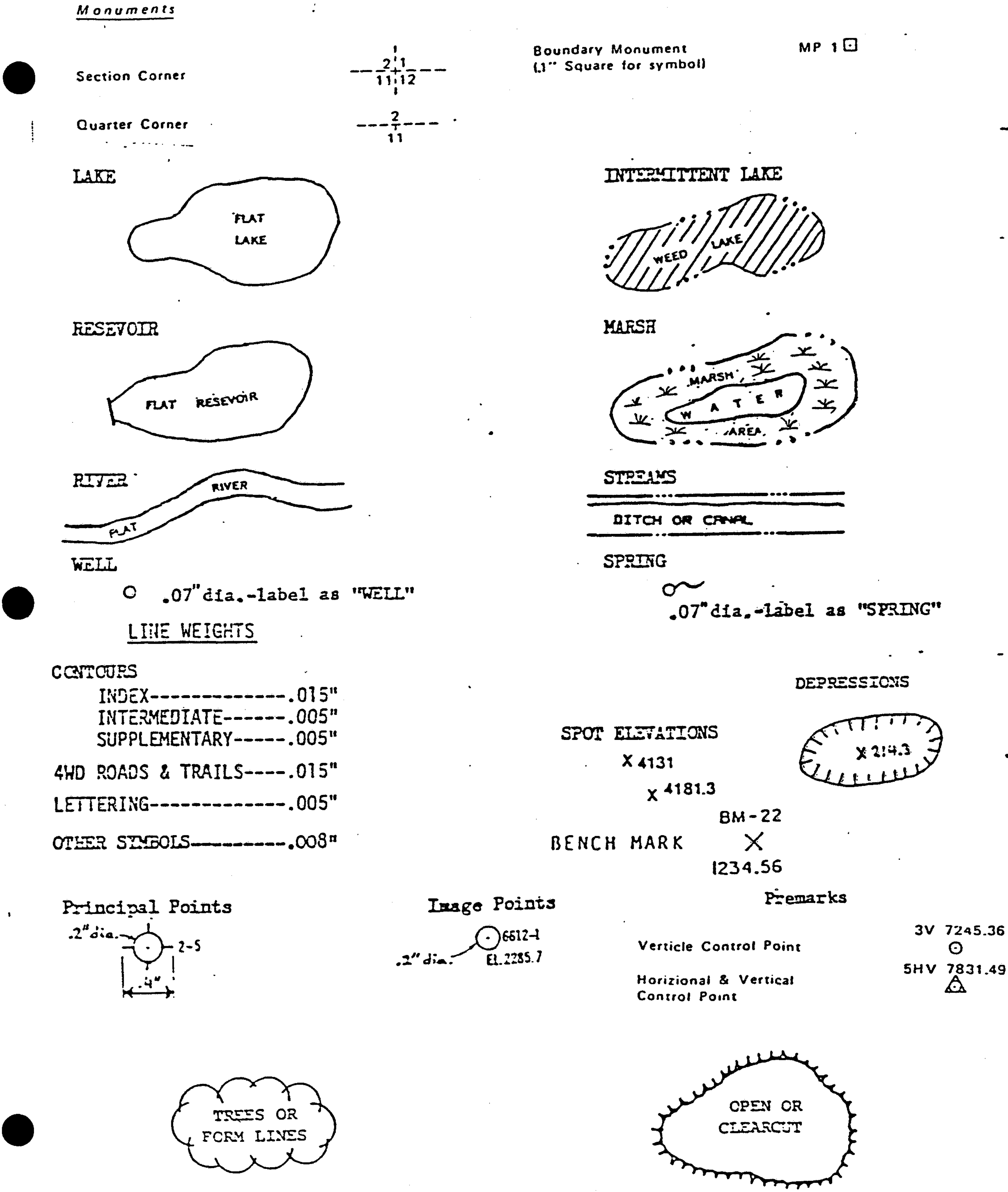
b. Final Map Requirements - Except for sheet layout, the final map sheets shall meet the manuscript map requirements. In addition, the final map sheets shall meet the following requirements.

