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Ark Land Company  
c/o Canyon Fuel Co., LLC  
Skyline Mines  
HC35Box 380  
Helper, Utah 84526  
435-448-2633

Nov. 23, 1999

Will Wilson  
Geologist  
US Forest Service  
115 W Canyon Road  
Ferron, Utah 84523

Dear Will:

Attached is copy of a report I wrote concerning the subsidence cracks near Trough Springs Ridge. Jeff DeFreest asked me to write up a report. Since you were closely involved with the project, I decided to send it to you. Let me know if you need additional copies.

Thanks for your help this summer, not only with the subsidence cracks, but with the drilling project as well. We currently plan to drill four additional holes on the Forest under the Flat Canyon exploration license next summer. I will keep you posted as those plans develop.

Thanks again for your help this summer.

Sincerely,

Mark Bunnell  
Geologist

Attach.

CR  
cc: Alan Rabinoff  
BLM State Ofc.  
George Tetreault  
BLM Price  
Pam Littig  
WDOG/M

W/W  
Cantor EIT

Copy Paul letter - Darn 3  
- Mike S.  
- Wayne  
ACT/002/005

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WJW

# TROUGH SPRINGS RIDGE SUBSIDENCE CRACKS: OCCURRENCE AND MITIGATION

Canyon Fuel Company, LLC  
Skyline Mines  
M. Bunnell  
11/99

## INTRODUCTION

In mid-August, 1999, a number of subsidence cracks (labeled "Area B" on Map 1) were observed immediately west of Trough Springs Ridge, located in the SW ¼, SE ¼, Sec. 23, T 13 S, R 6 E. No cracks were noticed in the area during earlier observations in June, with the exception of several minor cracks in the dirt road to the north (labeled Area A). It appears the majority of these cracks developed during July and August. On Sept. 1, 1999, Will Wilson (USFS) and I were looking at cracks in area B to determine the best mitigation technique when a sheep herder informed us there were more extensive cracks along the small ridge to the south. Upon investigation we found a zone of cracks approximately 700 ft. wide and 1500 ft. long. This zone, shown on Maps 1 and 2 (labeled "Area C"), was much more extensive than any observed or mapped to date in the Skyline area.

This report describes the location and characteristics of the cracks as well as their relationship to underground coal mining in the area. The cracks were filled-in and the area reseeded by Sept. 30, 1999. Mitigation techniques and results are also discussed.

## METHODOLOGY

Due to the large number and irregular, discontinuous nature of cracks in area C, an accurate mapping methodology had to be developed. A baseline was established running nearly parallel the cracks and "Brunton and chain" techniques were used to establish "rights-and-lefts" off the baseline. Using this method, effective mapping of individual discontinuous cracks was possible while maintaining fairly accurate location in relation to the underlying mine workings. This baseline together with mapped cracks are shown in detail on Map 2. During mapping, each crack was identified as to maximum width and depth. Cracks less than 1 ft. wide and 1 ft. deep were mapped as lines with no notations next to them. Surface geology was also mapped in the vicinity of the zone.

## GENERAL GEOLOGY

Figure 1 shows the general stratigraphic column of the near-surface based on two exploration boreholes located within 1500 ft. of the subsidence crack zone to the northeast and northwest (Map 1). Both holes were collared at about the same elevation as crack development within the crack zone, showing a zone of interbedded sandstone and siltstone, with at three prominent sandstone beds near the surface ranging in thickness

from 10 to 30 ft. The lower of these sandstone layers is exposed in the area of station 1200 to 1300 on the baseline (Map 2). Wherever cracks penetrated the soils at the surface, it was possible to observe fractured bedrock beneath. Cracks tended to propagate along preexisting joints and fractures in the rock. The principal joint orientation is about N 5 to 10 E with secondary joints running N 60 to 70 W. Cracks did not extend southward and downslope of the sandstone outcrop.

The crack zone is contained within the upper Blackhawk Formation. This portion of the formation is characterized by interbedded sandstone and siltstone with sandstone beds comprising approximately 50 to 70 percent. Underlying mineable coal seams include the Upper O'Connor and Lower O'Connor B seams. Beneath these two seams occur two additional seams which include the Lower O'Connor A and Flat Canyon seams. It is currently uncertain whether the two lower seams are economically mineable. Subsidence inducing mining (longwall mining) was conducted in the Upper O'Connor seam in the area from Nov. 91 through Feb. 92 and again from Jan. through Mar. 93. A second phase of mining occurred in the underlying Lower O'Connor B seam from Aug. through Oct. 98 and Feb. through Mar. 99. Crack development was associated exclusively with second seam mining.

