Horse Canyon Extension
Lila Canyon Mine

Chapter 6
Geology

Volume 5 of 7
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Chapter 6

6.1 SCOPE

This section presents the general geologic setting of the permit area based upon previous publications, permit applications for the adjacent Sunnyside and South Lease areas, and drilling records of U.S. Steel Corporations and Los Angeles Department of Water and Power. The objective of this chapter is to provide sufficient geologic information to support the mining and reclamation plan for the Lila Canyon Extension to the Horse Canyon Permit and to satisfy the rules found in R645-301-600.

All Maps and Plans were prepared by, or under the direction of, and certified by a qualified, registered, professional engineer, with assistance from experts in related fields.

The general geologic setting of the Book Cliffs coal field, of which the Lila Extension is a part, is presented together with a review of previous geologic studies of the area.

Stratigraphy, structure and coal geology in the permit area and vicinity are covered with appropriate illustrations.

Drill logs from exploration drill holes representative of areas planned to be mined during the permit period are included with a discussion of geologic characteristics of the coal, roof and floor rock.

Impacts of mining during the permit period are not expected to differ materially from presently or recently operated mines in the Book Cliffs area. Mining and surface hazards are considered to be normal considering the depth of cover and rock conditions.

Total sulfur in the coal mined during the permit period is expected to be less than 1.2 percent, of which pyritic sulfur will generally be 0.30 percentage point or less.

All basic exploration and interpretive data generated by the many exploration programs have been submitted to the Bureau of Land Management (BLM) or previously to the United States Geological Service (USGS).

6.2 METHODOLOGY

The geological characteristics of the Lila Extension and surrounding areas have been described in numerous government and private publications in addition to the exploration programs conducted by Kaiser Steel and Los Angeles Water and Power. The maps, figures and narratives of this chapter are derived from these data.

6.3 REGIONAL GEOLOGIC FRAMEWORK

Physiographically, the Lila Canyon Mine Project Area is included in

the Colorado Plateau province. The Unita Basin lies to the northeast, the San Rafael Swell to the southwest, and the Wasatch Plateau to the west. The Lila Canyon Mine is situated in the western Book Cliffs, an escarpment that extends east and south from Castle Gate to Green River, Utah, then east to Grand Junction, Colorado, a distance of 180 miles.

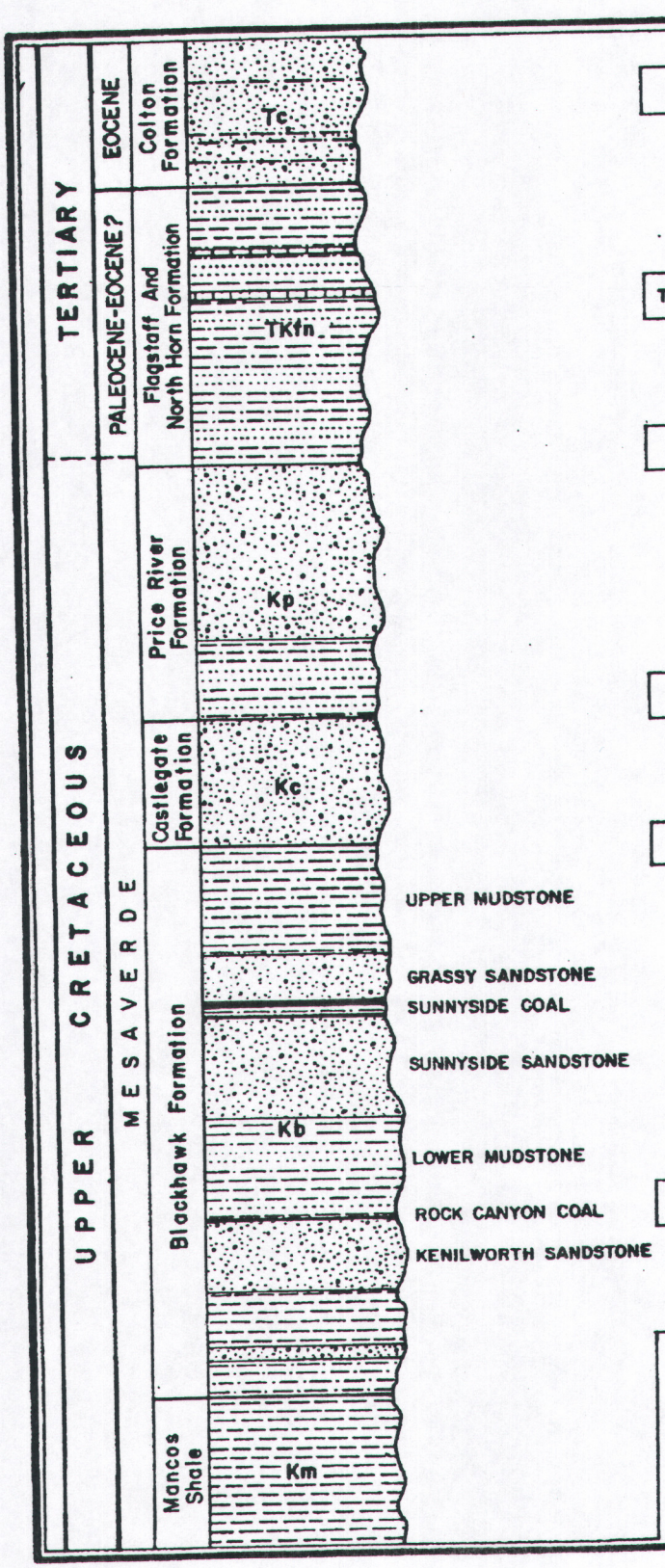
Rocks of Jurassic, Cretaceous, Tertiary and Quaternary ages outcrop in the region. The coal-producing Blackhawk Formation of Upper Cretaceous age dips gently at 3 to 8 degrees away from the broad regional dome of the San Rafael Swell to the south. The Lila Canyon Mine Project Area is located in the above-mentioned eastward dipping portion of the Book Cliffs escarpment.

6.4 GEOLOGY OF PROJECT VICINITY

6.4.1 STRATIGRAPHY

Many earth scientists have described and interpreted rocks in and around the project area. In 1928 Clark mapped the geology and coal outcrops in the western part of the Book Cliffs coal field. In 1936 Fisher mapped the area south and east of Clark's map along the Book Cliffss to the Utah-Colorado state line. The geology and coal deposits in the area have also been described by Abbott and Liscomb, Fisher, Erdmann, Reeside, and Young. Doelling has summarized and updated the geology and coal

information reported in earlier writings. Recent contributions to the understanding of the coal deposits are Osterwald and Mayberry, Balsley and Horne. The coal resources of the Book Cliffs coal field are exposed in the south to southwest facing Book Cliffs that form the southern margin of the Roan Plateau. The coal beds of economic importance in the Book Cliffs coal field are Upper Cretaceous in age, and are confined to the Blackhawk formation of the Mesaverde Group (See Figure 6-1). The Mesaverde in the project vicinity consist of three formations which are, in ascending order, the Blackhawk Formation, Castlegate Sandstone, and the Price River formation. The Upper Cretaceous Mancos Shale underlies and intertongues with the



DESCRIPTION OF UNITS

Tc — COLTON FORMATION: Upper Member - Sandstone and siltstone beds mostly maroon; forms cliffs and very steep slopes. Lower Member - Channel-fill deposits, lens-shaped siltstone deposits interbedded with mudstones; mostly gray and maroon; beds thinner than in the Upper Member; forms ledges and steep slopes. Thickness of formation: Up to 3,000 feet.

TKfn — FLAGSTAFF LIMESTONE AND NORTH HORN FORMATION: Interbedded siltstone, sandstone, mudstone, and limestone; beds mostly thin and lens-shaped; forms gentle slopes and ledges. Limestone beds rich in invertebrate fossils. Thickness of formation: 300 to 350 feet.

Kp — PRICE RIVER FORMATION: Bluecastle Sandstone Member - Fine- to medium-grained sandstone; a single bed composed of fluviatile, channel-fill deposits; forms cliffs and ledges. Mudstone Member - Interbedded and discontinuous mudstone, siltstone, and sandstone; mostly dark gray to dark brown; forms slopes and low ledges. Locally contains vertebrate fossils. Thickness of formation: 275 to 300 feet.

Kc — CASTLEGATE SANDSTONE: Fine- to medium-grained sandstone; local concentrations of clay galls at various horizons; forms high, abrupt cliffs and bare sandstone dip slopes. Thickness of formation: 145 to 160 feet.

