015/019 #1

SOUTH LEASE

ESCARPMENT STUDY

UTAH POWER & LIGHT - MINING DIVISION

GEOTECHNICAL BASELINE DATA

December 1988

SOUTH LEASE

ESCARPMENT STUDY

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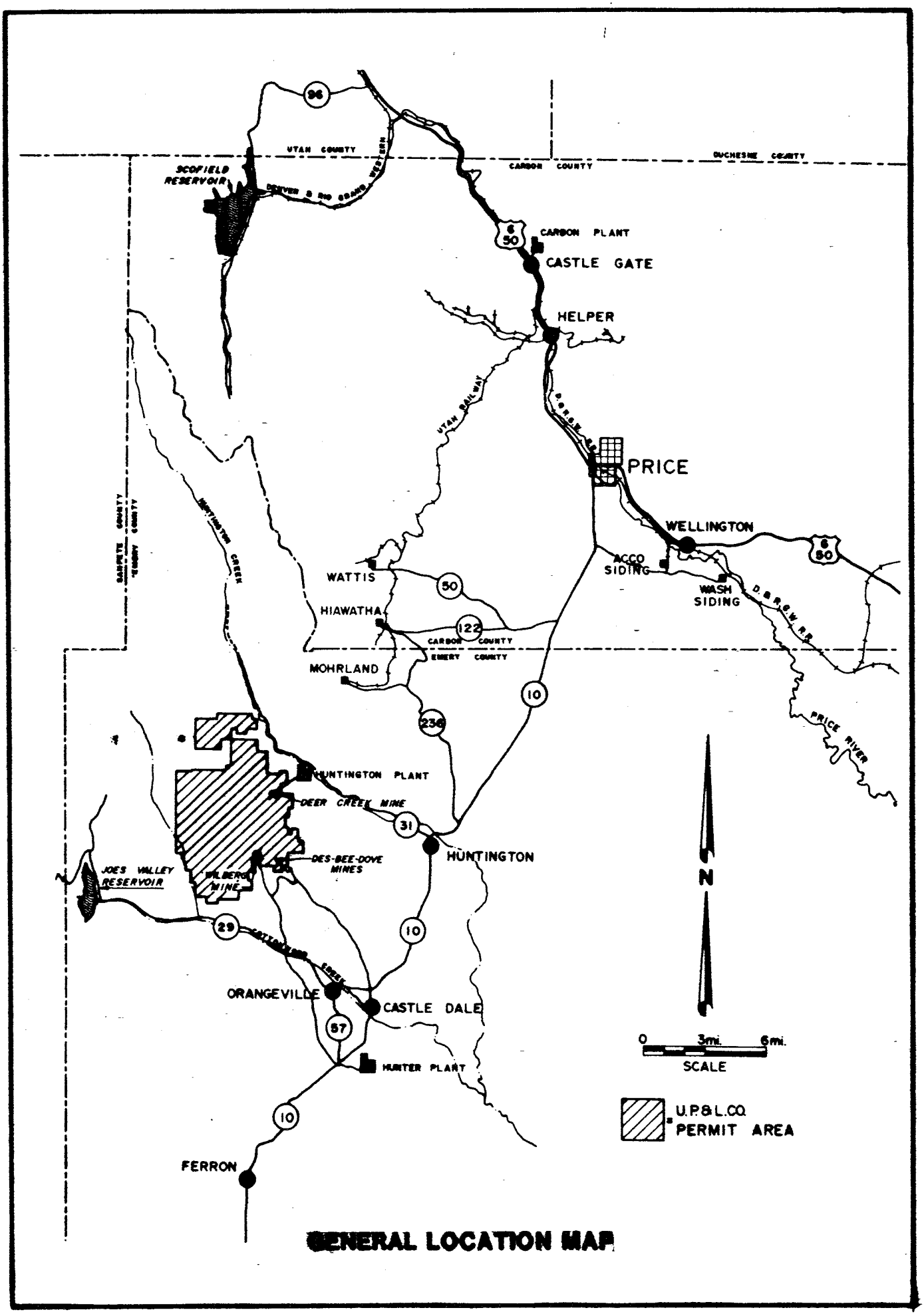


GENERAL LOCATION MAP

COAL SUMMARY

EM-83

COLLAR ELEVATION: 8,957.0
HOLE DEPTH: 1,540.0

LITHOLOGY	DEPTH IN HOLE-TOPS	ELEVATION TOPS	THICKNESS - FEET ROCK	COAL	SEAM
COAL	1,325.5	7,631.5		1.3	UPPER B.C.
ROCK	1,326.8	7,630.2	2.9		
COAL	1,329.7	7,627.3		4.5	BLIND CANYON
ROCK	1,334.2	7,622.8	1.0		
COAL	1,335.2	7,621.8		2.3	BLIND CANYON
BONE	1,337.5	7,619.5		0.4	BLIND CANYON
COAL	1,337.9	7,619.1		0.6	BLIND CANYON
BONE	1,338.5	7,618.5		0.3	BLIND CANYON
COAL	1,338.8	7,618.2		2.2	BLIND CANYON
BONE	1,341.0	7,616.0		0.4	BLIND CANYON
COAL	1,341.4	7,615.6		0.7	BLIND CANYON
ROCK	1,342.1	7,614.9	29.5		
COAL	1,371.6	7,585.4		1.2	COTTONWOOD
BONE	1,372.8	7,584.2		0.2	COTTONWOOD
COAL	1,373.0	7,584.0		1.2	COTTONWOOD
BONE	1,374.2	7,582.8		0.4	COTTONWOOD
COAL	1,374.6	7,582.4		2.7	COTTONWOOD
ROCK	1,377.3	7,579.7	67.4		
BONE	1,444.7	7,512.3		0.3	HIAWATHA
COAL	1,445.0	7,512.0		4.6	HIAWATHA
BONE	1,449.6	7,507.4		0.2	HIAWATHA
COAL	1,449.8	7,507.2		1.4	HIAWATHA
BONE	1,451.2	7,505.8		0.3	HIAWATHA
COAL	1,451.5	7,505.5		3.6	HIAWATHA
ROCK	1,455.1	7,501.9			

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

Detailed log

PROJECT: EAST MOUNTAIN DRILL HOLE: EM-83

LOCATION: 1595 E; 660'S; NW 32
COLLAR ELEV.: 8957
HOLE TYPE: PLUG
PLUG INTERVAL: 0 - 1540
CORE INTERVAL: ——
TOTAL DEPTH: 1540
DATE: 19 OCT 1981
SCALE: 1" = 10'
GEOLOGIST: Lloyd, Fry, Snider

GEOPHYSICAL DATA

LOG	FROM	TO
DENSITY:	1250	1500
H.R.D.:	1300	1475
E. LOG:	1250	1490
GAMMA:	1250	1525
CALIPER:		
S.P.:		

COAL SUMMARY:

SEAM	THICKNESS	INT.
Upper B.C.	4.5	
B.C.	6.9	1.0
COTTON.	5.7	29.5
HIAW.	10.4	67.4

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1200				BLACKHAWK FORMATION	1200 - 1251' INTERBEDS; Mudstone, dark gray Siltstone, med gray					
1210										
1220										
1230										
1240										
1250					1251-1253' MUDSTONE; dark gray					
					1253-1255' SILTSTONE, med gray					
					1255-1260.5' MUDSTONE; dark gray					
1260					1260.5-1270' INTERBEDS; Mudstone, dark gray Siltstone, med gray					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN

DRILL HOLE: EM-83

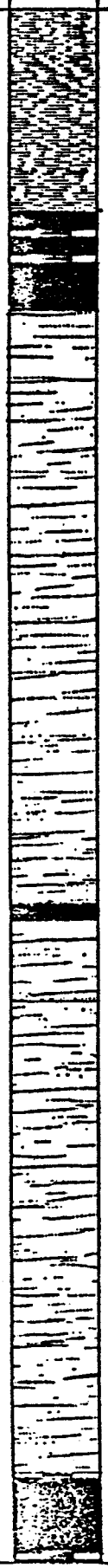
PAGE 2 OF 4

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1270				BLACKHAWK FORMATION	1270-1277' MUDSTONE; dark gray, silty					
1280					1277-1315' SANDSTONE; light gray, fine grained H_2O production started here					
1290										
1300										
1310										
1320					1315-1325.5' INTERBEDS; Mudstone, dark gray Siltstone, med gray HS is carbonaceous in part.					
					1325.5-1326.8' COAL; 1.3' UPPER BLIND CANYON					
					1326.8-1329.7' SILTSTONE; med gray					
1330					1329.7-1334.2' COAL; 4.5' UPPER BLIND CANYON					
					1334.2-1335.2' MUDSTONE; dark gray					
					1335.2-1342.1' COAL 6.9' BLIND CANYON bony: 1337.5-1337.9' 1338.5-1338.8' 1341.0-1341.4'					
1340					1342.1-1357.5' INTERBEDS; CMS Siltstone } med to dark gray					
1350										
					1357.5-1370.0' SILTSTONE; light gray, sandy					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM-83
PAGE 3 OF 4

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1360				BLACKHAWK FORMATION	1357.6 - 1371.6' SILTSTONE; light gray, sandy					
1370					1371.6-1372.8' COAL; 1.2' COTTONWOOD					
					1372.8-1373' BONE COAL 0.2					
					1373-1374.2' COAL; 1.2' COTTONWOOD					
					1374.2-1374.6' BONE COAL 0.4					
					1374.6-1377.3' COAL; 2.7' COTTONWOOD					
1380					1377.3-1411.5' INTERBEDS; Carb Mudstone Siltstone					
1390										
1400										
1410					1411.5-1412.5 COAL; 1.0'					
					1412.5-1417' INTERBEDS; Carb Mudstone Siltstone					
					1417-1444.7' INTERBEDS; Sandstone, Siltstone.					
1420										
1430										
1440										
					1444.7-1445' BONE COAL					
					1445-1447.6' COAL; 4.6' HIAWATHA					
					1447.6-1449.5 BONE COAL					
1450					1449.5-1451.3 COAL; 1.4' HIAWATHA					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM-83
PAGE 4 OF 4

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1450				BLACK HAWK F14	1449.8-1451.2' COAL; 1.4' HIAWATHA					
					1451.2-1451.5' BONE COAL					
					1451.5-1455.1' COAL; 3.6'					
					1455.1-1459' SILTSTONE; muddy, gray					
1460				STAR POINT SS	1459-1540' SANDSTONE; fine grained, light gray, well sorted					
					STAR POINT SS					
1470										
1540					T.D. 1540					

COAL SUMMARY

EM-85

Collar Elevation: 9362.6

Hole Depth: 1860

Strata	Depth In Hole-Tops	Elevation Tops	Thickness-Feet Rock	Thickness-Feet Coal	Seam
Coal	1592.2	7770.4		1.1	
Rock	1593.3	7769.3	0.5		
Coal	1593.8	7768.8		1.5	
Rock	1595.3	7767.3	50.3		
Coal	1645.6	7717.0		5.8	Upper Blind Canyon
Rock	1651.4	7711.2	4.4		
Coal	→ 1655.8	7706.8		3.8	Blind Canyon
Bone Coal	1659.6	7703.0		0.3	Blind Canyon
Coal	1659.9	7702.7		2.8	Blind Canyon
Rock	1662.7	7699.9	0.2		
Coal	1662.9	7699.7		0.5	Blind Canyon
Rock	→ 1663.4	7699.2	11.0		
Coal	1674.4	7688.2		5.2	Cottonwood
Rock Bone	1679.6	7683.0	0.3		
Coal	1679.9	7682.7		0.2	Cottonwood
Rock Bone	1680.1	7682.5	0.2		
Coal	1680.3	7682.3		2.1	Cottonwood
Rock	1682.4	7680.2	53.8		
Coal	1736.2	7626.4		1.6	
Rock	1737.8	7624.8	12.5		
Coal	→ 1750.3	7612.3		0.3	Hiawatha
Rock	1750.6	7612.0	0.3		
Coal	1750.9	7611.7		5.6	Hiawatha
Bone Coal	1756.5	7606.1		0.3	Hiawatha
Coal	1756.8	7605.8		2.5	Hiawatha
Rock	1759.3	7603.3	0.4		
Coal	1759.7	7602.9		0.4	Hiawatha
Rock	1760.1	7602.5			

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

Detailed Log

PROJECT: EAST MOUNTAIN

DRILL HOLE: EM-85

LOCATION: 1560'S, 990'W, NE32
COLLAR ELEV.: 9362.6
HOLE TYPE: PLUG
PLUG INTERVAL: 0-1860'
CORE INTERVAL: —
TOTAL DEPTH: 1860'
DATE: 10 OCT 1981
SCALE: 1" = 10'
GEOLOGIST: RC. FRY; K SNIDER

GEOPHYSICAL DATA

LOG	FROM	TO
DENSITY:	1575	1825
H.R.D.:	1600	1800
E. LOG:	1670	1825
GAMMA:	1550	1850
CALIPER:		
S.P.:		

COAL SUMMARY:

SEAM	THICKNESS	INT.
Upper B.C.	5.8	
B.C.	7.4	4.4
COTTON.	7.5	11.0
HIAWA	8.4	63.5

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1500				BLACKHAWK FORMATION	1400 - 1550 INTERBEDS; Siltstone, light gray, sandy. Mudstone, dark gray, dense.					
1510										
1520										
1530										
1540										
1550					1550 - 1560' SANDSTONE; light gray, fine-grained, poorly sorted.					
1560					1560 - 1592.2 INTERBEDS: [illegible]					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM 85
PAGE 2 OF 4

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1570					1560 - 1592.2 INTERBEDS; Mudstone Siltstone (see above)					
1580										
1590					1592.2 - 1593.3' COAL; 1.1' BEAR CREEK CANYON ?					
					1593.3 - 1593.8' MUDSTONE, dark gray					
					1593.8 - 1595.3' COAL; 1.5'					
1600				BLACKHAWK FORMATION	1595.3 - 1645.6' INTERBEDS, Mudstone, dark gray to black Siltstone, gray, muddy					
1610										
1620										
1630										
1640										
					1645.6 - 1651.4' COAL; 5.8' UPPER BLIND CANYON					
1650					1651.4' - 1655.8' MUDSTONE					
					1655.8 - [illegible] COAL; [illegible] BLIND CANYON					
					[illegible] COAL; 0.8'					
					[illegible] BLIND CANYON					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM-85
PAGE 2 OF 4

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1660				BLACKHAWK FORMATION	1659.9 - 1662.7' COAL; 2.8' BLIND CANYON					
					1662.7 - 1662.9' CARB MUDSTONE: Black					
					1662.9 - 1663.4' COAL; 0.5' BLIND CANYON					
					1663.4 - 1674.4' INTERBEDS; Mudstone, gray, dense Siltstone, light gray					
1670										
					1674.4 - 1679.6 COAL; 5.2' COTTONWOOD					
1680					1679.6 - 1679.9' CARB MUDSTONE					
					1679.9 - 1680.1' COAL; 0.2' LOWER COTTONWOOD					
					1680.1 - 1680.3' CARB MUDSTONE					
					1680.3 - 1682.4 COAL; 2.1' COTTONWOOD					
					1682.4 - 1693' INTERBEDS; Mudstone, gray, dense Siltstone, gray					
1690										
					1693 - 1723' SILTSTONE; light gray					
1700										
1710										
1720										
					1723 - 1736.2' MUDSTONE; gray, dense					
1730										
					1736.2 - 1737.8 COAL; 1.6'					
					1737.8 - 1750.3 MUDSTONE; gray, dense					
1740										
1750										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM-85
PAGE 4 OF 4

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1750				BLACKHAWK FM	1737.8 - 1750.3' MUDSTONE; gray, dense					
					1750.3 - 1750.6' COAL; 0.3' HIAWATHA					
					1750.6 - 1750.9' MUDSTONE; gray, dense					
					1750.9 - 1756.5 COAL; 5.6' HIAWATHA					
					1756.5 - 1756.8' BONE COAL; 0.3'					
					1756.8 - 1759.3' COAL; 2.5' HIAWATHA					
1760					1759.3 - 1759.7' CARB MUDSTONE					
					1759.7 - 1760.1' COAL; 0.4' HIAWATHA					
					1760.1 - 1766' INTERBEDS; Mudstone-Sandstone					
				STAR POINT SANDSTONE	1766 - 1860' SANDSTONE; Light gray, fine-grained, well sorted, well rounded STAR POINT SS					
1770										
1780										
1790										
1800										
1810										
1860					T.D. 1860'					

COAL SUMMARY

EM-88

Collar Elevation: 8977

Hole Depth: 1500

Strata	Depth In Hole-Tops	Elevation Tops	Thickness-Feet Rock	Thickness-Feet Coal	Seam
Coal	1226.2	7750.8		2.2	Upper Blind Canyon
Rock	1228.4	7748.6	7.6		
Coal	1236.0	7741		0.6	Upper Blind Canyon
Rock	1236.6	7740.4	13.3		
Coal	1249.9	7727.1		0.7	Blind Canyon
Rock	→1250.6	7726.4	36.7		
Coal	1287.3	7689.7		0.7	Cottonwood
Bone Coal	1288.0	7689		0.3	Cottonwood
Coal	1288.3	7688.7		4.0	Cottonwood
Rock	1292.3	7684.7	0.3		
Coal	1292.6	7684.4		4.2	Cottonwood
Bone Coal	1296.8	7680.2		0.4	Cottonwood
Coal	1297.2	7679.8		3.6	Cottonwood
Rock	1300.8	7676.2	58.7		
Coal	→1359.5	7617.5		9.7	Hiawatha
Rock	1369.2	7607.8			

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

Detailed log

PROJECT: EAST MOUNTAIN DRILL HOLE: EM-83

LOCATION: 502'N; 2820E; SW 32
COLLAR ELEV.: 8977
HOLE TYPE: PLUG
PLUG INTERVAL: —
CORE INTERVAL: 0-1500
TOTAL DEPTH: 1500
DATE: 17 OCT 1981
SCALE: 1" = 10'
GEOLOGIST: Hovd, Fry, Snider

GEOPHYSICAL DATA

LOG	FROM	TO
DENSITY:	1150	1480
H.R.D.:		
E. LOG:	1200	1425
GAMMA:	1150	1480
CALIPER:		
S.P.:		
TEMP	1310	1260

COAL SUMMARY:

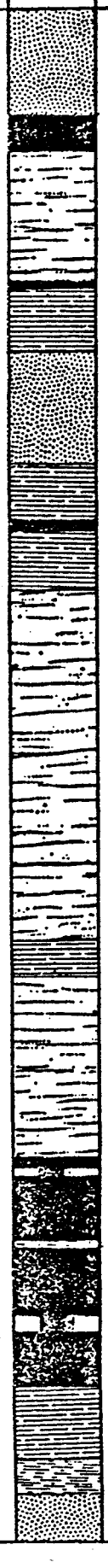
SEAM	THICKNESS	INT.
COTTON.	13.2	59.7
HIAW.	9.7	

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1150				BLACKHAWK FORMATION	1150 - 1173' INTERBEDS; Siltstone Mudstone					
1160										
1170					1173 - 1179' SANDSTONE					
1180					1179 - 1200 INTERBEDS; Mudstone Siltstone					
1190										
1200					1200 - 1206.5' SANDSTONE					
1210					1206.5 - 1219' INTERBEDS; Siltstone Mudstone					
1220					1219 - 1226.2 SANDSTONE					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM-88
PAGE 2 OF 3



DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1220				BLACKHAWK FORMATION	1219 - 1226.2' SANDSTONE					
					1226.2 - 1228.4' COAL; 2.2' UPPER BLIND CANYON					
1230					1228.4 - 1236' INTERBEDS, Mudstone, Siltstone					
					1236 - 1236.6' COAL; 0.6' UPPER BLIND CANYON					
					1236.6 - 1240' MUDSTONE					
1240					1240 - 1246.5' SANDSTONE					
					1246.5 - 1249.9' MUDSTONE					
1250					1249.9 - 1250.6' COAL; 0.7' BLIND CANYON					
					1250.6 - 1254' MUDSTONE					
					1254 - 1274.5' INTERBEDS; Sandstone Siltstone					
1260										
1270										
					1274.5 - 1276.5' MUDSTONE					
					1276.5 - 1287.3' INTERBEDS; Sandstone Siltstone					
1280										
					1287.3 - 1288' COAL; 0.7' COTTONWOOD					
1290					1288 - 1288.3' BONE COAL 0.3					
					1288.3 - 1292.3 COAL; 4.0' COTTONWOOD					
					1292.3 - 1292.6 CARB MUDSTONE 0.3					
					1292.6 - 1296.8 COAL; 4.2' COTTONWOOD					
					1296.8 - 1297.2 BONE COAL 0.4					
					1297.2 - 1300.8' COAL; 3.6' COTTONWOOD					
1300					1300.8 - 1305' MUDSTONE					
					1305 - 1307' SILTSTONE					
					1307' - 1324' SANDSTONE					
1310										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM-88
PAGE 3 OF 3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC	SAMPLE
1310				BLACKHAWK FORMATION	1307-1324' SANDSTONE					
1320										
					1324-1326.5 MUDSTONE					
					1326.5-1329 SANDSTONE					
1330					1329-1345' INTERBEDS; Sandstone Siltstone					
1340										
					1345-1359.5' INTERBEDS; Siltstone Carb Mudstone					
1350										
1360					1359.5-1369.2 COAL; 9.7' HIAWATHA					
1370				STAR POINT SANDSTONE	1369.2-1500' SANDSTONE; fine grained, well sorted STAR POINT SS					
1380										
1390										
1500					T.D. 1500'					

COAL SUMMARY

EM-89

Collar Elevation: 8888

Hole Depth: 1440

Strata	Depth In Hole-Tops	Elevation Tops	Thickness-Feet Rock	Thickness-Feet Coal	Seam
Coal	1072.4	7815.6		1.8	Upper Blind Canyon
Rock	1074.2	7813.8	3.4		
Coal	1077.6	7810.4		0.6	Upper Blind Canyon
Rock	1078.2	7809.8	12.3		
Coal	1090.5	7797.5		0.7	Blind Canyon
Rock	1091.2	7796.8	26.1		
Coal	1117.3	7770.7		1.5	Cottonwood
Rock	1118.8	7769.2	0.4		
Coal	1119.2	7768.8		6.2	Cottonwood
Rock	1125.4	7762.6	74.4		
Coal	1199.8	7688.2		0.7	
Rock	1200.5	7687.5	4.8		
Coal	1205.3	7682.7		1.1	
Rock	1206.4	7681.6	5.0		
Coal	1211.4	7676.6		9.0	Hiawatha
Rock	1220.4	7667.6			

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

Detailed log

PROJECT: EAST MOUNTAIN DRILL HOLE: EM-89

LOCATION: 1250' N; 700' E; SW) 33
COLLAR ELEV.: 8888
HOLE TYPE: PLUG
PLUG INTERVAL: 0-1440'
CORE INTERVAL: —
TOTAL DEPTH: 1440'
DATE: 21 OCT 1981
SCALE: 1" = 10'
GEOLOGIST: Semborski; Fry; Snider

GEOPHYSICAL DATA

LOG	FROM	TO
DENSITY:	1050	1300
H.R.D.:		
E. LOG:		
GAMMA:	1000	1300
CALIPER:		
S.P.:		
TEMP	360	1004

COAL SUMMARY:

SEAM	THICKNESS	INT.
COTTON	7.7 6.2	8/6
HIAW.	9.0	

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1000				BLACKHAWK FORMATION	1000-1002' SANDSTONE					
					1002-1010' INTERBEDS; Mudstone Siltstone					
1010					1010-1014.5' SANDSTONE					
					1014.5-1025.5' INTERBEDS; Siltstone Mudstone					
1020										
					1025.5-1036.5' SANDSTONE					
1030										
					1036.5-1072.4' INTERBEDS; Siltstone Mudstone					
1040										
1050										
1060										
1070										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM-39
PAGE 2 OF 3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1070				BLACKHAWK FORMATION	1072.4-1074.2' COAL; 1.8' UPPER BLIND CANYON					
					1074.2-1077.6' SILTSTONE; medium gray					
					1077.6-1078.2' COAL; 0.6' UPPER BLIND CANYON					
1080					1078.2-1090.5' SILTSTONE; medium gray					
1090					1090.5-1091.2' COAL; 0.7' BLIND CANYON					
					1091.2-1093.5' MUDSTONE; dark gray					
					1093.5-1102' INTERBEDS; Siltstone, med. gray; Mudstone, dark gray					
1100					1102-1104' MUDSTONE; dark gray, dense					
					1104-1117.3' SANDSTONE; light gray, fine grained, well sorted.					
1110										
					1117.3-1118.8' COAL; 1.5' COTTONWOOD					
1120					1118.8-1119.2' MUDSTONE; dark gray 0.4					
					1119.2-1125.4' COAL; 6.2' COTTONWOOD					
					1125.4-1128.5' MUDSTONE; dark gray,					
1130					1128.5-1187.5' SANDSTONE; light gray, fine grained, well sorted.					
1140										
1150										
1160										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MOUNTAIN
DRILL HOLE: EM-89
PAGE 3 OF 3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1160				BLACKHAWK FORMATION	1123.5-1187.5' SANDSTONE; see above					
1170										
1180										
1190					1187.5-1191' MUDSTONE					
					1191-1194.5' SILTSTONE					
					1194.5-1198' SANDSTONE					
					1198-1199.8' MUDSTONE					
1200					1199.8-1200.5' COAL; 0.7'					
					1200.5-1205.3' MUDSTONE					
					1205.3-1206.4' COAL; 1.1'					
					1206.4-1211.4 SILTSTONE					
1210					1211.4-1220.4 COAL; 9.0' HIAWATHA					
1220					1220.4-1222' MUDSTONE					
				STAR POINT SS	1222-1440' SANDSTONE, fine grained, well sorted. STAR POINT SS					
1230										
1240										
1440					T.D. 1440'					

COAL SUMMARY

EM-92

Collar Elevation: 8948.3

Hole Depth: 1460

Strata	Depth In Hole Tops	Elevation Tops	Thickness Feet Rock	Thickness Feet Coal	Seam
Coal	1230.2	7718.1		0.8	
Rock	1231.0	7717.3	2.7		
Coal	1233.7	7714.6		0.8	
Rock	1234.5	7713.8	14.8		
Coal	1249.3	7699.0		0.7	
Rock	1250.0	7698.3	23.4		
Coal	1273.4	7674.9		6.0	Upper Blind Canyon
Rock	1279.4	7668.9	3.9		
Coal	1283.3	7665.0		3.4	Blind Canyon
Bone Coal	1286.7	7661.6		0.4	Blind Canyon
Coal	1287.1	7661.2		3.3	Blind Canyon
Rock	1290.4	7657.9	0.4		
Coal	1290.8	7657.5		0.7	
Rock	1291.5	7656.8	12.3		
Coal	1303.8	7644.5		4.3	Cottonwood
Rock	1308.1	7640.2	0.7		
Coal	1308.8	7639.5		3.2	Cottonwood
Rock	1312.0	7636.3	50.8		
Coal	1362.8	7585.5		1.4	
Rock	1364.2	7584.1	9.1		
Coal	1373.3	7575.0		4.7	Hiawatha
Rock	1378.0	7570.3	0.2		
Bone Coal	1378.2	7570.1		0.8	Hiawatha
Rock	1379.0	7569.3	0.4		
Coal	1379.4	7568.9		3.8	Hiawatha
Rock	1383.2	7565.1			

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN
DRILL HOLE: EM-92
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DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1310				BLACK HAWK FORMATION	1309.8 - 1312' COAL; 3.2' COTTONWOOD					
					1312 - 1316' MUDSTONE, dense					
					1316 - 1350' SANDSTONE; Upward fining					
1320										
1330										
1340										
1350					1350 - 1351' CMS					
					1351 - 1357' SANDSTONE; Upward coarsening					
					1357 - 1362.8' MUDSTONE; silty, Upward coarsening w/ above sand					
1360					1362.8 - 1364.2 COAL; 1.4'					
					1364.2 - 1373.3' INTERBEDS; Sandstone, Mudstone, CMS					
1370					1373.3 - 1378' COAL; 4.7'. HIAWATHA					
					1378 - 1378.2' CMS 0.2'					
1380					1378.2 - 1379' BONE COAL; 0.8' HIAWATHA					
					1379 - 1379.4 CMS 0.4'					
				STAR POINT	1379.4 - 1383.2' COAL; 3.8' HIAWATHA					
					SANDSTONE; fg, well sorted					
1390										
					T.D. 1460'					
1400										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN
DRILL HOLE: EM-32
PAGE 2 OF 3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1220				BLACKHAWK FORMATION	1220 - 1230.2 INTERBEDS: Sandstone Siltstone					
1230					1230.2 - 1231' COAL; 0.8'					
					1231 - 1232.7 MUDSTONE; dense					
					1233.7 - 1234.5' COAL; 0.8'					
					1234.5 - 1239' MUDSTONE; dense					
1240					1239 - 1246' SANDSTONE;					
					1246 - 1249.3' SILTSTONE					
1250					1249.3 - 1250' COAL; 0.7'					
					1250 - 1256' SILTSTONE					
					1256 - 1269' SANDSTONE; Upward coarsening					
1260										
1270					1269 - 1272.4' SILTSTONE, carbonaceous lower 1/2					
					1272.4 - 1274.4' COAL; 6.0' UPPER BLIND CANYON					
1280					1278.4 - 1283.3' MUDSTONE, CMS [illegible]					
					1283.3 - 1286.7' COAL [illegible] Z-[illegible] CANYON					
					1286.7 - 1287.1' ZONE COAL; 0.4'					
1290					1287.1 - 1290.4 COAL; 3.3' BLIND CANYON					
					1290.4 - 1290.8' CMS					
					1290.8 - 1291.5 COAL; 0.7'					
					1291.5 - 1303.3' SANDSTONE; muddy top [illegible] case					
					1303.3 - 1304.1' COAL; 0.8' COTTONWOOD					
					1304.1 - 1305.3 CMS [illegible]					
					1305.3 - 1312' [illegible] 3.2' COTTONWOOD					