#### CRACK DESCRIPTION

Subsidence cracks formed along the crest of a small northwest-southeast oriented side-ridge. Appendix 1 is a collection of photographs of various cracks and slump structures within the zone. Cracks ranged in width from inches to over 5 ft. with depth varying from inches to over 25 ft. Map 2 shows two distinct parallel zones of fracturing which extend in a north/south orientation. The majority of cracks vary in orientation from N 5 E to N 20 W with some cracks turning in a N 60 to 80 W orientation. Cracks development appears to be influenced by primary and secondary jointing in the bedrock as well as mining orientation beneath.

#### CRACK RELATION TO MINING AND SUBSIDENCE

Maps 1, 2, 3, and 4 show mine development with various critical parameters. Maps 1 and 2 show mine workings with surface topography. Map 3 shows mine workings with cumulative subsidence contours as of Oct. 1998. Map 4 shows mine workings with overburden thickness contours above the Lower O'Connor B seam.

As previously mentioned, full extraction longwall mining occurred in two seams with mining oriented nearly parallel the overlying ridge crest. A major contributing factor to crack development on the surface is the presence of a narrow unmined zone called a fire barrier. This zone was designed to provide a barrier between blocks of longwall panels in the event of a gob fire. With two seams of mining on both sides of the fire barrier, a condition developed where up to 12 ft. of subsidence (Map 3) occurred on each side of the barrier with only 1 to 2 ft. of subsidence occurring immediately above the barrier (it should be noted that second seam mining on the west side of the barrier had not

yet been completed at the time of the 1998 subsidence survey shown on Map 3). As illustrated in Figure 2, a condition developed on the surface where it was placed under high tensional stress. Factors contributing to this condition were: 1) the fire barrier, 2) surface slopes downhill along each side of the fire barrier, 3) the occurrence of a jointed sandstone unit near the surface, and 4) two-seam longwall mining.

Map 4 shows overburden above the Lower O'Connor B seam in the area to range from 800 to 1100 ft. Normally, tension cracks are thought to develop at lesser amounts of overburden. In this case cracks diminish with lesser amounts of overburden, indicating that factors other than overburden are at work in this case. It should also be noted with the two seams, 18 to 20 ft. of coal has been extracted on either side of the fire barrier.

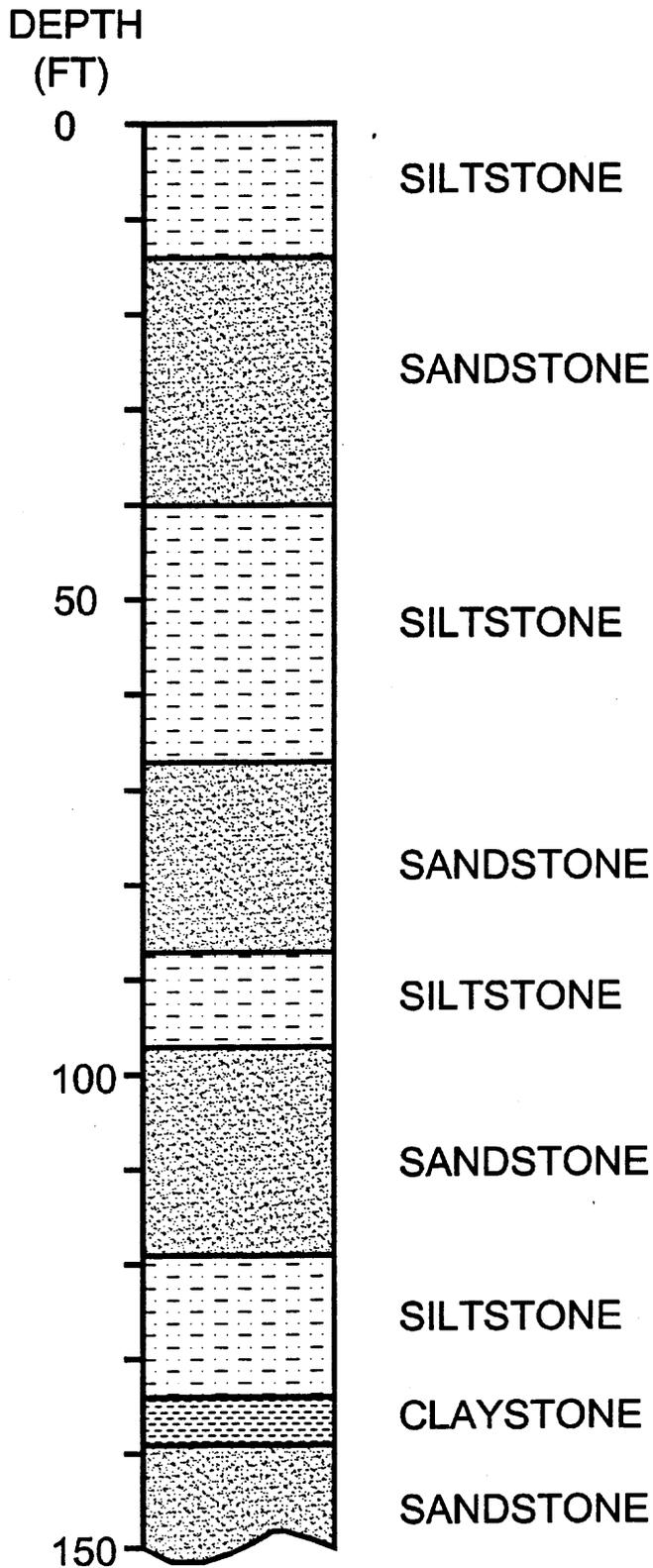
Map 2 shows detailed results of surface mapping. Crack development occurs primarily over the bleeder pillars indicating the location of the zone of maximum tension at the surface. No cracks were observed immediately above the center of the fire barrier.