Kb — BLACKHAWK FORMATION: Upper Mudstone Member - Mudstone and discontinuous sandstone, siltstone, and claystone; Grassy Sandstone Member - Fine to medium salt and pepper sand; Sunnyside coal. Sunnyside Sandstone - Arenaceous siltstone and very fine-grained to medium-grained sandstone, grading downward from coarser to finer; forms cliffs; sharp upper contact; transitional lower contact. Lower Mudstone Member - Mudstone and discontinuous siltstone, sandstone, and claystone; Rock Canyon coal bed at base. Kenilworth Member - Siltstone and very fine-grained to medium-grained sandstone; forms lower part of Book Cliffs. Thickness of formation: 550 to 600 feet.

Km — MANCOS SHALE: Dark gray fissile mudstone containing discontinuous layers of claystone and limy concretions. Intertongues with lower members of the Blackhawk Formation. Thickness of formation: 3,000 to 4,000 feet.

GEOLOGIC DESCRIPTIONS DERIVED FROM USGS MAP I-798, 1974

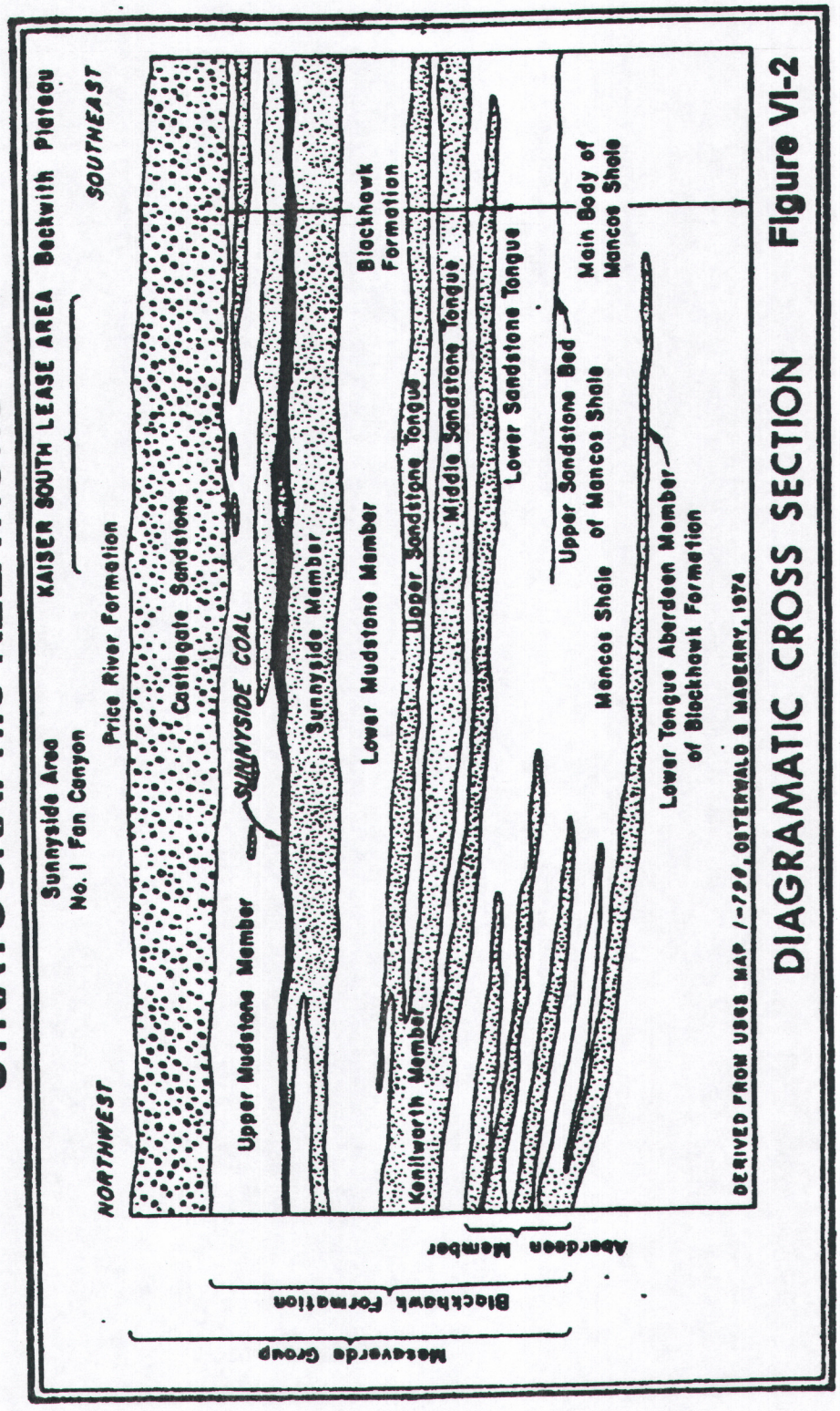
LILA CANYON MINE
Generalized Lithologic Section
Emery County, Utah
Figure VI-1

Blackhawk Formation. The Mancos Shale was deposited in an offshore marine environment and the Blackhawk Formation is a mixed marine and continental environment. The Castlegate Sandstone and the Price River Formation were formed in a continental environment. The bluish-gray shale of the Mancos Shale crops out below the base of the Book Cliffs and in places is capped by pediment deposits from the Pleistocene. Sandstone beds of the Blackhawk Formation crop out in steep and precipitous cliffs and ledges above the Mancos Shale (See Plate 6-1)

Osterwald and Mayberry (1974) divide the Blackhawk Formation into the following two members (See Figure 6-2): the Lower Mudstone Member and Kenilworth Member, 150 to 300 feet thick; and the Upper Mudstone and Sunnyside Member, 150 to 350 feet thick.

The Kenilworth Sandstone is composed of three sandstone tongues which thin eastward and are not traced east of Green River. The Lower Mudstone Member, a tongue of the Mancos Shale, is transitional upward into the Sunnyside Member.

The Rock Canyon coal bed is locate at the base of the Lower Member where found.



The Sunnyside Member contains the primary economic coal resource of the Book Cliffss, and in the Lila Canyon Mine Project Area the Sunnyside Sandstones contains two seams, the Upper Sunnyside and Lower Sunnyside seams. The Horse Canyon Mine is developed only in the Lower Sunnyside seam which maintains a thickness of 10 to over 16 feet throughout the Mine Project Area and probably a larger area to the northeast, east and south. The Upper Sunnyside seam never exceeds a 4-foot thickness in the Lila Canyon Mine Project Area. In the area south of Williams Draw the Upper Sunnyside seam becomes thicker. The Upper Sunnyside was not mined by U.S. Steel within the permit area.

Because the Sunnyside Sandstone is known to transmit ground water in the Sunnyside area that portion of the sandstone which underlies the Lower Sunnyside seam is occasionally considered to be a potential aquifer. However, Geneva Mine records indicate that the floor rock under the Lower Sunnyside seam consists of sandstone and shale of unknown thickness and that the mine was essentially dry until the Sunnyside Fault was intercepted down dip, at which time water flows were encountered. The records do not indicate that these Sunnyside Fault flows were excessive or sustained. The Sunnyside Member underlies the Sunnyside coal bed.

Possible explanations for the dryness of the Horse Canyon Mine include: shales in the floor which could impede ground-water flow, the

Sunnyside Sandstone is not saturated in the Horse Canyon area or lacks sufficient hydraulic conductivity to transmit water, or simply was not deep enough to encounter a saturated zone, or the east-west faults isolated the mine from saturated zones. Regardless of the reason the Horse Canyon mine was relatively dry despite being below the potentiometric surface indicated by the IPA Piezometers.

The coal seam in which the Lila Canyon mine is located has been correlated with both the upper and lower Sunnyside seams found to the north of the project area. For the Lila Canyon Mine project area the coal seam is referred to as the Sunnyside seam with a lower seam found in the southern margins of the area. Overlying the Sunnyside coal is the Grassy Sandstone Member. The Upper Mudstone Member contains numerous thin discontinuous coal seams near the top which become the Beckwith coal zone further east.

The Castlegate Sandstone is approximately 170 feet thick in the project area and forms abrupt cliff and sandstone dip slopes.

The Price River Formation lies above the Castlegate Sandstone. In the project vicinity it is divided into the upper Bluecastle Sandstone Member, 75 to 250 feet thick; and Mudstone member, 100 to 400 feet thick.

Tertiary strata successively overlying the Price river formation include the Flagstaff Limestone and North Horn Formation, 500 to 800 feet thick.

The Colton Formation caps the highest ridges in the project vicinity and consists of maroon sandstone and siltstones, and gray mudstones.

6.4.2 STRUCTURE

The Sunnyside seams outcrop along the Book Cliffss and in the canyons which incise them. Locally the seams are exposed at elevations ranging from 5,500 feet to 6,000 feet. The general strike of the beds in the Mine Project Area is N22°W dipping at 11 to 14 percent toward the east shown on Figure 6-3 and Plate 7-1-B).

The low relief of Little Park places the coal, for the most part, under less than 1,500 feet of cover. The deeper coal is generally in the eastern and northern portions of the property, with a small amount of reserve being deeper than 2,500 feet. (Plate 6-2)

The fault displacements range from a few feet up to 275 feet. Detailed mapping by Kaiser Corporation consultants note some differences in interpretations of fault alignments than those shown on the published maps.

