UTAH POWER & LIGHT COMPANY

1981 SUBSIDENCE REPORT

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APPENDICES

Wilberg Mine Subsidence
By John T. Boyd Company

Des-Bee-Dove Mines, Subsidence Study
By Engineering Enterprises, Inc.

Surface Subsidence Over Longwall Panels at the Deer Creek Mine
By Frederick K. Allgaier, Bureau of Mines

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OIL, GAS & MINING

1981 SUBSIDENCE REPORT

Introduction

In accordance with federal regulations 30 CFR 211, underground coal operators in 1977 were required to submit both subsidence and hydrological monitoring plans to the U. S. Geological Survey.

Monitoring plans were prepared under the published guidelines submitted in December 1977. Subsequent events have transferred environmental authority, which includes monitoring, from the U.S.G.S. to the Office of Surface Mining and finally to the State's Division of Oil, Gas and Mining.

Both monitoring plans have been initiated and presently are gathering field data.

This report concerns itself only with the subsidence aspects of mining. The hydrological monitoring reports are published separately (see reports dated 1979, 1980 and 1981).

Location

Mining takes place under a relatively flat plateau called East Mountain located about seven miles west of Huntington, Utah (Figure 1).

Mining under East Mountain is achieved in five mines located within two coal seams. The two largest mines, the

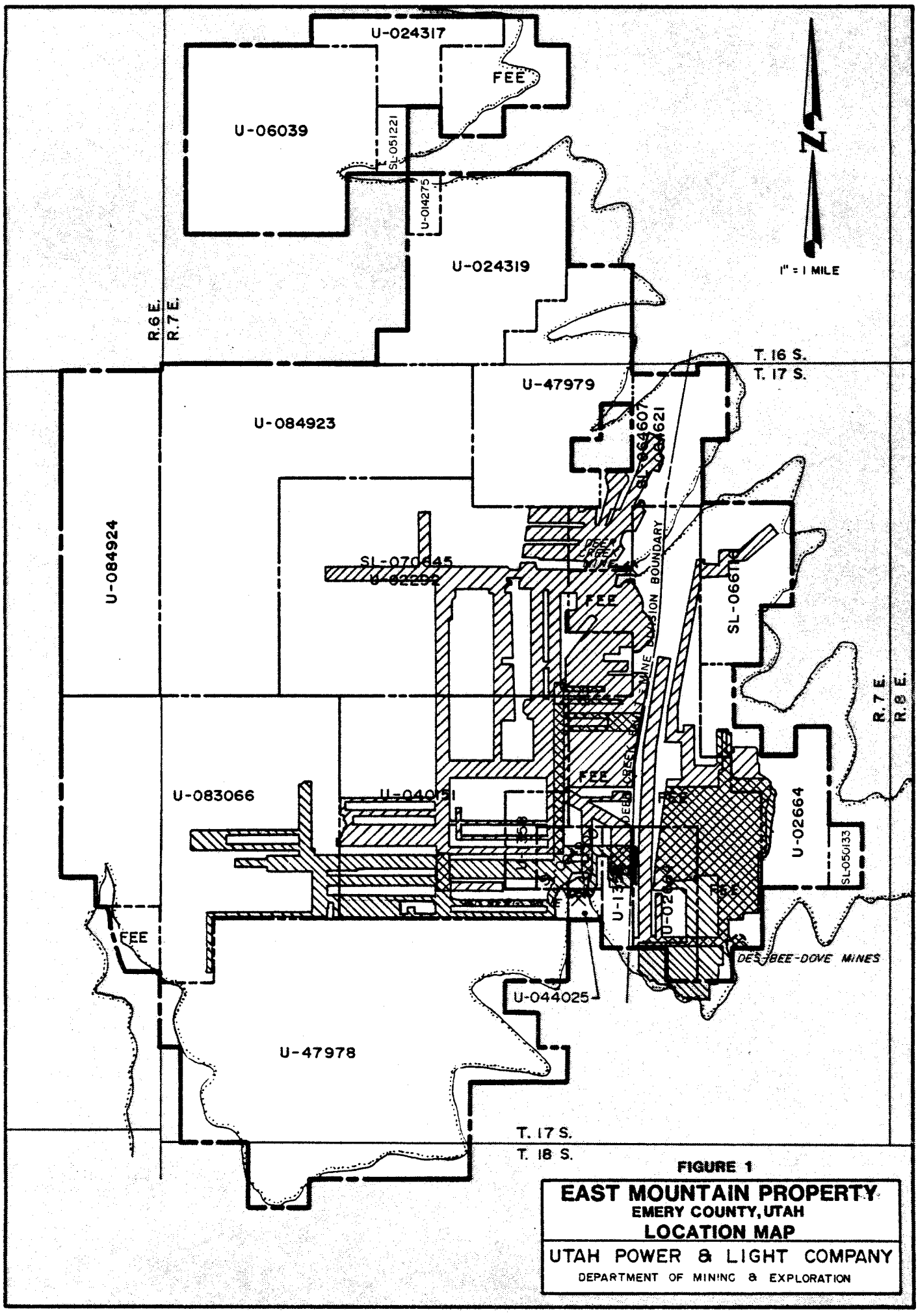


FIGURE 1

EAST MOUNTAIN PROPERTY
EMERY COUNTY, UTAH
LOCATION MAP

UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION

Deer Creek in the upper seam and the Wilberg Mine in the lower seam are superimposed. The other three mines, the Little Dove and the Beehive in the upper seam and the Deseret Mine in the lower seam are part of a single complex having common surface facilities. Mines within this complex called the Des-Bee-Dove complex are isolated from the Deer Creek and Wilberg Mines by the Deer Creek Fault.

With the exception of the Little Dove Mine, extensive mining had taken place in all the mines prior to the regulatory date of August 3, 1977 (SMCRA). Although regulatory exemption provides that these mined out areas be excluded from surface monitoring, it is felt that until conclusive evidence of subsidence is gathered, monitoring shall include the entire permit area. Mine workings existing prior to 1980 have not been previously monitored and may have already subsided.

On-the-ground inspections were made in conjunction with the hydrological water collection on East Mountain. These inspections failed to identify subsidence prior to 1980.

Mining Methods

When Utah Power & Light Company purchased both the Deer Creek and Wilberg Coal Mines in 1976, mining was done

exclusively by room-and-pillar methods utilizing continuous miners to extract coal. Over the past three years room-and-pillar gave way to newly-installed longwall mining systems. Presently, both mines employ two longwall systems.

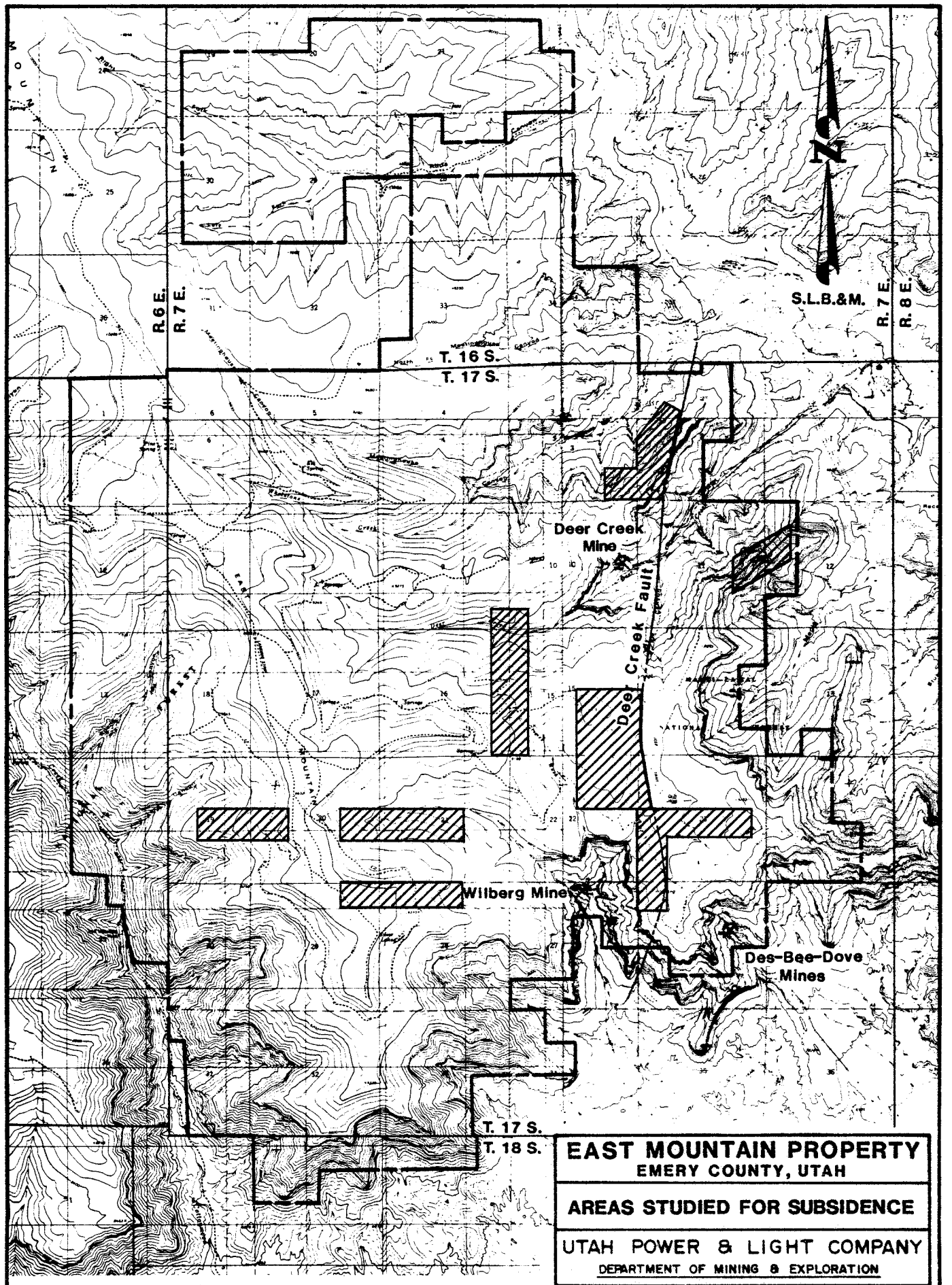
The longwall system differs from the room-and-pillar method in that a total extraction is achieved in the mining section. A section measures approximately 500 feet in width by 3000 feet or more in length. As coal is removed, caving begins, creating a controlled relaxing of roof pressures.

Longwall mining is the primary mining method in both the Deer Creek and Wilberg Mines. This mining system is considered the most effective mining method available to achieve the highest resource recovery with minimum subsidence effects.

Monitoring Methods

With such a large surface area to monitor it was reasoned that, economically, only photographic methods were affordable (Figure 2). Discussions with the U. S. Forest Service and the Office of Surface Mining resulted in a modified plan.

The OSM voiced concern it would like to see immediate data. What they asked for was monumented survey lines over the "next panel having pillars pulled". Each mine, Deer Creek,



EAST MOUNTAIN PROPERTY
EMERY COUNTY, UTAH

AREAS STUDIED FOR SUBSIDENCE

UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION

DATE: OCT. 21, 1982	BY: S.M. CHILD
SCALE: 1" = 1 Mile	FIGURE 2

Wilberg and the Des-Bee-Dove, all have on-the-ground monumented survey lines which are centered over mining sections that have been mined out. These physical surveys are henceforth referred to as conventional surveys.

Most significant of the three study sites is the area above the Deer Creek Mine. The U. S. Bureau of Mines expressed an early interest for subsidence data effected by longwall mining. An agreement was made and the study area was monumented.

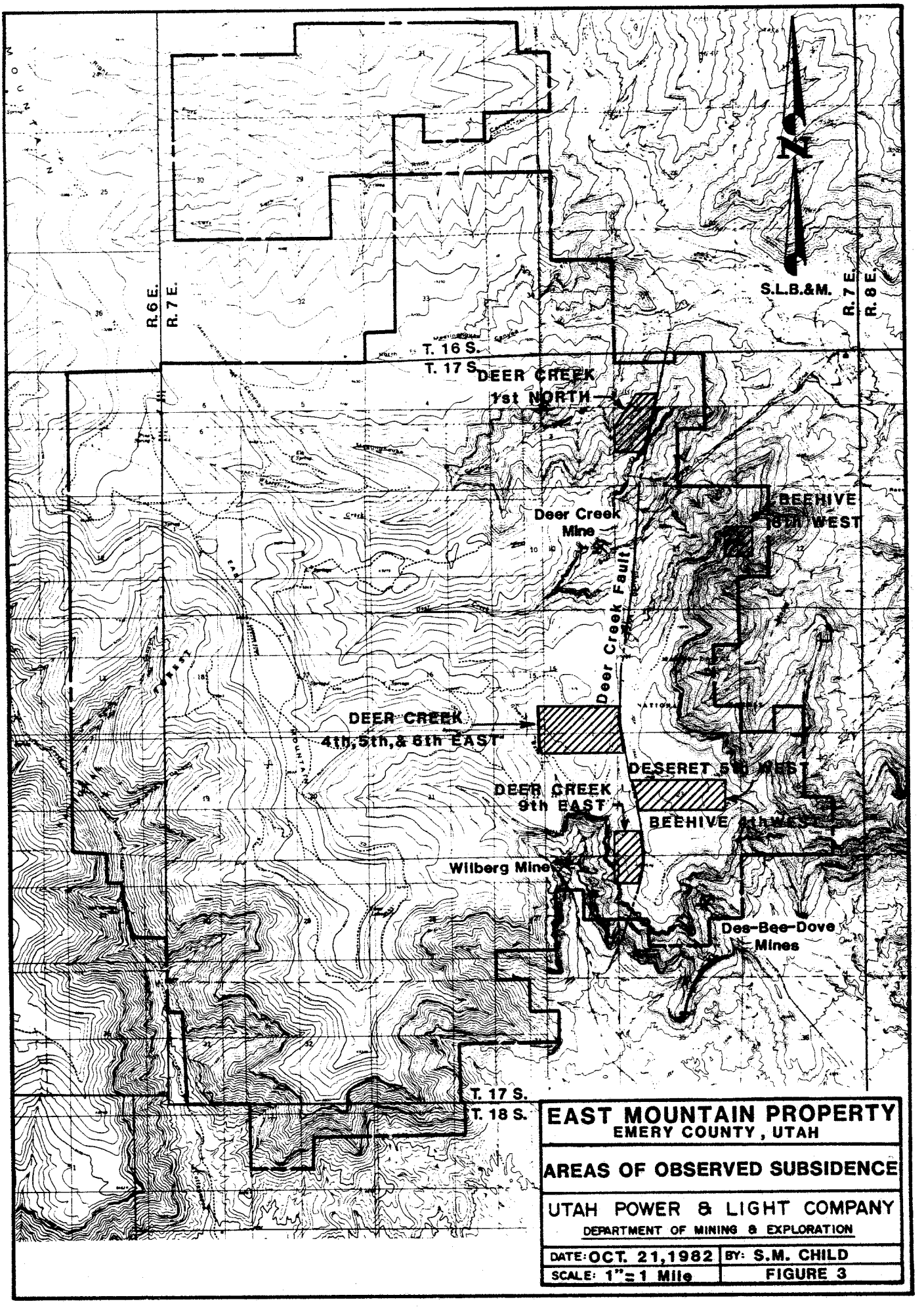
A ream of data now exists and will continue to be collected, hopefully until this double seam study area has been fully mined and subsidence has ceased. An interim report is included in this submittal.

According to the submitted Subsidence Monitoring Plan, all mined areas will be covered by an annual low altitude photogrammetical survey. Areas of known subsidence and areas which are suspect will be read and recorded.

An annual report, together with a one foot subsidence contour map, will be submitted to the regulatory authority. Accuracies are expected to be within plus or minus one foot of relative elevations. It is planned to continue the conventional surveys until it can be demonstrated by comparisons that results derived from aerial surveys are sufficient in themselves to evaluate subsidence.

Subsidence Locations

The subsidence monitoring program conducted on East Mountain has identified five areas which have been subjected to mining induced subsidence (Figure 3). Three of these areas were identified by annual aerial surveys and on-the-ground visual inspections. Subsidence in these areas was measured photogrammetically. The fourth area of subsidence is located above the Deseret and Beehive room-and-pillar sections. This location shows no visible signs of subsidence. Physical measurements reflect a small relaxation of strata. The fifth area of subsidence was identified from measurements made by the Bureau of Mines and contains no fractures or visible evidence on the land surface. The study areas of subsidence referred to in this report are as follows: (1) Deer Creek, 9th East, (2) Deer Creek, 1st North, (3) Beehive, 8th West, (4) Beehive and Deseret, 4th and 5th West, (5) Wilberg, 2nd West, and (6) Deer Creek, 4th, 5th and 6th East longwall areas.



EAST MOUNTAIN PROPERTY
EMERY COUNTY, UTAH

AREAS OF OBSERVED SUBSIDENCE

UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION

DATE: OCT. 21, 1982	BY: S.M. CHILD
SCALE: 1" = 1 Mile	FIGURE 3

Deer Creek 9th East

The topography in this area is rugged and variable (Figure 4). A steep talus slope extends upward from the coal seam elevation of 7600 feet to the base of the cliff formed by the Castlegate Sandstone which is located at an elevation of 8250 feet. The Castlegate Cliff is approximately 250 feet high and is overlain by a steep slope formed by the Price River Formation. At the top of this slope the coal seams are covered by 1100 to 1200 feet of overburden.

Mining in the Deer Creek 9th East section (Blind Canyon Seam) commenced in December 1979 with final pillar extraction completed in December 1981 (Figure 5). The mine workings intersected burned coal both on the south and west and are adjacent to the Deer Creek Fault to the east. Generally, the coal was mined to a height of nine feet.

Mining in the Wilberg Mine (Hiawatha Seam) began after the August 1981 reporting period. However, the Hiawatha Seam is known to be burned throughout much of this area which, to some degree, has the same effect as mined coal.

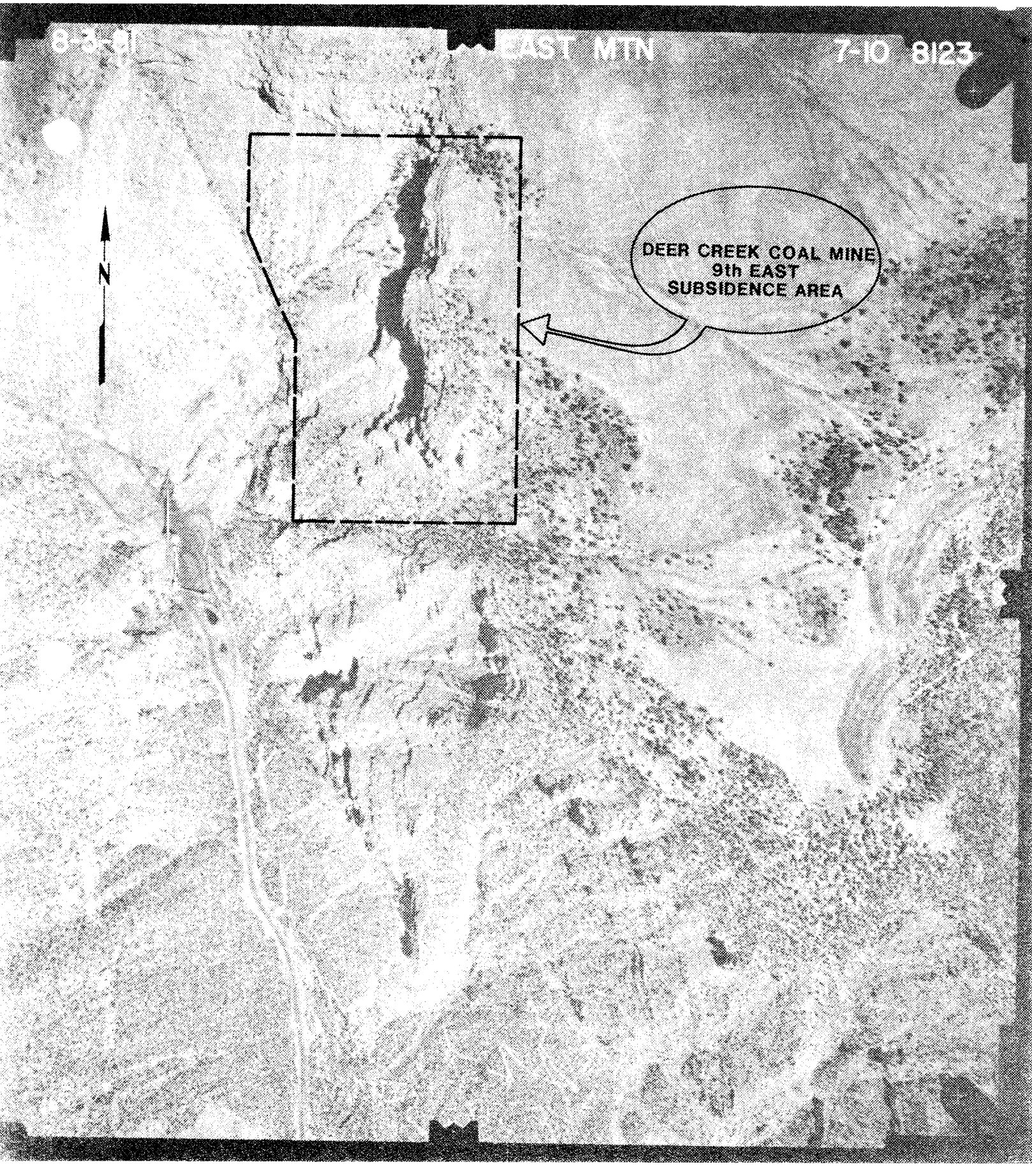
The subsidence which occurred prior to August 1980 is shown on Figure 6. The maximum subsidence measured is seven feet and is located immediately above the mine workings. Much of the subsidence is located several hundred feet away from the mine workings but is underlain by burned coal seams. It

is felt that the clinker beds adjacent to the mine workings were crushed when coal extraction created a shift in pressures.

Several fractures have been mapped from the aerial photos and are shown on Figure 6. The easternmost fractures are located along the trace of the Deer Creek Fault which also forms the eastern limit of subsidence. All of the fractures mapped are located in areas of the Castlegate Sandstone and the Price River Formation. These fractures follow the natural north-south trending joints which are present in the two sandstone units. The areas of maximum subsidence contain no visible fractures. This is due to the fact that mudstones of the Blackhawk Formation which are exposed on the surface in this area yield to the stress of subsidence without fracturing while the more competent sandstone in the areas of fractures will not yield causing slippage along the natural joints.

To insure safety of livestock and wildlife, this area, totaling 23 acres, has been fenced and posted. It is felt that the subsidence will not have an impact on the hydrology of the area because the land surface as well as the mine workings are dry indicating that groundwater is not present.