COAL LITHOLOGIC LOG
UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

Detailed Log

PROJECT: EAST MOUNTAIN DRILL HOLE: EM-92

LOCATION: 1650'S 2000'W; NE 32
COLLAR ELEV.: 8948.3
HOLE TYPE: PLUG
PLUG INTERVAL: 0-1460
CORE INTERVAL: —
TOTAL DEPTH: 1460
DATE: 3 SEPT 1982
SCALE: 1" = 10'
GEOLOGIST: WEBSTER : SNIDER

GEOPHYSICAL DATA

LOG	FROM	TO
DENSITY:	1150	1440
H.R.D.:	1150	1420
E. LOG:	1150	1447
GAMMA:	1150	1420
CALIPER:		
S.P.:		

COAL SUMMARY:

SEAM	THICKNESS	INT.
'ABC	6.0	
BC	7.1	3.9
COTT	8.2	12.4
HIAW	9.9	61.3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION from geolog	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1150				BLACKHAWK FORMATION	1150 - 1174' INTERBEDS; Siltstone Mudstone					
1160										
1170										
					1174 - 1190' MUDSTONE					
1190										
					1190 - 1200' INTERBEDS Siltstone Mudstone					
1200					1200 - 1216' SANDSTONE; silty top + base					
					1216 - 1220' MUDSTONE					

COAL SUMMARY

EM-93

Collar Elevation: 8964.7

Hole Depth: 1420

Strata	Depth In Hole Tops	Elevation Tops	Thickness Feet Rock	Thickness Feet Coal	Seam
Coal	1163.2	7801.5		0.8	
Rock	1164.0	7800.7	0.6		
Coal	1164.6	7800.1		1.0	
Rock	1165.6	7799.1	32.7		
Coal	1198.3	7766.4		4.8	Upper Blind Canyon
Rock	1203.1	7761.6	7.0		
Coal	1210.1	7754.6		1.9	Blind Canyon
Bone Coal	1212.0	7752.7		0.5	Blind Canyon
Coal	1212.5	7752.2		0.7	Blind Canyon
Bone Coal	1213.2	7751.5		0.3	Blind Canyon
Coal	1213.5	7751.2		2.8	Blind Canyon
Rock	1216.3	7748.4	13.6		
Coal	1229.9	7734.8		3.5	Cottonwood
Rock	1233.4	7731.3	83.8		
Coal	1317.2	7647.5		1.3	
Rock	1318.5	7646.2	4.8		
Coal	1323.3	7641.4		2.3	Hiawatha
Bone Coal	1325.6	7639.1		0.2	Hiawatha
Coal	1325.8	7638.9		1.7	Hiawatha
Rock	1327.5	7637.2	1.2		
Bone Coal	1328.7	7636.0		1.5	Hiawatha
Rock	1330.2	7634.5			

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

Detailed log

PROJECT: EAST MOUNTAIN DRILL HOLE: EM-93

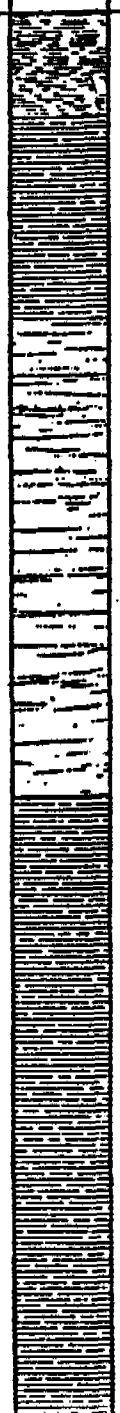
LOCATION: 1700'S, 700'E; NW 33
COLLAR ELEV.: 8916.7'
HOLE TYPE: PLUG
PLUG INTERVAL: 0-1420
CORE INTERVAL: —
TOTAL DEPTH: 1420
DATE: 27 AUG 1982
SCALE: 1" = 10'
GEOLOGIST: WEBSTER; SNIDER

GEOPHYSICAL DATA

LOG	FROM	TO
DENSITY:	1075	1375
H.R.D.:	1125	1350
E. LOG:	1075	1375
GAMMA:	1000	1350
CALIPER:		
S.P.:		

COAL SUMMARY:

SEAM	THICKNESS	INT.
UGC	4.8	
BC	6.2	7.0
COT	3.5	13.6
HIAW	4.2	99.9

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1000				BLACKHAWK FORMATION	? – 1005' SILTSTONE; lt brown, minor clay					
					1005-1015' MUDSTONE; med gray					
1010										
					1015 - 1030 INTERBEDS; Siltstone, MS, CMS					
1020										
					1033 - 1070 MUDSTONE; lt gray CMS zones					
1030										
1040										
1050										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY
DEPT. OF MINING & EXPLORATION

PROJECT: EAST MT.
DRILL HOLE: EM-93
PAGE 2 OF 5

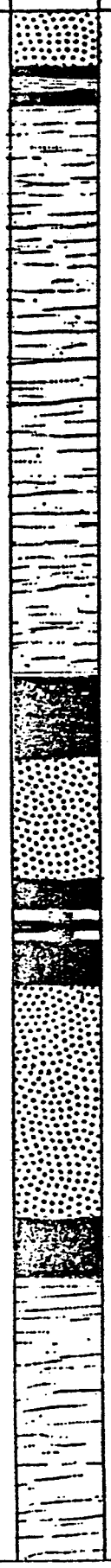
DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1070					1070 - 1090' SANDSTONE ; lt gray, V fine grnd.					
1090				BLACKHAWK	1090 - 1136' INTERBEDS ; SS, Vfg (60%) Sltst (30%) lt brown					
					1136 - 1155' SILTSTONE					
					1155 - 1163.2' SANDSTONE. VFG w/ some silty at top					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN
DRILL HOLE: EM-93
PAGE 3 OF 5

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1160				BLACKHAWK	1163.2-1164' COAL; 0.3' 1164-1164.6' SILTSTONE 1164.6-1165.6' COAL; 1.0' 1165.6-1180' INTERBEDS; Siltstone (70%) Mudstone (30%)					
1170										
1180					1180-1198.3' INTERBEDS; Sandstone Siltstone					
1190										
1200					1198.3-1203.1' COAL; 4.8' UPPER BLIND CANYON 1203.1-1210.1' SANDSTONE; coal rip-ups? at base					
1210					1210.1-1212' COAL; 1.9' BLIND CANYON 1212-1212.5' BONE COAL; 0.5' 1212.5-1213.2' COAL; 0.7' 1213.2-1213.5' BONE COAL; 0.3' 1213.5-1216.3' COAL; 2.8'					
1220					1216.3-1229.9' SANDSTONE; muddy zones					
1230					1229.9-1233.4' COAL; 3.5' COTTONWOOD 1233.4-1310' INTERBEDS: Siltstone (80%) Mudstone (20%) light brown to gray					
1240										
1250										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN
DRILL HOLE: EM-93
PAGE 4 OF 5

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1250				BLACKHAWK	1233.4 - 1310' INTERBEDS; Siltstone (80%) Mudstone (20%) light brown to gray					
1260										
1270										
1280										
1290										
1300										
1310					1310 - 1317.2' SANDSTONE; VF to silt above					
					1317.2 - 1318.5' COAL; 1.3'					
1320					1318.5 - 1323.3' SANDSTONE silty					
					1323.3 - 1325.6' COAL; 2.3' HIAWATHA					
					1325.6 - 1325.8' BONE COAL; 0.2'					
					1325.8 - 1327.5' COAL; 1.7' HIAWATHA					
					1327.5 - 1328.7' MUDSTONE; 1.2'					
					1328.7 - 1330.2' COAL; 1.5' HIAWATHA					
				STAR POINT	1330.2 - 1420 ? SANDSTONE; light gray, fine grained well sorted					
1340										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN
DRILL HOLE: EM-93
PAGE 5 OF 5

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1340				STAR POINT	1330.2 - 1420' SANDSTONE; light gray, fine grnd, well sorted					
1350										
1360										
1420										

COAL SUMMARY

EM-94C

COLLAR ELEVATION: 8,952.0
HOLE DEPTH: 1,360.0

LITHOLOGY	DEPTH IN HOLE-TOPS	ELEVATION TOPS	THICKNESS - FEET ROCK	COAL	SEAM
COAL	1,185.2	7,766.8		2.6	UPPER B.C.
ROCK	1,187.8	7,764.2	0.8		
COAL	1,188.6	7,763.4		1.1	BLIND CANYON
ROCK	1,189.7	7,762.3	39.8		
COAL	1,229.5	7,722.5		1.1	COTTONWOOD
BONE	1,230.6	7,721.4		0.3	COTTONWOOD
COAL	1,230.9	7,721.1		8.1	COTTONWOOD
ROCK	1,239.0	7,713.0	80.2		
BONE	1,319.2	7,632.8		0.2	
ROCK	1,319.4	7,632.6	0.1		
COAL	1,319.5	7,632.5		1.2	
ROCK	1,320.7	7,631.3	3.3		
COAL	1,324.0	7,628.0		6.1	HIAWATHA
BONE	1,330.1	7,621.9		0.3	HIAWATHA
COAL	1,330.4	7,621.6		3.2	HIAWATHA
ROCK	1,333.6	7,618.4	0.7		
COAL	1,334.3	7,617.7		0.3	HIAWATHA
ROCK	1,334.6	7,617.4			

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

Detailed log

PROJECT: EAST MOUNTAIN DRILL HOLE: EM-94C

LOCATION: 1275'N, 800'W; SE 32
COLLAR ELEV.: 8958.1'
HOLE TYPE: PLUG / CORE
PLUG INTERVAL: 0-1195'
CORE INTERVAL: 1185-1360'
TOTAL DEPTH: 1360
DATE: 30 AUG 1982
SCALE: 1" = 10'
GEOLOGIST: Webster; Fry; Snider

GEOPHYSICAL DATA

LOG	FROM	TO
DENSITY:	1100	1355
H.R.D.:	1100	1355
E. LOG:	1100	1355
GAMMA:	1100	1355
CALIPER:		
S.P.:		

COAL SUMMARY:

SEAM	THICKNESS	INT.
UBC	2.6	
BC	1.1	0.3
COTT	9.5	33.3
HIAW	9.6	95.0

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1100				BLACKHAWK FORMATION	1100 - 1107.5' MUDSTONE, gray					
					1107.5 - 1115' SANDSTONE					
1110					1115 - 1140' MUDSTONE; some CMS dk gray, minor coal (<10%)					
1120										
1130										
1140					1140 - 1150' INTERBEDDED Sandstone, fg (70%), Siltstone, (30%)					
1150					1150 - 1179.1 INTERBEDDED; Mudstone Siltstone					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN
DRILL HOLE: EM-94C
PAGE 2 OF 3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1170					1150 - 1179.9 SILTSTONE see above					
1180					1179.9 - 1180.7' CMS 1180.7 - 1185.2 MUDSTONE					
					1185.2 - 1187.9' COAL; 2.6' UPPER BLIND CAN. 1187.9 - 1190.4 MUDSTONE 1190.4 - 1191.5 COAL: 1.1' BLIND CANYON		1			
1190					1191.5 - 1205' SILTSTONE; CMS at base	85	2 3	1	100	
1200				BLACKHAWK FORMATION	1205' - 1223.5' INTERBEDS: Siltstone, sandy CMS	96	4 5 6	2	100	
1220					1223.5 - 1230.0' COAL: 1.1' COTTONWOOD 1230.0 - 1230.1' ZONE COAL: 0.2' 1230.1 - 1239.0' COAL: 8.1' COTTONWOOD	97	7 8	3	100	
1240					1239.0 - 1243.5' MUDSTONE, [illegible]		9			
1250					1243.5 - 1273.5' SANDSTONE; lt gray, fine to med grained, arenitic, massive, UFS erosional base w/ MS rip-ups	96	10 11	4	100	

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN
DRILL HOLE: EM-92C
PAGE 3 OF 3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1270				BLACKHAWK FORMATION	1243.5 - 1273.0' SANDSTONE; as above	96	11	4	100	
						94	12	5	100	
					1273.0 - 1275.0' INTERBEDS: SS, Sltst, rooted, bioturbated		13			
1280					1275 - 1288.5' SANDSTONE; lt gray, fine to med grnd, UFS; erosional base w/MS rip-ups		14			
1290					1288.5 - 1296' SANDSTONE; lt gray, fine to med grnd, UFS; sharp erosional base	91	15	6	[illegible]	
					1296 - 1302.5' MUDSTONE; dk gray, more carbonaceous toward base; thin coal at base 0.7'		16			
					1302.5 - 1319.2' MUDSTONE; lt gray, silty, non bioturbated, rooted	83	17	7	100	
					1319.2 - 1319.4' BONE COAL; 0.2'		18			
					1319.4 - 1319.5' MUDSTONE; 0.1'					
					1319.5 - 1322.7' COAL; 1.2' HIAWATHA	97	20	3	100	
					1320.7 - 1324.0' MUDSTONE; 2.3'					
					1324 - 1330.1' COAL; 6.1' HIAWATHA					
					1330.1 - 1330.4' BONE COAL; 0.3'					
					1330.4 - 1332.6' COAL; 2.2' HIAWATHA					
					1332.6 - 1334.3' MUDSTONE; 0.7'					
					1334.3 - 1334.6' BONE COAL; 0.3'		21			
				STONE POINT SANDSTONE	1334.6 - 1359.9 SANDSTONE; lt gray, fine [illegible]		22			
					1359.9 - 1360' SILTSTONE; muddy	100	23	9	100	

COAL SUMMARY

EM-97

COLLAR ELEVATION: 8,952.1
HOLE DEPTH: 1,380.0

LITHOLOGY	DEPTH IN HOLE-TOPS	ELEVATION TOPS	THICKNESS - FEET ROCK	COAL	SEAM
COAL	1,174.3	7,777.8		3.9	UPPER B.C.
ROCK	1,178.2	7,773.9	11.5		
COAL	1,189.7	7,762.4		1.3	UPPER B.C.
ROCK	1,191.0	7,761.1	14.2		
COAL	1,205.2	7,746.9		1.9	BLIND CANYON
ROCK	1,207.1	7,745.0	12.2		
COAL	1,219.3	7,732.8		4.7	COTTONWOOD
ROCK	1,224.0	7,728.1	78.3		
COAL	1,302.3	7,649.8		1.5	
ROCK	1,303.8	7,648.3	6.7		
COAL	1,310.5	7,641.6		4.1	HIAWATHA
BONE	1,314.6	7,637.5		0.4	HIAWATHA
COAL	1,315.0	7,637.1		0.5	HIAWATHA
BONE	1,315.5	7,636.6		0.3	HIAWATHA
COAL	1,315.8	7,636.3		0.6	HIAWATHA
ROCK	1,316.4	7,635.7		0.4	HIAWATHA
COAL	1,316.8	7,635.3		2.9	HIAWATHA
BONE	1,319.7	7,632.4			

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

Detailed log

PROJECT: EAST MOUNTAIN DRILL HOLE: EM-97

LOCATION: 2450'S, 600'E; NW33
COLLAR ELEV.: 8950 (est)
HOLE TYPE: PLUG
PLUG INTERVAL: 0 - 1380
CORE INTERVAL: —
TOTAL DEPTH: 1390
DATE: 26 SEPT 82
SCALE: 1" = 10'
GEOLOGIST: Webster · Snider

GEOPHYSICAL DATA

LOG	FROM	TO
DENSITY:	1100	1360
H.R.D.:	1100	1360
E. LOG:	1100	1360
GAMMA:	1100	1360
CALIPER:		
S.P.:		

COAL SUMMARY:

SEAM	THICKNESS	INT.
UBC	3.9	11.5
UBC	1.3	14.2
BC	1.9	12.2
COT	4.7	86.5
HIAW	2.2	

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1100				BLACKHAWK FORMATION	1100-1105: SANDSTONE; lt gray, v fine grnd.					
					1105-1137' INTERBEDS; Mudstone (70%) Siltstone (30%) gray black to lt brown					
1137					1137-1138.5' COAL: dk gray to black					
1138					1138.5-1152' SANDSTONE;					
1152					1152-1172' SANDSTONE; fine grnd.					

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN
DRILL HOLE: EM-27
PAGE 2 OF 3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC	SAMPLE
1170					1152-1172' SANDSTONE;					
					1172-1174.3' CMS - MUDSTONE;					
					1174.3-1178.2' COAL; 3.9' UPPER BLIND CANYON					
1180					1178.2-1189.7' INTERBEDS; Mudstone Siltstone					
1190					1189.7-1191' COAL; 1.3' UPPER 3C					
					1191-1205.2' INTERBEDS; Mudstone Siltstone Carb MS					
1200					1205.2-1207.1' COAL; 1.9' BLIND CANYON					
					1207.1-1219.3' INTERBEDS; Mudstone Siltstone					
1210				FORMATION	1219.3-1224' COAL; 4.7' COTTONWOOD					
					1224-1226' CMS					
					1226-1237' SILTSTONE [illegible] w/ [illegible] and [illegible]					
1220										
					1237-1276.3' SANDSTONE; [illegible] sequences. [illegible] at base					
1230										
1240										
1250										
1260										

COAL LITHOLOGIC LOG

UTAH POWER & LIGHT COMPANY

DEPT. OF MINING & EXPLORATION

PROJECT: EAST MTN!
DRILL HOLE: EM-97
PAGE 3 OF 3

DEPTH	PLUG	CORE	GRAPHIC LOG	FORMATION NAME	LITHOLOGIC DESCRIPTION	R.Q.D.	BOX NO.	RUN NO.	% REC.	SAMPLE
1260					1237 - 1276.5 SANDSTONE; see above					
1270										
1280					1276.5-1302.3' INTERBEDS; Mudstone Siltstone					
1290										
1300				BLACKHAWK	1302.3-1303.8' COAL; 1.5'					
					1303.8-1310.5' INTERBEDS: Mudstone Siltstone					
1310					1310.5-1314.6' COAL; 4.1' HIAWATHA					
					1314.6-1315' BONE COAL; 0.4'					
					1315-1315.5' COAL; 0.5'					
					1315.5-1315.8' BONE COAL; 0.3'					
1320					1315.8-1316.4 COAL; 0.6'					
					1316.4-1316.8 BONE COAL; 0.4'					
					1316.8-1319.7 COAL; 2.9'					
					1319.7-1333.5' SANDSTONE; abandoned dist. channel					
1330										
				STAR POINT	1333.5-1340' SANDSTONE - lt gray, fine grained					
1340					STAR POINT					

SOUTH LEASE JOINT STUDY

JOINT NO.	AREA	ORIENTATION STRIKE	DIP		CONTINUITY STRIKE	DIP	SPACING	MOISTURE
12	1	1	90	E	3	3	2	1
36	1	3	86	E	3	10	1	1
1	1	5	87	E	10	10	10	1
56	1	5	89	E	10	10	1.5	1
25	1	8	82	W	5	5	2	1
39	1	17	89	E	3	3	2	1
57	1	57	83	E		3	1	1
58	1	60	86	E		8	10	1
35	1	63	85	E		2	4	1
37	1	70	87	E	10	15	2	1
45	1	72	87	E	5	5	2	1
28	1	76	90	E	5	5	2	1
47	1	76	89	E	4	4	3	1
22	1	77	88	E	10	6	3	1
17	1	78	77	E	10	20	3	1
10	1	80	68	E	15	8	1	1
34	1	80	77	E	40	10	3	1
42	1	83	83	E	3	8	4	1
55	1	87	87	E	3	4	3	1
32	1	89	88	E	5	10	3	1
53	1	273	90	W	3	1	2	1
7	1	274	79	W	10	10	3	1
8	1	274	78	W	10	10	10	1
38	1	274	84	W	10	20	0.5	1
5	1	280	85	W		10	15	1
44	1	280	88	W	3	10	3	1
11	1	285	82	W	20	15	5	1
19	1	286	72	W	10	10	5	1
26	1	288	80	E	20	20	25	1
31	1	292	77	W	15	10	8	1
15	1	294	88	W	30	30	3	1
2	1	296	88	W	10	10	10	1
14	1	298	88	W	15	10	3	1
27	1	299	71	W	15	15	8	1
24	1	319	86	W	30	30	15	1
51	1	327	88	W	10	10		1
46	1	340	90	E	8		3	1
30	1	345	85	W	15	10	2	1
29	1	348	90	E	5	5	2	1
52	1	348	90	E	3	4	1	1
16	1	350	90	E		30	3	1
33	1	350	88	E	20	20	6	1
41	1	351	90	E	5	5	2	1
13	1	351	90	E	8	8	5	1
59	1	352	89	W	30	8		1
54	1	353	87	W	5	5	2	1
47	1	353	61	E	5	8	10	1
21	1	354	87	W	3	3	1	1
9	1	354	90	E	3	10	1	1
4	1	355	90	E	20	50	7	1
50	1	355	90	E	10	15	3	1
40	1	355	90	E	3	3	1	1

AREA 1

0-10	5
11-20	1
21-30	0
31-40	0
41-50	0
51-60	2
61-70	2
71-80	7
81-90	3
270-280	6
281-290	3
291-300	5
301-310	0
311-320	1
321-330	1
331-340	1
341-350	5
351-360	17

SOUTH LEASE JOINT STUDY

JOINT NO.	AREA	ORIENTATION STRIKE	ORIENTATION DIP		CONTINUITY STRIKE	CONTINUITY DIP	SPACING	MOISTURE
23	1	355	90	E	8	4	1	1
6	1	357	89	E	5	5	3	1
20	1	357	89	W	5	5	3	1
48	1	357	83	E	5	4	3	1
43	1	357	88	W	10	15	5	1
3	1	358	85	E	20	20	3	1
18	1	358	85	E	15	8	4	1
101	2	5	85	E	5	5	1	1
97	2	6	90	E	5	5	30	1
61	2	22	82	E	30	20	8	1
75	2	30	71	E	70	60	99	1
79	2	30	90	W	10	20	50	1
96	2	40	87	E	5	5	99	1
94	2	40	90	E	20	20	10	1
66	2	45	75	E	30	10	15	1
99	2	50	80	E	20	30	20	1
92	2	60	90	W	25	20	20	1
74	2	60	90	E	10	30	15	1
91	2	60	90	W	10	5	1	1
83	2	60	80	W	60	40	20	1
63	2	60	80	W	20	20	5	1
68	2	65	90	W	70	90	30	1
95	2	70	85	W	5	10	99	1
85	2	70	80	W	20	20	50	1
80	2	75	87	W	30	20	20	1
60	2	76	87	W	20	15	30	1
81	2	80	77	W	90	80	40	1
105	2	80	77	E	10	30	99	1
70	2	80	90	E	99	60	25	1
78	2	271	90	W	20	10	40	1
107	2	280	90	E	10	5	20	1
106	2	280	90	W	20	20	20	1
89	2	280	82	E	10	30	25	1
109	2	280	72	E	15	30	20	1
76	2	290	77	E	10	5	15	1
67	2	290	75	E	30	60	30	1
84	2	293	85	E	99	60	5	1
82	2	295	82	E	99	80	30	1
77	2	295	62	E	99	70	30	1
64	2	295	90	W	99	40	20	1
111	2	300	85	E	10	30	20	1
86	2	310	75	E	40	30	20	1
72	2	315	86	E	10	10	5	1
98	2	320	65	E	30	20	15	1
100	2	330	85	E	15	10	99	1
69	2	335	76	W	90	60	10	1
65	2	335	86	E	60	20	10	1
87	2	340	50	E	99	60	99	1
102	2	345	80	E	40	60	50	1
62	2	345	70	E	60	20	15	1
90	2	350	90	E	15	10	5	1
103	2	350	77	E	60	30	10	1

Area 2

1-10	2
11-20	0
21-30	3
31-40	2
41-50	2
51-60	5
61-70	3
71-80	5
81-90	0
271-280	5
281-290	2
291-300	5
301-310	1
311-320	2
321-330	1
331-340	3
341-350	6
351-360	5

SOUTH LEASE JOINT STUDY

JOINT NO.	AREA	ORIENTATION STRIKE	ORIENTATION DIP		CONTINUITY STRIKE	CONTINUITY DIP	SPACING	MOISTURE
104	2	350	76	E	50	60	10	1
71	2	350	90	E	70	30	30	1
110	2	354	86	E	20	30	5	1
108	2	355	90	W	10	10	5	1
93	2	355	65	E	10	15	99	1
88	2	355	81	E	20	40	3	1
73	2	357	87	E	30	30	30	1
156	3	6	90	W	2	2	0.5	1
112	3	6	90	W	20	10	5	1
137	3	6	90	W	5	3	2	1
147	3	14	82	E	8	15	30	1
144	3	24	90	W	20	6	2	1
113	3	24	90	E	25	3	8	1
136	3	25	84	E	20	20	2	1
132	3	30	59	E	15	8	4	1
141	3	30	83	E	5	3	3	1
149	3	37	86	E	10	10	5	1
148	3	37	86	E	10	2	1	1
138	3	38	78	E	20	5	3	1
118	3	44	89	E	3	3	5	1
114	3	50	90	W	10	3	4	1
162	3	50	90	E	4	4	2	1
135	3	50	75	E	40	12	10	1
155	3	52	85	E	15	8	6	1
154	3	60	82	W	10	8	5	1
142	3	60	81	E	1	1	0.3	1
164	3	60	87	W	5	8	2	1
151	3	62	88	W	3	5	2	1
161	3	62	87	W	5	3	2	1
125	3	63	90	W	1	1	2	1
127	3	64	82	E	10	6	6	1
126	3	64	82	E	4	4	5	1
129	3	67	76	E	10	3	2	1
116	3	68	87	W	4	3	3	1
158	3	72	82	E	10	6	2	1
134	3	75	87	E		99	99	1
159	3	75	87	E	5	15	15	1
133	3	78	84	E		20	99	1
117	3	78	90	W	5	3		1
121	3	80	86	W	75	5	8	1
153	3	83	71	E	5	5	1	1
139	3	84	90	E	3	4	5	1
119	3	87	81	E	99	20	30	1
123	3	89	90	E	3	5	50	1
145	3	89	90	E	8	4	4	1
160	3	274	81	W	10	6	4	1
163	3	286	71	W	40	8	8	1
165	3	290	76	W	99	20	4	1
128	3	293	74	W	60	25	2	1
146	3	305	83	W	10	7	1	1
131	3	306	90	E	12	8	20	1
150	3	306	88	E	6	15	15	1

Area 3

1-10	3
11-20	1
21-30	5
31-40	3
41-50	4
51-60	4
61-70	7
71-80	6
81-90	5
271-280	1
281-290	2
291-300	1
301-310	3
311-320	1
321-330	1
331-340	3
341-350	1
351-360	3

SOUTH LEASE JOINT STUDY

JOINT NO.	AREA	ORIENTATION STRIKE	ORIENTATION DIP		CONTINUITY STRIKE	CONTINUITY DIP	SPACING	MOISTURE
157	3	315	67	W	15	8	1	1
152	3	323	88	W	15	20	10	1
122	3	333	90	W	10	1	2	1
130	3	333	85	E	2	3	10	1
115	3	336	77	E	15	3	4	1
120	3	348	90	E	3	3	1	1
140	3	354	85	E	2	3	3	1
143	3	354	90	E	1	1	1	1
124	3	359	80	E	10	12	1	1
232	4	1	81	E	5	5	5	1
205	4	2	90	E	8	4	10	1
210	4	3	90	E	20		15	1
195	4	4	90	W	3	2	1	1
226	4	9	90	W	2	1	6	1
170	4	24	90	E	10	20	4	1
175	4	24	90	W	20	15	20	1
182	4	25	90	E	8	3	3	1
199	4	26	90	W	5	2	4	1
171	4	27	85	E	10	20	2	1
190	4	30	90	W	20	30	15	1
193	4	30	90	W	10	8	8	1
169	4	30	90	W	20	50	20	1
178	4	33	90	E	5	8	10	1
233	4	34	86	E	6	6	5	1
218	4	35	90	E	15	6	2	1
185	4	36	90	E	8	4	15	1
224	4	36	90	W	8		5	1
221	4	40	90	W	6	6	5	1
183	4	40	90	W	25	6	10	1
173	4	47	90	W	8	3		1
220	4	50	90	W	8	5	2	1
198	4	52	90	W	10	2	3	1
219	4	52	90	E	8	8	5	1
191	4	60	90	W	20	30		1
215	4	63	90	W	15	2	5	1
196	4	63	90	E	10	6	4	1
230	4	63	90	E	10	5	3	1
202	4	65	90	W	5		3	1
176	4	70	90	W	10	1	4	1
180	4	70	80	E	99	99	5	1
231	4	70	90	W	5	5	4	1
208	4	71	90	W	4	4	15	1
209	4	72	90	E	10	5	5	1
197	4	73	87	E	30	20	10	1
223	4	73	80	E	10	5	5	1
204	4	75	90	W	15	[illegible]	20	1
201	4	78	87	E	30	99	10	1
211	4	81	79	E	30	50	10	1
209	4	82	90	W	4	2	4	1
177	4	87	90	W	20	15	3	1
206	4	87	90	W	5	4	3	1
213	4	274	80	E	20	4	5	1

Area 4

1-10	5
11-20	0
21-30	8
31-40	7
41-50	2
51-60	3
61-70	7
71-80	6
81-90	4
270-280	2
281-290	0
291-300	4
301-310	2
311-320	6
321-330	3
331-340	5
341-350	2
351-360	2

SOUTH LEASE JOINT STUDY

JOINT NO.	AREA	ORIENTATION STRIKE	DIP		CONTINUITY STRIKE	DIP	SPACING	MOISTURE
187	4	280	90	W	20	10	3	1
234	4	295	84	W	5	4	3	1
225	4	299	83	W	25	8	15	1
166	4	300	35	W	99	30	30	1
167	4	300	85	W	50	30	30	1
192	4	304	90	E	10	8	8	1
212	4	308	90	W	10	3	2	1
168	4	313	85	W	50	50	20	1
184	4	315	85	W	8	4	10	1
186	4	315	90	E	10	4	5	1
194	4	315	90	E	20	3	5	1
172	4	318	90	E	10	3	6	1
189	4	320	90	E	40	30	10	1
227	4	325	90	E	4	1	2	1
181	4	325	90	W	20	20	15	1
216	4	329	90	W	6	2	4	1
217	4	335	90	E	6	4	3	1
207	4	336	90	E	15	5	8	1
223	4	338	90	E	10	3	6	1
188	4	340	90	W	4	4	3	1
222	4	340	90	E	10	6	3	1
174	4	345	90	E	5	3	1	1
229	4	350	90	W	3	4	6	1
200	4	352	90	E	3	2	2	1
214	4	354	90	E	5	5	8	1
179	4	354	87	E	2	5	0.5	1
239	5	10	75	W	15	30	5	1
255	5	12	90	W	5	10	4	1
263	5	12	58	W	15	15	15	1
260	5	20	90	W	10	12	5	1
253	5	28	90	W	10	20	15	1
262	5	28	90	E	99	10	50	1
257	5	30	90	E	40	20	20	1
236	5	30	90	E	5	15	1	1
252	5	35	82	W	5	10	12	1
246	5	35	90	W	12	10	4	1
240	5	36	90	W	20	15	5	1
237	5	45	79	W	30	20	1	1
249	5	50	81	E	10	15		1
238	5	84	90	E	3	10	8	1
243	5	85	79	E	4	5	3	1
264	5	275	85	E	15	15	3	1
241	5	278	82	W	5	5	3	1
247	5	282	90	E	5	5	5	1
245	5	284	90	E	20	10	8	1
251	5	290	73	W	10	15	15	1
254	5	291	87	W	15	15	10	1
248	5	295	80	W	10	6	4	1
250	5	308	84	W	15	15	3	1
256	5	315	77	W	20	15	10	1
258	5	320	61	W	15	10	20	1
259	5	330	76	W	25	15	10	1

Area 5

1-10 1
11-20 3
21-30 4
31-40 3
41-50 2
51-60 1
61-70 0
71-80 0
81-90 2
271-280 2
281-290 3
291-300 2
301-310 1
311-320 2
321-330 1
331-340 2
341-350 1
351-360 1

SOUTH LEASE JOINT STUDY

JOINT NO.	AREA	ORIENTATION STRIKE	ORIENTATION DIP		CONTINUITY STRIKE	CONTINUITY DIP	SPACING	MOISTURE
261	5	335	80	W	10	10		1
235	5	337	75	W	10	20	10	1
242	5	341	73	W	15	30	20	1
244	5	352	63	W	4	5	3	1
277	6	11	90	W	5	10	2	1
271	6	15	80	W	10	15	15	1
282	6	18	90	E	4	2	2	1
283	6	20	90	W	50	60	4	1
267	6	21	90	W	15	15	4	1
280	6	25	90	W	4	4	1	1
287	6	25	90	E	1	1	1	1
265	6	25	90	W	5	10	5	1
269	6	26	89	W	15	10	10	1
276	6	29	81	E	5	10	15	1
285	6	30	90	E	10	10	5	1
270	6	40	90	W	10	30	10	1
273	6	60	90	E	1	2	2	1
279	6	82	80	E	20	40	8	1
281	6	82	68	E	10	10	3	1
275	6	86	68	E	10	3	2	1
286	6	88	90	W	3	2	1	1
288	6	275	83	W	3	3	1	1
284	6	282	78	W	15	20	10	1
266	6	284	90	E	5	10	4	1
278	6	285	69	W	10	20	2	1
268	6	308	74	W	15	15	5	1
272	6	348	78	W	30	15	15	1
274	6	352	90	E	5	4	1	1

Area 6

1-10	6
11-20	4
21-30	7
31-40	1
41-50	0
51-60	1
61-70	0
71-80	0
81-90	4
271-280	1
281-290	3
291-300	0
301-310	1
311-320	0
321-330	0
331-340	0
341-350	1
351-360	1

CASTLEGATE SANDSTONE CLIFF STABILITY

Prepared by

Utah Power & Light Co.
Mining Division

November 1987

CASTLEGATE SANDSTONE CLIFF STABILITY STUDY

Utah Power & Light Company's East Mountain property is surrounded on all sides by a prominent cliff formed by the massive and resistive Castlegate Sandstone Member of the Mesa Verde Group. Where this cliff has been undermined in the extraction of the coal, it has been demonstrated that the stability of the cliff can be affected. In order to evaluate the possible impacts that underground coal mining might have on the cliffs, two semi-independent studies of the cliff stability were initiated. This report summarizes the findings of one of the studies. Findings of the second study, which is being completed by Seegmiller International, Inc., will be reported separately.

