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Abstract:

Rpt discusses areawide subsidence investig. conducted in Madisonville KY by U.S. Ofc of Surface Min. to determine mechanisms of abandoned underground mine subsid. and to access potential for future subsidence. Info and data from geotechnical investigations, subsidence damage surveys, borehole camera inspection of conditions in abandoned mines, and previous subsidence investigations are analyzed. Geologic data/damage survey reports/pillar strength calculations and abandoned mine gas info, and general discussion of available at abatement techniques are appended to this report.

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MADISONVILLE AREAWIDE SUBSIDENCE INVESTIGATION

OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT
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SEPTEMBER, 1986

PREFACE

This report concludes the first major areawide subsidence investigation undertaken by OSMRE. The overall purpose of the work was twofold; to reduce the response time from the reporting of a subsidence event to the initiation of abatement procedures and to improve abatement project cost-effectiveness through a more thorough initial analysis. Since initiating this first project in 1982, we have modified our approach to areawide investigations by emphasizing analysis of existing geotechnical reports before beginning exploratory drilling. The damage survey portion of the investigation methodology is a model for how these studies should be carried out and we are convinced similar surveys will pinpoint locations where subsidence is the greatest problem.

This document provides an excellent overview of the subsidence situation in the Madisonville area. Subsidence agencies, planners, engineers, public officials, and the citizens of Madisonville should inspect the available mine maps and if they are located in a subsidence-prone locality, take whatever steps are warranted, including the possible purchase of mine subsidence insurance available from the Kentucky State Risk and Insurance Services.

We thank the people and agencies for their assistance in the successful completion of this report. The Kentucky Natural Resources and Environmental Protection Cabinet, Division of Abandoned Lands, and the Kentucky Geological Survey have been supportive throughout the project. Excellent information was obtained from a number of Madisonville sources, particularly Donan Engineering and Robert Etue. The local officials in Madisonville were especially supportive particularly during the damage survey.

Jesse Craft, geologist, and George Kelley, former OSMRE geologist, designed the original project, performed the field investigations, and developed most of the technical information presented in the report. William Remy, engineering draftsman, did the final figure preparation and Thomas Crandall, geologist, and John Holbrook, supervisory physical scientist, were responsible for editing and final preparation of the document. The contribution of these staff members to the areawide investigation was invaluable.

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MADISONVILLE AREAWIDE SUBSIDENCE INVESTIGATION

ABSTRACT

An areawide subsidence investigation was conducted in Madisonville, Kentucky by U.S. Office of Surface Mining Reclamation and Enforcement to determine mechanisms of abandoned underground mine subsidence and to assess the potential for future subsidence. Information and data from geotechnical investigations, subsidence damage surveys, borehole camera inspection of conditions in abandoned mines, and previous subsidence investigations were analyzed.

The analyses indicate that pillar crushing, and in some locations, roof collapse, in the flooded mines of the Number 11 Coal underlying Madisonville are the dominant causes of subsidence. The high extraction ratio (up to 80 percent) and undersized pillars particularly in panel sections of the mine, leaves insufficient support for the overburden weight. Surface sag subsidence "troughs" develop as pillars progressively crush within worked-out mine panels. Larger pillars left in the Number 11 Coal mine entries, and in both entries and panels of some Number 9 Coal mines, apparently are competent enough to support the overburden at the present time although some subsidence of strata above the Number 9 mines has begun. Differential settlement at the surface is responsible for the extensive structural damage to buildings, and typically results where stronger entry, rib or barrier pillars provide support but are adjacent to collapsing panels. Soils problems may also be causing structural damage at some locations.

Crushing coal pillars are releasing large volumes of methane which migrate to the surface through rock fracture systems and through boreholes. Precautions during drilling and after uncapping of sealed boreholes are mandatory.

Geologic data, damage survey reports, pillar strength calculations and abandoned mine gas information, and a general discussion of available at abatement techniques are appended to the report. Other background information, geotechnical data, logs, maps and engineering reports are available in the Office of Surface Mining Reclamation and Enforcement, Eastern Technical Center, Pittsburgh, Pennsylvania.

INTRODUCTION

A subsidence investigation of the Madisonville, Kentucky area was conducted by U.S. Office of Surface Mining Reclamation and Enforcement (OSMRE) personnel at the request of the Kentucky Natural Resources and Environmental Protection Cabinet, Division of Abandoned Lands. The objectives of the investigation were to:

1. Collect and analyze information necessary to understand the conditions responsible for subsidence in the Madisonville, Kentucky area;

2. Summarize this information and make it available to appropriate agencies and the public to:

   a. reduce the response time between the occurrence of emergency subsidence events and the implementation of abatement procedures;

   b. facilitate public awareness and understanding of the existing problems; and,

3. Identify those locations within the Madisonville area where there is a potential for future mine-related subsidence.

This report consists of a main body of information and five appendices; Geology and Core Data (Appendix A), Subsidence Damage Survey (Appendix B), Pillar Strength Calculations (Appendix C), Abandoned Mine Gas (Appendix D), and Mine Subsidence Stabilization Techniques (Appendix E). In support of this report and its appendices, a library of related information including aerial photography, television survey logs and video tapes, surface maps, mine maps, and geologic structure maps, will be available to the public and to government agencies involved in subsidence control and abatement through OSMRE Eastern Technical Center, Pittsburgh, Pennsylvania.

Description of Study Area

During the past several decades, collapse of abandoned underground mines has caused numerous surface subsidence events in and around Madisonville, Kentucky (Figure 1). Many of these events caused extensive damage to surface structures. Based on the areal distribution of subsidence events, the boundaries of the Madisonville Areawide Subsidence Investigation were defined as that part of Madisonville lying south of the Louisville and Nashville Railroad; north of the Illinois Central Railroad; and extending from 2.5 miles east of the Pennyrile Parkway to the western city limits (Figure 2).

This boundary was defined to include:

1. Most of the homes in the Madisonville area which are located above known abandoned deep mines;

2. Many of the known mine subsidence events; and,

3. All OSMRE emergency mine subsidence projects.

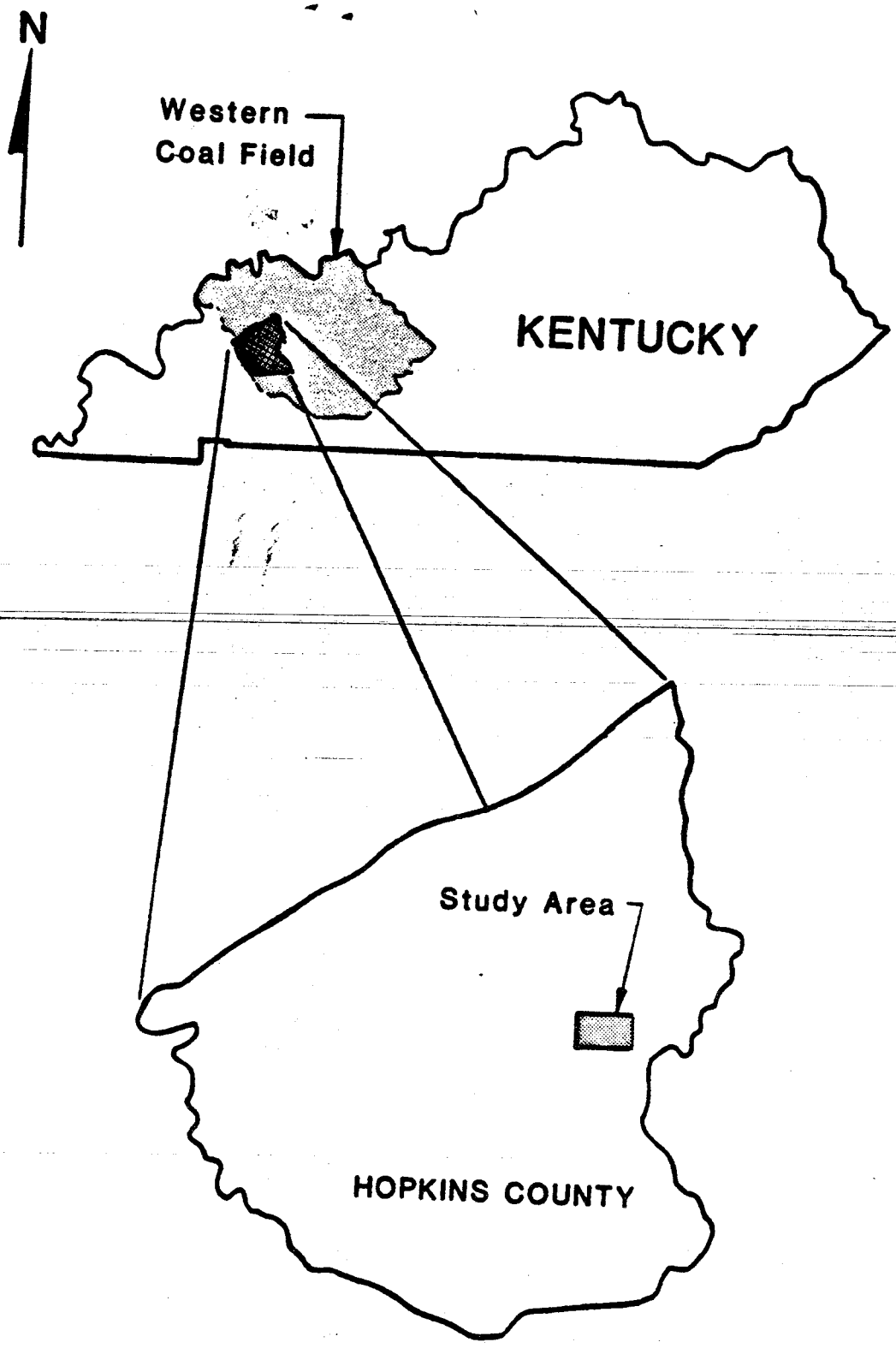

Figure 1. Location of study area, Madisonville, Kentucky.

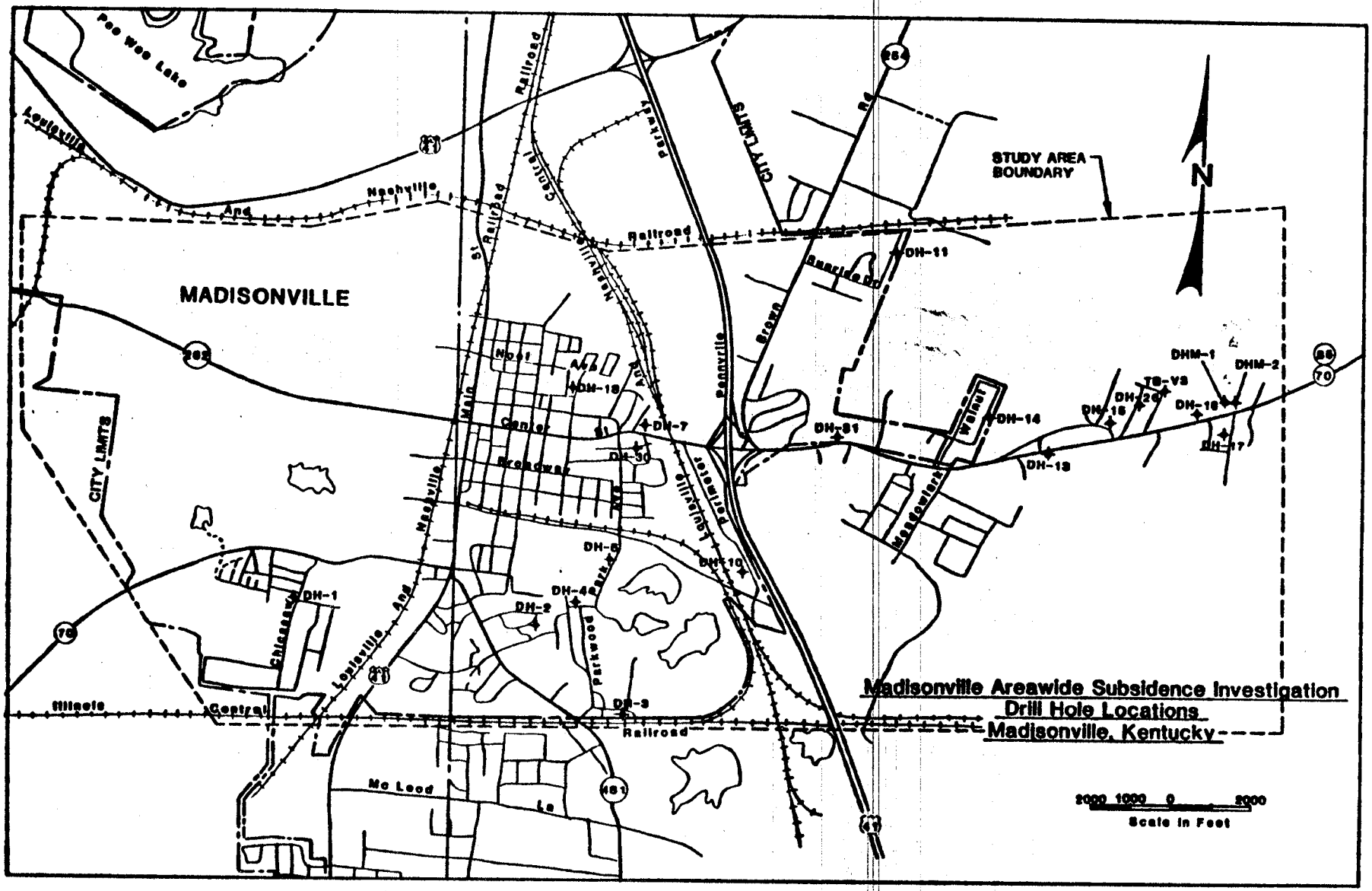

Figure 2. Study area boundary and drill hole locations, Madisonville, Kentucky.

Geology

The Madisonville area is underlain by consolidated sedimentary rocks of Middle to Late Pennsylvanian age, blanketed by a relatively thin layer of unconsolidated Quaternary alluvium (Figure 3). Only the the Sturgis Formation (Kehn, 1973) is exposed within the study area, except in the surface coal mines southeast and west of the city limits where excavations sometimes extend down to the base of the Number 11 Coal, the uppermost unit of the Middle Pennsylvanian age Carbondale Formation. The Sturgis Formation (Figure 4) is predominantly composed of siltstone and shale with interbedded limestone, sandstone, clay and coal (Kehn, 1973). The most prominent unit exposed in the study area is the Madisonville Limestone Member of the Sturgis Formation which underlies the central portion of Madisonville.

Rocks in the Madisonville area strike east-west and dip north (Figure 3). Madisonville is located on a large horst fault block located between the Reinecke Fault System just north of town (Figure 3) and the South Graham Fault located just south of the study area. These faults generally strike north-northeast and the fault planes are nearly vertical (Kehn, 1963).

A detailed description of the geology of the study area and cross sections which show the vertical and lateral distribution of the different stratigraphic units throughout the study area are included in Appendix A.

Soils

The engineering characteristics of the soils in the area are important because some sensitive soils interact with building foundations causing damage which resembles mine subsidence. Soils in the Madisonville area belong to the Loring-Grenada-Calloway association. This association consists of deep, moderately well drained to somewhat poorly drained, nearly level to sloping, medium-textured soils on uplands. Other soil types are interspersed within the Loring-Grenada-Calloway association in the Madisonville area. The U.S. Soil Conservation Service (Fehr and others, 1977) soil survey of Hopkins County, Kentucky contains detailed maps and descriptions of each soil type in the study area and their engineering properties.

Previous Investigations

Between 1981 and 1985, 18 subsidence events in the Madisonville area were investigated by OSMRE personnel (Table 1). Nine were designated mine-related, but not emergencies; two were determined to be not mine-related; and seven were determined to be emergencies. The reports of these investigation are on file at the OSMRE Eastern Technical Center, Pittsburgh, Pennsylvania.

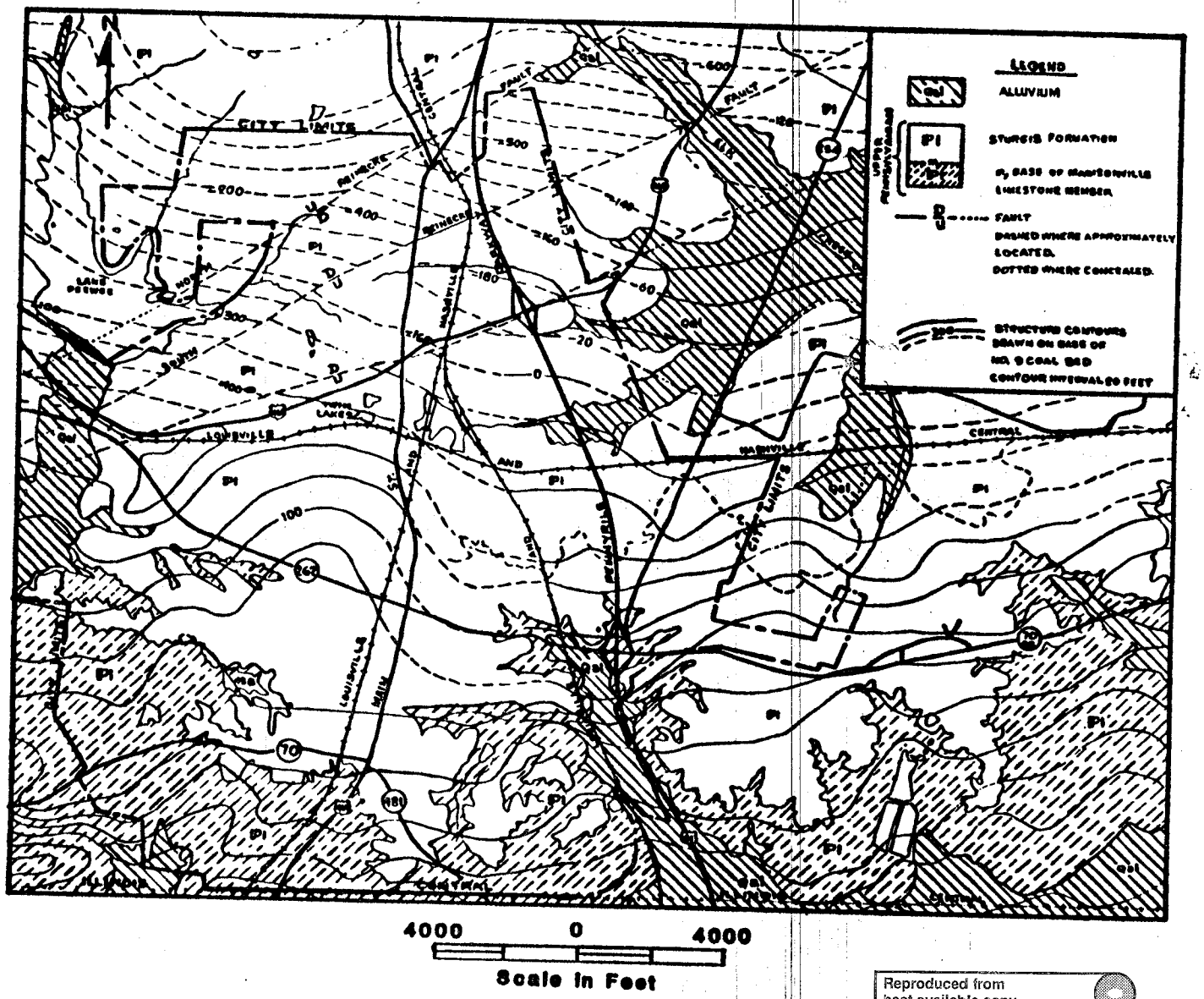

Figure 3. Geology and structure map of the Madisonville, Kentucky area. (From U.S.G.S. Map GQ-252, 1963 and GQ-346, 1964.)

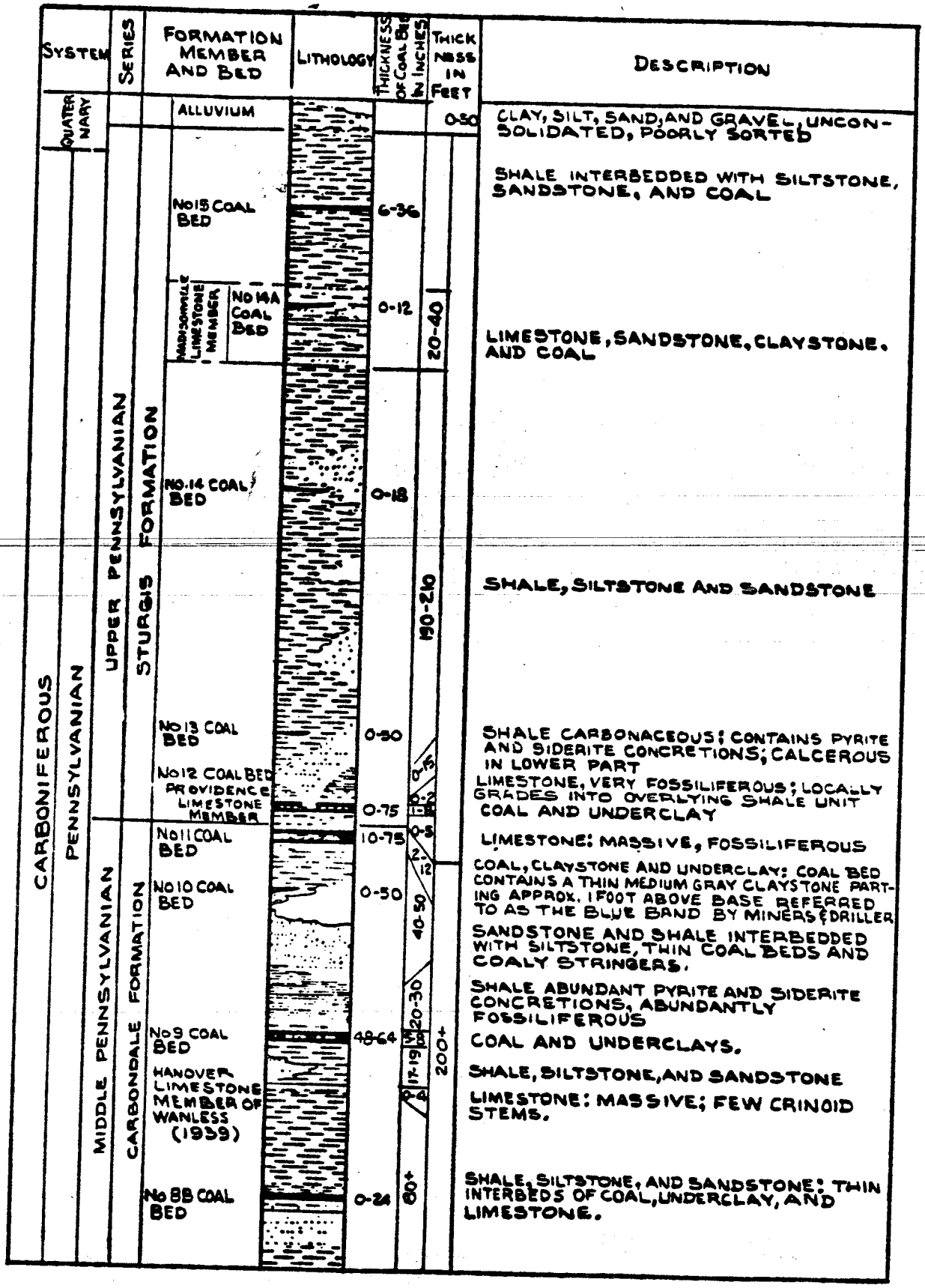

Figure 4. Generalized geologic section of the Madisonville, Kentucky area. (From U.S.G.S. GQ-252, 1963 and Kehn, 1973.)

Table 1. Subsidence Events Reported Between 1981 and 1985 in the Madisonville Area.

PROJECT NAME	SUBAREA	STATUS[1/]
Grapevine Baptist Church	1	NE
Redbud Subsidence	1	NE
Gordon Subsidence	2	E,d,p,c
Maddern Subsidence	2	E,d,p,c
Travis Gooden Subsidence	2	NM
Wells Subsidence	2	NE
Equitable Subsidence	3	E,d,p,c
Hardee's Subsidence	3	NE (associated with Wireman Subsidence)
Wireman Subsidence	4	E,d,p,c
Clark Subsidence	6	E,d,p,c
Cumberland Presbyterian Church	6	E,d,p,c
Shelley Moore Subsidence	6	E,d,p,c
Clinton Subsidence	NA[2/]	NE
Giardinella	NA	NE
Hardesty Subsidence	NA	NM
Menser Subsidence	NA	NE
Puckett Subsidence	NA	NE
Valentine Subsidence	NA	NE

1/ E = emergency project: d = exploratory investigation; p = planned remedial activity; and c = project completed.
NE = non emergency but mine-related
NM = not mine related
2/ NA = site outside designated area

INVESTIGATION METHODOLOGY

The basic approach used in the investigation consisted of collecting surface and subsurface subsidence information throughout the study area, conduct detailed field investigations in subareas where subsidence events had been clustered, and evaluate and publish the information obtained.

A variety of techniques, as shown below and discussed in the following pages, were used to gather detailed information.

1. Aerial photography.
2. A subsidence damage survey.
3. Collection and interpretation of all available mine maps for the study area.
4. Exploratory drilling.
5. Pillar strength analyses.
6. Camera inspection of boreholes.

Aerial Photography and Mapping

An aerial photographic overflight of the Madisonville Area was conducted during the spring of 1982. A planimetric base map was constructed from these photographs at a scale of 1 inch = 250 feet with a topographic contour interval of 2 feet (Maps 1A to 6A). All known subsidence events were plotted on the base maps. The aerial photographs were analyzed to locate previously unknown subsidence depressions in the area, and were also used to key the surface maps to the mine maps.

Damage Survey

Information about past subsidence events in the Area was obtained during the summer of 1982. A public request for citizen reports of possible mine subsidence events was released in the local paper on July 29. This press release explained the purpose of the study and requested that citizens with knowledge of subsidence events or with possible mine-subsidence damage to their homes call the local OSMRE Office. Callers were asked to provide the location of the event, name and phone number of a contact person, and a brief description of the occurrence or the damage observed. Many reports were received as a direct result of this press release and all were investigated by OSMRE personnel. Individual investigation reports are found in Appendix B.

In addition to reports from the Madisonville Area, reports were received from the adjoining communities of Earlington, Nortonville, and Anton, and from the farming area east of the study area. Reports of events from outside the defined study area have not been included in this report, but are on file in the OSMRE Eastern Technical Center and the Kentucky Division of Abandoned Lands, Frankfort, Kentucky.

Mine Maps

Maps were obtained for most of the mines which had operated in the Madisonville area. Sources of maps included mining companies, consulting engineering firms, individual landowners, the Kentucky Mine Map Repository at the University of Kentucky, and the collections of maps in the OSMRE Mine Map Repository, Pittsburgh, Pennsylvania.

The mine maps obtained were in many forms. They ranged from stable base mylar copies to faint copy-machine prints; from large maps of whole mines to small maps of the mined areas beneath one or two houses. Some maps were early drafts outlining the projected development of the mine, while others were copies of completed "as mined" maps. These maps are of variable degrees of accuracy due to uneven stretch in the original maps or copies and the photographic scale adjustment which was required to fit the mine maps to the surface topography.

Exploratory Drilling

Exploratory drilling was performed to collect detailed subsurface information:

1. Characteristics of the soil zone and other unconsolidated materials above the bedrock;

2. Nature and properties of the rock overburden; and,

3. Conditions in and adjacent to the abandoned mine workings.

The selection of borehole drilling sites in the study area was based on the following criteria:

1. The geographic distribution of subsidence damage;

2. The configuration of the mine workings; and,

3. The need for areawide sampling to adequately define the variety of soil, rock, and mine conditions.

Drilling in the Madisonville area was conducted during the summer of 1983. A total of 16 test borings were drilled; fifteen of which extended into the underclay below the Number 9 Coal. Continuous rock cores were obtained for all exploratory holes using NQ series diamond core-bits which drill a 3 inch hole and retrieve a 2-1/8 inch rock core. Drill holes were cased to bedrock and temporarily capped for later use. Soil samples were also retrieved for laboratory analyses. Water level was measured in all holes.

Each rock core was carefully examined in the field and then given to the Kentucky Geological Survey. Cores are available for examination in the Well Cutting and Core Library, Kentucky Geological Survey, Lexington, Kentucky.

In addition to the boreholes drilled as part of the areawide study, test borings from emergency investigations conducted in the Madisonville area have also been discussed in this report.