#### MITIGATION

After site visits and consultation with US Forest Service personnel, a decision was reached to walk a track-hoe into the area to push in the crack walls and completely cover the cracks as quickly as possible to ensure the safety of hunters and any others that may pass through the area (hunting seasons were about to begin). After the cracks were filled, approximately 1000 ft. of silt fence was installed and the area was seeded. Shortly before track-hoe work was started, an archeological resource survey was conducted.

Because it was not possible to compact or consolidate the material pushed into the cracks, it is likely that some settling of material in the crack will occur, especially during spring runoff. Cracks will have to be closely observed during early summer to ensure no further surface cracks or settling has occurred. Depending on severity of potential settling, track-hoe work may be necessary.

# FIGURE 1



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**ARK LAND COMPANY**  
SKYLINE MINES, HC36 BOX 380, HELPER, UT. 84526

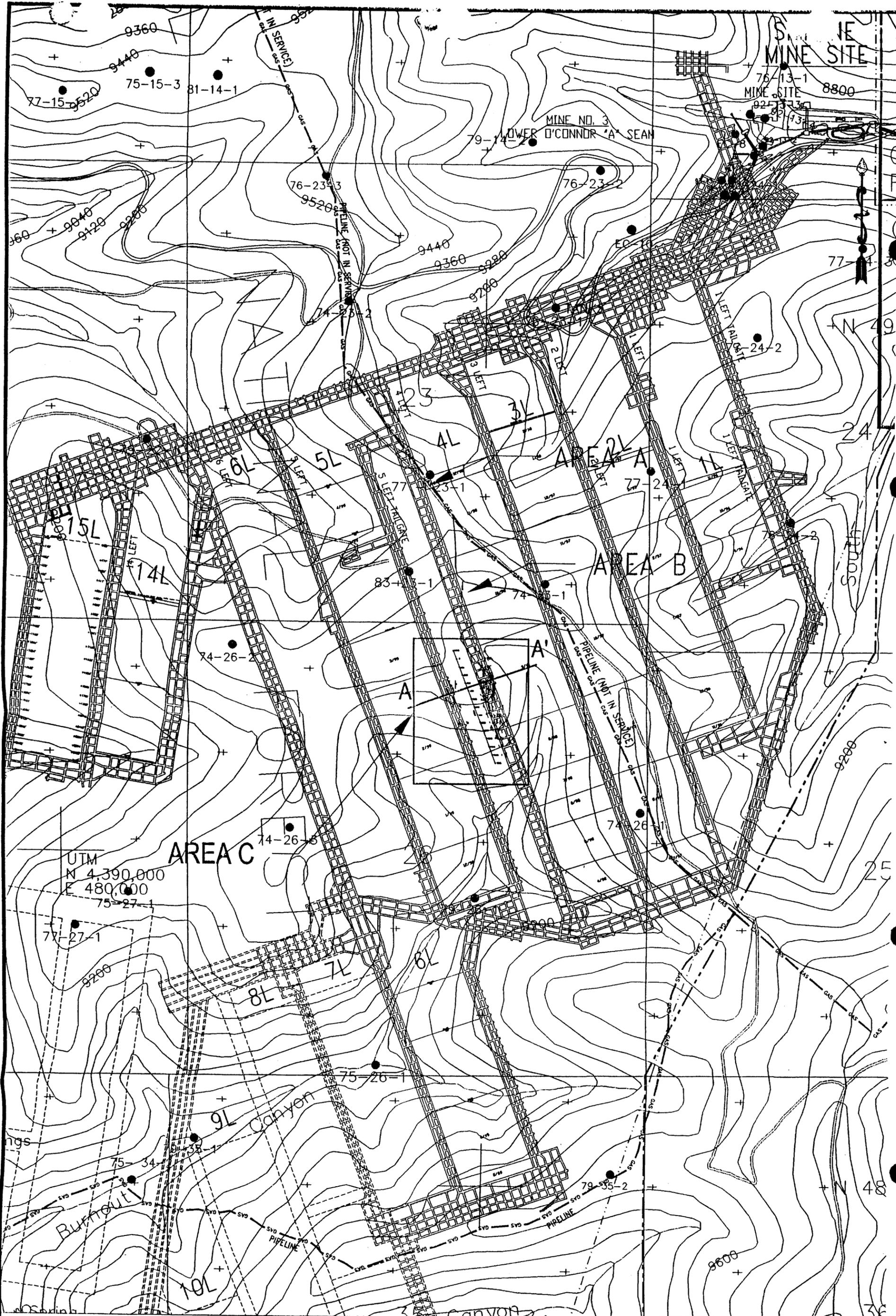
**FIGURE 1**  
**NEAR-SURFACE STRAT COLUMN**  
**TROUGH SPRINGS RIDGE**  
**SUBSIDENCE CRACK ZONE**

SCALE  
1"=50'

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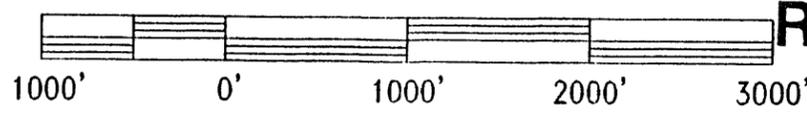
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MAP 1