DATA COLLECTION

The Castlegate Sandstone is a very competent, massive unit. Therefore, where it is exposed on outcrop, it yields to stress only along joints within the rock. This is unlike other formations which crop out on East Mountain such as the North Horn formation which yields to stress through plastic deformation. Because the joints play an important part in the way that stress is relieved in the Castlegate Sandstone, it was important to map the nature of the joints which are present in the cliff surrounding the southern end of East Mountain.

The joints within the Castlegate Sandstone cliff were mapped in detail. The mapping included measuring the location, strike, and dip of the joints as well as their spacing and continuity, both horizontally and vertically. A total of 288 joints was mapped on the cliff. The majority of the mapping was completed by Messrs. Charles Semborski and Kurt Snider. Every effort was made to obtain a statistically random sampling of the joints present. It is important to point out that the joints which are perpendicular to the cliff are easier to recognize than those which are parallel to the cliff. Special attention was given to identification of all joints, even those of a subtle nature, because of their orientation with respect to the cliff. The raw data collected was also supplied to Seegmiller International for use in its study.

In addition to the field mapping low level aerial stereo photographs were inspected to augment the mapping, and helicopter reconnaissance was conducted to gain an overall understanding of the cliff's stability in both the pre-mining and post-mining condition. Dr. Ben Seegmiller was also present during the helicopter reconnaissance.

DATA INTERPRETATION

The important factors which influence the stability of the Castlegate Sandstone cliff include the stratigraphy of the sandstone itself, topography, orientation of the joints in respect to the escarpment, and the stability of the subsurface material which includes the presence of burned coal or underground mine workings. All of these factors have been included in this interpretation.

Stratigraphy

The Castlegate Sandstone is the upper member of the Mesa Verde Group and overlies the Blackhawk Member unconformably. Within the study area its lower contact is gradational and variable. The thickness of the Castlegate Sandstone is variable and ranges from 260 feet to 380 feet within the study area. This unit is comprised predominantly of medium to fine-grained moderately sorted sandstone having trough cross stratification interbedded with thin, lenticular, discontinuous beds of pebble conglomerate and mudstone. The entire sequence was deposited in a braided stream environment so that none of the individual units is continuous. However, the predominance of sandstone allows for several troughs to be deposited in succession to form what appears from a distance to be a massive unit.

The presence of the thin lenticular beds of mudstone within the Castlegate Sandstone appears to play an important role in the stability of the cliff. Cliff exposure and drill hole data were inspected to identify the distribution of mudstone units within the Castlegate Sandstone. It was determined that the mudstone beds are more prevalent on the east side of East Mountain in Newberry Canyon than on the west side in Miller Canyon. The mudstone beds present in Newberry Canyon are located 80 to 120 feet down from the top of the Castlegate Sandstone and are eight to 15 feet in thickness. On outcrop they appear to continue for distances of up to one-fourth of a mile. In Miller Canyon the mudstone beds are much less prevalent than to the east, and they are less continuous laterally. In some locations within the Castlegate Sandstone no mudstone beds could be identified. The impact of the mudstone beds on cliff stability will be discussed later in the report.

Joints

The strata present on East Mountain contain joints or natural fractures induced by tectonic stresses to which they are subject. Normally, joints are found as sets of two fractures at nearly right angles to each other. Most of the joints are vertical or near vertical and extend from well below the coal seams through the Flagstaff Limestone present on the highest portions of the plateau. These joints form natural planes of weakness in the Castlegate Sandstone whereby blocks of the sandstone can move vertically or settle near the outcrop. In order to better understand the direction the joints were trending throughout the study area, the strikes of the joints were plotted as rose diagrams (see Attachment 1). Rose diagrams, as well as a composite diagram representing all of the 288 joint measurements taken along the escarpment, for five different areas along the escarpment have been made.

On the north side of Newberry Canyon (Area 1) the most common joint trend measured is N 10 W with a complementary trend of N 80 E. The escarpment is roughly parallel to the N 80 E trend, and much of the failure in that region appears to have occurred by the spalling of slabs of sandstone located between the joint system and the escarpment. The south side of Newberry Canyon (Area 2) shows the same joint trend in addition to several other joints which trend from N 70 W to N 60 E. It may be that the additional joint sets were also present to the north but were not identified due to the orientation of the escarpment.

Moving in a clockwise direction around the escarpment from Newberry Canyon toward Miller Canyon (Area 6) it appears that the primary joint pattern rotates clockwise to where the primary joint's trend is N 30 E with a complementary trend of N 80 W. The change in joint direction, along with a different trend of the escarpment in Miller Canyon as compared to Newberry Canyon, allows for different cliff stability conditions in the two areas.

The spacing and continuity of the joints in the various areas was also measured. (See Table 1.)

TABLE 1

Area	No. of Joints	Continuity Strike	Continuity Dip	Joint Spacing
1	59	11.7	10.7	4.4
2	52	36.8	31.7	30.4
3	54	15.5	9.0	10.4
4	69	15.2	13.9	7.5
5	30	15.9	13.6	9.7
6	24	10.9	13.4	5.3
All Areas	288	16.0	13.9	11.6

Table 1 shows that the average spacing between joints is 11.6 feet and that the average continuity is 16.0 and 13.9 feet on strike and dip, respectively. The joint spacing and continuity in Area 2 is much greater than in any other area. The reason is unknown. It appears that joint spacing in all other areas inspected is similar.

Foundation Failure

Failure of the Castlegate Sandstone escarpment observed within the study area has been caused by numerous factors acting in combination. In every case, however, in which large blocks of sandstone have become unstable and collapsed, the foundation material of the cliff has insufficient compressive strength to support the mass of rock above. Figure 1 illustrates how the foundation failure occurs. The initial condition which exists is the disruption by settling (caused naturally or by mining) of a thin slab (generally less than 50 feet in thickness) of the cliff that extends from the escarpment into a joint, causing the thin slab to settle downward (foundation failure). Further settling causes block rotation in which the bottom of the slab moves outward toward the escarpment. In time, the slab falls from the cliff by mass wasting. The areas in which cliff failure was observed by field mapping are shown as red fractures on Attachment 1.

For several months the area above the 6th and 7th East longwall panels in the Cottonwood Mine has been the focus of attention regarding cliff stability. Mining in the 6th East panel began in September, 1986 and was completed in March, 1987. Mining in the 7th East panel began in April, 1987 and was completed in August, 1987. Movement on the cliffs above the longwall panel was first observed in February, 1987. This area is located in the Northeast ¼ of Section 28 and the Northwest ¼ of Section 27, Township 17 South,

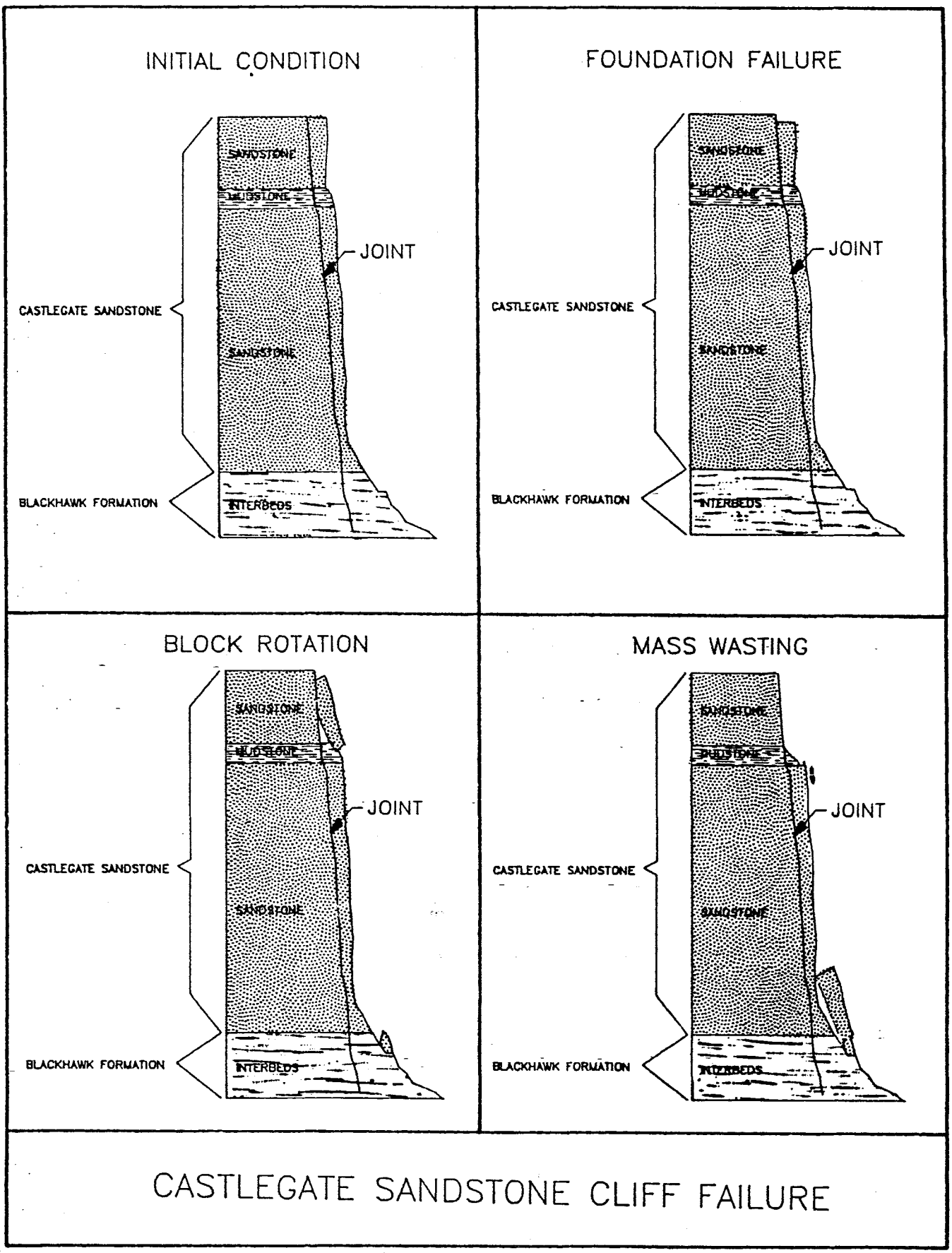

INITIAL CONDITION
SANDSTONE
MUDSTONE
JOINT
CASTLEGATE SANDSTONE
SANDSTONE
BLACKHAWK FORMATION
INTERBEDS
FOUNDATION FAILURE
SANDSTONE
MUDSTONE
JOINT
CASTLEGATE SANDSTONE
SANDSTONE
BLACKHAWK FORMATION
INTERBEDS
BLOCK ROTATION
SANDSTONE
MUDSTONE
JOINT
CASTLEGATE SANDSTONE
SANDSTONE
BLACKHAWK FORMATION
INTERBEDS
MASS WASTING
SANDSTONE
MUDSTONE
JOINT
CASTLEGATE SANDSTONE
SANDSTONE
BLACKHAWK FORMATION
INTERBEDS
CASTLEGATE SANDSTONE CLIFF FAILURE

FIGURE 1

Range 7 East. It is quite apparent that the cliff instability was spawned by the mining activities below. The factors which played the greatest role in the cliff movement were 1) strong north-south and east-west jointing, 2) the cliff escarpment's being roughly parallel to the east-west jointing, and 3) the weak mudstone layer present in the middle of the Castlegate Sandstone. Cliff movement has been monitored since it was first observed, and it appears that the movement has stabilized. The debris which fell from the cliff formed talus slopes below the cliff. The talus slopes are shown as shaded areas on Attachment 1. The cliff movement had little if any impact on the current land use in the area. Perhaps the greatest effect was the visual impact on the area. It is important to point out that the spalling of material from the cliff in this area is a natural phenomenon. The material would eventually have become unstable and fallen even if the underlying coal were never mined, but the time it took for this natural process to occur was accelerated by mining. The acceleration was on the order of magnitude of thousands of years.

The only region within the study area in which mining has occurred is in the 6th and 7th East longwall panel, but several areas of naturally occurring cliff movement were mapped. In most cases the naturally occurring cliff movement is more significant than that caused by mining. The areas in which cliff movement was noticed in unmined areas are in the Southwest ¼ of Section 33; the South ½ of Section 32, Township 17 South, Range 7 East; the North ½ of Section 5, Township 17 South, Range 7 East; and the North ½ of Section 5, Township 18 South, Range 7 East. It is speculated that the underlying coal has been naturally burned in these areas. The overburden pressures on the clinker beds formed from the burned coal were too great and caused them to yield, propagating movement of the Castlegate Cliff. The cliff movement in the Southern ½ of Section 32, Township 17 South, Range 7 East was great enough to create graben structures 40 feet deep and as much as 150 feet back from the escarpment. This movement appears to be more significant than any which has been observed associated with mining anywhere on East Mountain.

SUMMARY

The cliffs surrounding the southern end of East Mountain are all undergoing natural weathering and mass wasting, dictating that none of the cliffs are stable and will remain in their current state for long periods of time. Many natural or manmade conditions can and will cause the degradation of the cliffs to be accelerated. These conditions may include heavy rainfall, seismicity, frost wedging, and mining. It is safe to assume that underground mining anywhere on East Mountain will accelerate the degradation process to some degree. In the areas where steep escarpments exist, the amount of acceleration may be more pronounced.

The cliff movement in the area of the 6th and 7th East longwall panels in the Cottonwood Mine has, without question, been accelerated by mining. This cliff movement has had little or no effect on the current land use of the area.

Because of the geologic conditions present, it is felt that anywhere the Castlegate Cliff is undermined by longwall or room and pillar mining methods (pillar extraction), the degradation of the cliff will be accelerated to some degree. In

many cases the amount of acceleration will be nil, to the point that no noticeable change will occur in one's lifetime. In other areas the impact will be almost immediate.

The geologic factors which influence the cliff stability vary in the different areas of the study area. Because of the rotation of the joint trends between the Newberry Canyon and Miller Canyon areas and the change in relationship between the escarpment trend and the joints, the acceleration of degradation in the Miller Canyon area will be much less than in the Newberry Canyon area. The Castlegate Sandstone within the Miller Canyon area contains fewer mudstone lenses, which reduces the chance for foundation failure, from conditions found in the Newberry Canyon area. Where the setup entries are currently located for 9th and 10th West longwall panels in the Cottonwood Mine below Miller Canyon, it is likely that mining will have no immediate effect on cliff stability.

The area in which mining beneath the escarpment is most likely to accelerate escarpment failure is the southern portion of the escarpment (see Attachment 1). Much movement of the cliffs has already occurred in that area, and any additional condition which disrupts the material supporting the escarpment will surely cause an almost immediate impact on the cliff. However, at worst case, the cliff failure will have little or no impact on the land use of the area above or below the escarpment and the visual effects of any cliff movement should blend in with the visual quality of the surrounding areas.

RCF/961

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL — SHEET 1 OF 3

MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

CLIENT UTAH POWER & LIGHT — PROPERTY EAST MTN

LOCATION IN MINE _____ — BY SNIDER/SEMBORSKI — DATE 8/26/87

CO-ORDINATES: NORTH _____ EAST _____ BENCH ELEVATION _____

BEARING OF FACE _____

SOUTH LEASE #1 [redacted]

REMARKS:																					
ROCK	CHARACTER (RANGE 0.1cm to 99 cm)																				
	HARDNESS	7	—	—	—	—	—	—	—	—	—	—	—	—	—	4	7	—	—	—	↓
	TYPE	88		—	—	—	—	—	—	—	—	—	—	—	—						↓
ING	HARDNESS																				
	THICKNESS (RANGE 0.1mm to 99.9mm)																				
	TYPE																				
SPACING (RANGE 0.1dm to 99dm)		1'0"	1'0"	3'	7'	5'	3'	3'	1'0"	1'	1'	5'	2'	5'	3'	3'	2'	3'	3'	4'	5'
MOISTURE		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	↓
ESTIMATED JRC																					
ROUGHNESS	ANGLE: SHORTER BASE																				
	ANGLE: LONGER BASE																				
	DESCRIPTION	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	↓
CONTINUITY	DIP (RANGE 0.1m to 99m)	1'0"	1'0"	1'0"	2'0"	5'0"	1'0"	-5'	1'0"	1'0	1'0	1'5	-3'	-8'	5'	3'0	3'0	2'0	8'	—	↓
	STRIKE (RANGE 0.1m to 99m)	1'0"	1'0"	2'0+	2'0"	7'	-5'	1'0"	1'0	8'	5'	2'0	-8'	-8'	1'5	2'0	7'	1'0	5'	10'	-5'
STRUCTURE TYPE		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
DIP		E 87	S 83	E 85	- 90	S 85	E 89	S 79	S 79	- 90	S 68	S 82	- 90	- 90	S 88	S 88	- 90	S 77	E 85	S 72	W 89
STRIKE		E 154	W 164	W 152	N 150	W 180	W 183	W 186	W 176	W 190	E 180	W 175	E 161	W 190	W 162	W 166	W 190	E 178	W 182	W 174	W 183
		N 1	N 2	N 3	N 4	N 5	N 6	N 7	N 8	N 9	N 10	N 11	N 12	N 13	N 14	N 15	N 16	N 17	N 18	N 19	N 20

SOIL FRACTURE MEASUREMENT

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 2 OF 3

CLIENT UTAH POWER & LIGHT
PROPERTY EAST MOUNTAIN
LOCATION IN MINE
BY SNIDER/SEMOVSKI DATE 8/26/87
CO-ORDINATES: NORTH EAST BENCH ELEVATION
BEARING OF FACE

SOUTH LEASE #1 [redacted]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
REMARKS:						OPEN FRACTURES 0-3' WIDE		CLOSE FRACTURING												
ROCK CHARACTER (RANGE 0 cm to 99 cm)																				
ROCK HARDNESS	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
ROCK TYPE	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
LING HARDNESS																				
LING THICKNESS (RANGE 0.1mm to 99.9mm)																				
TYPE																				
SPACING (RANGE 0 dm to 99 dm)	1	3	1	15	2	25	8	2	2	2	8	3	6	3	4	1	2	0.5	2	1
MOISTURE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
ESTIMATED JRC																				
ROUGHNESS ANGLE SHORTER BASE																				
ROUGHNESS ANGLE LONGER BASE																				
ROUGHNESS DESCRIPTION	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CONTINUITY DIP (RANGE 0 m to 99 m)	3	6	4	3	5	200	5	5	5	1	1	1	2	1	2	1	5	2	3	3
CONTINUITY STRIKE (RANGE 0 m to 99 m)	3	1	8	3	5	300	5	5	5	5	5	5	2	4	?	8	1	2	3	3
STRUCTURE TYPE	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
DIP	W	S	-	W	W	N	S	-	-	W	S	S	E	S	S	E	S	S	E	-
	87	88	90	86	88	80	71	90	90	85	77	83	88	77	85	36	87	84	89	90
STRIKE	W		E	W	E	W	W	E	W	W	W	W	W	E	E	E	E	W	E	SW
	16		17	41	38	17	61	76	12	15	63	90	10	80	63	31	70	56	17	50
	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL

MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 3 OF 3

CLIENT UTAH POWER & LIGHT

PROPERTY EAST MOUNTAIN

LOCATION IN MINE

BY SNIDER & SEMBORSKI DATE 8/26/87

CO-ORDINATES: NORTH EAST BENCH ELEVATION

BEARING OF FACE

SOUTH LEASE #1 [redacted]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
REMARKS:																		PRICE RIVER FORMATION	"	"
ROCK CHARACTER (RANGE 0.1cm to 99 cm)																				
ROCK HARDNESS	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	
ROCK TYPE	SS	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	
FILLING HARDNESS																				
FILLING THICKNESS (RANGE 0.1mm to 99.9mm)																				
FILLING TYPE																				
SPACING (RANGE 0.1dm to 99dm)	2.1	4.1	5.1	3.1	2.1	3.1	10.1	3.1	3.1	3.1	?.1	1.1	2.1	2.1	3.1	1.5	10.1	10.1	?.1	
MOISTURE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
ESTIMATED JRC																				
ROUGHNESS ANGLE SHORTER BASE																				
ROUGHNESS ANGLE LONGER BASE																				
ROUGHNESS DESCRIPTION	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
CONTINUITY DIP (RANGE 0.1m to 99m)	5.1	8.1	5.1	1.1	5.1	?.1	8.1	4.1	4.1	5.1	0.1	4.1	1.1	5.1	4.1	1.1	8.1	8.1	8.1	
CONTINUITY STRIKE (RANGE 0.1m to 99m)	5.1	3.1	0.1	3.1	5.1	8.1	5.1	5.1	4.1	0.1	0.1	3.1	3.1	5.1	3.1	0.1	?.1	?.1	30.1	
STRUCTURE TYPE	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
DIP	90	75	88	85	85	90	61	83	89	90	88	90	90	87	87	89	83	86	89	
STRIKE	N19W	N33E	N3W	N80W	N72E	N20W	N7W	N3W	N76E	N5W	N33W	N12W	N81W	N7W	N37E	N5E	N57E	N60E	N81W	N

ROUGHNESS DESCR.: 1 — SLICKENSIDED, 2 — SMOOTH, 3 — DEFINED RIDGES, 4 — SMALL STEPS, 5 — VERY ROUGH

MOISTURE: 1 — DRY, 2 — WET, 3 — FLOWING

STRUCTURE TYPE: 1 — FAULT, 2 — JOINT, 3 — BEDDING PLANE, 4 — CLEAVAGE, 5 — DIKE, 6 — SILL

HARDNESS: 0 — VERY SOFT SOIL, 1 — SOFT SOIL, 2 — FIRM SOIL, 3 — STIFF SOIL, 4 — VERY STIFF SOIL, 5 — VERY SOFT ROCK, 6 — SOFT ROCK, 7 — HARD ROCK, 8 — VERY HARD ROCK, 9 — VERY, VERY HARD ROCK

JOINT SURVEY FIELD FORM

SEEGMILLER INTERNATIONAL

MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 1 OF 3

CLIENT UTAH POWER & LIGHT

PROPERTY

LOCATION IN MINE

BY RC Fry

DATE 8-29-87

CO-ORDINATES: NORTH EAST BENCH ELEVATION

BEARING OF FACE

SOUTH LEASE #2 [redacted]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
REMARKS:																		Variety Clay Tailing & Shale Tailing (to Jones 18)		
ROCK CHARACTER (RANGE 0 cm to 99 cm)																				
ROCK HARDNESS	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	6
ROCK TYPE	55	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	55	55
FILLING HARDNESS																				
FILLING THICKNESS (RANGE 0.1mm to 99.9mm)																				
FILLING TYPE																				
SPACING (RANGE 0 dm to 99 dm)	0	0	1	0	2	1	1.5	3	1	1	2	3	5	3	1	9	1.5	3	4	5
	3	8	5	5	0	0		0	3	0	5	0		0	5	9		0	0	0
MOISTURE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ESTIMATED JRC	08	10	08	12	10	12	12	8	10	8	7	8	12	5	10	8	8	7	10	12
ROUGHNESS ANGLE SHORTER BASE																				
ROUGHNESS ANGLE LONGER BASE																				
ROUGHNESS DESCRIPTION																				
CONTINUITY DIP (RANGE 0 m to 99 m)	15	20	20	20	40	20	10	60	90	60	60	30	10	30	30	65	5	70	10	20
CONTINUITY STRIKE (RANGE 0 m to 99 m)	210	30	60	20	9	60	30	30	270	290	290	270	110	230	210	270	10	299	220	210
STRUCTURE TYPE	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
DIP	72	E	E	W		E	E	E		W			E	E		E	E	E		
	78	82	70	80	90	86	75	75	90	76	90	90	86	87	90	71	77	62	90	90
STRIKE	76	E	W	E	W	W	E	W	E	W	E	W	W	W	E	E	E	W	W	E
	22	15	15	60	65	25	45	10	65	25	80	10	45	03	60	30	70	65	89	30
	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

HARDNESS
- 0 — VERY SOFT SOIL
- 1 — SOFT SOIL
- 2 — FIRM SOIL
- 3 — STIFF SOIL
- 4 — VERY STIFF SOIL
- 5 — VERY SOFT ROCK
- 6 — SOFT ROCK
- 7 — HARD ROCK
- 8 — VERY HARD ROCK
- 9 — VERY, VERY HARD ROCK

ROUGHNESS DESCR.
- 1 — SLICKENSIDED
- 2 — SMOOTH
- 3 — DEFINED RIDGES
- 4 — SMALL STEPS
- 5 — VERY ROUGH

MOISTURE
- 1 — DRY
- 2 — WET
- 3 — FLOWING

STRUCTURE TYPE
- 1 — FAULT
- 2 — JOINT
- 3 — BEDDING PLANE
- 4 — CLEAVAGE
- 5 — DIKE
- 6 — SILL

JOINT SURVEY FIELD FORM

SEEGMILLER INTERNATIONAL

MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 2 OF 3

CLIENT UTAH POWER & LIGHT

PROPERTY

LOCATION IN MINE

BY RC Fry

DATE 8-29-87

CO-ORDINATES: NORTH EAST BENCH ELEVATION

BEARING OF FACE

[redacted]

SOUTH LEASE #2 [redacted]