FIGURE 5

PHOTOGRAMMETRIC DRAFTING STANDARDS

(Dimensions at final scale)

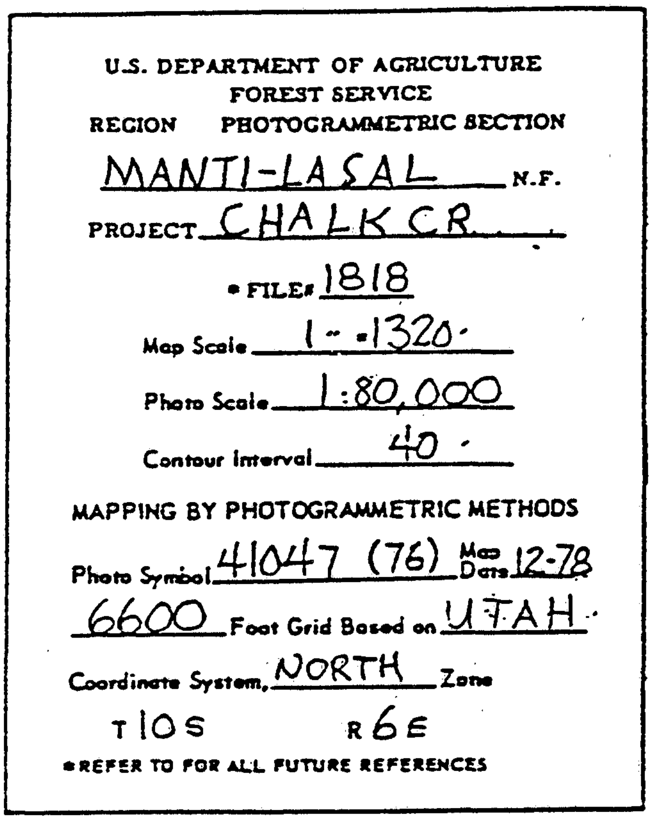




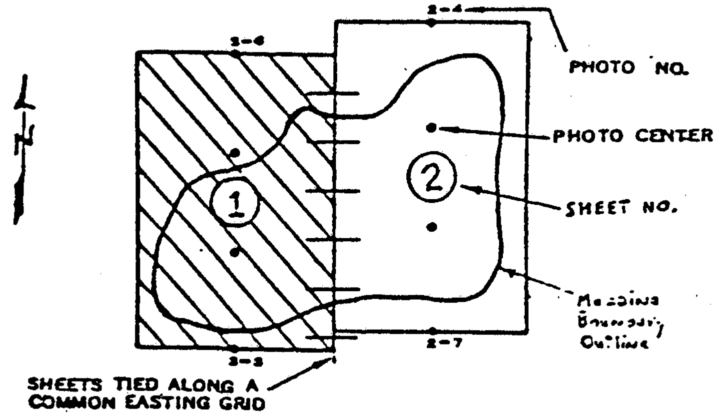
Freehand the outlines as compiled and label inside.

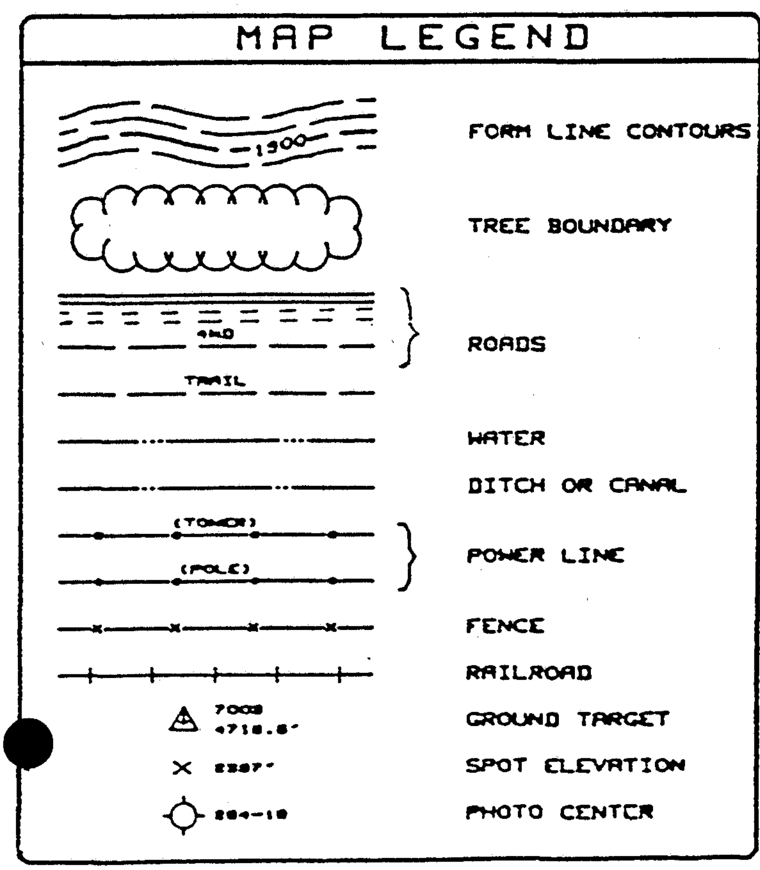
Figure 5 (cont.)