Pillar Strength Analyses

Pillar strengths were calculated to determine the compressive strength of the coal pillars left in place in order to assess their ability to support the strata above the mine. Calculations were based on the extraction ratio and dimensions of the smallest panel and entry pillar adjacent to each drill hole as shown on the mine maps. These calculations were analyzed along with other subsurface information to evaluate a pillar's susceptibility to failure. Details of the calculations are found in Appendix C.

Camera Inspection of Boreholes

A borehole TV camera was used to augment the information found during borehole drilling. Bedding plane separations, fractures in the rocks, and voids were identified and examined. The depths and movements of ground water into the boreholes were recorded. The condition of the mine roof, pillars, and floor was determined wherever observation was possible.

HISTORY OF MINING

Underground coal mining in the Madisonville area began about 1870 with the opening of the Reinecke Mine in the Number 11 Coal. Since then, at least ten mines have operated within the area. These mines were in operation for varying periods of time between the mid-1920's and the late 1960's. Underground mining beneath Madisonville was stopped in 1971 when the city passed an ordinance forbidding underground mining of coal within its boundaries. Surface mining was started around 1950 and has become the dominant mining method in the area today.

Coal production has come chiefly from the Number 9 and Number 11 Coals, although the Number 12 Coal is often mined along with the Number 11 during strip mining operations. The Number 11 underground minable reserves are depleted in the area although strip mining of the Number 11 coal continues just outside the area. There are minable reserves of the Number 9 Coal remaining in the area.

The Number 11 Coal lies approximately 200 feet below the surface in the Madisonville area, and is an average of 6 feet thick. The Number 9 Coal is 80-100 feet deeper than the Number 11 Coal and averages 5 feet thick. Both seams are deepest in the northern part of the area.

Mine Locations

Figures 5 and 6 show the locations of mines beneath the study area in the Number 11 and Number 9 coal seams, respectively. Unshaded sections indicate where mine maps are not available although mining is known to have occurred in at least some of these areas. The specific mines which underlie the area and the maps which show these mines are listed below:

Mines in the Number 11 Coal	Mines in the Number 9 Coal
Coil (Maps 2B, 4B & 5B)	Atkinson (Map 2C)
East Diamond (Maps 2B, 5B & 6B)	East Diamond (Maps 2C, 4C, 5C & 6C)
North Diamond #2 (Map 1B)	Grapevine (No detailed maps available)
Pleasant View (Map 1B)	North Diamond #1 (Map 1C)
Reinecke (Maps 1B & 3B)	Pleasant View (Map 1C)
Sunset (Map 2B)	Sunset (Map 2C)
Trio (Maps 5B & 6B)	Victoria (Maps 1C & 2C)
Victoria (Maps 1B & 2B)	

Older workings tend to be located west and south of Madisonville. However, as the city grew and underground mining continued, most of Madisonville now came to overlie abandoned mine workings. Most of the outlying areas proposed for future annexation will also be underlain by abandoned coal mine workings.

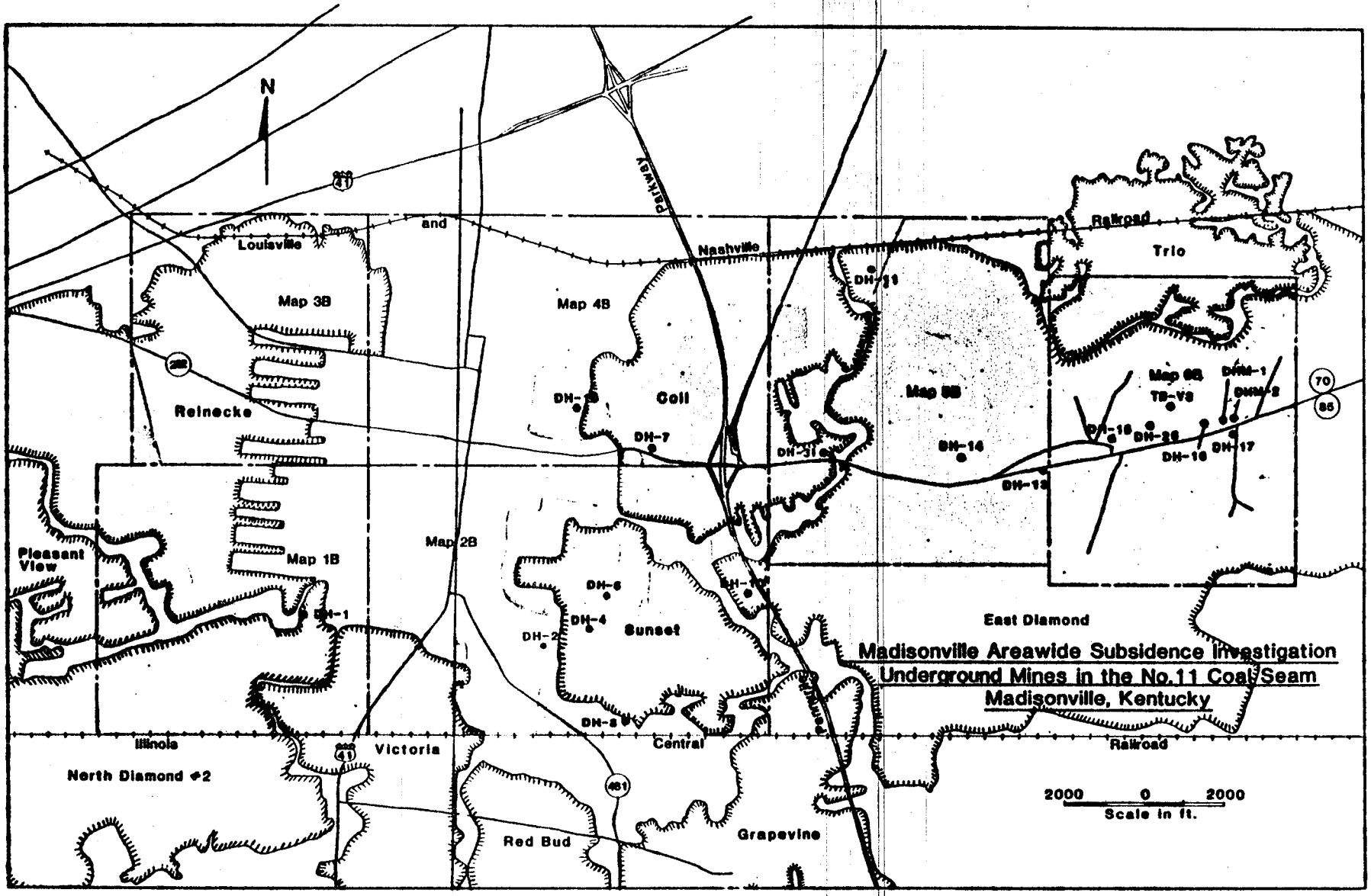

Figure 5. Location of underground mines in the Number 11 Coal within the study area. Shaded area identifies mine maps included in this report. "DH" is location of exploratory drill holes.

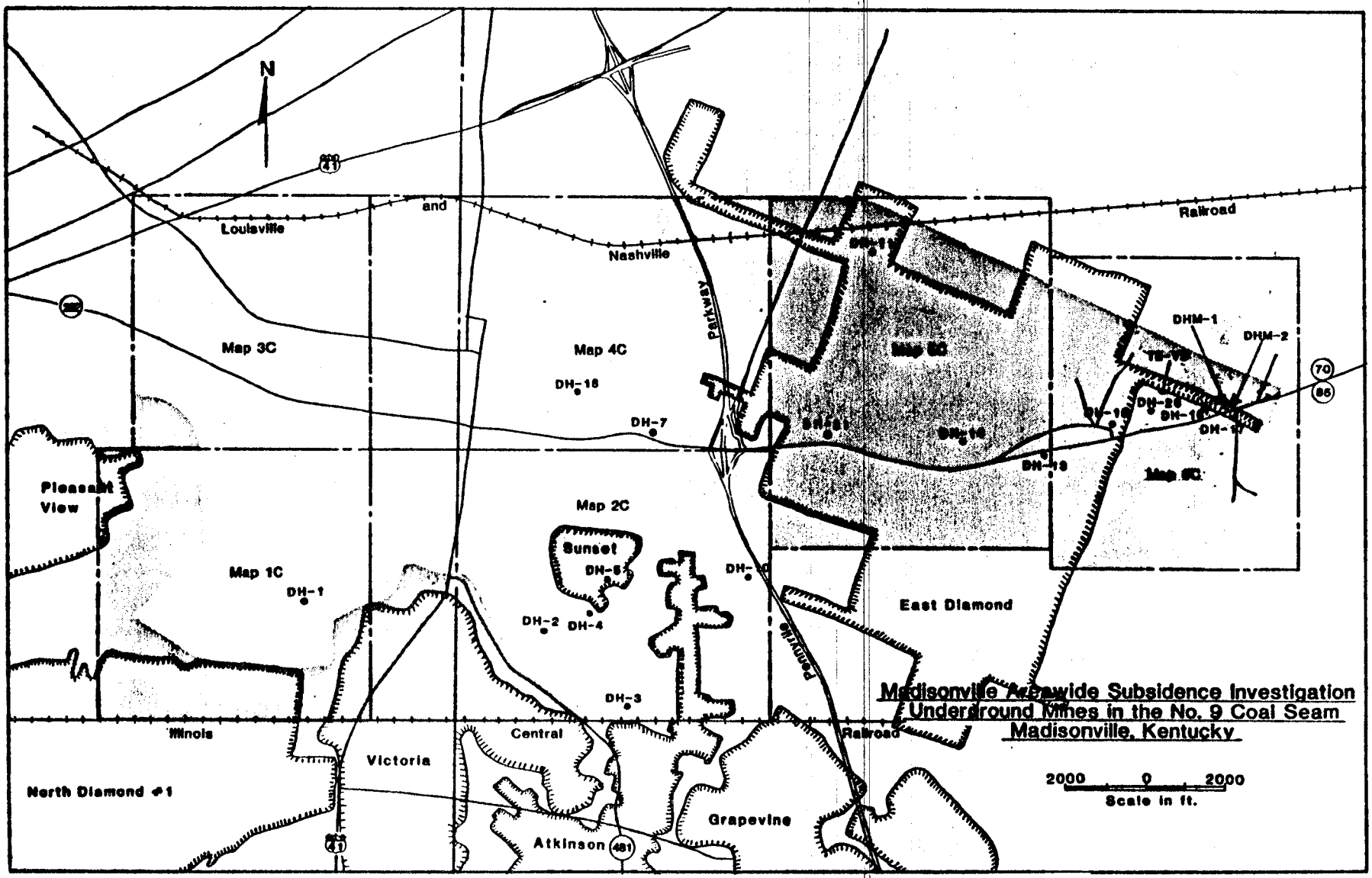

Figure 6. Location of underground mines in the Number 9 Coal within the study area. Shaded area identifies mine maps included in this report. "DH" is location of exploratory drill holes.

Mine Design

Mine workings in both the Number 11 and Number 9 Coal seams were generally developed from a single shaft and both seams were often mined at the same time. Mines were generally developed with main entries oriented in a north-south to northwest-southeast direction, with secondary mains running at right angles to the mains. Panels, typically 400 feet by 800 feet, were developed off these secondary mains. Within the panels, "rooms" 25-30 feet wide were typically extended about 400 feet in the common "room-and-pillar" design. Pillars 15-20 feet wide by 50-60 feet long were left between rooms for roof support. Boyd (1978) calculated that in the Sharpe Addition area of Madisonville, extraction reached 83 percent in some Number 11 panels, and up to 68 percent in some Number 9 panels.

Irregular mine map patterns indicate that extensions of rooms often terminated abruptly, perhaps because the roof stratum was weak or because mine workings entered one of the fault zones in the area. These roof conditions often required mining operators to offset their entry and panel development by 45 degrees. Panel dimensions and the size and shape of rooms and pillars are more irregular in the older mines.

Pillar pulling during retreat from the panel was not a common practice in the Western Coal Field of Kentucky. However, pillar shaving is indicated by the variability in size of many pillars, mine map notations and the recollections of local miners. Larger barrier pillars were often left between panels and almost always at mine property lines. Coal reserves were left under some buildings and the railroad right-of-ways. The variations in sizes of panel pillars, barrier pillars, and unmined reserves indicate different amounts of coal were left to support the overburden strata. The differences in sizes also affect the timing and nature of subsequent subsidence.

SUBSIDENCE EVALUATION

Six subareas having common conditions were selected for a detailed study in the Madisonville area (Figure 7). The boundaries of these subareas were defined based on the following factors:

1. Distribution (i.e., clustering) and/or the apparent relationship of subsidence events;

2. Land surface configuration;

3. Soil properties and characteristics; and,

4. Configuration (including boundaries) of the underlying mines.

The boundaries of the subareas are arbitrary. Conditions may be similar beyond the boundaries shown, but the available data are too sparse to make valid boundary extensions at this time. Many sections of the Madisonville area have not experienced subsidence and, hence, were not included in the subareas as currently defined.

Parts of the study area are hilly and apparent subsidence events in these terrains require careful consideration because soil and slope problems can cause surface damage which resembles mine-caused subsidence.

Subarea 1

Subarea 1 is located in the southwestern part of Madisonville (Figure 7) and includes the subsidence affected residences on Chicasaw Drive and the immediate surrounding area (Figure 8).

Subsidence events

One subsidence incident, at 813 Chicasaw Drive, was reported during the damage survey. An examination of the damage to the interior of the house revealed plaster cracks and sticking doors. External damage included "Z"-shaped breaks open about 0.5 inch at the southwest corner. One wall bulged slightly and had a horizontal break. The house had been jacked up in the center along the east-west axis.

The field investigation also found fractures in foundations and brick facings in four nearby houses:

1. The northeast corner of the house to the north of 813 Chicasaw Drive was broken;

2. The southeast corner of the house diagonally to the northwest from 813 Chicasaw Drive had dropped;

3. The house to the south of 813 Chicasaw Drive has had both the northwest and southwest corners repaired, but new cracks indicated the property was still moving; and,

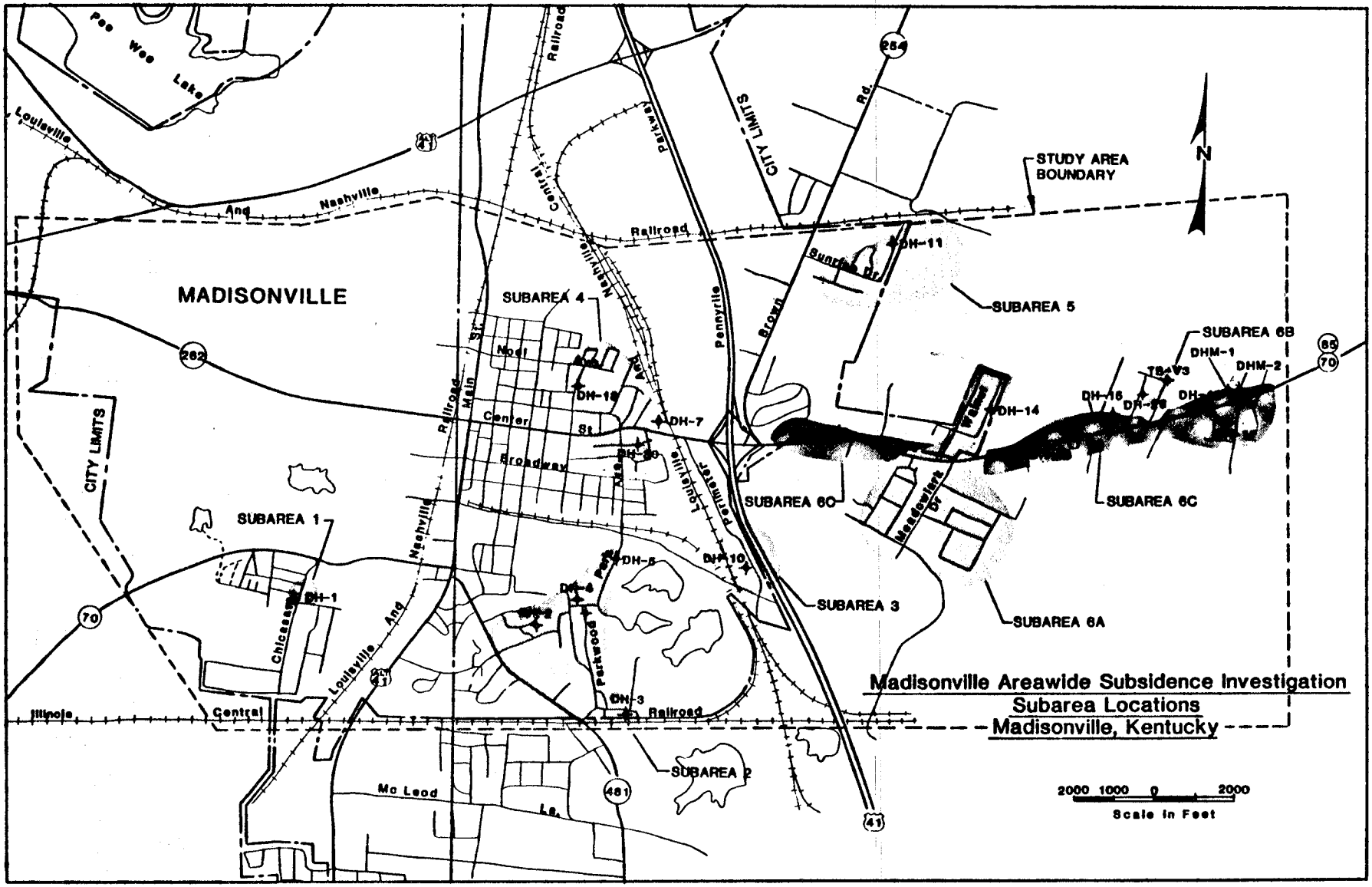

Figure 7. Location map of Subareas discussed in text, Madisonville, Kentucky.

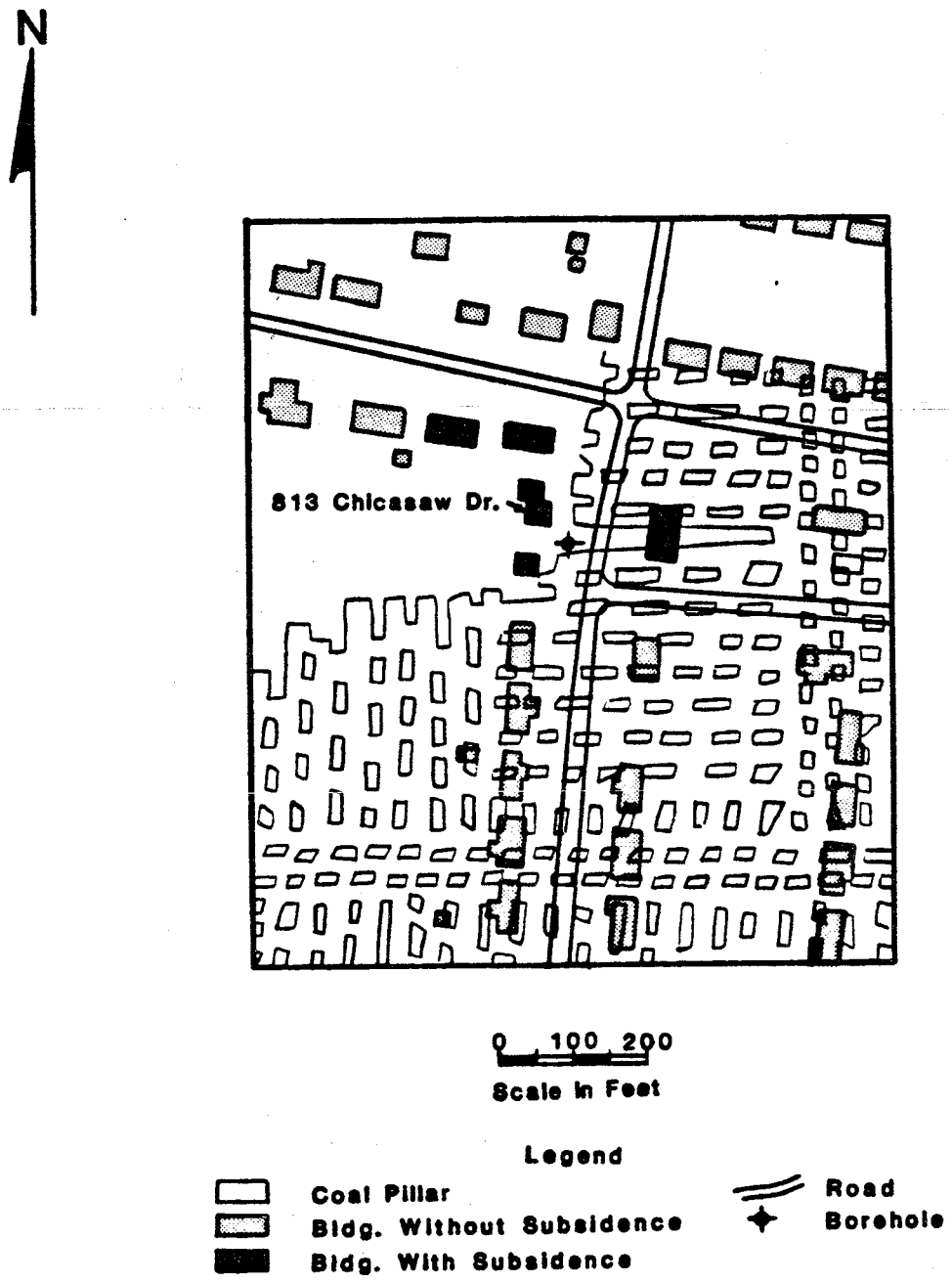

Figure 8. Mine map of Number 11 Coal with cultural features and location of drill hole (DH-1). For more detailed information see Number 11 Coal Map 1B and Topographic Map 1A. There are no Number 9 Coal mine maps for this site (Map 1C).

4. The east wall of the house to the east of 813 Chicasaw Drive and across the street, has had several cracks repaired.

Based upon the clustering of damaged dwellings, a borehole identified as drill hole 1 (DH-1, Figure 8), was drilled adjacent to the dwellings to investigate the subsurface conditions.

Findings

The North Diamond #2 Mine in the Number 11 Coal (Figure 5) underlies Subarea 1 at a depth of about 200 feet. Analyses of the core obtained from DH-1 (Table 2) indicated caved and broken material at 197-207 feet, which is the stratigraphic position of the Number 11 Coal. Alignment of the surface topography map with the North Diamond #2 in the Number 11 Coal mine map (Figure 8), indicated that DH-1 should have penetrated a barrier pillar in the Number 11 Coal; however, it penetrated a void instead. This probably indicates the available maps are not the final "as mined" drawings of the mine development or that the overlay of the surface map on the mine map was not exact.

Drill hole 1 penetrated 6 feet of in-place coal at the level of the Number 9 Coal and found only a few fractures in the strata between the Number 9 and 11 Coals (Table 2). Available maps of mines in the Number 9 Coal (Map 1C) do not show the coal near DH-1 to have been mined.

Horizontal and vertical fractures in the core samples of the rock strata above the Number 11 Coal (Table 2) indicate mine roof and overburden collapse. The television camera survey of this hole found small voids and vertical and horizontal fractures in the rocks down to a depth of 85 feet, indicating overburden failure. Water entering the borehole prevented a clear view of the rock below 50 feet and all visibility of the borehole wall ended at 85 feet due to turbulence in the water caused by gas bubbles entering at the 90 foot level. Methane has been identified in other test holes and is the most probable source of the gas bubbles observed during the television camera survey. Jets of water were observed at depths of 38, 43.5, and 73 feet, identifying zones of fracture porosity which may have been created by mine-related subsidence. The precise depth of the water surface in DH-1 could not be measured because of the water turbulence.

The mine map of the North Diamond #2 Mine (Map 1B) shows the rooms to be at least 30 feet wide and separated by pillars ranging from 16 to 18 feet across their narrowest face. The entry pillars are approximately 15 feet wide across each face. Using these dimensions the calculated extraction ratio is approximately 85 percent in the panel and 80 percent in the entries. Analysis of the strength of a small pillar in the panel (Table 3) indicates the compressive strength of pillars to be 1008 psi but the overburden weight to be 1172 psi. The strength of the small pillars, therefore, is inadequate to sustain the weight of the overlying rock strata (for further information on pillar strength calculations see Appendix C). Strength analysis for the smallest entry pillar indicates a compressive strength of 915 psi with an overburden loading of 949 psi. This indicates entry pillars should also crush. Both calculations were performed without consideration of other factors which could reduce pillar strength such as pore water pressure and continued pillar deterioration.

Table 2. Summary of Data from Core Holes Drilled During Madisonville Areawide Subsidence Investigation

SUBAREA #	CORE HOLE #	DEPTH TO WATER	DEPTH TO #11 COAL	CONDITIONS AT #11 COAL	CONDITIONS OF STRATA ABOVE #11 COAL SEAM	DEPTH TO #9 COAL	CONDITIONS AT #9 COAL SEAM	CONDITIONS OF STRATA BETWEEN #9 & #11 COAL
1	DH-1	85.5'	200'	1' void & 9' roof caved void fill	Some horiz. & vert. fractures. Numerous water jets.	298'	6' coal in place	Few fractures
2	DH-2	74.5'	223'	6.5' void with gob	Few fractures	309'	6.5' coal in place	Few fractures
2	DH-3	61-63'	192'	5' void w/ 2.5' gob	Few angle & horiz. fractures	269'	6' coal in place	Few fractures
2	DH-4	86.4'	228'	6.5' open void	Few horiz. fractures	320'	6.5' coal in place	Few fractures
2	DH-5	55.2'	231'	6.5' coal in place	Few angle & horiz. fractures	307'	6.5' gob	Horizontal & angle fractures
3	DH-10	80-150' gas surge	151'	16' collapsed zone	Horiz. & angle frac. & broken zones	237'	5.5' coal in place	Few fractures
4	DH-7	177'	227'	8.5' collapse roof & gob	Vertical, horiz. & angle frac.	322'	4.5' roof collapse	Some horiz. & angle fractures
4	DH-18	210'	254'	7.5' open void	Some horiz. & angle fractures	346'	6' coal in place	Few fractures
5	DH-11	105-120' gas surge	283'	1.5' open void	Vertical, horiz. & angle frac. many broken zones	372'	5.5' coal in place	Angle & horizontal fractures
6	DH-13	240' gassy	269'	4' roof collapse & gob	Vertical, angle & horizontal fractures	341'	5.5' void with fill	Fractures & broken zones
6	DH-14	228-237'	267'	1' coal - void closed	Broken & fractured	350'	6.5' coal in place	Few fractures
6	DH-15	149'	269'	4.5' broken coal	Few breaks	342'	13' voids & broken zones	Badly broken roof
6	DH-16	154'	224'	6.5' coal in place	Few fractures	317'	5' coal in place	Few fractures
6	DH-17	62'	204'	4.5' gob fill	Horiz. & angle frac.	283'	5' coal in place	Few fractures
6	DH-26	------	253'	7.5' coal in place	Horiz. & angle frac. w/broken zones	---	----------	----------
6	DH-31	------	262'	5' coal in place	Fractures throughout	349'	5' coal in place	Frac. 10' above roof

Table 3. Summary of Subarea 1 Pillar Strength Analyses

[See Appendix C for more detail.]

HOLE NUMBER	COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
DH-1	11	PANEL	85	16	6.5	1008	200	172
DH-1	11	ENTRY	80	13	6.5	915	200	193

Discussion

Based on the damage cluster, the mine map, fractures in the overburden and the pillar strength calculations, it appears the damage in this subarea is due to a trough subsidence. If the mine map portion of Figure 8 is reasonably accurate, the damage pattern in this subarea represents an "edge" effect of trough subsidence above an extensively mined panel which occurs near an unmined coal rib. The coal rib underlying the west of Chicasaw Drive (Figure 8) would not collapse. However, if the pillars in the mined panel section to the south or the east are undergoing collapse, the rock strata would tilt and break across the edge of the rib, which is acting as a fulcrum. Houses most susceptible to damage from this "edge" effect would be those situated in the zone above the rib where the rock fractures which are developing in the overburden reach the surface. Houses farther to the east and south, in the central area of the panel and away from the edge of the rib, may also subside but would experience less structural damage because there is not the differential settlement typically found along the "edge".