	STRUCTURE TYPE	DIP	STRIKE	STRUCTURE TYPE	CONTINUITY: DIP (RANGE 0lm to 99m)	CONTINUITY: STRIKE (RANGE 0lm to 99m)	ROUGHNESS: DESCRIPTION	ROUGHNESS: ANGLE SHORTER BASE	ROUGHNESS: ANGLE LONGER BASE	ESTIMATED JRC	MOISTURE	SPACING (RANGE 0ldm to 99dm)	FILLING: THICKNESS (RANGE 0.1mm to 99.9mm)	FILLING: TYPE	FILLING: HARDNESS	ROCK: TYPE	ROCK: HARDNESS	ROCK: CHARACTER (RANGE 0lcm to 99 cm)	REMARKS:
1	2	87W	75E	2	20	30				06	1	20			6				
2	2	77W	80E	2	80	90				10	1	40			6				
3	2	82E	65W	2	80	99				08	1	30			6				
4	2	80W	60E	2	40	60				08	1	20			6				
5	2	85E	67W	2	80	99				08	1	05			6				
6	2	80W	70E	2	20	20				10	1	50			6				
7	2	75E	50W	2	30	40				10	1	20			6				
8	2	50E	20W	2	60	99				08	1	99			6				
9	2	81E	05W	2	40	20				10	1	02			6				
10	2	82E	80W	2	30	10				08	1	25			6				
11	2		90W	2	10	15				08	1	05			6				
12	2		90E	2	05	10				08	1	01			6				
13	2		90E	2	20	25				08	1	20			6				
14	2		75E	2	15	10				04	1	99			6				
15	2		90	2	20	20				08	1	10			6				
16	2	85W	70E	2	10	95				08	1	99			6				
17	2	87E	40E	2	05	05				08	1	99			6				
18	2		90E	2	05	05				08	1	30			6				
19	2	65E	30W	2	20	30				08	1	15			6				
20	2	80E	50E	2	30	20				08	1	20			6				

3 4

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

JOINT SURVEY FIELD FORM

SEEGMILLER INTERNATIONAL

MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 3 OF 3

CLIENT UTAH POWER & LIGHT

PROPERTY

LOCATION IN MINE

BY RC Fry

DATE 8-29-87

CO-ORDINATES: NORTH EAST BENCH ELEVATION

BEARING OF FACE

[redacted]

SOUTH LEASE #2 [redacted]

REMARKS:																					
ROCK	CHARACTER (RANGE 01cm to 99 cm)																				
	HARDNESS	6	5	6	6	6	6	6	6	6	6	6									
	TYPE																				
FILLING	HARDNESS	5																			
	THICKNESS (RANGE 0.1mm to 99.9mm)																				
	TYPE																				
SPACING (RANGE 0.1dm to 99dm)		99	01	50	10	10	99	20	20	05	20	05									
MOISTURE		01	01	01	01	01	01	01	01	01	01	01									
ESTIMATED JRC		10	08	08	08	08	08	10	08	08	08	08									
ROUGHNESS	ANGLE: SHORTER BASE																				
	ANGLE: LONGER BASE																				
	DESCRIPTION																				
CONTINUITY	DIP (RANGE 0.1m to 99m)	10	05	60	80	60	30	20	05	10	30	30									
	STRIKE (RANGE 0.1m to 99m)	15	05	40	60	50	10	20	10	10	15	20	10								
STRUCTURE TYPE		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
DIP		85E	85E	80E	77E	76E	77E	90	90	90	72E	86E	85E								
STRIKE		30W	05E	15W	10W	10W	80E	80W	80E	05W	80W	06W	60W								
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

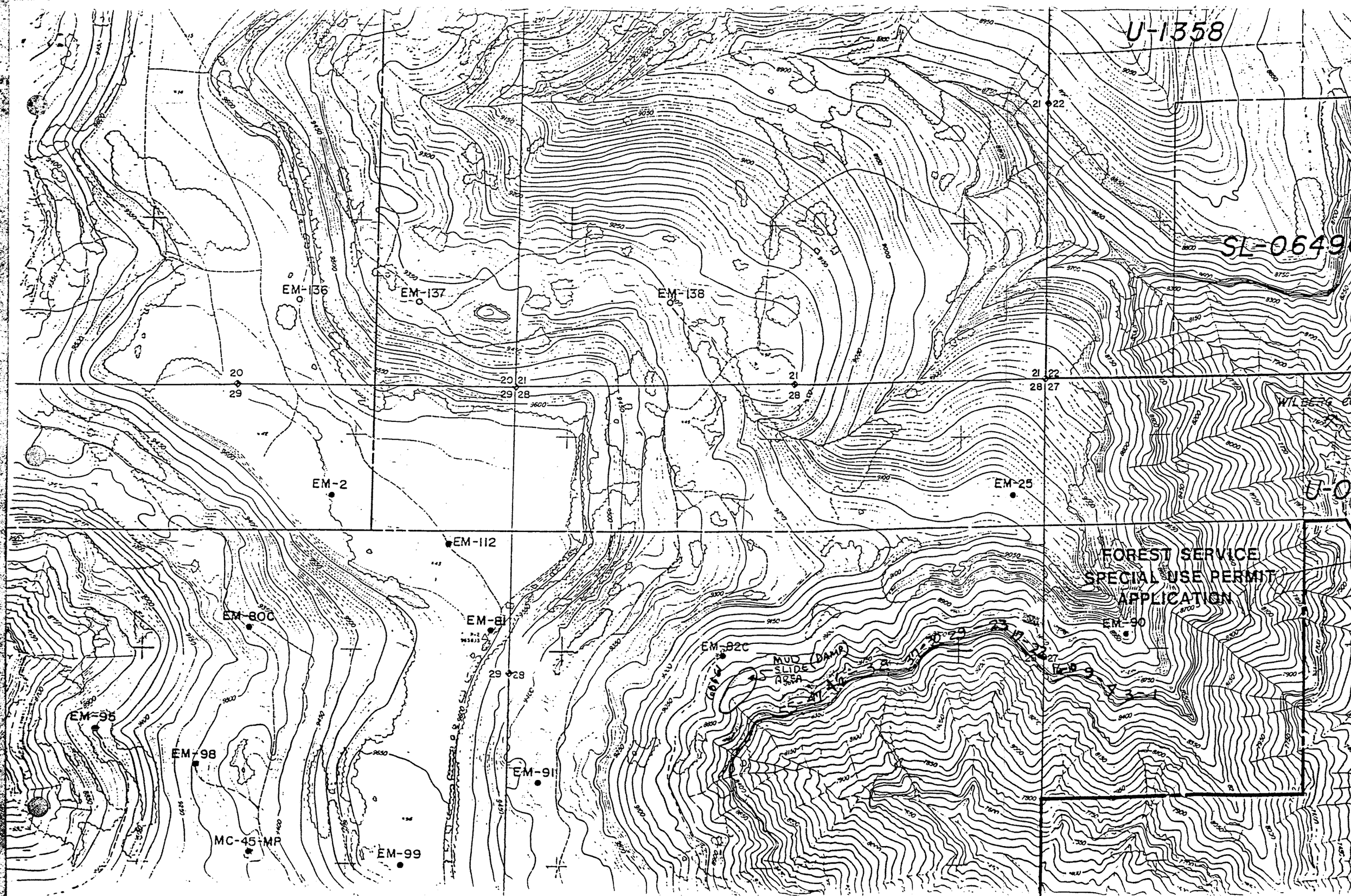
ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL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U-0
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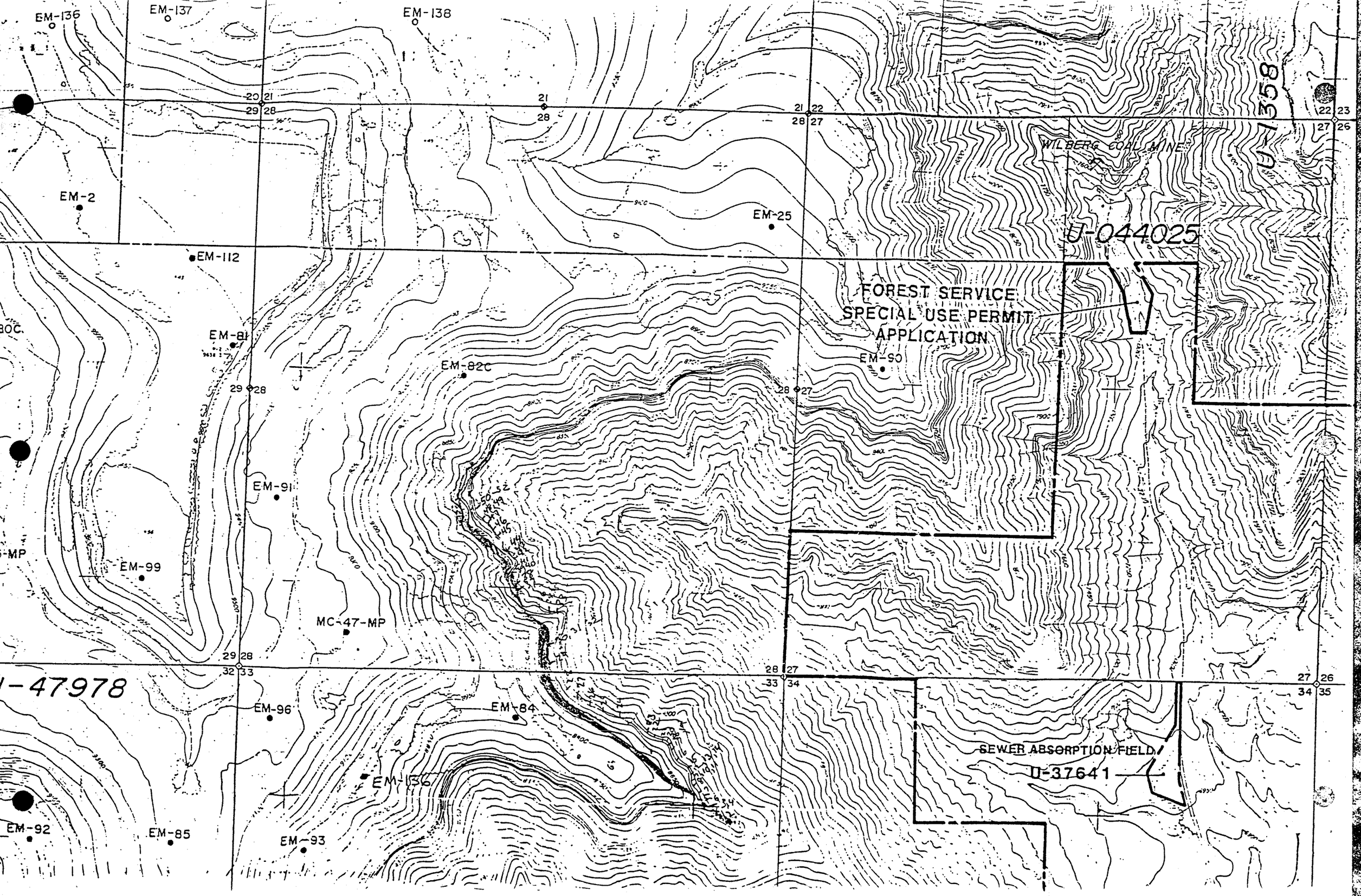
EM-137
EM-138
EM-2
EM-25
EM-112
EM-80C
EM-81
EM-82C
EM-90
EM-95
EM-98
EM-91
MC-45-MP
EM-99
MUD SLIDE (DAM) AREA
FOREST SERVICE
SPECIAL USE PERMIT
APPLICATION
WILBERG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EM-137
EM-138
EM-2
EM-112
EM-25
WILBERG COAL MINE
U-7358
U-044025
FOREST SERVICE
SPECIAL USE PERMIT
APPLICATION
EM-81
EM-82C
EM-90
EM-91
EM-99
MC-47-MP
U-47978
EM-96
EM-84
EM-136
SEWER ABSORPTION FIELD
U-37641
EM-92
EM-85
EM-93

FIELD DISCONTINUITY SURVEY

SEESMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 1 OF 3

[redacted]

CLIENT UTAH POWER & LIGHT
PROPERTY EAST MOUNTAIN
LOCATION IN MINE
BY SNIDER/SEMBOROSKI DATE 9/2/87
O-ORDINATES: NORTH EAST BENCH ELEVATION
BEARING OF FACE

SOUTH LEASE #3 [redacted]

REMARKS:																							
ROCK	CHARACTER (RANGE 0.1cm to 99 cm)																						
	HARDNESS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	TYPE	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
LING	HARDNESS																						
	THICKNESS (RANGE 0.1mm to 99.9mm)																						
	TYPE																						
	SPACING (RANGE 0.1dm to 99dm)		20	1	15	15	12	10	1	15	16	05	1		15	1	12	12	18	12	14		
	MOISTURE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	→
	ESTIMATED JRC																						
ROUGHNESS	ANGLE: SHORTER BASE																						
	ANGLE: LONGER BASE																						
	DESCRIPTION	D	2	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	2	2	2
CONTINUITY	DIP (RANGE 0.1m to 99m)	7	5	2	0	5	5	0	5	3	3	2	2	3	6	5	3	4	3	9	7	0	2
		1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
	STRIKE (RANGE 0.1m to 99m)	0	8	0	0	6	3	5	5	0	5	2	2	5	0	5	5	4	0	5	0	0	0
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
STRUCTURE TYPE		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
DIP		W	E	S	S	E	W	S	S	N	S	I	S	E	E		N	I	S	N	N	S	S
		3	2	6	6	3	3	3	1	2	5	0	7	2	7	1	5	0	1	7	7	6	6
STRIKE		N	E	E	E	W	E	W	E	E	E	E	W	E	E	W	E	E	W	E	W	W	W
		5	4	7	7	4	2	2	3	0	2	6	5	2	1	6	2	5	4	0	7	7	0
		5		3	3	5	6	3	3	6	5	1	4	7	1	2	6	5	1	6	6	7	7
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 2 OF 3

CLIENT UTAH POWER & LIGHT
PROPERTY EAST MOUNTAIN
LOCATION IN MINE
BY SNYDER/SEMBORSKI DATE 9/2/87
CO-ORDINATES: NORTH EAST BENCH ELEVATION
BEARING OF FACE

SOUTH LEASE #3

REMARKS:													PRICE RIVER FORMATION										
ROCK	CHARACTER (RANGE 0 cm to 99 cm)																						
	HARDNESS	C																					
	TYPE	½																					
FILLING	HARDNESS																						
	THICKNESS (RANGE 0.1mm to 99.9mm)																						
	TYPE																						
SPACING (RANGE 0 dm to 99 dm)		0.5	6	2	2	0	2.0	4	100	100	15	2	2	3	15	7	11	0.3	1	2	4		
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
MOISTURE		—	—	—	—	—	—												-		/		
ESTIMATED JRC																							
ROUGHNESS	ANGLE: SHORTER BASE																						
	ANGLE: LONGER BASE																						
	DESCRIPTION	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
CONTINUITY	DIP (RANGE 0 m to 99 m)	4	6	5	3	3	8	8	20	20	7	2	3	5	4	2	3	1	1	6	4		
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
	STRIKE (RANGE 0 m to 99 m)	4	0	9	0	2	2	5	2	2	4	0	5	0	5	2	5	1	1	0	3		
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
STRUCTURE TYPE		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
DIP		S	S	S	S	N	1	E	S	E	S	E	1	S	1	E	S	1	1	1	1		
		32	22	24	76	35	60	59	74	37	55	38	60	73	60	32	35	75	90	90	90		
STRIKE		E	E	W	E	W	W	E	E	E	E	E	E	E	E	W	E	E	W	E	E		
		64	11	13	69	72	57	50	78	75	50	55	16	33	24	16	22	16	6	34	39		
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

FIELD DISCONTINUITY SURVEY

SEECMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 3 OF 3

[redacted]

CLIENT UTAH POWER & LIGHT
PROPERTY EAST MOUNTAIN
LOCATION IN MINE
BY SNIDER/SEMBOROSKI DATE 9/2/87
CO-ORDINATES: NORTH EAST BENCH ELEVATION
BEARING OF FACE

SOUTH LEASE #3 [redacted]

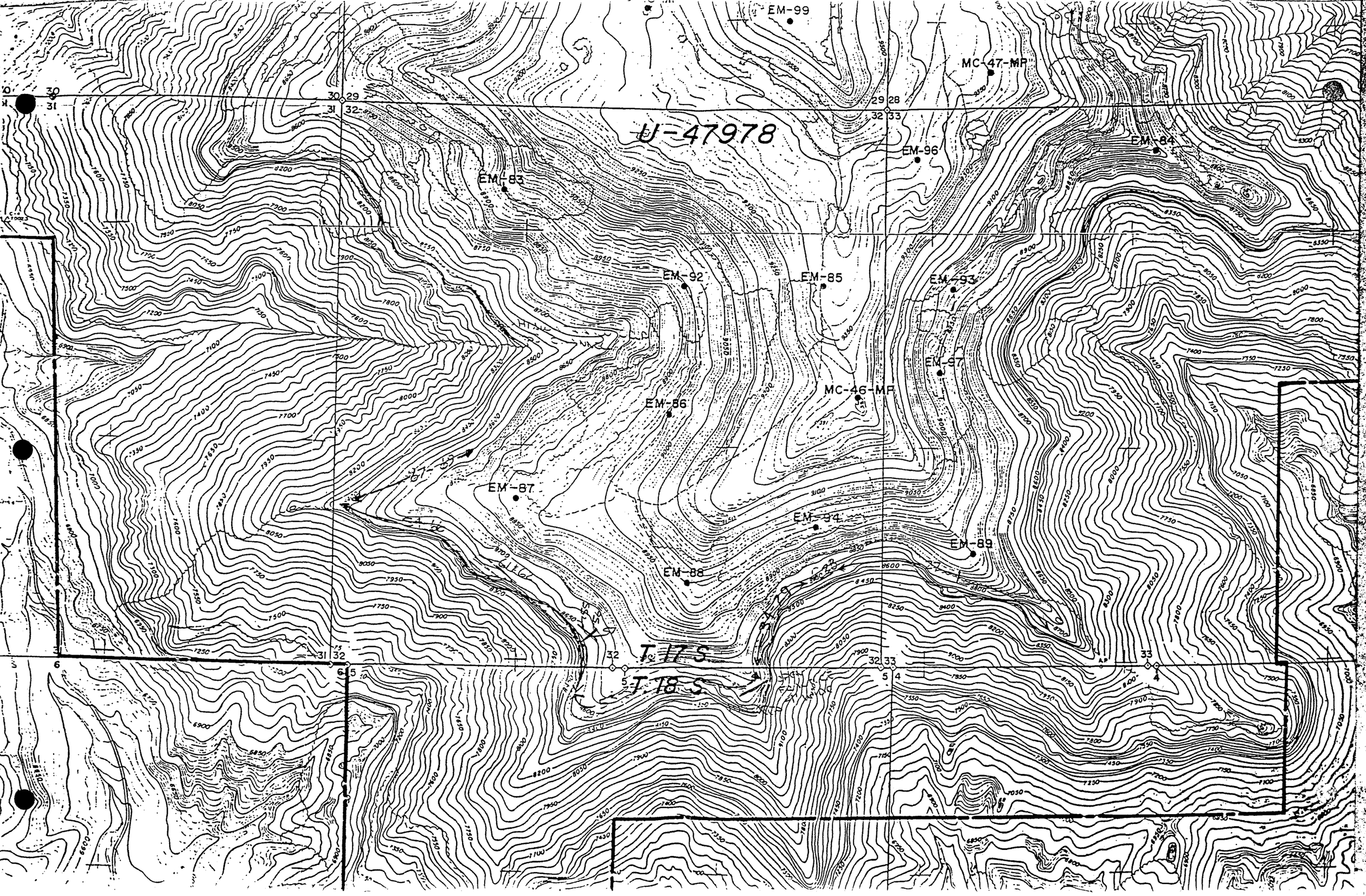
REMARKS:	SLUMP AREA > PACKS [illegible] FIRM [illegible]							CASTLE GATE FM	LARGE OPEN FRACTURE, 10' SEPARATION												
ROCK CHARACTER (RANGE 0 cm to 99 cm)																					
ROCK HARDNESS	CLAY																				
ROCK TYPE	3	7 SS	7 SS	7 SS	7 SS	7 SS	7 SS	6 SS/SH	7 SS	6 SS/SH	7	6 SS/SH	7 SS	7 SS							
FILLING HARDNESS																					
FILLING THICKNESS (RANGE 0.1mm to 99.9mm)																					
FILLING TYPE																					
FILLING SPACING (RANGE 0 dm to 99 dm)	5		4	4	3		5	30		8	2		50	1	2						
FILLING MOISTURE	—	—	—	—	—	—	—	—	—	—	—	—	—	—							
ESTIMATED JRC																					
ROUGHNESS ANGLE SHORTER BASE																					
ROUGHNESS ANGLE LONGER BASE																					
ROUGHNESS DESCRIPTION	1	2	2	2	2	2	2	5 #4		5 #4	2		5 #4	2	2						
CONTINUITY DIP (RANGE 0 m to 99 m)	0	1	3	3	3	3	3	2	3	5	1	3	0	1	1						
CONTINUITY STRIKE (RANGE 0 m to 99 m)	0	3	0	5	4	5	3	20	3	75	0	20	3	0	1						
STRUCTURE TYPE	1	2	2	2	2	2	2	2	2	2	1	1	2	2	2						
DIP		1	1	E	N	1	S	1	N		1		1	N	1						
			6	7	7	9	5	3	6	8	7	8		3	5						
STRIKE	6 E	4 E	5 E	4 W	3 E	3 E	4 E	7 E	1 W	3 E	2 W	8 E		1 W	1 E						
	1 N	2 N	5 N	2 N	6 N	7 N	4 N	8 N	1 N	3 N	2 N	8 N	2 N	1 N	4 N	5 N	6 N	7 N	8 N	9 N	10 N

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL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EM-85
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MC-46-MP
EM-86
EM-87
EM-94
EM-89
EM-88
T. 17 S.
T. 18 S.

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 1 OF 4

CLIENT UTAH POWER & LIGHT
PROPERTY EAST MOUNTAIN
LOCATION IN MINE
BY Swiger/Sunbourset DATE 9/3/87
CO-ORDINATES: NORTH EAST BENCH ELEVATION
BEARING OF FACE

SOUTH LEASE #4

REMARKS:																					
ROCK	CHARACTER (RANGE 01cm to 99 cm)																				
	HARDNESS	7																			
	TYPE	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
FILLING	HARDNESS																				
	THICKNESS (RANGE 0.1mm to 99.9mm)																				
	TYPE																				
SPACING (RANGE 01dm to 99dm)	FT	5	4	3	2	5	5	5	3	6	5	5	6	2	5	6	3	2	5	5	3
	IN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MOISTURE		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
ESTIMATED JRC																					
ROUGHNESS	ANGLE: SHORTER BASE																				
	ANGLE: LONGER BASE																				
	DESCRIPTION	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	2	3	3	3
CONTINUITY	DIP (RANGE 01m to 99m)	FT 1	2	4	6	3	5	6	6	3	2	8	1	1	5	4	5	5	5	6	4
		IN 1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	1	3	1	3
	STRIKE (RANGE 01m to 99m)	FT 5	6	6	5	3	3	6	10	10	3	5	2	4	0	3	0	5	5	6	5
		IN 1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
STRUCTURE TYPE		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
DIP		1	1	1	1	1	1	1	1	1	1	5	1	1	5	1	1	2	1	5	4
		0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
		9	9	9	9	9	9	9	9	9		3	9	9	3	9	9	9	3	3	3
STRIKE		E	N	W	E	E	E	E	W	W	E	W	E	W	E	W	E	E	E	E	W
		3	1	5	5	2	0	0	0	2	6	1	5	5	0	3	3	1	1	4	5
		6	2	2	2	5	5	4	2	2	3	6	1	1	2	1	6	7	7	3	6
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL

MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 2 OF 4

CLIENT UTAH POWER & LIGHT

PROPERTY EAST MOUNTAIN

LOCATION IN MINE

BY SNIDER/SCHIBOWSKI DATE 9/3/97

CO-ORDINATES: NORTH EAST BENCH ELEVATION

BEARING OF FACE

SOUTH LEDGE #4

No.	Structure Type	Strike	Dip	Continuity: Strike (Range 0 m to 99 m)	Continuity: Dip (Range 0 m to 99 m)	Roughness: Description	Roughness: Angle: Longer Base	Roughness: Angle: Shorter Base	Estimated JRC	Moisture	Spacing (Range 0 dm to 99 dm)	Filling: Type	Filling: Thickness (Range 0.1 mm to 99.9 mm)	Filling: Hardness	Rock: Type	Rock: Hardness	Rock: Character (Range 0 cm to 99 cm)	Remarks
1	2	N 14 E	90	1	3	3				1	1				5	7		
2	2	N 12 E	90	1	2	3				1	4					1		
3	2	N 22 E	90	3	20	3	4			1	0					1		
4	2	N 12 E	90	1	1	2				1	1					1		
5	2	N 26 E	90	1	2	2				1	4					1		
6	2	N 13 W	90	3	1	2				1	2					1		
7	2	N 22 E	75	3	20	3	4			1	0				4	1		
8	2	N 15 E	90	7	7	2				1	3					1		OPEN FRACTURE 6' WIDE
9	2	N 12 E	90	1	1	2				1	5				5	7		
10	2	N 15 E	90	5	2	3	4			2	0					1		
11	2	N 12 E	90	3	4	2				1	0					1		
12	2	N 30 E	90	5	4	2				1	1					1		
13	2	N 24 W	90	1	5	2				1	3					1		
14	2	N 71 E	90	4	4	2				1	5					1		
15	2	N 32 E	90	4	2	4				1	4					1		
16	2	N 13 E	90	2		2					5					1		
17	2	N 18 E	75	2	5	2				1	0					1		
18	2	N 52 W	90	1	3	4				1	2					1		
19	2	N 33 W	80	2	4	5				1	5					1		
20	2	N 16 W	90	5	5	2				1	8					1		

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL

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SHEET 3 OF 4

CLIENT UTAH POWER & LIGHT

PROPERTY EAST MOUNTAIN

LOCATION IN MINE

BY SMIDGE/SEMBIRSN DATE 3/3/87

COORDINATES: NORTH EAST BENCH ELEVATION

BEARING OF FACE

SOUTH LEASE #4

#	Strike (Range 0 to 99)	Dip (Range 0 to 99)	Structure Type	Strike (Range 0 to 99m)	Dip (Range 0 to 99m)	Description	Longer Base	Shorter Base	Estimated JRC	Moisture	Spacing (Range 0 dm to 99 dm)	Thickness (Range 0.1mm to 99.9mm)	Hardness	Type	Rock Character (Range 0 cm to 99 cm)	Rock Hardness	Rock Type	Remarks
1	N24E	90	2	1	1	3				—	2.0							
2	N10E	90	2	1	1	3				—	1.1							
3	N10E	90	2	1	1	2				—	1.3		—	—				
4	N20E	90	2	1	1	2				—	1.0		—	—				
5	N16W	87E	2	1	1	4				—	0.5		—	—				
6	N10E	85	2	1.5	1.5	3	4			—	5.0		—	—				
7	N20W	90	2	1.0	1.2	3				—	1.5		—	—				
8	N25E	90	2	1.3	1.3	2				—	1.3		—	—				
9	N20E	90	2	1.5	1.5	3				—	1.1		—	—				
10	N25W	85S	2	1.8	1.1	2				—	1.1		—	—				
11	N36E	90	2	1.2	1.4	2				—	1.1		—	—				
12	N45W	90	2	1.0	1.1	3				—	1.1		—	—				
13	N30W	90	2	2.0	1.0	2				—	1.3		—	—				
14	N20W	90	2	1.4	1.1	1				—	1.3		—	—				
15	N20W	90	2	1.0	3.0	3				—	1.0		—	—				
16	N20E	90	2	2.0	3.0	1				—	1.5		—	—				
17	N10E	90	2	2.2	3.0	4				—			—	—				
18	N56W	90	2	1.0	1.2	3				—	1.8		—	—				
19	N20E	90	2	2.1	1.0	2				—	1.8		—	—				
20	N45W	90	2	2.0	1.3	2				—	1.5		—	—				

SEAM FRACTURE

SEAM FRACTURE

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL

MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 4 OF 4

CLIENT UTAH POWER & LIGHT

PROPERTY EAST MOUNTAIN

LOCATION IN MINE

BY [illegible]/SEEGMILLER DATE 1/3/87

CO-ORDINATES: NORTH EAST BENCH ELEVATION

BEARING OF FACE

SOUTH LEASE #4

REMARKS:		JRC FEATURES																			
ROCK	CHARACTER (RANGE 0 cm to 99 cm)																				
	HARDNESS	7	7	7	7	7	7	7	7	7											
	TYPE	55	55	55	55	55	55	55	55	55											
FILLING	HARDNESS																				
	THICKNESS (RANGE 0.1mm to 99.9mm)																				
	TYPE																				
SPACING (RANGE 0 dm to 99 dm)		30	30	20	20	14	12	19		11											
MOISTURE		1																			
ESTIMATED JRC																					
ANGLE	SHORTER BASE	LARGE																			
	LONGER BASE																				
DESCRIPTION		4	4	4	2	3	4	2	2	2											
DIP (RANGE 0 m to 99 m)		30	70	50	50	20	20	10	10	10											
STRIKE (RANGE 0 m to 99 m)		20	150	150	20	10	10	10	10	15											
STRUCTURE TYPE		1	1	2	2	2	2	2	2	2											
DIP		35		85	1	90	85	90	90	90											
		35		85		90	85	90	90	90											
STRIKE		0W		7W	0E	4E	7E	2W	7E	5W											
		N16	N	N17	N20	N24	N27	N14	N17	N15	N	N	N	N	N	N	N	N	N	N	N
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

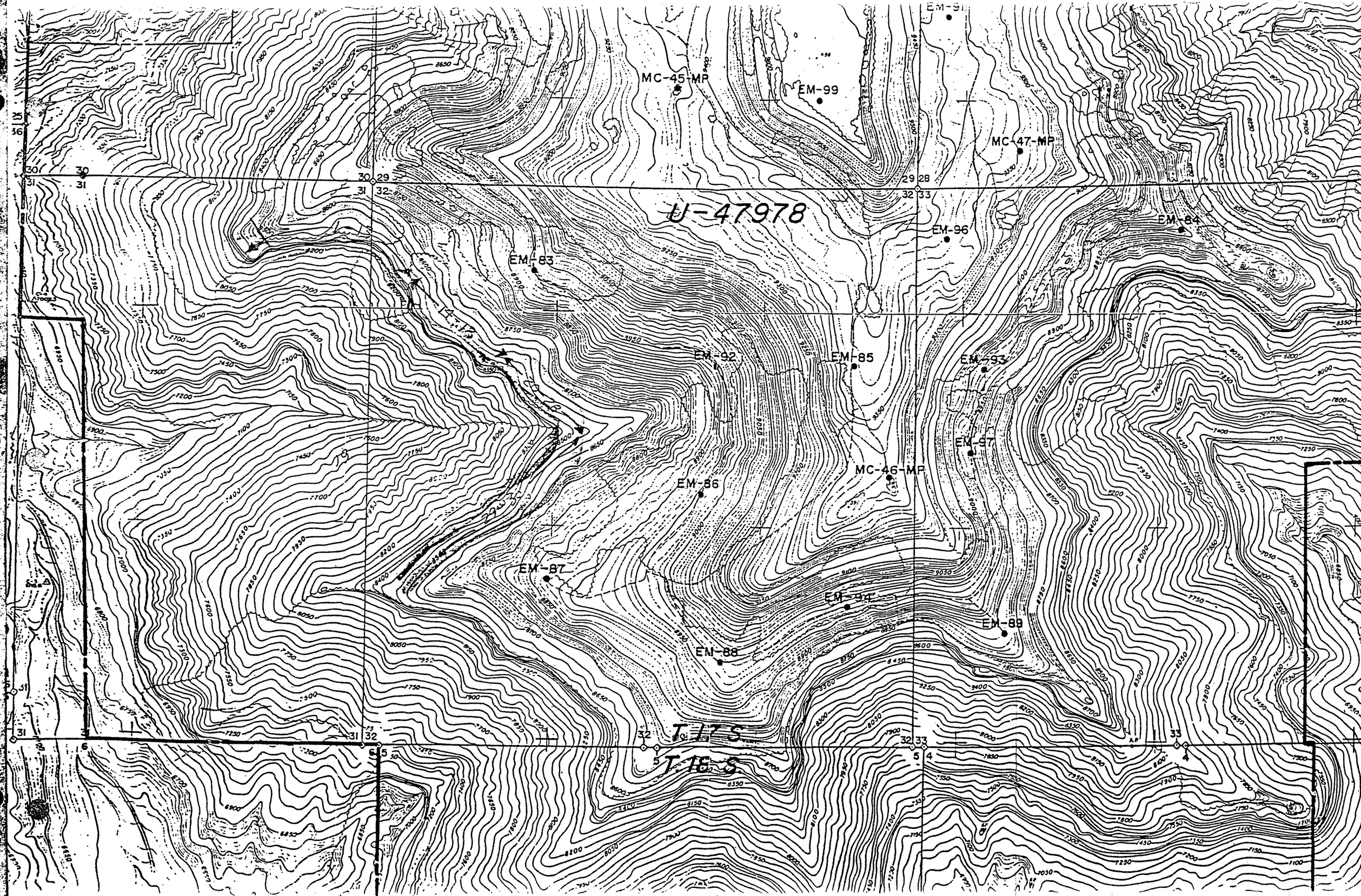
ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL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EM-97
MC-46-MP
EM-86
EM-87
EM-94
EM-89
EM-88
T. 17 S.
T. 18 S.