In the aftermath of the initial subsidence event a special study was commissioned to analyze present mining conditions in 1st Right of the Wilberg Mine. This report and conclusions have been included (see John T. Boyd Company).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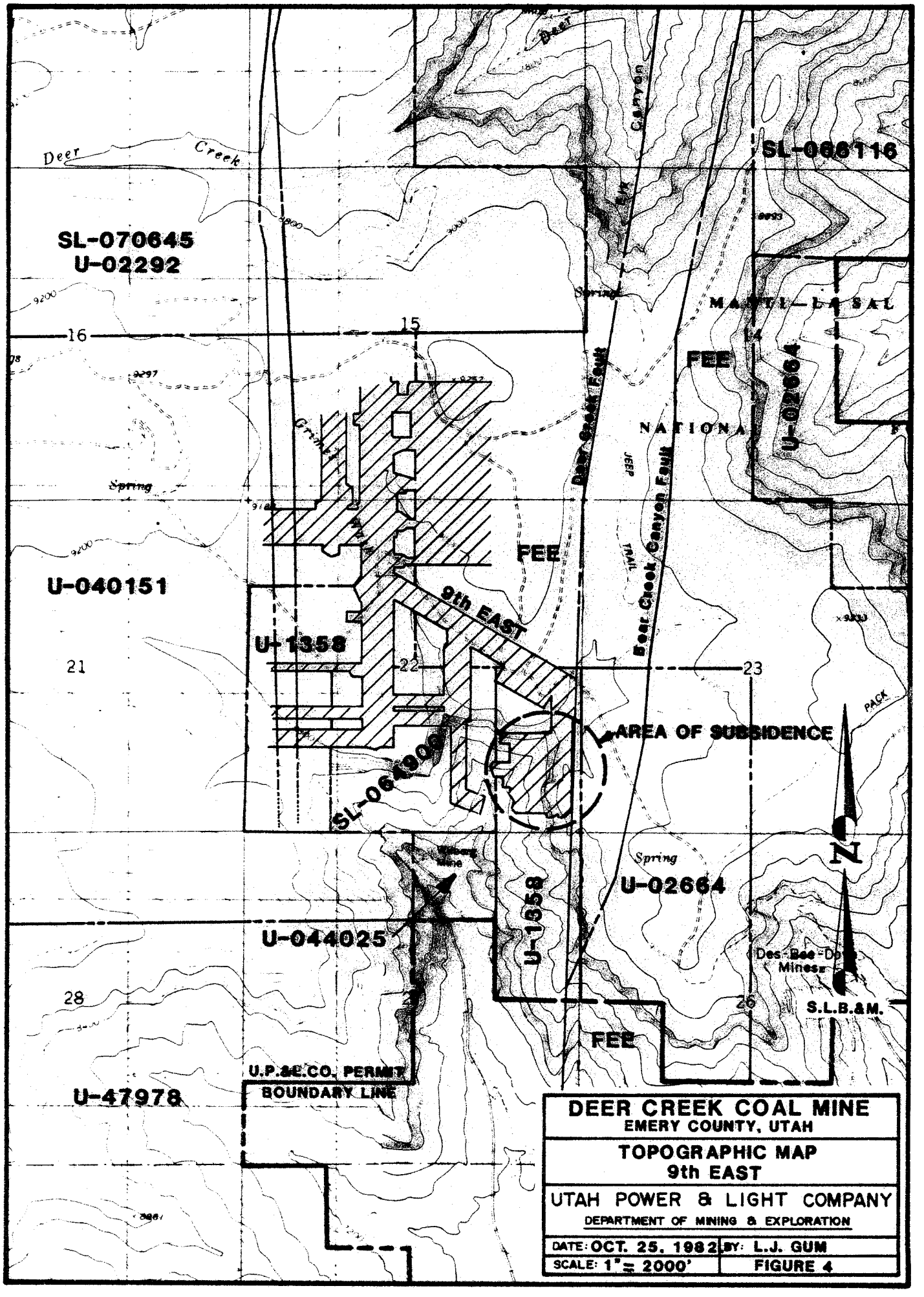
EAST MTN
7-10 8123
N
DEER CREEK COAL MINE
9th EAST
SUBSIDENCE AREA

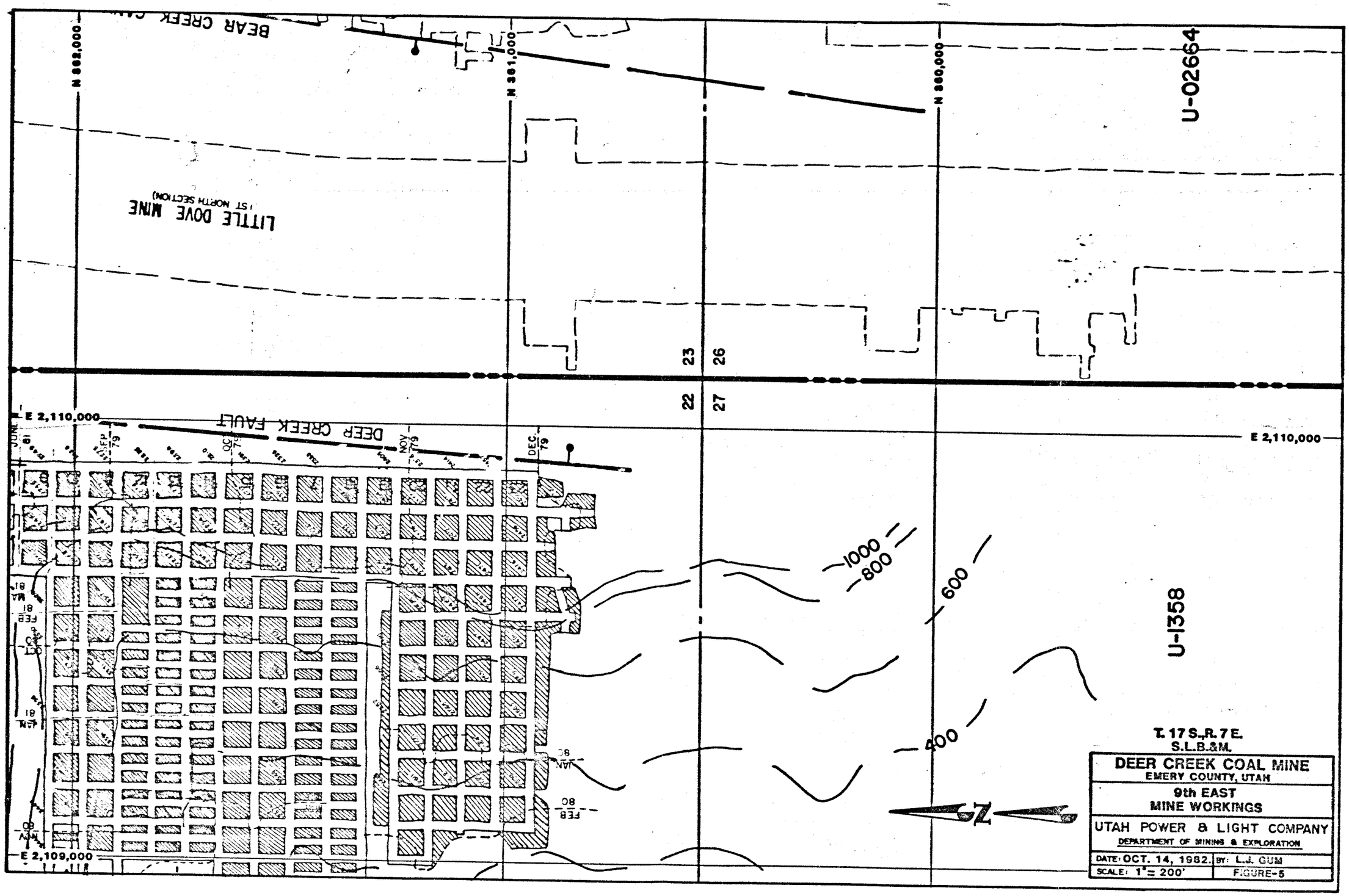


DEER CREEK COAL MINE
EMERY COUNTY, UTAH

TOPOGRAPHIC MAP
9th EAST

UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION

DATE: OCT. 25, 1982	BY: L.J. GUM
SCALE: 1" = 2000'	FIGURE 4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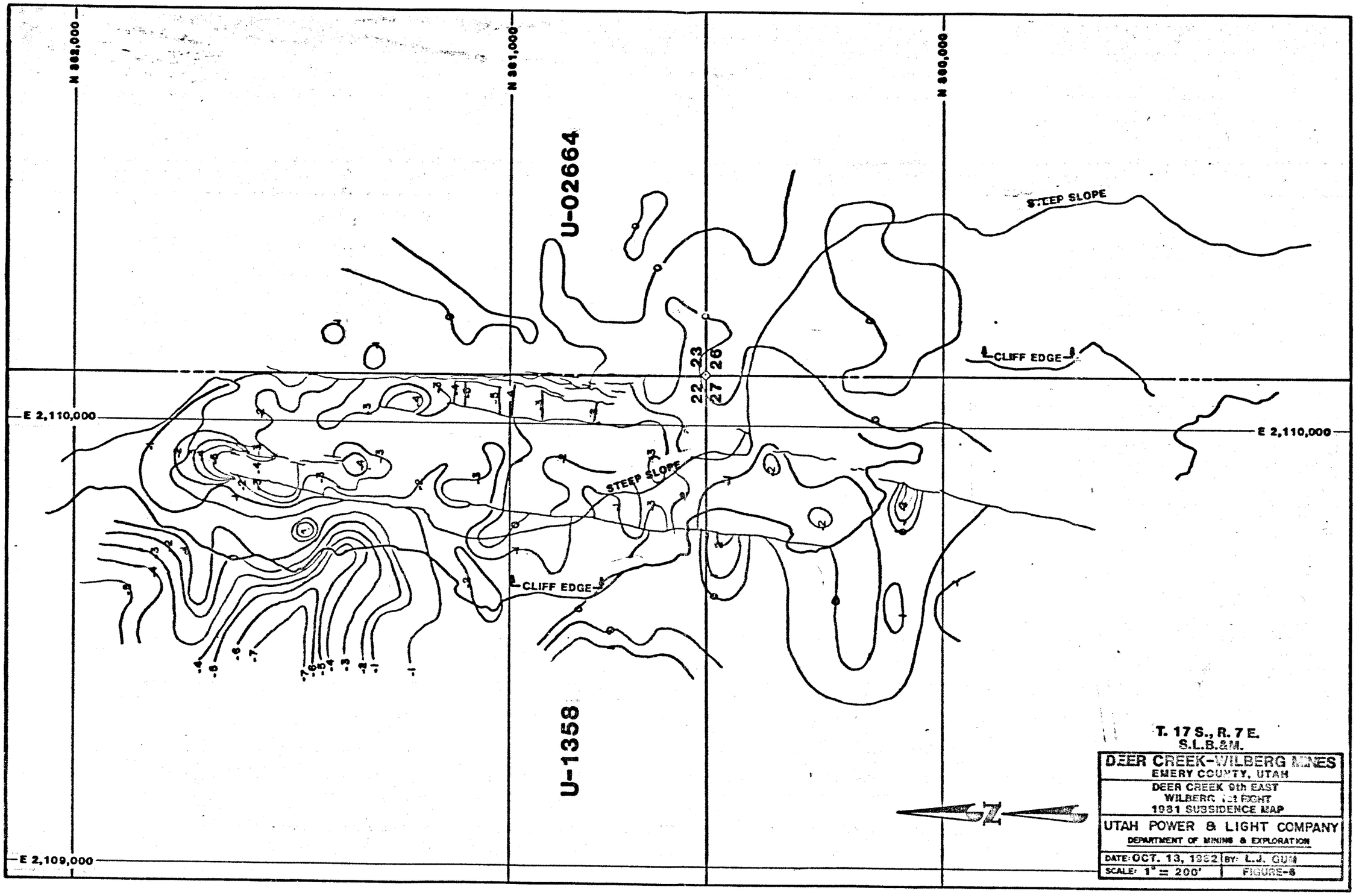
N 881,000
N 880,000
U-02664
LITTLE DOVE MINE
(1ST NORTH SECTION)
23
26
22
27
E 2,110,000
E 2,110,000
DEER CREEK FAULT
JUNE 81
SEP 79
OCT 79
NOV 79
DEC 79
JAN 80
FEB 80
MAR 81
FEB 81
JAN 81
NOV 80
1000
800
600
400
U-1358
E 2,109,000
T. 17 S., R. 7 E.
S.L.B.&M.
DEER CREEK COAL MINE
EMERY COUNTY, UTAH
9th EAST
MINE WORKINGS
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 14, 1982.
BY: L.J. GUM
SCALE: 1" = 200'
FIGURE-5


N 882,000
N 881,000
N 880,000
U-02664
STEEP SLOPE
CLIFF EDGE
23
26
22
27
E 2,110,000
E 2,110,000
STEEP SLOPE
CLIFF EDGE
U-1358
E 2,109,000
T. 17 S., R. 7 E.
S.L.B.&M.
DEER CREEK-WILBERG MINES
EMERY COUNTY, UTAH
DEER CREEK 9th EAST
WILBERG 1st RIGHT
1981 SUBSIDENCE MAP
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 13, 1982
BY: L.J. GUM
SCALE: 1" = 200'
FIGURE-8

Deer Creek 1st North

The topography in this area is rugged, being part of a narrow cliff bounded ridge located between Deer Creek Canyon and the south fork of Meetinghouse Canyon (Figure 7). The cliff is formed by the Castlegate Sandstone and consists of several smaller ledges totaling about 250 feet in height. Because of the topographic relief in this area, the Blind Canyon Seam is covered with overburden which varies from 500 to 1200 feet.

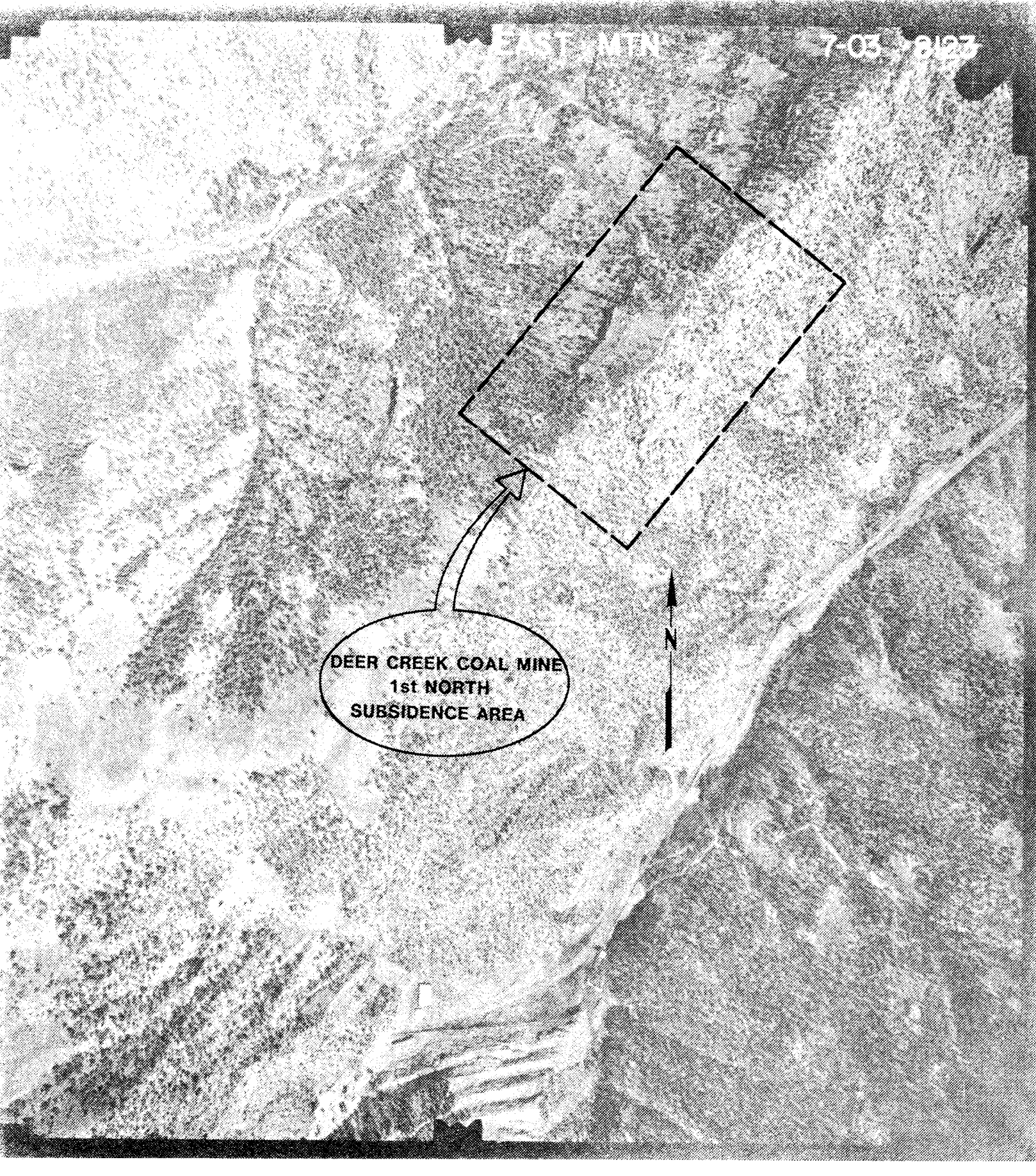
Mining in this area began in September of 1974 with final pillar extraction completed in February of 1978. The mine workings, as shown on Figure 8, were extended northward to intersect the abandoned Paramount Mine and burned coal. Burned coal surrounds all of these mine workings. Generally coal was mined to a height of eight feet. Although mining had been completed in this area prior to August 1980 when the initial aerial subsidence surveys were flown, subsidence has been measured between 1980 and 1981.

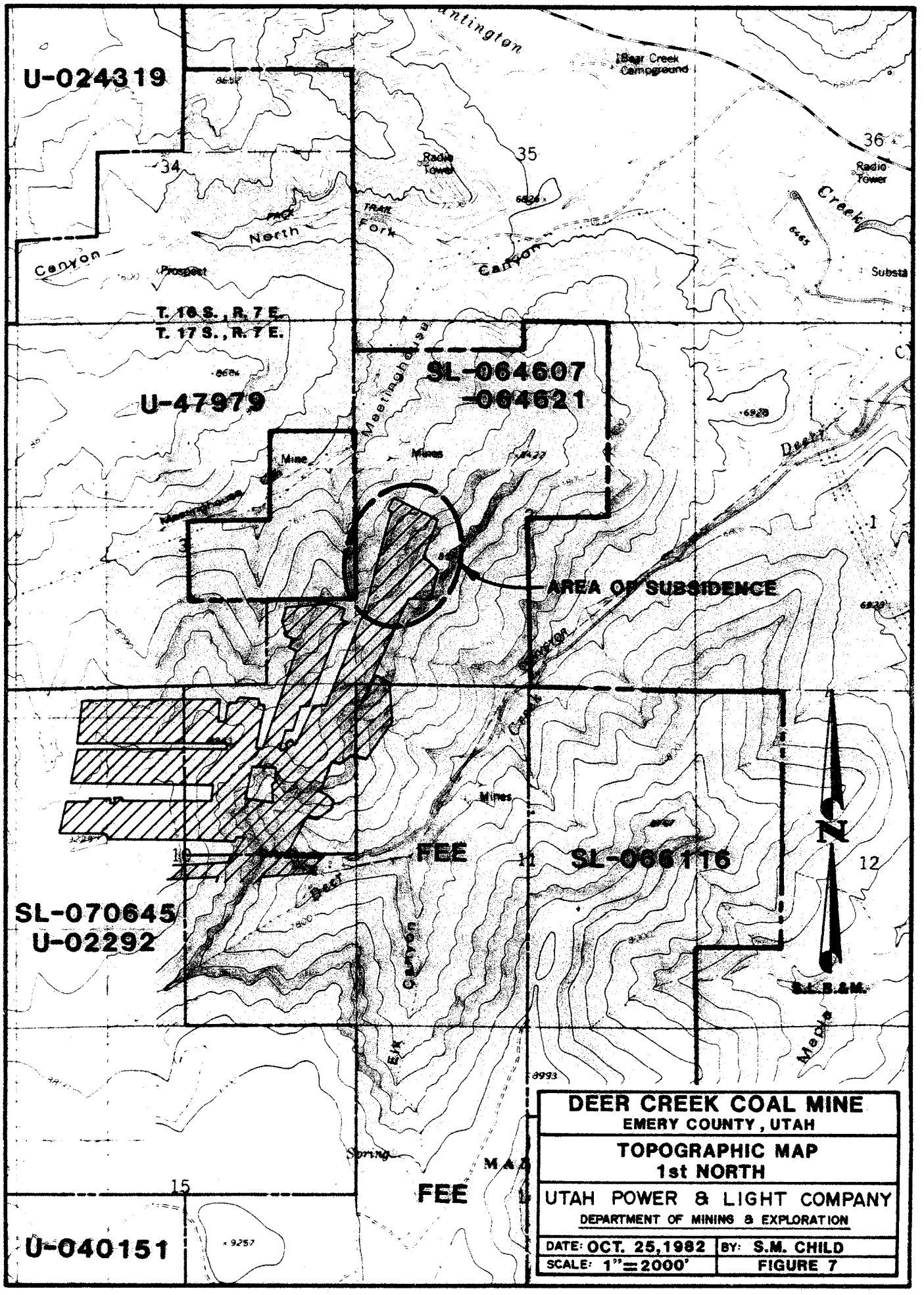
Between August of 1980 and 1981, the land surface above the 1st North area of the Deer Creek Mine subsided a maximum of two feet (Figure 9). Subsidence totaling 1.5 feet has occurred as far as 250 feet from being over the mine workings. The subsided area is within expected limits

assuming a draw angle of 27 degrees. It is possible that the pressure adjustments caused by coal extraction could have crushed the clinker beds of the burned coal adding to the subsidence in these areas.

Several fractures have been observed which are associated with the subsidence (Figure 9). All of the fractures are located in areas of Castlegate Sandstone and Price River Formation outcrops. No fractures have, as yet, been observed above the mine workings where maximum subsidence has occurred.

An on-site inspection made during August 1982 revealed little sign of livestock or wildlife having passed through this area. The subsidence is not expected to have an impact on the hydrology of the area as well because the strata, being located on a narrow ridge, received too little recharge to produce significant groundwater. Field inspections made in 1979 failed to identify any springs in or near this disturbed site.


EAST MTN
7-03 8/93
DEER CREEK COAL MINE
1st NORTH
SUBSIDENCE AREA
N

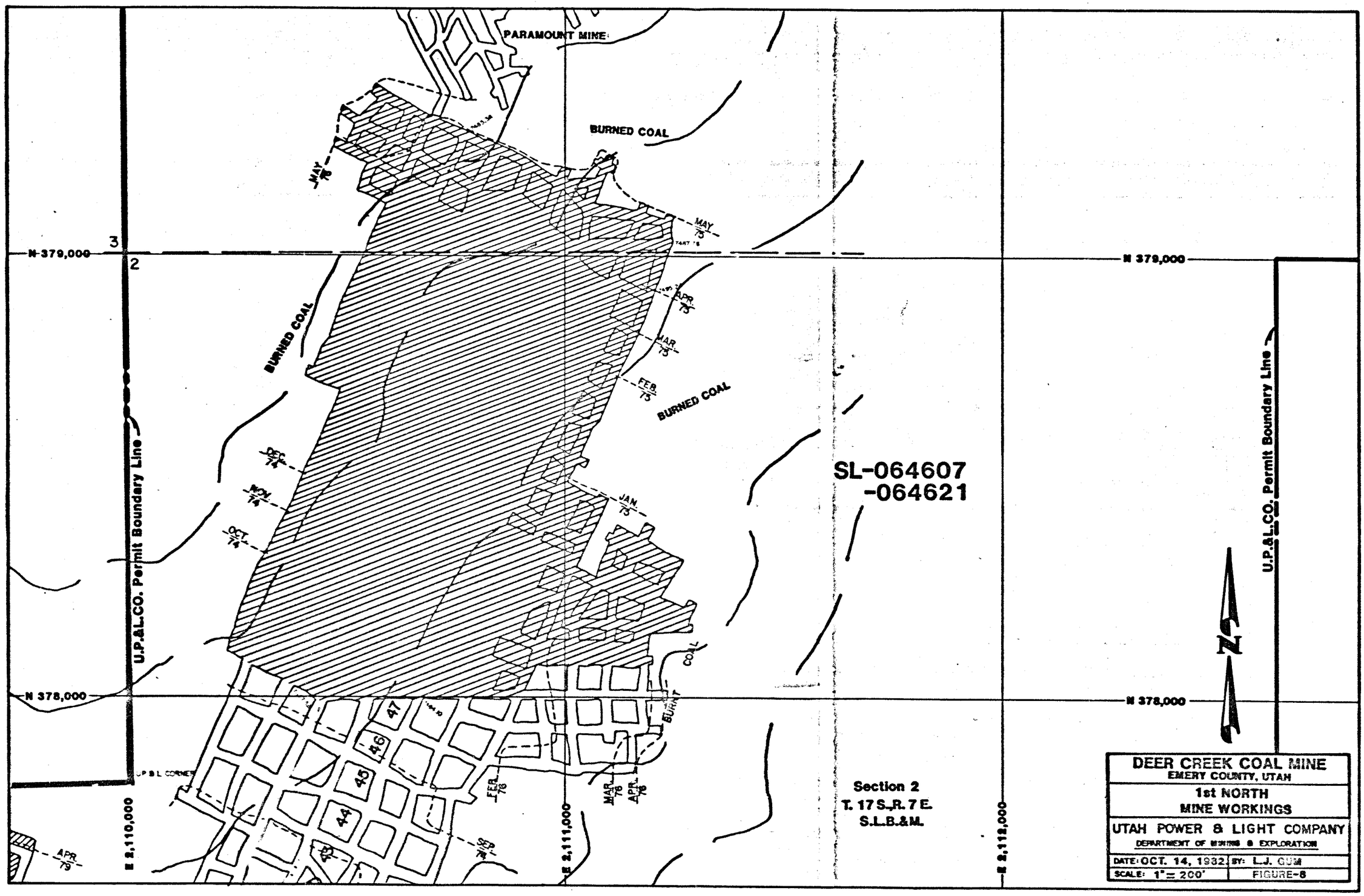


DEER CREEK COAL MINE
EMERY COUNTY, UTAH

TOPOGRAPHIC MAP
1st NORTH

UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION

DATE: OCT. 25, 1982	BY: S.M. CHILD
SCALE: 1" = 2000'	FIGURE 7


PARAMOUNT MINE
BURNED COAL
BURNED COAL
BURNED COAL
BURNT COAL
MAY 75
MAY 75
APR. 75
MAR. 75
FEB. 75
JAN. 75
DEC. 74
NOV. 74
OCT. 74
FEB. 76
MAR. 76
APR. 76
SEP. 76
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47
46
45
44
43
3
2
N-379,000
N 379,000
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U.P.&L.CO. Permit Boundary Line
U.P.&L.CO. Permit Boundary Line
U.P.&L. CORNER
E 2,110,000
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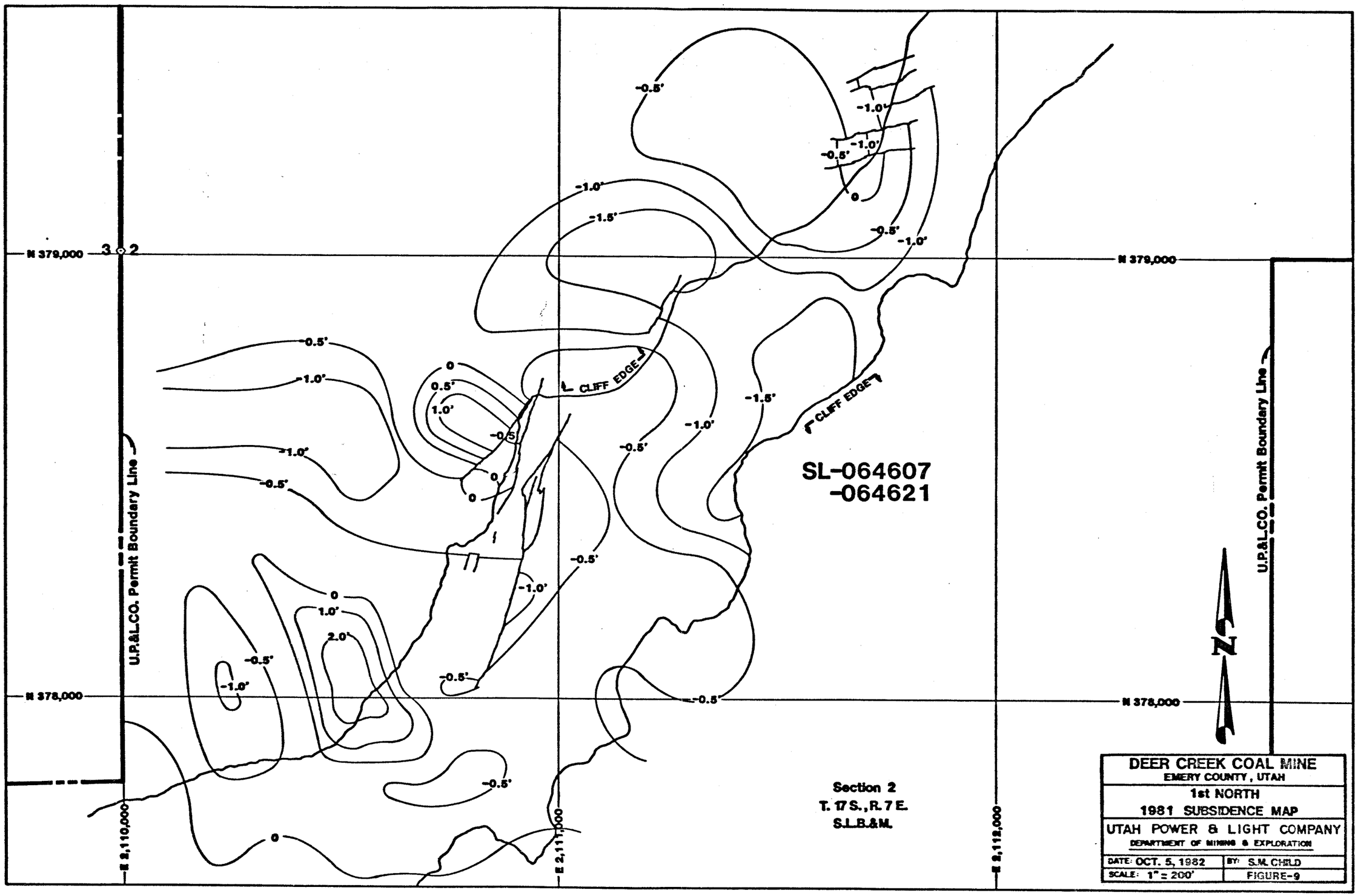
E 2,112,000
SL-064607
-064621
Section 2
T. 17 S., R. 7 E.
S.L.B.&M.
N
DEER CREEK COAL MINE
EMERY COUNTY, UTAH
1st NORTH
MINE WORKINGS
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 14, 1982
BY: L.J. GUM
SCALE: 1" = 200'
FIGURE-8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E 2,110,000
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U.P.&L.CO. Permit Boundary Line
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CLIFF EDGE
CLIFF EDGE
SL-064607
-064621
Section 2
T. 17 S., R. 7 E.
S.L.B.&M.
N
DEER CREEK COAL MINE
EMERY COUNTY, UTAH
1st NORTH
1981 SUBSIDENCE MAP
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 5, 1982
BY: S.M. CHILD
SCALE: 1" = 200'
FIGURE-9

Beehive Mine 8th West

First signs of mining disturbance occurred along a narrow ridge located between Deer Creek Canyon and Maple Gulch (Figure 10). The Castlegate Sandstone caps the top of this ridge forming a cliff 250 feet high. Below this cliff are steep cedar covered slopes which lead to the valley below. The coal seam overburden varies from 300 feet to as much as 1100 feet in this area.