There is no evidence of a trough subsidence. However, the houses in this section of Madisonville are relatively new and if the ground was graded when the houses were constructed, any surface evidence of prior subsidence would have been destroyed. If roof collapse had occurred, extensive subsurface rock fracturing should be evident in DH-1. However, the fractures observed in DH-1 are concentrated mainly in the lower part of the overburden above the Number 11 Coal, indicating that all of the overburden above the mine has not broken. This finding is also consistent with pillar crushing and a trough subsidence.

Soil related structural problems cannot be ruled out in this subarea. The Loring and Zanesville soils of the subarea are somewhat water sensitive and may permit soil-foundation deformation. However, soil movement is not considered a cause of the structural damage observed since the nature and orientation of the cracks in the five buildings are not consistent with movement of the houses downslope to the southeast.

Conclusions

Pillar crushing in the North Diamond #2 Mine in the Number 11 Coal is considered to be the cause for the subsidence damage in the subarea. Because of the presence of other inadequate sized pillars beneath the subarea, additional damage to structures, roads and land surfaces can be expected as other small pillars collapse.

Subarea 2

Subarea 2 (Figure 7) is an area about 1/2 square mile southeast of the Madisonville business district. It includes Park Avenue, Parkwood Drive, Reed Avenue, and the Montrose Subdivision. Park Avenue and Parkwood Drive parallel the crest of a north-south trending ridge.

Two common factors prevail in this subarea:

1. The terrain is dominated by hillslopes that are steeper than in other parts of the study area; and

2. many buildings have been damaged by episodes of surface subsidence spanning a few years to over twenty years.

The Sunset and Atkinson Mines underlie this subarea. The Sunset Mine in the Number 11 Coal (Map 2B) ranges from 192-231 feet in depth. The Sunset and Atkinson Mines in the Number 9 Coal (Map 2C) underlie only part of the subarea and are at a depth of about 308 feet.

Subsidence events

Numerous damage reports were received during the field survey (Appendix B). During the investigation of these reports, additional houses were identified that either experienced problems in the past or have had recent damage. Interviews with homeowners indicated that some building deformation has continued for several years.

Several houses in the Montrose Subdivision in the northwestern part of the subarea were damaged. The house adjacent to drill hole 2 (DH-2) (Figure 9) had experienced gradual subsidence for more than 25 years. The 1982 subsidence damage report from 601 Montrose Drive also revealed another persistent history of subsidence and damage exceeding 25 years. In both instances, the subsidence began approximately 10 years after the Sunset Mines were abandoned.

Houses along Parkwood Drive in the eastern part of the subarea subsided several years ago. The damage was sudden and severe enough to permit homeowners to claim casualty losses on their income taxes. Most of these houses have since been repaired at the expense of the homeowners. During the 1982 survey, apparently new cracks were observed in the foundation, brick facing, and interior surfaces at 541 Park Avenue, indicating that some movement process was affecting the structure.

One subsidence report was received from Reed Avenue near the southern part of the subarea. The damage survey was extended to the streets nearby and several additional damaged houses were observed or were reported by residents.

During the spring of 1984, continued surface subsidence and resultant damage to the residences at 601 Montrose Drive and along Park Avenue resulted in OSMRE subsidence emergency investigations. After completion of additional drilling and soil and rock core sampling (Etue and others, 1984; Etue and others, 1985) two emergencies (Gordon Subsidence and Maddern Subsidence, Table 1) were declared.

Findings

Four core holes were drilled in Subarea 2 during this investigation. The

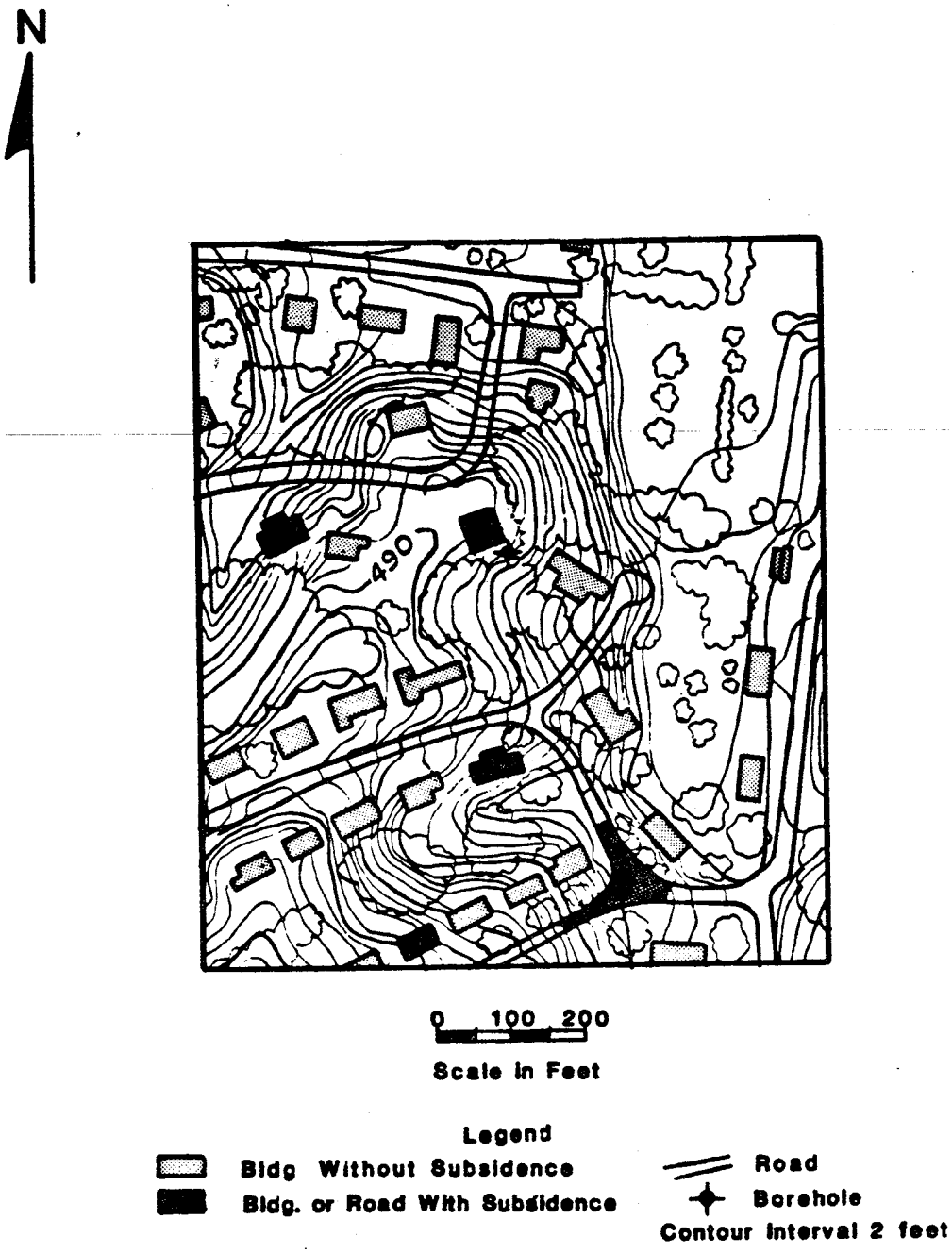

Figure 9. Topographic map with cultural features and location of drill hole (DH-2). No mine maps are available for this site even-though maps of nearby mining indicate mining has taken place. For more detailed information see Number 11 Coal Map 2B, Number 9 Coal Map 2C and Topographic Map 2A.

core from drill hole 2 (DH-2), located south of Hillcrest Drive in the Montrose Subdivision (Figure 9), contained a 2 foot open void 17 feet below the surface (Table 2). The void was in limestone and was 5 feet below the bedrock-regolith interface. An additional 6.5 feet of void, partially filled with gob, was encountered at 223 feet at the level of the Number 11 Coal seam (Table 2). A few fractures were also observed in the overburden above the mine level but the lack of roof material indicates roof fall has not occurred. A 6.5 foot thickness of coal was in place in the Number 9 Coal seam at a depth of 309 feet and the strata between the Number 9 and 11 Coals showed little evidence of fracturing (Table 2). Water was observed in DH-2 at approximately 75 feet below the surface. Escaping gas from an unknown depth and strata caused minor fluctuations of the water level in the drill hole.

Although the available mine maps do not extend to the DH-2 site, the void encountered in the Number 11 Coal indicates that the Sunset Mine extended at least this far. Based on the pattern for the Sunset Mine east entries (Map 2B), and an assumed comparable pattern for the west entries, a mining panel would probably extend beneath the location of DH-2. Assuming the same size pillars and a comparable extraction ratio of 80 percent, the pillars in this panel should crush. In the cross entries of the east entries, however, pillars are larger and the extraction ratio is lower and calculations indicate that these should not crush at the mine depth of 223 feet (Table 4). Therefore entry pillars beneath DH-2 should not crush, assuming comparable size and extraction percentage.

Table 4. Summary of Subarea 2 Pillar Strength Analyses

[See Appendix C for more detail.]

HOLE NUMBER	COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
DH-2	11	PANEL	80	21	6.5	1161	223	268
DH-2	11	ENTRY	65	26	6.5	1315	223	462
DH-3	11	PANEL	80	12	6.5	885	192	213
DH-3	11	ENTRY	25	24	6.5	1253	192	956
DH-4	11	PANEL	85	14	6.5	946	228	142
DH-4	11	ENTRY	60	12	6.5	885	228	355
DH-5	11	PANEL	85	8	6.5	762	231	122
DH-5	11	ENTRY	75	16	6.5	1008	231	253
DH-5	9	PANEL	85	12	6.5	885	307	151
DH-5	9	ENTRY	75	18	6.5	1069	307	290

Drill hole 3 (DH-3) (Figure 10) was sited to provide information regarding subsurface conditions in the Reed Avenue part of the subarea. A 5 foot void with 2.5 feet of gob or roof fall material was found at 192 feet and solid coal was drilled at the Number 9 Coal seam level (Table 2). Horizontal and angle fractures in the strata above the Number 11 Coal also suggest that subsidence has occurred. Although mine maps are not available for either coal seam under DH-3, the presence of a void at the Number 11 Coal depth indicates that mining did occur, probably as part of the Sunset Mine (Map 2B). Examination of the Sunset Mine map and particularly of the mine development nearest DH-3, reveals that if the mine development pattern had been extended westward, a panel would have been penetrated by DH-3. Pillar analysis, based on a probable panel extraction ratio of 80 percent, indicates that pillars in these panels would be expected to crush. However, pillar analysis for the entry area indicates adequate pillar strength to support the overburden (Table 4).

Drill hole 4 (DH-4) was positioned just south of 601 Montrose Drive (Figure 11) and penetrated a void in the Number 11 Coal (Table 2). The Number 9 Coal was in place. Horizontal fractures were found in the strata above the Number 11 Coal but no roof collapse appears to have occurred. Methane gas and sewage odors were noted. Water depth in the drill hole was 86 feet, indicating that the mines were flooded.

Superposition of the surface features over the Sunset Mine map (Figure 11) indicates DH-4 most likely penetrated either a cross entry or a room just south of the cross entry. Therefore the residence at 601 Montrose Drive is probably positioned at least partly above the cross entry pillars. Pillar crush analysis for these cross entry pillars (Table 4) indicates that they should not crush. The smaller pillars in nearby panels, however, probably would crush (Table 4). An additional hole drilled into a panel north of DH-4 (Etue and others, 1985) found crushed pillars and collapsed overburden in the Number 11 Coal. Large volumes of gas (69.5 percent methane, 3.8 percent oxygen) flowed from this drill hole when drill rods were removed. This is consistent with the release of gases from the coal in zones of pillar crushing (Appendix D).

Drill hole 5 (DH-5) was drilled south of 541 Park Avenue (Figure 12) and penetrated a 6.5 foot pillar in the Number 11 Coal 231 feet below the surface. However, angle and horizontal fractures were present in the overlying strata (Table 2) suggesting collapse of overburden into nearby voids. No mine map was available for the Number 9 Coal at this site but gob material 6.5 feet thick was found in DH-5 at a depth of 307 feet (Table 2), the position of the Number 9 Coal. Some angle and horizontal fractures were also found between the Number 9 and 11 Coals (Table 2). Pillar analyses for panels in the Number 9 and 11 Coals (Table 4) indicate that crushing could be expected.

Continued damage to 541 Park Avenue prompted the drilling of two additional drill holes (TB-1 and TB-2; Figure 12) in September of 1983 to augment the findings from DH-5. Both drill holes penetrated pillars in the Sunset Mine at the Number 11 Coal level. Only minor fracturing of strata above was observed in either core (Etue and others, 1984). Damage continued in this locality and two more holes were drilled in the fall of 1984. Voids of 4 feet at the Number 11 Coal and 3 feet at the Number 9 Coal were penetrated (Etue and others, 1984).

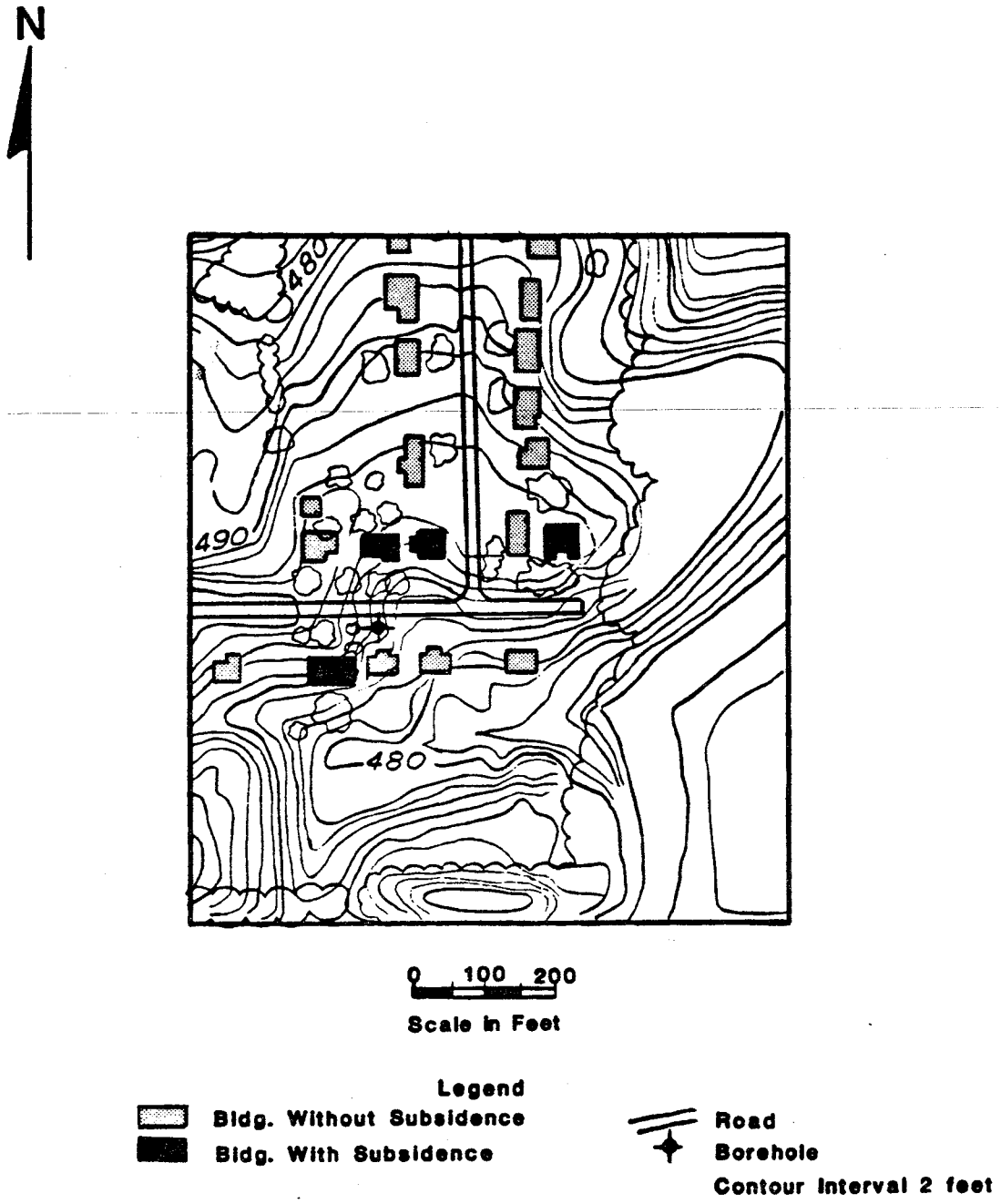

Figure 10. Topographic map with cultural features and location of drill hole (DH-3). No mine maps are available for this site even-though maps of nearby mining indicate mining has taken place. For more detailed information see Number 11 Coal Map 2b and Topographic Map 2A. There are no Number 9 Coal mine maps for this site (Map 2C).

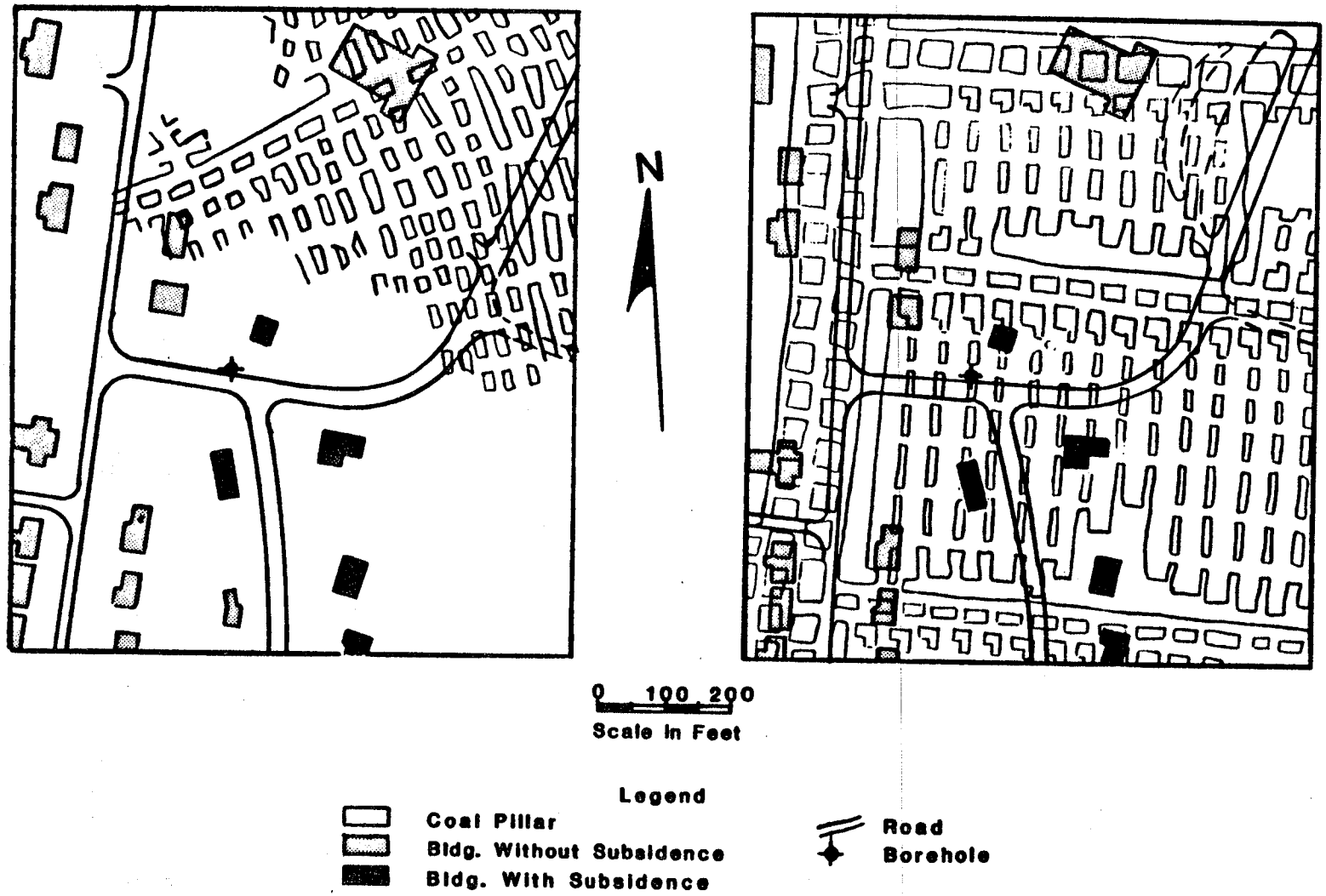

Figure 11. Mine map of Number 11 Coal (right) and Number 9 Coal (left) with cultural features and location of drill hole (DH-4). For more detailed information see Number 9 Coal Map 2C, Number 11 Coal Map 2B and Topographic Map 2A.

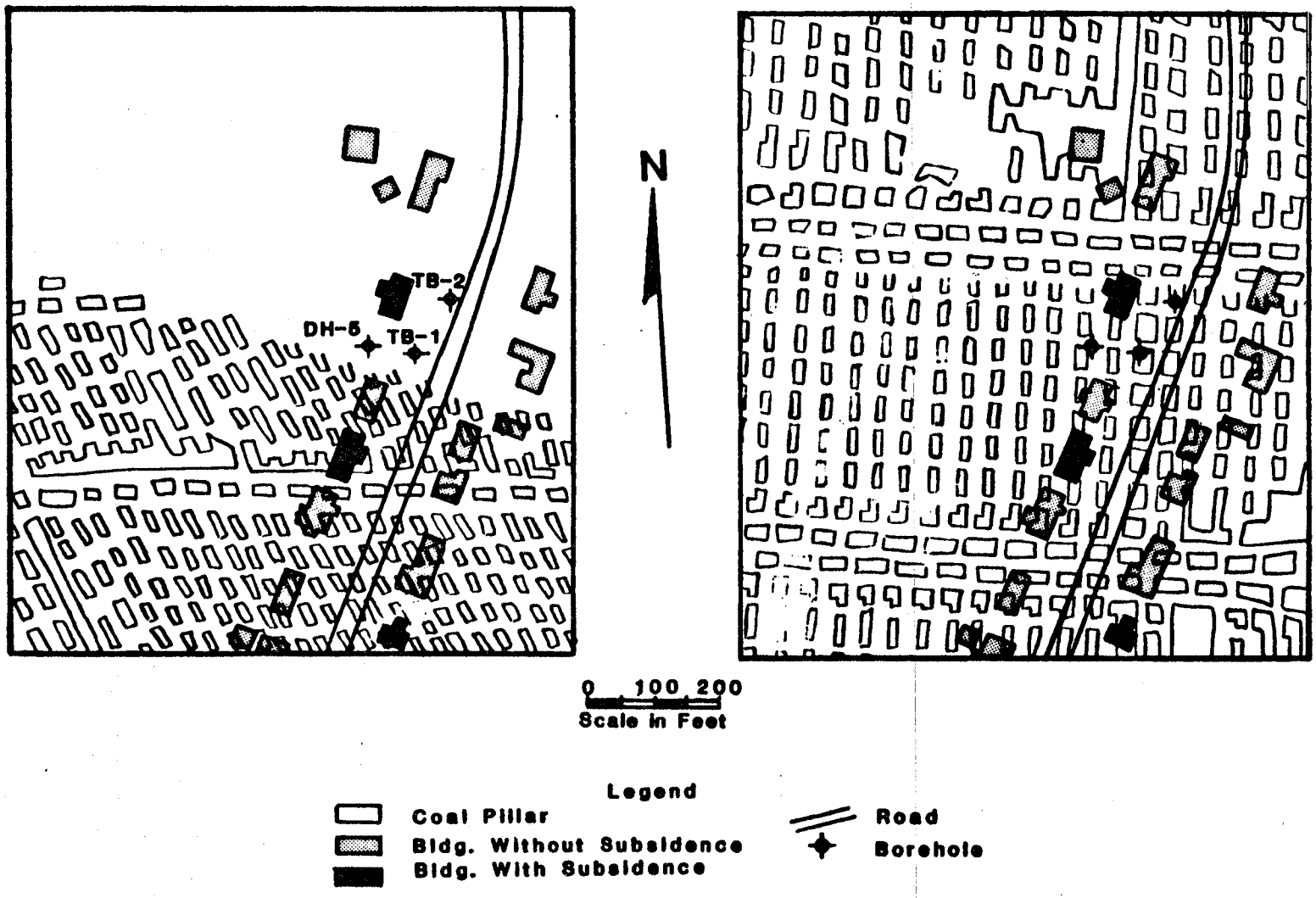

Figure 12. Mine map of Number 11 Coal (right) and Number 9 Coal (left) with cultural features and location of drill holes (DH-5, TB-1 and TB-2). For more detailed information see Number 9 Coal Map 2C, Number 11 Coal Map 2B and Topographic Map 2A.

Discussion

The lack of overburden fractures and roof collapse material at mine level in DH-2 suggests roof collapse has not occurred. Ground-water solutioning of a limestone bed (karst effects) presumably contributed to the development of the near surface void in DH-2, rather than the vertical migration of a mine void.

Further complicating analysis of this part of the subarea is the fact that one house on the hill west of DH-2 has foundation deformation indicative of downslope movement of the soil. The soils derived from the weathering of underlying shales and limestones tend to have plastic, moist clay/silt layers (for further information see Etue and others, 1985b). Plastic soils respond to seasonal changes in water content by both expanding and contracting and also by squeezing out when loads such as buildings are applied. Desiccation cracks observed on the surface of lawns in this subarea during the summer of 1983 reflect the expansive/contractive nature of the soil. Drought conditions prevailed in Kentucky during the summers of 1982, 1983, and 1984, but the winter and springs of those years were very wet. Wetting and drying of some soils cause them to expand and contract. The mobility of such soils, combined with the steep hillslopes, can exert lateral stresses to building foundations which often respond by breaking. The cracks and distortions thus produced can mimic the effects caused by mine subsidence.

As a result of this uncertainty, analysis of any future damage that was near DH-2 will require a careful subsurface geotechnical evaluation to specifically identify the cause.

From drill data (DH-3) it appears that roof collapse is the cause of damage to structures near Reed Avenue. Pillar strength analyses indicates that pillar crushing may also be taking place at this site.

Beneath 601 Montrose Drive (DH-4) plastic soil conditions were found not only in the surface layer but also just above the underlying bedrock. Water levels indicated a perched water table in the soil above the bedrock. Expansion/contraction and squeezing can be expected when these soil conditions exist. However, from all available data, it appears that collapse in the mine panel south of 601 Montrose Drive and DH-4 (Figure 11), probably caused both the initial damage to houses along Parkwood Drive and the less severe adjustments which have continued to affect these dwellings. The house at 601 Montrose Drive is near or above the cross entry but could be within the zone of tensional forces produced by the panel subsidence to the south. As the pillars to the north now crush, tensional forces from the north could also affect the house. Furthermore, the elasticity of the soils under the house may shift and adjust to subsidence in the underlying rock strata. These changes would then be transmitted to the house.

To the south of 541 Park Avenue (DH-5), fractures were found in several zones above the Number 11 Coal. Mine voids encountered by Etue and others at

this site were much smaller than the thickness of coal which indicates that pillar crushing, pillar punching of roof clays or clay partings within the coal may be occurring. Pillar strength calculations indicate the panel pillars should crush (Table 4). Tests on soil samples above the rock strata (Etue and others, 1984b) indicated acceptable engineering properties for house construction. Therefore, it was concluded by Etue and others that panel collapse has apparently caused a surface trough subsidence to develop near the location of DH-5. Pillars in the cross entries and between panels resist crushing but the smaller panel pillars do not. As the subsidence progresses, houses along Park Avenue are being affected in a pattern consistent with their proximity to the edge of the panel.

Conclusions

Subarea 2 demonstrates the problems encountered when an investigation attempts to distinguish between soils or slope-stability problems and mine-related subsidence. Soils and/or karst effects near DH-2 may be contributing to subsidence problems. Locations DH-4 and DH-5 demonstrate typical surface effects due to subsidence caused by failure in the panel area of a mine. High panel extraction ratios and small pillar sizes do not provide sufficient support for the thick overburden and pillar crushing results. Lower extraction and larger pillar sizes in the cross entries indicate these zones are less likely to fail.

The presence of varying amounts of methane found in all drill holes in this subarea requires constant checking for dangerous accumulations. Precautions during drilling must be observed.

Subarea 3

Subarea 3 consists of a shopping mall and associated parking lot located west of the Pennyrile Parkway in the south central portion of the study area (Figure 7). The orientation and development of the depressions in both the highway and mall parking lot, and the presence of the alluvial Belknap soil association (Fehr and others, 1977) throughout the locale, prompted establishing this subarea.