FIELD DISCONTINUITY SURVEY

DESGMILLER INTERNATIONAL

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SHEET 1 OF 2

CLIENT UTAH POWER & LIGHT

PROPERTY EAST MOUNTAIN

LOCATION IN MINE

BY DAVIES / SEMBORSKI DATE 9/9/87

CO-ORDINATES: NORTH EAST BENCH ELEVATION

BEARING OF FACE

SOUTH LEASE #5 [redacted]

	STRUCTURE TYPE	DIP	STRIKE	STRUCTURE TYPE	STRIKE (RANGE 0 to 99)	DIP (RANGE 0 to 99)	DESCRIPTION	LONGER BASE	SHORTER BASE	ESTIMATED JRC	MOISTURE	SPACING (RANGE 0.0m to 99.9m) FT	TYPE	THICKNESS (RANGE 0.1mm to 99.9mm)	HARDNESS	TYPE	HARDNESS	CHARACTER (RANGE 0.1cm to 99 cm)	REMARKS:
1	N 23 W	76 W	21	N 23 W	102	02	2					10							
2	N 30 E	30 -	2	N 30 E	15	52	2					16							
3	N 46 E	76 W	2	N 46 E	50	20	2					15							
4	N 34 E	90 -	2	N 34 E	31	10	2					18							
5	N 10 E	75 W	2	N 10 E	15	30	2					15							
6	N 36 E	90 -	2	N 36 E	22	52	2					15							
7	N 32 W	32 S	2	N 32 W	15	15	2					13							
8	N 19 W	73 W	2	N 19 W	15	30	2					30							
9	N 35 E	79 S	2	N 35 E	14	52	2					13							
10	N 19 W	83 W	2	N 19 W	11	52	2					13							
11	N 76 W	90 -	2	N 76 W	20	12	2					18							
12	N 35 E	90 -	2	N 35 E	21	10	2					14							
13	N 73 W	90 -	2	N 73 W	15	15	2					15							
14	N 55 W	3[illegible] V	2	N 55 W	10	62	2					12							
15	N 50 E	31 S	2	N 50 E	10	15	2					?							
16	N 52 W	34 S	2	N 52 W	15	15	2					13							
17	N 70 W	73 S	2	N 70 W	10	15	2					15							
18	N 35 E	32 N	2	N 35 E	15	10	2					12							
19	N 23 E	90 -	2	N 23 E	10	20	2					15							
20	N 69 W	37 S	2	N 69 W	15	15	4					10							BLACKHAWK FM

STRUCTURE TYPE	ROUGHNESS DESCR.	FILLING TYPE	ROCK TYPE	HARDNESS
1 — FAULT 2 — JOINT 3 — BEDDING PLANE 4 — CLEAVAGE 5 — DIKE 6 — SILL	1 — SLICKENSIDED 2 — SMOOTH 3 — DEFINED RIDGES 4 — SMALL STEPS 5 — VERY ROUGH	MOISTURE 1 — DRY 2 — WET 3 — FLOWING		0 — VERY SOFT SOIL 1 — SOFT SOIL 2 — FIRM SOIL 3 — STIFF SOIL 4 — VERY STIFF SOIL 5 — VERY SOFT ROCK 6 — SOFT ROCK 7 — HARD ROCK 8 — VERY HARD ROCK 9 — VERY, VERY HARD ROCK

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS

SHEET 2 OF 2

CLIENT UTAH POWER & LIGHT
PROPERTY EAST MOUNTAIN
LOCATION IN MINE
BY
DATE 9-9-87
CO-ORDINATES: NORTH EAST
BENCH ELEVATION
BEARING OF FACE

SOUTH LEASE #5 [redacted]

REMARKS:																					
ROCK	CHARACTER (RANGE 0.1cm to 99 cm)																				
	HARDNESS	7	—	—	—	—	—	—	—	—	—										
	TYPE	8	—	—	—	—	—	—	—	—	—										
RING	HARDNESS																				
	THICKNESS (RANGE 0.1mm to 99.9mm)																				
	TYPE																				
SPACING (RANGE 0.1dm to 99dm)	FT	4	10	20	20	10	5		50	5	3										
	IN	1	1	2	2	1	1		5	1	1										
MOISTURE		—	—	—	—	—	—	—	—	—	—										
ESTIMATED JRC																					
ROUGHNESS ANGLE	SHORTER BASE																				
	LONGER BASE																				
ROUGHNESS	DESCRIPTION	2	2	2	3	2	2		2	3	2										
CONTINUITY	DIP (RANGE 0.1m to 99m)	FT	0	5	0	5	2		0	0	0										
		IN	0	1	0	1	1		1	1	0										
	STRIKE (RANGE 0.1m to 99m)	FT	5	2	4	5	5		0	0	5										
		IN	1	2	2	1	2		1	1	1										
STRUCTURE TYPE		2	2	2	2	2	2		2	2	2										
DIP		1	5	5	0	5	5		0	5	5										
		5	7	7	9	7	7		9	8	9										
STRIKE		2E	5W	5E	0W	0W	5W		3E	5E	5N										
		1	4	3	4	3	2		2	1	2										
		N	N	N	N	N	N		N	N	N										
		1	2	3	4	5	6		7	8	9	10	11	12	13	14	15	16	17	18	19	20

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

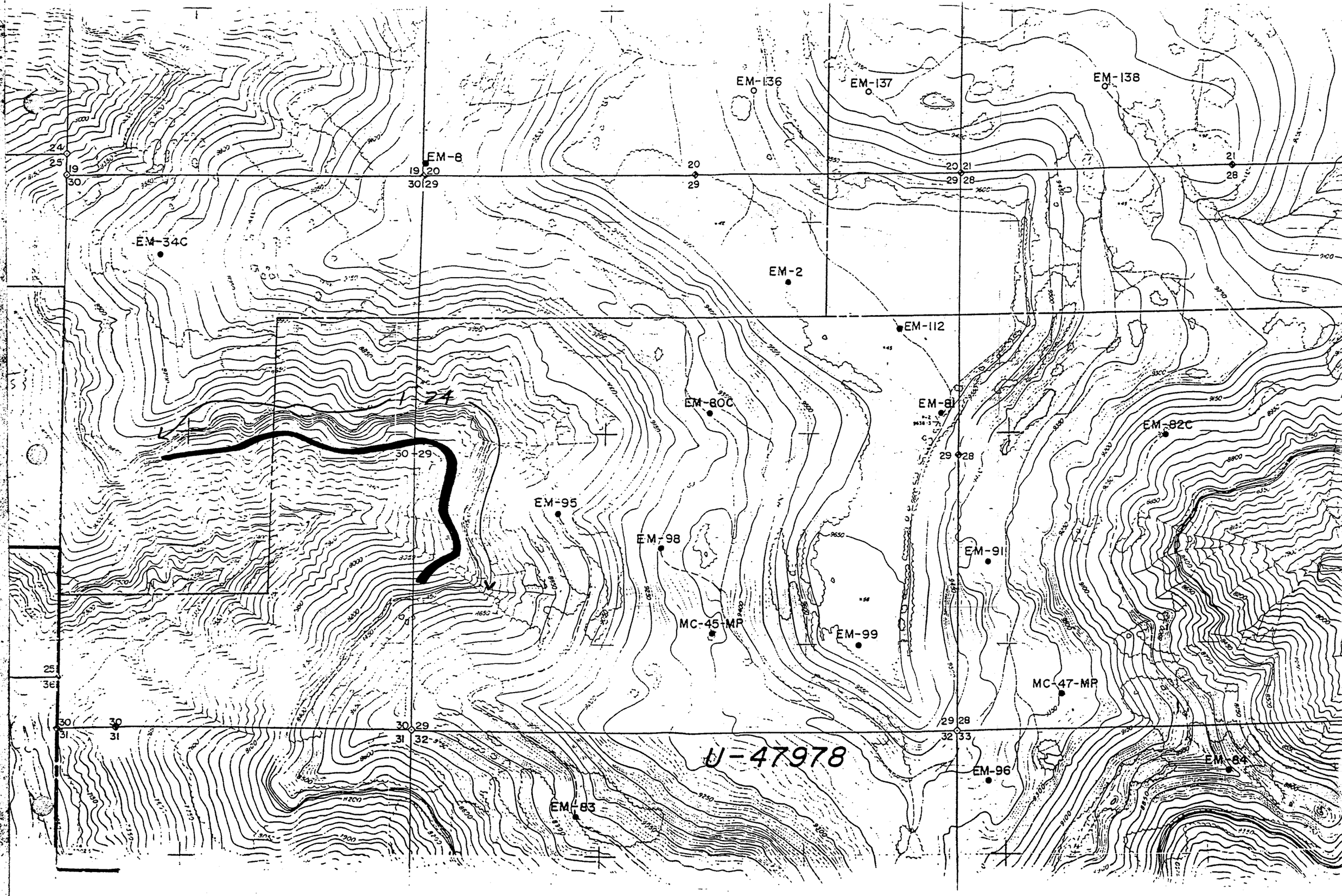
ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL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EM-137
EM-138
EM-8
EM-34C
EM-2
EM-112
EM-80C
EM-81
EM-82C
EM-95
EM-98
EM-91
MC-45-MP
EM-99
MC-47-MP
EM-96
EM-84
EM-83
U-47978

FIELD DISCONTINUITY SURVEY

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SHEET 1 OF 2

CLIENT UTAH POWER & LIGHT
PROPERTY EAST MOUNTAIN
LOCATION IN MINE
BY
DATE 9/23/87
CO-ORDINATES: NORTH EAST BENCH ELEVATION
BEARING OF FACE

SOUTH LEASE #6 [redacted]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
REMARKS:																				
ROCK CHARACTER (RANGE 0.1cm to 99 cm)																				
ROCK HARDNESS	7																			
ROCK TYPE	SS																			
FILLING HARDNESS																				
FILLING THICKNESS (RANGE 0.1mm to 99.9mm)																				
FILLING TYPE																				
SPACING (RANGE 0.1dm to 99dm) FT	10	10	15	15	12	1	12	15	12	12	18	1	13	12	4	10	15	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MOISTURE	1																			
ESTIMATED JRC																				
ROUGHNESS ANGLE SHORTER BASE																				
ROUGHNESS ANGLE LONGER BASE																				
ROUGHNESS DESCRIPTION	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CONTINUITY DIP (RANGE 0.1m to 99m) FT	10	30	15	15	12	42	32	10	10	20	02	42	10	02	02	60	20	10	12	33
CONTINUITY STRIKE (RANGE 0.1m to 99m) FT	15	10	10	30	11	15	10	15	15	10	04	41	10	10	50	15	20	10	11	33
STRUCTURE TYPE	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
STRUCTURE TYPE DIP	W39	S0	W30	W73	E90	W50	S63	E31	E90	S69	S0	E90	S69	E60	E60	S73	E90	E90	E90	W35
STRUCTURE TYPE STRIKE	N26	N4	N15	N12	N60	N8	N36	N29	N11	N75	N32	N25	N32	N3	N20	N75	N30	N33	N25	N35

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL

FIELD DISCONTINUITY SURVEY

SEEGMILLER INTERNATIONAL
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SHEET 2 OF 2

CLIENT UTAH POWER & LIGHT
PROPERTY EAST MOUNTAIN
LOCATION IN MINE
BY SNIDER/KEMBORSKI DATE 9-23-87
CO-ORDINATES: NORTH EAST BENCH ELEVATION
BEARING OF FACE

SOUTH LEASE #6

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
REMARKS:																					
ROCK	CHARACTER (RANGE 0 cm to 99 cm)																				
	HARDNESS	7	—	—	—																
	TYPE	SS	—	—	—																
FILLING	HARDNESS																				
	THICKNESS (RANGE 0.1mm to 99.9mm)																				
	TYPE																				
SPACING (RANGE 0 dm to 99 dm)		5	4	4	5																
		1	1	1	1																
MOISTURE		—	—	—	→																
ESTIMATED JRC																					
ROUGHNESS	ANGLE: SHORTER BASE																				
	ANGLE: LONGER BASE																				
	DESCRIPTION	2	2	2	2																
CONTINUITY	DIP (RANGE 0 m to 99 m)	10	10	15	15																
		1	1	1	1																
	STRIKE (RANGE 0 m to 99 m)	15	15	15	15																
		1	1	1	1																
STRUCTURE TYPE		2	2	2	2																
DIP		60	90	90	74																
		1	1	1	1																
STRIKE		E	W	E	W																
		25	76	21	52																
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

HARDNESS
0 — VERY SOFT SOIL
1 — SOFT SOIL
2 — FIRM SOIL
3 — STIFF SOIL
4 — VERY STIFF SOIL
5 — VERY SOFT ROCK
6 — SOFT ROCK
7 — HARD ROCK
8 — VERY HARD ROCK
9 — VERY, VERY HARD ROCK

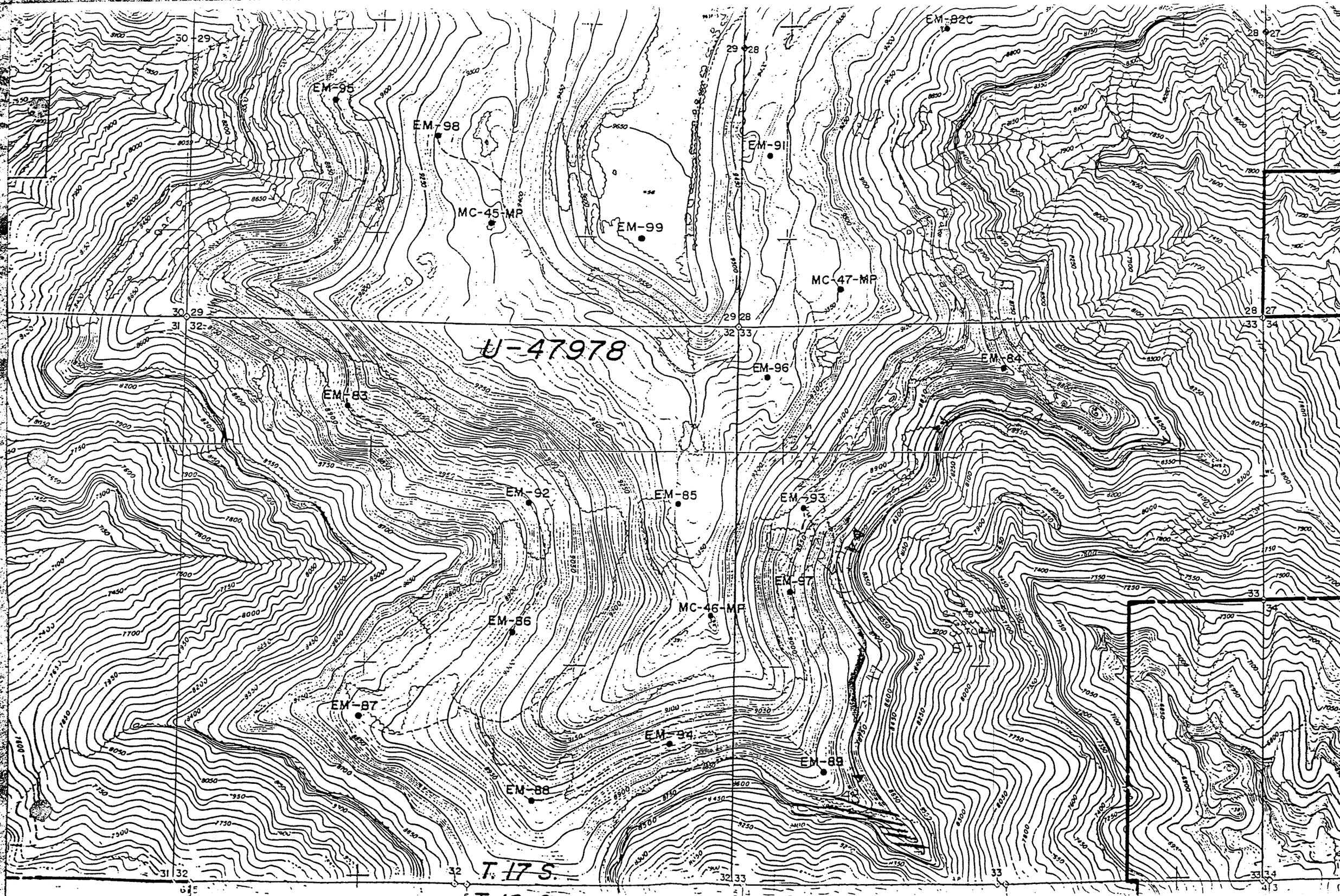
ROCK TYPE

FILLING TYPE

ROUGHNESS DESCR.
1 — SLICKENSIDED
2 — SMOOTH
3 — DEFINED RIDGES
4 — SMALL STEPS
5 — VERY ROUGH

MOISTURE
1 — DRY
2 — WET
3 — FLOWING

STRUCTURE TYPE
1 — FAULT
2 — JOINT
3 — BEDDING PLANE
4 — CLEAVAGE
5 — DIKE
6 — SILL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T. 17 S.

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Salt Lake City, Utah 84111 U.S.A.
Phone: (801)- 363-0606 Cable: ROCKENGR
TELEX: 5106008248 (SEEGMILLER SLC)

SURFACE STABILITY EVALUATION

6E/7E AND 9W/10W PANELS

COTTONWOOD MINE

Emery County, Utah

PREPARED FOR

UTAH POWER & LIGHT COMPANY
Huntington, Utah

By

Dr. Ben L. Seegmiller
Principal Consultant

November 1987

Approved: Ben L. Seegmiller 11/4/87
Ben L. Seegmiller, P.E. #3485 Utah
President, Seegmiller International

Copy 3 of 6

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SEEGMILLER INTERNATI

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SUMMARY/CONCLUSIONS

An evaluation of surface stability above the 6E/7E and 9W/10W longwall panels at the Cottonwood Mine is made in this report. Specifically, the past stability of the Castle Gate Sandstone cliffs above the presently mined 6E/7E panels and the future stability of this cliff sandstone above the 9W/10W panels are addressed. Field data, including geologic discontinuity and geotechnical characteristics of the subject areas, were collected during two site visits, one in August and one in September of 1987. A complete data evaluation was made and the following have been concluded:

- The 6E/7E panels had many adverse characteristics, relative to surface displacements.
- Best surface stability areas are [1] located where probable surface compression exists, such as in canyon heads and [2] obtained by orienting the panels perpendicular to adjacent cliff areas.
- The 9W/10W panels are properly located and oriented such that surface damage in the sandstone cliffs should be minimal to non-existent.
- A surface displacement monitoring program is needed for the 9W/10W panels to check on any possible surface movements during the mining of the first 1000 feet of panel.

INTRODUCTION

A surface stability evaluation for the 6th East/7th East and 9th West/10th West longwall panels at the Cottonwood Mine, Emery County, Utah is the subject of this report. The study was originally requested by Mr. James Hislop, Chief Mining Engineer, Utah Power & Light Company.

The Cottonwood Mine is located on the west side of Grimes Wash and longwall mining is taking place under East Mountain. Since September of 1986, mining has been concentrated in the 6th East(6E) panel and subsequently, in 1987, in the 7th East(7E) panel. The longwall mining has resulted in surface subsidence along the north side of Newberry Canyon. The subsidence is particularly pronounced in the Castle Gate Sandstone cliffs, which are located approximately 800 feet vertically above the Hiawatha coal seam and the mining panels. Failures along the sandstone cliffs are of particular concern to Utah Power & Light Company (UP&L) because eagle nesting sites are known to exist in certain of the cliff areas. If possible, it is desired that such eagle nesting sites remain undisturbed. Near-future mining is planned in longwall panels designated 9th West(9W) and 10th West(10W), which are located adjacent to Miller Canyon approximately 2 miles west of the 6E/7E panels as shown in Figure 1. Owing to the fact that the 9W/10W panels will be under and adjacent to Castle Gate Sandstone cliffs in Miller Canyon, the possibility of surface subsidence in the cliffs and any related eagle nesting areas exists. In order to evaluate the present mining plans and the related surface stability, Seegmiller International(SEEGMILLER) was retained to perform an analysis of the situation. The present report is the culmination of that analysis.

The basic purposes of the study and of this report are to [1] assess the mining plans, [2] analyze surface geologic discontinuities and related geotechnical characteristics, [3] compare similarities/differences between 6E/7E panels and 9W/10W panels, [4] predict/evaluate future surface stability in the 9W/10W panel area and [5] make any necessary remedial modifications/recommendations to improve future surface stability. The study has involved two site visits, computer analysis of field data and the evaluation of probable field tensile/compression zones, panel orientation and geotechnical characteristics.

The report first presents the field data and their analyses. Prediction/evaluation, relative to mine layout, potential problem zones and minimal damage zones, is then given. Recommended remedial measures complete the report. Discontinuity computer analyses examples are appended.

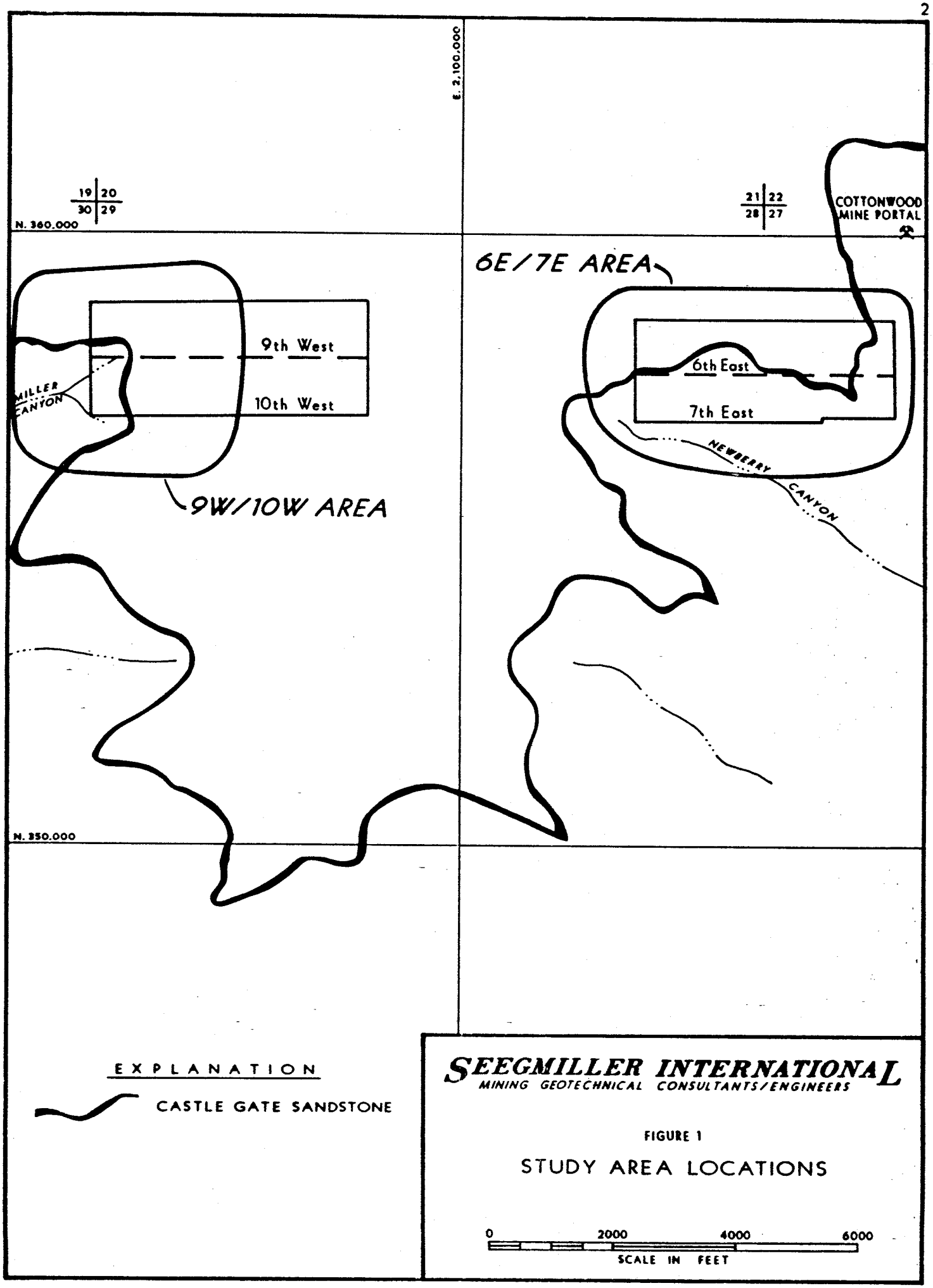


FIGURE 1

STUDY AREA LOCATIONS

MINING PLANS

6E/7E PANELS

A general plan view of the 6E/7E Panels, showing the approximate surface expression of Castle Gate Sandstone in the Newberry Canyon area, is given in Figure 2. The 6E/7E longwall panels were located such that the surface exposure of the Castle Gate Sandstone is approximately parallel to the panel lengths and is above the central portion of these panels. A north-south section across the panels is shown in Figure 3.

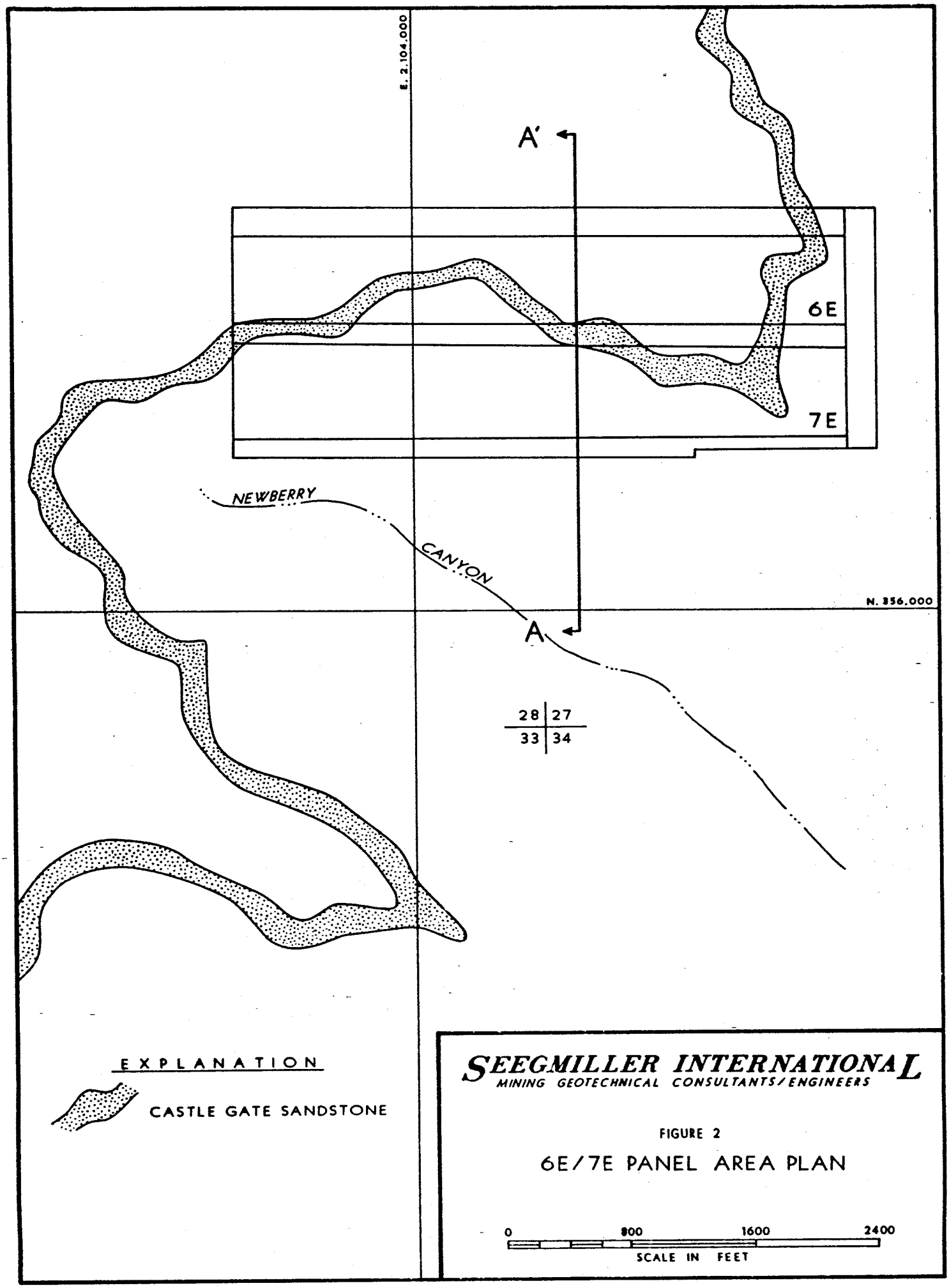
9W/10W PANELS

The general relationship of the 9W/10W panels and the surface expression of the Castle Gate Sandstone is shown in Figure 4. The original plan for these panels called for them to continue in the west direction under Miller Canyon for some 1100 additional feet. However, recent evaluations of coal quality dictated that the panels be ended at Crosscut 49. Crosscuts 50 and 51 now form the bleeders on the west end, as shown in the plan view and in Section BB', which is presented in Figure 5.