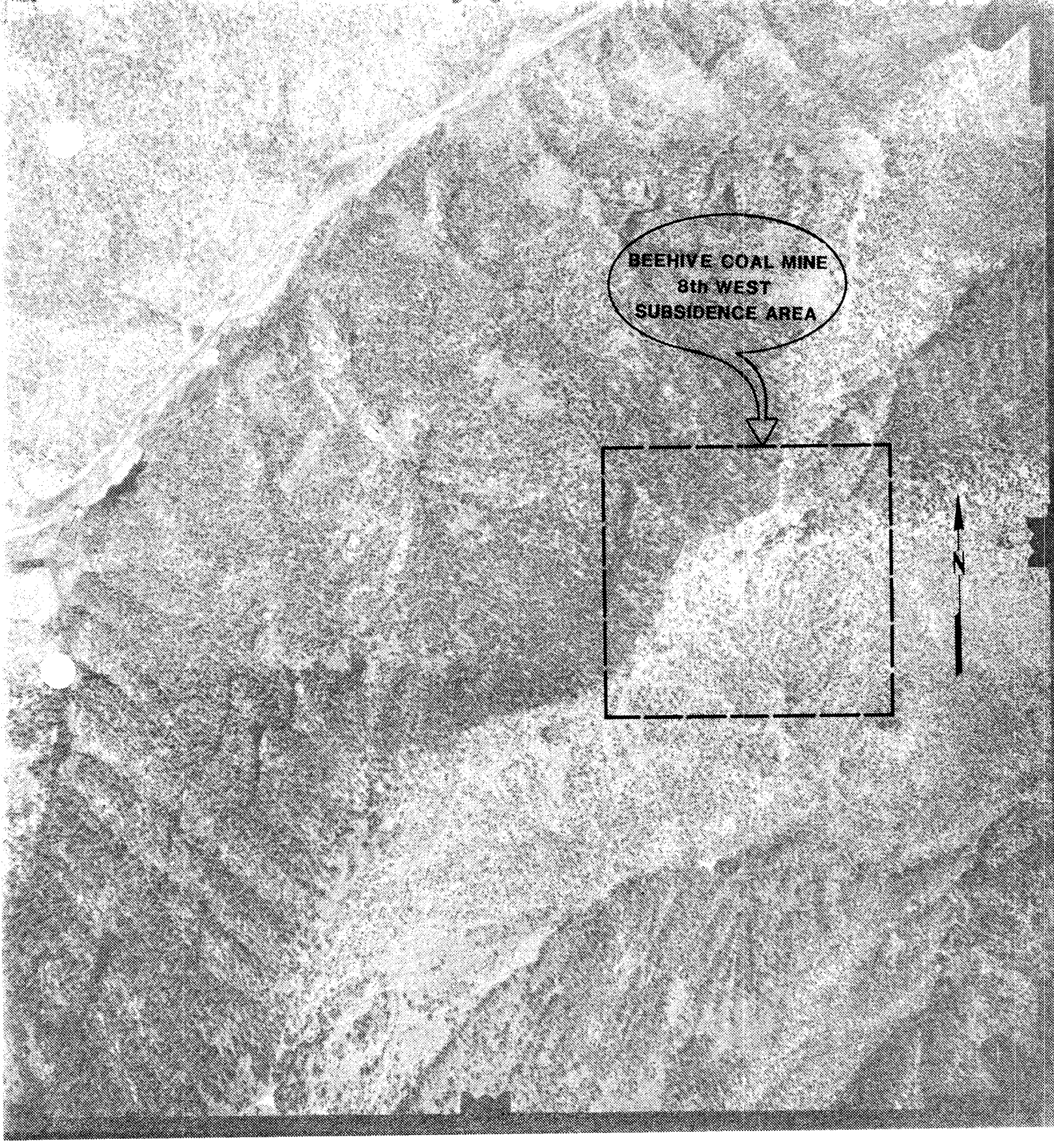
Mining in this area began in May of 1980 with pillar extraction in progress in August 1981 (Figure 11). The mine workings had been extended northward in a narrow corridor bounded by the Bear Creek Fault on the west and burned coal on the east. The workings were then driven in a northeast direction in an area surrounded by burned coal.

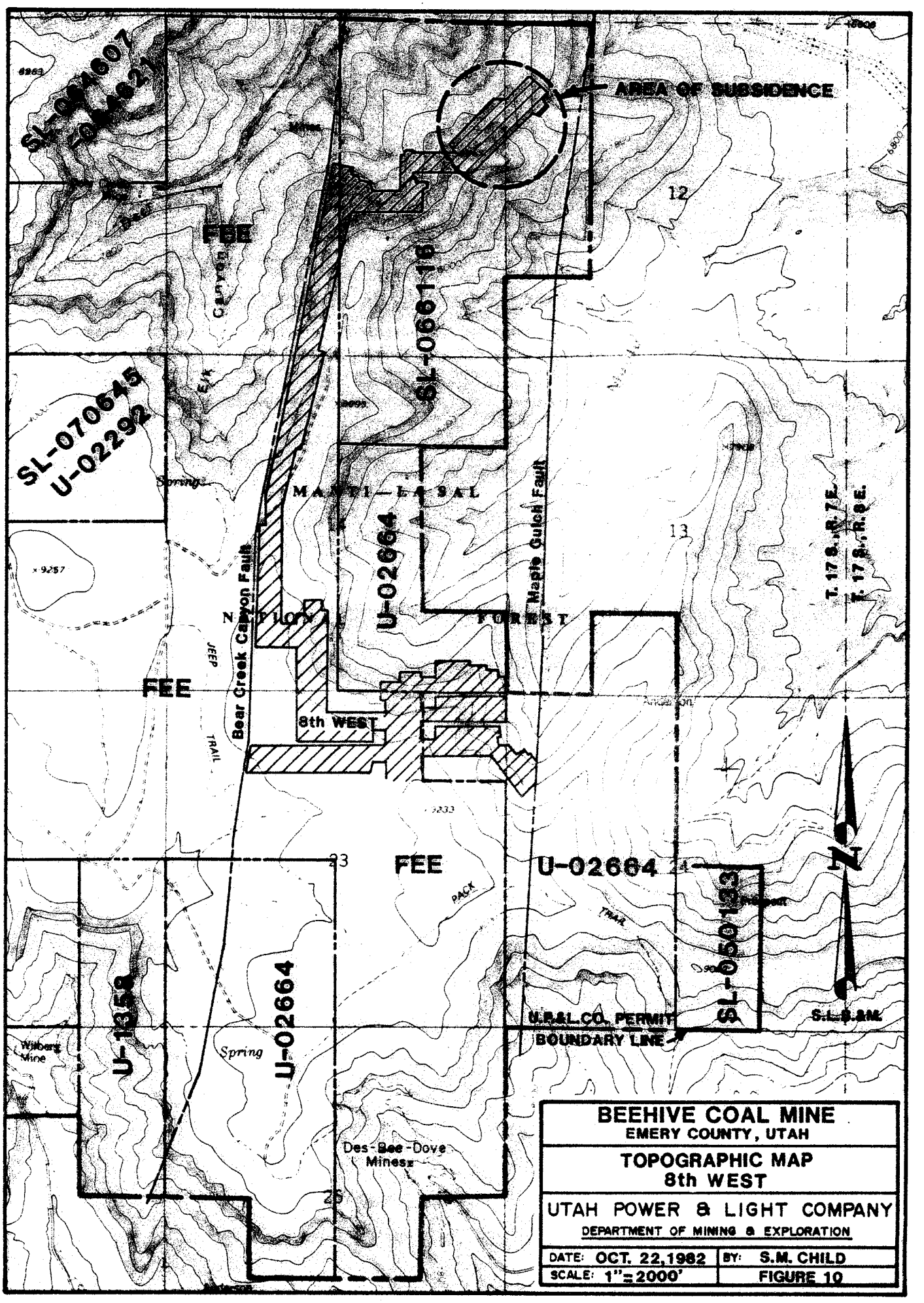
The 1981 subsidence study has identified areas which have subsided up to three feet (Figure 12). The area of maximum subsidence is located up to 300 feet away from areas underlain by mine workings. If this subsidence were to be entirely caused by the mining a draw angle which approaches 40 degrees would have occurred which is highly unlikely. As in the other areas previously discussed, it is felt that mining has shifted pressures onto the coal clinker beds causing them to be crushed.

Several surface fractures are evident. All are located within outcrops of the Castlegate Sandstone mostly

trending along joints of this strata. No surface disturbance was observed in the Blackhawk Formation. Between the narrow ridges and precipitous slopes very limited land use can be expected.

Numerous field inspections failed to locate surface or groundwater in any form. Groundwater storage and recharge would be limited by the existing steep terrain.


BEEHIVE COAL MINE
8th WEST
SUBSIDENCE AREA
N

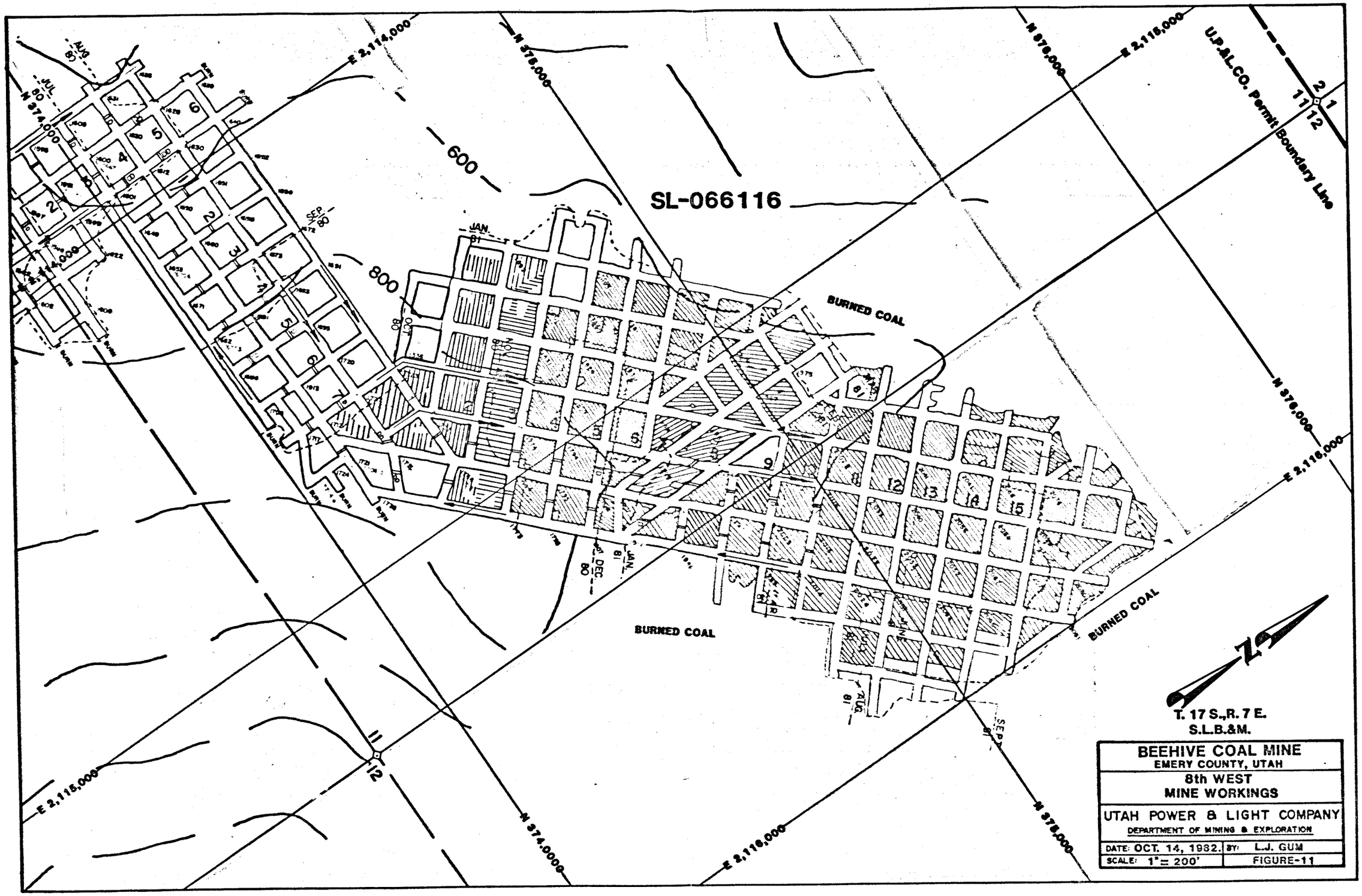


BEEHIVE COAL MINE
EMERY COUNTY, UTAH

TOPOGRAPHIC MAP
8th WEST

UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION

DATE: OCT. 22,1982	BY: S.M. CHILD
SCALE: 1" = 2000'	FIGURE 10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BURNED COAL
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U.P.&L.CO. Permit Boundary Line
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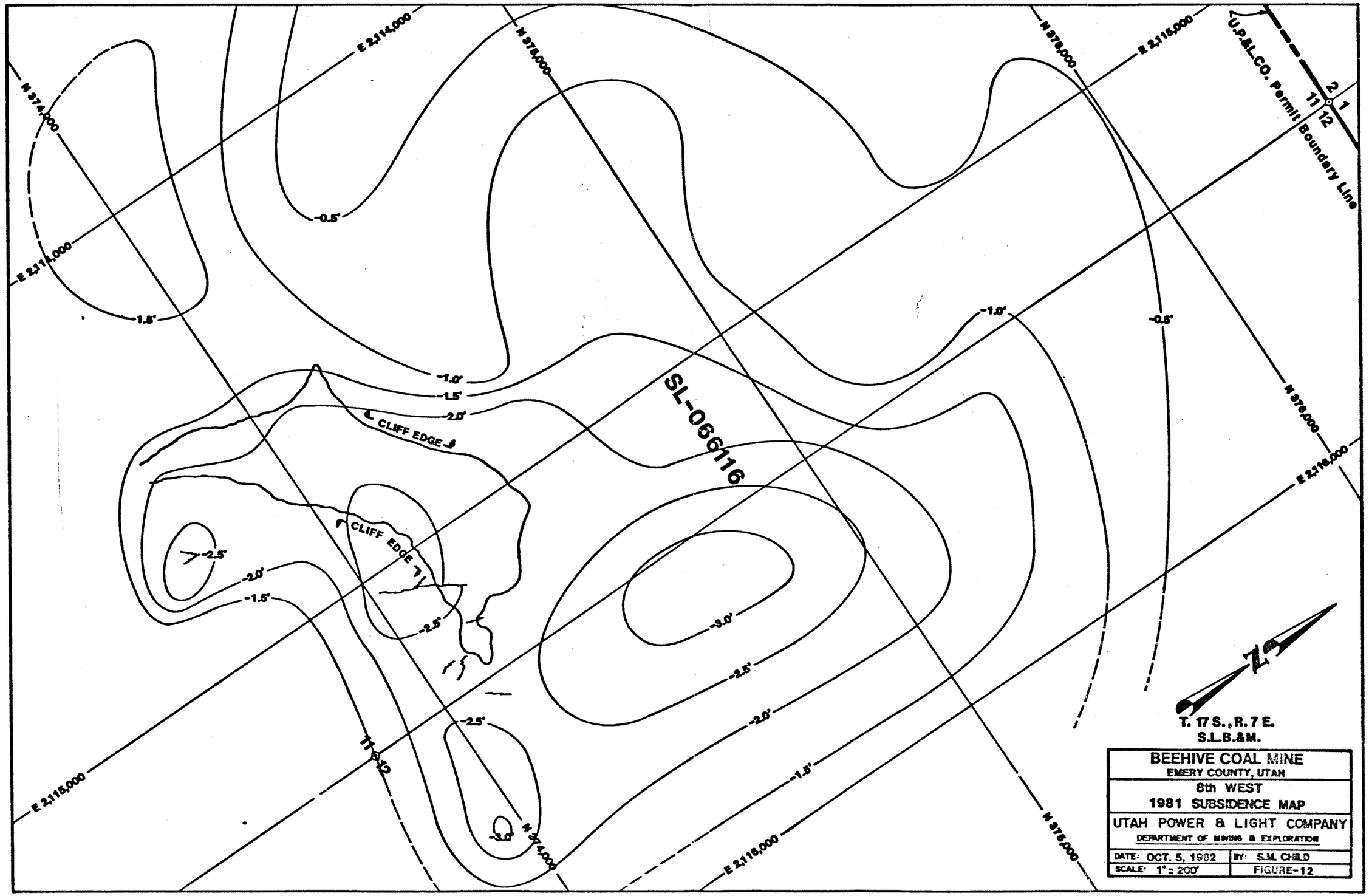
E 2,115,000
E 2,116,000
N 376,000
N 374,000
JUL 80
AUG 80
SEP 80
JAN 81
DEC 80
AUG 81
SEP 81
T. 17 S., R. 7 E.
S.L.B.&M.
BEEHIVE COAL MINE
EMERY COUNTY, UTAH
8th WEST
MINE WORKINGS
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 14, 1982.
BY: L.J. GUM
SCALE: 1" = 200'
FIGURE-11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-2.5'
-3.0'
SL-066116
CLIFF EDGE
N
T. 17 S., R. 7 E.
S.L.B.&M.
BEEHIVE COAL MINE
EMERY COUNTY, UTAH
8th WEST
1981 SUBSIDENCE MAP
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 5, 1982
BY: S.M. CHILD
SCALE: 1" = 200'
FIGURE-12

Beehive 4th West, Deseret 5th West

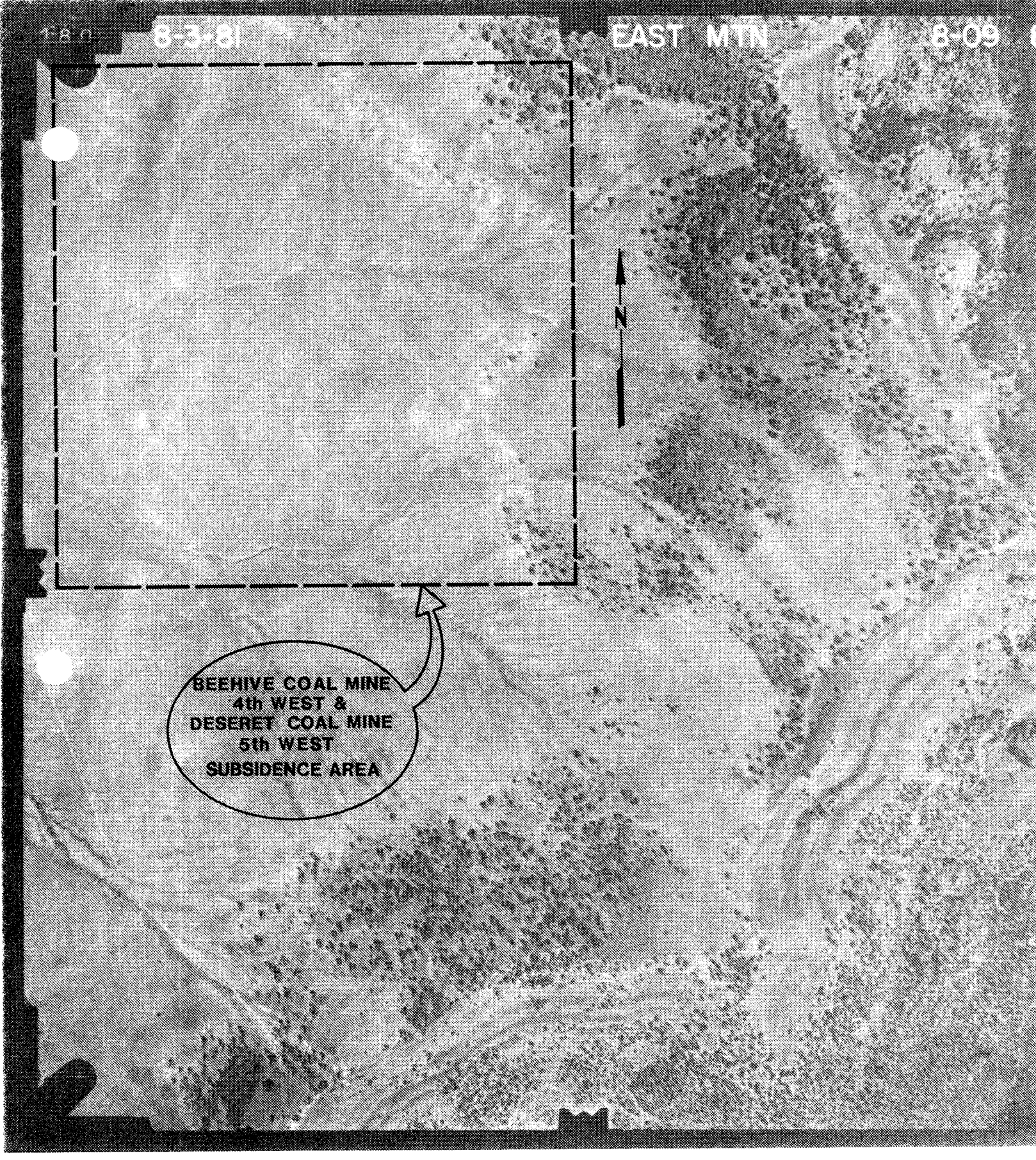
Land surfaces above this study area are gentle, rolling sagebrush covered hills contrasting the previously discussed 8th West site (Figure 13). Cliffs formed by the Castlegate Sandstone aren't present and the coal seams are covered by a greater thickness of overburden which ranges between 1300 to 1600 feet thick.

Mining in the upper seam was completed prior to the subsidence monitoring. Deseret Mine (lower seam) pillar extraction was in progress in August 1980 and was completed March 1981. The coal was mined to a height of nine feet in each of these mines. Figure 14 shows the location of the Deseret workings which were being mined during this subsidence monitoring period.

Monitoring utilizes a conventional monumented grid centered over previously mined 4th West and recently mined 5th West. Subsidence results will not reflect true mining relationships because of coal extraction in the upper seam (4th West) prior to monitoring. This situation was created by the Office of Surface Mining's persistence to monitor the next panel pulled regardless of circumstances.

Survey monuments were set in October of 1980 and have been resurveyed monthly when weather and access permitted. To date only 1.7 feet of subsidence has been measured (Figure 15).

No visual effects of fracturing are associated with this study site. Monitoring will continue through 1983 and terminated if no further subsidence is detected.