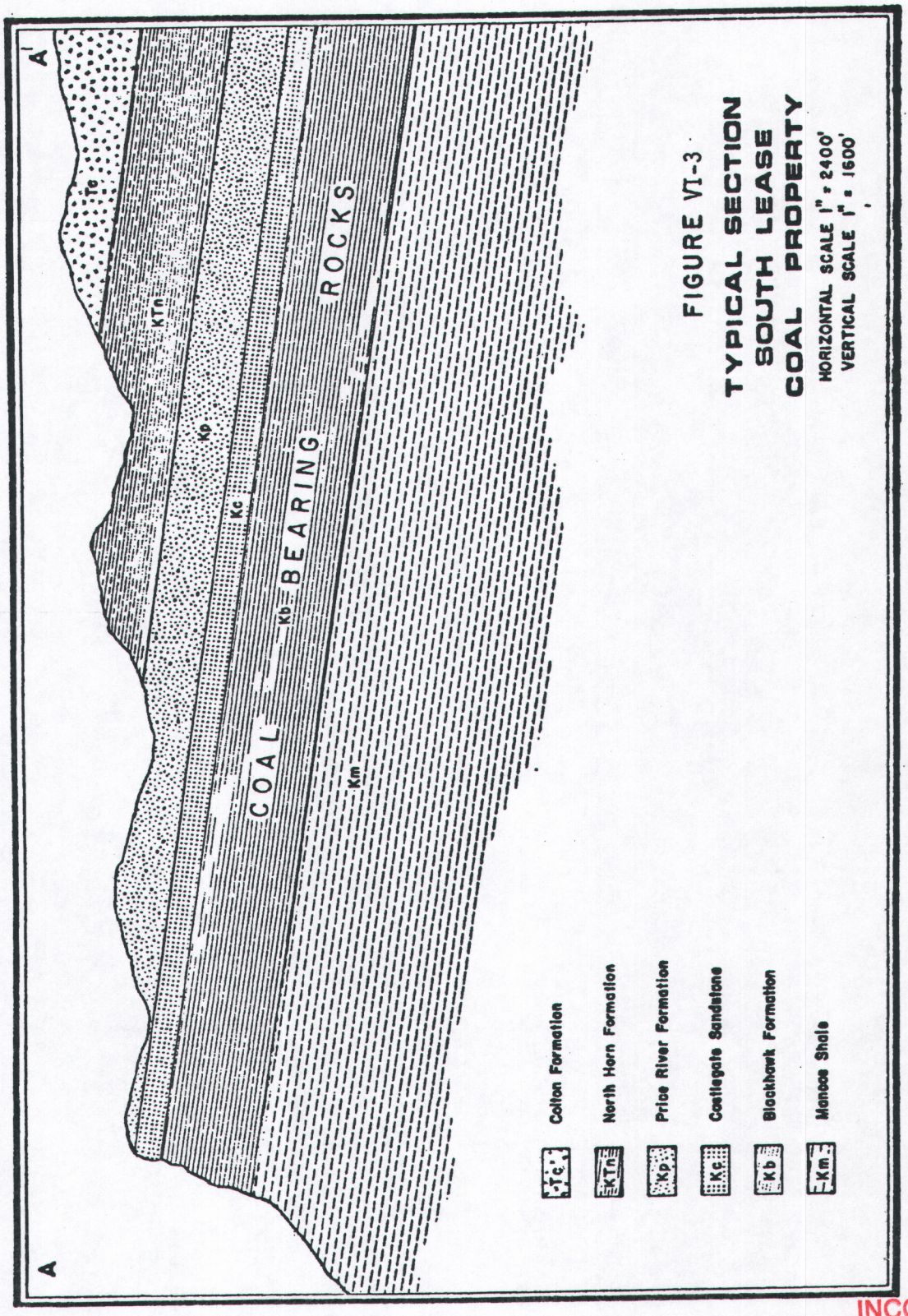


FIGURE VI-3
TYPICAL SECTION
SOUTH LEASE
COAL PROPERTY
HORIZONTAL SCALE 1" = 2400'
VERTICAL SCALE 1" = 1600'

6.5 GEOLOGY OF COAL BED AND ADJACENT UNITS

6.5.1 EXPLORATION AND DRILLING

Kaiser Steel Corporation and Los Angeles Water and Power have conducted several exploration programs on the leasehold commencing in 1948 (Figure 6-4). Highlights of the programs are summarized in the following paragraphs.

1948 to 1949: Four drill holes were completed following acquisition of the first leases. Geological and coal analytical data were obtained.

1957 to 1962: Two holes were completed and the last of the eight contiguous coal leases was acquired.

In addition to the drilling, an exploration test entry was driven 6,080 feet into the property from U.S. Steel's Geneva Mine. A total of 120,000 tons of coal was extracted from the workings and used for coke-making. The entry was terminated when a fault having a displacement of approximately 50 feet was encountered, The entry was sealed after roof falls in the Geneva Mine made these entries inaccessible. The Horse Canyon mine is now sealed as well. Geological, analytical, and mining data were acquired.

1974 to 1975: A major exploration programs was completed consisting of 17 new core holes and one redrilled hole (S-5B) totaling 23,000 feet. During this program, core samples were obtained, 18 of which were from the main Sunnyside seam. Core recovery for these samples was 95 percent.

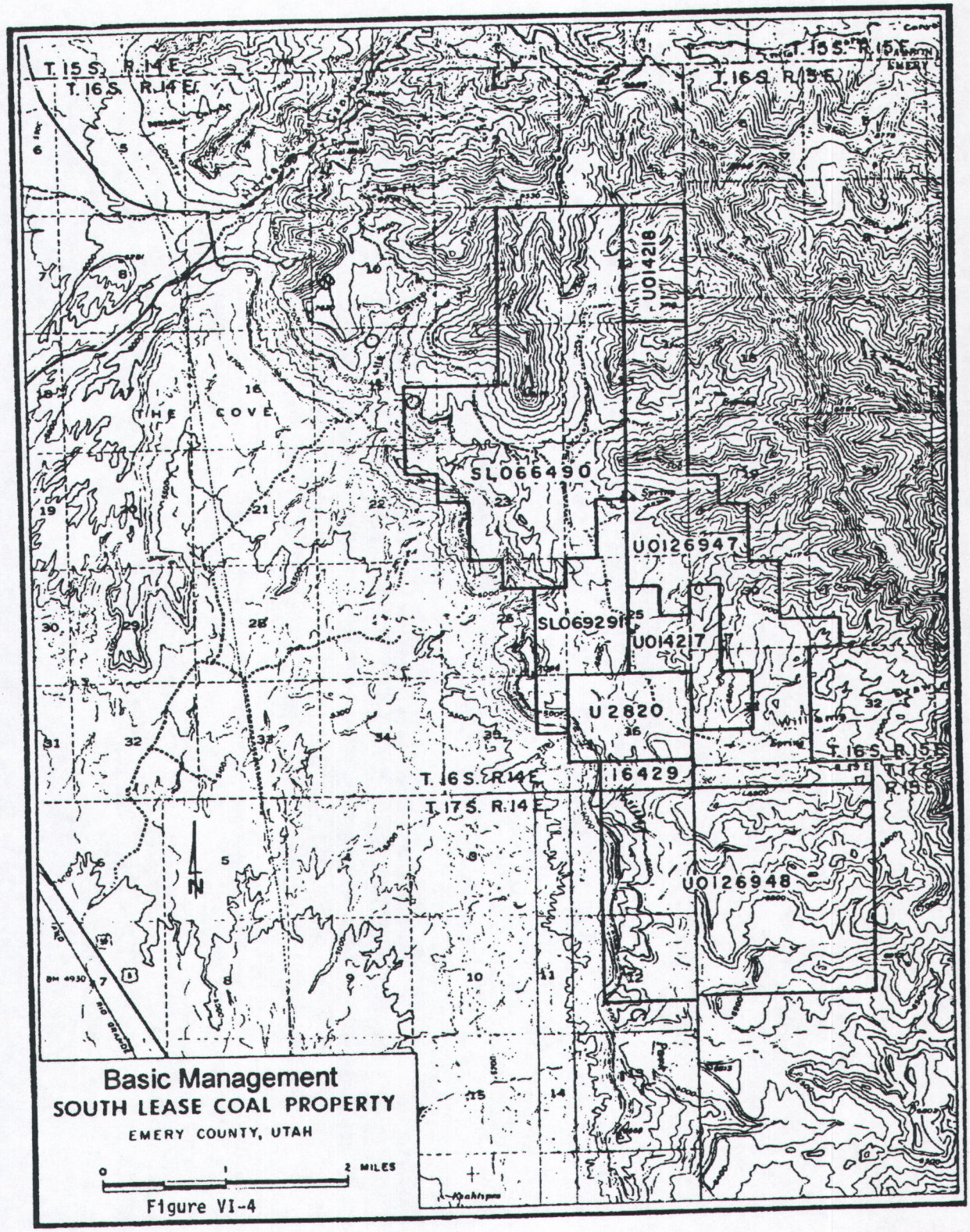


Figure VI-4

No raw proximate analysis was done on the samples, only washability studies. The drilling data from the 1948-1949, 1957-1962, and the 1974-1975 drilling programs are presented on Table 6-1. Outcrop measurements were also taken during the 1974-1975 program and are summarized on Table 6-2.