FIELD DATA REVIEW/ANALYSIS

MAPPING PROGRAM

Seegmiller Data. Over a two-day period geological discontinuities were examined in the field. One day was spent in the 6E/7E area where discontinuities and geotechnical characteristics were noted in two distinct sites. The first site was on the west slope


E. 2,104,000
A'
6E
7E
NEWBERRY
CANYON
N. 356,000
A
28 27
33 34
EXPLANATION
CASTLE GATE SANDSTONE
SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
FIGURE 2
6E/7E PANEL AREA PLAN
0 800 1600 2400
SCALE IN FEET

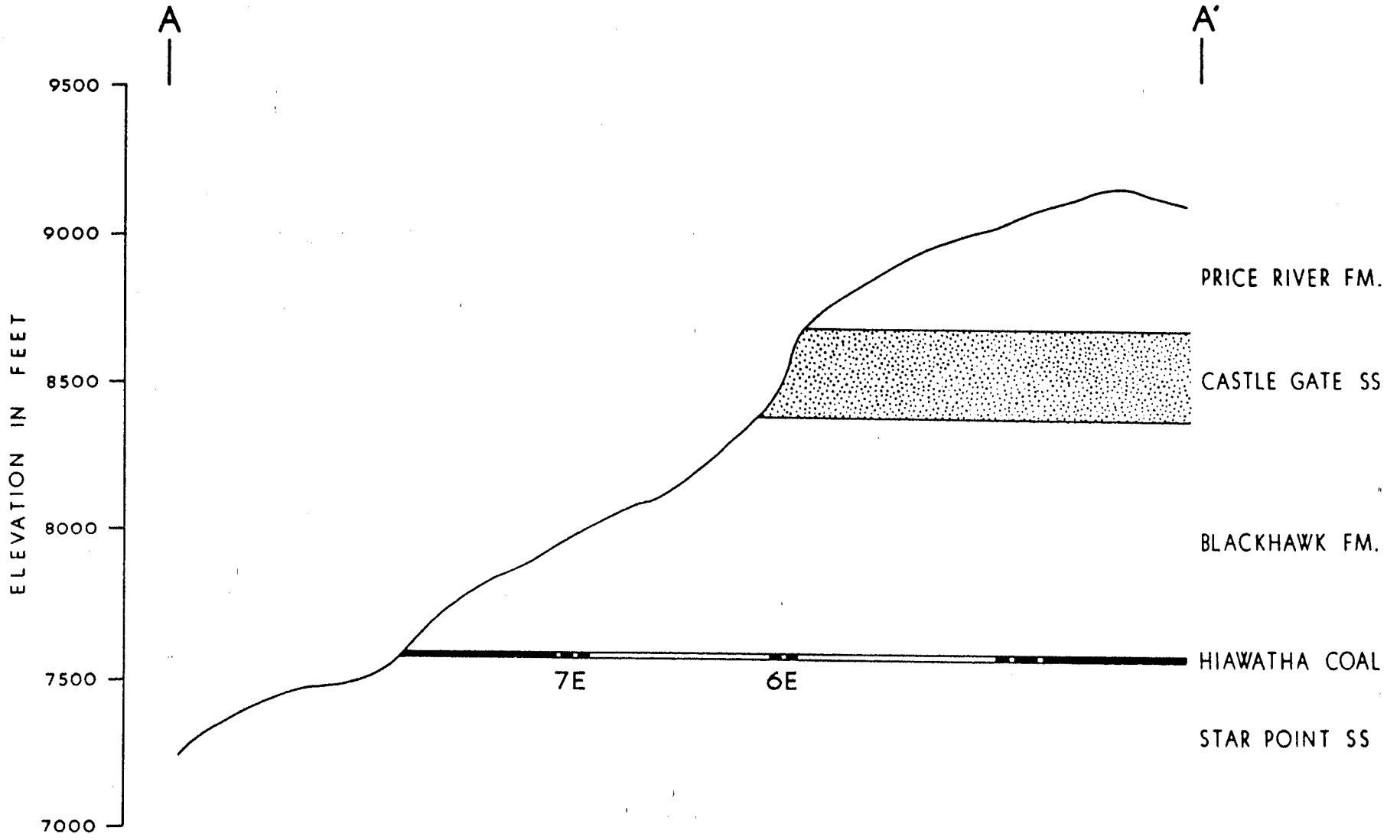
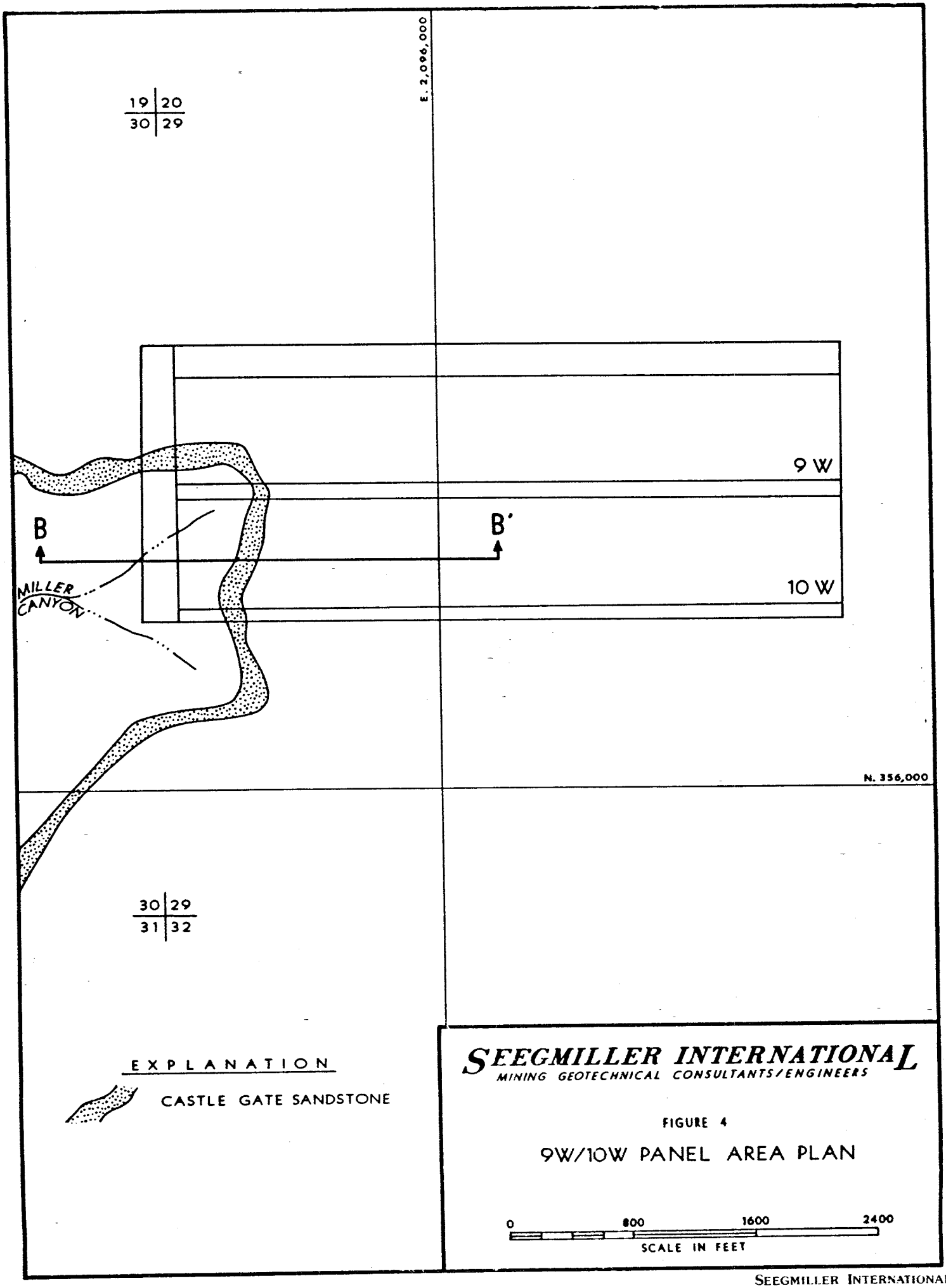


FIGURE 3

6E / 7E PANEL AREA SECTION AA'


E. 2,096,000
19 | 20
30 | 29
9 W
10 W
B
B'
MILLER CANYON
N. 356,000
30 | 29
31 | 32
EXPLANATION
CASTLE GATE SANDSTONE
SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
FIGURE 4
9W/10W PANEL AREA PLAN
0
800
1600
2400
SCALE IN FEET

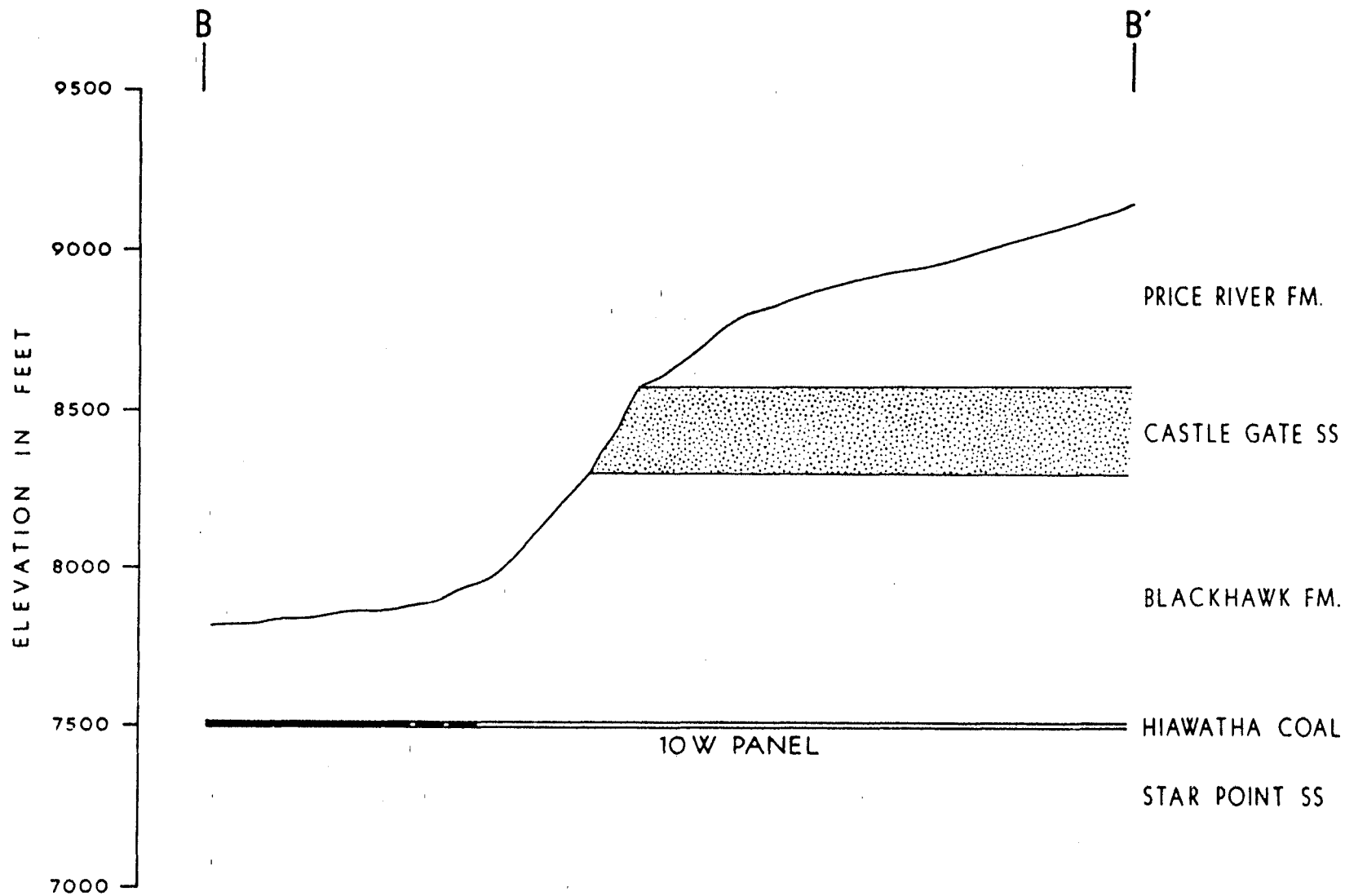


FIGURE 5

9W/10W PANEL AREA SECTION BB'

of Grimes Wash and was designated Site 1. The second site, Site 2, was located along the Castle Gate Sandstone cliff areas on the north slope of Newberry Canyon. A second day was spent in Miller Canyon above the proposed 9W/10W panel area. Discontinuities and related geotechnical characteristics were noted in the general area designated as Site 3. The three sites are located as shown in Figure 6. Specific data collected, relative to geologic discontinuities, included spacial orientation, discontinuity type, strike and dip continuity, relative roughness, Joint Roughness Coefficient(JRC) and spacing.

Cottonwood Data. Discontinuity data were collected by UP&L geologists using the SEEGMILLER format. The data came from six mapping sites along the Castle Gate Sandstone exposures on the south end of East Mountain, as shown in Figure 7. Specific items noted for each discontinuity included spacial orientation, discontinuity type, strike and dip continuity, relative roughness, spacing and rock hardness.

DISCONTINUITIES ANALYSIS

Seegmiller Data. The data from the 6E/7E area(Sites 1 and 2) have been analyzed and compared to the data from the 9W/10W area (Site 3). For each area, a Schmidt net and a characteristic data analysis were produced. The 6E/7E area had one major discontinuity set and one moderate/minor discontinuity set as follows:

Major	—	N 75° ± 20° W;	90° ± 10°
Moderate/Minor	—	N 07° ± 05° E;	90° ± 03°

The 9W/10W area had a much smaller data base, but had one distinct major set as follows:

N 22° ± 10° E; 90° ± 07°

The characteristic analysis shows only one significant difference, and that is in the strike continuity. The 6E/7E area has approximately a 50% greater strike continuity than the 9W/10W area. The Schmidt nets and characteristic analyses details are presented

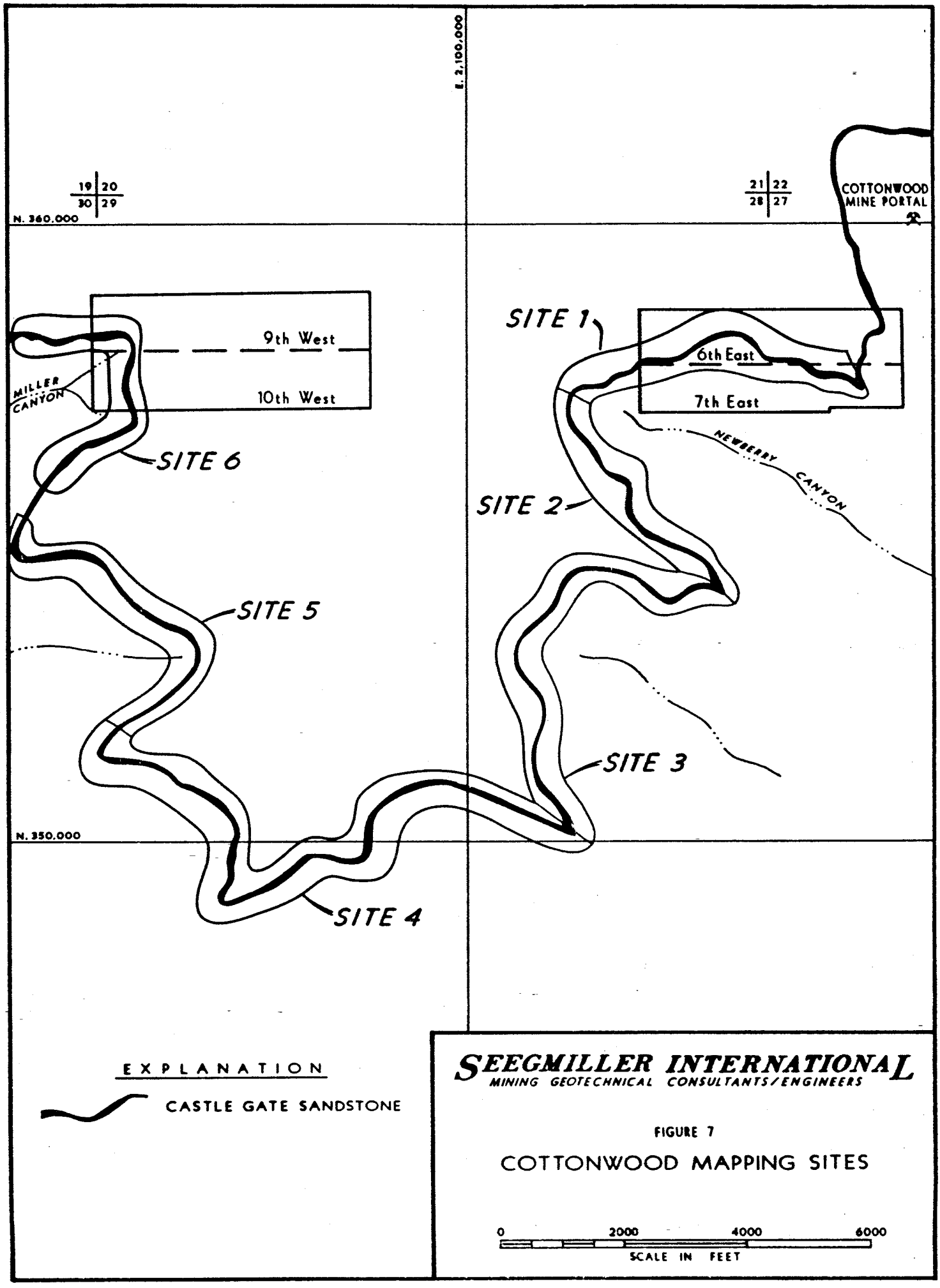


FIGURE 7

COTTONWOOD MAPPING SITES

in Appendix I.

Cottonwood Data —Site 1 versus Site 6. The data from Site 1 were the closest to the 6E/7E area, and they were analyzed by Schmidt net and for geotechnical characteristics. The results show that one major set and one minor set exist as follows:

Major — N 05° ± 10° W; 90° ± 05°
Minor — N 90° ± 25° E; 85° ± 10° S

The 9W/10W area was located in the area of Site 6. It has one major set as follows:

N 22° ± 10° E; 90° ± 10°

The characteristics from both areas were very similar and no significant differences were noted. The details of the computer analyses are presented in Appendix II.

Cottonwood Data – Sites 1 & 2 versus Sites 5 & 6. Sites 1 and 2 represent data collected in the eastern area near 6E/7E and, together, have a variety of slope strikes. Sites 5 and 6 represent data collected in the western area near 9W/10W and, together, have slope strikes which are quite variable. Such a comparison of sites may help to eliminate possible mapping bias that always exists when mapping on a slope striking in one direction only. Sites 1 and 2 have one major set and one minor set as follows:

Major — N 05° ± 10° W; 90° ± 07°
Minor — N 90° ± 25° E; 85° ± 07° S

The discontinuities of Sites 5 and 6 indicate one major set and one minor set as follows:

Major — N 25° ± 12° E; 90° ± 10°
Minor — N 85° ± 20° W; 85° ± 10° W

The geotechnical characteristics evaluation shows that the continuities of Sites 1 and 2 are approximately 60% greater than those of Sites 5 and 6. The spacings of Sites 1 and 2 are more than twice the spacings of Sites 5 and 6. Further, the sandstone at Sites 1 and 2 is distinctly softer than those sandstones examined at Sites 5 and 6. Analyses details in terms of the computer output are presented in Appendix III.

Cottonwood Data – South-Dipping Slopes versus West-Dipping Slopes. A comparison of slopes, which have south dips, was made with slopes having west dips. The south-dipping slopes have two major sets which are as follows:

N 10° ± 10° W; 90° ± 07°
N 82° ± 20° E; 87° ± 03° E

The west-dipping slopes have one major set and one moderate set as follows:

Major — N 25° ± 15° E; 90° ± 10°
Moderate — N 25° ± 10° W; 77° ± 04° W

Comparing characteristics of the two, it is found that the only significant difference exists in the spacing. The west-dipping slopes have a spacing which is approximately 50% larger than the south-dipping slopes. Details of the analyses are given in Appendix IV.

Analysis Discussion. The Schmidt net analyses show that almost all data have essentially vertical dips. In very minor cases, some discontinuities dip very steeply to the south. The SEEGMILLER data show that a major N 75° W discontinuity set is found in the 6E/7E area, whereas the Cottonwood data indicate a major N 05° W set. The reason for this difference is not completely understood and, such a difference may be due to mapping method or to actual mapping site differences. The SEEGMILLER data were, in part, collected on the east dipping slope in Grimes Wash and high angle discontinuities such as the N 75° W set would have been more predominant. The Cottonwood data were collected along the south dipping slope of Newberry Canyon where again high angle discontinuities such as the N 05° W set would have been more predominant. In the 9W/10W area, excellent agreement is found between SEEGMILLER data and Cottonwood data. The only

major discontinuity set, which is found, is the N 22°-25° E set. The west-dipping slopes agree well with the data found in the 9W/10W area. The south-dipping slopes show two major orthogonal sets, which loosely approximate other data found in the 6E/7E area. The geotechnical characteristics of 6E/7E discontinuities are similar in many ways to the south-dipping slopes, but 6E/7E discontinuities may have greater continuities, spacings and the host sandstones may be softer. West-dipping slopes apparently have greater discontinuity spacings than south-dipping slopes. In summary, the following may be stated about the discontinuities analyses:

- The N 22° E discontinuity set found to predominate in the 9W/10W areas exists only as a very minor set in the 6E/7E area.
- The two major discontinuity sets, N 75° W and N 05° W, found above 6E/7E do not appear to exist above 9W/10W.
- The geotechnical characteristics of the discontinuities appear to present a mixed-bag of results. Little can be stated with certainty, relative to strength differences from the 6E/7E area to the 9W/10W area, except that the discontinuities above the 6E/7E panels probably have greater continuities and could more easily be involved with surface instability.

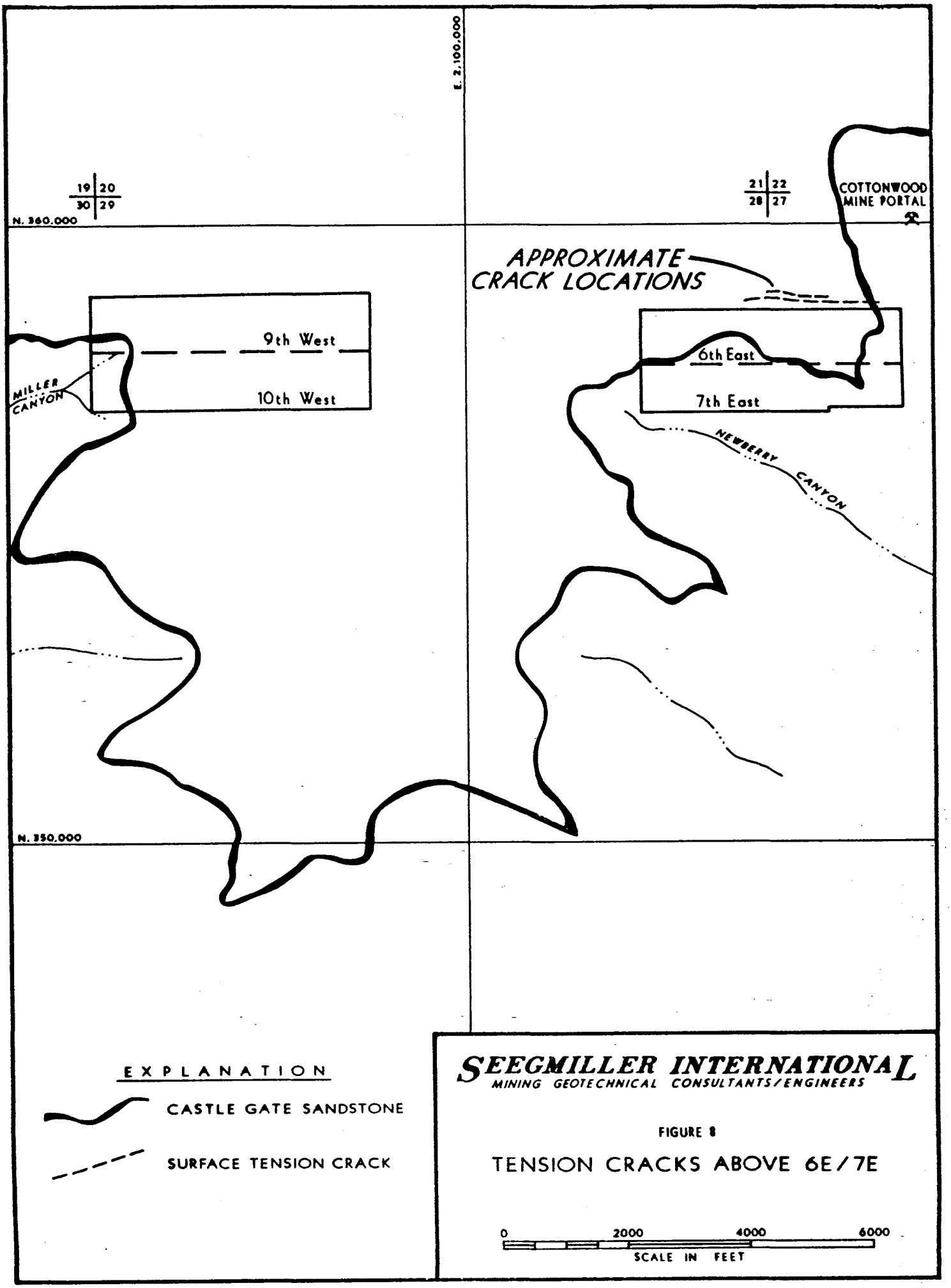
OBSERVATIONAL DATA: 6E/7E AREA

Discontinuities. The geologic discontinuities of concern are the joints, which occur at relatively high angles to the flat-lying stratigraphic bedding planes. A site examination along the top of the Castle Gate Sandstone in August of 1987 indicated that the joints typically were of two sets. The first set, a major set, had a strike of approximately N 75° W, while the second, a minor set, had a strike of approximately N 10° E. Both sets

had approximately vertical dips. Spacings were on the order of 10 to 20 feet and continuities of 20 feet or more were common. In general, the discontinuities combined to give the area a definite and distinct large blocky appearance.

Geotechnical Characteristics. The area, as a whole, has fairly strong sandstone with estimated intact compressive strengths on the order of 6000 to 8000 psi. The rock mass, however, has the appearance in many places of being blocky and possibly more open and loose. This is due, in part, to the probable tensile condition prevailing along the cliffs in the 6E/7E area. A tensile zone commonly occurs in plateau cliffs which form a convex shape. In effect, there are no confining stresses on the sides of the cliffs on a convex point and the rock mass tends to be in a more open and loose state, as a whole.

Failure Modes. The observed failure modes along the Castle Gate Sandstone cliffs on the north side of Newberry Canyon appear to include [1] rock falls, [2] toppling failure and [3] foundation failure and related slumping/toppling. In addition, major surface tension cracks have formed above the 6E/7E panel area and are located as shown in Figure 8. The rock fall failures have occurred where blocks of rock have been bounded by discontinuities. Subsurface movements have allowed these blocks to be freed on all sides, and they have simply fallen as a result of gravity. The toppling failures have occurred where relatively long and slender blocks of rock existed. These long and slender blocks are the result of relatively continuous vertical joints with spacings on the order of 5 to 10 feet. The blocks remain stable as long as their weight vectors pass through their lowermost horizontal surface. When a subsurface movement occurs and the weight vector is shifted to the interface of the base and a vertical joint, located on the canyon side of the block, the block tilts and topples into the canyon. Foundation failure and related slumping/toppling can occur where a shale is found at the base of the Castle Gate Sandstone or where a major shaly interbed exists within the sandstone. In effect, a subsurface movement causes a large block of rock to lose the previously existing shear resistance from adjacent blocks or the in-place rock that held it in place. The block then exerts a larger bearing load on the underlying shale and eventually a foundation failure occurs in the shale. Once the foundation failure begins, the block may simply slump to a more stable position or it could rotate either outward or to the side and toppling could occur. The major surface tension cracks were formed as a result of classical subsidence as the underlying longwall panels were pulled. Of particular importance is that these major surface tension cracks form parallel to the long direction of the panel.