8-3-81
EAST MTN
8-09
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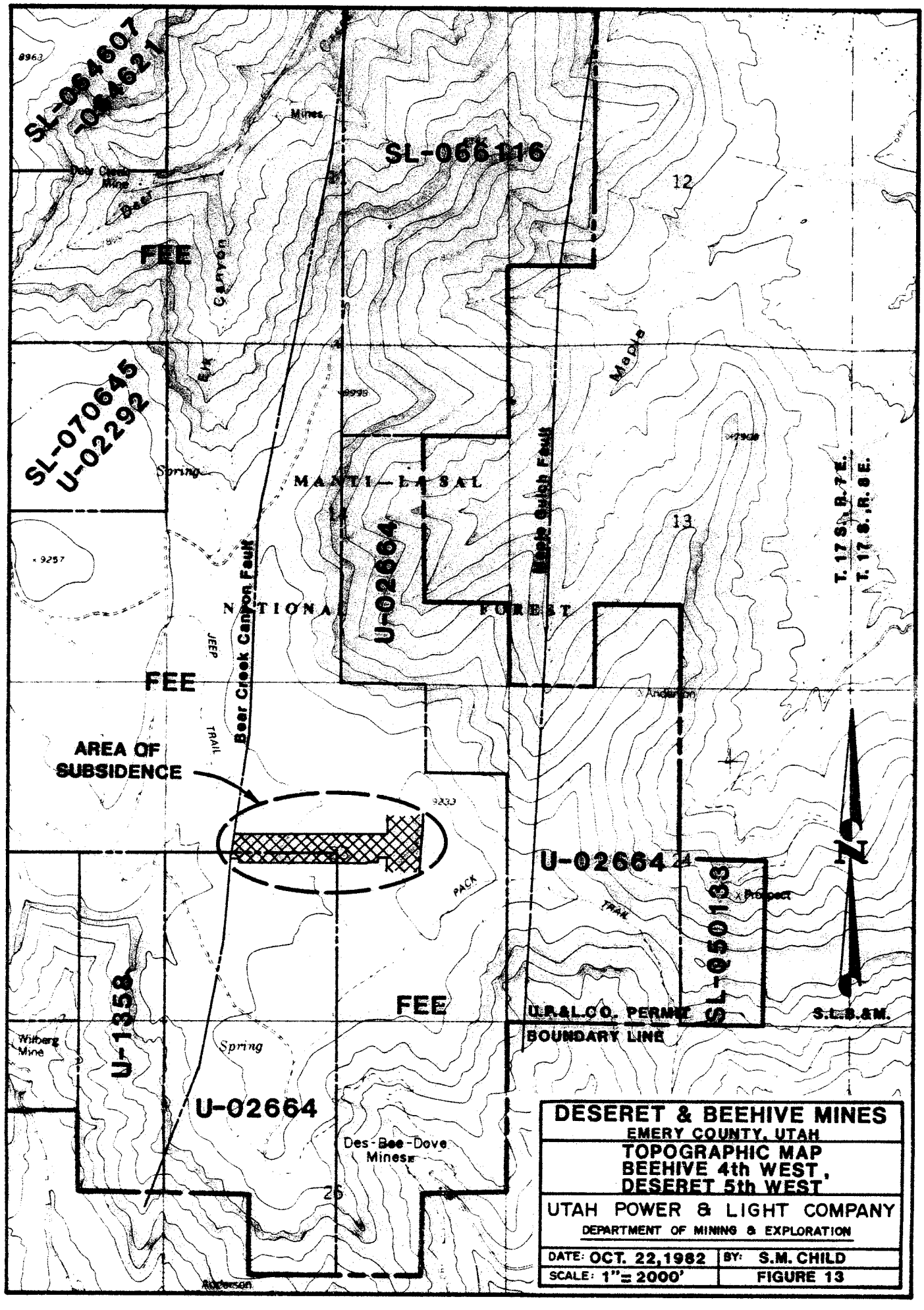
BEEHIVE COAL MINE
4th WEST &
DESERET COAL MINE
5th WEST
SUBSIDENCE AREA

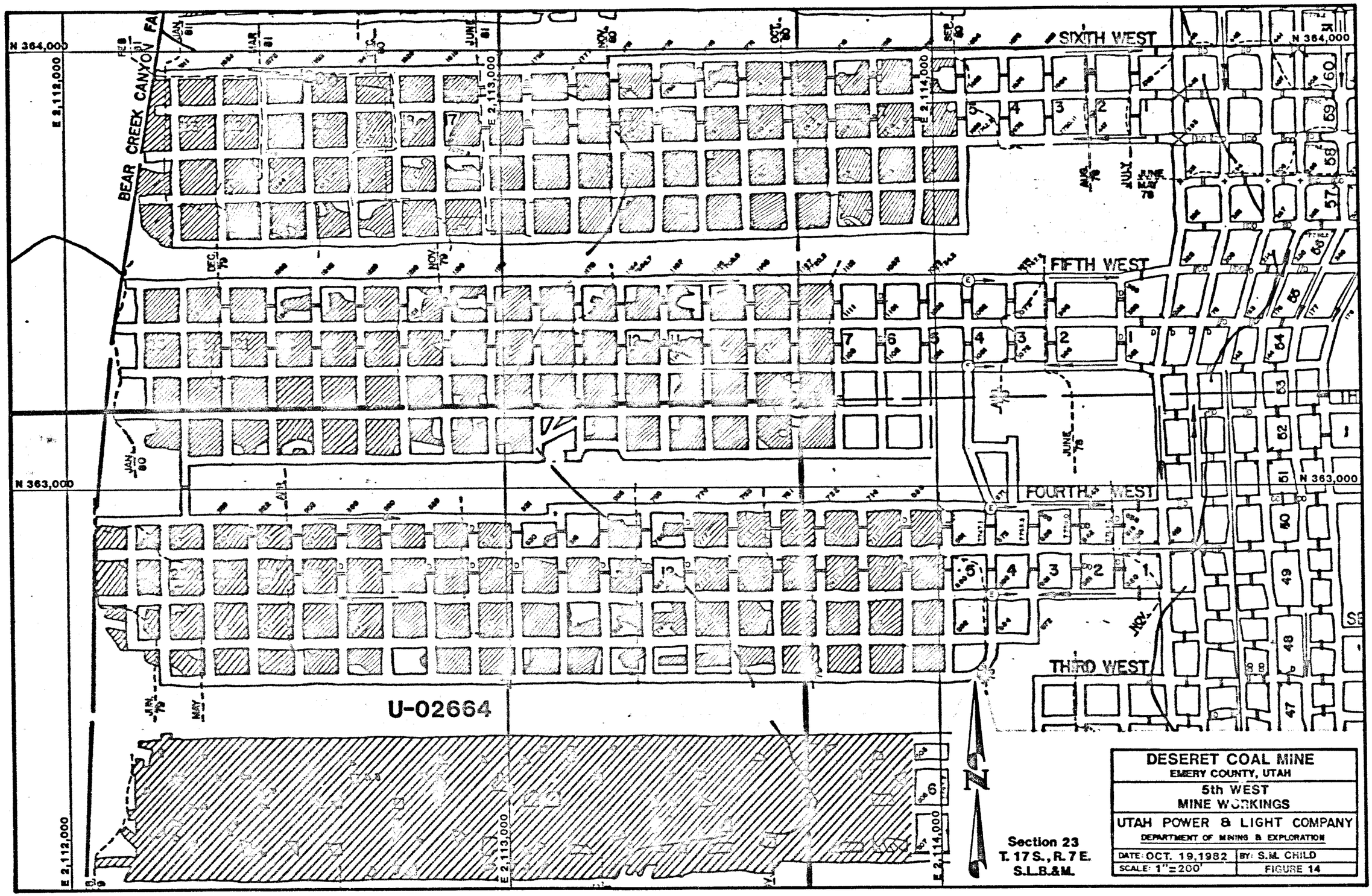


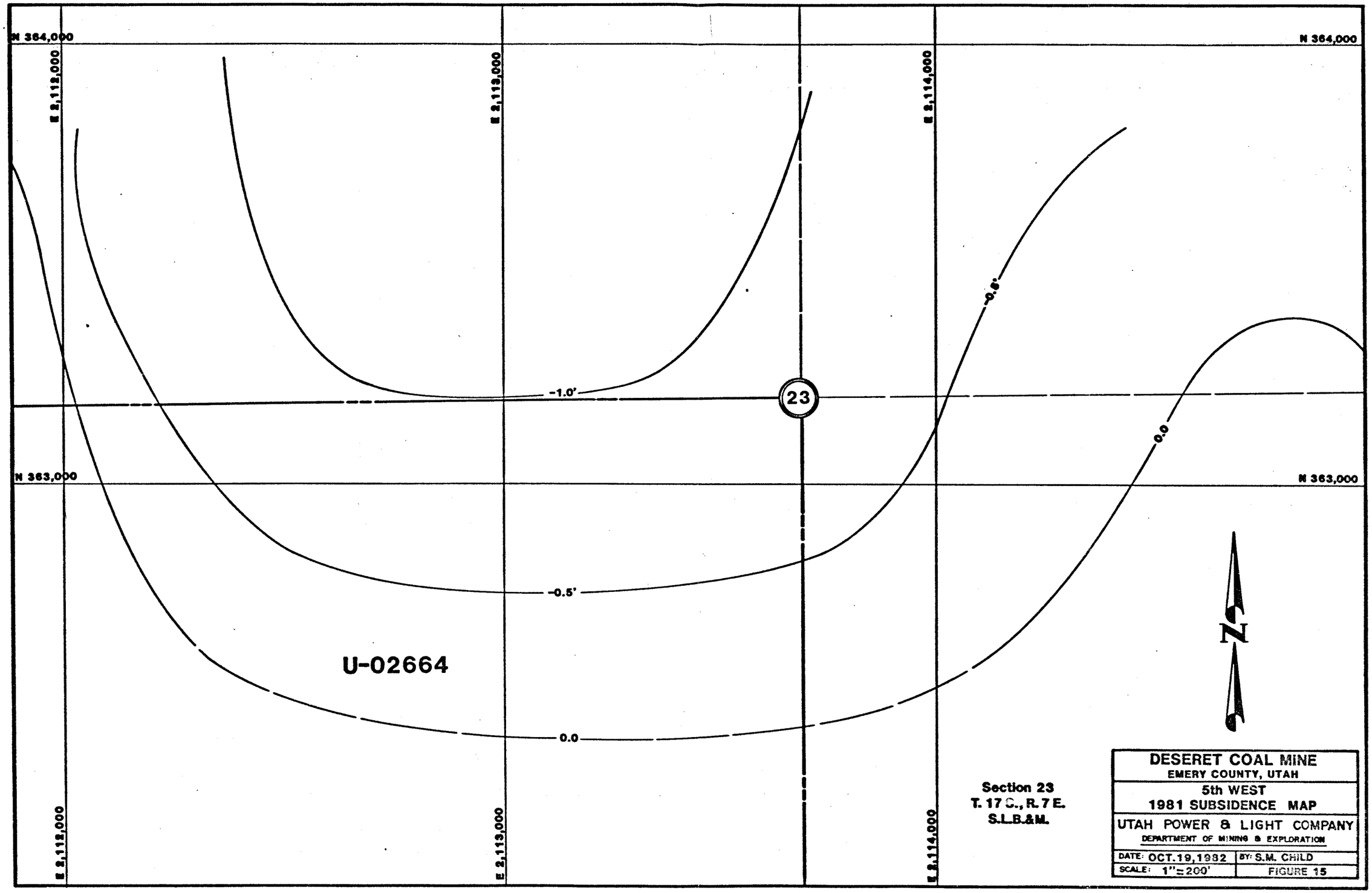
DESERET & BEEHIVE MINES
EMERY COUNTY, UTAH

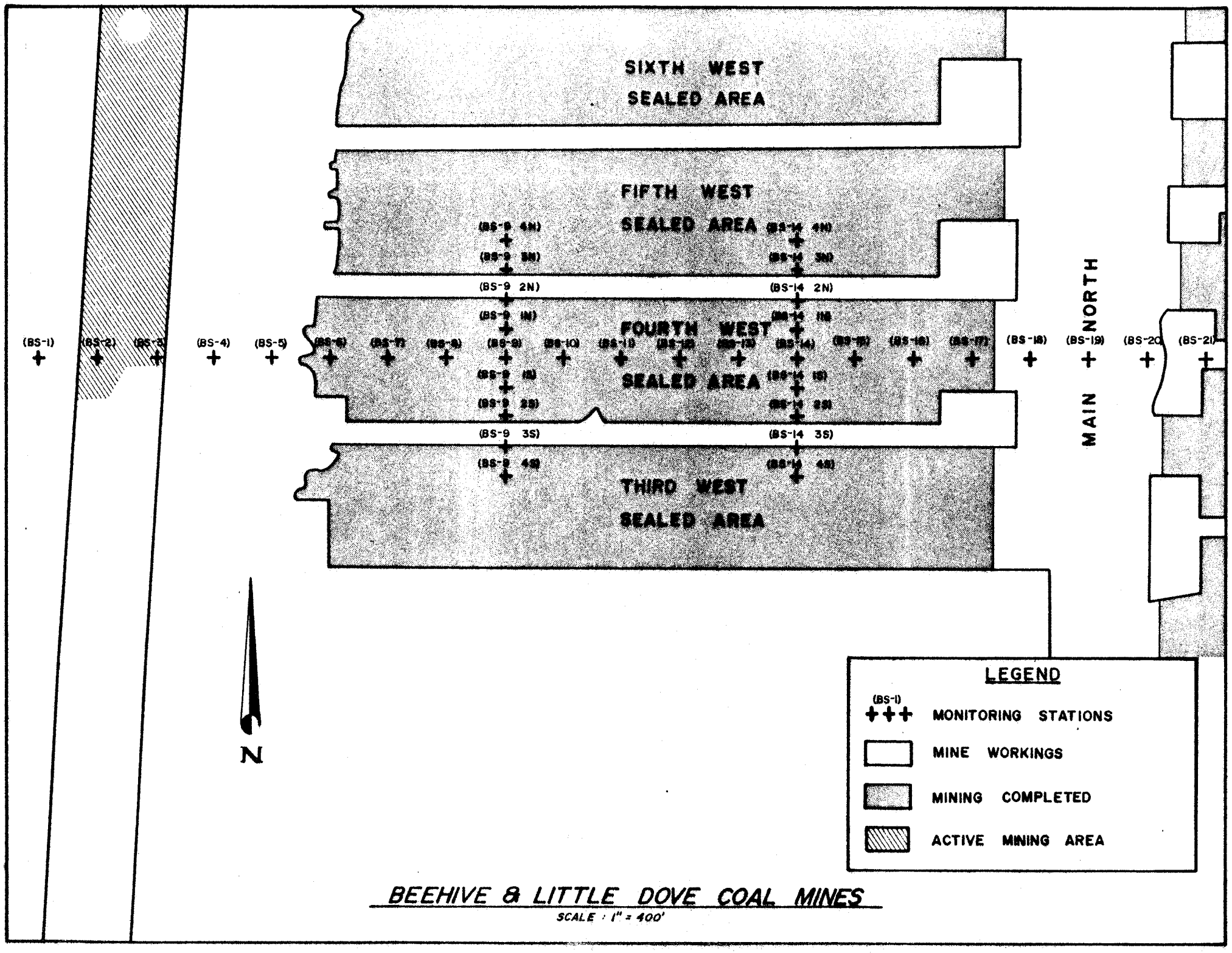
TOPOGRAPHIC MAP
BEEHIVE 4th WEST,
DESERET 5th WEST

UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION

DATE: OCT. 22, 1982	BY: S.M. CHILD
SCALE: 1" = 2000'	FIGURE 13

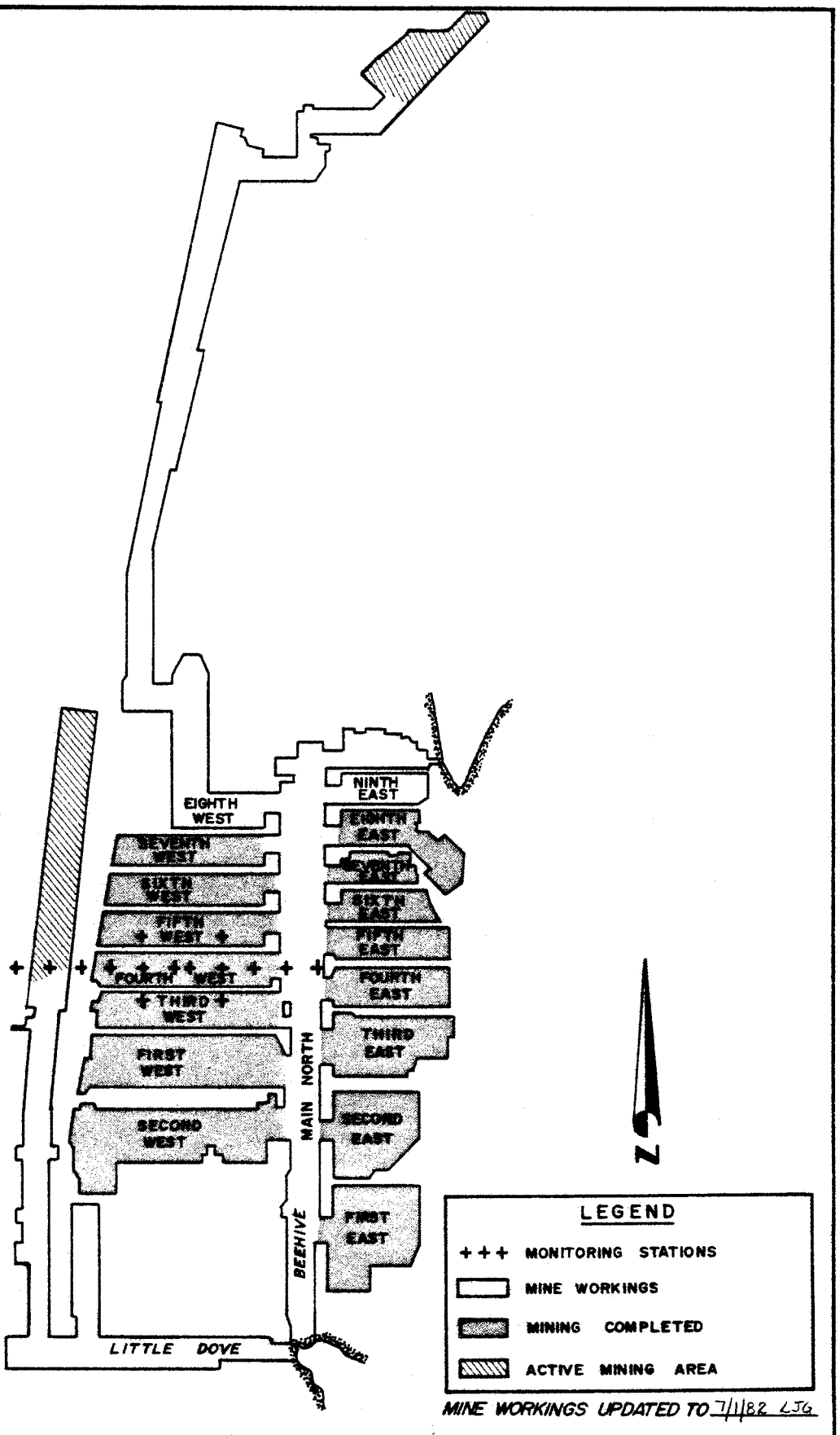

SIXTH WEST
FIFTH WEST
FOURTH WEST
THIRD WEST
BEAR CREEK CANYON
N 364,000
N 363,000
E 2,112,000
E 2,113,000
E 2,114,000
U-02664
N
Section 23
T. 17 S., R. 7 E.
S.L.B.&M.
DESERET COAL MINE
EMERY COUNTY, UTAH
5th WEST
MINE WORKINGS
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 19,1982
BY: S.M. CHILD
SCALE: 1"=200'
FIGURE 14


N 364,000
N 364,000
E 2,112,000
E 2,113,000
E 2,114,000
-1.0'
23
-0.5'
0.0
N 363,000
N 363,000
-0.5'
U-02664
0.0
N
E 2,112,000
E 2,113,000
E 2,114,000
Section 23
T. 17 S., R. 7 E.
S.L.B.&M.
DESERET COAL MINE
EMERY COUNTY, UTAH
5th WEST
1981 SUBSIDENCE MAP
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT.19,1982
BY: S.M. CHILD
SCALE: 1"=200'
FIGURE 15



BEEHIVE & LITTLE DOVE COAL MINES

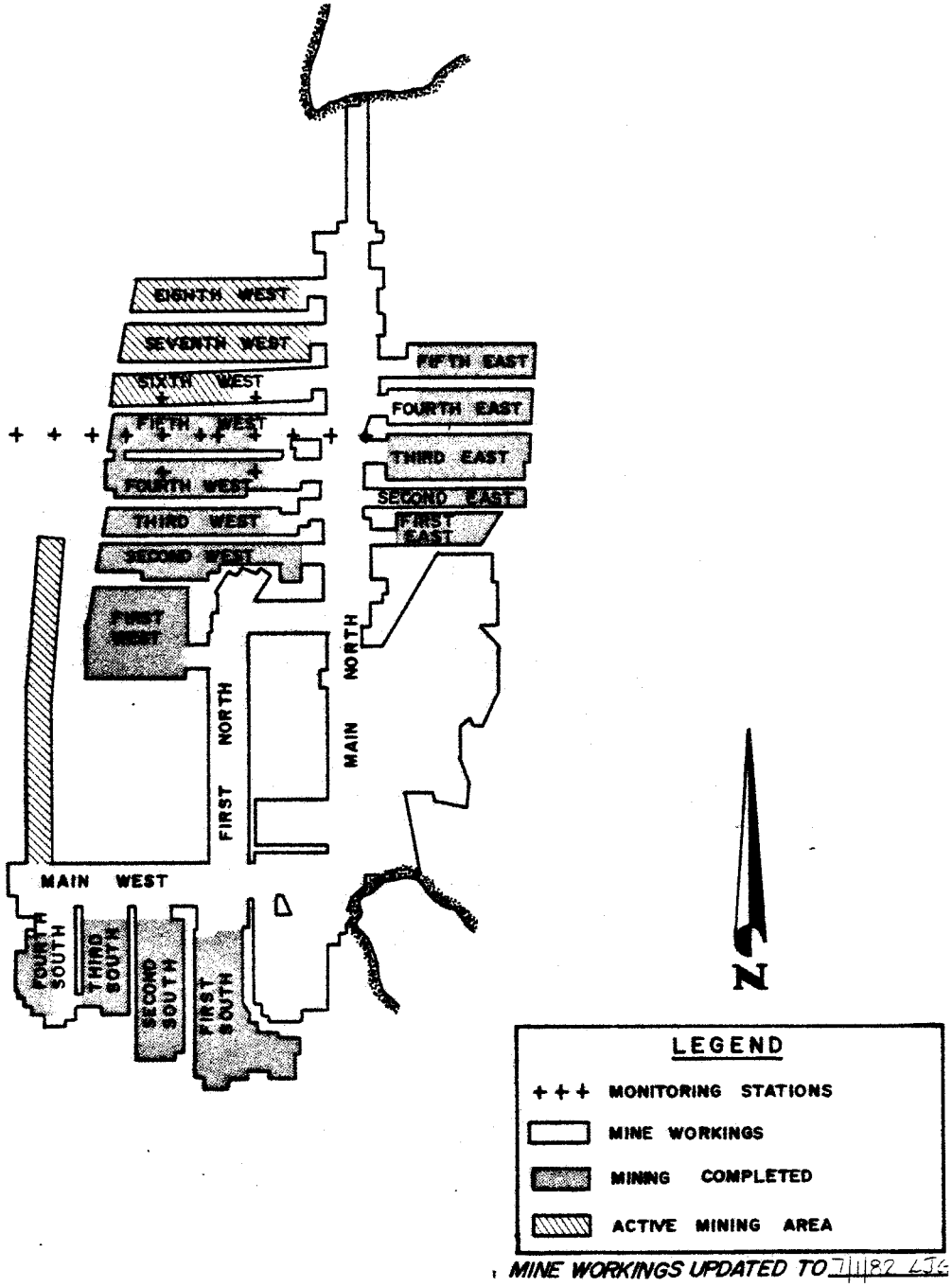
SCALE : 1" = 400'



MINE WORKINGS UPDATED TO 7/1/82 LJG

BEEHIVE & LITTLE DOVE COAL MINES

SCALE: 1" = 2000



MINE WORKINGS UPDATED TO 7/1/82 LJG

DESERET COAL MINE

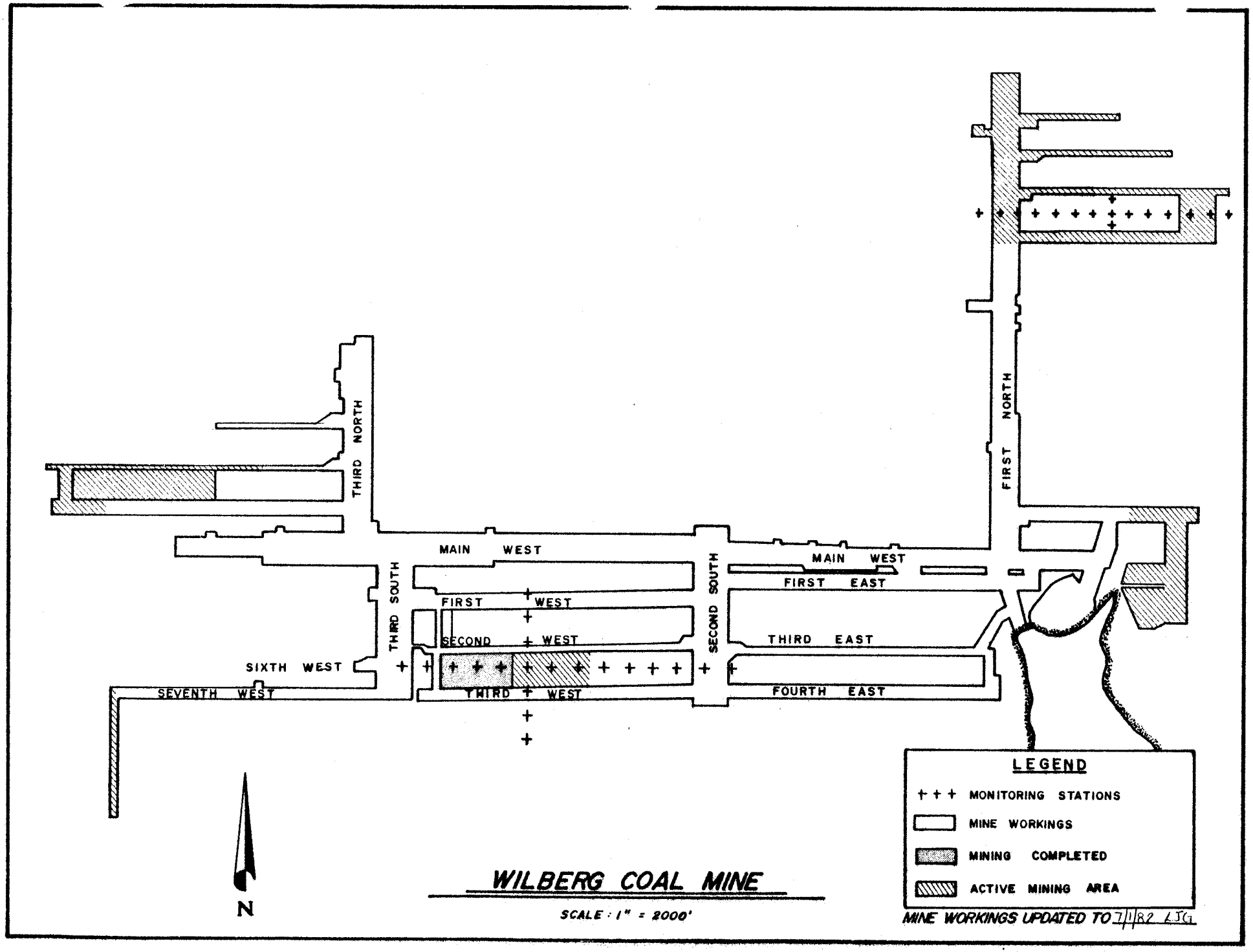
SCALE: 1" = 2000'