1980 to 1981: Plans to exploit the coal reserve were commenced with feasibility and preliminary mine planning. Eight core holes were drilled to confirm reserves and to examine key points in the previously proposed initial Mine Project Area including: shaft site, rock tunnel line at shaft site and seam intersection and main haulageway intersections. Results of the drilling are summarized in Table 6-3.

In 1981, one core hole (S-32) was drilled and converted to a down-dip water monitoring hole. A series of short drill holes to determine the stream profile of Little Park Wash was completed. Two alluvial water monitoring holes were placed above and below planned Kaiser mine facilities, and three crest staff gages were placed in Little Pak Wash and William Draw Wash. Holes #A-26, A-28, and A-31 were drilled 19 years ago and no known data exists. S-32 is located approximately three miles south of Lila Canyon and is separated from Lila by at least two known fault systems. For this reason the information obtained from S-32 was not considered in the hydrologic evaluations completed for Lila Canyon. However, the drill log along with the Chronology of Development and Pump tests are included in Appendix 6-1.

Table VI-1

DRILL HOLE SUMMARY
SOUTH LEASE COAL PROPERTY
1974-75

Drill Hole	Coordinates		Collar Elevation	Total Depth	Main Seam			Seam Separation	Lower Seam		
	Latitude	Departure			Depth	Elevation	Thickness		Depth	Elevation	Thickness
S-1	S916	E63257	6,960'	999'	960' 6"	5,999' 6"	17' 1"				
S-2	S3001	E65668	6,825'	1,000'	973' 9"	5,851' 3"	11' 6"				
S-3	N3678	E66213	7,070'	1,596'	1,567'	5,503'	13' 6"				
S-4	S12377	E69984	6,647'	1,055'	1,022' 8"	5,624' 4"	10' 4"	5' 1"	1,038' 1"		2"
S-5	S23972	E70942	6,152'	261'	212' 8-1/4"	5,939' 3-3/4"	7' 4-3/4"	17' 11-1/4"	238' 1/4"		3' 5"
S-6	S17396	E68485	6,380'	225'	194' 7"	6,185' 5"	13' 4"	Upper and Lower Seams Together			
S-7	S20423	E69541	6,282'	204.5'	166' 9-1/2"	6,115' 2-1/2"	6' 9-1/4"	8' 3-1/4"	181' 10"		4' 1-1/2"
S-8	S20880	E73512	6,480'	934'	887' 5"	5,592' 7"	7' 6"	14' 11-1/2"	909' 10-1/2"		4' 1"
S-9	S25013	E77309	6,345'	1,245'	1,149' 6"	5,195' 6"	4'				
S-10	S20562	E78251	6,530'	1,504'	1,459' 9"	5,070' 3"	4' 3-1/2"				
S-11	S14129	E71718	6,558'	915'	869' 4"	5,688' 8"	8' 2-1/2"	15' 8-1/4"	893' 2-3/4"		2' 6"
S-12	S17057	E72439	6,597'	954.5'	918' 1-3/4"	5,678' 10-1/4"	8' 2-3/4"	11' 1/2"	937' 4"		3' 4-3/4"
S-13	S13478	E75340	6,715'	1,551'	1,521' 4"	5,193' 8"	6' 1-1/2"	15' 1"	1,542' 7-1/2"		1' 6-3/4"
S-14	S17429	E76268	6,630'	1,430'	1,396' 7-1/2"	5,233' 4-1/2"	5' 1"				
S-15	S8662	E68442	6,668'	974'	934' 10-3/4"	5,733' 1-1/4"	11' 2"				
S-16	S5550	E71238	6,850'	1,600'	1,567'	5,283'	11' 5-1/2"				
S-17	S2542	E70549	7,028'	1,738'	1,706' 4-3/4"	5,321' 7-1/4"	13' 7"				
S-18	N979	E69923	7,105'	1,920'	1,885' 3-1/2"	5,219' 8-1/2"	13' 6-1/2"				
S-19	N7539	E67056	7,237'	2,095'	2,060' 7"	5,176' 5"	13' 7-1/2"				
S-20	N524	E66671	6,957'	1,399'	1,365' 1/2"	5,591' 11-1/2"	13' 3-1/2"				
S-21	S6375	E67844	6,782'	1,107'	1,077' 6"	5,704' 6"	13' 1-1/2"				
S-22	S9841	E72247	6,720'	1,451'	1,419'	5,301'	11' 3-1/2"	8' 3-1/2"	1,438' 7"		1'
S-23	S11332	E74160	6,710'	1,615'	1,585' 5-1/2"	5,124' 6-1/2"	10' 6"	6' 6"	1,602' 6-1/2"		1' 9"

TABLE VI-2

OUTCROP PROSPECT SUMMARY

South Lease
Emery County, Utah

Outcrop Prospect No.	Coal Thickness (Ft.)
OC-01	12.0
OC-1a	10.1
OC-1b	9.2
OC-02	12.25
OC-2	10.3
OC-03	11.4
OC-3	8.8
OC-3a	10.2
OC-4	10.8
OC-6	8.1
OC-7	8.7
OC-8	5.0
OC-9	4.3
OC-9a	8.0
OC-9b	5.0
OC-10	5.5
OC-11	5.6

TABLE VI-3

KAISER STEEL CORPORATION

1980 DRILLING PROGRAM

DRILL HOLE DATA

DRILL HOLE	ELEVATION (Ft.)	SUNNYSIDE MINE GRID COORDINATES SOUTH (Ft.)	SUNNYSIDE MINE GRID COORDINATES EAST (Ft.)	SL&M SEC.	SL&M TWP.	SL&M RANGE	LOCATION (Ft.)	DATE STARTED	DATE COMPLETED	DATE CEMENTED	ROCK BITTED INTERVAL (Ft.)	CORED INTERVAL (Ft.)	TOTAL DEPTH (Ft.)	E-LOG	FEDERAL LEASE NO.	STATE LEASE NO.
KSC-S-24-80	6,429.45	16,197.1	67,463.7	1	17S	14E	620 FNL-3,260 FEL	7-14-80	7-16-80	8-12-80	0-20 170-450	20-170 450-550	550	X	U-0126948	-
KSC-S-25-80	6,497.42	17,145.4	69,601.4	1	17S	14E	1,580 FNL-1,120 FEL	7-17-80	7-19-80	8-13-80	0-390	390-568	568	X	U-0126948	-
KSC-S-26-80[2]	6,470.86	14,377.4	68,002.8	36	16S	14E	1,190 FSL-2,880 FEL	8- 1-80	8- 1-80	8-13-80	0-280	280-350	350	X	-	ML-16429
A-26[1]	6,471.00			36	16S	14E	9'S 57E from S-26	8-13-80	8-13-80	-	0-21	-	21	-	-	ML-16429
KSC-S-27-80	6,309.32	19,265.1	69,872.0	1	17S	14E	1,960 FSL-850 FEL	7-12-80	7-13-80	8-11-80	0-205	205-280	280	X	U-0126948	-
KSC-S-28-80[2]	6,203.46	22,375.9	69,897.3	12	17S	14E	1,160 FNL-740 FEL	8- 2-80	8- 4-80	8-11-80	0-115	115-156	156	X	U-0126948	-
A-28[2]	6,203.00			12	17S	14E	5.8'S 86E from S-28	8-11-80	8-11-80	8-11-80	0-70	-	70	-	U-0126948	-
KSC-S-29-80	6,735.82	14,609.8	70,213.4	36	16S	14E	960 FSL-670 FEL	7-27-80	7-29-80	7-30-80	0-820	820-894	894	X	-	ML-16429
KSC-S-30-80	6,729.63	16,298.3	70,709.2	6	17S	15E	1,820 FNL-5 FWL	7-19-80	7-]]-80	8-13-80	0-850	850-895	895	X	U-0126948	-
KSC-S-31-80[2]	6,354.34	18,721.4	71,056.0	6	17S	15E	1,150 FSL-350 FWL	8- 4-80	8- 5-80	8-10-80	0-450	450-495	495	X	U-0126948	-
A-31[1]	6,354.00			6	17S	15E	18.8'N 84W from S-31	8-10-80	8-10-80	-	0-20	-	20	-	U-0126948	-

1/ Established as water observation hole in surface alluvium.
2/ Unsuccessful water observation hole.