E. 2,100,000
19 20
30 29
N. 360,000
21 22
28 27
COTTONWOOD MINE PORTAL
APPROXIMATE CRACK LOCATIONS
9th West
10th West
MILLER CANYON
6th East
7th East
NEWBERRY CANYON
N. 350,000
EXPLANATION
CASTLE GATE SANDSTONE
SURFACE TENSION CRACK
SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
FIGURE 8
TENSION CRACKS ABOVE 6E/7E
0
2000
4000
6000
SCALE IN FEET

No similar surface cracks are known to have occurred perpendicular to the panels in the north-south direction. Displacements of up to 5 feet were noted toward the central and west end of the cracks. Minimum displacements of only inches were noted toward the east end of the cracks in the Castle Gate Sandstone.

OBSERVATIONAL DATA: 9W/10W AREA

Discontinuities. The cliff discontinuities on the north side of Miller Canyon appear to predominantly strike N 20° E and have essentially vertical dips. They have spacings on the order of 20 to 50 feet and continuities in excess of 50 feet. A few discontinuities striking N 70° W were observed toward the west end of the north canyon side. The east and south cliff slopes of Miller Canyon have far fewer observable discontinuities. The only major set noted strikes about N 15° E and has an approximately vertical dip. Spacings are on the order of 10 feet and continuities are up to 50 feet, but only in one direction. In the other direction, the rock is solid and massive.

Geotechnical Characteristics. The north side of Miller Canyon has a gross blocky nature to the cliffs in some areas and yet appears quite massive in others. The Castle Gate Sandstone has portions which are very solid for hundreds of vertical feet and no shaly interbeds are found. The east and south slopes have portions which are very massive with essentially no joints cutting them. Weathering has caused irregular erosion to occur in several large areas and the sandstone has a carved and sculptured appearance. Small, and even large blocks are not obvious when looking perpendicular to these slopes. Some slabs are noted, however, when a view parallel to the slope strike is made. General compressive strengths of intact cliff sandstone are estimated to be on the order of 7500 psi. The rock mass tends to generally appear tight and solid. This would be due, in part, to the fact that the head of Miller Canyon has a probable compressive condition prevailing along the cliffs adjacent to the 9W/10W panels. A compressive condition is commonly found where a concave zone exists in plateau cliffs. In effect, the surrounding rocks are all giving confining stresses to the plateau cliffs because yielding cannot occur except along a single plateau face. The rock is, therefore, tighter and more compact as a whole.

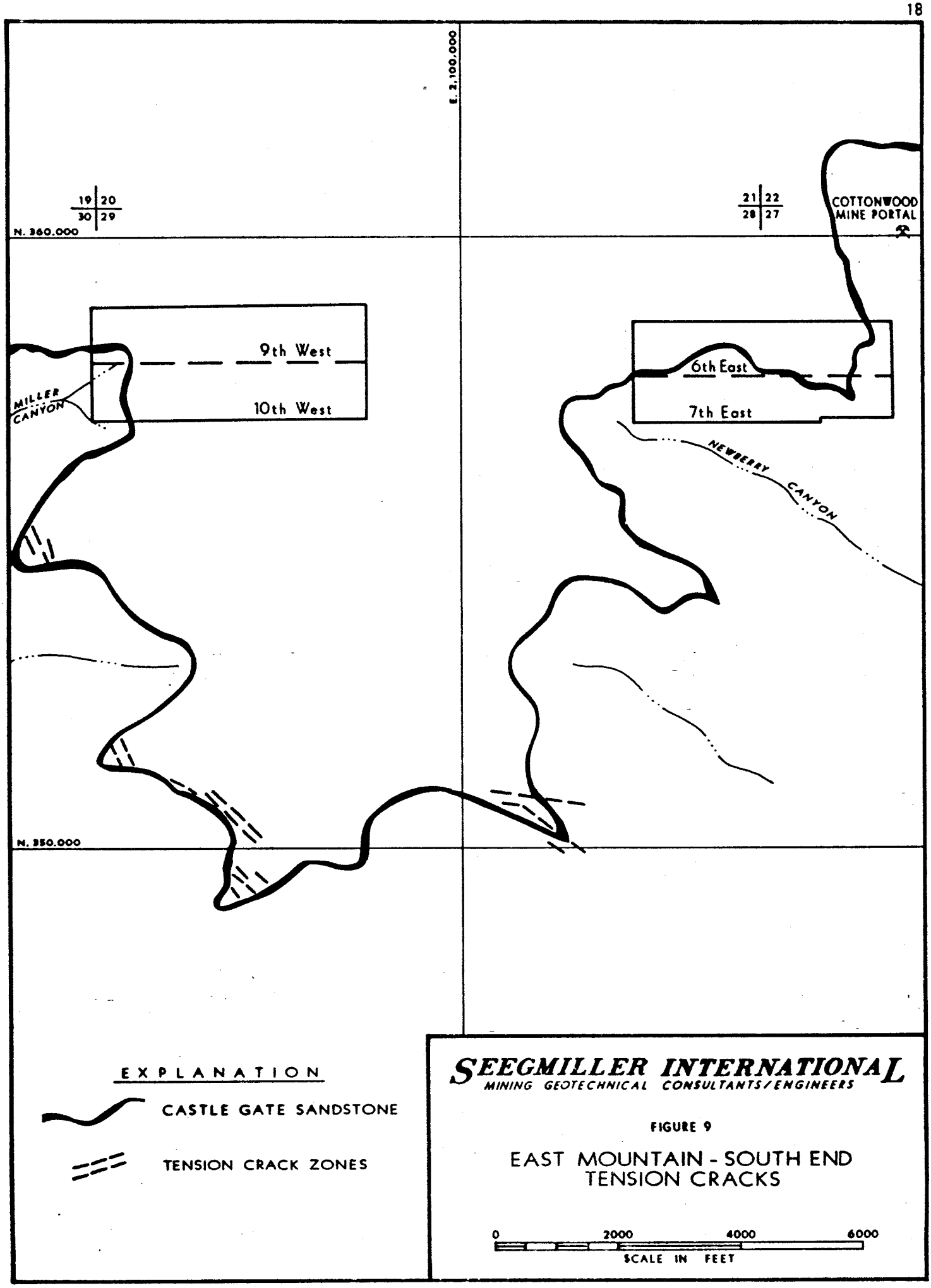
East Mountain - South End(unmined areas)

In September, a second field visit was made to the study areas. The second visit involved viewing the Castle Gate Sandstone cliffs from a helicopter. In addition to viewing the two study areas, the entire cliff area along the south end of the East Mountain plateau was observed in some detail. The most important observation made was that major tension cracks already exist along much of the convex cliff areas where a probable tensile condition prevails. General zones where tension cracks were observed are shown in Figure 9. The tension cracks generally trend northwest-southeast. They have continuities on the order of up to hundreds of feet. In effect, what is being observed is the natural geologic phenomenon of mountain erosion and breakup that goes on constantly throughout the world. The heads of the canyons, where a probable compressive condition prevails, were observed to generally be more solid, massive and stable.

PREDICTION/EVALUATION

Mine Layout Effects

6E/7E Panels. The layout of 6E/7E could not really have been much worse for surface stability. Most importantly, a major portion of these panels is under a probable tension zone on a convex Castle Gate Sandstone cliff area. Further, the long direction of the panels is almost parallel to the strike of the cliff. Classic subsidence theory predicts that maximum surface subsidence will be noted down the length of the panel as opposed to the zone beyond the start-up room at the end of the panel. The major surface tension crack noted above the panels is evidence of subsidence parallel to the panel length. No subsidence was noted beyond the end of the panel eastward in Grimes Wash. Another problem with the layout is that a major discontinuity set(N 75° W) essentially parallels the panels and the cliff. These relatively long discontinuities have formed two sides of almost all toppling mode failures found on the north side of Newberry Canyon. The blocky nature of the cliff sandstones also has contributed to their expansion and subsequent failure by one or more modes. Consequently, the surface disturbance in the Castle Gate Sandstone


E. 2,100,000
19 20
30 29
N. 360,000
21 22
28 27
COTTONWOOD MINE PORTAL
9th West
10th West
MILLER CANYON
6th East
7th East
NEWBERRY CANYON
N. 350,000
EXPLANATION
CASTLE GATE SANDSTONE
TENSION CRACK ZONES
SEEGMILLER INTERNATIONAL
MINING GEOTECHNICAL CONSULTANTS/ENGINEERS
FIGURE 9
EAST MOUNTAIN - SOUTH END
TENSION CRACKS
0
2000
4000
6000
SCALE IN FEET

cliffs above the 6E/7E panels was easily triggered by the subsurface subsidence, as longwall mining took place.

9W/10W Panels. The layout of these panels is very good for minimal disturbance to the Castle Gate Sandstone cliffs. The reasons for this include the fact that the panels are located at the head of Miller Canyon under a probable compression, or concave, cliff area. The cliff sandstones are relatively tight and massive at the canyon head indicating lateral confinement. Secondly, the panels are oriented directly away from the cliff area. Classical subsidence theory indicates that the maximum subsidence will occur down the length of the panels with very little subsidence over the panel ends where good buttressing and lateral resistance are located. Mining of 6E/7E panels showed that very little subsidence occurred at the east panel end, even when the sandstone cliff zone was located in a probable tensile zone. Therefore, very little, if any, surface disturbance should occur in the 9W/10W zone adjacent to the panel end. The tight, massive nature of the Castle Gate Sandstone in the Miller Canyon area should keep it together, as a single unit, much better than the blocky cliff zones above the 6E/7E panel. Only one major discontinuity set appears in the east and south slopes of Miller Canyon. That discontinuity set strikes N 25° E and should be perpendicular to the major direction of mining and subsidence. Displacements on the major discontinuity set are expected to be relatively minor.

Potential Problem Zones

Potential future problem zones will be those in probable tensile zones or convex cliff areas. Mining should be avoided under such zones, if sandstone cliff zones are to have minimal damage. These probable tensile zones already have major tension cracks in most of them. Any subsurface displacement will likely cause surface movements and possible cliff failures. In addition, panels oriented parallel to any cliff zone, particularly if it is inside the surface trace of a 20° draw angle, will likely have surface displacement and related sandstone cliff damage. The 20° angle of draw generally exceeds actual past angles of draw found to exist in the area. An additional aggravating factor is to have a major discontinuity set paralleling the panel length when that panel is parallel to the adjacent slope. The worst problem areas will probably be those in convex cliff zones oriented parallel to the cliffs with major discontinuity sets parallel to the panel.

MINIMAL DAMAGE ZONES

The best surface stability will occur adjacent to probable compressive zones where the cliff area is concave-shaped, such as at the head of a canyon. Minimal damage should prevail in the surface sandstone cliffs when the panels are oriented perpendicular to the cliffs. Such perpendicular orientation should be especially good if the panel is less than about 500 feet out beyond the vertical projection of the sandstone cliff. Major discontinuity sets oriented perpendicular to the panel may have less disturbing effects on sandstone cliffs also oriented perpendicular to the panel. Exceptions may be found as to the best orientation for a major discontinuity set because other factors, including panel orientation and panel location, may outweigh the discontinuity orientation factor.

RECOMMENDED REMEDIAL MEASURES

The remedial measures for the 9W/10W panel area are few, because the present location and orientation are already very good for minimizing damage to the surface cliff exposures of Castle Gate Sandstone. The general location under the head of a canyon, where a probable surface compression zone exists, is very good. In addition, the orientation is also very good because it is perpendicular to the cliff sandstone at the head of the canyon. Also favorable is the orientation of the major discontinuity set, which is perpendicular to the length of the panel. Only one improvement could be made and that would be to have careful surface monitoring of the Castle Gate Sandstone shortly before and during the pulling of the first 1,000 feet of panel. Such monitoring would apply to both the 9W and 10W panels. The recommended monitoring means are twofold. First, it is recommended that detailed visual monitoring be used, as well as recording the sandstone cliff conditions with still photography. A series of photos of the area should be taken periodically from several fixed points. Secondly, it is recommended that several glass prisms be strategically placed on key cliff areas. These glass prisms may be located in X, Y and Z coordinates to the nearest 1/10 inch using a light-ranging instrument. Periodic measurements would give a very accurate measurement of any movements as a function of mining advances. Such documented monitoring would serve to provide hard evidence to back up the conclusions of the present study.

APPENDIX I

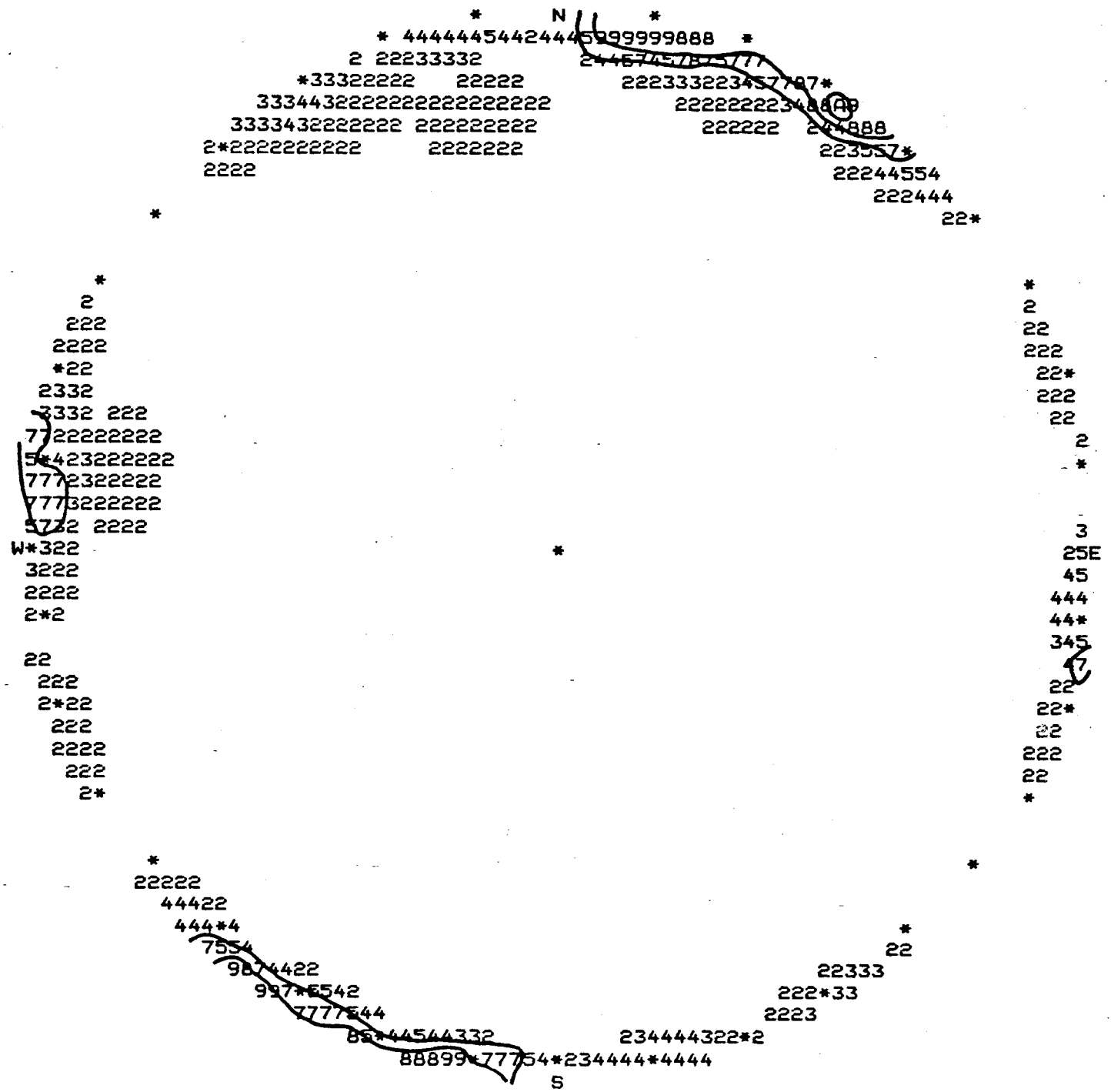
SEEGMILLER DISCONTINUITY ANALYSIS

Schmidt Nets & Characteristic Statistics

6 E / 7 E AREA

SEEGMILLER DATA - SITES 1&2: 6E/7E AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
34 OBSERVATIONS. HIGHEST LEVEL COUNT IS 8



SEEGMILLER DATA - SITES 1&2: 6E/7E AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 0	.00 - 2.35
2	1 - 1	2.35 - 4.71
3	2 - 2	4.71 - 7.06
4	3 - 3	7.06 - 9.41
5	4 - 4	9.41 - 11.76
6	5 - 4	11.76 - 14.12
7	5 - 5	14.12 - 16.47
8	6 - 6	16.47 - 18.82
9	7 - 7	18.82 - 21.18
A	8 - 8	21.18 - 23.53

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
34 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 32 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	0	.0
7	60.0 - 70.0	0	.0
8	70.0 - 80.0	2	5.9
9	80.0 - 90.0	32	94.1

DISCONTINUITY TYPE	
JOINT	70.6%
TENSION CRACK	29.4%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	29.4%
DEFINED RIDGES	47.1%
SMALL STEPS	5.9%
VERY ROUGH	5.9%
NO DATA	11.8%

ESTIMATED JRC	
0 - 2	.0%
3 - 4	.0%
5 - 6	.0%
7 - 8	26.5%
9 - 10	20.6%
11 - 12	23.5%
13 - 14	5.9%
15 - 16	.0%
17 - 18	5.9%
19 - 20	5.9%
20 <	.0%
NO DATA	11.8%
MEAN	11.1
STD. DEV.	3.5

SPACING (FT)	
< .50	.0%
.50- 1.00	.0%
1.00- 2.00	.0%
2.00- 3.00	2.9%
3.00- 4.50	.0%
4.50- 6.00	20.6%
6.00- 9.00	5.9%
9.00-12.00	17.6%
12.00<	41.2%
NO DATA	11.8%
MEAN	19.3
STD. DEV.	24.3

ROCK TYPE: SANDSTONE

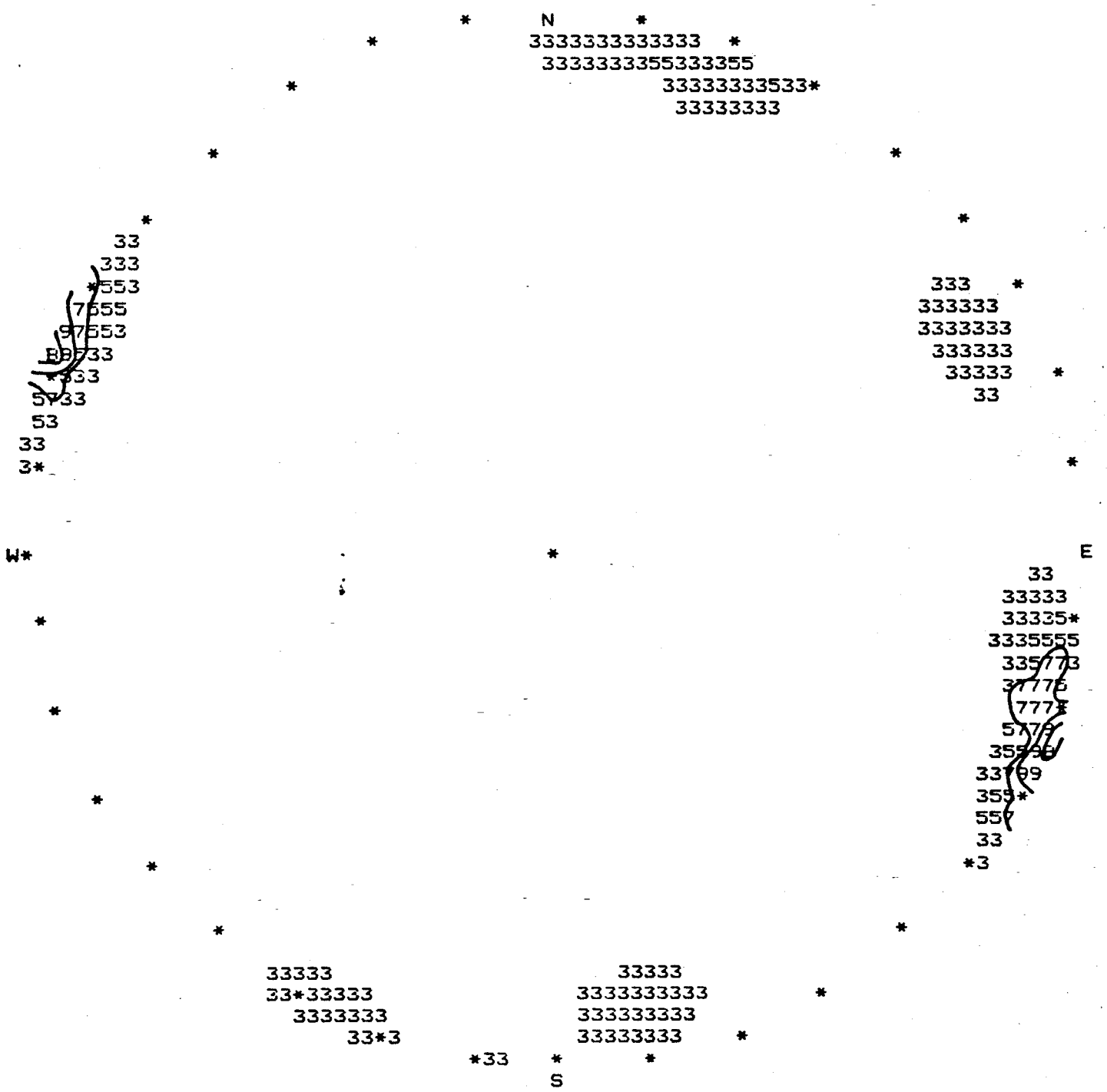
HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
< 3	.0%	.0%
3- 6	8.8%	14.7%
6- 15	38.2%	52.9%
15- 30	29.4%	20.6%
30- 45	2.9%	.0%
45- 75	2.9%	.0%
75-150	5.9%	.0%
150-300	.0%	.0%
300<	.0%	.0%
NO DATA	11.8%	11.8%
MEAN	23.0	13.7
STD. DEV.	22.9	6.5

9 W / 10 W AREA

SEEGMILLER DATA - SITE 3: 9W/10W AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
11 OBSERVATIONS. HIGHEST LEVEL COUNT IS 5



SEEGMILLER DATA - SITE 3: 9W/10W AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 0	.00 - 4.55
2	1 - 1	4.55 - 9.09
3	2 - 1	9.09 - 13.64
4	2 - 2	13.64 - 18.18
5	3 - 2	18.18 - 22.73
6	3 - 3	22.73 - 27.27
7	4 - 3	27.27 - 31.82
8	4 - 4	31.82 - 36.36
9	5 - 4	36.36 - 40.91
A	5 - 5	40.91 - 45.45
B	6 - 5	45.45 - 50.00

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
11 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 9 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	0	.0
7	60.0 - 70.0	0	.0
8	70.0 - 80.0	2	18.2
9	80.0 - 90.0	9	81.8

DISCONTINUITY TYPE	
JOINT	100.0%
TENSION CRACK	.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	54.5%
DEFINED RIDGES	45.5%
SMALL STEPS	.0%
VERY ROUGH	.0%
NO DATA	.0%

ESTIMATED JRC	
0 - 2	.0%
3 - 4	.0%
5 - 6	.0%
7 - 8	54.5%
9 - 10	18.2%
11 - 12	27.3%
13 - 14	.0%
15 - 16	.0%
17 - 18	.0%
19 - 20	.0%
20 <	.0%
NO DATA	.0%
MEAN	9.3
STD. DEV.	2.0

SPACING (FT)	
< .50	.0%
.50- 1.00	.0%
1.00- 2.00	.0%
2.00- 3.00	.0%
3.00- 4.50	.0%
4.50- 6.00	.0%
6.00- 9.00	27.3%
9.00-12.00	36.4%
12.00<	36.4%
NO DATA	.0%
MEAN	15.0
STD. DEV.	12.2

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
< 3	.0%	.0%
3- 6	9.1%	.0%
6- 15	54.5%	72.7%
15- 30	27.3%	27.3%
30- 45	9.1%	.0%
45- 75	.0%	.0%
75-150	.0%	.0%
150-300	.0%	.0%
300<	.0%	.0%
NO DATA	.0%	.0%
MEAN	16.9	15.3
STD. DEV.	10.7	5.9

A P P E N D I X I I

COTTONWOOD DISCONTINUITY ANALYSIS

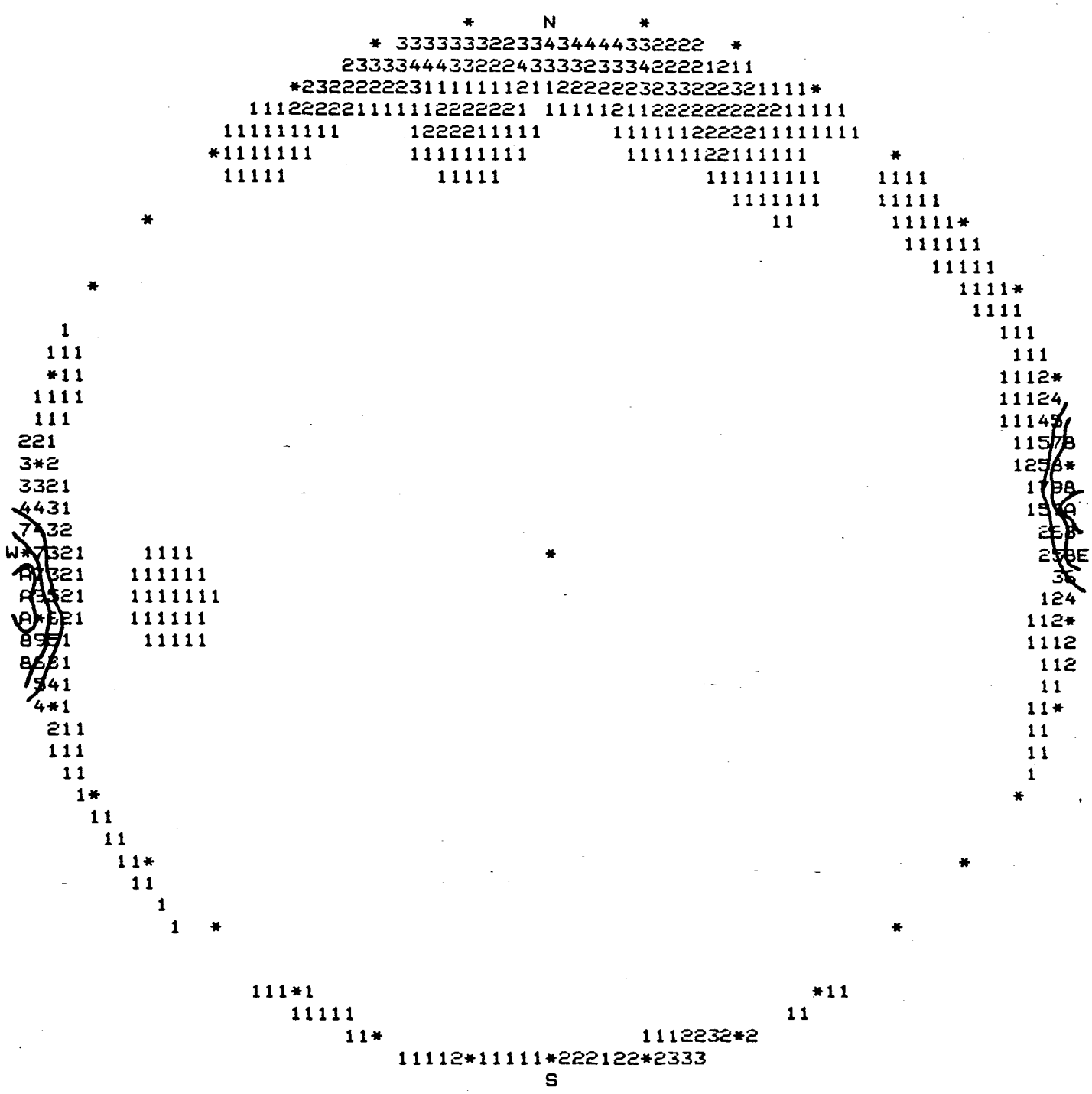
SITE 1 versus SITE 6

Schmidt Nets & Characteristic Statistics

SITE 1 – 6 E / 7E AREA

COTTONWOOD DATA - SITE 1: 6E/7E AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
58 OBSERVATIONS. HIGHEST LEVEL COUNT IS 22



COTTONWOOD DATA - SITE 1: 6E/7E AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 2	.00 - 3.79
2	3 - 4	3.79 - 7.59
3	5 - 6	7.59 - 11.38
4	7 - 8	11.38 - 15.17
5	9 - 11	15.17 - 18.97
6	12 - 13	18.97 - 22.76
7	14 - 15	22.76 - 26.55
8	16 - 17	26.55 - 30.34
9	18 - 19	30.34 - 34.14
A	20 - 22	34.14 - 37.93

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
58 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 49 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	0	.0
7	60.0 - 70.0	2	3.4
8	70.0 - 80.0	7	12.1
9	80.0 - 90.0	49	84.5

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	96.6%
DEFINED RIDGES	.0%
SMALL STEPS	.0%
VERY ROUGH	3.4%
NO DATA	.0%

SPACING (FT)	
< .50	1.7%
.50- 1.00	12.1%
1.00- 2.00	20.7%
2.00- 3.00	27.6%
3.00- 4.50	5.2%
4.50- 6.00	8.6%
6.00- 9.00	5.2%
9.00-12.00	10.3%
12.00<	5.2%
NO DATA	3.4%
MEAN	4.6
STD. DEV.	4.4