Subsidence events

The mall was opened in 1980 and began to exhibit structural damage as early as 1981. Subsidence has continued to cause damage to floors and walls of the buildings and has created depressions in the parking lot. In addition, by the summer of 1982, severe depressions, in excess of 2 feet, had developed in the Pennyrile Parkway east of the mall.

Test drilling by the developer prior to construction of the mall penetrated 11.5 feet of fill material and unconsolidated fluvial sediments, but drilling was not advanced to bedrock. The first engineering study to

investigate damage occurring at the mall (Grant, oral communication, 1981) had observed water saturation in most of the unconsolidated fill materials and fluvial sediments down to the underlying bedrock at 25 feet. The study also found a 3 foot organic-rich layer just above the bedrock. Artesian conditions were observed at the surface when the drilling penetrated this organic zone, indicating that water located above the bedrock is under pressure.

Continued subsidence at the mall prompted the owners to again seek engineering assistance in the fall of 1983. The findings of the second investigation (Erdmann, 1984) were consistent with earlier results and soil and water conditions were thought to be responsible for settlement. A survey of control points during the spring of 1984 established that subsidence was continuing in this subarea at the rate of 0.375 inches per month.

With this continuing and rapid rate of subsidence, a request for emergency consideration was referred to OSMRE during July 1984. After field investigation, an emergency was declared in the fall of 1984. The subsequent investigatory drilling (Etue and Mylotta, 1985) did not find evidence of either staining along fractures or materials from the unconsolidated layers filling fractures in the rock overburden below the fluvial sediments. Piping of the fluvial sediments or water into the mine workings through fractures in the overburden was, therefore, ruled out as a subsidence cause. The drilling program also found pillars generally intact but mine workings were often filled with collapsed roof material. Water depths in the drill holes confirmed the findings from previous studies that a perched water table existed in the unconsolidated surface materials.

Findings

Drill hole 10 (DH-10) was located in the center of the mall parking lot (Figure 13) and penetrated fractured and broken rock above the East Diamond Mine in the Number 11 Coal (Table 2). Numerous angle, vertical, and horizontal fractures which are typical in rock strata above a collapsing mine, were observed. Broken and collapsed materials were first encountered at 135 feet and continued downward for 16 feet which is estimated to be the top of the Number 11 Coal.

Continued drilling through less fractured rock penetrated 5.5 feet of Number 9 Coal at a depth of 237 feet (Table 2), probably indicating the Number 9 Coal has not been mined.

Pillar strength analyses for panel pillars in the East Diamond Mine indicate that crushing can be expected below 184 feet (Table 5). Therefore, pillar crushing would not be expected at this site, since the Number 11 Coal is shallower than this depth. However, gas, an indication of possible pillar crushing, was encountered when the highly fractured zone above the Number 11 Coal was penetrated by the drill. Water levels fluctuated between 80 to 150 feet deep in drill holes. This fluctuation is thought to be related to a build-up in gas pressure which caused surges in water level rather than actual water level fluctuations.

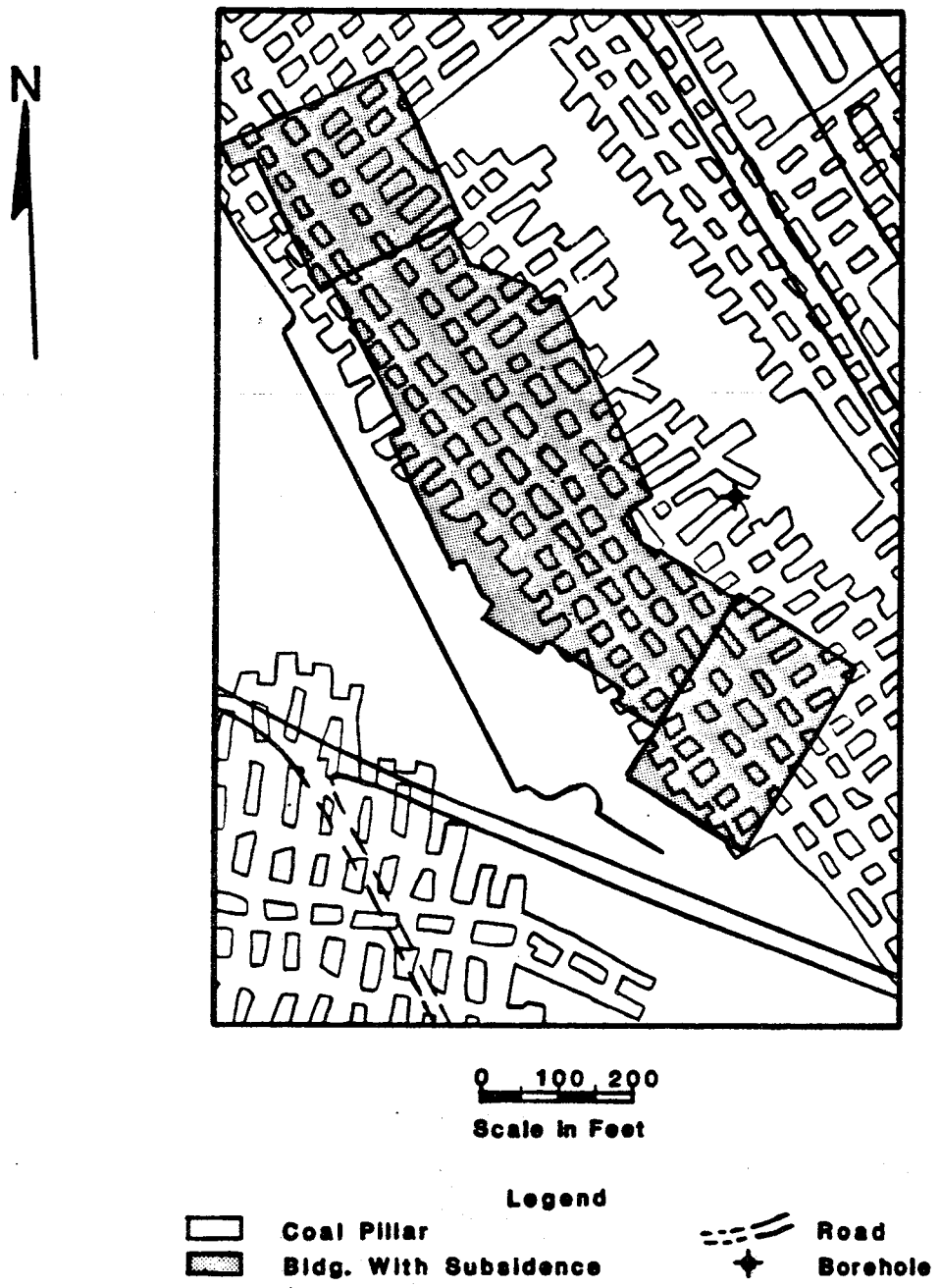

Figure 13. Mine map of Number 11 Coal with cultural features and location of drill hole (DH-10). For more detailed information see Number 11 Coal Map 2B and Topographic Map 2A. There are no Number 9 Coal mine maps for this site (Map 2C).

Table 5. Summary of Subarea 3 Pillar Strength Analyses

[See Appendix C for more detail.]

HOLE NUMBER	COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
DH-10	11	PANEL	80	13	6.5	915	151	184
DH-10	11	ENTRY	75	17	6.5	1038	151	261

Discussion

The investigation clearly showed failure of the mine roof. The lack of a recognizable surface trough at the site of DH-10 could have been obscured by grading of the site or the parking lot itself.

The artesian condition found by Grant could have affected the unconsolidated sediments in several ways. First, the water draining out near the surface through the drill hole or ruptures in the clay layer which forms a seal above the pressurized zone could lower the land surface as the zone of depression developed around the "leak" area. Second, the water under pressure could create localized "quick" conditions such as quicksand, quicksilt, or quickclay, causing sediments to become extremely mobile and lowering their bearing strength. Saturating soil with water could permit surface areas with loads such as buildings to sink and permit unloaded areas such as parking lots to rise as the sediments moved in response to differential loading. The third possible mechanism acting on the surface soils would be "piping." The drilling has shown that the overburden rock is highly fractured. It is possible that the fine fluvial sediments could be piped downward into the fractures. Any one or any combination of these factors could be responsible for movement at the shopping mall. However, soil conditions cannot be excluded as a potential cause for structural damage in this subarea.

Roof problems probably existed at the time of mining. The mine map (Map 2B) shows a 45 degree change in room alignment, a procedure often used in mines with roof problems. The large rib of coal left east of the mall area (Figure 13), is also consistent with mining practices where roof problems develop. The core logs (Appendix A) indicated that the roof was composed of weak black shale rather than the typical Providence Limestone found as the mine roof rock at other drilling locations.

The west edge of the mall is located above a barrier pillar between the East Diamond and Sunset Mines. Analyses of cross sections constructed from drill hole data (Etue and Mylotta, 1985) indicated that the roof failure is progressive and is moving toward the northwest between the barrier and the rib.

Conclusions

Roof collapse seems to be the dominant mechanism causing the subsidence in the subarea. However, the subsidence in this subarea is different from that observed in most other subareas. There is a potential for soil conditions as a cause of structural damage at the mall.

Subarea 4

Subarea 4 (Figure 7) encompasses East Center Street, Buckner Street, Branch Street and the 200 and 300 blocks of Park Avenue. The subarea was defined to include the Wireman emergency project (Sumner, 1981) and adjacent areas that were undermined by the Coil Mine in the Number 11 Coal (Map 4B).

Subsidence events

Subsidence at the Wireman site began during the spring of 1981. A restaurant, five houses, two boatyard buildings, and a service station were involved. The restaurant developed cracks and tile began to fall from both the interior and exterior surfaces. The deteriorating conditions eventually forced the management to close the restaurant. The boatyard buildings and service station developed cracks in foundations, floors and walls. A surface depression developed behind the restaurant which disrupted drainage, causing rain water to accumulate and stagnate.

During the 1982 damage survey (Appendix B), a citizen reported damage to a business building across Center Street from the restaurant. Numerous cracks in the cement blocks and floors were evident during the field investigation of this building and five additional buildings with external damage were identified nearby. Two citizen reports were also received from the 200 and 300 blocks of Park Avenue (Appendix B), a few blocks west of Buckner Street. Damage at each was relatively minor. While the drilling program was being conducted in 1983, another citizen report of damage was received (Appendix B).

Findings

Drill hole 7 (DH-7) was sited in a central location relative to a number of damaged buildings (Figure 14). The Number 11 Coal was encountered at a depth of 226.5 feet (Table 2). Horizontal and angle fractures were observed in rock strata above the Number 9 Coal but these fractures did not extend up to the Number 11 Coal. The roof at the Number 9 level had collapsed and the 4.5 foot void was filled.

Map 4B shows the proximity of the damaged buildings to barrier pillars in the Coil Mine which were left under the railroad at the east side of the subarea and to the irregular block of coal left between panels to the west. Based on the pattern of the nearby mining as shown on the mine map (Figure 14) and an extraction ratio of 85 percent, the panel pillars should crush. Some panel pillars have probably failed and others may fail in the future. Pillar strength analysis for the cross entry pillars at 80 percent extraction (Table 6), indicates they are barely adequate to support the weight of the overburden load and may also be failing.

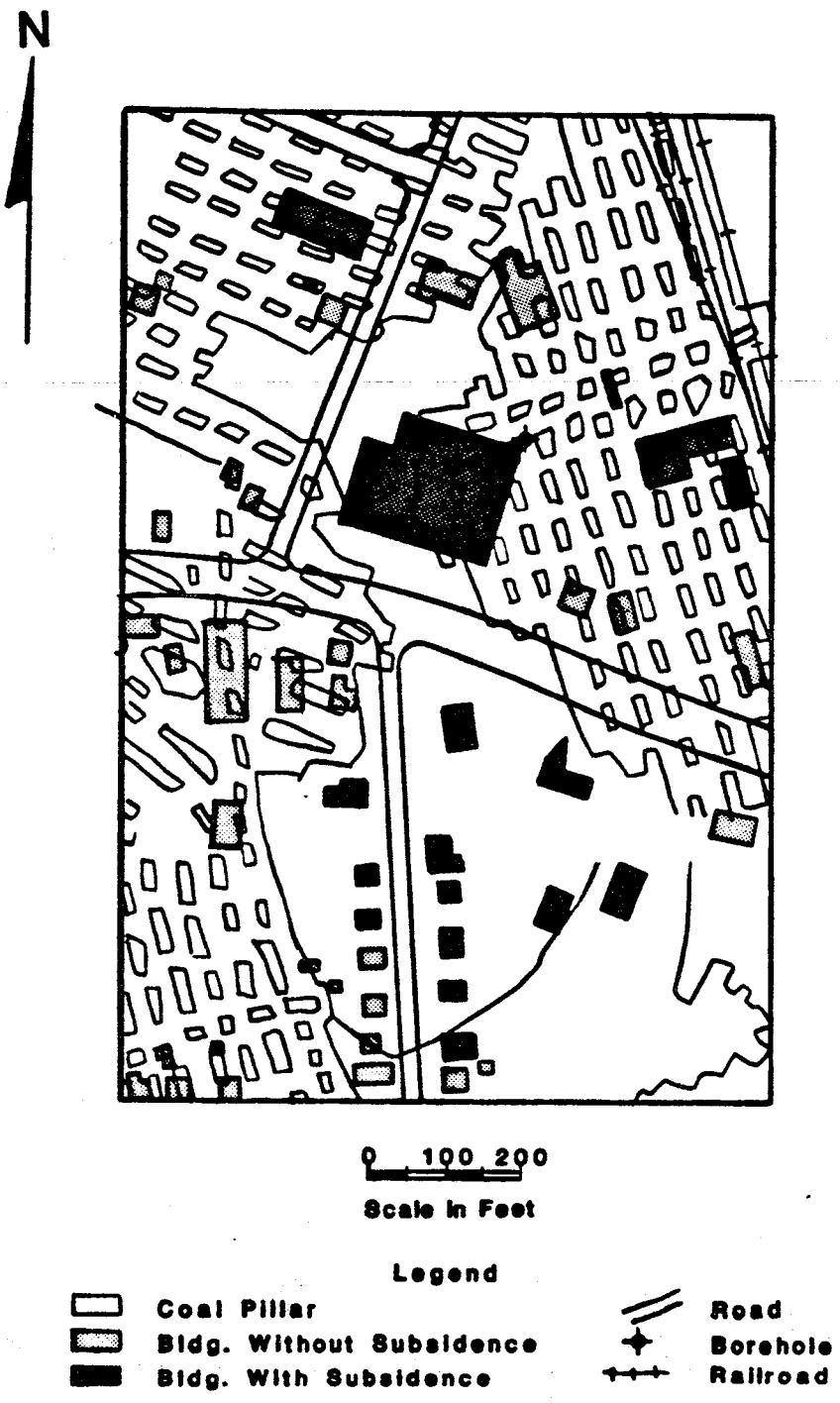

Figure 14. Mine map of Number 11 Coal with cultural features and location of drill hole (DH-7). For more detailed information see Number 11 Coal Maps 2B and 4B and Topographic Maps 2A and 4A. There are no Number 9 Coal mine maps for this site (Maps 2C and 4C).

Table 6. Summary of Subarea 4 Pillar Strength Analyses

[See Appendix C for more detail.]

HOLE NUMBER	COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
DH-7	11	PANEL	85	17	6.5	1038	227	177
DH-7	11	ENTRY	80	19	6.5	1100	227	221
DH-18	11	PANEL	80	16	6.5	1008	254	233
DH-18	11	ENTRY	70	13	6.5	915	254	266

An additional drill hole, (DH-18) was sited (Figure 15) to the northwest of DH-7 (Map 4B). A 7.5 foot open void was encountered at the Number 11 Coal at a depth of 254 feet. Horizontal and angle fractures were observed in the core from rocks above the Number 11 Coal (Table 2). Six feet of in place coal was found in the Number 9 Coal at a depth of 346 feet.

Based on the pattern of nearby mining as shown on the mine map (Figure 15), extraction ratios are approximately 80 percent for the panel pillars and 70 percent for the entry pillars. Calculated strengths (Table 6) show panel pillars have probably failed. The cross entry pillars are larger than the panel pillars and the extraction ratio is lower. These pillars should not crush (Table 6). However, deterioration of the pillars could have occurred allowing entry pillar failure to eventually occur.

The Number 9 Coal was in place at DH-18 (Table 2). The collapsed void conditions found at the level of the Number 9 Coal beneath DH-7, however, indicate that the mine maps are not complete and that panels were developed farther westward. It is also possible that mining occurred near DH-18 and that the Number 9 Coal found in the drilling is a pillar or barrier. Horizontal and angle fractures were observed in the rock strata above the Number 9 Coal at both DH-7 and DH-18, indicating that some overburden movement is occurring. These fractures were not observed to have extended upward to the level of the Number 11 Coal, either in the core logs or as a result of inspection with the borehole camera.

Discussion

In the Wireman investigation the silty alluvial Belknap soils were shown to overlie bedrock. These soils typically maintain a high water level, often to within 1 foot of the surface. In the vicinity of the Wireman site, mine subsidence fractures extended to the interface between the wet soils and the bedrock. Water apparently drained into the fractures causing drying of the soils and resultant changes in their physical strength (Sumner, 1981). Seasonal wetting and drying could cause these soils to expand and contract which could result in damage to buildings. However, if these soils consistently remain either wet or dry, their expansion or contraction should not be a major factor in structural damage.

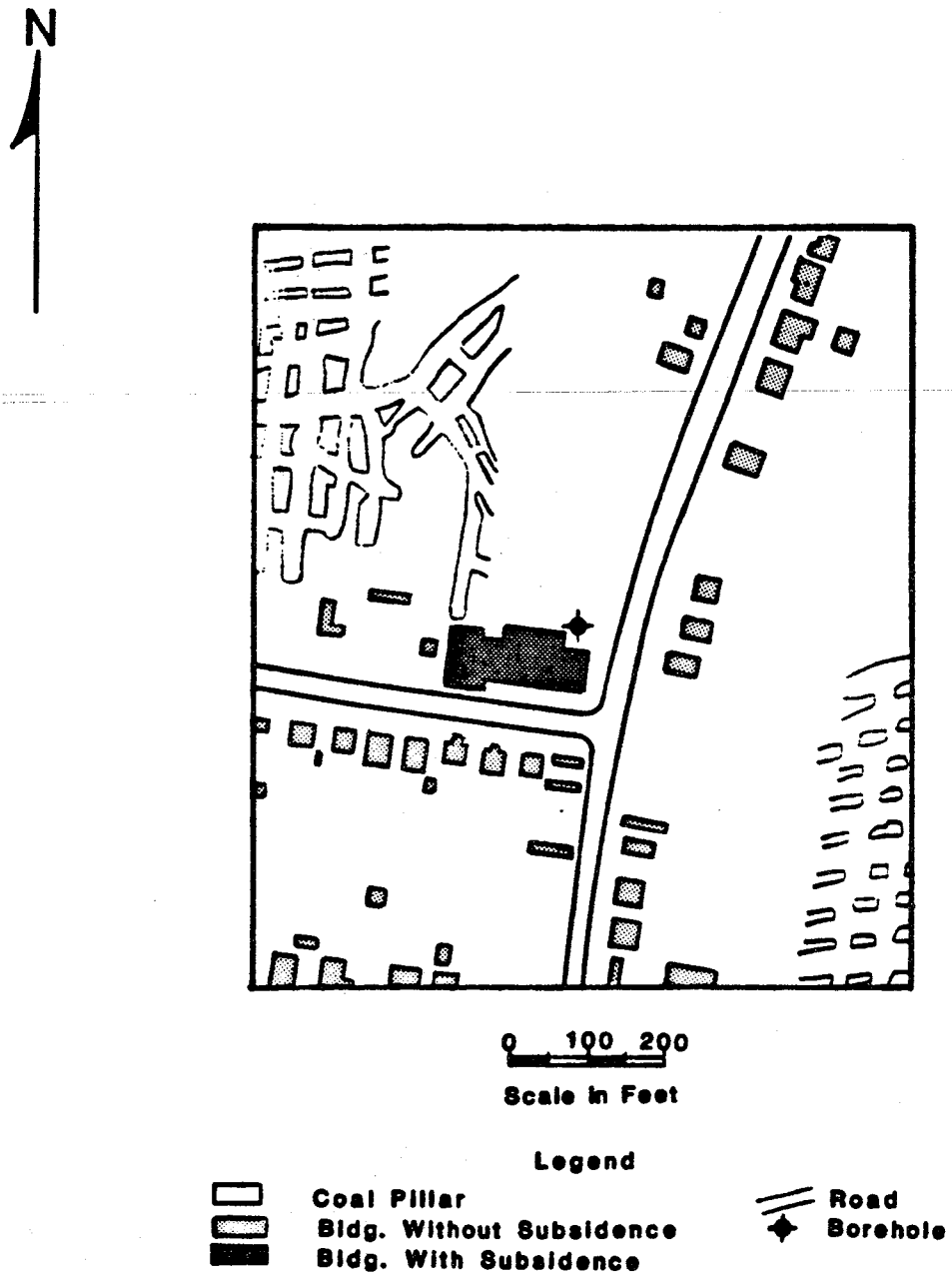

Figure 15. Mine map of Number 11 Coal with cultural features and location of drill hole (DH-18). For more detailed information see Number 11 Coal Map 4B and Topographic Map 4A. There are no Number 9 Coal mine maps for this site (Map 4C).

Drilling during the Wireman emergency investigation (Sumner, 1981) found extensive horizontal, vertical and angle fracturing. Small open voids were also observed during the borehole television camera survey conducted during the investigation. Water was encountered at 253.5 feet and the Number 11 Coal was found at 275 feet, indicating flooding below this level.

The drilling program in Subarea 4 encountered some difficulty due to large amounts of gas. Gas pressure in the exploratory holes blew water 30 feet into the air when the holes were uncapped and it took two days to vent the gas. No samples were collected for analysis at these sites, but the smell of hydrogen sulfide was evident. In nearby holes where gas analyses were made, the gas contained considerable methane (see Appendix D).

The Coil Mine map reveals a more confusing pattern of mining than is typically encountered in nearby mines. The pattern for panels frequently shifts, usually at 45 degree angles, and ribs and barriers are often irregularly shaped. This pattern of mining is typically utilized when roof problems are encountered during mining.

Conclusions

Panel pillar crushing in the Coil Mine in the Number 11 Coal is considered the subsidence mechanism at work near DH-7. There is also some evidence that overburden movement has occurred above the Number 9 Coal mine workings but the movement has not yet extended to the level of the abandoned Coil Mine in the Number 11 Coal. The lack of mine maps and other information near DH-18 indicates geotechnical investigations would be required to further define the situation and to develop appropriate abatement procedures if additional subsidence occurs near this site.

Alluvial soil conditions present in this subarea dictate that special geotechnical analyses should also be performed during construction projects and mine subsidence abatement programs. Caution is also suggested when drilling in this area due to the potential for methane gas explosion.

Subarea 5

Subarea 5 (Figure 7) is the northernmost part of the Madisonville area to have experienced multiple subsidence events. It encompasses Pepper Drive, Sunrise Drive, Sunrise Place and farm property east of Pepper Drive.

Subsidence events

Only three damage reports were received, but several additional damaged structures were identified during the subsequent field investigation. The investigation also revealed that roads, fields and nearby woods contained subsidence depressions.

Investigation of the damage report from 1150 Pepper Drive established that the northeast corner of the house had dropped 5-6 inches causing extensive damage to the house. The upper part of the house had twisted, causing the structural beams to separate and penetrate through the roof. Extensive wall damage occurred inside the house. The plaster ceilings and most of the plumbing had to be replaced. Surface cracks had developed in the driveway, affecting the carport and nearby shed. A depression 3-5 inches deep developed in the yard which filled with water after heavy rains. A large crack

developed in the roadway in front of the house. This crack crosses the road and marks the boundary of a trough which is approximately 3 feet deep at the midpoint. A similar trough occurs on Pepper Drive at its southeast junction with Sunrise Drive.

A field investigation at 1170 Pepper Drive determined that interior walls and ceilings, as well as the exterior walls and foundation, were cracked. Investigations behind (east) 1170 Pepper Drive, located a 100 foot-wide depression in the woods. The depression had apparently been deepening for a number of years and occasionally had been filled with truckloads of dirt. The depression now retains water most of the year. Large trees in and near the depression have tilted and some have been killed, presumably by inundation. Four additional houses exhibiting external structural damage were observed at the northeast end of Pepper Drive on the east side of the street.

Another damage report came from a farm owner whose property lies just east of Pepper Drive. The farmer reported several earlier subsidence events on his land and on his neighbors' land. Most of these apparently were small depressions which are now obscured. Several other depressions were later identified on the aerial photographs and subsequently examined in the field.

Findings

An 18 inch void found at 283 feet in drill hole 11 (DH-11, Table 2) indicates that the Number 11 Coal (Figure 16) has been mined beneath this location, although the map of the East Diamond Mine in the Number 11 Coal does not show workings beneath this subarea. Analysis of the core from DH-11 (Table 2) and of the borehole camera information revealed many vertical, horizontal and angle fractures in the rock strata above the Number 11 Coal. These fracture patterns provide additional evidence that subsidence is related to mining of the Number 11 Coal. Only a few fractures were observed in the rock strata above the Number 9 Coal (Table 2). The mine map of the Number 9 Coal (Figure 16) indicates that DH-11 was drilled into a large block of coal.

The pattern of mining in the East Diamond Mine in the Number 11 Coal, if projected westward, would indicate that a panel probably underlies the site of DH-11. Extraction ratios were estimated to be 75 percent in panels and entries nearby. Pillars in both panels and entries are calculated to crush (Table 7) at the mine depth of 283 feet.

Table 7. Summary of Subarea 5 Pillar Strength Analyses

[See Appendix C for more detail.]

HOLE NUMBER	COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
DH-11	11	PANEL	75	14	6.5	946	283	237
DH-11	11	ENTRY	75	15	6.5	977	283	265
DH-11	9	PANEL	80	23	6.5	1223	372	270
DH-11	9	ENTRY	70	27	6.5	1346	372	378

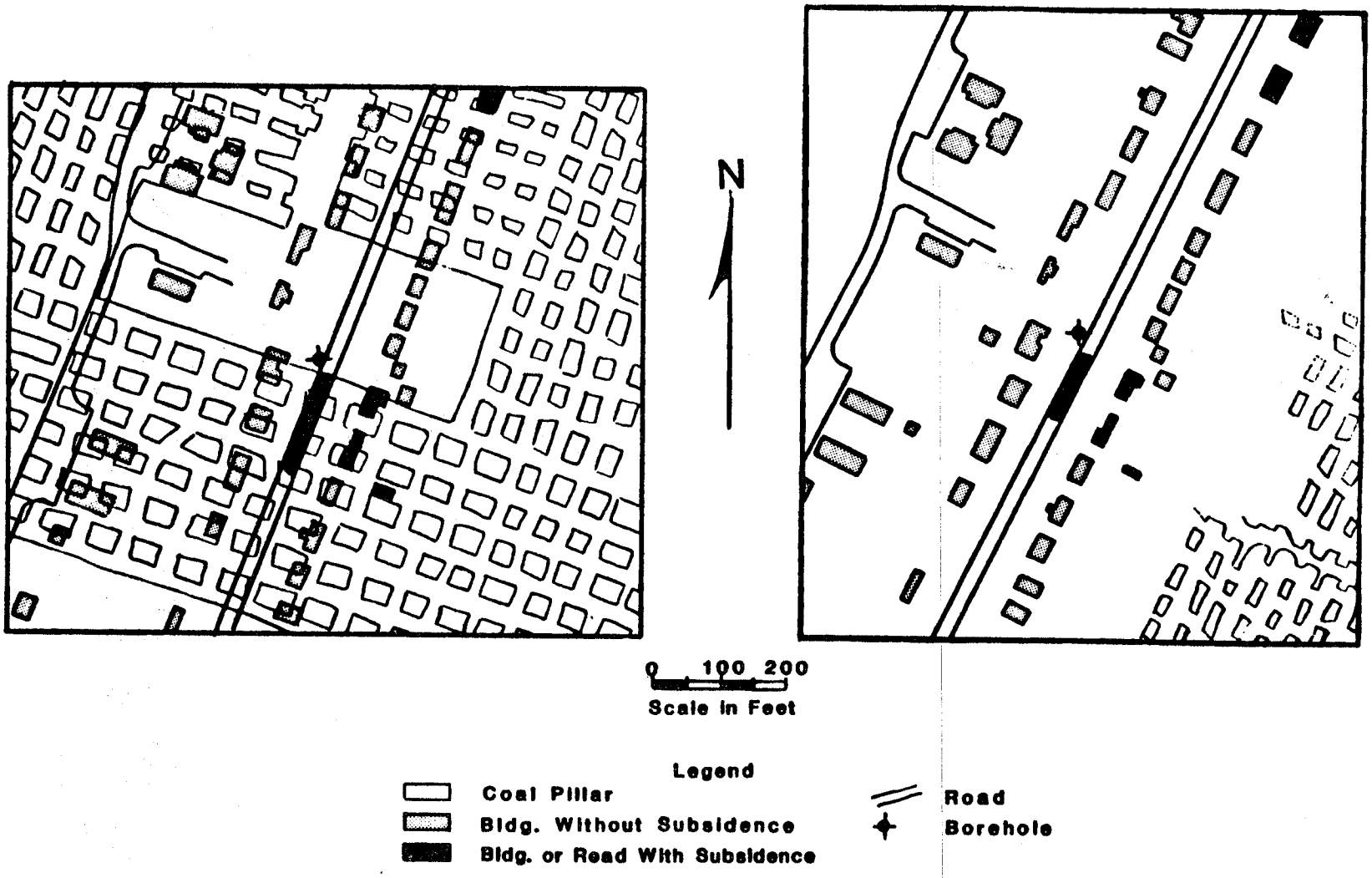

Figure 16. Mine map of Number 11 Coal (right) and Number 9 Coal (left) with cultural features and location of drill hole (DH-11). For more detailed information see Number 11 Coal Map 5B, Number 9 Coal Map 5C and Topographic Map 5A. Number 11 Coal map is incomplete.