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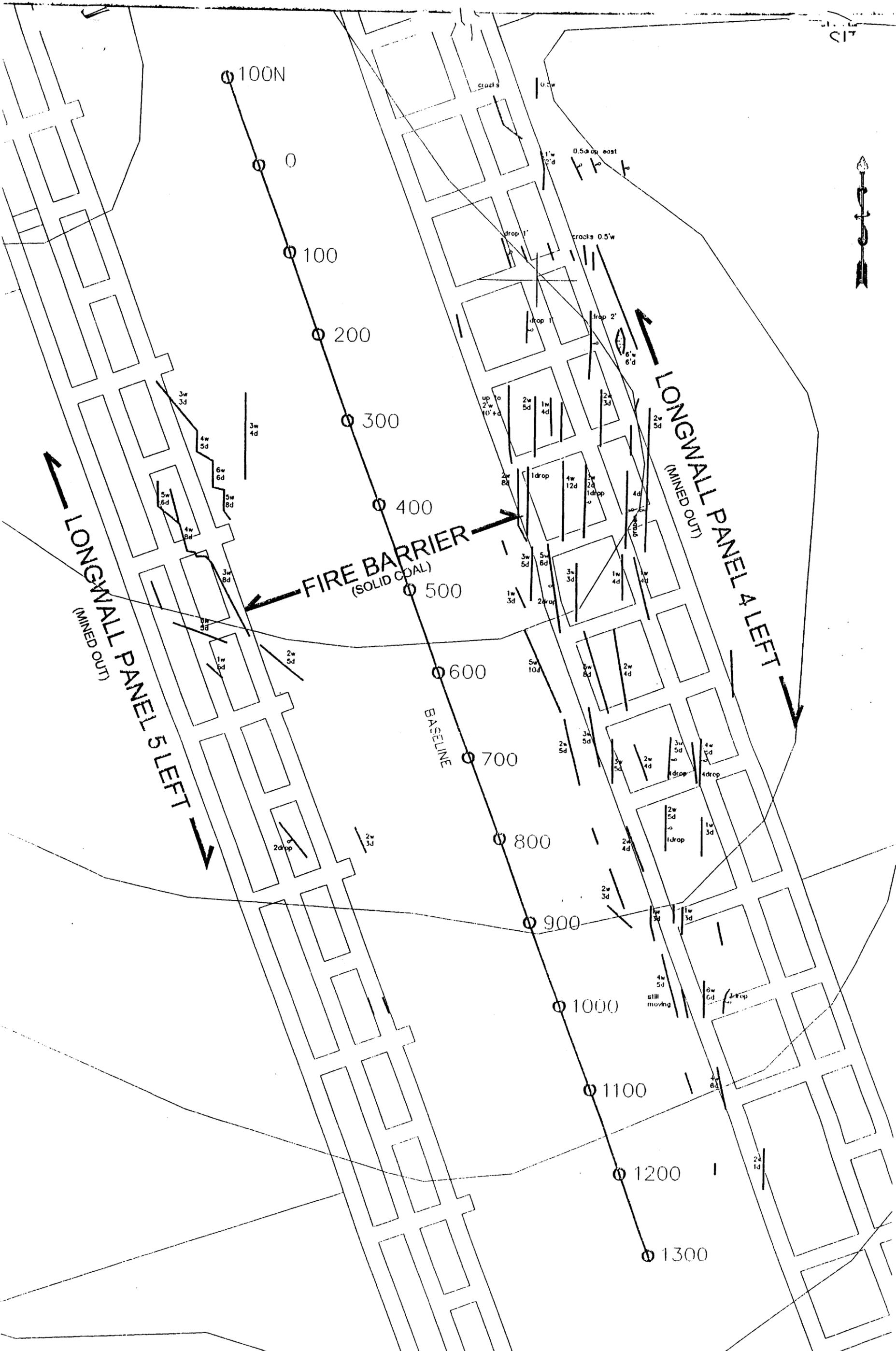
TROUGH SPRINGS RIDGE SUBSIDENCE CRACKS  
FIRE BARRIER ZONE  
SKYLINE MINE 3, LEVELS 1 & 2



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Skyline Mine

DATE: 9/30/99	CK BY: M. BUNNELL	REVIS
SCALE: 1"=1000'	DR BY: M. BUNNELL	

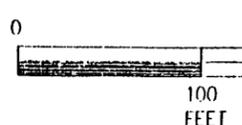
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**LEGEND:**

- Subsidence Crack
- 3w width (ft)
- 6d depth (ft)