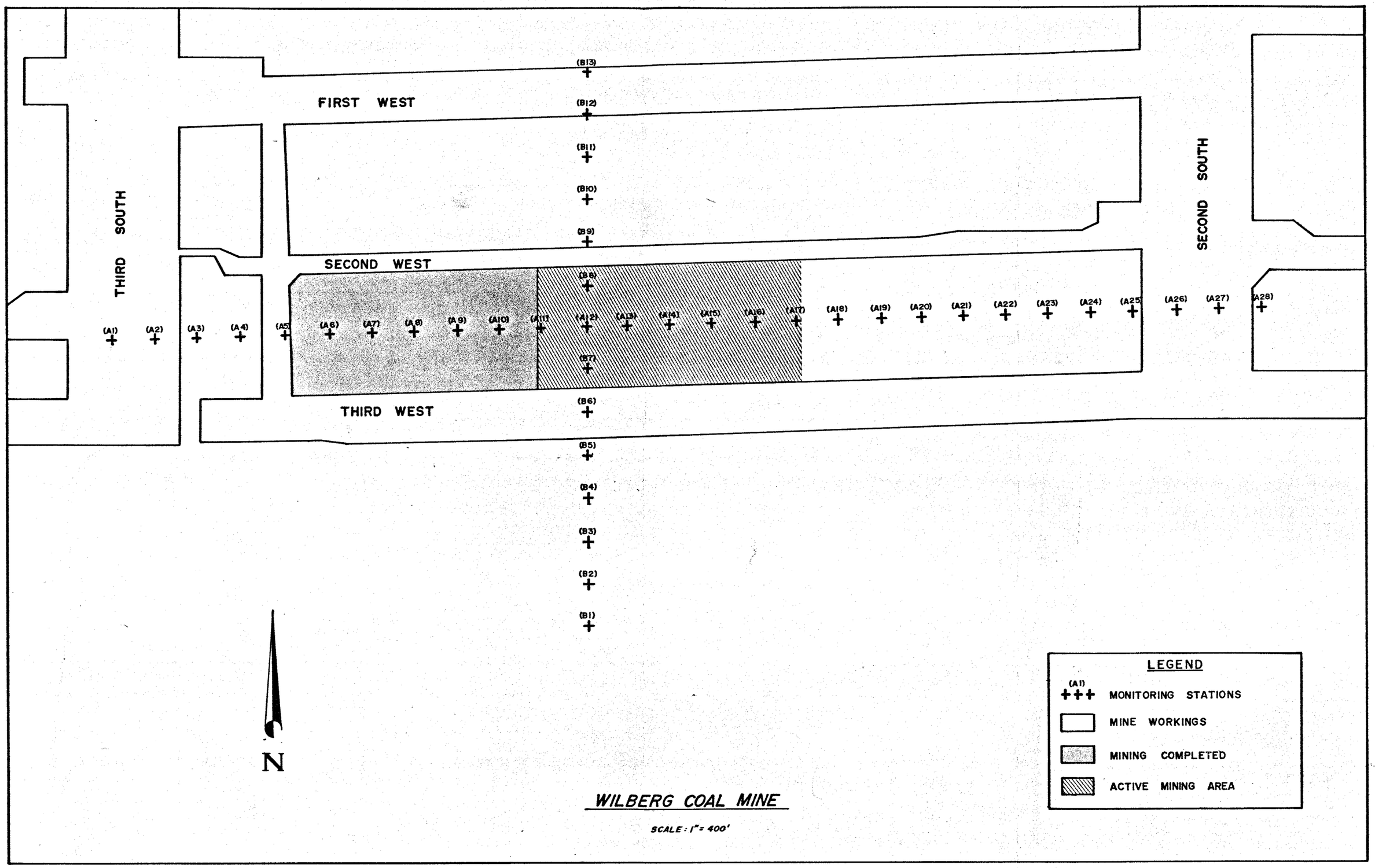
Wilberg Mine 2nd West

Longwall mining in Wilberg Mine began in August 1980. A monumented survey grid was installed and read initially on September 17, 1980. Unfortunately, this mining section was abandoned due to unforeseeable mining conditions after approximately 60% of the panel had been extracted.

Five resurveys were completed and recorded, the last being July of 1982. A final survey is planned next July and if no movement is detected conventional surveying will be terminated. This site will be covered under the annual photogrammetrical survey.

This study site is geologically located within the Flagstaff Formation. Surface topography is divided between a flat limestone cap covering the west half and east facing slopes that form the upper drainage of Grimes Wash situated over the eastern section of the panel.


THIRD NORTH
FIRST NORTH
MAIN WEST
MAIN WEST
THIRD SOUTH
SECOND SOUTH
FIRST WEST
SECOND WEST
THIRD WEST
FIRST EAST
THIRD EAST
FOURTH EAST
SIXTH WEST
SEVENTH WEST
N
LEGEND
MONITORING STATIONS
MINE WORKINGS
MINING COMPLETED
ACTIVE MINING AREA
WILBERG COAL MINE
SCALE : 1" = 2000'
MINE WORKINGS UPDATED TO 7/1/82 LJG



WILBERG COAL MINE

SCALE: 1" = 400'

Deer Creek Mine 4th, 5th and 6th East

This study site is not located along the Castlegate Sandstone escarpment of East Mountain as are the first three subsidence areas discussed herein. The topography is made up of gently rolling slopes with a relief of about 400 feet (Figure 16). The coal seams are covered by overburden ranging from 1400 to 1800 feet.

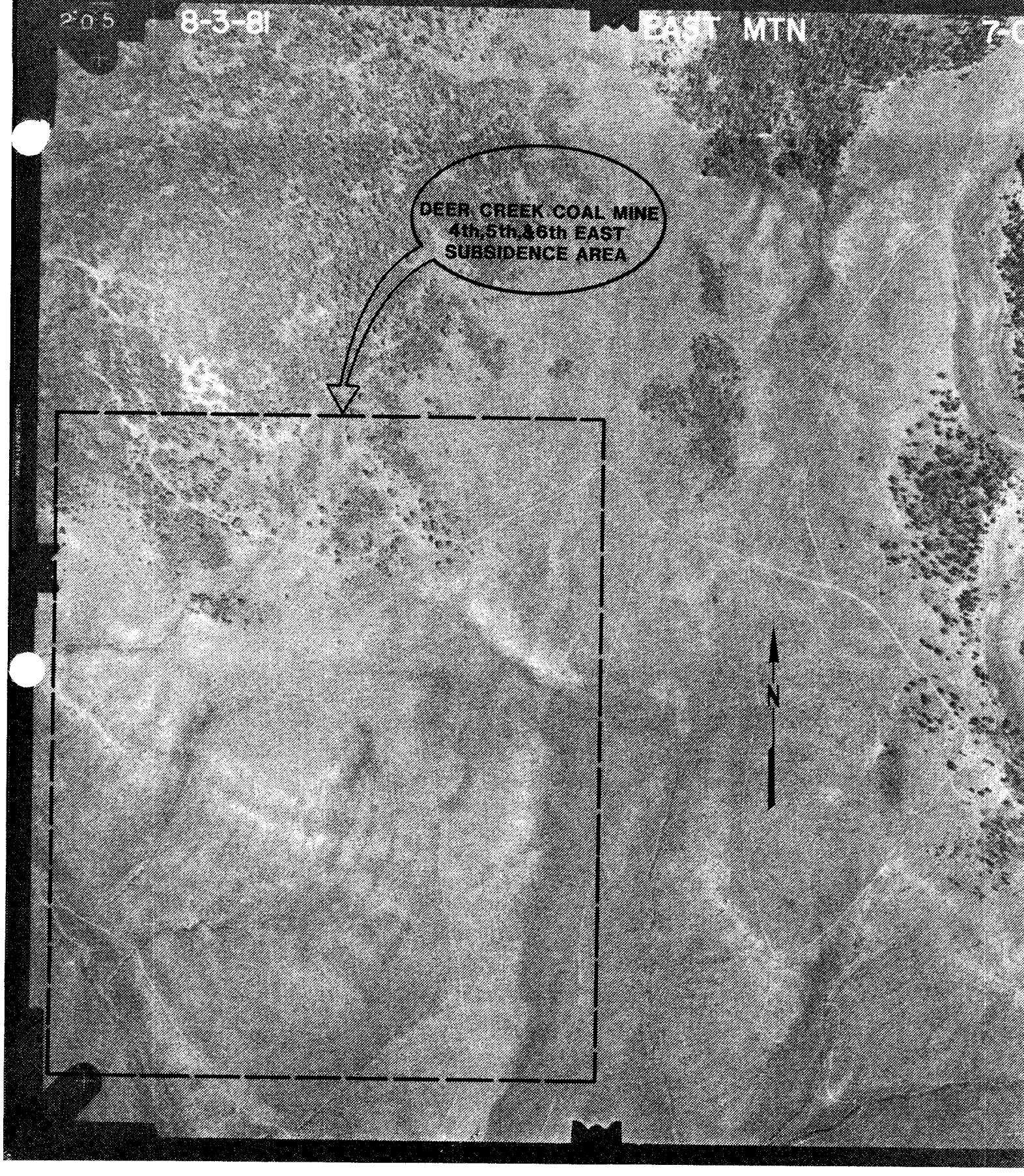
Because longwall methods were to be used in this area to mine coal from two seams the Bureau of Mines selected this sight for a detailed subsidence monitoring study. The timing of our mine development was such that they could monitor subsidence over four adjacent longwall panels in the Deer Creek Mine (Blind Canyon Seam), and an equal number of panels in the Wilberg Mine (Hiawatha Seam). A copy of an interim report is included in the appendix to this report.

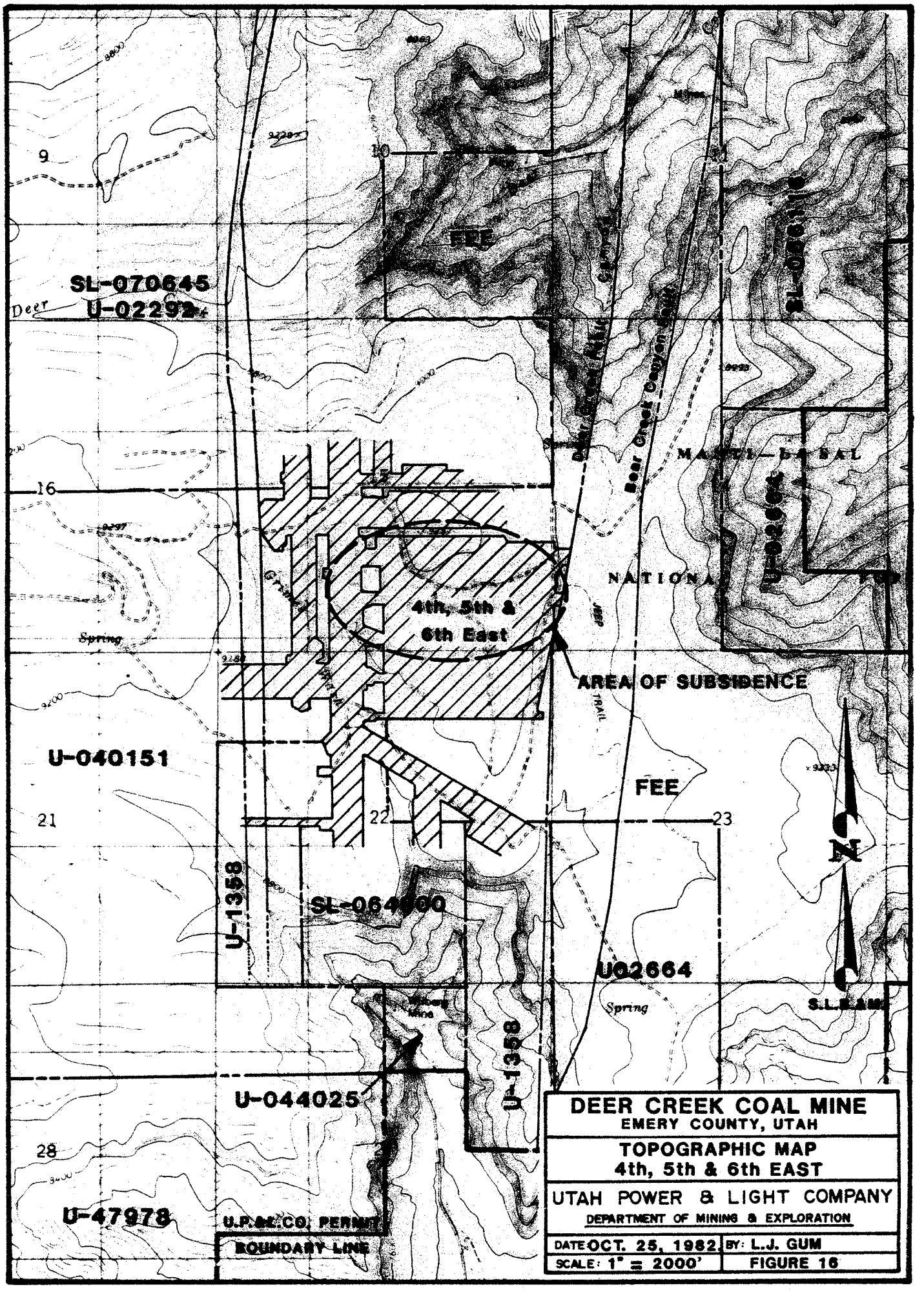
The Bureau of Mines began subsidence monumentation in the fall of 1978 over the first panel to be mined. Initial longwall mining began in July of 1979 and continued through August 1981. At that time two and one-half longwall panels had been completed (Figure 17). Throughout this period the Bureau of Mines established monuments well ahead of the retreating longwalls. Longwall mining in the Wilberg Mine in this area had not begun as of August 1981.

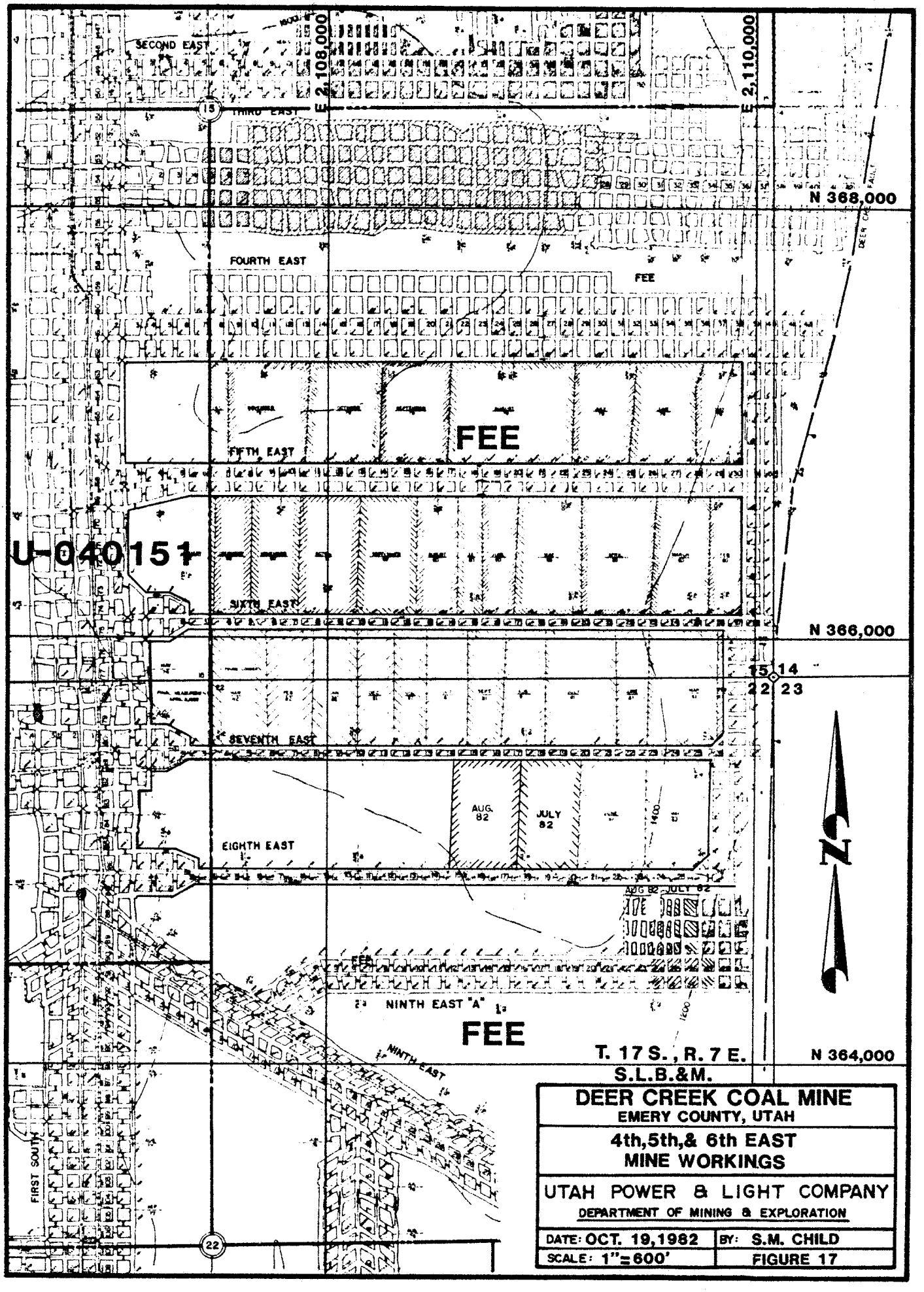
The Bureau of Mines study identified a maximum sub-

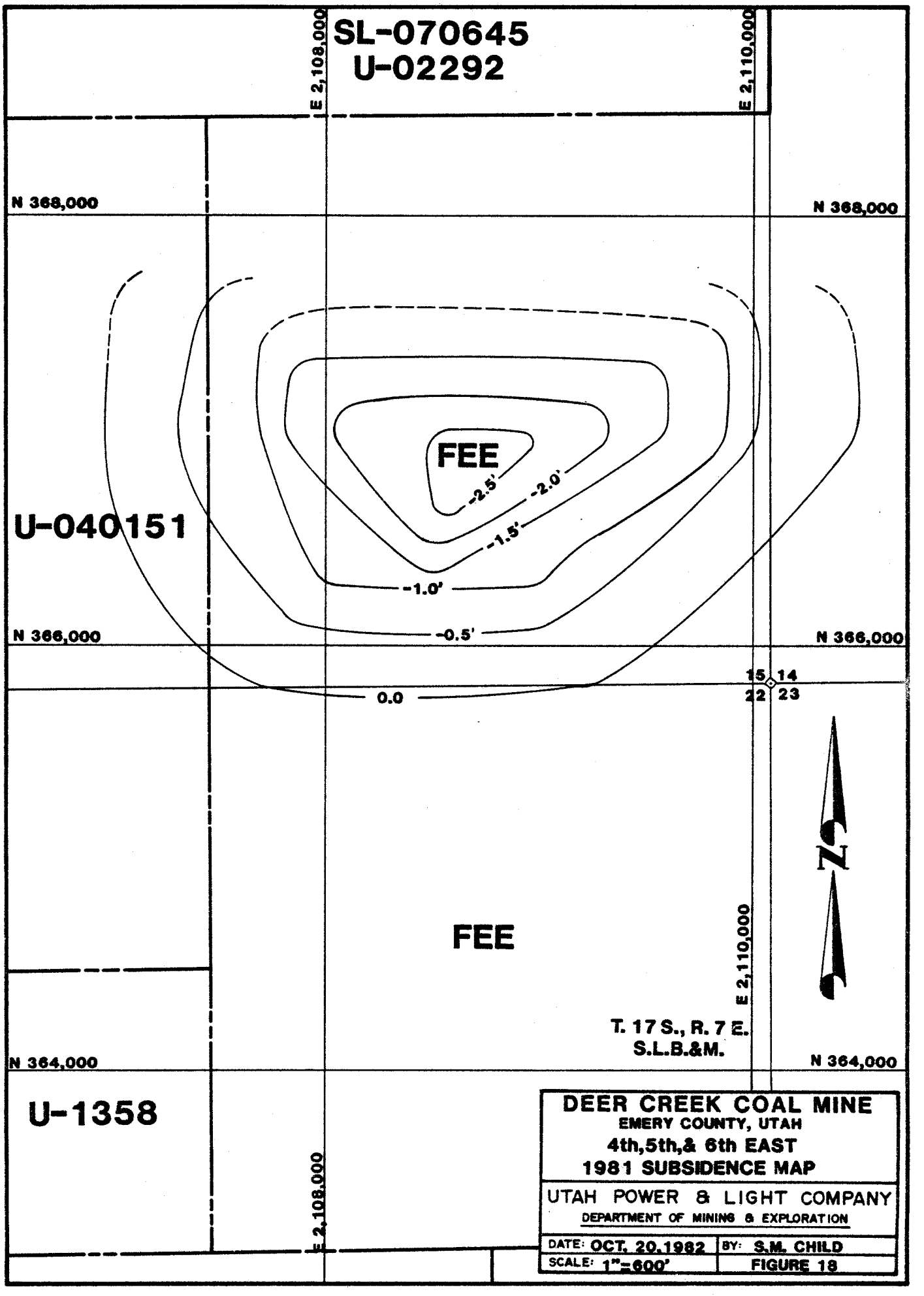
sidence of 2.6 feet over the 5th and 6th East longwall panels (Figure 18). This subsidence was expressed as a gentle sagging of the strata without visible fracturing. Several inspections of this area were made in the field and from a helicopter without locating any visible evidence of subsidence. The rock formation exposed on the surface, the North Horn Formation, is comprised predominantly of mudstone that yield to the stresses caused by subsidence without fracturing.

The area is currently used in the summer months for grazing livestock but the subsidence has not altered the usefulness of the land for this purpose. No springs have been identified within the area of subsidence but springs located one-fourth mile west of the area show no apparent effect from subsidence.