Example TITLE BLOCK



Sheet Index
hachure ONLY the representative sheet





Position the Title Block, Map Legend and Sheet Index such that the map is "balance

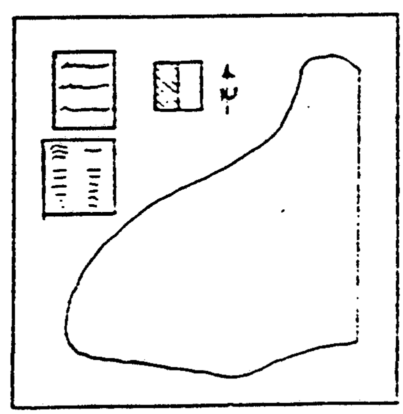


Figure 5 (cont.)

(1) Sheet Size and Layout - Sheets shall be the size specified in Special Project Specifications. Each sheet shall have a border and title block in the lower right hand corner.

A title block and bar scale shall be shown on each final map sheet. The title blocks shall include the following statements:

(a) Date of photography, scale of aerial photography, and scale at which map was compiled.

(b) Statement of datum basis of map grid and elevation.

A small scale, correctly oriented, map sheet index shall be shown on each map sheet. The index shall show all sheets and their numbers. The sheet upon which the index is located shall be crosshatched.

(2) Drafting - Final map sheets shall be either scribed or drafted with ink at the final map scale. The drafting method chosen shall be used for all sheets.

Map details shall be clear, sharp, and legible after reproduction. Lettering shall not be done freehand.

c. Map Accuracy

(1) Topography - At least 90 percent of all elevations determined from contours shall be within 0.5 contour interval of true elevation, and all elevations so determined shall be within 1.0 contour interval of true elevation except as follows:

(a) Where the ground is obscured by brush or tree cover, contours shall be plotted from the stereoscopic model, making use of spot elevations measured photogrammetrically in places where the ground is visible. In these areas, at least 90 percent of the elevations determined from contours shall be within 1.0 contour interval of true elevation. All elevations so determined shall be within 2 contour intervals of true elevation. Contours within these areas shall be shown as dashed lines.

(b) In densely wooded areas where spot elevations cannot be determined, contours shall not be drawn. They shall be outlined and labeled "ground not visible" or "GNV".

(2) Spot Elevations - At least 90 percent of all spot elevations shall be within 0.25 contour interval of true elevation. All spot elevations shall be within 0.50 contour interval of true elevation.

(3) Planimetric Features - At least 90 percent of all well-defined planimetric features such as structures, paved roads, intersections, etc., shall be within 0.025 inch of their true position. All shall be within 0.050 inch of their true position.

(4) Coordinate Grid Ticks - The plotted position of all coordinate grid ticks shall not vary by more than 0.01 inch from their true grid position.

(5) Horizontal Control - The plotted position of all horizontal control points shall not vary by more than 0.01 inch from their calculated position.

Acceptance or rejection of the map or portions thereof will be the responsibility of the lessee and based on whatever means they feel necessary to perform (generally field survey methods).

d. Map Accuracy Tests - The Forest Service may elect to evaluate map accuracy and precision based on a sample of test points. The test points will be randomly selected models and representative of the feature being tested.