Gas trapped in DH-11 was of sufficient pressure to blow the borehole cap 20 feet into the air when it was removed for the television camera inspection. The television survey showed gas bubbles escaping from porous rock strata and fracture zones. The surface elevation of the water in the borehole was difficult to determine because gas rising in the borehole caused frothing and 20-30 foot surges of the water surface level within the drill hole; however, the water level is estimated to be at least 150 feet above the flooded mine. Local residents who worked in these mines recall that excessive gas buildup was also a problem during mining.

Discussion

The damage pattern, the small void above the mine floor, and the presence of methane all suggest pillar crushing and resultant trough subsidence in Subarea 5. However, the lack of mine maps prevents further definition of the boundaries of the trough. The trough subsidence, which began in the late 1970's, can be expected to continue as the remaining smaller pillars crush and the voids are closed by the downward movement of the overburden. The pillar strength calculations indicate additional panels are likely to collapse.

Conclusions

Pillar crushing, and possibly roof collapse, in the East Diamond Mine in the Number 11 Coal are considered to be the cause of subsidence damage in this subarea. There is the possibility of gas reaching the surface through the subsidence cracks developing in the overburden. Appropriate precautions should be taken, especially in buildings that have basements below ground surface level.

Subarea 6

Subarea 6 (Figure 7) is located adjacent to Kentucky Route 85/70 and extends eastward from the Pennyrile Parkway for about 2.5 miles. The subarea generally overlies the East Diamond Mine which was mined both the Number 9 and 11 Coals. A small section of the west end of the subarea overlies the eastern edge of the Coil Mine (Map 5B).

Numerous damage reports were received from this area during the initial survey (see Appendix B). During field investigations, additional damaged structures were identified. These investigations also observed a repetition of surface circular sags, cracks in the roads and shallow trough depressions throughout the area.

Apparent subsidence events are clustered in three parts of the subarea (Figure 7):

1. The Sharpe and Scanfield Additions (Subarea 6A) located one mile east of the Pennyrile Parkway. The Scanfield Addition is on the north side of Route 85/70 and the Sharpe Addition is on the south side.

2. Continental Drive (Subarea 6B), located approximately 2 miles east of the Parkway and extending 0.5 miles northeastward from Route 85/70.

3. A zone adjacent to Route 85/70 (Subarea 6C) extending approximately 2.5 miles east of the Parkway.

Each of these parts is discussed separately below.

Subarea 6A-Sharpe and Scanfield Additions

Subsidence events

Structures in the Sharpe and Scanfield subdivisions have been damaged by more than thirty subsidence events since the late 1960's. Sudden "overnight" subsidence events have been typical in this area, with many reported to have occurred in January of 1977. Other structures have been subsiding gradually for several years. Affected buildings are shown on Map 5A. When these subdivisions were developed, the land was essentially level with a few gentle slopes that required minor grading during development.

The field investigation (Appendix B) found damage to structures in the Sharpe Addition ranging from a few minor cracks to total destruction of one building. Some house interiors have cracks in the plaster, doors and windows sticking, twisted door frames, and warped paneling. Brittle exterior facings made of brick and stone were cracked and broken. Differential settlement of the ground surface left one house in the Sharpe Addition with the west end lowered by 36 inches and the east end lowered by 18 inches. Several houses have parts that are stable while other parts are actively subsiding, causing the house to be pulled apart.

Only one homeowner in the Scanfield Addition reported subsidence damage.

Findings

One exploratory hole (DH-14) was drilled in the Scanfield Addition (Figure 17) to determine subsurface conditions. This hole was sited near a northeast trending surface crack along the east side of the Scanfield Addition. The drill hole core data (Table 2) indicated broken and collapsed rock in the East Diamond Mine in the Number 11 Coal and fractures extending upwards in the rock overburden above the mine. The Number 9 Coal was in place with only a few fractures in the rock immediately above the coal (Table 2). No holes were drilled in the Sharpe Addition during this study since the landowners were in litigation against the coal companies.

Boyd (1978), in an engineering evaluation of the Sharpe Addition concluded that, "...the mine designers expected surface subsidence..." This was based on Boyd's analysis of the strengths of pillars in both panels and entries beneath the Sharpe Addition. Boyd calculated that panel subsidence would occur in both the Number 9 and 11 Coal panels. His calculations indicate that cross entry pillars in both mines, while stronger than panel pillars, were also too small and could crush. He concluded that only the pillars in the main entries had sufficient strength to support the overburden weight.

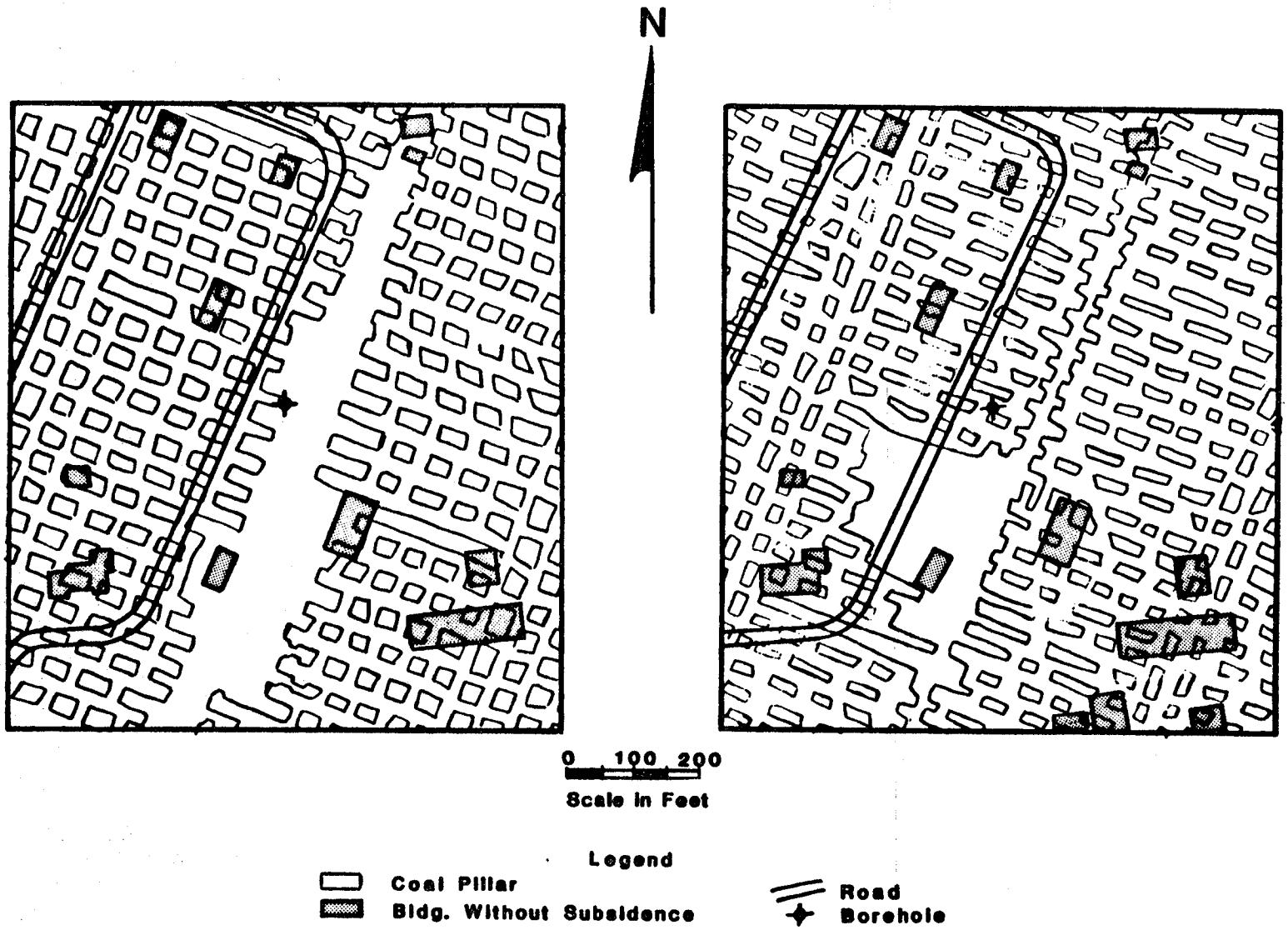

Figure 17. Mine map of Number 11 Coal (right) and Number 9 Coal (left) with cultural features and location of drill hole (DH-14). For more detailed information see Number 11 Coal Map 5B, Number 9 Coal Map 5C and Topographic Map 5A.

Pillar strength calculations (Table 8) indicate that the smaller pillars in the East Diamond Mines in both the Number 9 and 11 Coals should crush under the existing overburden loads. The pillars in the entry areas of both mines show strengths slightly above the overburden loads and would be capable of supporting the loads until pillar deterioration reduce the strength of the pillar to the point of failure.

Table 8. Summary of Subarea 6A Pillar Strength Analyses

[See Appendix C for more detail.]

HOLE NUMBER	COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
DH-14	11	PANEL	70	10	6.5	823	267	231
DH-14	11	ENTRY	70	15	6.5	977	267	284
DH-14	9	PANEL	80	29	6.5	1407	350	297
DH-14	9	ENTRY	70	28	6.5	1376	350	387

Main entry pillars and larger blocks of coal will probably not crush.

Subarea 6B-Continental Drive

Subsidence events

Seven houses on the east side and three houses on the west side of the north end of Continental Drive (Figure 18) began to subside in February 1981. Foundations, facings, windows, and interior walls were severely damaged and one house was rendered uninhabitable. After an initial investigation (Kilburg and Alvi, 1982), an emergency subsidence abatement project was undertaken and completed by September 1983.

During the 1982 damage survey, two houses south of the original emergency project area showed evidence of recent subsidence damage. The new evidence resulted in the expansion of the abatement program to include these structures.

Findings

Numerous holes were drilled throughout the Continental Drive area during the initial drilling to investigate the emergency subsidence event and during the subsidence stabilization program. Two drill holes were analyzed to establish conditions occurring in the mine; DH-26, drilled during the present investigation at the south end of the project, and TB-V3 (Kilburg and Alvi, 1982) at the north end of the project (Figure 18). Drill hole 26 penetrated solid coal in the Number 11 Coal, so the condition of the mine void could not

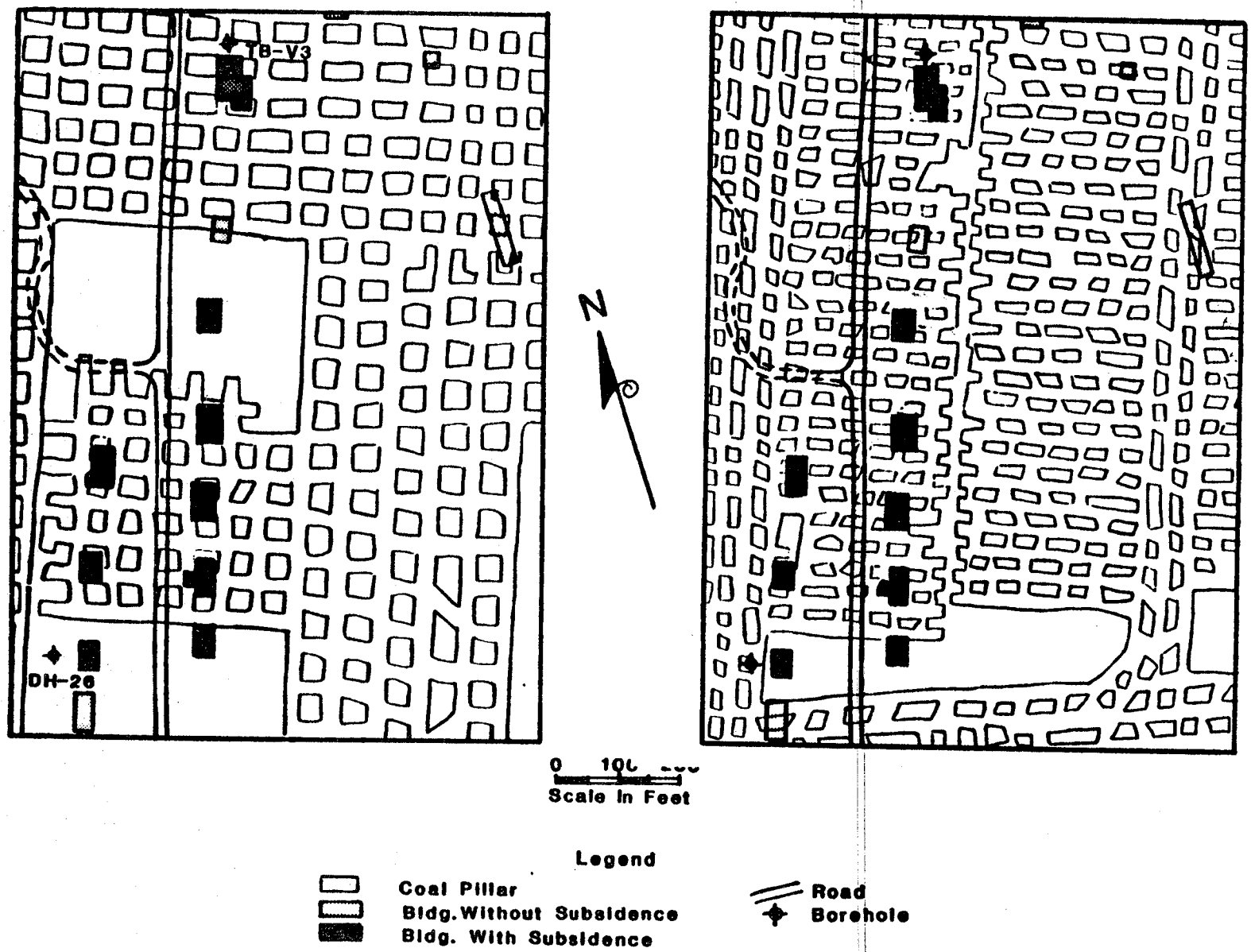

Figure 18. Mine map of Number 11 Coal (right) and Number 9 Coal (left) with cultural features and location of drill holes (DH-26 and TB-V3). For more detailed information see Number 11 Coal Map 6B, Number 9 Coal Map 6C and Topographic Map 6A.

be evaluated. Drill hole TB-V3 penetrated a roof fall area with a two foot void.

Analysis of the East Diamond Mine map in the Number 11 Coal indicates extraction ratios of approximately 65 percent in the entry area and 70 percent in the nearby panel (Table 9). The pillars are larger at the south end of the area than at the north end of the mine under Continental Drive. Pillar strength calculations indicate adequate strength for pillars in the panel and in the entry at the south end, but the smaller pillars in the panel at the north end would not be capable of supporting the overburden loads.

Table 9. Summary of Subarea 6B Pillar Strength Analyses

[See Appendix C for more detail.]

HOLE NUMBER	COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
DH-26	11	PANEL	70	15	6.5	977	253	314
DH-26	11	ENTRY	65	20	6.5	1131	253	420

A barrier pillar in the Number 11 Coal parallels Continental Drive just behind the houses on the east side of the road. The damage pattern shows that the houses on this side of the road rotated to the west and downward which is consistent with a trough subsidence and breakup of houses over the "edge" of a barrier pillar (see edge effect discussion included in Subarea 1). Houses west of the road generally rotated toward the east, i.e., toward the road, suggesting that the center of the long axis of the trough is beneath Continental Drive. The southernmost houses on Continental Drive are near a large barrier pillar (Figure 18) and showed evidence of tension pulling toward the northeast.

Subarea 6C-Route 85/70 East From Madisonville

Subsidence events

This subarea extends about 2.5 miles east from the intersection of Route 85/70 with the Pennyrile Parkway (Figure 7). The subarea is defined by the existence of a series of sag subsidence events that occur on and adjacent to the highway but are not apparently associated with the other sag subsidence events in the subarea (i.e., the Sharpe and Scanfield Additions and Continental Drive). Route 85/70 in this subarea contains a series of humps and trough-like depressions. When the road was built there were no humps or sags according to a local engineer (J. Donan Sr., personnel communication).

The Liberty Baptist Church and nearby parsonage located about 1.5 miles east of the Sharpe and Scanfield Additions had been severely damaged. The church has several cracks at the north end of the building, but is most severely damaged near the middle of the structure where vertical cracks widen upward. This probably indicates downward displacement at both ends of the

building. The parsonage had been twisted and damaged to the extent that its exterior was replaced. The septic tile field for the parsonage also had to be rebuilt because of disruption of drainage.

During the spring and summer of 1984 two other subsidence events were investigated in the subarea: the Cumberland Presbyterian Church located near the western end of the subarea, investigated by Etue and Sydnor (1984a), and damage to the Stegelman and Moore residences (Etue and Sydnor, 1984b) located at the eastern end of the subarea. Damage was severe enough at each of these sites to be declared emergencies and remedial measures were initiated.

Findings

Hole 13 (DH-13) was drilled to investigate the evidence for mine-related subsidence associated with the highway sags. The drill hole was sited in the center of a surface trough depression that crosses Route 85/70 (Figure 19) about 1 mile east of the Sharpe and Scanfield Additions. Inspection of the core log (Table 2) indicates that the East Diamond Mine in the Number 11 Coal collapsed in this area. The overburden shows subsidence-induced fractures in the overburden from the mine level to the surface. "Gassy" conditions were encountered when the drill hole penetrated the fractures just above the collapsed area, indicating crushing of the coal pillars. A 5.5 foot void with some fill or gob was encountered at the East Diamond Mine in the Number 9 Coal level. However, examination of the core between the two mines showed fractures extending only 35 feet above the Number 9 Coal.

Pillar strength analyses (Table 10) support pillar crushing in the East Diamond Mine in the Number 11 Coal as the cause for subsidence. The extraction ratio for the panel and entry areas is 80 percent. Calculations indicate inadequate strengths of smaller pillars in both the panel and the entry. Similar calculations for the pillars in the East Diamond Mine in the Number 9 Coal show the entry pillars are capable of supporting the overburden loads but the panel pillars are not large enough.

Analysis of the maps showing mining beneath the Liberty Baptist Church (Figure 20) indicates that part of the church is protected by a larger set of pillars in the Number 11 Coal. The core analysis of drill hole 15 (DH-15, Table 2) shows the Number 11 Coal is crushed. Fracturing extends from the Number 11 Coal to the surface. Extraction ratios are fairly typical for this part of the mine; approximately 80 percent in the panels and 70 percent in the entry system (Table 10). Pillar strength calculations show that the smaller panel pillars should crush at depths greater than 175 feet. The Number 11 Coal is at a depth of 269 feet at this site. The entry pillars are larger than panel pillars and extraction ratios are lower, so these pillars should be capable of supporting the overburden.

The church is sited (Figure 20) above a panel close to the entry pillars in the Number 9 Coal. Core data from DH-15 (Table 2) shows roof collapse in the East Diamond Mine in the Number 9 Coal. Thirteen feet of caved and broken rock were found above the roof. Route 85/70 south of the church shows surface depressions which are typical of sag/trough subsidence.

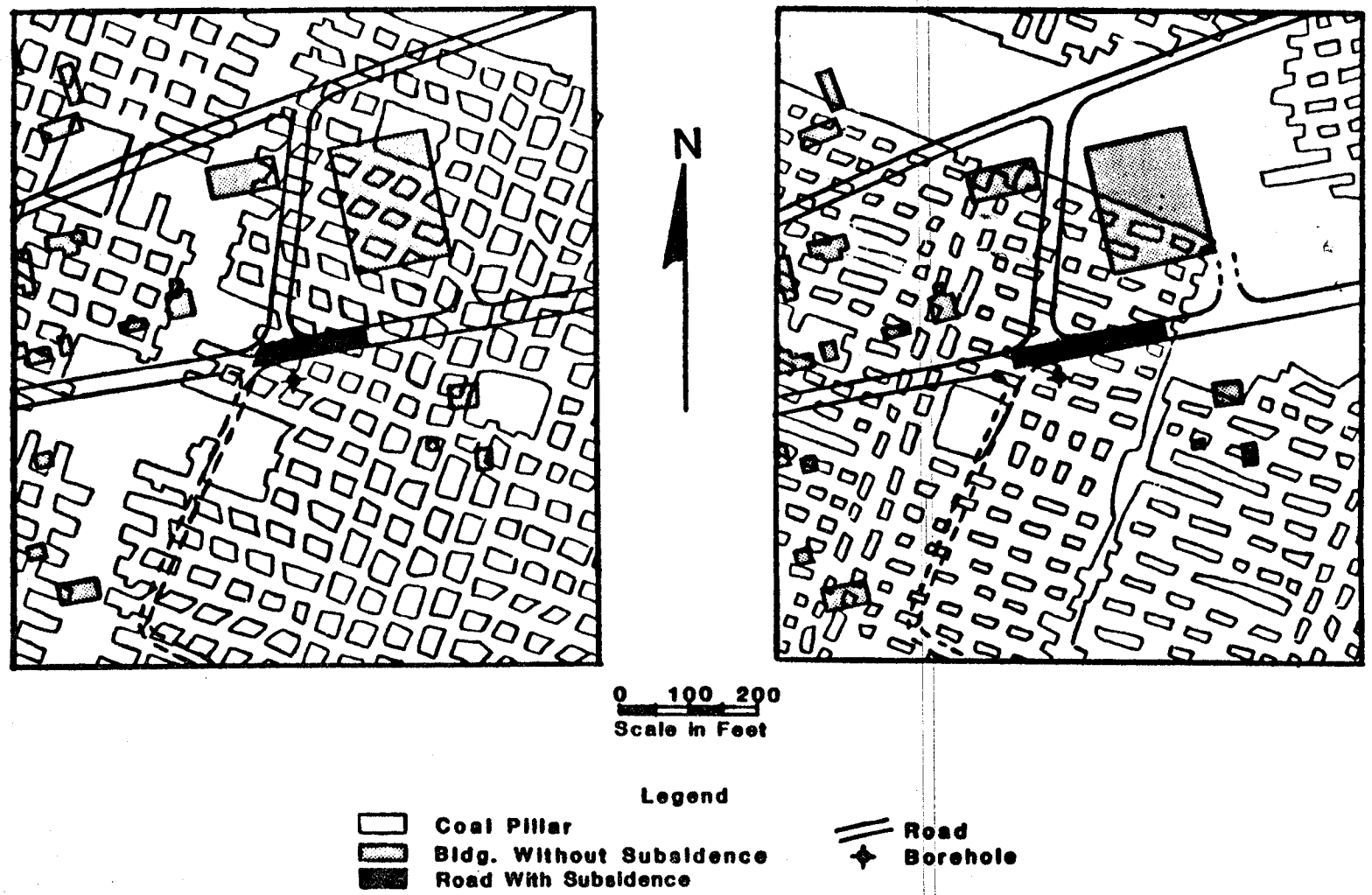

Figure 19. Mine map of Number 11 Coal (right) and Number 9 Coal (left) with cultural features and location of drill hole (DH-13). For more detailed information see Number 11 Coal Map 5B and 6B, Number 9 Coal Map 5C and 6C, and Topographic Map 5A and 6A.

Table 10. Summary of Subarea 6C Pillar Strength Analyses

[See Appendix C for more detail.]

HOLE NUMBER	COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
DH-13	11	PANEL	80	16	6.5	1008	269	192
DH-13	11	ENTRY	80	11	6.5	854	269	206
DH-13	9	PANEL	80	16	5.5	1063	341	203
DH-13	9	ENTRY	50	35	5.5	1754	341	898
DH-15	11	PANEL	80	13	6.5	915	269	175
DH-15	11	ENTRY	70	16	6.5	1008	269	314
DH-15	9	PANEL	65	21	5.5	1281	342	463
DH-15	9	ENTRY	65	21	5.5	1107	342	389
DH-31	11	PANEL	80	14	5	1020	262	205
DH-31	11	ENTRY	80	9	5	1060	262	234
DH-31	9	PANEL	65	17	5	1380	349	513
DH-31	9	ENTRY	60	18	5	1419	349	556
DHM-1	11	PANEL	80	15	7	957	210	211
DHM-1	11	ENTRY*	85	15	7	957	210	144
DHM-1	9	PANEL	80	25	6.5	1284	284	297
DHM-1	9	ENTRY	60	25	6.5	1284	284	503
DH-16	11	PANEL	80	15	6.5	1060	224	234
DH-16	11	ENTRY	70	18	6.5	1069	224	322
DH-16	9	PANEL	75	14	5	980	317	256
DH-16	9	ENTRY	70	18	5	1180	317	355
DH-17	11	PANEL	75	15	6.5	977	204	265
DH-17	11	ENTRY	70	19	6.5	1100	204	331

* Data from drill hole DHM-1 used for depth to mine and overburden thickness but pillar size and percent extraction was calculated for the entry area just south of DHM-1.

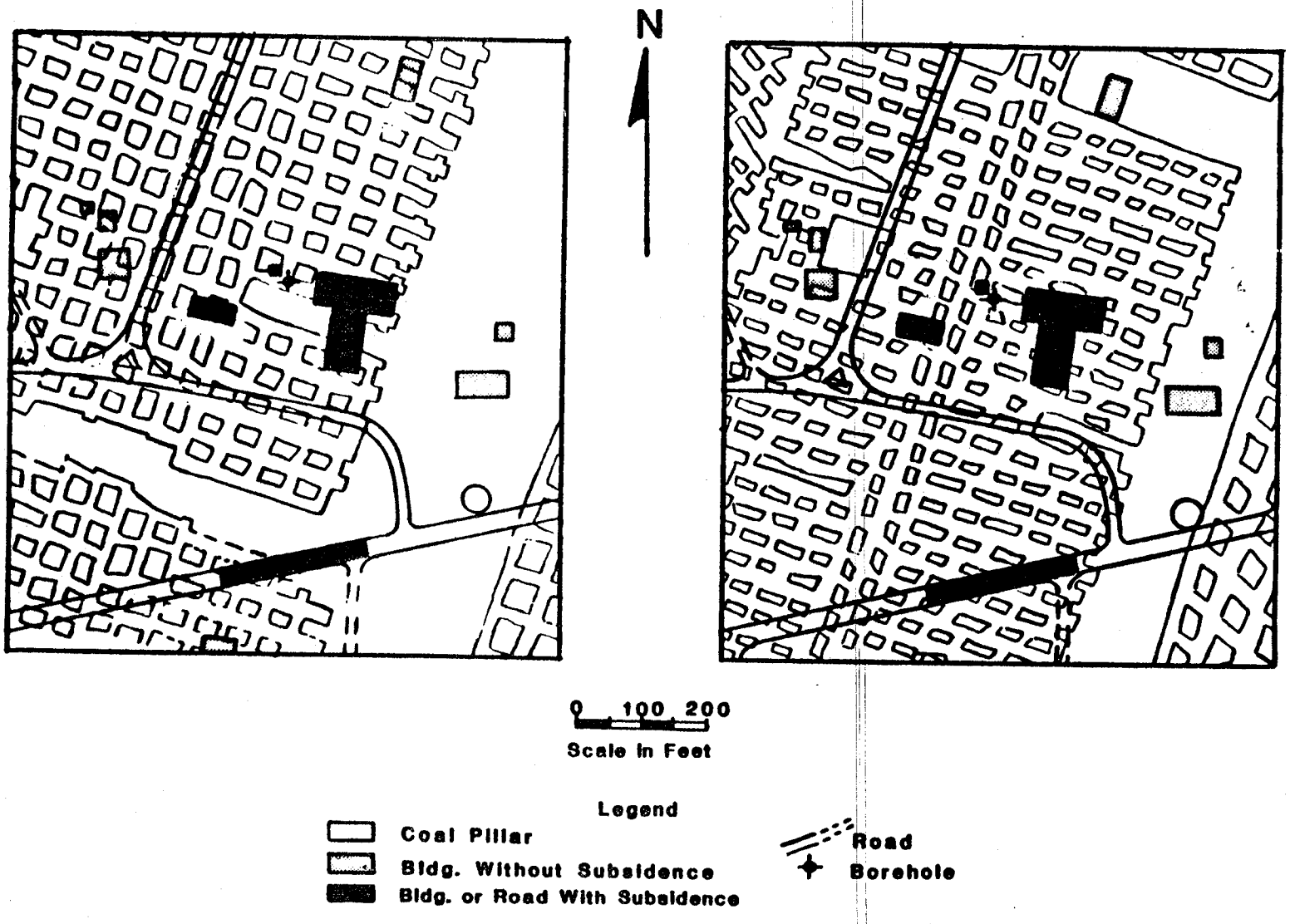

Figure 20. Mine map of Number 11 Coal (right) and Number 9 Coal (left) with cultural features and location of drill hole (DH-15). For more detailed information see Number 11 Coal Map 6B, Number 9 Coal Map 6C and Topographic Map 6A.