2'0 5
8-3-81
EAST MTN
DEER CREEK COAL MINE
4th,5th,&6th EAST
SUBSIDENCE AREA
N

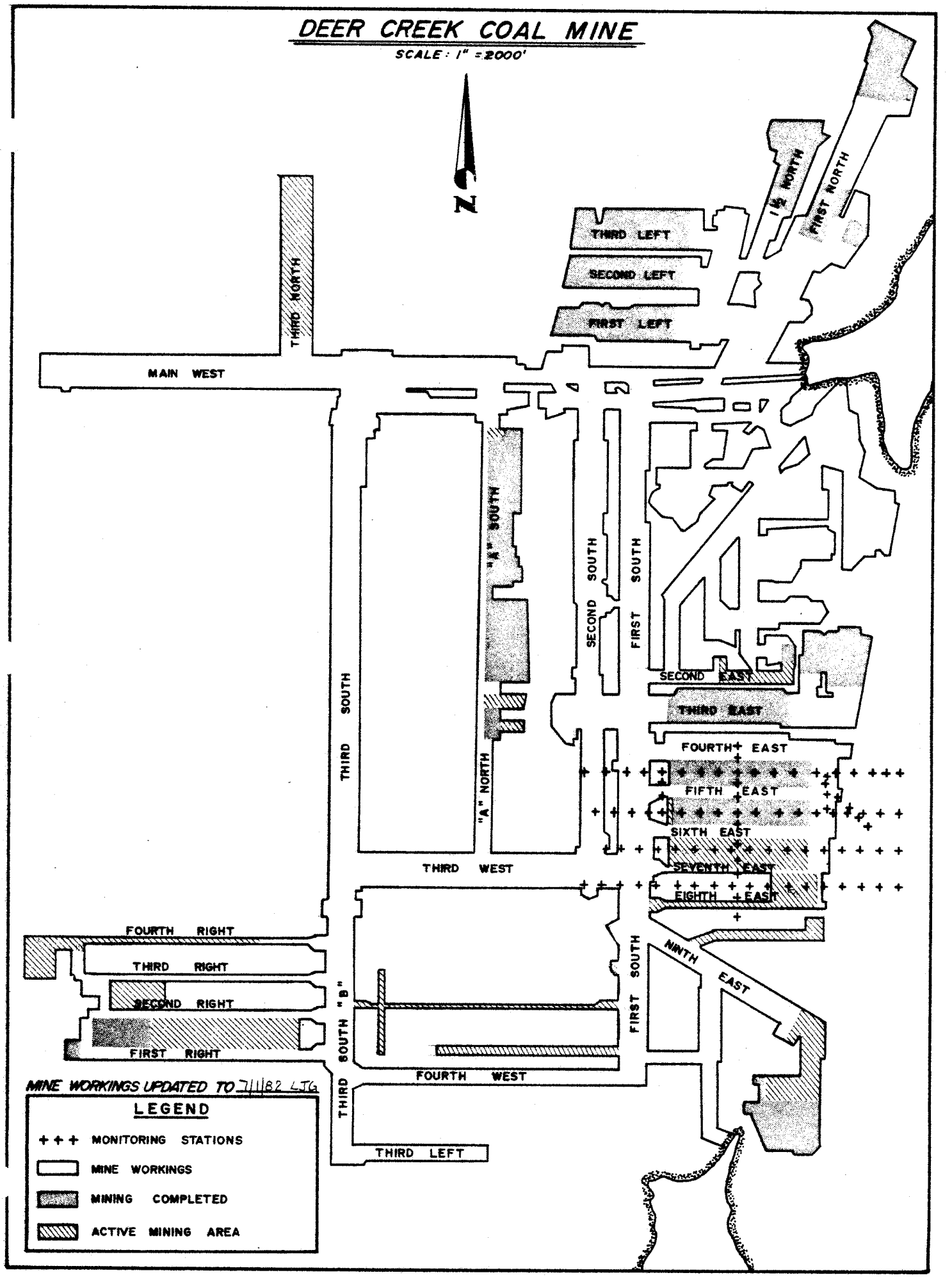

SL-070645
U-02292
FEE
4th, 5th &
6th East
AREA OF SUBSIDENCE
U-040151
FEE
U-1358
SL-064000
U02664
U-1358
U-044025
U-47978
U.P.&L.CO. PERMIT
BOUNDARY LINE
N
DEER CREEK COAL MINE
EMERY COUNTY, UTAH
TOPOGRAPHIC MAP
4th, 5th & 6th EAST
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 25, 1982
BY: L.J. GUM
SCALE: 1" = 2000'
FIGURE 16

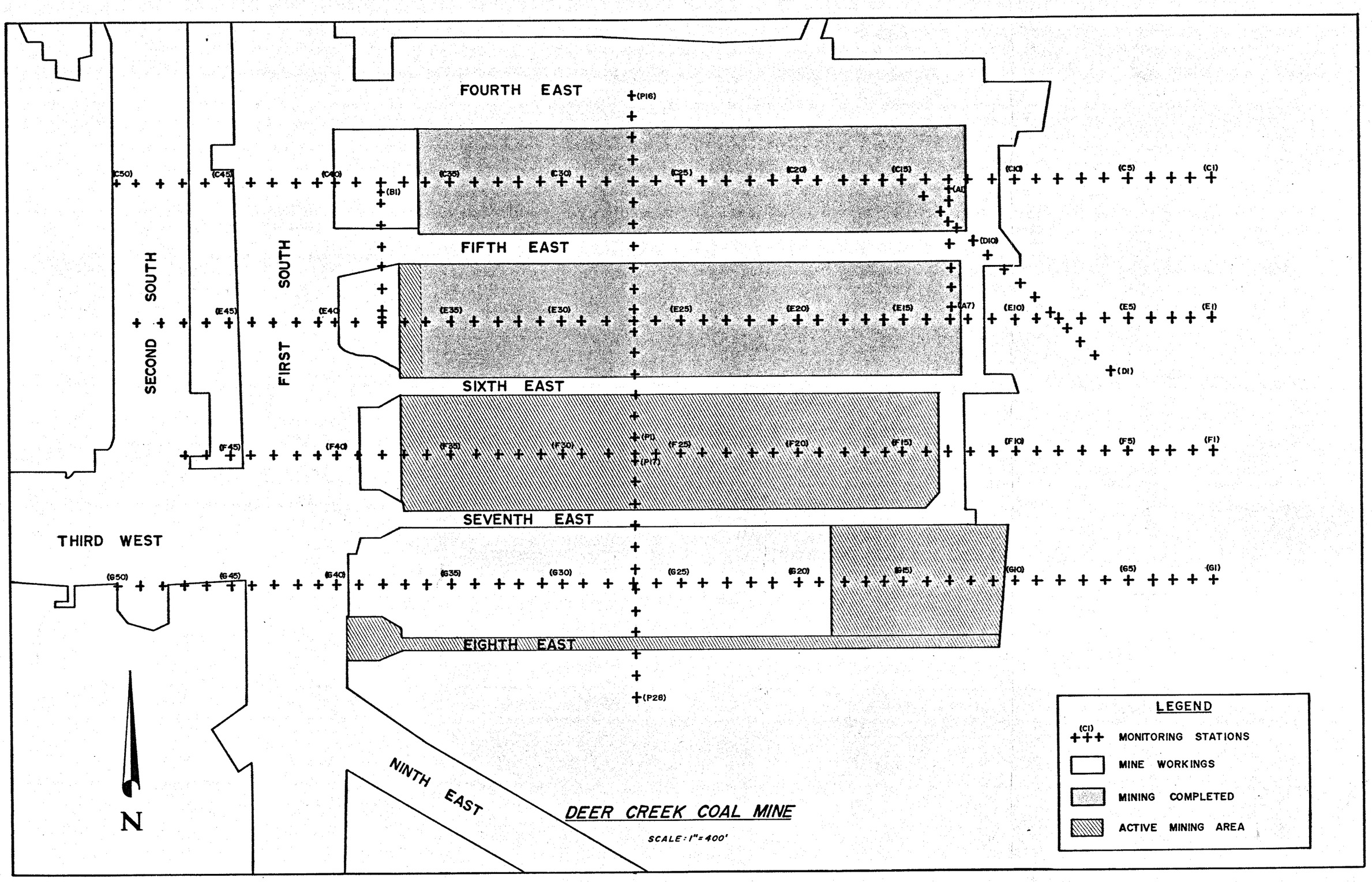

SECOND EAST
THIRD EAST
E 2,108,000
E 2,110,000
N 368,000
FOURTH EAST
FEE
FEE
FIFTH EAST
U-040151
SIXTH EAST
N 366,000
15 14
22 23
SEVENTH EAST
AUG. 82
JULY 82
EIGHTH EAST
AUG 82 JULY 82
NINTH EAST "A"
FEE
NINTH EAST
T. 17 S., R. 7 E.
S.L.B.&M.
N 364,000
FIRST SOUTH
N
DEER CREEK COAL MINE
EMERY COUNTY, UTAH
4th,5th,& 6th EAST
MINE WORKINGS
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 19,1982
BY: S.M. CHILD
SCALE: 1"=600'
FIGURE 17


SL-070645
U-02292
E 2,108,000
E 2,110,000
N 368,000
N 368,000
FEE
-2.5'
-2.0'
-1.5'
-1.0'
-0.5'
0.0
U-040151
N 366,000
N 366,000
15 14
22 23
N
FEE
E 2,110,000
T. 17 S., R. 7 E.
S.L.B.&M.
N 364,000
N 364,000
U-1358
E 2,108,000
DEER CREEK COAL MINE
EMERY COUNTY, UTAH
4th,5th,& 6th EAST
1981 SUBSIDENCE MAP
UTAH POWER & LIGHT COMPANY
DEPARTMENT OF MINING & EXPLORATION
DATE: OCT. 20,1982
BY: S.M. CHILD
SCALE: 1"=600'
FIGURE 18

DEER CREEK COAL MINE

SCALE: 1" = 2000'




FOURTH EAST
FIFTH EAST
SIXTH EAST
SEVENTH EAST
EIGHTH EAST
NINTH EAST
THIRD WEST
SECOND SOUTH
FIRST SOUTH
(P16)
(B1)
(A1)
(D10)
(A7)
(D1)
(P1)
(P17)
(P28)
(C50)
(C45)
(C40)
(C35)
(C30)
(C25)
(C20)
(C15)
(C10)
(C5)
(C1)
(E45)
(E40)
(E35)
(E30)
(E25)
(E20)
(E15)
(E10)
(E5)
(E1)
(F45)
(F40)
(F35)
(F30)
(F25)
(F20)
(F15)
(F10)
(F5)
(F1)
(G50)
(G45)
(G40)
(G35)
(G30)
(G25)
(G20)
(G15)
(G10)
(G5)
(G1)
N
DEER CREEK COAL MINE
SCALE: 1" = 400'
LEGEND
(C1)
MONITORING STATIONS
MINE WORKINGS
MINING COMPLETED
ACTIVE MINING AREA

Summary

As of August 1981, Utah Power and Light has identified five areas of mine related subsidence. Three of the subsided areas are very similar in geologic setting and observed subsidence effects. These are located in areas of steep slopes and cliffs formed by the Castlegate Sandstone. The mine workings were located adjacent to large areas of burned coal. These factors helped promote fracturing which reached the surface.

The fourth and fifth areas are different in geologic setting and in the observed subsidence. The area is located within the interior of the property with much greater overburden above the coal seam. Although large areas of coal have been removed by longwall methods, the strata has subsided without the development of surface fractures.

Because the majority of mining on this property will take place in areas with similar geologic conditions as present above the Deer Creek 4th, 5th and 6th Right sections, it is expected that the subsidence should be similar to that area.

inspections of this area were made in the field and from a helicopter without locating any visible evidence of subsidence. The rock formation exposed on the surface, the North Horn Formation, is comprised predominantly of mudstone that yield to the stresses caused by subsidence without fracturing.

The area is currently used in the summer months for grazing livestock but the subsidence has not altered the usefulness of the land for this purpose. No springs have been identified within the area of subsidence but springs located one-fourth mile west of the area show no apparent effect from subsidence.

APPENDICES

Wilberg Mine Subsidence
By John T. Boyd Company

Des-Bee-Dove Mines, Subsidence Study
By Engineering Enterprises, Inc.

Surface Subsidence Over Longwall Panels
at the Deer Creek Mine
By Frederick K. Allgaier, Bureau of Mines

JOHN T. BOYD COMPANY

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Marjorie C. Rist
Administrative Assistant

Vice Presidents
Arthur E. Belton
James W. Boyd
Phillip D. Clady
Marcellus M. Fitzwater, Jr.
James T. Jones
Ronald L. Lewis
David J. Morris
James D. O'Donovan
Robert M. Quinlan
John W. Sabo
Lawrence M. Thomas
Herman Van Houten

August 23, 1982
File: 1618 9.1

Utah Power & Light Company
41 N. Redwood Road
P.O. Box 899
Salt Lake City, UT 84110

Attention: Mr. Merrill Heward
Manager of Mining and Exploration

Subject: Wilberg Mine Subsidence

Gentlemen:

Utah Power & Light Company's (UP&L) representatives were notified during the miners vacation of a lowering of the surface and accompanying surface fractures in an area 2,000 ft. east of the Wilberg mine portal. The major portion of this disturbed area located on the Wasatch Plateau is approximately 1,200 ft. long in a north/south direction and 300 ft. wide. Surface movement varies up to an 11 ft. displacement. It parallels the Deer Creek fault and intercepts the cliff edge at the southern limit, which is the northeast canyon wall above the Wilberg mine parking lot.

Boyd Company's assignment is to (1) investigate and render an opinion on the cause of the surface subsidence and (2) recommend the extent (percent) of underground extraction of the remaining coal reserve in 1st Right area (Hiawatha seam) at Wilberg mine. Our findings are based on a field inspection on July 15, 1982 and data provided by UP&L Mining and Exploration group.

Introduction

UP&L's Emery County coal reserves (East Mountain property) are located in the Wasatch Plateau of central Utah, approximately 25 miles south of Price (see Plate 1). The nearest population centers are the towns of Huntington and Orangeville, approximately eight miles distance.

The topography of the area is mountainous and is characterized by east and south facing escarpments which are incised by a few deep and narrow V-shaped canyons. Relief along the escarpment is approximately 1,000 ft. Surface elevations in the East Mountain property range from 7,000 to 10,200 ft. above mean sea level.

The rocks which outcrop on the property belong to the following stratigraphic units (listed in ascending order): Startpoint sandstone, Blackhawk formation, Castlegate sandstone and Price River formation (see Plate 2). All the coal reserves occur in the lower 150 ft. of the Blackhawk formation.

The basic synclinal structure of rocks underlying the East Mountain property is modified by a series of displacement faults. Two sets of faults are present within the property. The Deer Creek fault (major) is tangent to the eastern shear line of the surface subsidence (see Plate 6).

Three panels of coal in the Blind Canyon seam, directly under and west of the subsided area, were mined by extracting pillars through the Deer Creek mine. Directly 110 ft. below in the Hiawatha seam, one panel was mined by pillar extraction through Wilberg mine (see Plates 3 and 7).

One unit of continuous mining equipment was operating in this area, 1st Right of Wilberg mine. The unit had just finished developing the second panel. Estimate of coal mined in these two panels follows:

	Acres[a]	Mining Recovery (%)	Tons (000) In-Place	Tons (000) Mined
Full Recovery - 1st Panel	12.66	75.0[b]	182	136
Development (1st Mng.) 2nd Panel	7.70	45.6	111	51
TOTAL	20.36	63.8	293	187

(a) Includes 1st Right entries
(b) Estimated.

The overlying Blind Canyon seam was fully mined. Furthermore there is evidence along the cropline and underground that the coal seams have burned extensively in this area.

Boyd's Findings

1. The major disturbed surface area is located to the east of mine workings in the Wilberg (Hiawatha seam) and Deer Creek (Blind Canyon seam) mines. The offset between the mined seams and the surface is at an angle parallel to the dip of the Deer Creek fault which has approximately 50 ft. displacement in this area.
2. Mining in each seam extracted approximately 8 ft. of coal; however, the seams are much thicker and it is assumed in the burned area all seams were affected. Both the Blind Canyon and Hiawatha seams have evidence underground of burned areas in the southern portion, and the Hiawatha seam also had a burned area between 1st Right (Wilberg mine) and Deer Creek fault (see Plate 7).

3. The mined over areas (pillars mined) (Blind Canyon and Hiawatha seams) and adjacent burned coal areas in all seams caused immediate roof failure. This action induced movement along the Deer Creek fault trace, a zone of weakness. The cliff face rotated in a clockwise direction, because of cantilever effect, with subsidence occurring as the result of stress on the cliffward side of the main fault (see Plate 5). Plate 4 illustrates the surface movement. Hiawatha seam has approximately 1,100 ft. of overburden in the affected area.

4. Aerial mapping indicates surface subsidence occurred over the entire mined out area; typically, the surface was lowered one foot on the western portion of the area to 11 ft. on the east, adjacent to Deer Creek fault. Much of the major subsided area (1,200 x 300 ft.) shows abrupt earth movement. This is in contrast to the subsidence area over a mined out longwall area in the same general area. First longwall panel width was 480 ft. and the second was 540 ft. with overburden ranging from 1,500 to 1,800 ft. and mining height 7 to 8 ft. The maximum subsidence is 3 ft. and there is no sign of surface fracturing.

5. Therefore, it is Boyd Company's opinion the combination of the following factors resulted in strata failure and surface subsidence:

   (a) Proximity of the Deer Creek fault and associated parallel fractures.
   (b) Burned areas in the vicinity of the fault in possibly four seams, Upper Blind Canyon, Lower Blind Canyon (Deer Creek mine), Cottonwood and Hiawatha (Wilberg mine).
   (c) Proximity to the outcrop and Castlegate sandstone escarpment.
   (d) Full extraction of coal pillars parallel and adjacent to the Deer Creek fault for 1,300 ft. (3 panels) in the Blind Canyon seam and 400 ft. (1 panel) in the Hiawatha seam.

Recommendations

Because of the unusual subsidence that occurred and its location and proximity to critical surface facilities, i.e., the lower parking lot and main electrical substation, (see Plate 6), coupled with possible damage, make safety the prime consideration. Therefore, we recommend only partial mining recovery (45%) on a uniform basis be considered for the remaining coal reserved in 1st Right area of Wilberg mine. This mining is between the Wilberg mine lower parking lot where the mine electrical substation is located and the major subsided area shown on Plate 7. The possibility of adjustment (or secondary) faulting in the established zone of weakness could cause failure to the northeast canyon wall. The elevation change from the parking lot to the top of the canyon wall is approximately 1,200 ft.

Estimated coal loss because of partial mining in 1st Right area, if all pillars in Panels 2 and 3 and 1st Right entry pillars were fully extracted as opposed to leaving the pillars intact, is shown below.

To raise total mining extraction from 45% on development to 75% for total mining, 55% is mined from each 60 x 60 ft. pillar.

Tons in-place in 60 x 60 x 8 ft. pillar	=	1,195	tons/pillar
Mine @ 55% Recovery	=	657	tons/pillar
2nd Panel remaining pillars 48 x 657 tons	=	31,500	tons
3rd Panel (undeveloped) pillars 50 x 657 tons	=	32,800	tons
Total Coal Loss in Pillars		64,300	tons

We recommend that 3rd Panel, with rooms to the right, be partially mined on 45% recovery, as shown on Plate 7. With 6.58 acres recovery equals 42,700 tons. The remaining 55% of the 60 x 60 ft. pillars will support the 1,100 ft. of overburden.

Calculations For Pillar Support

From Tabulation 1, furnished by UP&L, the average compressive strength of 1.305 in. core by 1.305 in. in height from the Hiawatha seam is 3,274 psi. Using technical paper "A Relationship Between the Ultimate Compressive Strength of Cubes and Cyclinders for Coal Specimens" by Christopher Haycocks and others at V.P.I. 1979, the following formula was used:

$$K = 0.94\ r\ Scyl.\ \sqrt{D}$$

where:
- K = Constant
- r = Cube to cyclinder strength ratio (1.4 from chart)
- Scyl. = Strength of cylindrical test specimen with diameter to height ratio of 1

$$K = 0.94 \times 1.40 \times 3{,}274 \times \sqrt{1.305} = 4{,}922 \text{ psi}$$

From technical paper "Design of Pillars for Overburden Support" by Charles T. Holland, Mining Congress Journal, April 1962, the ratio of 3 in. cube specimen (4,922 psi) to estimated ultimate strength of coal is a cube having edge dimensions equal to the seam thickness is approximately 4 times 1,230 psi compressive strength.

Then from Bureau of Mines Technical Paper 605 formula:

$$S = K \sqrt{\frac{L}{H}}$$

where:
- S = Ultimate compressive strength of pillar
- K = Constant determined from tests
- L = Smallest dimension of coal pillar
- H = Height of coal seam

$$S = 1{,}230 \sqrt{\frac{60 \text{ ft.}}{8 \text{ ft.}}} = 3{,}368 \text{ psi}$$

Load on pillar with 1,100 ft. of cover and 55% of coal support remaining and allowing 1 psi per foot of overburden.

$$\text{Pillar Load} = \frac{1{,}100 \text{ ft.} \times 144 \text{ lbs./ft.}^3}{.55 \times 144 \text{ sq. in./ft.}^2} = 2{,}000 \text{ psi}$$

$$\text{Safety Factor} = \frac{3368}{2000} = 1.7$$

Therefore, the 60 ft. pillar should not fail and further subsidence, caused by removing any additional coal by partial mining 45%, on a uniform basis, in 3rd Panel, 1st Right in Wilberg mine should not occur.

Consideration was given to splitting the 60 ft. pillars in one direction, thus yielding 398 tons per pillar or a total of:

2nd Panel 48 Pillars @ 398 Tons	=	19,100 tons
3rd Panel 50 Pillars @ 298 Tons	=	19,900
Total in Pillar Splits (excluding rooms)		39,000 tons

This increases the total recovery to 59.2%. Therefore, the average load on the remaining 20 ft. pillar is:

$$\text{Load on Pillar} = \frac{1{,}100 \text{ ft.} \times 1 \text{ psi/ft.}}{.408} = 2{,}696 \text{ psi}$$

The allowable load is:

$$S = 1230 \sqrt{\frac{20 \text{ ft.}}{8 \text{ ft.}}} = 1{,}945 \text{ psi}$$

$$\text{Safety Factor} = \frac{\text{Allowable Load}}{\text{Estimated Pillar Load}} = \frac{1{,}945}{2{,}696} = .72$$

Since the safety factor with splitting the pillars is less than one, we do not recommend this method. Any movement in the overlying strata may cause fracturing of the cliffs on the escarpment thus jeopardizing safety to employees and property.

Boyd Company is also recommending the subsidence area and escarpments be regularly monitored by aerial mapping and photographing.

Included with this report is Tabulation 1, Coal Core Compressive Strength, and the following plates:

Plates:

1: General Location Map East Mountain Property
2: Generalized Columnar Section
3: Subsidence Area
4: Sequence of Surface Movement
5: Sequences and Sections of Strata Movement
6: Relief Map of Subsidence Area
7: Mining Plan - 1st Right, Wilberg Mine, Hiawatha Seam

Respectfully submitted,

JOHN T. BOYD COMPANY
By:

James W. Boyd

James W. Boyd

TABULATION 1

COAL CORE COMPRESSIVE STRENGTH
EAST MOUNTAIN PROPERTY
Emery County, Utah

UTAH POWER & LIGHT COMPANY

August 1982

DEER CREEK COAL MINE
UTAH POWER AND LIGHT

Sample No.	L x D in.	S. G.	Lat. Press. psi	Comp. Strength psi	Comp. Strength σ_{1-3}, psi	Young's Mod. x 10^6 at 50% ult. Stress secant	tangent	Poisson's ratio sec. tan.	Shear Strength psi	Tan ϕ Coef. of Int. friction	Remarks
1	2.627 x 2.080	1.292	0	3090	3240	0.455	0.513	0.38 0.43			Coal
2	2.622 x "	1.298	0	4473	4658	0.589	0.523	0.37 0.44			"
3	2.595 x "	1.298	500	6327	6619	0.599	0.630	---- ----			"
4	2.615 x "	1.290	1000	7592	7953	0.584	0.545	---- ----	1150	0.83269	"
5	2.518 x "	1.278	1000	7622	7928	0.571	0.567	---- ----			"
6	2.595 x "	1.303	1500	10653	11144	0.672	0.649	---- ----			"
7	2.612 x "	1.318	1500	9182	9617	0.613	0.637	---- ----			"
1	2.624 x "	1.232	0	2060	2159	0.309	0.244	0.40 0.52			Fractured. Not used in Mhr's analysis
2	2.275 x "	1.256	500	7063	7200	0.537	0.476	---- ----			Coal
3	2.614 x "	1.382	1500	9652	10111	0.750	0.721	---- ----	1038	0.76421	"
4	2.199 x "	1.294	0	3679	3724	0.530	0.451	0.40 0.59			"
5	2.145 x "	1.190 1.285	1500	10006	10074	0.620	0.697	---- ----			"

DRILL HOLE A-30, DEER CREEK COAL MINE
HIAWATHA CANYON SEAM

Core Dia 1.305"
" Length 1.305"

Sample No.	Depth ft.	L x D in.	S. G.	Lat. Press. psi	Comp. Strength psi	Comp. Strength σ_{1-3}, psi	Young's mod. x 10^6 at 50% ult. stress secant	tangent	Poisson's ratio sec. tan.	Remarks
1	56.0 - 57.0	1.296 x 1.305	1.260	0	3433	3433	-----	-----	---- ----	no X-Y chart; short sample, coal
2	57.0 - 58.7	2.600 x "	1.270	0	2242	2521	0.372	0.407	0.39 ----	Coal
2A	" "	2.596 x "	1.289	0	2504	2815	0.400	0.435	0.60 ----	"
3	58.7 - 60.7	2.603 x "	1.294	0	2093	2384	0.277	0.348	0.28 ----	"
3A	" "	2.600 x "	1.296	0	2466	2773	0.312	0.396	0.34 0.47	"
4	60.7 - 62.7	2.600 x "	1.319	0	3139	3529	0.477	0.513	0.41 0.49	"
4A	" "	2.567 x "	1.277	0	4409—	4949	0.401	0.483	0.34 0.43	"
4B	" "	2.600 x "	1.255	0	2940	3193	0.348	0.460	0.33 ----	"
5	62.7 - 64.7	2.592 x "	1.298	0	2877	3233	0.367	0.450	0.33 0.46	"
5A	" "	2.603 x "	1.246	0	3176	3571	0.375	0.462	0.44 ----	"
5B	" "	2.575 x "	1.263	0	2317	2602	0.333	0.424	0.27 ----	"
6	64.7 - 65.8	2.370 x "	1.314	0	3886	4317	0.409	0.443	---- ----	"