Water levels measured are shown in the `"Chronology of Development". Water quality analysis for S-32 is also included in Appendix 6-1. The location of S-32 is shown on Plate 7-1.

1993- 1994 IPA Three holes were completed by the Los Angeles Department of Water and Power. These holes were added to confirm the coal quality and to provide for ground water monitoring. (See Table VI-4 for drilling summary).

Additional drill holes are not anticipated at this time. If in the future additional drill holes are required, section R645-301.630 will be addressed.

One oil exploration hole has been drilled on the property by Forest Oil Company. The location of the hole is shown on Plate 6-2. The depth of the hole is 12,602' other details are not known.

6.5.2 STRATIGRAPHY

The Upper Cretaceous Mesa Verde group of strata are of the greatest interest in the project area. The Mancos Shale at the base of the cliffs is overlain by the Blackhawk Formation which contains the Sunnyside and other coal seams. In the Little Park Wash area are exposures of the Price river and North Horn Formations. Farther east and at higher elevations are deeply eroded areas of the Tertiary Colton Formation. The stratigraphic sequence with formational descriptions are shown on Figure 6-1.

Table 6-4

INTERMOUNTAIN POWER AGENCY
1993-1994 DRILLING SUMMARY

	STATE PLANE		Ground	Total	Main Seam		
Hole #	North	East	Elevation	Depth	Depth	Elevation	Thickness
IPA#1	400,026	2,336,932	7034	1741	1655	5379	12.4
IPA#2	397,355	2,333,735	6865	1213	1060	5805	10.3
IPA#3	393,724	2,335,785	6810	1268	1046	5764	11.0

The Sunnyside main seam is of primary interest in the Lila Extension. This seam contains more than 90 percent of the in place reserves, extends over the entire property and varies in thickness from 45 inches to more than 18 feet. Average coal thickness for the coal seam is 9.9 feet. The highest coal occurs in the northern two-thirds of the Lila Extension (Plates 6-3). South of Williams Draw, the main seam thins and a lower seam, which is local in area, occurs. The lower seam ranges in thickness from zero to 5.7 feet and is separated from the main seam by 2.7 feet to more than 15 feet (Plate 6-4). The true relationship of the lower seam and Sunnyside main seam is not clear.

The coal is relatively hard and bright, with about 20 percent thin to medium dull bands. It has moderately well-developed cleat. Thin coatings of calcite occur on some cleat faces. Pyrite occurs in thin surface coatings and occasional nodules. Resin blebs are common.

Some thin partings are present in the Sunnyside main coal seam.

Overlying the Sunnyside coal is the Grassy Sandstone unit. The Unit is comprised of 40 to 70 feet of fine to medium grained sandstone which rests directly on the coal over the southern three fourths of the property. In the north, this sandstone is separated from the coal by up to four feet of carbonaceous mudstone and siltstone.

The upper and lower few feet of the sandstone are thinly interbedded with carbonaceous siltstone. The sandstone is commonly cross bedded and

tight, however the lower portion has been reworked. The reworked section varies in thickness for each drill hole. Few pyrite nodules were noted in cores. Usually the contract with the coal is sharp or well defined. Near the southeastern corner of the lease, a gradational contract is common.

The rock section between the Sunnyside main seam and lower seam in the south is composed of sequence of siltstone, sandstone, and carbonaceous mudstone. The upper portion of this unit, or floor rock of the upper coal, is generally mudstone with some siltstone, slightly carbonaceous, commonly with well developed planar parting. Highly carbonaceous or coaly mudstone forms the lower section of the parting, or roof rock of the lower coal. The interval between these is a very fine to medium grained sandstone, often interbedded with shale. Sandstone contacts with the upper shale and lower mudstone are sharp.

The floor rock of the main seam in the central part of the property consists of an interval of up to 20 feet of shale and mudstone, grading down to thinly interbedded sandstone and mudstone. The deeper coal in the north and east rests directly on the massive Sunnyside Sandstone (Plate 6-5).

6.5.3 STRUCTURE

6.5.3.1 Topographic Setting

The coal seams outcrop in the Book Cliffs escarpment 550 to 700 feet

from the base of the cliffs and dip uniformly 11 to 14 percent to the east. At the base of the cliffs, the average elevation is 5,500 to 6,000 feet, while the elevation of Little Park, which constitutes most of the Lila Extension, ranges from 6,200 and 7,000 feet. The highest prominence on the property is 8,516 feet on the north boundary line above Lila Canyon.

6.5.3.2 Overburden

The relief of Little Park places the coal, for the most part, under less than 1,500 feet of cover. The deeper coal is generally in the eastern and northern portions of the property, with a small amount of reserve being deeper than 2,500 feet (Plates 6-2 and 6-6).

6.5.3.3 Faulting

In the Lila Canyon Mine Plan Area, a major system of transverse, easterly trending normal faults, radial from the San Rafael Swell, have been mapped. The dips may be greater than 16 percent in the vicinity of some faults.

The geologic fault pattern is that of a series of horsts and grabens. Vertical displacements of the faults in the general area range from 15 feet to more than 275 feet with displacement diminishing toward the east. Near some of these major breaks, surface expressions of en-echelon multiple and

auxiliary fault sets with small displacements are common.

Fault data is summarized in the following: Table 6-5, Figures 6-5 and 6-6, and Plates 6-1 and 6-2.

The east-west trending primary faults have divided the lease into several blocks. With the absence of major disruptions along the strike, these blocks extend 9,000 to 13,000 feet from the outcrop to the easterly property boundary line and vary from 3,200 to 12,000 feet in width.

Within the permit area vertical displacements as long as 205 feet have been measured at the outcrop in these major faults. Drilling has disclosed displacements in two of these, the South Boundary fault and Williams Draw fault, to diminish toward the east, while the Entry fault displaced 50 feet in the central part of the lease, may disappear before reaching the outcrop and easterly lease boundary line.

The fault set defining the Central Graben disrupts the coal from the outcrop down-dip for approximately 5,000 feet. The possible complex nature of the structure in this block, due to secondary faulting and fracturing, may affect recovery of the coal.

The Lila Canyon faults, which were intercepted in the exploratory entry, appear to be increasing in vertical displacement toward the east. Structure contours drawn from drill hole S-19 and mine data show the block north of the south Lila Canyon fault to be lower than indicated by surface mapping of the fault lines.

No surface expression of the faults are visible in some parts of the lease. On the basis of exposures at the escarpment, as well as in the nearby Geneva Mine, the fault traces were projected into areas where drilling has disclosed anomalies in the structure.

En-echelon faulting or fracturing near the major displacements is common in the Geneva Mine, particularly in the transverse fault systems. Roof falls have been abnormally high in these areas, even though the strata indicate competent roof rock.