The information above suggests that the larger pillars in the Number 11 Coal beneath the church (Figure 20) and the somewhat stronger cross entry pillars under the parsonage have resisted crushing, at least temporarily. However, the panel pillars, and possibly some cross entry pillars, have apparently crushed causing a sag subsidence.

The Cumberland Presbyterian Church is located at the edge of a panel in the East Diamond Mine in the Number 11 Coal, with part of the church above a cross entry and part of it over a barrier pillar (Figure 21). Core log analysis of DH-31 (Table 2) shows both the Number 9 and 11 Coals are in-place. Fractures were observed from the Number 11 Coal to the surface and some fracturing was noted in rock 10 feet above the Number 9 Coal.

Calculation of extraction ratios and pillar strengths (Table 10) indicates that the panel and entry pillars in the East Diamond Mine in the Number 11 Coal are too small to support the overburden loads and at least some of the smaller pillars have probably failed. Apparently the collapse of some pillars near, but not directly under, the church is producing a subsidence depression which reached the church.

The Moore-Stegelman subsidence is occurring above the East Diamond Mine in the Number 11 Coal where entry and panel pillars, as well as a large barrier pillar occur (Figure 22). The Moore house is situated above the edge of a panel and is separated from a large barrier pillar to the south by an entry system. Drill hole DHM-1 (DHM-1) intersected a 7 foot open void in the Number 11 Coal at a depth of 210 feet. Other drilling between the house and the road has shown the entry area to be failing and high concentrations of gas were encountered (Etue and Sydnor, 1984b). This drilling also shows the mine is still intact under the house but pillar strength calculations indicate that the pillars under the house should crush below 144 feet (Table 10).

Interpretation of this information indicates the subsidence trough lies within the highway right-of-way and the Moore house was in the tension zone of this trough prior to the 1982 damage survey. Since then, the trough has expanded beneath the house and the structure is now being affected by compression. There is no evidence of subsidence from the Number 9 Coal extending into the Number 11 Coal mine, although the pillar strength calculations indicate that the smaller panel pillars in the Number 9 Coal mine should fail (Table 10).

The Stegelman residence is located two houses west of the Moore residence. The house is located partly over a large barrier pillar in the East Diamond Mine and partly over a panel. Drill hole 16 (DH-16, Figure 22) was drilled into this barrier pillar (Table 2). Extraction ratios in the East Diamond Mine in the Number 11 Coal are about the same as in the area of the Moore house and the pillar strength calculations indicate pillar crushing should occur at a depth less than the overburden thickness (Table 10). The subsidence is probably related to failure of the pillars in the panel. The house is being pulled apart by the tension generated by the trough subsidence north of the house.

Severe damage was also observed at the Jones residence, located directly east of the Moore house and south of Route 85/70. Numerous cracks were observed in the cellar walls, and in the exterior and interior walls of the house. The southwest corner of the structure has dropped several inches.

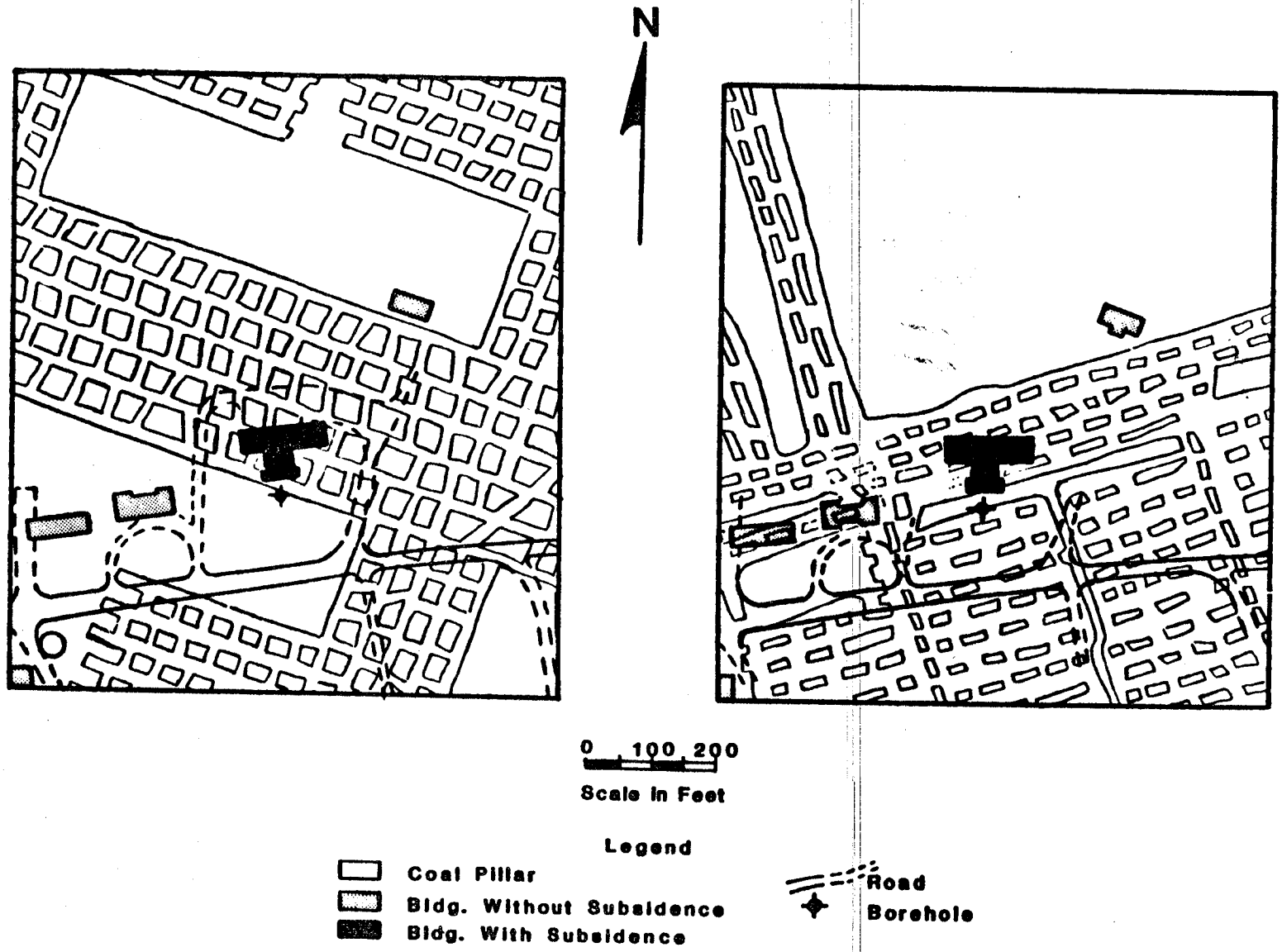

Figure 21. Mine map of Number 11 Coal (right) and Number 9 Coal (left) with cultural features and location of drill hole (DH-31). For more detailed information see Number 11 Coal Map 5B, Number 9 Coal Map 5C and Topographic Map 5A.

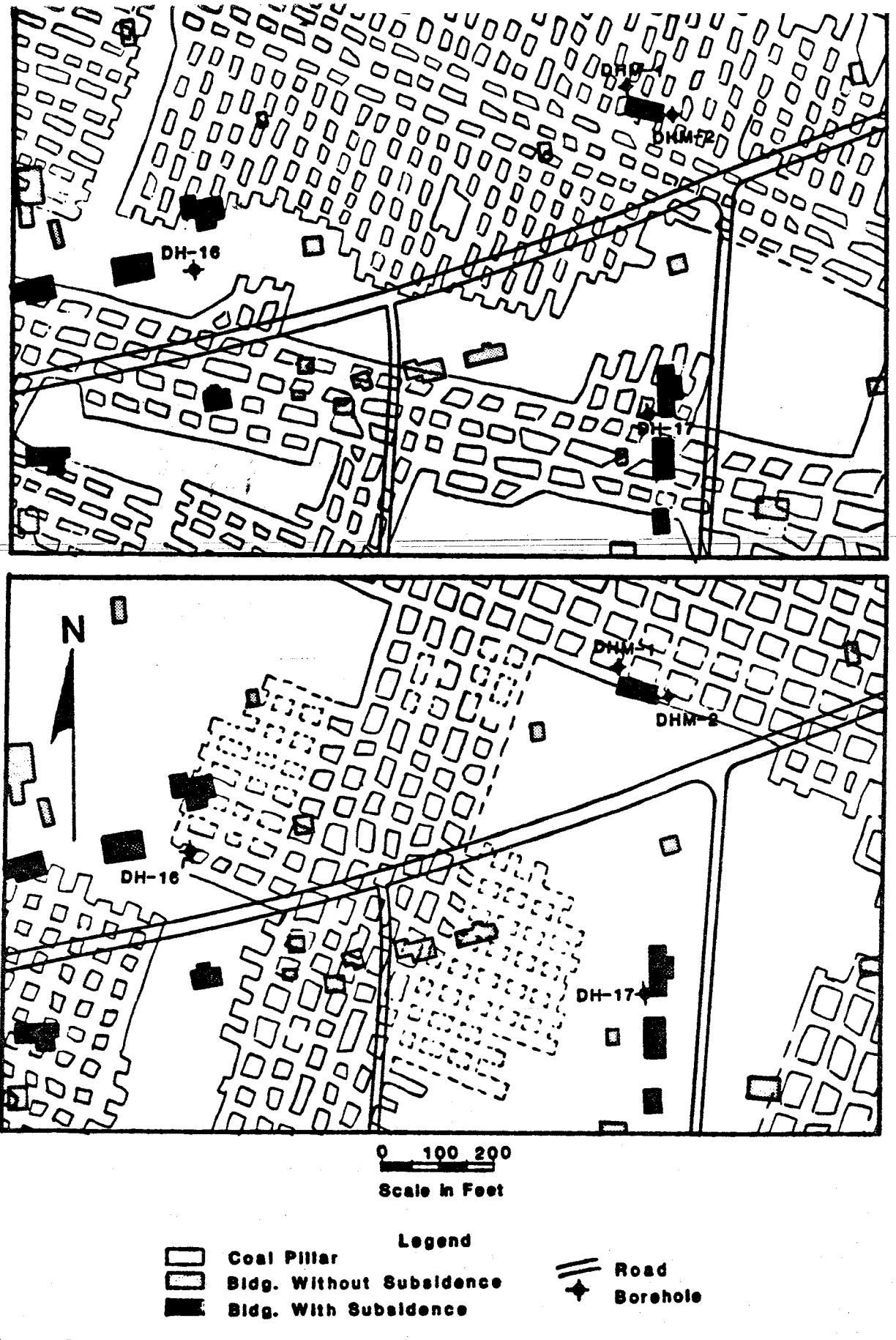

Figure 22. Mine map of Number 11 Coal (top) and Number 9 Coal (bottom) with cultural features and location of drill holes (DH-16, DH-17, DHM-1 and DHM-2). For more detailed information see Number 11 Coal Map 6B, Number 9 Coal Map 6C and Topographic Map 6A.

DH-17 (Figure 22) core contains numerous horizontal and angle fractures scattered throughout the overburden. Drilling found a 4.5 foot roof collapse "gob" area at the depth of the Number 11 Coal (Table 2). Coring into the Number 9 Coal found coal in place. The core between the Number 9 and Number 11 Coals contained a few fractures.

Pillar strength analysis of the East Diamond Mine in the Number 11 Coal shows that the pillars in both the panel and the entry areas are adequate to support the overburden. The mine map, however, indicates the development of a panel directly under the house and extending to the north.

Discussion

Examination of the mine maps for Subarea 6 (Map 5B, 5C, 6B, and 6C) reveals a generally consistent pattern in both mines. However, mine development in the Number 11 Coal has progressed much farther than in the Number 9 Coal. Calculations show that the panel pillars in the Number 11 Coal have a high potential for failure (Table 11), especially in areas where there are a large number of small pillars. The entry pillars are slightly stronger.

Table 11. Summary of Subarea 6 Pillar Strength Analyses

COAL SEAM	PANEL OR ENTRY	% REMOVED	MINIMUM PILLAR WIDTH (ft)	PILLAR HEIGHT (ft)	PILLAR STRENGTH (psi)	DEPTH ROOF (ft)	CRUSH DEPTH (ft)
11	PANEL	80	15	6.3	973	240	210
11	ENTRY	75	16	6.3	1005	240	256
9	PANEL	70	20	5.4	1218	336	347
9	ENTRY	60	25	5.4	1403	336	538

The drilling program in this subarea has shown that there is some overburden stress fracturing between the Number 9 and Number 11 Coals (Table 2), but very little evidence that this failure extends upward to the Number 11 Coal. Pillar strength calculations, however, indicate a potential for pillar failure in the Number 9 Coal which could induce future surface subsidence problems. This could provide a greater vertical movement, since collapse of voids in both seams could occur.

In addition to the extra strength provided by the larger entry and barrier pillars between and around the panels, reserves were deliberately left under older buildings to protect those buildings from mine-related surface subsidence. The location of these larger reserves are shown on Maps 5B, 5C, 6B, and 6C. Buildings over these reserves, however, may not escape surface damage because the upward migration of fractures from subsiding areas could

affect the land surface at least 100 feet laterally from the point of actual mine collapse. When the panel pillars collapse, additional stress is placed in the remaining pillars in the vicinity. The progressive collapse of adjacent pillars in a "domino sequence" causes initial surface sags to expand into elongate troughs.

Conclusions

Crushing of panel pillars in the East Diamond Mine in the Number 11 Coal is the main source of mine-related surface subsidence in Subarea 6. The East Diamond Mine in the Number 9 Coal has substantially lower extraction ratios and larger pillars than those in the Number 11 Coal, which has apparently prevented pillar crushing to date. Drilling evidence indicates some roof falls in parts of mines in the Number 9 Coal, but no evidence was found to indicate a vertical extension of these voids and related fractures to the elevation of the Number 11 Coal.

Mine-related subsidence in this subarea is probably caused by crushing of panel pillars which create trough subsidence at the surface. All of the mines are flooded and are releasing methane and other gases when penetrated by drilling. Because of the small pillars remaining, mine-related surface subsidence can be expected to continue in Subarea 6. Adjustments in existing surface troughs can be expected as void spaces in the rock strata compress or adjacent pillars fail.

CONCLUSION

The Madisonville area has a history of mine-related surface subsidence. The 1982 damage survey (Appendix B) identified 64 cases of possible mine-related damage to surface structures. Further, OSMRE has investigated 18 subsidence complaints within the limits of the Madisonville East and West U.S.G.S. 7.5' topographic quadrangles. As of May 1986, a total of $2,316,174 has been spent in the study area for emergency mine stabilization activity.

Sixteen exploratory holes were drilled during the Madisonville Areawide Subsidence Investigation to investigate specific areas where surface patterns indicated a strong possibility that underground mine failure was affecting the surface. The study also utilized information gathered from other sources, including emergency project drilling programs. Detailed mine map analyses and pillar strength calculations were performed for each of the defined drill sites.

Geotechnical examination of the subsurface conditions in the Madisonville area has established the following findings:

1. Crushed, granulated coal found by drilling into pillars, as well as the high volumes of methane gas flowing from the drill holes, are evidence that the pillars are crushing. There has been no evidence to date that the methane and other gases released by the crushing of the coal pillars is reaching the surface through the subsidence fractures. It is an environmental hazard, however, that should be considered in any area of major surface disturbance associated with failure of the mine overburden.

2. Underground mining in the Madisonville area has always been of the room-and-pillar type with little, if any, pillar pulling or retreat mining.

3. The pattern of room-and-pillar mining developed throughout the area resulted in high extraction ratio in the panels and in some of the panel entries.

4. In the older mines, panel layout and pillar size and shape are more random than in the newer mines, causing mining patterns and extraction ratios to be more variable within each individual mine.

5. There is no evidence that mine and overburden failure in the Number 9 Coal mines had progressed upward to the Number 11 mines or that mines in the Number 9 Coal are involved in surface subsidence events.

Evidence collected during the study strongly indicates pillar crushing (Subareas 1, 2, 4, 5 and 6) and roof collapse (Subarea 3), with accompanying roof-to-floor closure, as the dominant mechanisms for failure in the Madisonville area. Data suggest that pillars fail sequentially until a support system is encountered that is large enough to carry the weight of the overburden. The size of the surface disturbance which results is determined by the location of the failed pillar(s), i.e., in the center of a mined out panel or near the edge. The surface expressions of the progressive failures are "migrating" subsidence troughs at the surface. A study by McKim (1985) showed there is a potential for pillar punching in the Madisonville area, but none was detected in this study.

Residents of the Madisonville area are encouraged to inquire into the mine conditions beneath their homes and, if necessary, take advantage of mine subsidence protection offered by the State Risk and Insurance Services. For more information regarding the mine subsidence insurance program, contact:

Leroy Morgan, Director
State Risk and Insurance Services
229 West Main Street
Frankfort, Kentucky 40601
(502) 564-6055

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APPENDIX A - GEOLOGY AND CORE DATA

The strata in the study area (Figure A-1) consist of up to 50 feet of sandy shale, shale, siltstone, the Number 15 Coal, and approximately 20 feet of sandy, silty, shaley strata; all of which overlie the 20 to 40 foot thick Madisonville Limestone Member. The Madisonville Limestone Member itself consists of three separate limestone units separated by grayish-brown claystones in the upper part and by grayish, fine-grained, sandstone interbedded with shale in the lower part.

The 145 to 155 feet of strata between the Madisonville Limestone and the Number 13 Coal (Figure A-1) consist of interfingering layers of shale, siltstone and sandstone similar to the units above the Madisonville Limestone Member. There are a few thin, discontinuous coal and limestone beds with some thin zones of siderite (iron carbonate) nodules, particularly in the lower part. The lower part usually contains the Anvil Rock Sandstone Member (Hutchinson, 1912). The Number 13 Coal ranges in thickness from 0 to 50 inches and is locally strip-mined where the overburden is thin; it sometimes interfingers with the Anvil Rock Sandstone.

The 28 to 42 foot thick strata from the Number 13 Coal to the top of the Number 12 Coal consists of underclay, interbedded gray to dark-gray shale with calcareous shale and siderite bands. The Anvil Rock Sandstone may occupy most of this interval. The Number 12 Coal ranges in thickness from 0 to 75 inches within the study area and is separated from the Number 11 Coal by 3 to 6 feet of the massive, finely crystalline-to-dense Providence Limestone Member with some interbedded thin, fossiliferous black shale beds. This limestone marks the base of Upper Pennsylvanian age Sturgis Formation.

The Sturgis Formation is underlain by the Middle Pennsylvanian age Carbondale Formation (Figure A-1). The uppermost unit of the Carbondale Formation is the Number 11 Coal, which ranges from 10 to 75 inches thick and is underlain by 3 to 6 feet of underclay and shale, 15 feet of sandstone, 0 to 50 inches of the Number 10 Coal, 35 to 50 feet of sandstone and sandy shale, and 20 to 30 feet of medium-gray to black shale, which contains abundant pyrite and siderite concretions and plant fossils and is massive when fresh, but fissile when weathered. This shale unit is underlain by the Number 9 Coal, which ranges between 48 to 64 inches thick, and an underclay of 12 to 32 inches.

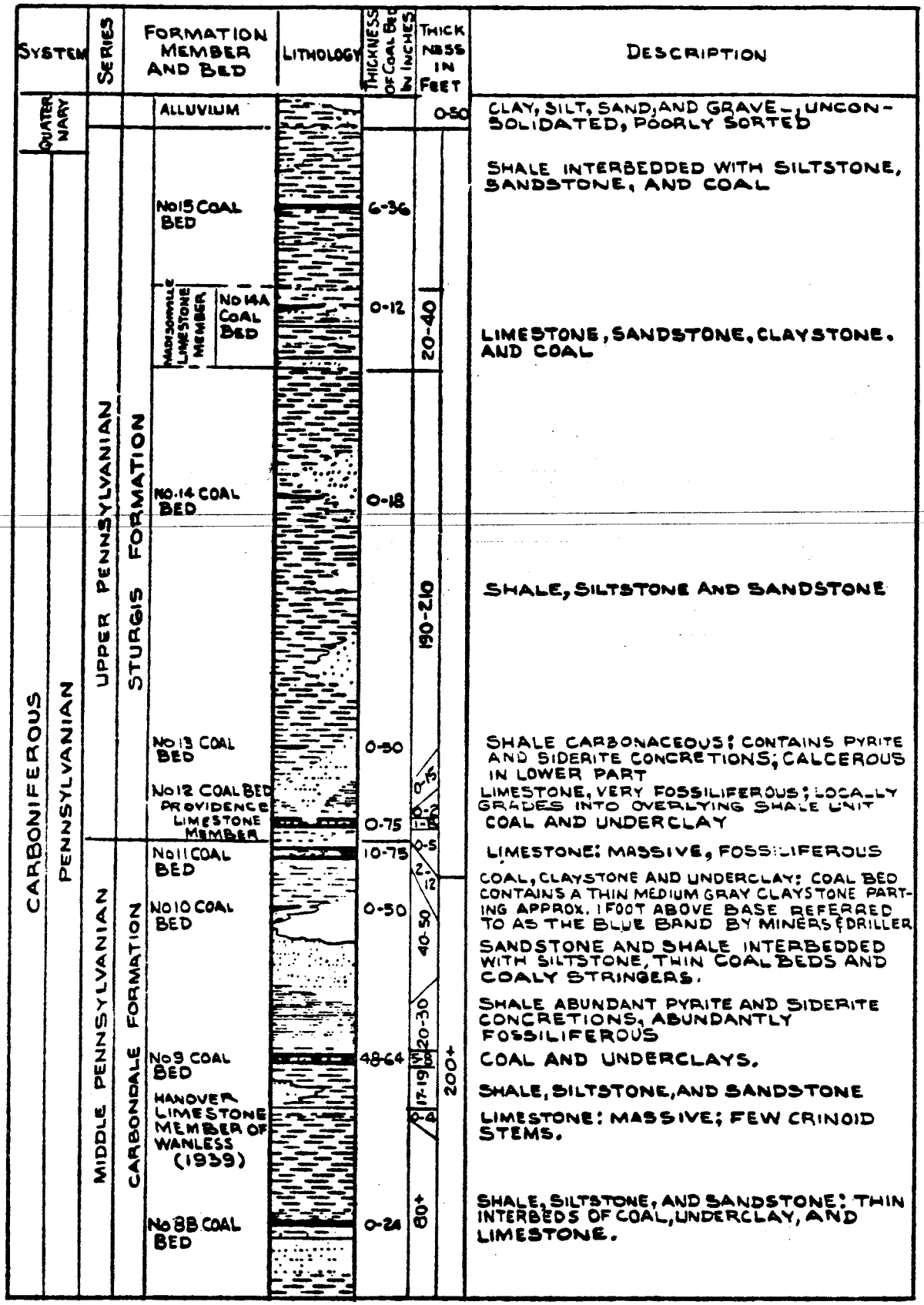


Figure A-1. Generalized geologic section of the Madisonville, Kentucky area. (From U.S.G.S. GQ-252, 1963 and Kehn, 1973.)

Core Data

Logs of 16 cores obtained from the Madisonville area are attached as Plates 1, 2, and 3. Each plate is a cross section showing the vertical and lateral distribution of the stratigraphic units throughout the study area. A base map (Figure A-2) shows the cross section lines and the location of the boreholes projected to them.