MAP 2



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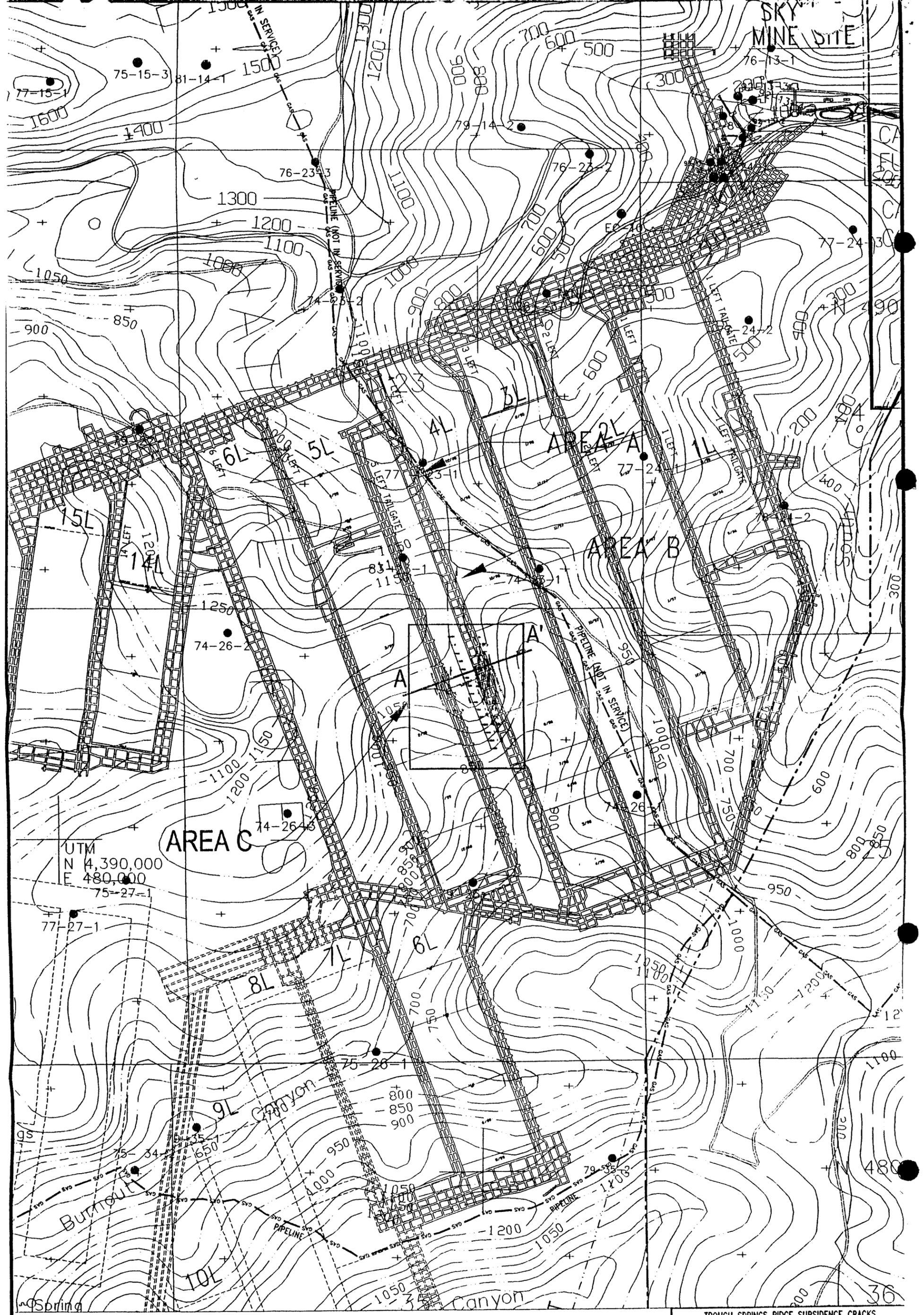
DETAIL OF TROUGH SPRINGS RIDGE SUBSIDENCE CRACKS  
AREA C (FIRE BARRIER ZONE)  
SKYLINE MINE 3, LEVELS 1&2



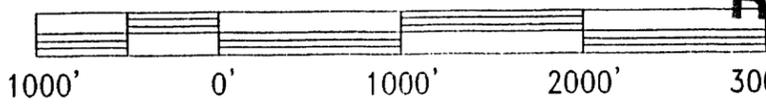
Canyon Fuel Company, II  
Skyline Mine

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MAP 4