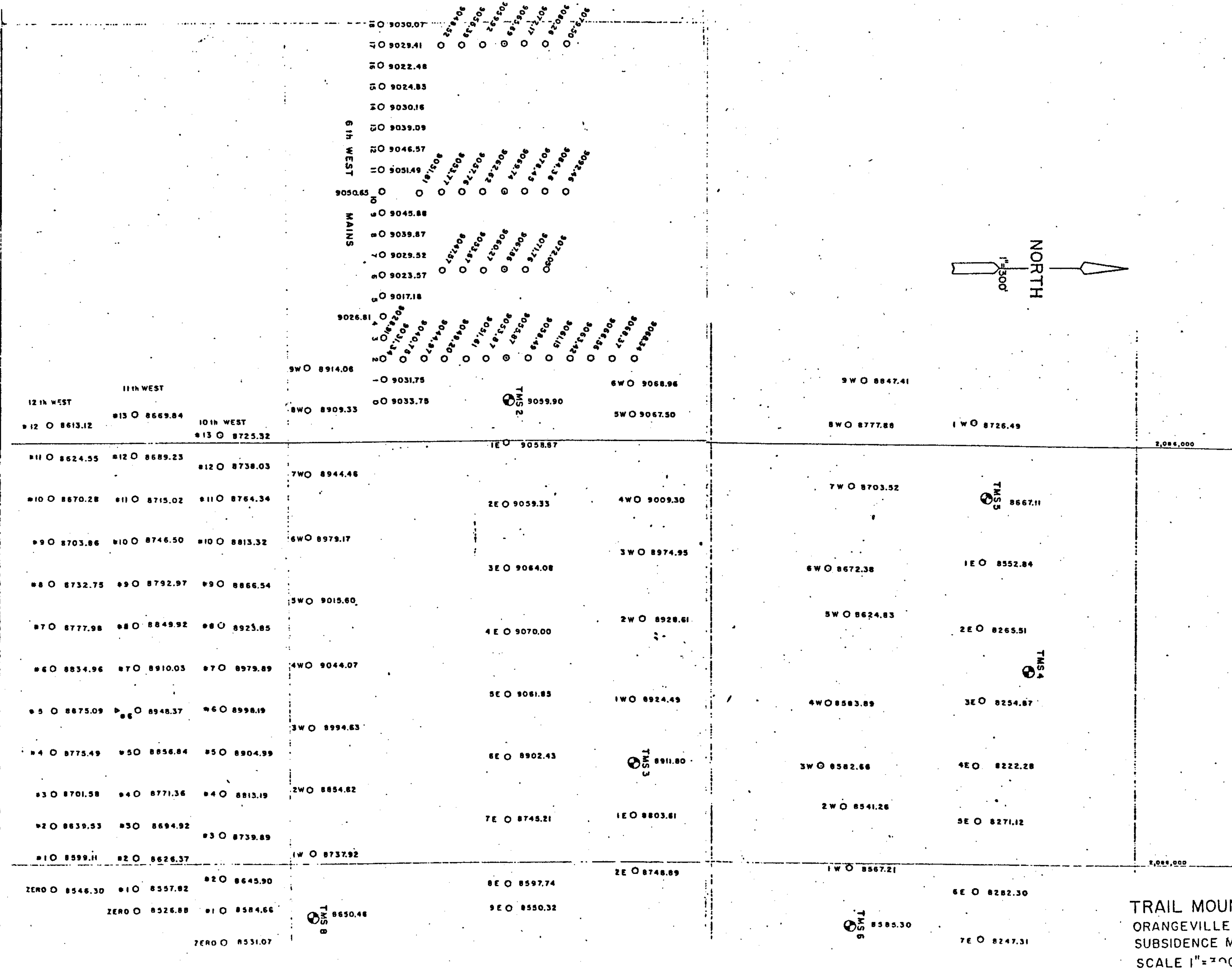
The position and elevation of test points will be determined by the Forest Service using photogrammetric or ground survey methods of equal or better precision than those used for map production. Discrepancies will be calculated between the test values and map values. Statistical methods of hypothesis testing will be used to determine if the mean and standard error of the sample of discrepancies indicate that map accuracy requirements have been met. Tests for accuracy will apply to the models in which tests were performed.

All required materials or suitable duplicate thereof will be provided to the Forest Service as requested to insure and assist in the successful implementation and continuation of this program.

APPENDIX 4 1985 - 86 Subsidence Data
U. S. Forest Service Based on Aerial Flights

APPENDIX 5 TMCC 1986 Subsidence Data
Implementation of Conventional Survey
Monumentation Plan (Baseline Data)

FIGURE 12-4



TRAIL MOUNTAIN COAL CO.
ORANGEVILLE, UTAH 84537
SUBSIDENCE MONITORING POINTS
SCALE 1" = 300' OCT. 15, 1986
NOV. 15, 1986

APPENDIX 6 Locations within the Tract 1 Mine Plan Area and Their Verticle Displacement and Naritive Comparison to Tract 2**

**Ch 12-Rev 2-04-87

EarthFax

EarthFax
Engineering Inc.
Engineers/Scientists
7324 South 1300 East
Suite 100
Midvale, Utah 84047
Telephone 801 561-1555

February 4, 1987

Mr. Allen P. Childs
Mine Engineer
Trail Mountain Coal Company
P.O. Box 370
Orangeville, Utah 84537-0370

Subject: Preliminary observations of subsidence at the Trail Mountain Mine, 1984-1986

Dear Allen:

We have reviewed the subsidence data provided in a transmittal by Mr. William H. Boley dated January 28, 1987 (see Appendix A). These data consist of seven points where elevation measurements were taken in 1984 and again in 1986 (precise dates not provided). The transmittal also contained computed changes in elevation.

Insufficient data were provided to permit a detailed analysis of subsidence in the mine area. Mr. Boley indicated in his transmittal that additional data would be provided at a later date. With these additional data points, contours of subsidence can be prepared and more-detailed conclusions can be drawn. It is anticipated that the additional data will be available in April 1987.

A map showing the location of the subsidence monitoring stations included in Mr. Boley's transmittal and the coinciding changes in ground-surface elevation between 1984 and 1986 is included herewith as Plate 12-5. No springs are known to exist within the area of these measurements. A profile showing elevation changes (from west to east) is provided in Figure 1.