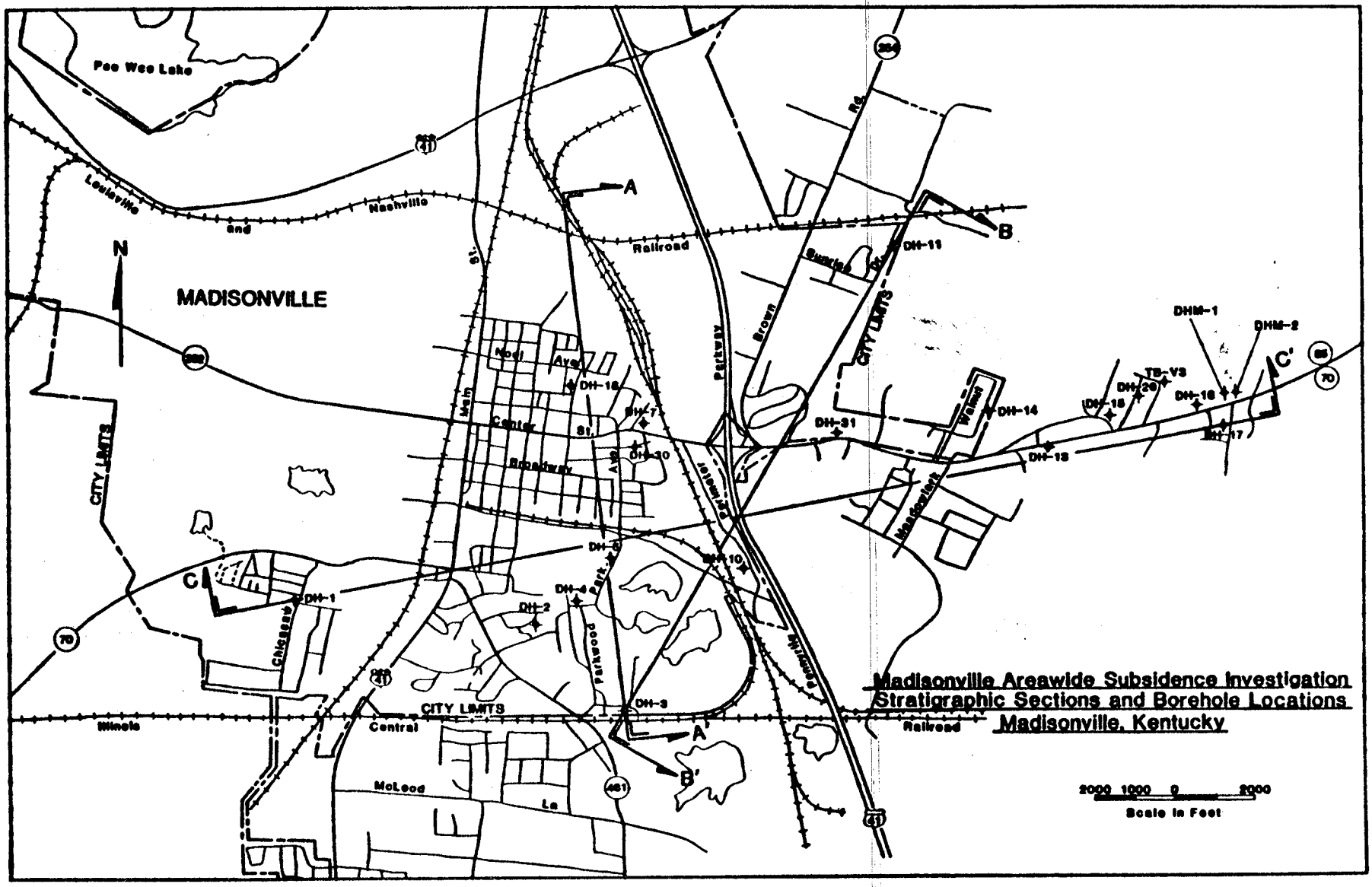
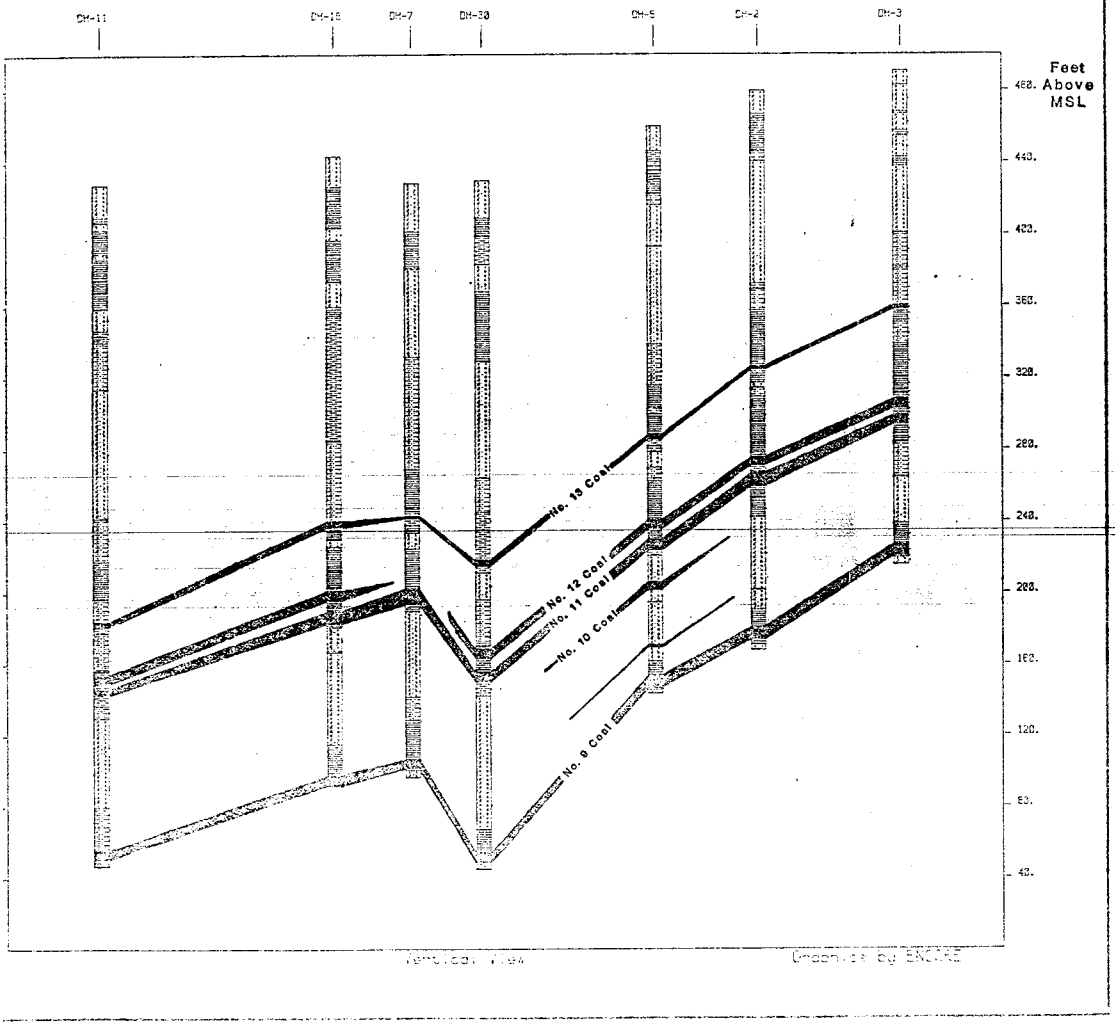


Figure A-2. Location of cross sections and boreholes in the Madisonville, Kentucky area.

PLATE 1

DISONVILLE A-A'



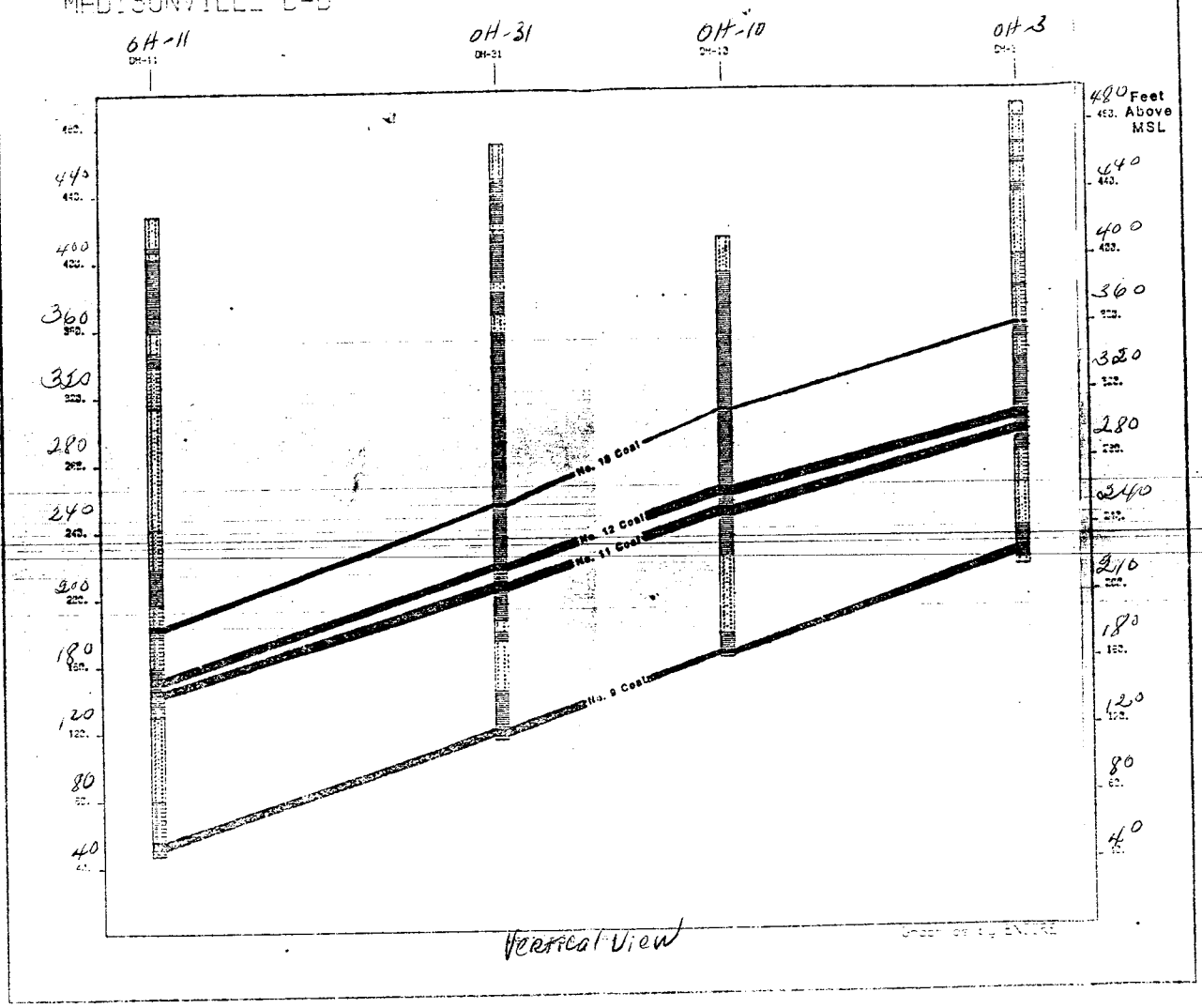
LEGEND

- Limestone
- Siltstone
- Shale
- Coal
- Clay
- Sandstone

Vertical Exaggeration = 25

PLATE 2

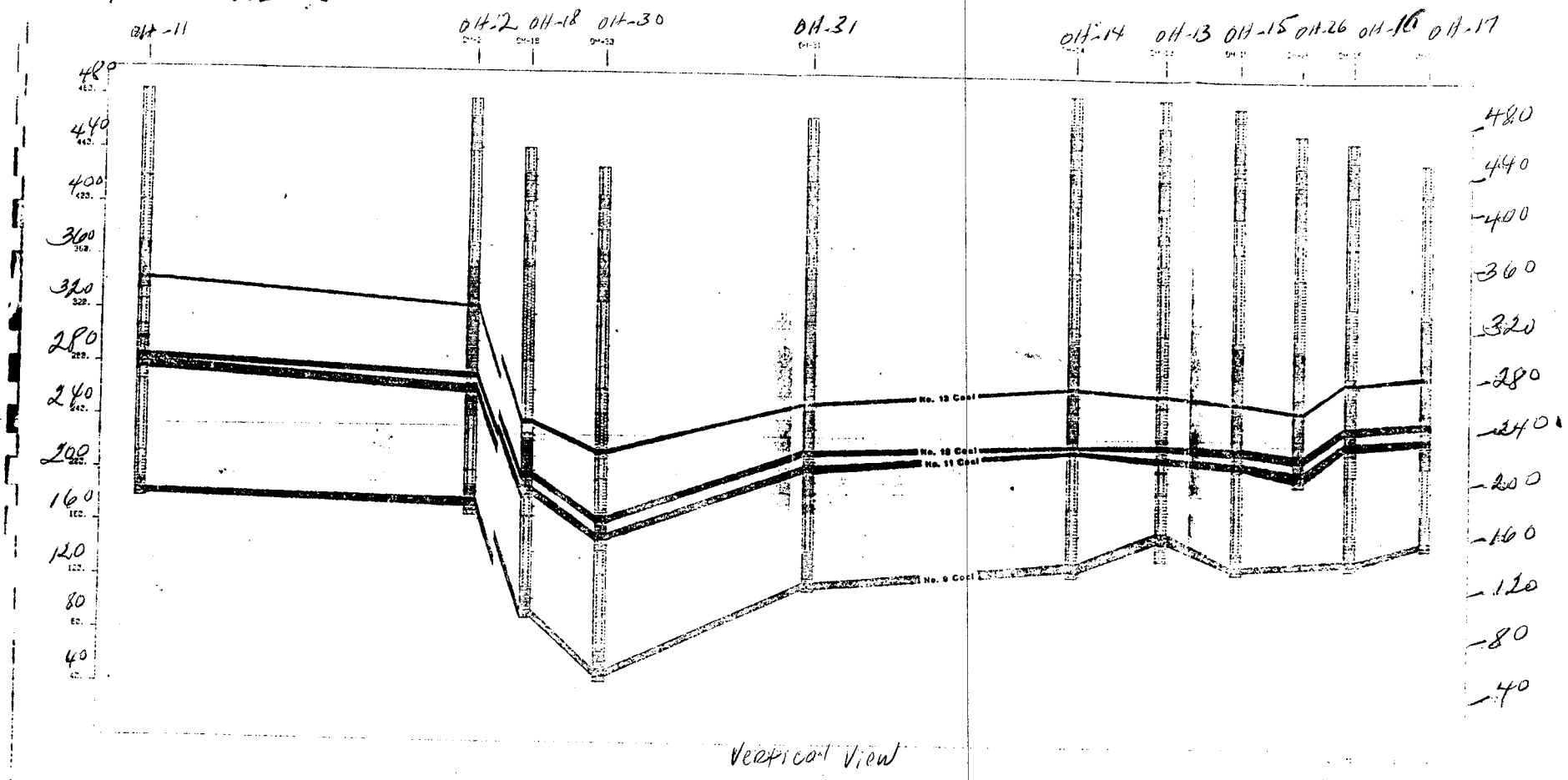
MADISONVILLE B-B



Vertical View

PLATE 3

MADISONVILLE C-C



Vertical View

APPENDIX B - SUBSIDENCE DAMAGE SURVEY

At each site the extent of damage was evaluated and the history of the subsidence event which reportedly caused the damage documented. While evaluating events at a particular location, OSMRE personnel also investigated nearby areas for evidence of surface subsidence and additional damaged structures.

Scales used during the damage survey are shown below.

INTENSITY

1. Minor cracking without evidence of house movement.

2. Many small cracks with or without evident house movement.

3. House movement in inches, with inside and outside evidence. Foundation cracks with "Z"-shaped and horizontal cracks having separations of less than 1 inch.

4. Severe movement greater than 12 inches, with cracks, bowed walls and bulging basement floors.

5. Damage greater than No. 4 plus utility damage. Potential for some degree of building failure.

TIMING

a. Currently happening.

b. Within last two years.

c. Two to five years ago.

d. More than five years ago.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 1 REPORT #: 1

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: John Edminston

ADDRESS: 813 Chicasaw Drive, Madisonville

TELEPHONE NUMBER: 825-2885

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same, and others nearby.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 1-2
TIMING (a-c): a

Some cracks in plaster. Several doors sticking. Had to jack along east-west center-line of house. Southwest corner of house has Z-shaped breaks in foundation blocks that have 1/2 inch openings. Horizontal break in foundation where wall bulges.

House just north has northeast corner broken (2a). House to northwest has southeast corner down, with several horizontal and Z-shaped breaks in the brick facing (2a). House just south has both northwest and southwest corners repaired and then damaged by continued active movement (2a). House to the east across the street has several cracks recently repaired on east wall (2a).

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 1

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Ronnie Hartford

ADDRESS: 129 Woodlawn Drive (Montrose Subdivision)

TELEPHONE NUMBER: 825-2804

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORTED BY CITIZEN:

Bricks cracking in basement. Would like to know if it is caused by subsidence.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley and T. Cook

INVESTIGATED: 8-4-82 INTENSITY (1-5): 2-3 TIMING (a-c): a

House is about 20 years old. Its earlier history is not known. Currently active since November (1981) with all cracks getting larger. Outside has horizontal cracks at sillplate along north side and all corners have active Z-shaped cracks. The basement foundation has vertical cracks which pass through the bricks on both the north and south side. Z-shaped cracks along south and west side at southwest corner. Water has been entering several cracks requiring the use of a sump pump. Cellar floor has north-south crack. Living room ceiling has west-east crack in plaster. The sense of motion is to drop toward the northwest and the southeast part seems stable.

White brick house across street (Jack Jewell) has some problems. House at 114 Woodlawn observed to have northwest corner down.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 2

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Steve Emery

ADDRESS: 110 Hillcrest Drive (Montrose Subdivision)

TELEPHONE NUMBER: 821-1301

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

House built into hill--up-hill part breaking up.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley & T. Cook

INVESTIGATED: 8-4-82 INTENSITY (1-5): 1 TIMING (a-c): b?

House about 18 years old but purchased by present owner in January 1982. Few Z-shaped cracks in brick. Slight bow in east end. Sense of movement to southeast.

Next house west (uphill) also experiencing problems. Terry Cullen (Federal Mine Inspector) was not home at time of survey.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 3

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Marvin Dunn

ADDRESS: 252 Hillcrest Drive, Madisonville (Montrose Subdivision)

TELEPHONE NUMBER: 821-5298

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

House built around 1956-57 and within 1 year sidewalks in front and along house had cracked. Inside, two plastered rooms have large cracks. Others ash paneled. Several plaster cracks covered with ash beams. Mr. Dunn has a mine map (Peabody) showing Woodlawn Drive just south was legally mined. He believes his coal was stolen although the house was advertised as not undermined.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-4-82 INTENSITY (1-5): 3 TIMING (a-c): b

Major cracking occurred within first 2 years but activity has continued for more than 24 years. Cellar foundation cracks have caused water problems. West end cracked prior to 1966, north wall has bowed inward. Cracks greater than 1 inch show that carport has heaved. Rotation both toward east and west.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 4

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Don Maddern

ADDRESS: 541 Park Avenue, Madisonville

TELEPHONE NUMBER: Home: 821-9567 Office: 821-1744

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORTED BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-30-82 INTENSITY (1-5): 2 TIMING (a-c): a

They bought the house 2 years ago. South wall started to crack and bow during an earthquake a few years ago. The garage doorway and walls south, southeast, and west have cracked. The walk and driveway by doors have cracks as well as cracks in the retaining wall south of the garage and in the garage floor. Inside plaster is reported to continue to break at this time.

House two doors south had north wall break-up to the degree that it had to be replaced. Large crack in ground southwest of this area.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 5

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Judge Lawrence Gorden (Hopkins County District Court)

ADDRESS: 601 Montrose Drive, Madisonville

TELEPHONE NUMBER: Home: 821-3781 Office: 821-3174

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same. Home--near armory/city park.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Built house about 22 years ago (1960). A few years later subsidence occurred from old Sunset Mine. Sunset is minedout/abandoned, and openings closed over.

Ground cracked. House supports sagging and floors sagging. The whole area was affected in this way.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-3-82 INTENSITY (1-5): 2-3 TIMING (a-c): a

Subsidence occurred about 10 years after the Sunset Mine was abandoned. Both the inside and the outside has continued to show slow continuous damage for 20-22 years. Motion seems to be down toward the west. Foundation walls bulging inward and have both horizontal and Z-shaped cracks. Brick facing on west end of house replaced this year (1982). [Note: Several houses in this area may have extensive surface repair which now obscures past problems!!]

Parkwood Drive had several houses that experienced major subsidence. Apparently, casualty losses were allowed by the IRS providing some relief for those landowners affected. The house southeast across the street was most severely strained, almost to the point of total loss, during the earlier subsidence cycle.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 6

DATE RECEIVED: 8-3-82

NAME OF PERSON REPORTING: L. Courington

ADDRESS: 1193 Grapevine, Madisonville (Corner of Hickory Hollow)

TELEPHONE NUMBER: Not given.

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Undermined 10-12 years ago probably by Coil Mine (not possible GCK). Noticed activity for last 5 years.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 1 TIMING (a-c): a

House is over crawl space. Many plaster cracks (sheetrock) especially over doors. Doors and windows sticking. Walls in northwest corner cracked on inside. Bricks on northwest corner evidence dropping. Garage has cracks in cement blocks and the floor is broken. The west side of the house seems most affected.

House on other side of Hickory has also been affected.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 7

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: James H. Harris

ADDRESS: 119 Spence Avenue, Madisonville (off Grapevine)

TELEPHONE NUMBER: 821-1428

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks across basement. Had to lower gutters 6 inches.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 1-2 TIMING (a-c): a

Activity began about 2 or 3 years ago. Horizontal cracks in north wall and wall bows inward. West wall active prior to 2 years ago. Horizontal and vertical cracks in south wall near southwest corner. Southwest end (corner) seems to be sinking.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 8

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Arthur Jones

ADDRESS: 194 Spicer Avenue, Madisonville (off Grapevine)

TELEPHONE NUMBER: 825-3929

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Five or six cracks in his walls and foundation.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-30-82 INTENSITY (1-5): 1 TIMING (a-c): a

House is about 6 years old. Northwest corner is dropping based on cracks. Front step slab is cracked and down 1/2 inch in the middle. Driveway is broken. Inside plasterboards have several cracks. Door frames are not square and doors stick.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 2 REPORT #: 9

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: B. H. Crabtree (Lives in Hansen)
Rents to Don Yates

ADDRESS: 265 Reed Avenue (Madisonville) behind Grapevine School

TELEPHONE NUMBER: 322-8857

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Bricks breaking on the house. House settled 1961 and has probably been stable for past 10 years. Several other houses are affected including one next door and one across the street.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 3 TIMING (a-c): a,b

Brick wall on north side of house is pulling away. House seems to be rotating south and southeast. Z-shaped and horizontal cracks in foundation are actively opening. Other houses affected: house next door to east (3a) and third house east (2a) both lower. House to southwest has wall caving in and concrete front porch recently fell off (2a). Originally, an open crack developed that ran across the street and passed through the Crabtree house.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 4 REPORT #: 1

DATE RECEIVED: 8-4-82

NAME OF PERSON REPORTING: Mr. Tucker from Tucson, Arizona. (Owned house for last 4 years.)

ADDRESS: 332 Park Avenue, Madisonville

TELEPHONE NUMBER: John D. Woods (tenant): 821-2175

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks have developed in foundation and walls inside. Foundation is cracked and has shifted, probably in the last 2 years, and certainly since Mr. Tucker bought the house 4 years ago.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 1+ TIMING (a-c): a

Several plaster cracks. Doors sticking. Z-shaped cracks in outside foundation walls. Southwest corner dropping. Southeast corner dropping. Patio foundation has shifted to west about 1 inch. Sidewalk cracked. Kitchen sink has pulled toward west away from the wall.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 4 REPORT #: 2

DATE RECEIVED: 8-4-82

NAME OF PERSON REPORTING: Margaret Harris

ADDRESS: 221 Park Avenue, Madisonville

TELEPHONE NUMBER: 821-5988

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Ground gases. Has had trouble for 2 years--Western Kentucky Gas Company expert from Owensboro checked and called it ground gases.

Has had to do expensive protective work against these gases.

Hopes you might identify and help, although she is not aware of subsidence as such.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G.C. Kelley

INVESTIGATED: 8-4-82 INTENSITY (1-5): 1+ TIMING (a-c): a

Has lived here 21 years. Talked with husband about this over 8 years ago. About 3 years ago had tests by Western Kentucky Gas Company. They have dug out a drain and replaced it and replaced the furnace. Have filled cracks in basement floor for water problems. Both she and her mother are periodically sick. Last summer (1981), mother would sit and feel like *vomiting. She has had several medical tests such as sugar--all seems well, yet she still feels sick. Condition clears up when away from home for several days! Jim Potts has some problems with his garage--also got sick!

A hole keeps opening at southeast corner which has been active at least 1 year. A small sinkhole is present south of house. House moved south about three years ago--ground cracked about 12 years ago during earthquake (4.+) and cellar and bedroom windows cracked.

Front walk broken and steps have dropped about 1 foot over many years (soil or slump rotation?) House just north has sticking doors.

[Note: I had several air samples taken and analyzed. Results were within normal air sample ranges. GCK]

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 4 REPORT #: 3

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Horace Cates

ADDRESS: Business behind Wendy's north of East Center Street

TELEPHONE NUMBER: Home: 821-1747 Business: 821-4244

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Have some damage there from mine settlement which happened a month or so ago.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 2+ TIMING (a-c): a

In office: doors and cabinet doors won't stick or shut. Paneling popped late March 1982. Office only 3 or 4 years old.

In shop: cracks in floor and walls. Three Z-shaped cracks in block wall at back (north). One inch crack repaired but it is still active. East wall is away from floor--floor seems to have pulled west. Driveway is pulled (west) away from building foundation.

Metal building to west dropped 2-4 inches. (See following two reports.)

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 4 REPORT #: 4

DATE RECEIVED: 8-6-82

NAME OF PERSON REPORTING: Horace Cates (at time of his investigation)

ADDRESS: East Center Street (Next to Long John Silver Restaurant.)

TELEPHONE NUMBER: Not given.

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Reported by Cates as having occurred at the same time as his March 1982 events.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 3+ TIMING (a-c): a

(External observations only--no contact with owner.) Northeast corner of building has dropped about 6 inches. Metal siding and windows have been broken. Sheetmetal placed over windows, after they broke, has been twisted. Concrete floorslab has a 2 inch open crack.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 4 REPORT #: 5

DATE RECEIVED: 8-6-82

NAME OF PERSON REPORTING: Horace Cates (At time of his subsidence investigation.)

ADDRESS: Off East Center Street behind (north) of Jorden's.

TELEPHONE NUMBER: Not given.

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 2 TIMING (a-c): a

(External observations only.) Cement block building that has several Z-shaped and horizontal cracks. South east corner cracks indicated it is down. North wall also cracked. This building also strained in March 1982.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 5 REPORT #: 1

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Bremen Ferrell, Sr.

ADDRESS: 1150 Pepper Drive, Madisonville

TELEPHONE NUMBER: 821-8839

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Serious subsidence damage.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-30-82 INTENSITY (1-5): 3 TIMING (a-c): a-b

Initial problem began to develop about 2 years ago (1980). Driveway and carport cracked. The house dropped about 5 inches toward the northeast then and has continued (down about 8 inches now). Twisting of the house caused 2 x 4s to go through the roof. The shed in back has also settled as has the lawn (3 inches). Cracks in siding have opened 2 inches or more. Crack crossing road has entered lawn and killed shrub.

The house is now sinking toward northwest.

He showed me a 100 foot wide sinkhole behind his property and noted that several truck loads of fill had been dumped into it. It was still active, collected water and worried families with children. Trees in and around the hole were dead apparently due to the wetness caused by water accumulations.

A trough subsidence that crosses the road nearby has sunk about 3 feet. Other troughs are evident in and around this subdivision.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 5 REPORT #: 2

DATE RECEIVED: 7-30-86

NAME OF PERSON REPORTING: Richard Lamb

ADDRESS: 1170 Pepper Drive, Madisonville

TELEPHONE NUMBER: 812-5639 (Call Friday, as he will be absent till then)

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

(Maybe same as address above) Owns house and others nearby.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

No details provided on telephone.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-30-82 INTENSITY (1-5): 2 TIMING (a-c): a

Owner not contacted directly, but Mr. Ferrell next door was aware of the damages suffered at this location. Essentially, interior walls, ceiling (plaster) cracked and actively opening. Some doors and windows sticking. Exterior walls have cracks.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 5 REPORT #: 3

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Lucian Johnson

ADDRESS: 801 Brown Road, Madisonville

TELEPHONE NUMBER: 821-1913

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Off Brown Road east of the Pepper Drive Development.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

1. sinking in heavily timbered area, timber dead (2 occurrences); 2. sinking in pond, vegetation dead; and, 3. earth cracking and souring (2 occurrences).

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-3-82 INTENSITY (1-5): 1? TIMING (a-c): a,b

(Location of sinks located on field map.) This farm has the sink reported behind the houses on Pepper Drive that have been active for several years. Landowner showed me 2 additional sinks with standing water and dead timber. Cracks and sinks have also occurred in the fields. Time has obscured most linear scars. Since the buildings are not occupied the damage is not considered great. Since the couple that own and work this farm are in their nineties, this land may become available for housing development in the near future.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 1

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Shelly Moore

ADDRESS: Route 3, Route 85/70, Madisonville (at Pond River Road)

TELEPHONE NUMBER: 821-3320

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Large house with many cracks. Never reported before.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 3 TIMING (a-c): a

Brick house that has horizontal and Z-shaped cracks in bricks and foundation on all sides. Garage floor at west end of house has severe problems with broken floor and foundation. The house may be stable along an east west mid-line and rotating toward both the north and south. A major drop has occurred in Route 85 at the intersection with Pond River Road just southeast from the house.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 2

DATE RECEIVED: 8-5-82

NAME OF PERSON REPORTING: Johnny Toms (for his aunt, Dolly Moore)

ADDRESS: Route 3, Box 130, Madisonville

TELEPHONE NUMBER: Peabody Mine: 825-4600 Home: 821-0479

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Bricks are cracked. Patio is broken, and breaking away.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-5-82 INTENSITY (1-5): 2 TIMING (a-c): a

Z-shaped cracks on west end. Horizontal cracks along south side and southwest corner. Retaining wall by patio broken and patio cracked. Patio pulled away from house on south side. Z-shaped and horizontal cracks on east end. Front (north) seems good, but bricks pulled away around door. Patio door opens hard. Few cracks evident inside. Active last few years. House due north across Route 85 has problems (see Denver Tomes sheet). House next door (east) has problems (Harold Puckett sheet).

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 3

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Harold Puckett

ADDRESS: Route 3, Box 133, Madisonville, (Country Boy Farm)

TELEPHONE NUMBER: 821-1776

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

House--cracks in living room, have been paneled over, large cracks in ceiling. Barn--cracks in foundation.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-5-82 INTENSITY (1-5): 2 TIMING (a-c): a

Brick house with crawl space. Many active cracks inside--some have been hidden with panels and beams. A 1 inch wide crack extends north-south. Front slab cracked. Vertical cracks in front (north) and west sides extend through bricks. South side has vertical and horizontal cracks. The foundation for a room addition on the south side has vertical and Z-shaped cracks on west, south, and east side. Patio on east pulling toward east and it has vertical cracks in the foundation. Windows and frames rattle during surface mining explosions. At least four houses to north across Route 85 have damage (Well, Metser, Green, McDonald).