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TROUGH SPRINGS RIDGE SUBSIDENCE CRACKS  
 AREA C (FIRE BARRIER ZONE)  
 OVERBURDEN CONTOURS



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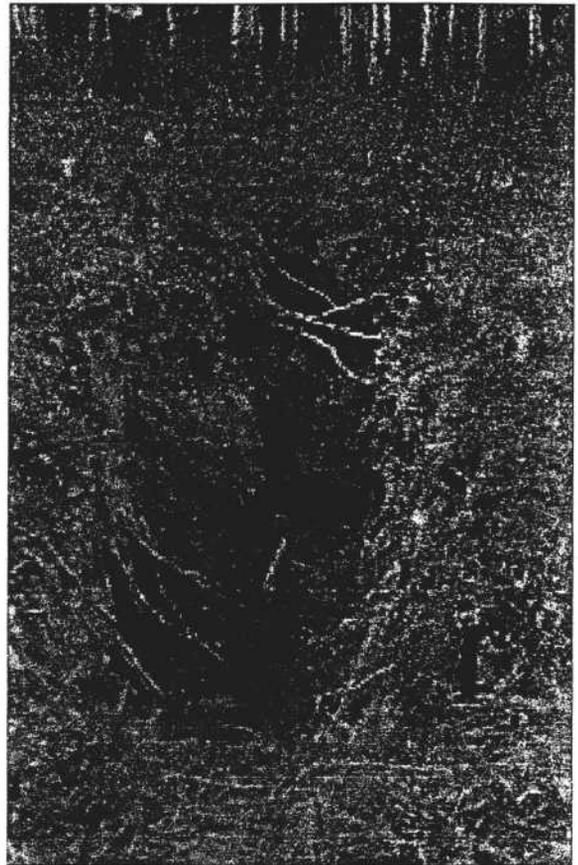
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DATE: 9/30/99	CK. BY: M. BUNNELL	REVISION
SCALE: 1"=1000'	DR. BY: M. BUNNELL	