According to Dunrud (1976), both positive and negative changes in elevation are typical expressions of subsidence. Positive changes occurred in the western portion of the study area where the overburden thickness was greatest. Negative changes occurred in the eastern portion of the study area where the overburden thickness was least and where mining was most recently completed. Once again, due to the limited data base, more detailed conclusions cannot be drawn at this time.

A comparison of mine panel width/mean overburden depth ratios to subsidence ratios for the Trail Mountain Mine with similar measurements from other mines reported by Dunrud (1976) indicate that subsidence amounts at the Trail Mountain Mine are typical. These conclusions may be refined as new data become available.

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Please contact us when the additional data are available from the Forest Service. At that time, we should be able to prepare contour maps and more detailed analyses of subsidence effects at the mine.

Sincerely,

Richard B. White, P.E.
Principal Hydrologist

Enclosure

Reference Cited

Dunrud, C.R. 1976. Some Engineering Geologis Factors Controlling Coal Mine Subsidence in Utah and Colorado. U.S. Geological Survey Professional Paper 969. Washington, D.C.

APPENDIX A

Preliminary Subsidence Data as Obtained
From the U.S. Forest Service

MESSAGE DISPLAY

TO   C.REED

From: William H. Boley
Postmark: Jan 28,87   12:40 PM

Subject: Forwarded: TRAIL MTN. MINE SUBSIDENCE MONITORING (INTERIM PT.READIN

Comments:
From William H. Boley:
DON'T REMEMBER IS I FORWARDED THIS TO YOU OR NOT. .IF I DID ,NOW
YOU HAVE IT TWICE.

Message:
From LYNN H. WIESE:R04A:

N.	E	84 ELEV.	86 ELEV.	DIFF.
351,500.09375	2,086,000.00781	8731.92285	8732.18652	+0.26367
	200.00000	8761.10758	8761.99902	+0.89144
	399.98438	8802.67871	8803.01953	+0.34082
	600.02344	8853.60059	8854.08984	+0.48925
	2,086,800.00000	8907.87988	8907.84570	-0.03418
	87,000.00000	8964.62012	8963.77148	-0.84864
351,500.18750	200.00000	8977.04883	8976.01367	-1.03516

We have 130 pts. over this panel,will send later if needed. L.Wiese.