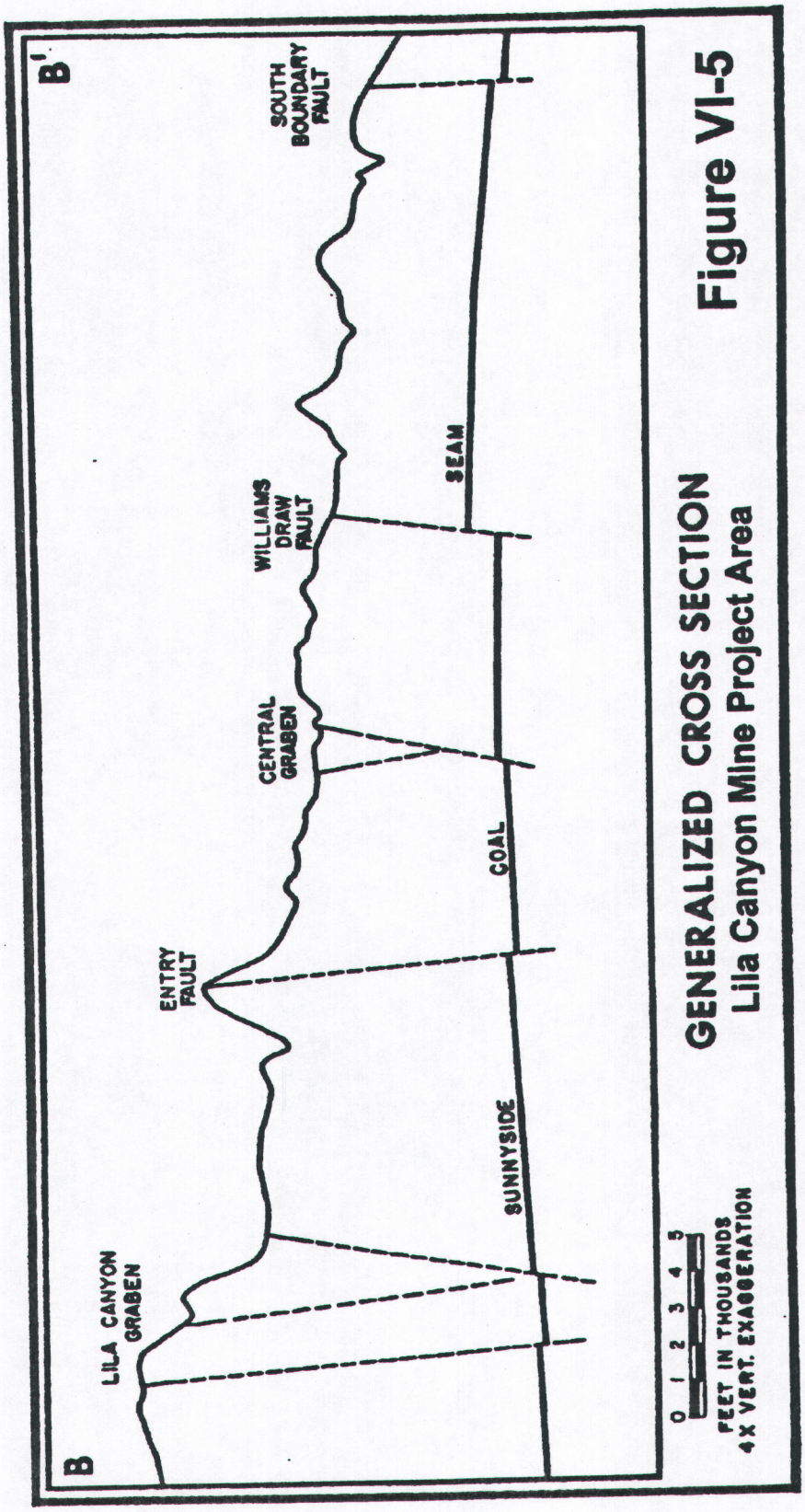
Auxiliary or branch faulting associated with the main faults is much less frequent than the multiple faulting; but, it does occur, most commonly with the low-angle faults.

Undoubtedly, many small faults will be encountered in mining; nonetheless, future mine configurations will conform to the major fault patterns, with the large displacements of the faults providing natural barriers between sections or mines.

The Sunnyside fault, a north south trending fault, found in Horse Canyon and Columbia mines is believed to be located east of the new Lila Canyon proposed permit area. No indications of the Sunnyside fault have been found within permit area "B".

Table 6-5

Major South Lease Faults					
Fault	Strike	Range of dips	Displacement (in feet)		
			West	Middle	East
North Lila Canyon	N10°E	S70°	13	42	?
Middle Lila Canyon	N7°E	S70°	8	10	?
South Lila Canyon	N89°E	N60°	17	25	?
Entry	S85°E	S55-30°	0	50	0
Cliffs Graben	Apparently does not extend into the Lease				
Central Graben Auxiliary	N87°E	S87-60°	205	0	?
Central Graben Main	N82°E	N52-77°	145	50	40
Williams Draw	S88°E	N56-68°	195	125	50
South Boundary	S84°E	S81-78°	72	45	15



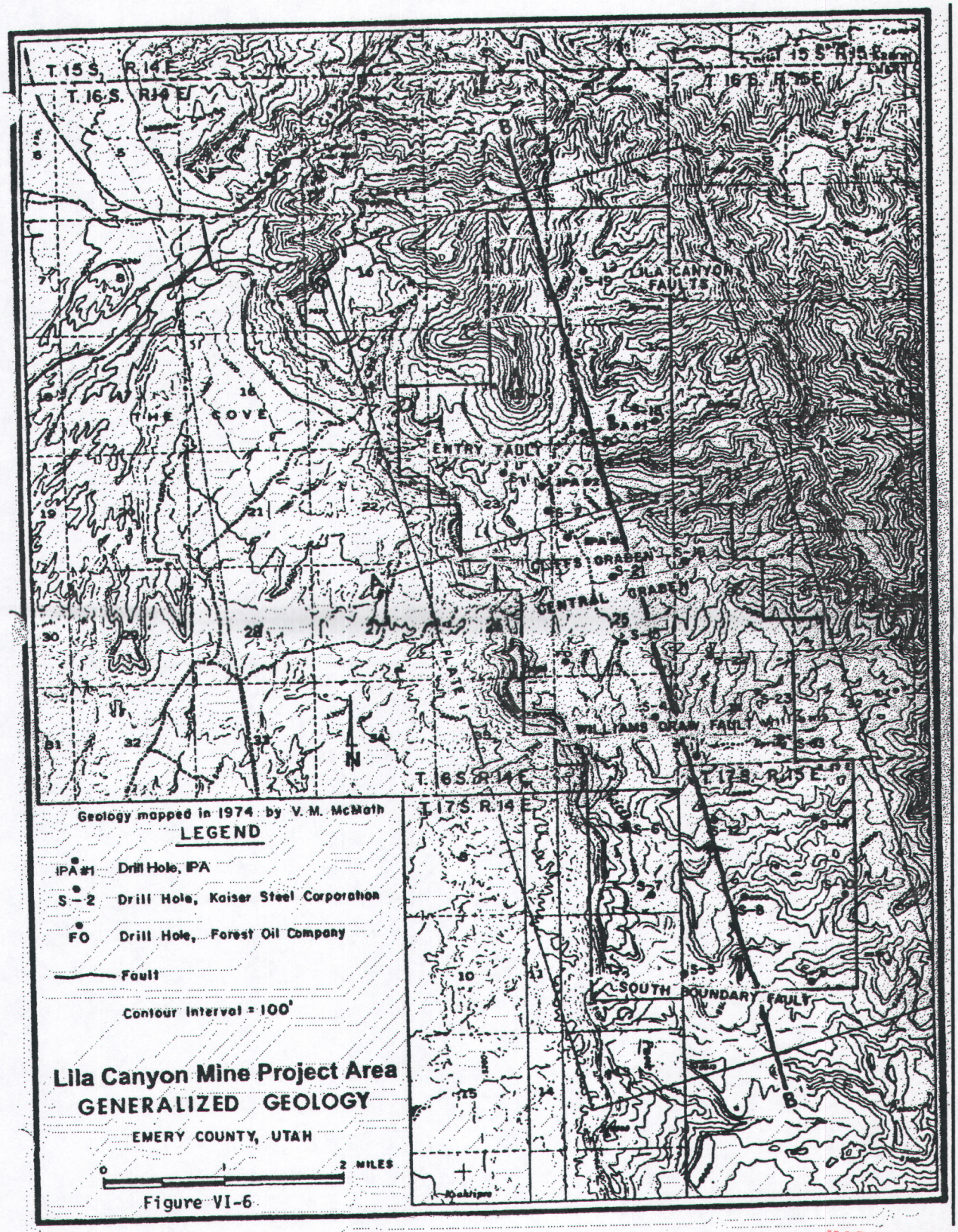
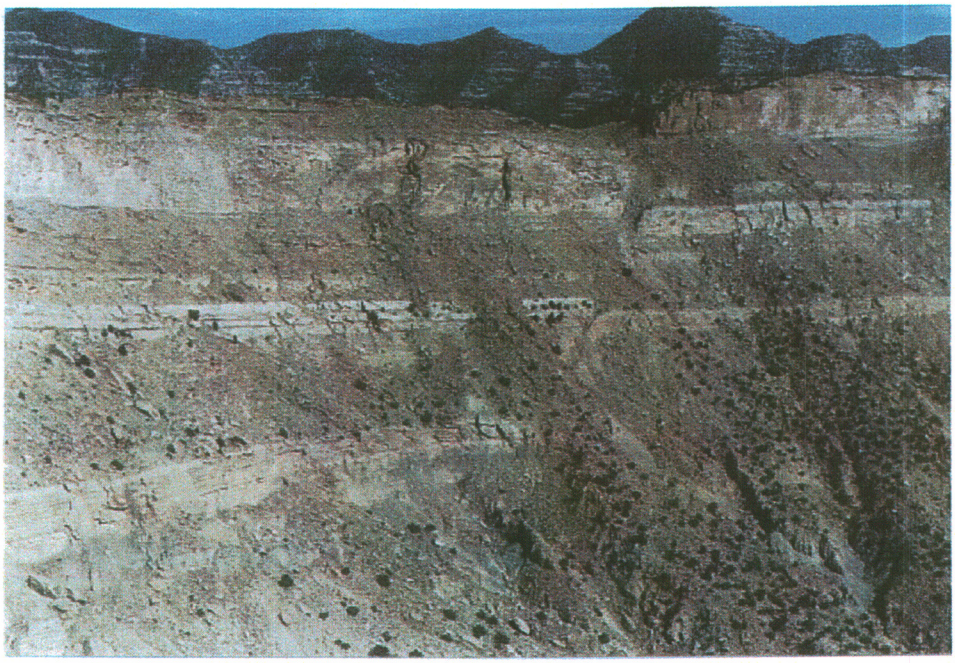
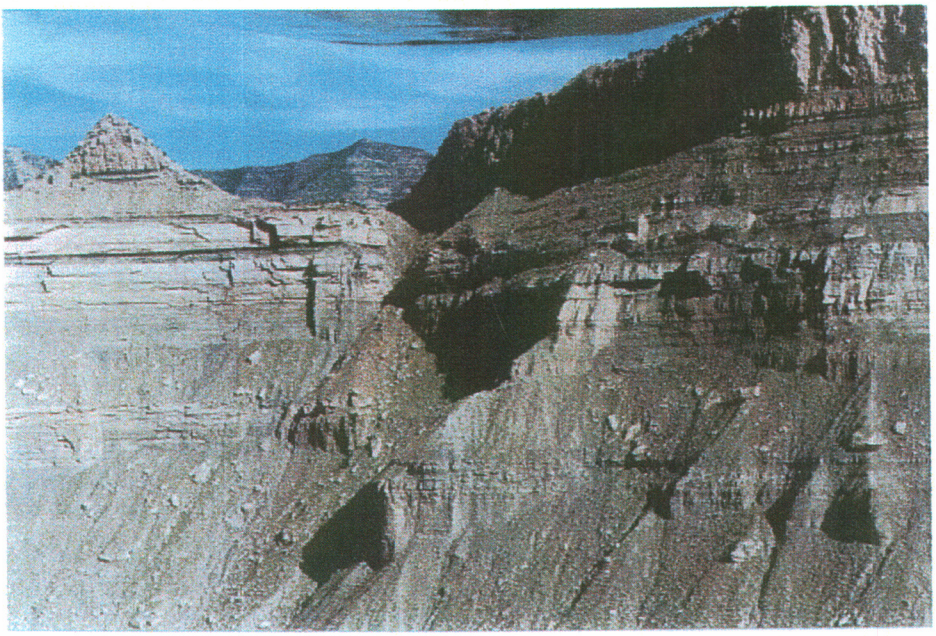