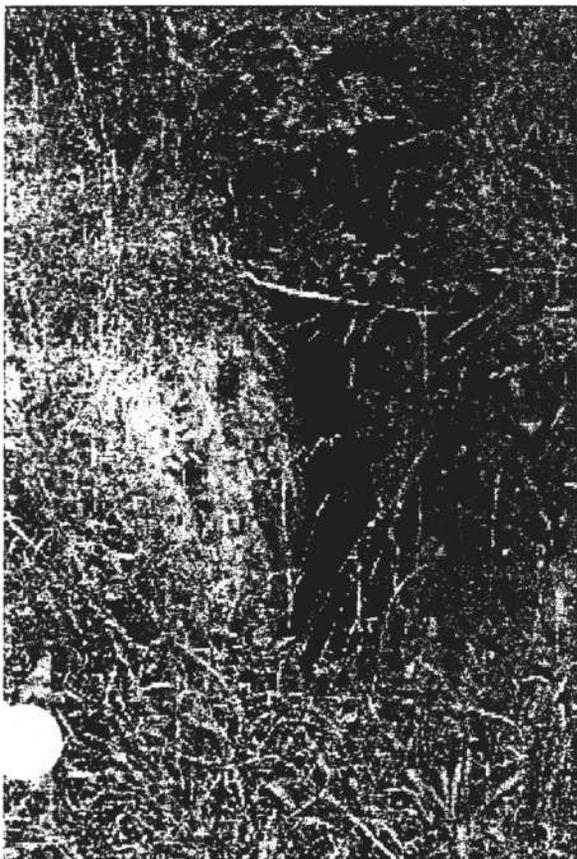
**APPENDIX**



Crack approx 3' wide, 6' deep. Area C.



Crack approx 4' wide, 4' deep. Area C.



Crack approx 1' wide, 6' deep. Area C.



Crack approx 2' wide, 5' deep. Area C.  
Note tendency for crack to follow jointing.



Crack approx 4' wide, 4' deep. Area C.



Crack approx 3' wide, 3' deep. Area C.



Crack approx 2' wide, 6' deep. Area C.



Deepest tension crack in area C. Bedrock is exposed approx. 4-5' beneath surface. Crack approximately 3' wide +25' deep



Crack with 1' vert. scarp. Approx 1' wide, 2' deep.  
Note aspen that has been uprooted.



A "graben"-type crack. Boundary cracks  
are approximately 7' apart.



"Graben"-type slump or crack with a  
4' scarp.



Larger "graben"-type feature with boundary  
scarps approximately 20' apart. Note aspens  
falling toward center.



Scarp on hillside (approx. 2') with uprooted aspen.



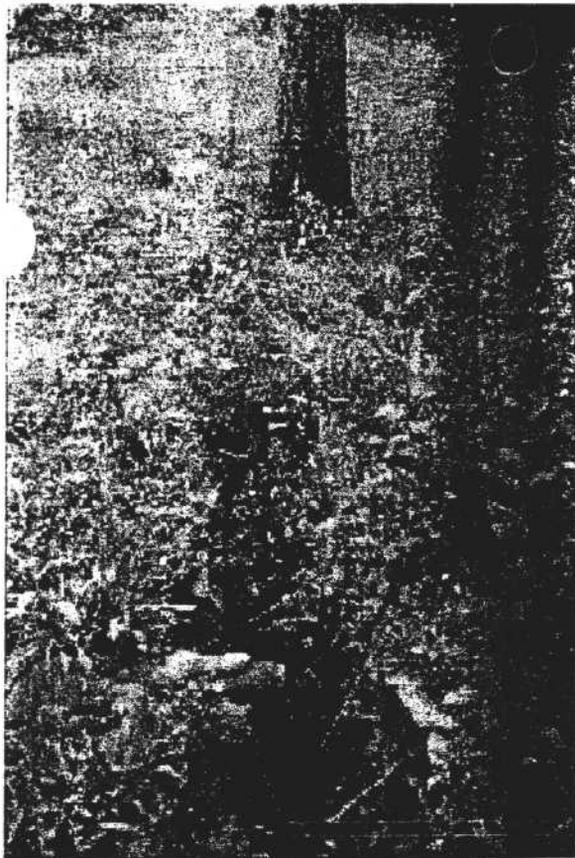
Crack approximately 4' wide, 6' deep.  
Note tendency to follow jointing.