1.280

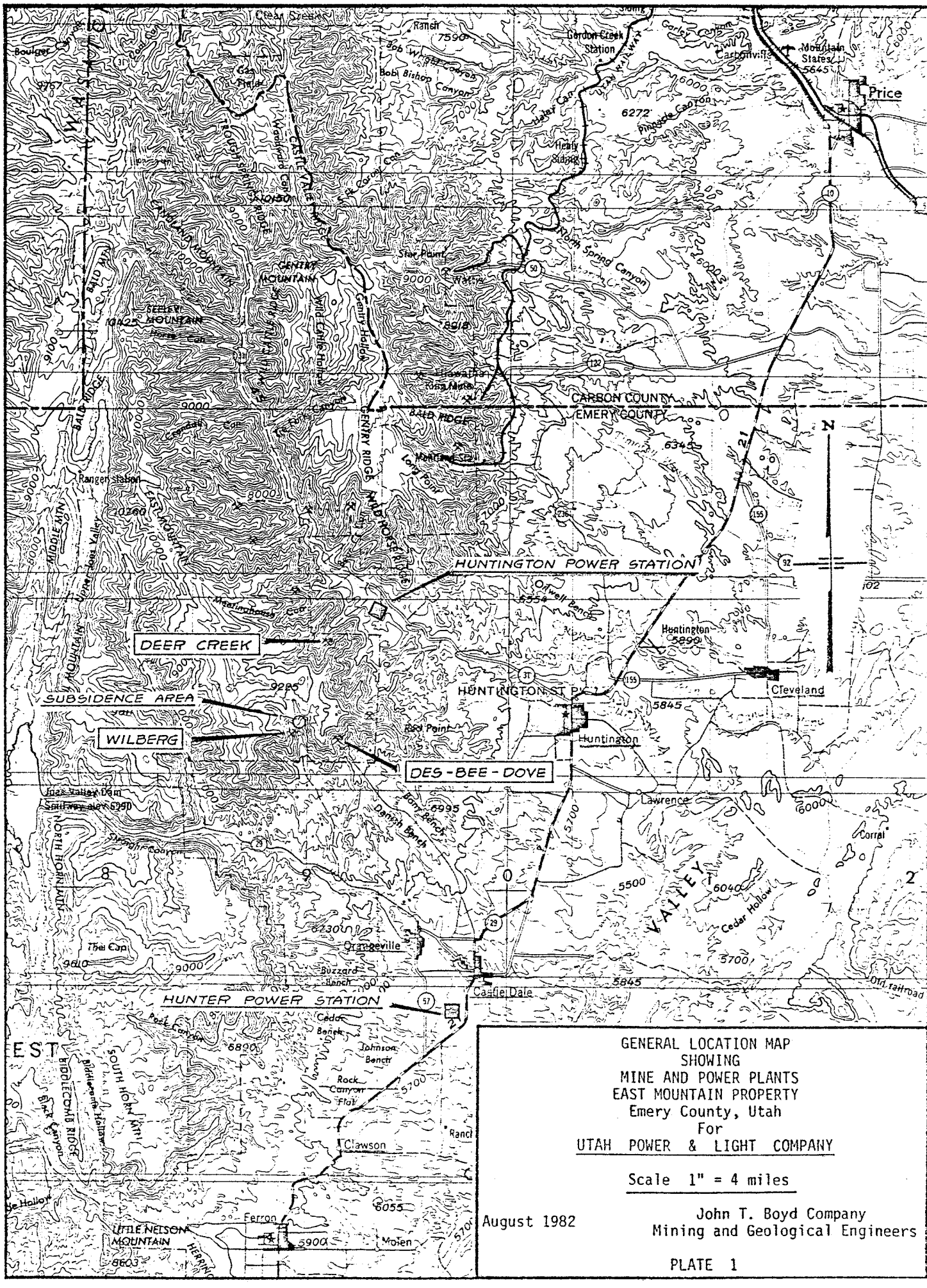
$\bar{X}$ = 3274
$\hat{s}$ = 763

TABULATION 1

COAL CORE COMPRESSIVE STRENGTH
EAST MOUNTAIN PROPERTY
Emery County, Utah

UTAH POWER & LIGHT COMPANY

August 1982



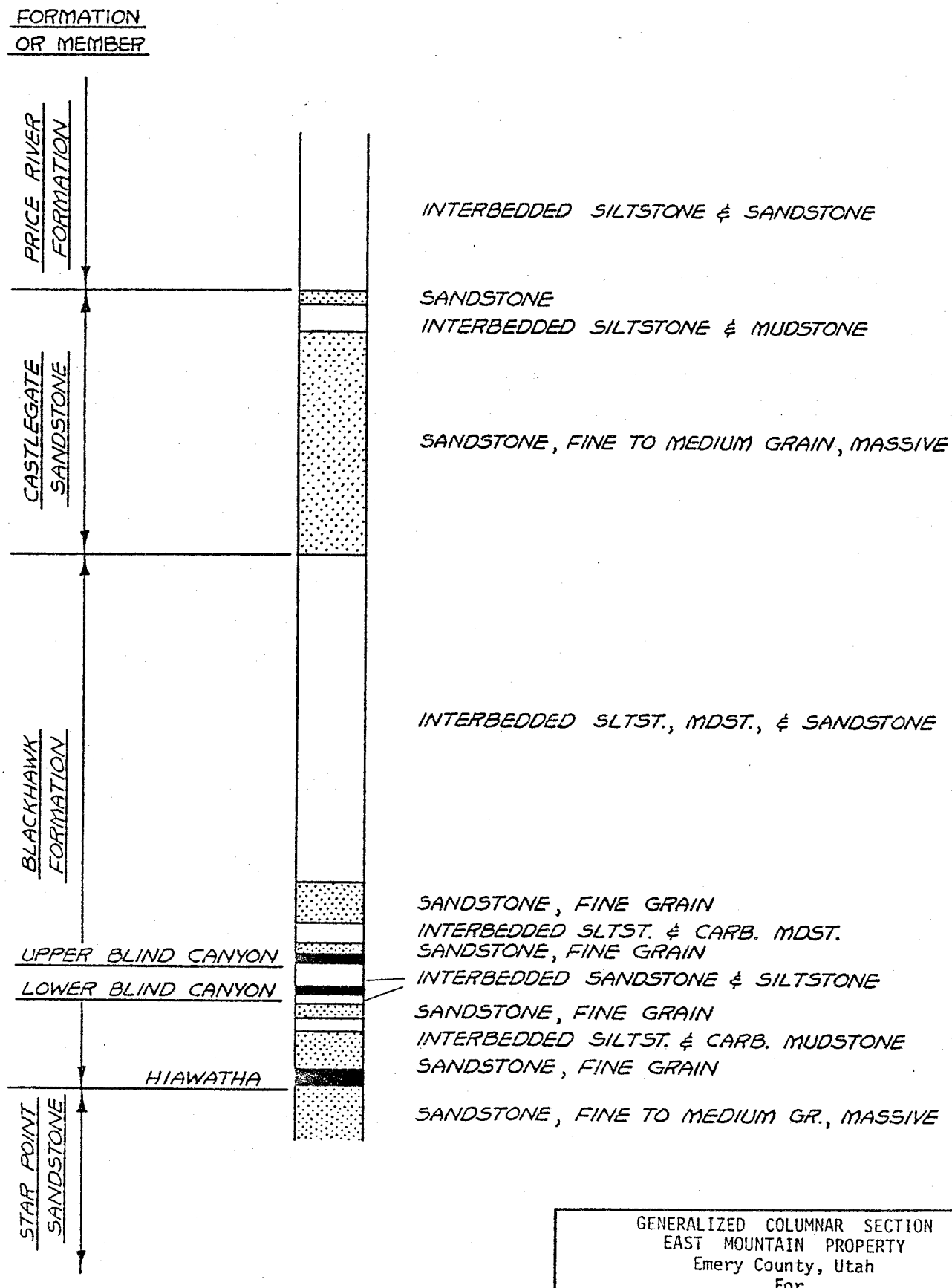
GENERAL LOCATION MAP
SHOWING
MINE AND POWER PLANTS
EAST MOUNTAIN PROPERTY
Emery County, Utah
For
UTAH POWER & LIGHT COMPANY

Scale 1" = 4 miles

August 1982

John T. Boyd Company
Mining and Geological Engineers

PLATE 1



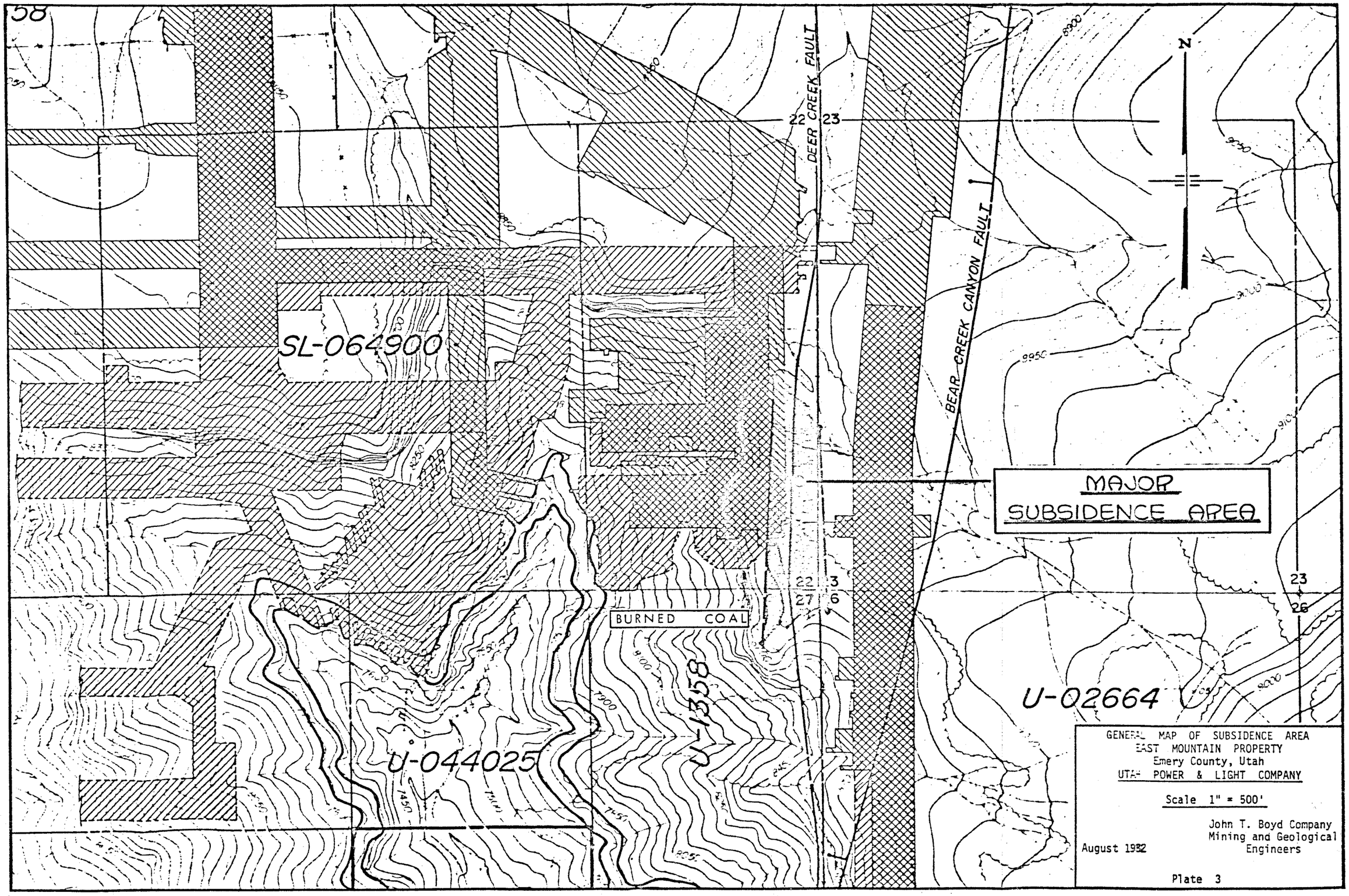
GENERALIZED COLUMNAR SECTION
EAST MOUNTAIN PROPERTY
Emery County, Utah
For
UTAH POWER & LIGHT COMPANY

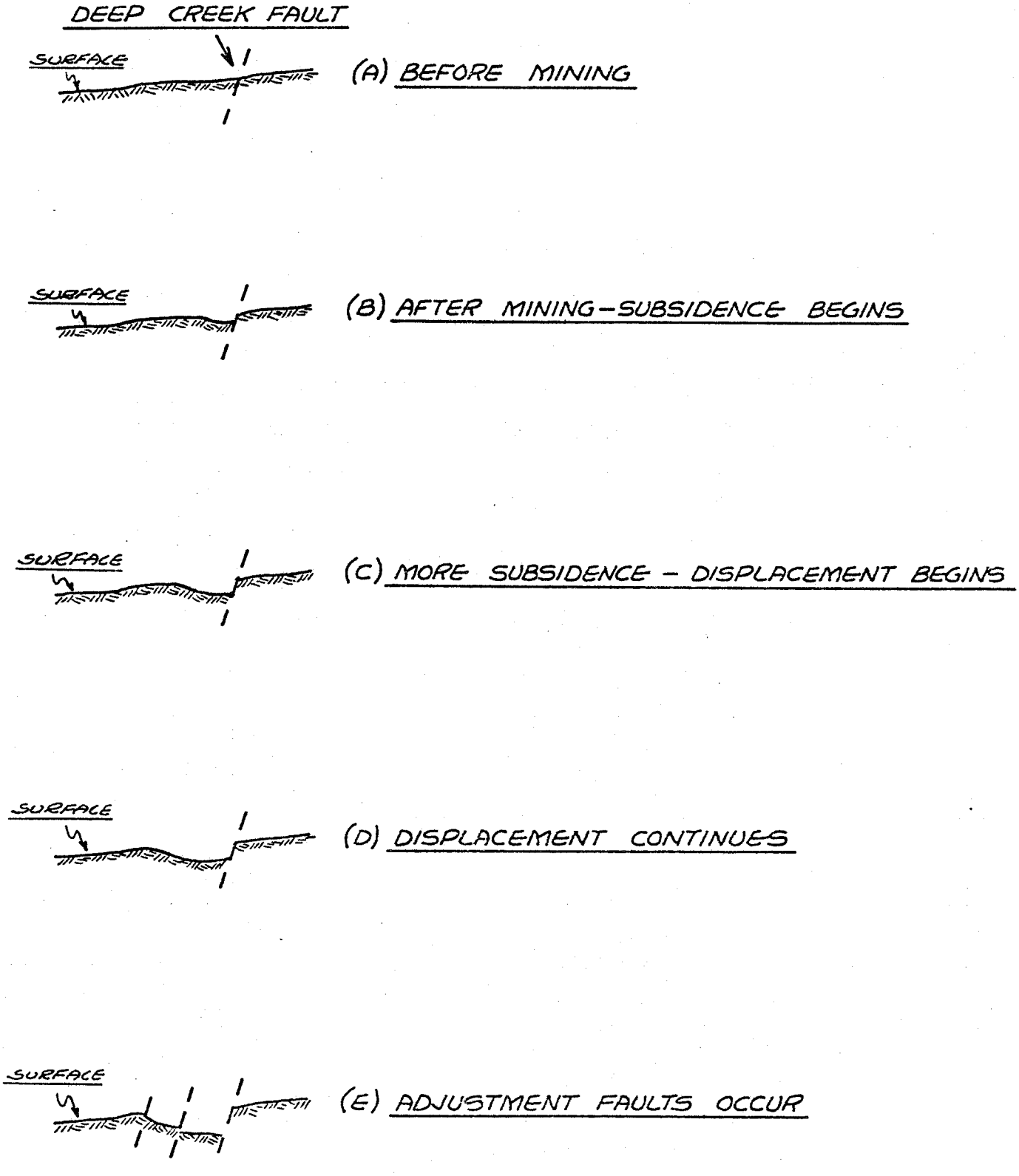
Not to Scale

John T. Boyd Company
Mining and Geological
Engineers

August 1982

Plate 2


58
N
DEER CREEK FAULT
BEAR CREEK CANYON FAULT
22
23
SL-064900
MAJOR
SUBSIDENCE AREA
BURNED COAL
22
27
3
6
23
26
U-1358
U-02664
U-044025
GENERAL MAP OF SUBSIDENCE AREA
EAST MOUNTAIN PROPERTY
Emery County, Utah
UTAH POWER & LIGHT COMPANY
Scale 1" = 500'
John T. Boyd Company
Mining and Geological
Engineers
August 1982
Plate 3



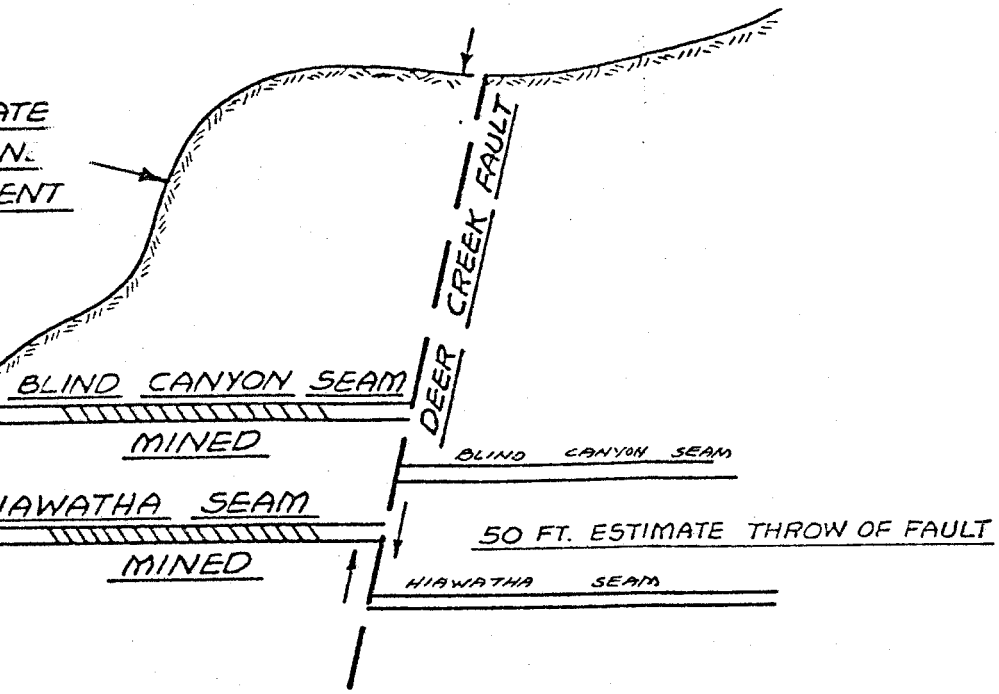
SEQUENCE OF SURFACE MOVEMENT
EAST MOUNTAIN PROPERTY
Emery County, Utah
For
UTAH POWER & LIGHT COMPANY

Not to Scale

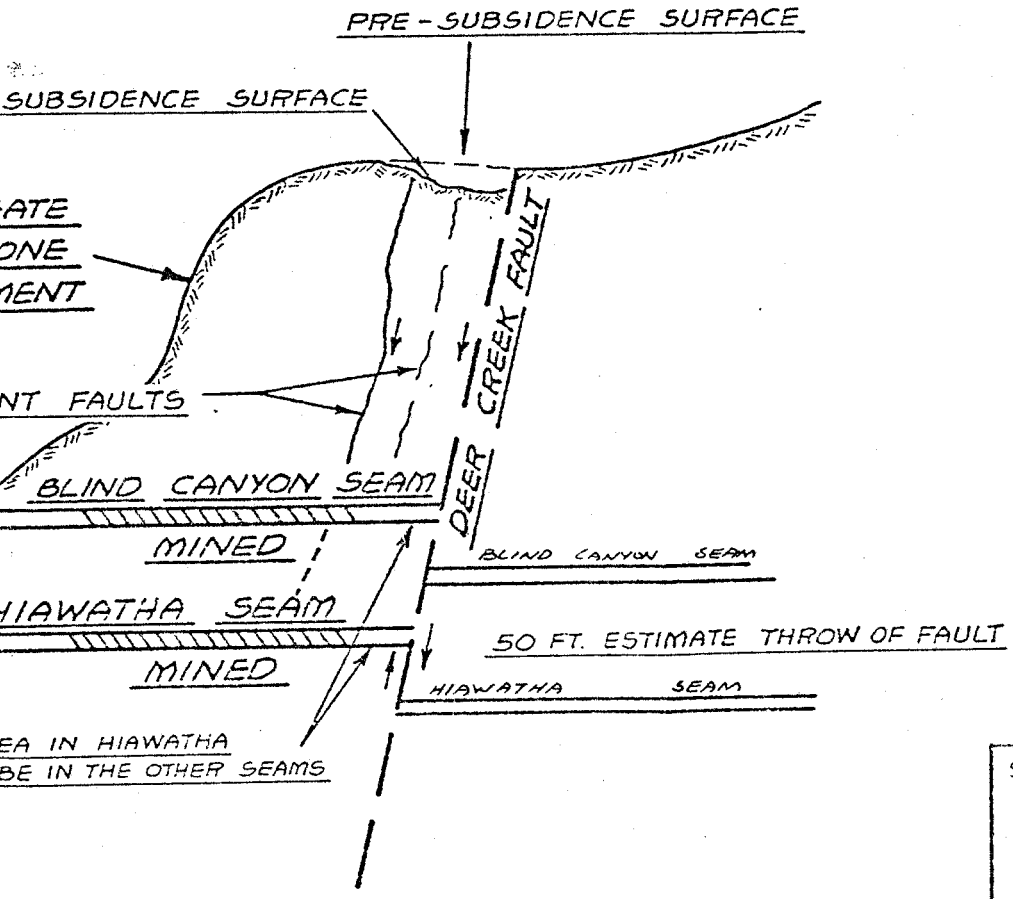
John T. Boyd Company
Mining and Geological
Engineers

August 1982

Plate 4



EARTH MOVEMENT STARTS



D SUBSIDENCE CONTINUES

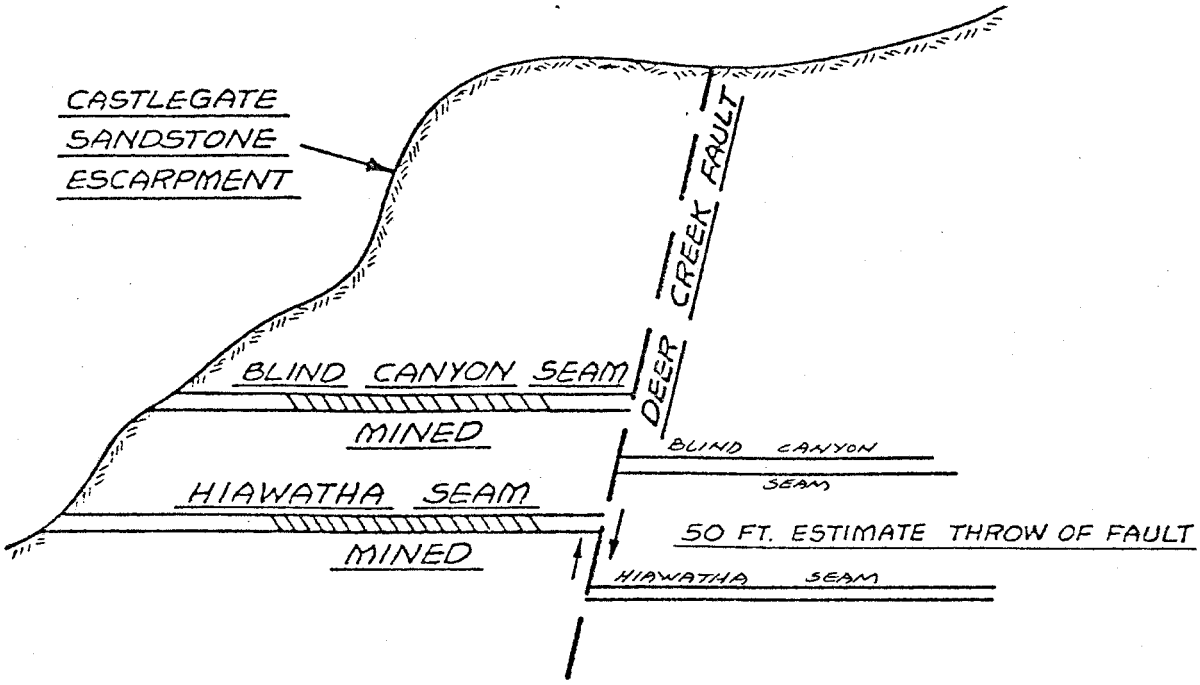
SEQUENCES & SECTIONS OF STRATA MOVEMENT
EAST MOUNTAIN PROPERTY
Emery County, Utah
For
UTAH POWER & LIGHT COMPANY

Not to Scale

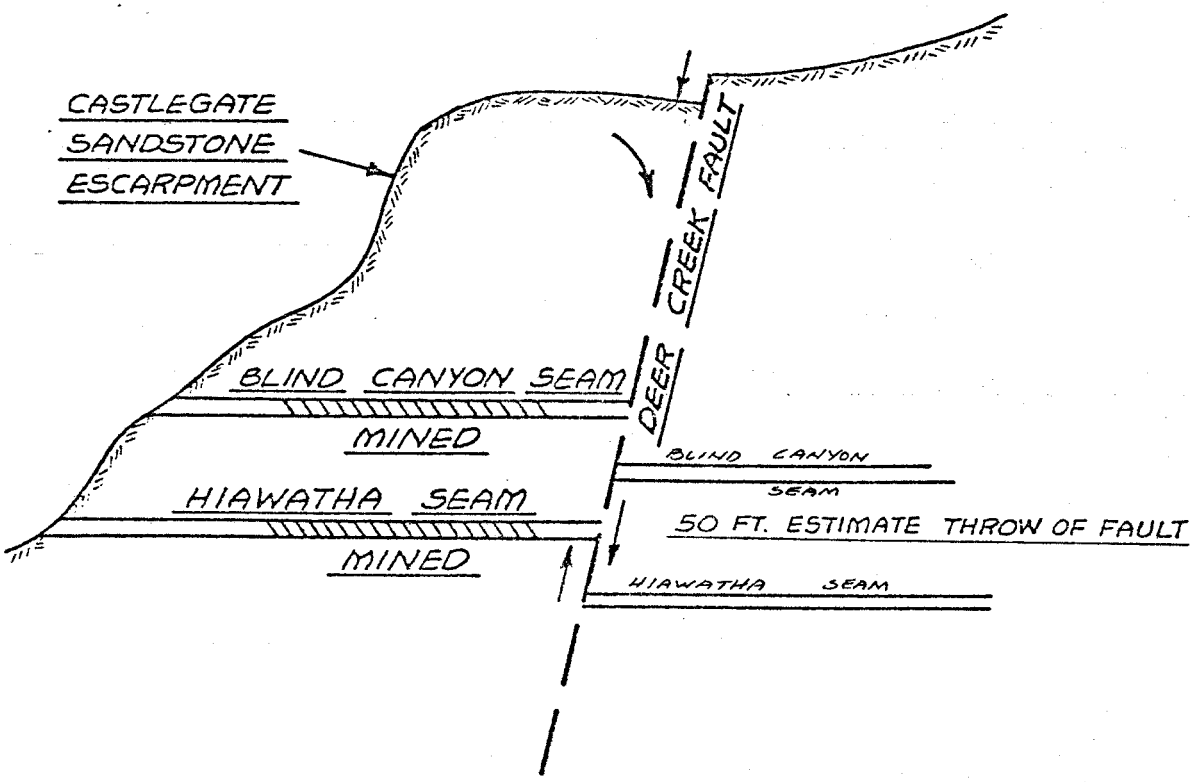
John T. Boyd Company
Mining and Geological
Engineers