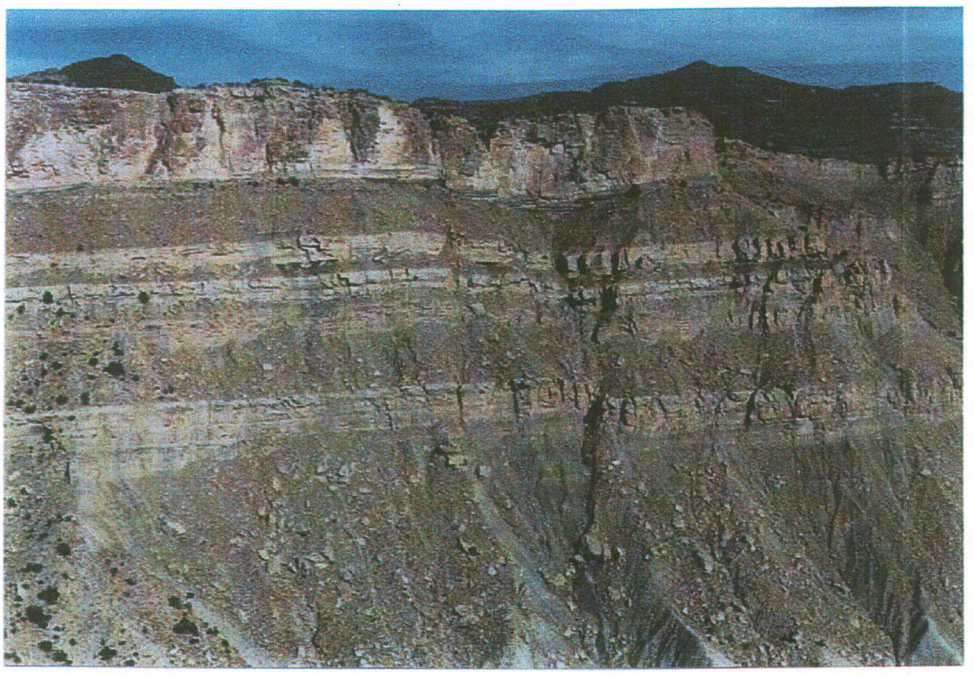
Figure VI-6



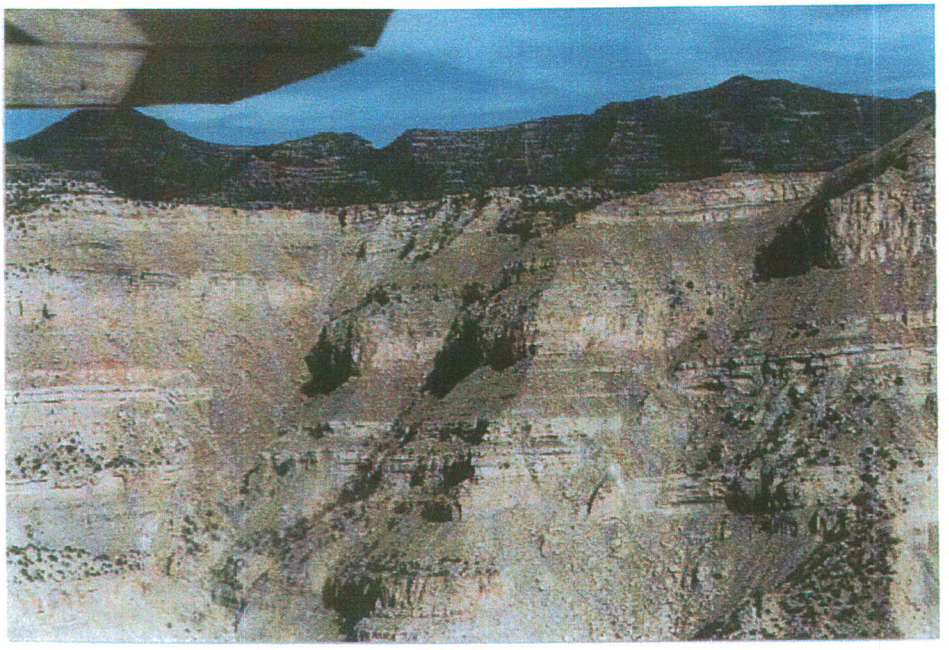
Williams Draw Fault



South Boundary Fault



Cliffs Graben



Central Graben

Entry Fault Near Lila Canyon Portals

No-Name South of Entry Fault

6.5.3.4 Burns

The South Lease Coal has not been as extensively burned as have the seams on properties to the north. The central and southern cliff exposures in the Lease show no evidence of burn; however, a few areas along the outcrop near the northwest part of the Lease have been affected. No evidence of burning was found in the drill holes.

6.5.3.5 Joints and Fractures

There appear to be at least three sets of steeply dipping joints, one trending north to northwest about parallel to the strike of the beds, one trending west-northwest (N5 to 25^{0}W), and one trending northeast to east-northeast (N75 to 85^{0}E), about parallel to the dip of the beds. These joints probably play an important part in the transmission of groundwater from the surface and certainly do control the mechanics of rockfalls at the cliff faces as well as the steep break lines that are known to exist.

6.5.4 COAL RESERVES

The coal reserves found in the Lila Extension has been submitted to the Bureau of Land Management (BLM) included in the Resource Recovery Protection Plan (R^2P^2).

6.5.4.1 Reserve Calculations

Reserve calculation methods have been submitted to the BLM under the Resource Recovery Protection Plan (R^2P^2) and the Logical Mining Unit submitted per 45 CFR 3482 and 43 CFR 3487 filled in November of 1993 ("November 1993 application").

6.5.4.2 Coal Quality

The average in-seam raw coal, based on core testing, contains 8.5% ash, 1.12% total sulfur for the main seam ,and 9.3% ash, 1.33% total sulfur for the lower seam, on dry coal basis. The low ash contents indicate that the coal seams are quite clean with very little shaly parting material.

Pyritic sulfur content generally constitutes about one-fourth to one-third of the total sulfur, averaging less than 0.35%. The balance is almost all organic sulfur since sulfate sulfur is negligible low.

Total sulfur and forms of sulfur are determined following standard procedures established by the American Society of Testing and Materials (respectively ASTM D-3177 and D-2492). Total, pyritic and sulfate sulfur are actually analyzed with the organic sulfur calculated by difference.

Pyrite and marcasite are iron sulfide minerals having identical chemical compositions (FeS_2 with 46.6% Fe and 53.4% S). They cannot be distinguished by normal sulfur analysis procedures. Alkalinity should be quite low since water soluble alkalies average only 0.007% Na_20 and

0.002% K_20 on a dry coal basis.

6.5.5 ADJACENT UNITS (OVERBURDEN)

A description of the adjacent units can be found under Section 6.5.2 (Stratigraphy).