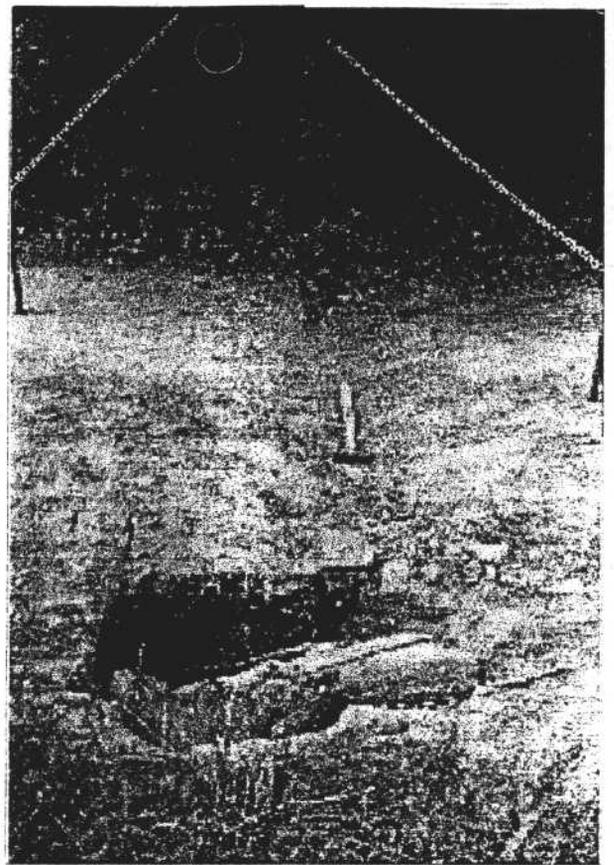
Crack in road approx. 2' wide, 1' deep. Area A.



Crack in road. Area A.



Crack approx  
1' wide, 6' deep.  
Note split in  
tree. Area B.



Crack in old road approx.  
2' wide, 6' deep. Area B.



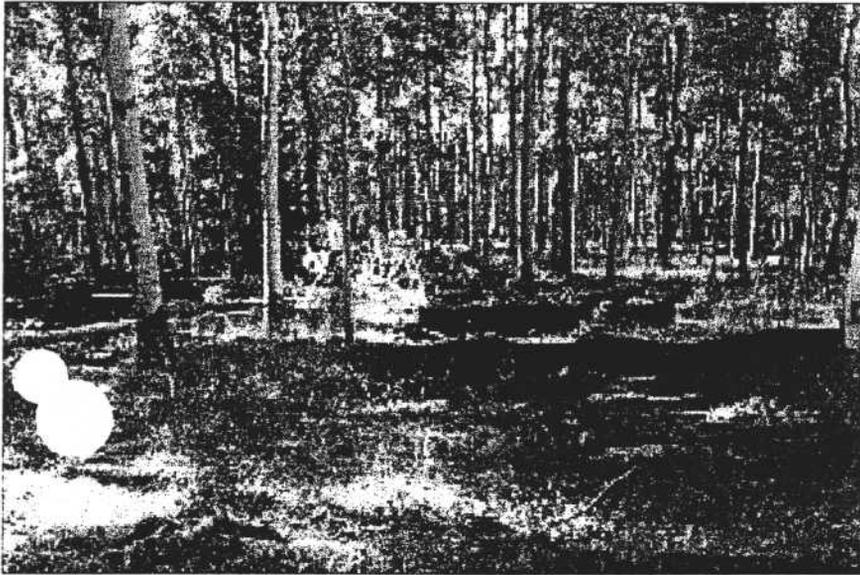
Reclamation of crack.



Reclamation of crack zone, Area C.  
Note use of silt fence.



Hillside reclaimed in Area C.



Reclaimed crack zone in Area C.  
Note use of silt fence.



Use of small track-hoe enabled reclamation  
with minimal surface impact.