ROCK TYPE: SANDSTONE

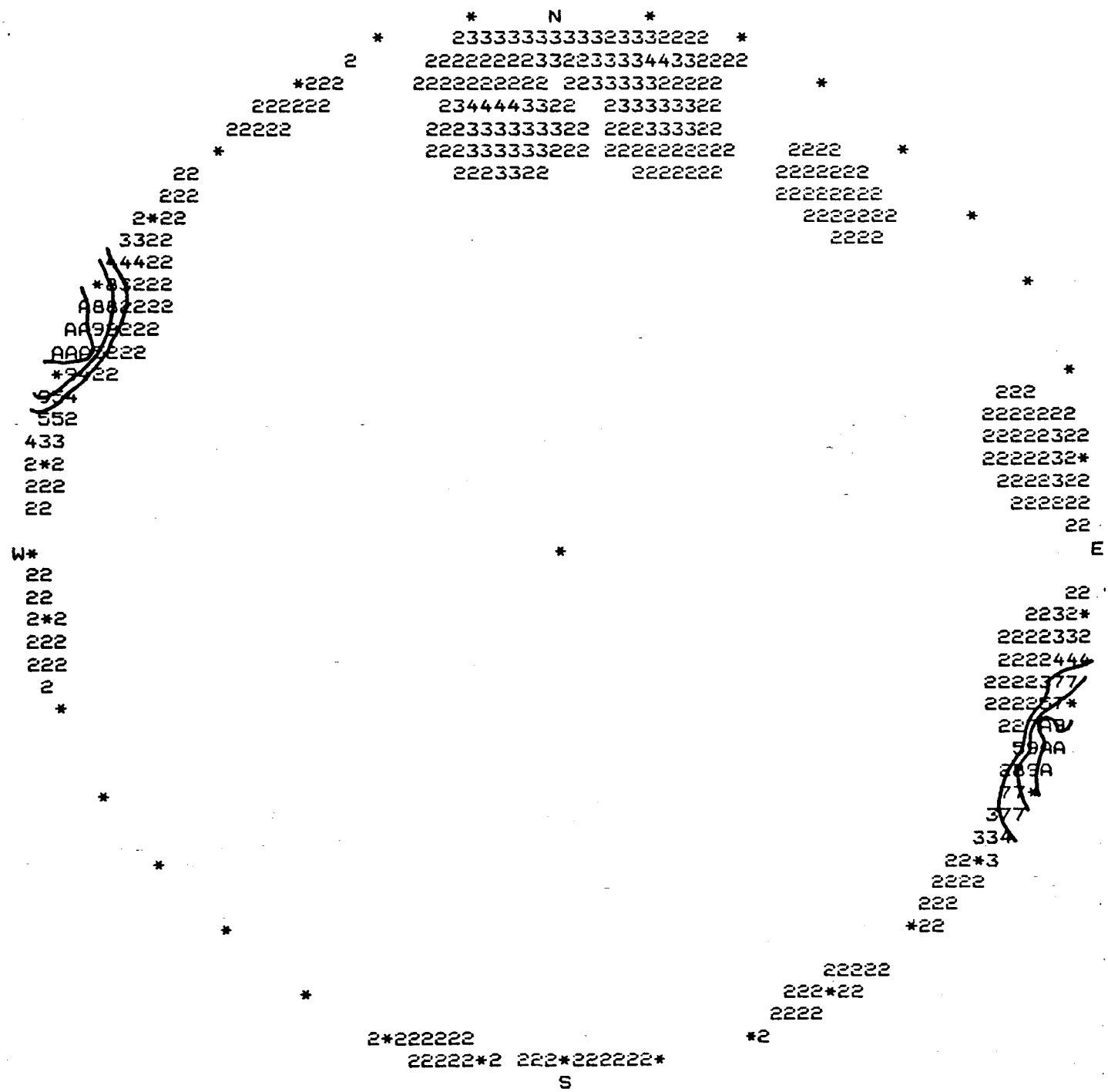
HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
< 3	13.8%	8.6%
3- 6	20.7%	25.9%
6- 15	43.1%	50.0%
15- 30	10.3%	10.3%
30- 45	1.7%	.0%
45- 75	.0%	1.7%
75-150	1.7%	1.7%
150-300	.0%	.0%
300<	.0%	.0%
NO DATA	8.6%	1.7%
MEAN	11.9	11.8
STD. DEV.	14.4	14.3

SITE 6 — 9 W / 10 W AREA

COTTONWOOD DATA - SITE 6: 9W/10W AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
24 OBSERVATIONS. HIGHEST LEVEL COUNT IS 8



COTTONWOOD DATA - SITE 6: 9W/10W AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT		PERCENTAGES	
1	1 -	0	.00 -	3.33
2	1 -	1	3.33 -	6.67
3	2 -	2	6.67 -	10.00
4	3 -	3	10.00 -	13.33
5	4 -	4	13.33 -	16.67
6	5 -	4	16.67 -	20.00
7	5 -	5	20.00 -	23.33
8	6 -	6	23.33 -	26.67
9	7 -	7	26.67 -	30.00
A	8 -	8	30.00 -	33.33

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
24 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 18 POINTS

NMBR	RANGE(DEGREES)		NUMBER	PERCENT
1	.0 -	10.0	0	.0
2	10.0 -	20.0	0	.0
3	20.0 -	30.0	0	.0
4	30.0 -	40.0	0	.0
5	40.0 -	50.0	0	.0
6	50.0 -	60.0	0	.0
7	60.0 -	70.0	3	12.5
8	70.0 -	80.0	3	12.5
9	80.0 -	90.0	18	75.0

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	100.0%
DEFINED RIDGES	.0%
SMALL STEPS	.0%
VERY ROUGH	.0%
NO DATA	.0%

SPACING (FT)	
(.50	.0%
.50- 1.00	20.8%
1.00- 2.00	20.8%
2.00- 3.00	4.2%
3.00- 4.50	12.5%
4.50- 6.00	12.5%
6.00- 9.00	4.2%
9.00-12.00	12.5%
12.00(	12.5%
NO DATA	.0%
MEAN	5.3
STD. DEV.	4.7

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
(3	16.7%	20.8%
3- 6	25.0%	8.3%
6- 15	45.8%	45.8%
15- 30	8.3%	16.7%
30- 45	.0%	4.2%
45- 75	4.2%	4.2%
75-150	.0%	.0%
150-300	.0%	.0%
300(	.0%	.0%
NO DATA	.0%	.0%
MEAN	11.1	14.1
STD. DEV.	10.6	13.5

APPENDIX III

COTTONWOOD DISCONTINUITY ANALYSIS

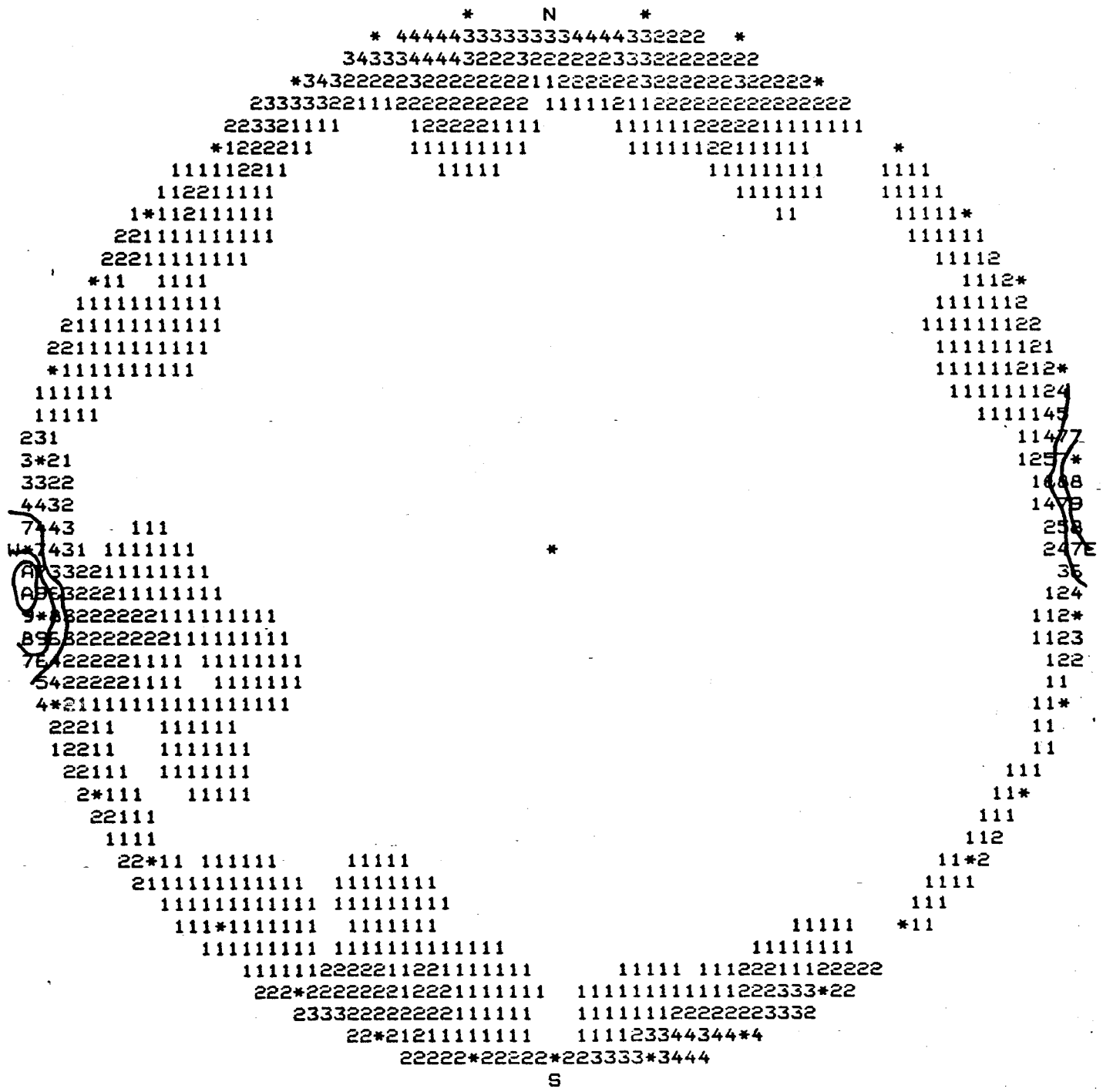
SITES 1 & 2 versus SITES 5 & 6

Schmidt Nets & Characteristic Analysis

SITES 1 & 2 — 6 E / 7E AREA

COTTONWOOD DATA - SITES 1&2: 6E/7E AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
110 OBSERVATIONS. HIGHEST LEVEL COUNT IS 29



COTTONWOOD DATA - SITES 1&2: 6E/7E AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 2	.00 - 2.64
2	3 - 5	2.64 - 5.27
3	6 - 8	5.27 - 7.91
4	9 - 11	7.91 - 10.55
5	12 - 14	10.55 - 13.18
6	15 - 17	13.18 - 15.82
7	18 - 20	15.82 - 18.45
8	21 - 23	18.45 - 21.09
9	24 - 26	21.09 - 23.73
A	27 - 29	23.73 - 26.36

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
110 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 85 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	1	.9
7	60.0 - 70.0	5	4.5
8	70.0 - 80.0	19	17.3
9	80.0 - 90.0	85	77.3

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	50.9%
DEFINED RIDGES	.0%
SMALL STEPS	.0%
VERY ROUGH	1.8%
NO DATA	47.3%

SPACING (FT)	
< .50	.9%
.50- 1.00	8.2%
1.00- 2.00	10.9%
2.00- 3.00	15.5%
3.00- 4.50	2.7%
4.50- 6.00	10.0%
6.00- 9.00	3.6%
9.00-12.00	10.0%
12.00<	36.4%
NO DATA	1.8%
MEAN	17.0
STD. DEV.	24.6

ROCK TYPE: SANDSTONE

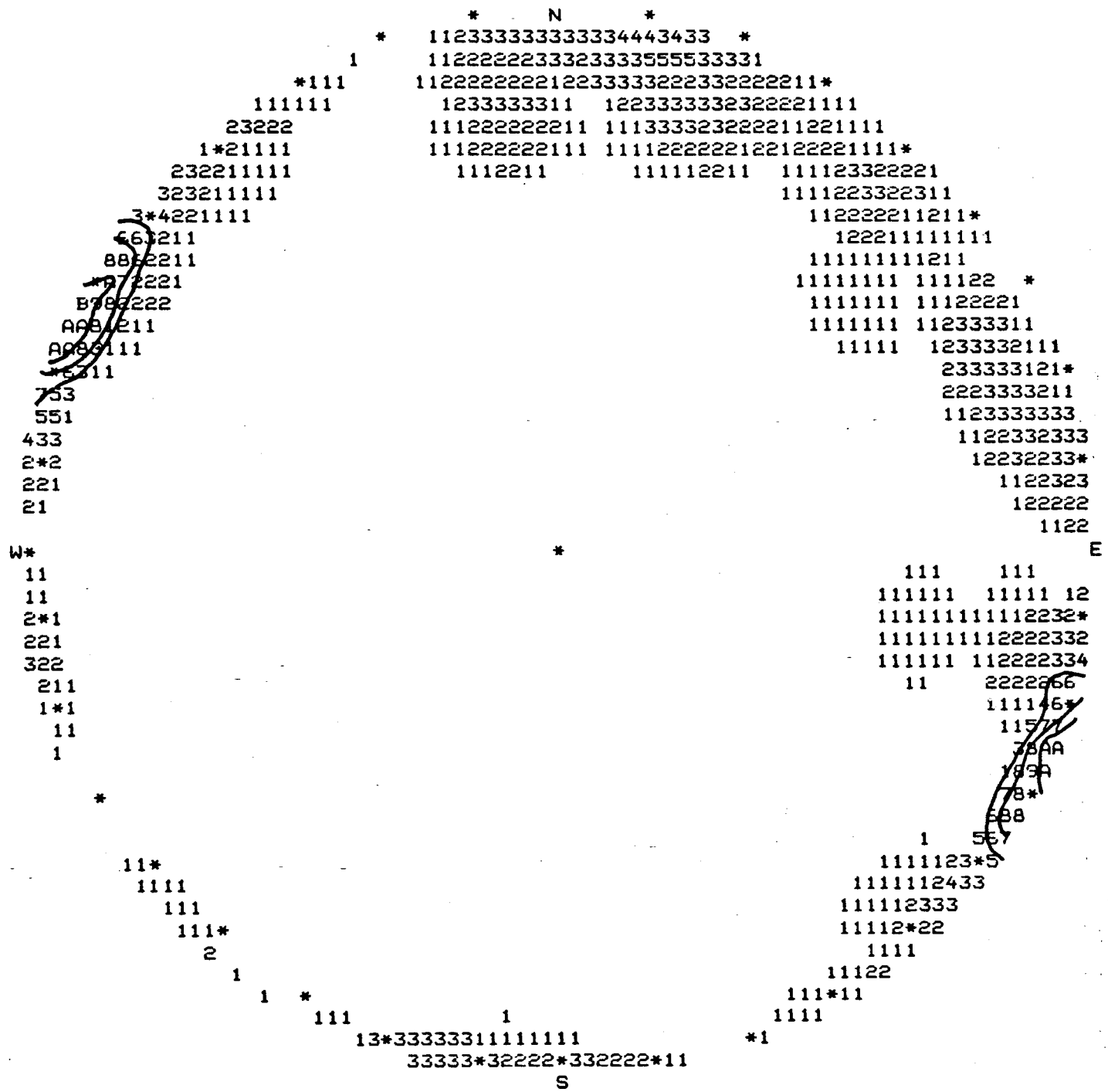
HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	3.6%
SOFT ROCK	43.6%
HARD ROCK	52.7%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
< 3	7.3%	4.5%
3- 6	14.5%	19.1%
6- 15	35.5%	34.5%
15- 30	20.0%	24.5%
30- 45	2.7%	2.7%
45- 75	7.3%	9.1%
75-150	8.2%	4.5%
150-300	.0%	.0%
300<	.0%	.0%
NO DATA	4.5%	.9%
MEAN	24.2	21.3
STD. DEV.	27.4	21.6

SITES 5 & 6 — 9 W / 10 W AREA

COTTONWOOD DATA - SITES 5&6: 9W/10W AREA

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
57 OBSERVATIONS. HIGHEST LEVEL COUNT IS 14



COTTONWOOD DATA - SITES 5&6: 9W/10W AREA

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 1	.00 - 2.46
2	2 - 2	2.46 - 4.91
3	3 - 4	4.91 - 7.37
4	5 - 5	7.37 - 9.82
5	6 - 6	9.82 - 12.28
6	7 - 8	12.28 - 14.74
7	9 - 9	14.74 - 17.19
8	10 - 11	17.19 - 19.65
9	12 - 12	19.65 - 22.11
A	13 - 13	22.11 - 24.56
B	14 - 15	24.56 - 27.02

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
57 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 41 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	1	1.8
7	60.0 - 70.0	4	7.0
8	70.0 - 80.0	11	19.3
9	80.0 - 90.0	41	71.9

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	94.7%
DEFINED RIDGES	3.5%
SMALL STEPS	1.8%
VERY ROUGH	.0%
NO DATA	.0%

SPACING (FT)	
< .50	.0%
.50- 1.00	10.5%
1.00- 2.00	8.8%
2.00- 3.00	10.5%
3.00- 4.50	10.5%
4.50- 6.00	17.5%
6.00- 9.00	5.3%
9.00-12.00	14.0%
12.00<	17.5%
NO DATA	5.3%
MEAN	7.9
STD. DEV.	8.3

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
< 3	8.8%	14.0%
3- 6	24.6%	12.3%
6- 15	49.1%	50.9%
15- 30	12.3%	17.5%
30- 45	1.8%	1.8%
45- 75	1.8%	1.8%
75-150	1.8%	1.8%
150-300	.0%	.0%
300<	.0%	.0%
NO DATA	.0%	.0%
MEAN	13.5	14.8
STD. DEV.	14.7	15.2

APPENDIX IV

COTTONWOOD DISCONTINUITY ANALYSIS

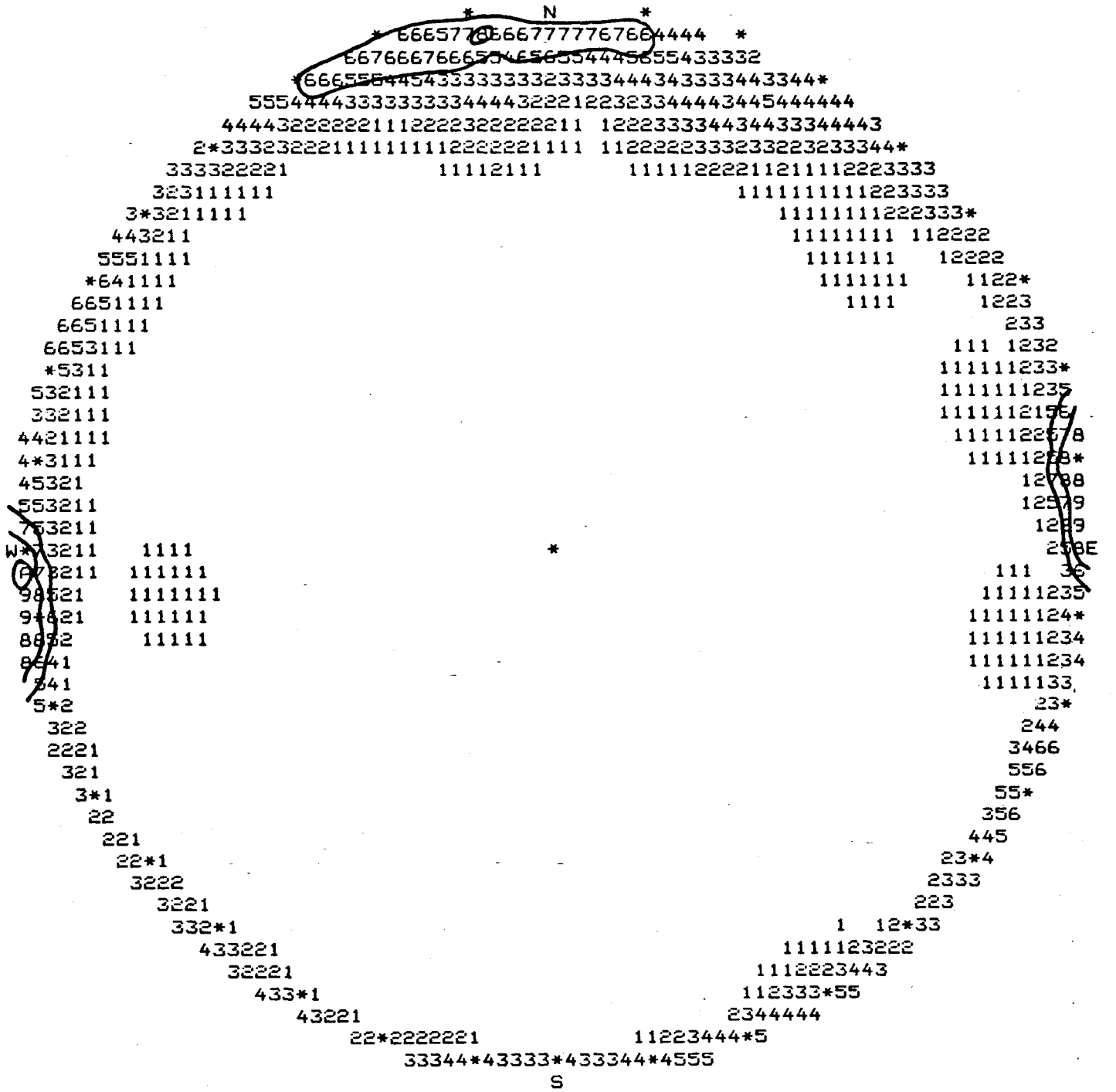
SOUTH-DIPPING versus WEST-DIPPING SLOPES

Schmidt Nets & Characteristic Analysis

ALL SOUTH-DIPPING SLOPES

COTTONWOOD DATA - ALL SOUTH DIPPING SLOPES

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
175 OBSERVATIONS. HIGHEST LEVEL COUNT IS 29



COTTONWOOD DATA - ALL SOUTH DIPPING SLOPES

KEY TO SYMBOLS USED----------

SYMBOL	ACTUAL COUNT	PERCENTAGES
1	1 - 2	.00 - 1.66
2	3 - 5	1.66 - 3.31
3	6 - 8	3.31 - 4.97
4	9 - 11	4.97 - 6.63
5	12 - 14	6.63 - 8.29
6	15 - 17	8.29 - 9.94
7	18 - 20	9.94 - 11.60
8	21 - 23	11.60 - 13.26
9	24 - 26	13.26 - 14.91
A	27 - 29	14.91 - 16.57

PERCENTAGE OF CIRCLE AREA USED AS UNIT AREA IS 1.0 PERCENT

---------- DIP RING ANALYSIS ----------

9 RINGS OF 10.00 DEGREES EACH
175 OBSERVATIONS

MINIMUM SECTION IS 1 WITH 0 POINTS

MAXIMUM SECTION IS 9 WITH 150 POINTS

NMBR	RANGE(DEGREES)	NUMBER	PERCENT
1	.0 - 10.0	0	.0
2	10.0 - 20.0	0	.0
3	20.0 - 30.0	0	.0
4	30.0 - 40.0	0	.0
5	40.0 - 50.0	0	.0
6	50.0 - 60.0	0	.0
7	60.0 - 70.0	6	3.4
8	70.0 - 80.0	19	10.9
9	80.0 - 90.0	150	85.7

DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	79.4%
DEFINED RIDGES	12.0%
SMALL STEPS	6.9%
VERY ROUGH	1.7%
NO DATA	.0%

SPACING (FT)	
< .50	2.3%
.50- 1.00	8.6%
1.00- 2.00	15.4%
2.00- 3.00	16.6%
3.00- 4.50	9.7%
4.50- 6.00	16.0%
6.00- 9.00	5.1%
9.00-12.00	9.7%
12.00<	12.6%
NO DATA	4.0%
MEAN	6.3
STD. DEV.	6.8

ROCK TYPE: SANDSTONE

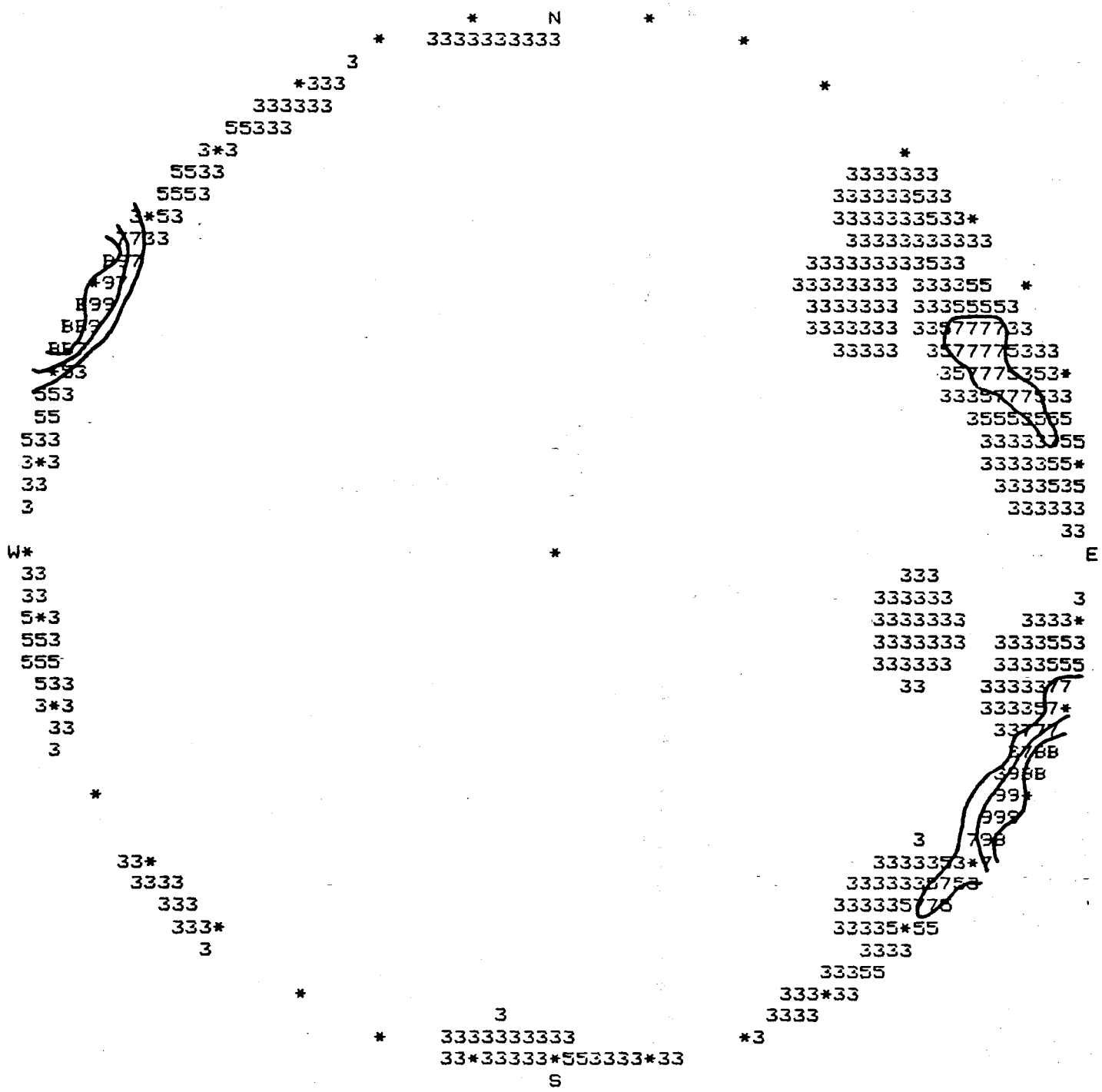
HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
< 3	10.3%	15.4%
3- 6	24.0%	28.6%
6- 15	42.9%	36.0%
15- 30	13.7%	13.1%
30- 45	1.7%	.6%
45- 75	1.7%	2.9%
75-150	2.9%	2.3%
150-300	.0%	.0%
300<	.0%	.0%
NO DATA	2.9%	1.1%
MEAN	14.0	12.9
STD. DEV.	17.5	16.8

ALL WEST-DIPPING SLOPES

COTTONWOOD DATA - ALL WEST DIPPING SLOPES

----------POLAR EQUAL AREA PROJECTION----------
PLOTTING CIRCLE RADIUS IS 4.0 INCHES
----------LEVEL PLOT TYPE 1 ----------
23 OBSERVATIONS. HIGHEST LEVEL COUNT IS 5



DISCONTINUITY TYPE	
JOINT	100.0%
NO DATA	.0%

ROUGHNESS	
SLICKENSIDED	.0%
SMOOTH	91.3%
DEFINED RIDGES	8.7%
SMALL STEPS	.0%
VERY ROUGH	.0%
NO DATA	.0%

SPACING (FT)	
< .50	.0%
.50- 1.00	8.7%
1.00- 2.00	4.3%
2.00- 3.00	4.3%
3.00- 4.50	4.3%
4.50- 6.00	17.4%
6.00- 9.00	4.3%
9.00-12.00	21.7%
12.00<	26.1%
NO DATA	8.7%
MEAN	10.8
STD. DEV.	10.6

ROCK TYPE: SANDSTONE

HARDNESS	
VERY SOFT SOIL	.0%
SOFT SOIL	.0%
FIRM SOIL	.0%
STIFF SOIL	.0%
VERY STIFF SOIL	.0%
VERY SOFT ROCK	.0%
SOFT ROCK	.0%
HARD ROCK	100.0%
VERY HARD ROCK	.0%
VERY, VERY HARD ROCK	.0%
NO DATA	.0%

LENGTH (FT)	CONTINUITY STRIKE	CONTINUITY DIP
< 3	8.7%	17.4%
3- 6	17.4%	4.3%
6- 15	47.8%	56.5%
15- 30	17.4%	17.4%
30- 45	4.3%	.0%
45- 75	.0%	.0%
75-150	4.3%	4.3%
150-300	.0%	.0%
300<	.0%	.0%
NO DATA	.0%	.0%
MEAN	17.2	16.1
STD. DEV.	20.3	19.3