--------========X=======-------

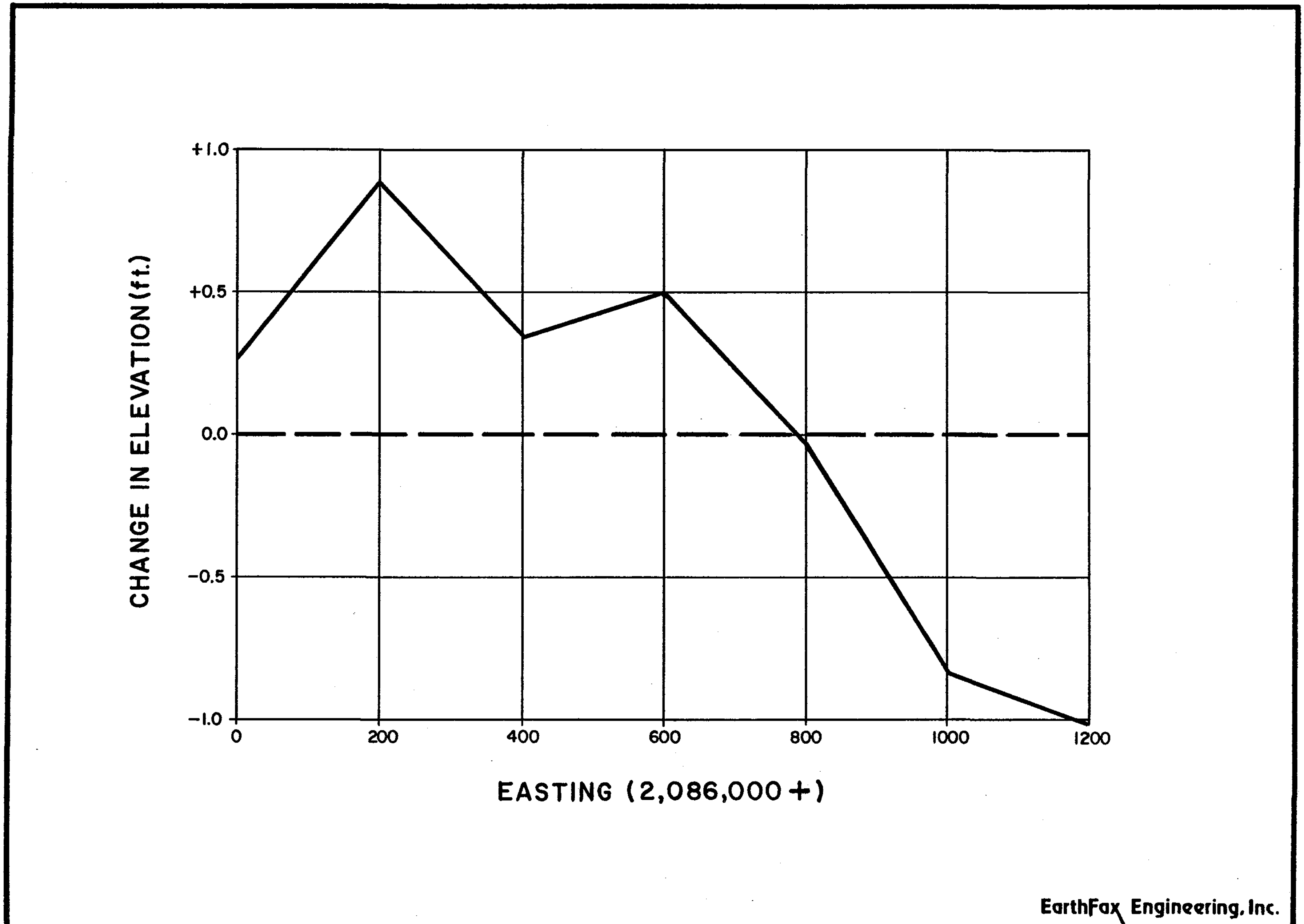
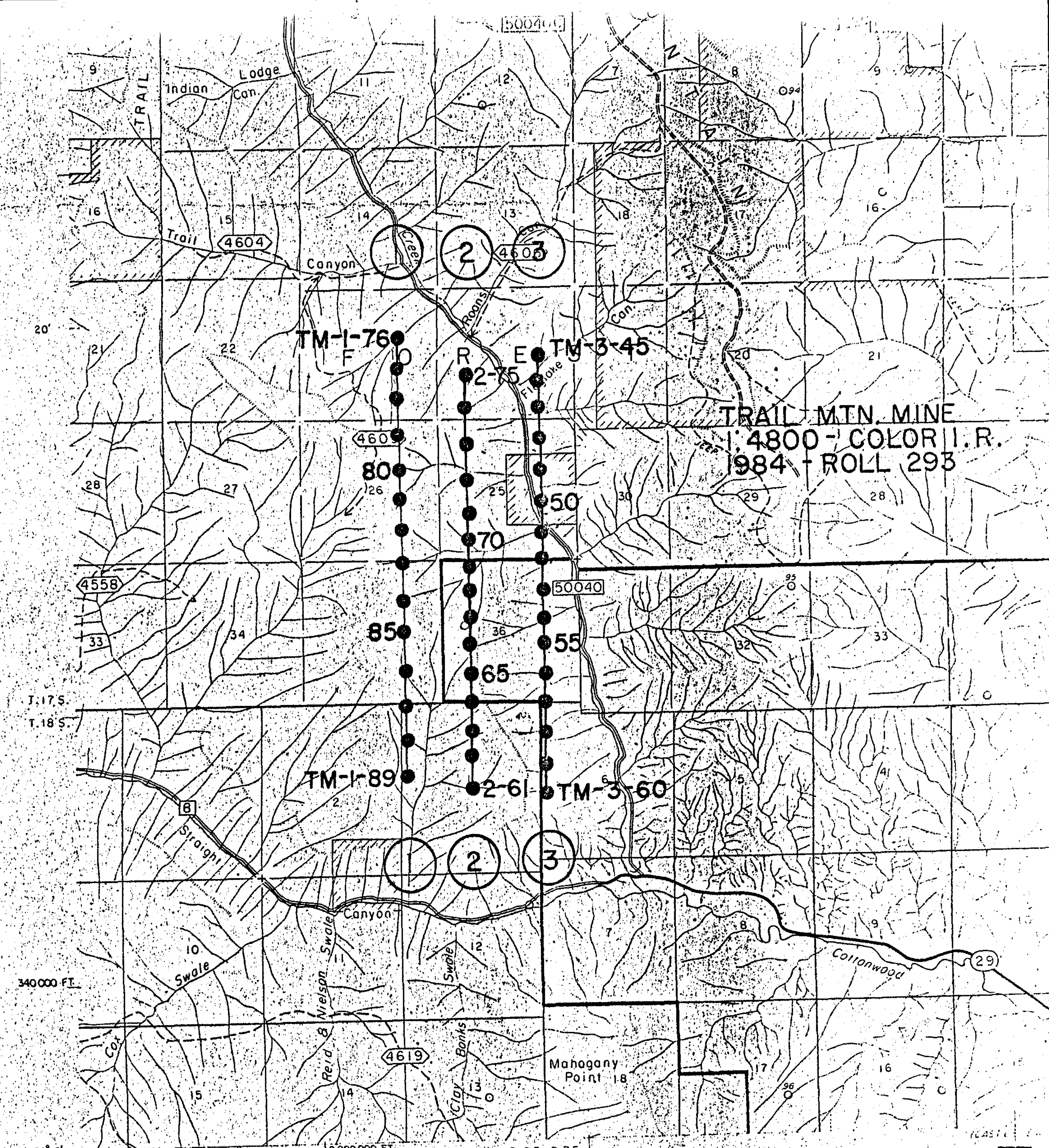