August 1982

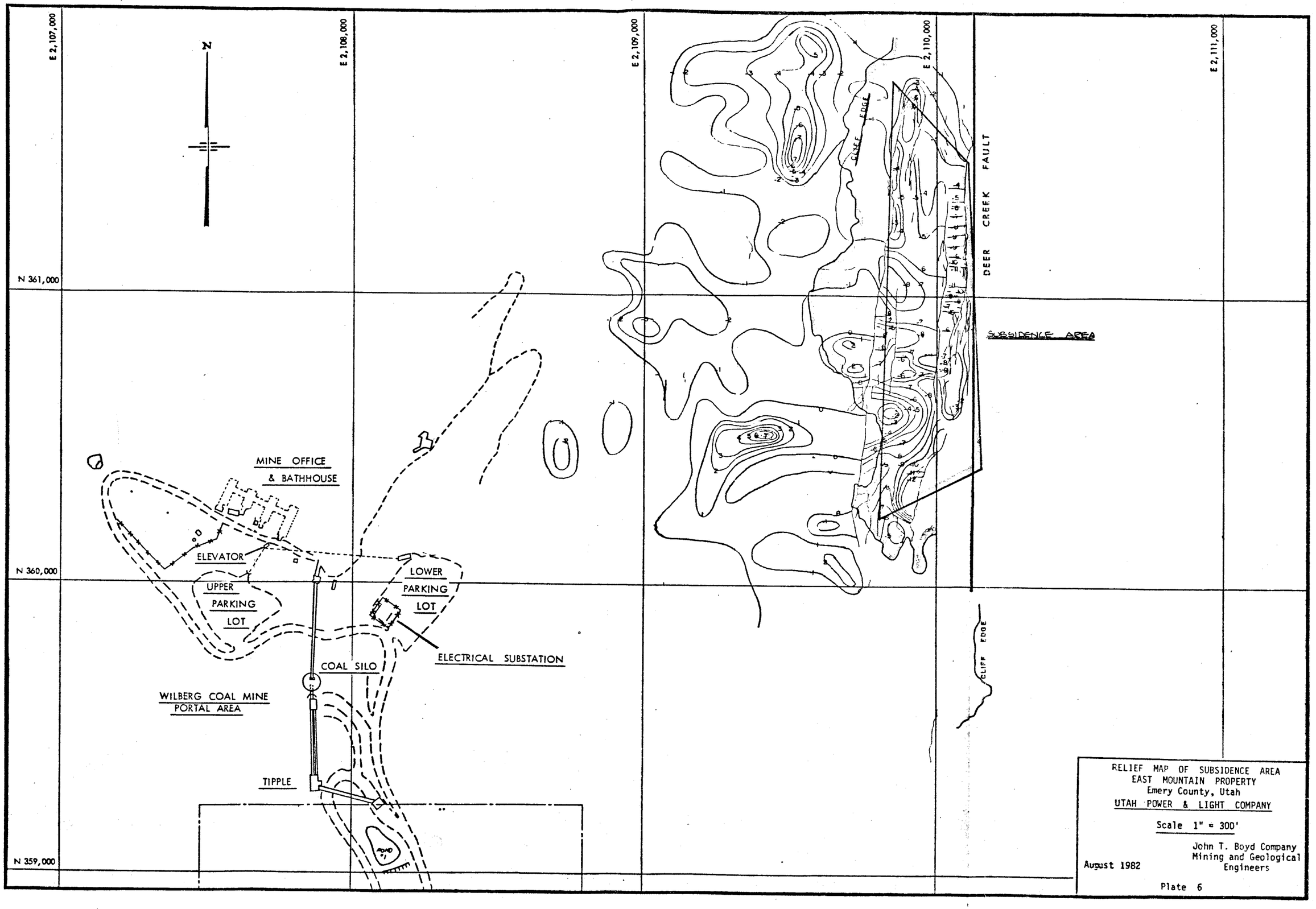
Plate 5



(A) BEFORE MINING



(C) STRATA COLLAPSE



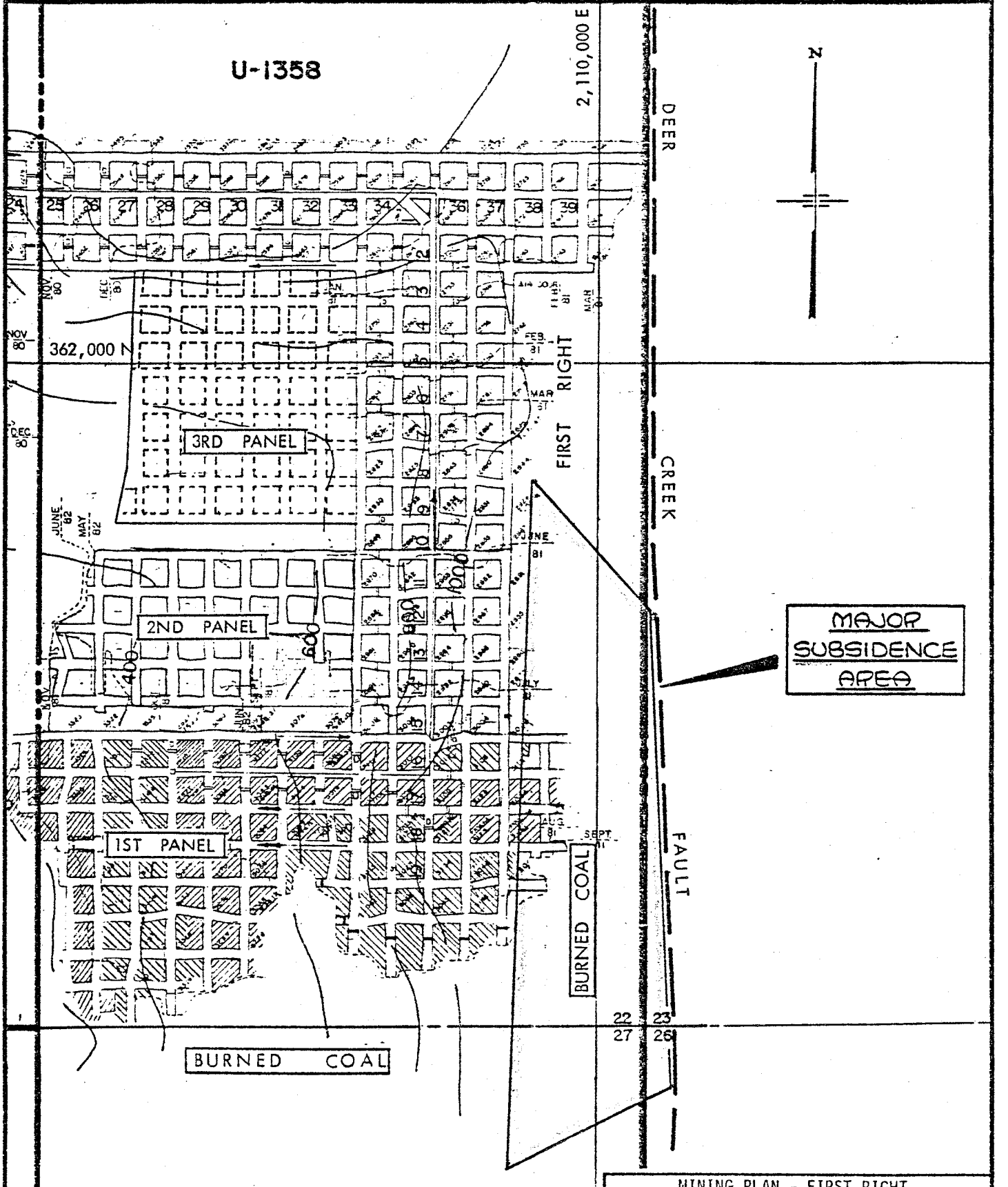
RELIEF MAP OF SUBSIDENCE AREA
EAST MOUNTAIN PROPERTY
Emery County, Utah
UTAH POWER & LIGHT COMPANY

Scale 1" = 300'

August 1982

John T. Boyd Company
Mining and Geological
Engineers

Plate 6



MINING PLAN - FIRST RIGHT
WILBERG MINE - HIAWATHA SEAM
EAST MOUNTAIN PROPERTY
Emery County, Utah
UTAH POWER & LIGHT COMPANY

Scale 1" = 300'

August 1982

John T. Boyd Company
Mining and Geological
Engineers

Plate 7

REPORT OF SUBSIDENCE STUDY

LOCATED ON EAST MOUNTAIN ABOVE THE

DES-BEE-DOVE
COAL MINES

from October 1980
to July 1982

By

Intermountain Aerial Surveys
A Division of Engineering Enterprises, Inc.

Salt Lake City, Utah

SUBSIDENCE STUDY

DES-BEE-DOVE COAL MINES

STATION	VABM OCT 80	JULY 82	DIFF. 80 to JULY 82
P-3	9239.89	9239.89	Fixed
BS-21	9223.5	9223.60	+0.1
BS-20	9210.2	9210.32	+0.1
BS-19	9201.9	9202.00	+0.1
BS-18	9188.7	9188.74	0
BS-17	9167.2	9167.14	-0.1
BS-16	9147.1	9146.73	-0.4
BS-15	9125.4	9124.75	-0.7
BS-14	9106.7	9105.91	-0.8
BS-13	9085.8	9084.81	-1.0
BS-12	9062.3	9061.21	-1.1
BS-11	9038.3	9037.15	-1.2
BS-10	9016.5	9015.38	-1.1
BS-9	8993.3	8992.14	-1.2
BS-8	8962.8	8961.74	-1.1

SUBSIDENCE STUDY

DES-BEE-DOVE COAL MINES

STATION	VABM OCT 80	JULY 82	DIFF. 80 to JULY 82
BS-7	8931.0	8930.08	-0.9
BS-6	8900.6	8899.81	-0.8
BS-5	8867.4	8867.45	0
BS-4	8846.5	8846.56	+0.1
BS-3	8806.6	8806.76	+0.2
BS-2	8795.2	8795.36	+0.2
BS-1	8785.6	8785.67	+0.1

SUBSIDENCE STUDY

DES-BEE-DOVE COAL MINES

STATION	VABM OCT 80	JULY 82	DIFF. 80 to JULY 82
BS-14			
#1 No.	9103.0	9102.16	-0.8
#2 No.	9098.8	9097.88	-0.9
#3 No.	9087.4	9086.34	-1.1
#4 No.	9076.8	9075.74	-1.1
BS-14			
#1 So.	9105.2	9104.46	-0.7
#2 So.	9095.0	9094.32	-0.7
#3 So.	9082.8	9082.18	-0.6
#4 So.	9079.4	9078.88	-0.5

SUBSIDENCE STUDY

DES-BEE-DOVE COAL MINES

STATION	VABM OCT 80	JULY 82	DIFF. 80 TO JULY 82
BS-9			
#1 No.	8983.8	8982.48	-1.3
#2 No.	8973.9	8972.44	-1.5
#3 No.	8960.0	8958.44	-1.6
#4 No.	8946.8	8945.12	-1.7
BS-9			
#1 So.	8995.7	8994.72	-1.0
#2 So.	8992.6	8991.73	-0.9
#3 So.	8980.6	8979.85	-0.8
#4 So.	8958.3	8957.61	-0.7

DIRECT' _____

FROM _____

TO _____

SPIRIT LEVELING

SHEET _____ OF _____

DATE 20 JUL 82

JOB NO. 821C

INST. NO. _____

CHIEF PARTY _____

ADJ. BY _____

STA.	BK. PG.	NO. Turns	DIFFERENCE ELEVATION D1 (F)	D2 (B)	D3 (F)	D4 (B)	AVERAGE DIFFERENCE	DIST.	ALLOW ERROR	ADJ.	ADJUSTED DIFFERENCE	ELEVATION
			P-3 STABILITY CHECK									
			NOV. 1981									
A-2A												
					VABM		+1963.05					
P-3V									+ 1995.17			
					LEVELS		+ 32.12					
P-3												
			JULY 1982									
A-2A												
					VABM		+1963.20					
P-3V									+ 1995.28			
					LEVELS		+32.08					
P-3												

REPORT OF SUBSIDENCE STUDY

LOCATED ON EAST MOUNTAIN ABOVE THE

DES-BEE-DOVE
COAL MINES

From October 1980
To November 1981

By

Intermountain Aerial Surveys
A Division of Engineering Enterprises, Inc.

Salt Lake City, Utah

SUBSIDENCE REPORT
DES-BEE-DOVE COAL MINES

I. Scope of Work

A. Establish Monuments on East Mountain above the "Des-Bee-Dove" Mine System as directed. Included sketch shows locations as related to mine workings. Computation sheets identify station location by State Plane Coordinate System (Utah Central Zone Modified C.A.F. = 1.0004350)

B. Monitor elevation changes on Monuments at monthly intervals as long as weather allows practical access.

II. Procedures

A. Elevations were established in 1980 by use of trigonometric leveling. Vertical angles were measured with a Wild T-2 theodolite. Accepted survey practices were utilized to insure reasonable accuracies.

B. 1981 Elevations were monitored by differential leveling. Third order technique and accuracies were observed.

C. Horizontal point determination was accomplished by employing third order techniques. Wild T-2 theodolites and AGA Model 78 Distance Measuring Equipment were used.

III. Control Datum

Control point "P-3" is used as the reference monument for this study. It is located on East Mountain, east of the monitoring line (See computation sheets). Its stability has been tested by recalculating several control networks which have passed thru the station throughout the last several years. To insure against the possibility of future subsidence it will be tied to control point "M-2" at systematic periods throughout the monitoring year by trigonometric leveling. M-2 is located near the portal of the Deseret Mine and is outside of the area of any suspected subsidence.

SUBSIDENCE STUDY

DES-BEE-DOVE COAL MINES

STATION	VABM OCT. '80	JULY '81	AUG. '81	SEPT. '81	OCT. '81	NOV. '81	DIFF. '80 to NOV. '81
P-3	9239.89	9239.89	9239.89	9239.89	9239.89	9239.89	Fixed
BS-21	9223.5	9223.56	9223.56	9223.55	9223.56	9223.56	0
BS-20	9210.2	9210.27	9210.28	9210.26	9210.27	9210.28	0
BS-19	9201.9	9201.96	9201.98	9201.95	9201.97	9201.98	+ 0.1
BS-18	9188.7	9188.67	9188.69	9188.67	9188.68	9188.70	0
BS-17	9167.2	9167.11	9167.14	9167.10	9167.10	9167.14	- 0.1
BS-16	9147.1	9146.79	9146.81	9146.77	9146.74	9146.76	- 0.3
BS-15	9125.4	9124.95	9124.96	9124.90	9124.84	9124.82	- 0.6
BS-14	9106.7	9106.23	9106.24	9106.17	9106.06	9105.98	- 0.7
BS-13	9085.8	9085.27	9085.27	9085.17	9085.02	9084.90	- 0.9
BS-12	9062.3	9061.74	9061.75	9061.58	9061.43	9061.32	- 1.0
BS-11	9038.3	9037.70	9037.70	9037.48	9037.33	9037.27	- 1.0
BS-10	9016.5	9015.90	9015.89	9015.64	9015.50	9015.49	- 1.0
BS-9	8993.3	8992.61	8992.59	8992.35	8992.23	8992.25	- 1.0
BS-8	8962.8	8962.15	8962.12	8961.91	8961.80	8961.83	- 1.0

SUBSIDENCE STUDY

DES-BEE-DOVE COAL MINES

STATION	VABM OCT. '80	JULY '81	AUG. '81	SEPT. '81	OCT. '81	NOV. '81	DIFF. '80 to NOV. '81
BS-7	8931.0	8930.39	8930.37	8930.19	8930.10	8930.16	- 0.8
BS-6	8900.6	8899.99	8899.99	8899.86	8899.77	8899.85	- 0.7
BS-5	8867.4	8867.23	8867.29	8867.24	8867.23	8867.36	0
BS-4	8846.5	8846.31	8846.38	8846.36	8846.36	8846.50	0
BS-3	8806.6	8806.47	8806.56	8806.55	8806.54	8806.70	+ 0.1
BS-2	8795.2	8795.07	8795.17	8795.15	8795.14	8795.31	+ 0.1
BS-1	8785.6	8785.38	8785.48	8785.44	8785.43	8785.60	0

SUBSIDENCE STUDY

DES-BEE-DOVE COAL MINES

STATION	VABM OCT. '80	JULY '81	AUG. '81	SEPT. '81	OCT. '81	NOV. '81	DIFF. '80 to NOV. '81
BS-14							
#1 No.	9103.0	9102.55	9102.56	9102.48	9102.36	9102.24	- 0.8
#2 No.	9098.8	9098.34	9098.35	9098.27	9098.13	9097.98	- 0.8
#3 No.	9087.4	9086.88	9086.89	9086.79	9086.64	9086.46	- 0.9
#4 No.	9076.8	9076.36	9076.38	9076.28	9076.10	9075.89	- 0.9
BS-14							
#1 So.	9105.2	9104.73	9104.74	9104.67	9104.57	9104.51	- 0.7
#2 So.	9095.0	9094.52	9094.54	9094.48	9094.40	9094.36	- 0.6
#3 So.	9082.8	9082.34	9082.36	9082.31	9082.22	9082.21	- 0.6
#4 So.	9079.4	9079.00	9079.03	9078.99	9078.92	9078.92	- 0.5

SUBSIDENCE STUDY

DES-BEE-DOVE COAL MINES

STATION	VABM OCT. '80	JULY '81	AUG. '81	SEPT. '81	OCT. '81	NOV. '81	DIFF. '80 to NOV. '81
BS-9							
#1 No.	8983.8	8983.11	8983.08	8982.77	8982.61	8982.61	- 1.2
#2 No.	8973.9	8973.19	8973.15	8972.81	8972.62	8972.61	- 1.3
#3 No.	8960.0	8959.28	8959.23	8958.85	8958.66	8958.63	- 1.4
#4 No.	8946.8	8946.06	8946.00	8945.57	8945.38	8945.35	- 1.4
BS-9							
#1 So.	8995.7	8995.05	8995.05	8994.85	8994.77	8994.80	- 0.9
#2 So.	8992.6	8991.96	8991.97	8991.79	8991.73	8991.77	- 0.8
#3 So.	8980.6	8980.00	8980.02	8979.87	8979.83	8979.88	- 0.7
#4 So.	8958.3	8957.70	8957.72	8957.61	8957.57	8957.62	- 0.7

Project East Mountain Subsidence Mapping Control
Job # 8036
Date 18 February 1981
Sheet 5 of

Utah Central Zone

es 4 Ang Error 4.0

-0.1609 E 0.2817
ute 0.32442413 N Az119-43-34.6
eter 8688.2500 1 ft in 26781

Point	Iden.	So. Azim.	Adj. S.L. Length	Sea Level North	East	C.A.F. = 1.0004350 North	East
	MT-7	205-33-59.7	0.00				
2	MT-6			366492.69	2110199.82	366652.11	2111117.76
		26-22-25.9	3773.35				
3	DS-1A			363112.09	2108523.60	363270.04	2109440.81
		270- 0- 5.2	4595.61				
4	DS-20			363111.97	2113119.21	363269.93	2114038.42
		303-32-27.9	319.12				
5	Stump			362935.65	2113385.19	363093.53	2114304.51
		284-32-39.4	0.00				
	P-3						

ject East Mountain Subsidence Study (Beehive)
Job # 8036
Date 11 March 1981
Sheet 50

Utah Central Zone

C.A.F. = 1.0004350

t	Iden.	So. Azim.	Length	North	East
	BS-14 1 South			363169.87	2112839.94
	BS-14 1 North			363369.82	2112839.94
	BS-14 2 North			363469.85	2112839.95
	BS-14 3 North			363569.24	2112839.95
	BS-14 4 North			363669.43	2112839.96
	BS-14 2 South			363069.91	2112839.94
	BS-14 3 South			362969.38	2112839.93
	BS-14 4 South			362869.09	2112839.93
	BS-9 1 South			363169.94	2111840.07
	BS-9 2 South			363069.88	2111840.06
	BS-9 1 North			363369.68	2111840.07
	BS-9 2 North			363470.10	2111840.08
	BS-9 3 North			363570.16	2111840.08
	BS-9 4 North			363670.63	2111840.09
	BS-9 3 South			362970.01	2111840.06
	BS-9 4 South			362870.50	2111840.05

Project East Mountain Subsidence Study (Beehive)
Job # 8036
Date 11 March 1981
Sheet 49

Utah Central Zone

C.A.F. = 1.0004350

oint	Iden.	So. Azim.	Length	North	East
	BS-1A				
		270- 0- 5.2	0.00		
	BS-1			363270.02	2110239.96
	BS-2			363270.01	2110439.81
	BS-3			363270.01	2110639.83
	BS-4			363270.00	2110840.11
	BS-5			363270.00	2111040.01
	BS-6			363269.99	2111239.86
	BS-7			363269.99	2111439.74
	BS-8			363269.98	2111639.63
	BS-9			363269.98	2111840.07
	BS-10			363269.97	2112039.67
	BS-11			363269.97	2112239.73
	BS-12			363269.96	2112439.72
	BS-13			363269.96	2112639.93
	BS-14			363269.95	2112839.94
	BS-15			363269.95	2113039.83
	BS-16			363269.94	2113239.50
	BS-17			363269.94	2113439.03
	BS-18			363269.93	2113638.86
	BS-19			363269.93	2113838.62
	[illegible]			[illegible]	[illegible]
	BS-21			363270.06	2114238.67

BS-20 listed on printout sheet 5

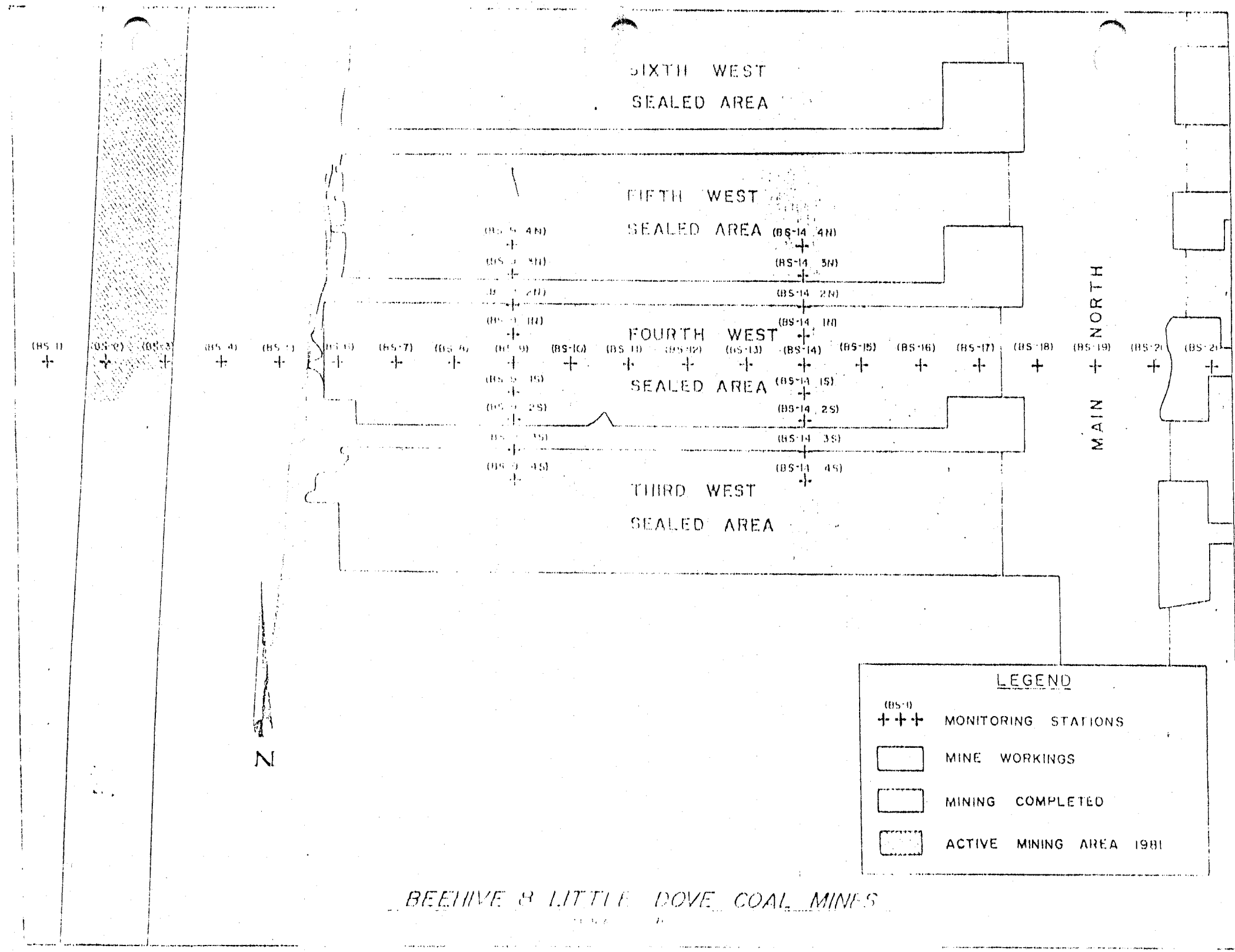
Project East Mountain Subsidence Mapping Control
Job # 8036
Date 18 February 1981
Sheet 1

Utah Central Zone

25 4 Ang Error -8.4

-0.0316 E -0.1706
ate 0.17346686 N Az100-29-15.2
ster 22041.9810 1 ft in 127067

Point	Iden.	So. Azim.	Adj. S.L. Length	Sea Level North	East	C.A.F. = 1.0004350 North	East
	MT-3	32-38-45.2	0.00				
2	MT-2			365345.74	2108279.78	365504.67	2109196.88
		295-16-13.6	5645.69				
3	Stump			362935.65	2113385.19	363093.52	2114304.51
		284-32-39.4	312.10				
4	P-3			362857.27	2113687.29	363015.11	2114606.75
		72-19- 1.0	16084.10				
5	P-2			357971.70	2098363.14	358127.42	2099275.93
		265-33-46.3	0.00				
	MT-6						



BEEHIVE & LITTLE DOVE COAL MINES