Table 6-6 provides typical engineering properties of the rocks in the stratum immediately above and below the coal seam to be mined.

6.5.5.1 Rock Characteristics, Acid-Toxic, Pyrite, Clay and Alkalinity

Over the southern three-fourths of the property, a fine-to-medium-grained sandstone lays directly on the main seam of coal. In the north, up to four feet of carbonaceous mudstone and siltstone separate the sandstone from the coal. The contact with the coal is usually sharp and well-defined.

The rock section between the main and lower seams in the south, where the lower seam is thicker, is composed of a sequence of siltstone, sandstone, and carbonaceous mudstone.

Pyrite, which can be an indicator of potential acid- and- toxic forming materials, was observed sporadical in many of the cores both above and below the coal seam. Analyses of the rock above and below the coal seam has demonstrated that despite the Pyrite, three is not an acid or toxic forming materials problem above or below the coal seam.

Extraction of the coal will be by underground mining. Similar mining in the Sunnyside area shows that the major portion of any out of seam rock

that must be remove is disposed of in dry areas underground and will never reach the surface. A minor amount will be included with the mine-run coal as dilution rock.

Results of acid and toxic testing completed on drill holes S-24 and S-25 can be found in Appendix 6-2. Testing was completed for the strata immediately above and below the coal seam as well as for the rock slope material. These tests were run on drill holes and at the original projected slope location. The present proposed slope location is approximately three miles to north but located in the same strata. Except that the present projected slopes will start at the top of the Mancos shale and will be driven up to the coal seam but not beyond as was originally proposed by Kaiser.

Analysis of the strata immediately above and below the seam being mined at the Lila Canyon fan portal, collected by BXG, and an analysis of the Horse Canyon refuse pile have been included in Appendix 6-2. None of the analysis have an acid-base potential that would indicate an acid-toxic problem.

Kaiser Steel's Sunnyside Mine mined coal in the same horizons as those in the Lila Extension. With over 100 years of mining experience at the Sunnyside Mine operation, there has been no proven problems with acid-forming alkaline or toxic materials in production or waste disposal. The above statement is made based on history, data substantiating this assertion is beyond the scope of this MRP and is not included.

A small amount of acid- and toxic- drainage occurred at the base of the Sunnyside Mine refuse pile. The Lila Canyon refuse pile is not at all designed like the Sunnyside pile. Acidic water has seeped from the base of a refuse pile at Sunnyside. Even with the seepage there were no offsite problems or impacts because of the buffering environment. The refuse piles at Sunnyside contained reject material from the washing of coal. This reject would have an elevated sulfur content much higher than Lila. The Sunnyside piles were above ground, Lila is totally incised, below the surface. The events at Sunnyside that lead to the seepage of acidic water from the bottom of the refuse pile cannot happen at Lila.

Appendix 5-7 states: "Since coal washing is not proposed, the refuse will not contain consolidated reject, which is higher in sulfur. The refuse pile is completely incised and will be compacted and covered with 4' of material. Thus eliminating the potential of water percolation causing problems. Drainage over the compacted pile with 4' of cover will be diverted into the sediment pond."

Table 6-6
Typical Engineering Properties of Rocks
stratum immediately above and below coal seam

Hole #	Remarks	Depth	Compressive Strength (psi)	Tensile	Lat. Pressure (psi)	Young's Mod x10^6	Poission's Ratio	Apparent Sp Grav.	Shear Strength (psi)	Coef. of Int. Fric.
S-18	Roof	1861.1-1863.8	11170	507	0	1.83	0.16	2.332	2607	.79843
	Roof	" - "	12392		500	2.14		2.255		
	Roof	" - "	15493		1000	2.66		2.222		
	Roof	" - "	19394		2000	3.13		2.226		
	Roof	1878.1-1879.9	15391	687	0	1.75	0.10	2.362		
	Roof	" - "	14935		0	2.89	0.13	2.545		
	Roof Base	1883.8-1884.8	15977	693	0	1.93	0.12	2.364		
	Floor	1905.0-1907.7	15708	1175	0	3.23	0.07	2.577		
	Floor	" - "	27057		500	3.69		2.581		
	Floor	" - "	27060		1000	4.31		2.593		
	Floor	" - "	22514		2000	4.55		2.578		
S-22	Roof	1392.2-1395.0	7899	440.5	0	1.73	0.30	2.285		
	Roof	" - "	12906		500	2.34		2.229	1755	1.01703
	Roof	" - "	14841		1000	2.78		2.210		
	Roof	" - "	16582		1500	2.77		2.235		
	Roof	1406.1-1409.3	8738	475.5	0	2.00	0.26	2.262		
	Roof	" - "	14490		500	2.46		2.277	1848	1.08903
	Roof	" - "	19093		1000	3.00		2.187		
	Roof	" - "	18419		1500	3.51		2.200		
	Roof	1414.0-1417.7	11215	607	0	2.18	0.26	2.375		
	Roof	" - "	9331		0	2.47	0.15	2.385		
	Roof	1415.8-1417.7	12706	718	0	2.63	0.12	2.242		
	Floor	1430.3-1434.0	10789	663	0	2.86	0.20	2.474		
	Floor	" - "	13642		500	3.43		2.503	2688	0.80750
	Floor	" - "	17655		1000	3.85		2.517		
	Floor	" - "	18279		2000	2.67		2.500		
	Floor	1434.0-1435.9	10477	1076	0	1.83	0.10	2.519		
	Floor	1436.0-1438.1	12519	689	0	2.15	0.21	2.559		
	Floor	1438.1-1440.0	3538		0	2.9	0.44	1.374		
	Floor	1440.0-1442.0	10975	602	0	2.12	0.22	2.272		
	Floor	" - "	10766		0	2.16	0.23	2.259		

6.6 GEOLOGIC EFFECTS OF MINING

6.6.1 MINING HAZARDS

Mining hazards other than those normally associated with underground coal mining are not anticipated. Conditions are not expected to be significantly different than those associated with the Geneva, Columbia, and Sunnyside mines.

Water

Subsurface water inflow associated with fault or fracture systems are possible, however, this potential is not expected to be significant in the Lila Extension. Minor water inflows from the Geneva Tunnels is anticipated.

Gas

Gas in the Geneva mine was not a problem although an increase was detected as mining reached deeper levels over 2,000 feet. In view of the relatively low cover over the Lila Extension coal, and proximity up dip to the outcrop, methane is not anticipated to be a problem.

Seismic Disturbances

Coal mine bump phenomenon has long been observed in the Columbia, Geneva, and Sunnyside mines. In the Lila Extension where faults are closely spaced, highly stressed rock and coal are likely to occur.

6.6.2 SURFACE HAZARDS

Surface subsidence can be expected in the Lila Extension. The impact will vary with depth of overburden and mining methods, i.e. full extraction versus leaving of supports which will affect coal recovery.

6.6.3 IMPACTS OF MINING

6.6.3.1 Subsurface Water

Occurrences of groundwater in the Geneva Mine are similar to conditions at Sunnyside and are projected to be similar in the Lila Canyon Extension. Little or no water is observed in the raise areas within .25 to 1 mile of the coal outcrop. Flows of water encountered while mining were reduced to seeps or dry up in a short period of time. This water is thought to be in place with little or no recharge. Drill holes in the South Lease property below Williams Draw did not encounter groundwater within 1 to 1.25 miles of the coal outcrop. For this reason subsurface water is not expected near the cliff escarpment.

Mining of the exploration test entry from the Geneva Mine during years 1957 to 1962 encountered in-place water in the Sunnyside coal seam. This water was allowed to collect in short cuts made into the down dip entry which was sufficient to keep excess water from working areas. The exploration entry (Geneva Tunnel) was terminated when the Entry fault was

encountered. More than two months was spent drilling to ascertain the nature of the fault and locate the coal seam. There is no mention in the records of excess water or that water was encountered in the Entry fault area.

As a result of the above paragraph the quantity of water along faults is thought to be much less than originally anticipated.

In the Geneva Mine water flows and seeps were reported to be 1 to 24gpm. As mining progresses down dip, localized fracture systems and faults may contain some small amounts of water.

6.6.3.2 Toxic Wastes

Rock occurring above and below the coal seam other than that closely associated with the coal is not expected to be brought to the surface. Such waste rock, if removed, will be disposed of in worked-out areas of the mine.

A minor amount of rock will be included with the mine run coal as dilution rock, some of which will be rejected as waste from the rotary breaker. This reject material will be stockpiled in a designated area on the surface. As discussed in Section 6.5.5.1, toxic waste production is not anticipated.

6.6.3.3 Subsidence

Subsidence is expected during the life of the mine, however, there is

not anticipated major effects due to subsidence during the permit term or thereafter. Surface subsidence effects on mining are discussed in Chapter5. The subsidence control plan is all so discussed in Chapter 5.

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