Figure 1. Net change in ground surface elevation above the 10th West mine panel, 1984 - 1986.

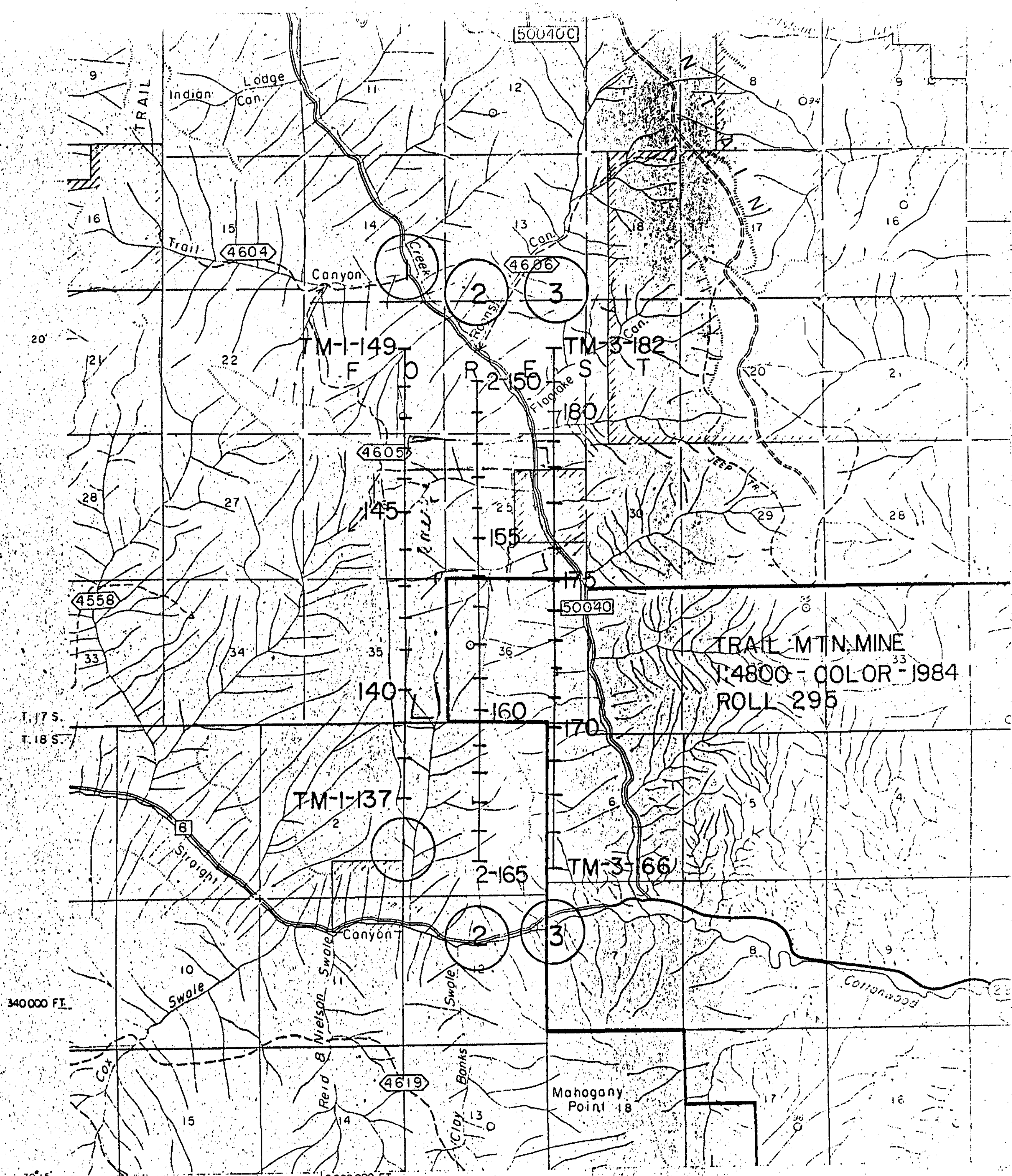


USFS Planimetric Series Map
Constructed by Photogrammetric Methods
From 1:60,000 Photography Dated 1954-55
Polyconic Projection 1927 NAD
10,000 ft. Grid Based on Utah Coordinate System,
Central Zone
Edited and Revised 1963

21-A

GAP FLIGHT A

FIGURE 12-2



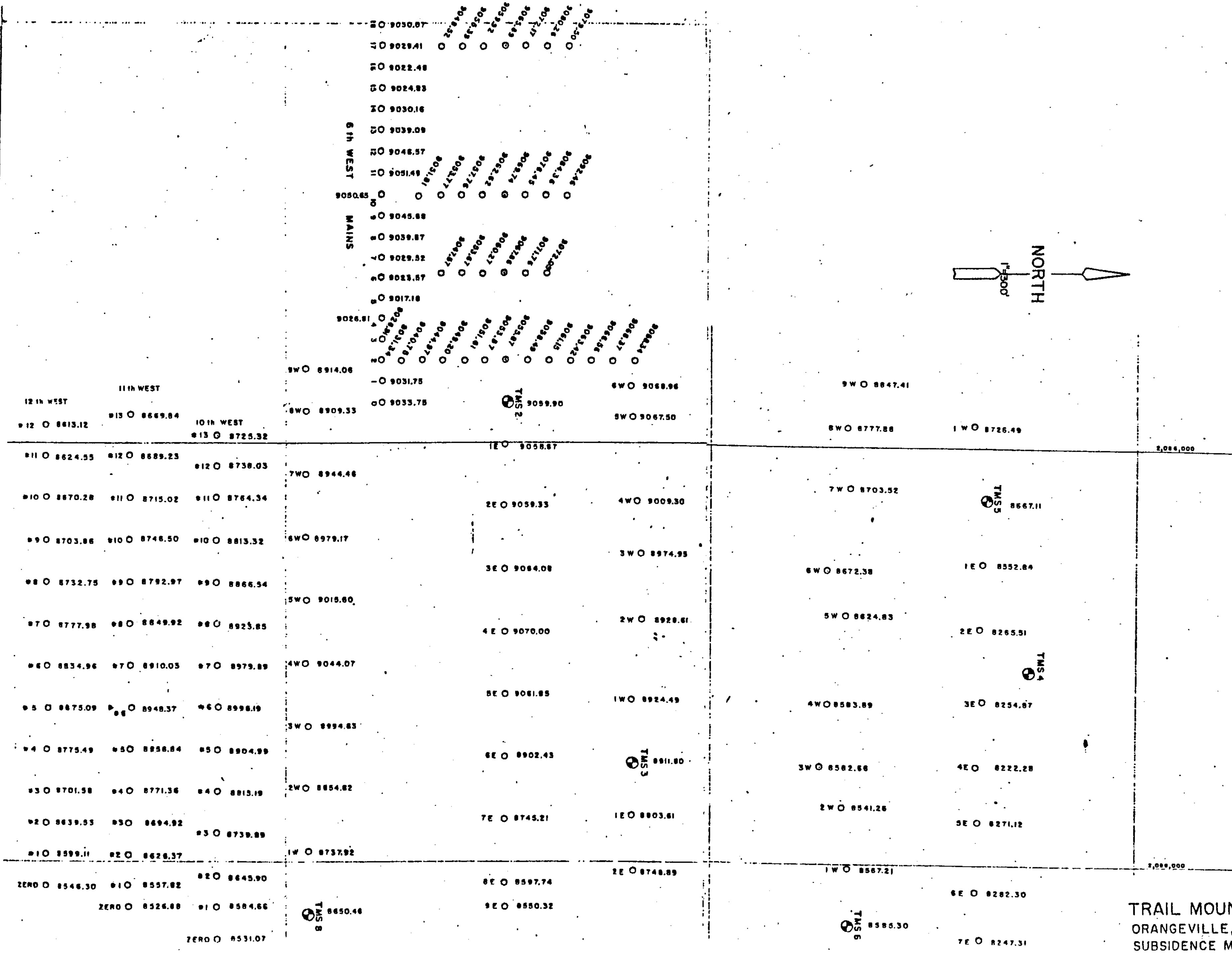
USFS Planimetric Series Map
Constructed by Photogrammetric Methods
From 1:60,000 Photography Dated 1954-55
Polyconic Projection 1927 NAD
10,000 ft. Grid Based on Utah Coordinate System,
Central Zone
Edited and Revised 1963

21-A

GAP FLIGHT 'A'

FIGURE 12-3

FIGURE 12-4



TRAIL MOUNTAIN COAL CO.
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SCALE 1"=300' OCT. 15, 1986
NOV. 15, 1986