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 4

DATE RECEIVED: 8-3-82

NAME OF PERSON REPORTING: Denver Tomes

ADDRESS: Route #3, Route 85/70, Madisonville (second house east of the Christ Assembly Church)

TELEPHONE NUMBER: 821-7700

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracking inside house, has already been fixed twice. Chimney and basement wall is severely cracked.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-5-82 INTENSITY (1-5): 2 TIMING (a-c): a

Many cracks in plasterboard on first floor. Bedroom has sheetrock compressed near floor. Many Z-shaped cracks in foundation along west and north sides. Cellar floor dips northwest. South foundation wall paneled--water enters behind paneling. Vertical cracks pass through bricks in many places on north side--water enters. Chimney has vertical, horizontal, and Z-shaped cracks and cannot be used. Active for 2 years or more and still active. A 2-to-3 inch wide by 2-300 foot long crack developed 4 or 5 years ago that crossed the road, lawn, extended through the house and into the woods.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 5

DATE RECEIVED: 7-29-82

NAME OF PERSON REPORTING: Daniel Knight

ADDRESS: Liberty Baptist Church, Route 85/70, Madisonville

TELEPHONE NUMBER: 821-2687 or 821-1739

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Church and parsonage.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Windows and walls bowed and cracked.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-29-82 INTENSITY (1-5): 3 TIMING (a-c): a

Church has shifted several inches. Windows and walls are bowed. Walls have vertical, horizontal and Z-shaped cracks at both ends of new addition. Lawn and parking areas have settled and cracked. Septic system for house required redraining.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 6

DATE RECEIVED: 8-5-82

NAME OF PERSON REPORTING: Brasie Jones

ADDRESS: Route 5, Box 278, Pond River Road, Madisonville

TELEPHONE NUMBER: 825-4498

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Walls and foundation breaking in many places. Has called Cimmerron Coal Company three or four times.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-5-82 INTENSITY (1-5): 4 TIMING (a-c): a

Damage has developed over past 3 years. Horizontal cracks on north side by patio. Patio is cracked and pulled away from house. Vertical cracks at northeast corner extend through bricks. Retaining wall rotating into bank at base although in position at top. Front porch cracked. Two Z-shaped cracks in front wall are open 1/2 inch or more. South wall bowed and southeast corner down. Bricks are pulled away from wall. Horizontal cracks in south wall. Southwest corner down about 2 inches--both vertical and Z-shaped cracks present. All cellar walls bowed in--west side worse than east side; all have vertical, horizontal and Z-shaped cracks. Wall near middle of cellar is bowed toward north. Many sheetrock cracks in walls and ceiling. Punching and crushing of the sheetrock has also occurred.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 7

DATE REC VED: 8-5-82

NAME OF] SON REPORTING: Alan Polk

ADDRESS: oute 5, Box 280, Pond River Road, Madisonville (Next to B. Jones)

TELEPHONE NUMBER: 825-0882

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Wooden house is shifting and breaking.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-5-82 INTENSITY (1-5): 1-2 TIMING (a-c): a

Kitchen door is warped and archway twisted in last 18 months. Sheetrock seams are opening. House about 33 years old but a new part only 4 years old has been damaged in last 6 months. Some cracks have opened in last 2 months. Back porch is down 8 inches in a 10 foot span. The foundation has 6 vertical cracks along south side and 2 on north. Several horizontal cracks occur in foundation.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 8

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Donald L. Johnson

ADDRESS: Route 5, Box 287, Pond River Road, Madisonville

TELEPHONE NUMBER: 821-4580

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Seaming in bricks cracking lately. Also, settlement in house possibly due to Cimmerron blasting.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-5-82 INTENSITY (1-5): 1 TIMING (a-c): a

Some doors sticking. Activity began about 2 years ago. Noticed an increase in blasting last year. Patio corner down at northwest corner and along west side. South end of garage doors cracked at edges and by windows. Very minor at this time.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 9

DATE RECEIVED: 7-31-82

NAME OF PERSON REPORTING: Bailey

ADDRESS: 125A Continental Drive, Madisonville

TELEPHONE NUMBER: Not given.

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 5 TIMING (a-c): a

Most damage occurred in November of 1979 at same time as many others on this street and in this area. Four on this street are in a lawsuit.

Bricks, wall foundation, and cellar floor very badly broken with 4-6 inch open spaces. Gas supply pipe has broken four times. Movement continues.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 10

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Luther Ferguson

ADDRESS: 1670 Continental Drive, Madisonville

TELEPHONE NUMBER: 821-6821

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same--others also affected along Continental Drive.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 3+ TIMING (a-c): a-b

House has crawl space. Front is 8 inch lower to west (toward Continental Drive). Shift was sudden with almost all motion occurring in one day in August of 1979 or 1980. Same day as others, and also the bad one across the street. Not many cracks developed. Owner not sure if related to explosions.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 11

DATE RECEIVED: 8-3-82

NAME OF PERSON REPORTING: Terry Norman

ADDRESS: 1688 Continental Drive, Madisonville

TELEPHONE NUMBER: 821-4869

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Sidewalks and brickwork pulling away from house. Blocks in foundation in back cracking in seams. Doors shutting tight and sheetrock cracking in corners in bath, kitchen and hallway.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-4-82 INTENSITY (1-5): 1-2 TIMING (a-c): a

Conditions observed that were reported above. Brickwork pulled about 1/2 inch from house. Few cracks in house or outside, but it is active.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 12

DATE RECEIVED: 7-29-82

NAME OF PERSON REPORTING: James E. Welch

ADDRESS: 1621 Continental Drive, Madisonville

TELEPHONE NUMBER: 821-4195

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

House, walls and foundation.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 1-2 TIMING (a-c): a

Many small cracks in facing. Front has a Z-shaped crack. Foundation has one small crack.

An earthquake occurred between 1969 and 1972. He has log of some blasts for fall 1981 and April 1981--September 1981.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 12

DATE RECEIVED: 7-31-82

NAME OF PERSON REPORTING: Compton

ADDRESS: 1614 Continental Drive, Madisonville

TELEPHONE NUMBER: 821-0163

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 3 TIMING (a-c): a

Cracks developed in basement floor and walls at northwest, north, and south. Floor cracks first developed that ran north-south. In last 2 weeks, two cracks developed running east-west. Activity started last November (1981) after a big blast. (Later found to be from Cimmerron 1.1" on seismic.)

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 13

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Robert Reynolds

ADDRESS: 1660 Continental Drive, Madisonville

TELEPHONE NUMBER: 825-3049

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 3 TIMING (a-c): b

Started October 1979 after a large 8 am blast. By 8:05 house was down. Rotated to west and northwest. Bar-beam rotation lowered front (west) and raised back (east) of house by 8 inches. Many cracks in brick facing and interior and carport floor. South end has worst damage outside. Severe cracking of cellar floor and foundation. It was estimated that repair costs would be $30,000,. 3 years ago.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 14

DATE RECEIVED: 7-31-82

NAME OF PERSON REPORTING: Garry Patterson

ADDRESS: 1613 Continental Drive, Madisonville

TELEPHONE NUMBER: 821-7935

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 1 TIMING (a-c): a

One east-west separation in ceiling tile open about 1/4 inch has opened since November 1981. This house is located just to the south of the major area of Continental Drive affected by the earlier events.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 15

DATE RECEIVED: 7-31-82

NAME OF PERSON REPORTING: Stokes

ADDRESS: 1619 Continental Drive, Madisonville

TELEPHONE NUMBER: Not given.

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 2 TIMING (a-c): a

Cracks developing in back wall and garage. Cracks in south bedroom ceiling. Water entering a sink northeast of house is not yet major. Events started in November 1981.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 16

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: R. L. Sullivan

ADDRESS: 320 Meadowlark Lane, Madisonville

TELEPHONE NUMBER: 821-8911

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks and movement of his house has damaged it until it's nearly worthless.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-2-82 INTENSITY (1-5): 2+ TIMING (a-c): a

Problems developed shortly after a January 27, 1977, 4:30 pm blast in the surface mine nearby. Mr. Sullivan noticed new cracks developing in the front of his house in April 1982. House has rotated downward toward south, and north end has adjusted. Tensional effects include many Z-shaped and some horizontal cracks and separations in walls. Broken foundations and cellar floor.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 17

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Howard Wheeler

ADDRESS: 1919 Darrell Court, Madisonville

TELEPHONE NUMBER: 821-6661

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-2-82 INTENSITY (1-5): 4-5 TIMING (a-c): a

House began movement January 27, 1977. House rotated north and northeast toward the Buntin house next door. House has crawl space. All corners have cracks indicating differential strain. Differential settlement from one end of the house to the other is about 18 inches.

The road in front of the house was almost flat prior to subsidence. An open crack crossed the road but it has since been resurfaced. Drainage problems have developed at the culverts under the road nearby.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 18

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Buntin

ADDRESS: Darrell Court, Madisonville

TELEPHONE NUMBER: Not given.

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-2-82 INTENSITY (1-5): 4 TIMING (a-c): c

Damage began January 27, 1977. This house continued to move for 2 years or more. Many Z-shaped and horizontal cracks. Rotation downward to the west end. Crack in garage wall of more than 2 inches is still opening.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 19

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Jesse R. Moore

ADDRESS: 160 Jacklin Drive, Madisonville

TELEPHONE NUMBER: 821-1303

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-2-82 INTENSITY (1-5): 3 TIMING (a-c): a

Most damage started about 1 year ago but some at the south end had started earlier. House rotated east and southeast. House is twisted. Garage damaged at north end. Cracks in front drive. Few cracks noted inside because most repairs have been made. Door frames are all twisted. House movement still active.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 20

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Agnes Smith

ADDRESS: 136 Cathlyn Drive, Madisonville

TELEPHONE NUMBER: 821-8004

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Has had (group) court case pending for 5 years. Damage continues. West end of her house has fallen 18 inches, and they have lost many bricks. Some neighbors' (not hers) pipes have been broken. All are concerned about continuing subsidence.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-4-82 INTENSITY (1-5): 3-4 TIMING (a-c): a

Started in 1977 perhaps February 27, after a heavy blast from Cimmerron. House west end dropped first, then east end dropped later. Surface damage largely repaired.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 21

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: James Martin

ADDRESS: 338 Jacklin Drive, Madisonville

TELEPHONE NUMBER: 821-4682

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Bricks are cracked and window frames are pulled away. Shower tiles have been replaced twice because tile continues to break loose.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-7-82 INTENSITY (1-5): 2+-3 TIMING (a-c): a

House with crawl space leans to south. Horizontal cracks north and south side with bricks pulled 1.5 inches. Vertical cracks on west side. Windows pulled and rhomboidal distorted all around the house patio has shifted again and carport floor down 2 inches. Inside, doors stick and sheetrock cracked at stress points around doors and windows. Cimmerron surface was due south about 1/2 mile around 1977-1978.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 22

DATE RECEIVED: 8-10-82

NAME OF PERSON REPORTING: Mrs. Morrow

ADDRESS: 180 Meadowlark Lane (Jacklin Drive), Madisonville

TELEPHONE NUMBER: 821-2563

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

House has many cracks. There is a new area of her front yard that has sunk.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cooks

INVESTIGATED: 8-16-82 INTENSITY (1-5): 1 TIMING (a-c): a

House is 23 years old, residents have lived here 13 years. Crack below window in kitchen. House will not stay level. Cracks above doors and below windows, door will not shut. All rooms are sheetrock. House was leveled 3 years ago and continually getting worse. Outside back, concrete slab has dropped. Crack in front of house in foundation. Cracks in brick near porch stoop. Ceiling of carport is sagging. In front yard, small area has dropped, driveway has cracked. Problems started about 5 years ago.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 23

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Mr. Sanz

ADDRESS: 144 Jacklin Drive, Madisonville

TELEPHONE NUMBER: 825-0946

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-2-82 INTENSITY (1-5): 3 TIMING (a-c): a

Many cracks in brick facing but few inside. House has rotated east-southeast about 8 inches downward. Driveway has 3 north-south breaks. Most activity occurred this spring (March-April). Gas line appears stressed! Estimate to fix set at $32,100.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 24

DATE RECEIVED: 8-4-82

NAME OF PERSON REPORTING: Mrs. Roscoe Oldham

ADDRESS: 190 Jacklin Drive, Madisonville

TELEPHONE NUMBER: 825-4745

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks in bricks. Driveway is moving away from house. Two floors are becoming unlevel.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-4-82 INTENSITY (1-5): 1-2 TIMING (a-c): a

Damage began winter of 1977-78 and continues. Cracks inside and doors are out of alignment. Hall slants to north. Driveway has cracks, has dropped and pulled away from house. Drop seems to be toward west. Small crack through bricks at south end of garage and garage is pulled a little to south. House and patio are pulled apart. Horizontal crack in east wall near north end. Two Z-shaped cracks at north end were fixed in November and one is now open. Brick has pulled from house at window-a new event.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 25

DATE RECEIVED: 8-6-82

NAME OF PERSON REPORTING: Fred Stokes

ADDRESS: 1948 Darrell Court, Madisonville

TELEPHONE NUMBER: Home: 821-2239 or Office: 821-5216

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition) across road from Buntin residence.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Several cracks in house. House tilted to the east 6.5 to 7 inches.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-7-82 INTENSITY (1-5): 2-3 TIMING (a-c): a

Bricks house with crawl space. Doors sticking and sheetrock cracking and stressed at corners of doors and cracked at seams. Fireplace cracked and was repaired. Outside bricks have 3/8 inch cracks; patio is cracked as is the doorway concrete. Gas is now leaking!! Driveway has old east-west cracks and new (last year) north-south cracks. House foundation cracked in several places. Z-shaped cracks near window. House has rotated about 7 inches over a 90 foot span.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 26

DATE RECEIVED: 8-5-82

NAME OF PERSON REPORTING: William Ruddell

ADDRESS: 329 Cathlyn Drive, Madisonville

TELEPHONE NUMBER: 821-9689

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Lives in tri-level home, has cracking between levels. Basement walls are cracked, steps broken loose from house. Guttering is unlevel, with downspouts needed on opposite ends. Also, patio pulling away from house.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 3 TIMING (a-c): a

Random stone facing. House rotated downward to north 8-10 inches in 1977. Rate of activity now slower but continues. House twisted to northwest. All doors and windows twisted. Seals on thermalpane windows broken. Sidewalk and steps broken. Dirt under patio dropped 6 inches. Z-shaped cracks in foundation blocks at southeast corner. Horizontal cracks on east foundation--wall is bowing in. Vertical cracks under middle of house. Cracks in west wall. Driveway crack new last summer (1981). Southeast mid-house corner dropped. Cracks in east and south wall facing. Gas supply line broke once and water supply line broke four times.

House next door 3a. Shifted north and patio and front of house have dropped. Window seals broken and new cracks are currently developing. Foundation cracks east and west side.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 27

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Paul Morgan

ADDRESS: Highway 85/70 East, Madisonville

TELEPHONE NUMBER: 821-3607

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (northeast of Sharpe's Addition and adjacent to it).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Concrete block building directly above a mine. Concrete is splitting; floors are breaking up and ceiling beam looks about to fall.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-31-82 INTENSITY (1-5): 2+ TIMING (a-c): a

Concrete block building dropped at both north and south ends and also rotated east. Floor settled and unlevel and wall cracked. House nearby has a few cracks.

Son's house about 200 feet south of block building, also rotated to east and has stressed gas line (pipe bent!!) 2+a.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 28

DATE RECEIVED: 8-1-82

NAME OF PERSON REPORTING: Mrs. John Ewing

ADDRESS: 1968 Linden Drive, Madisonville

TELEPHONE NUMBER: 821-5287

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Began in 1977 House moved 1/4 inch per square(?) foot and still moving. Cracked ceiling and walls inside and out. East side moved down. Driveway moved and broken. Foundation cracked and main inside wall now moving. (Rogers, Ewing, Buntin, and Smith were all affected in January-February 1977, Ewing most affected in May 1977.)

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-1-82 INTENSITY (1-5): 3-4 TIMING (a-c): a

Began in 1977 and continues (see above). South wall bowed. Many cracks inside and out. Rotation seems to be both to the east and west away from the middle. Owner has record of blasting she heard.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 29

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Mrs. Denton

ADDRESS: 1977 Linden Drive, Madisonville

TELEPHONE NUMBER: 825-3833

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

House and carport affected. Carport is torn up, and falling away from house. Fireplace is damaged. Walls and windows are cracked

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-2-82 INTENSITY (1-5): 2-3 TIMING (a-c): a

Most damage occurred prior to 1976, but is continuing today. Doors sticking. Carport cracked and broken (see above). Two inch open crack on fireplace. Doors and windows sticking. Some repairs made. Stress seems to be at west end--the end nearest the Ewing residence.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 30

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Sally Taylor

ADDRESS: 585 Evergreen Circle, Madisonville

TELEPHONE NUMBER: 825-2067

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (in subdivision just east of the Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks in basement wall.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-2-82 INTENSITY (1-5): 2 TIMING (a-c): a

Damage started in September 1980. Crack in north foundation wall is still opening. House is on rock. South wall has Z-shaped and horizontal cracks. West wall window shows slight opening. Horizontal cracks also in north wall.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: 6 REPORT #: 31

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Mrs. Odie Lee Peacock

ADDRESS: Scanfield Subdivision, Route 3, Madisonville

TELEPHONE NUMBER: 821-4128

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same (Scanfield Subdivision is north of Route 70/85 by Sharpe's Addition).

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 7-30-82 INTENSITY (1-5): 2 TIMING (a-c): a-b

Has lived here since 1975. Cracks have developed since and some are new "today." Blasting very noticeable. Lawyer got $5,000 for them from Coal Company (??). Cracks in plaster mainly at east end of house. Cracks in brick facing at east end and in garage. Foundation cracks and east wall is bowed in. Cracks in sidewalk and driveway.

THE FOLLOWING DAMAGE REPORTS REPRESENT ISOLATED REPORTS INVESTIGATED IN THE AREAWIDE STUDY WHICH WERE NOT IN THE SIX DEFINED SUBAREAS.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: ISOLATED REPORT #: 1

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: John and Nora Stewart

ADDRESS: 130 Sugg Street (and garage apartment, 133 Sugg Street, occupied by Pearl Stewart), Madisonville

TELEPHONE NUMBER: 821-7022

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

House and garage apartment across the street occupied by mother.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Front porch is of brick and bricks keep sliding off.

Mother's garage apartment has dropped 3 inches.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-4-82 INTENSITY (1-5): 1 TIMING (a-c): b

Front porch wall on both sides have tilted outward causing both supporting posts to tilt outward. House 30-35 years old. Have lived here since 1975, but condition worst in last year.

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129 Sugg Street--Pearl Stewart garage apartment. Have owned since built 15-20 years ago. Front of garage cracked and lowered by about 1 inch. Breaks in concrete blocks at northeast corner.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 2

DATE RECEIVED: 10-8-82

NAME OF PERSON REPORTING: Mrs. Carl Hoffman

ADDRESS: 777 Sugg Street, Madisonville

TELEPHONE NUMBER: 821-6486

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Back yard sinking.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: Tom Cook

INVESTIGATED: 10-19-82 INTENSITY (1-5): 1 TIMING (a-c): a

Lived here 32 years. Last 3 to 4 years yard has started sinking. Has sunk 6 inches in spots and getting deeper each year. Small hairline cracks noted in foundation.

On city sewage. Underground Reinecke worked out in this area more than 30 years ago.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 3

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Luke Cox

ADDRESS: 807 Homewood Drive, Madisonville

TELEPHONE NUMBER: 825-2611

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracked outside brick on home. Cracked garage slab, and all the way down the driveway. Entire under house (??)--pillars that hold the joists have shifted.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-6-82 INTENSITY (1-5): 2 TIMING (a-c): c

Houe 12 years old. Have lived here 7 years. Crack started in garage floor agbout 2 years ago seems to have stopped now. Garage crack was repaired a year ago. Floor has been leveled twice in last 4 years. Concrete driveway had cracked so bad that it had to be black-topped about 2 years ago. Bricks have been replaced by garage 2.5 years ago. Bricks cracked all-the-way-through near front porch. On north side, crack under window and 1/2 inch crack above window. Ground cracked under the house. Back patio has dropped down. Sheetrock cracked in bedroom below window. Cracks above doors in bedroom and door sticks.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 4

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Chi Chi Mills

ADDRESS: 31 West Jagoe Street, Madisonville

TELEPHONE NUMBER: Home: 821-3860 or Business: 821-2020

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks in foundation, on outside. Cracks inside with woodwork pulling away from walls.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-6-82 INTENSITY (1-5): 1 TIMING (a-c): b

House about 30 years old and occupant has lived here for that period of time. Problem occurred about 2 years ago. Cracks in concrete block foundation on west side of house. Cracks also in back of house on west [?] side. Crack by closet door in hall. Cracks around built in kitchen cabinets.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 5

DATE RECEIVED: 8-6-82

NAME OF PERSON REPORTING: Ava Wilson

ADDRESS: 632 Victoria Street, Madisonville

TELEPHONE NUMBER: Not given.

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-6-82 INTENSITY (1-5): 1 TIMING (a-c): b

House 20 to 25 years old but owner has had it since 1979. Concrete block house. Back corner of house has hairline crack. Crack above front porch in wall. Front of house has hairline cracks. Closet door in bedroom on south side will not shut.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 6

DATE RECEIVED: 8-2-82

NAME OF PERSON REPORTING: Mrs. Minerva Sharp

ADDRESS: 671 West Broadway, Madisonville

TELEPHONE NUMBER: 821-2678

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Had to have 16 pillars installed under the house because of subsidence damage. Insurance company said they didn't cover it. Driveway cracked and porches pulled 2 inches away from foundation.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-5-82 INTENSITY (1-5): 3 TIMING (a-c): c

Front porch steps have dropped and also sidewalk. House next door also damaged. Blasting by D&M (?) a few years ago would shake house. Back of house had to be jacked up and foundation replaced. Additional pillars also added under house. Hairline cracks in driveway.

House built in 1925 and lived here since. Apparently problems have ceased. All repairs done about 5 years ago.

Second house up had concrete front porch pulled away from house.
It has cracks and the bedroom ceiling sagged. House next door has sagged in center.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #:7

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Danney Clayton

ADDRESS: 345 East Broadway, Madisonville

TELEPHONE NUMBER: 821-0746

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

House and yard affected. House sinking. Cracks in ceiling. Porch broken. House in yard (filled it in last year, and it has fallen in again). There is one hole near the corner of his house and a crack along the living room.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-5-82 INTENSITY (1-5): 1 TIMING (a-c): a

House 20-25 years old has lived in it 10 years. One hole in front yard about 4 inch diameter and very deep. Hairline crack in concrete front porch. Another hole near front of house. Street in front of house cracking. One crack across entire *living room ceiling has been repaired this year. Kitchen door not square and sinking to one side. Cracks above door. Hole back of house near foundation looks like a drill hole. It has just been noticed that the door facing that hole is sagging. Holes in yard have been here less than 5 years.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 8

DATE RECEIVED: 8-5-82

NAME OF PERSON REPORTING: Roger Jones

ADDRESS: 846 East Broadway, Madisonville

TELEPHONE NUMBER: Home: 821-5589 or wife's work: 825-4266 (Chris)

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

This house is one block from where one house fell in. Foundations are separating around front porch. Sidewalk is breaking up.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-9-82 INTENSITY (1-5): 1 TIMING (a-c): a

Have lived in house since built 4 years ago. Problems noticed around the first of this year, has continually worsened. Front porch stoop has pulled away from house 1-2 inches and has dropped 1-3 inches. Also walk has cracked.

Next door neighbors are about the same.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 9

DATE RECEIVED: 8-6-82

NAME OF PERSON REPORTING: Mrs. John Davis

ADDRESS: 1168 Devonshire Street, Madisonville

TELEPHONE NUMBER: 821-2005

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks in brick and across basement floor. (Also blasting complaint.)

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-9-82 INTENSITY (1-5): 1 TIMING (a-c): a

House bought in 1977 when new. Problem noticed in last 2-3 years. Basement was redone in 1979. Cracks in basement floor and several areas of basement walls. Cracks have been growing for past 1.5 years. All window seals have had to be caulked. Some bricks cracking on east side of house. Dirt next to foundation sinking in. Front porch pulling away from wall of house. Front sidewalks cracked. Garage door facing (?) has cracked, and has been caulked. Hairline crack in garage floor.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 10

DATE RECEIVED: 8-3-82

NAME OF PERSON REPORTING: Mrs. Hamman

ADDRESS: 1160 Denvonshire Street, Madisonville

TELEPHONE NUMBER: 825-3318

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Has damage she thinks is either subsidence or blasting.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 8-4-82 INTENSITY (1-5): 1 TIMING (a-c): a

Bought house 1976 when new. Basement floor pulled away from wall 1978 or 1979 has been repaired. Hairline cracks in basement floor. Front porch floor has dropped 1/2 inch. Front walk raised and lowered. Small crack across concrete drive. East side of house has small cracks. Sliding glass door has 1/2 inch crack in jam. Problems--little at a time. Dirt put around house in May 1982. Small hairline cracks in bricks on front of *house. Garage *door had to be adjusted about 2 years ago. Crack in garage floor.

Three houses down--corner of master bedroom sunk, had to be jacked up. Lady next door had basement reworked.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 11

DATE RECEIVED: 8-4-82

NAME OF PERSON REPORTING: Jim Day

ADDRESS: 1370 West Noel Avenue, Madisonville

TELEPHONE NUMBER: 821-1912 or 821-6186

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks in brick on back of house. Door won't fit. Step to pavement broken. Plaster cracked. Basement steps cracked and tilted. Mine blasting within 1 mile. Air and ground blast observed.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 2 TIMING (a-c): a

Reinecke Mine. Vertical fractures in south wall facing. Pipes pulled 2 inches. Some earlier damage but last 2 years more activity as blasting came closer. Doors continue to stick. Crack in kitchen. [NOTE: This house has a reinforced foundation!!]

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: Isolated REPORT #: 12

DATE RECEIVED: 10-18-82

NAME OF PERSON REPORTING: Travis Gooden

ADDRESS: 232 South Scott Street, Madisonville

TELEPHONE NUMBER: 825-4597

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

House starting to split.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: T. Cook

INVESTIGATED: 10-19-82 INTENSITY (1-5): 2 TIMING (a-c): a

House built in 1940's. Owned by current owner for 2 years. Small crack in front porch. Crack in front wall of house. Small holes in front of yard. Sidewalk has dropped 1 inch in last year. Backyard has begun to sink: 20 x 40 feet has dropped about 4 inches in last 2 years. Ceiling in living room has small crack. Ceiling in family room and walls cracked. Ceramic tile in bathroom fell off. Wall of kitchen leaning. Possible floor dropping down. Ceiling pulling away from crown molding in bedroom.

THE FOLLOWING MADISONVILLE DAMAGE SURVEY REPORTS ARE FOR HOUSES THAT ARE IMMEDIATELY SOUTH OF THE AREAWIDE STUDY AREA AND THE SIX SUBAREAS AS DEFINED

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: South Side REPORT #: 1

DATE RECEIVED: 8-4-82

NAME OF PERSON REPORTING: Mrs. John T. Carroll

ADDRESS: 1170 Eastview Drive, Madisonville

TELEPHONE NUMBER: Home: 821-1867 or Work: 821-3611

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same and neighbors.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks in bricks in house within the last year. Some places where sheetrock is shifting.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-6-82 INTENSITY (1-5): 1 TIMING (a-c): a,c

House dropped about 8 inches 12 years ago. Steam came out in road and in other houses. Latest activity began last year. Vertical cracks on north side through bricks. Northwest corner dropping--1/4 inch openings. Inside, 12 feet from west end--dropped 5/8 inch. Sheetrock has cracks and one door sticks near west corner. Other houses along street also affected. Cracks in house across road and next door to north. "Four or five houses right around here."

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: South Side REPORT #: 2

DATE RECEIVED: 8-3-82

NAME OF PERSON REPORTING: John Eliassen

ADDRESS: 1113 Bradford Street, Madisonville

TELEPHONE NUMBER: 821-6891

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

Cracks in corner and along side of house at bedroom end.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-4-82 INTENSITY (1-5): 1 TIMING (a-c): a

Movement toward west. First noticed last fall. Doors stick and small cracks developed in facing. House to east has small cracks at east end and cracks in sidewalk and driveway.

POTENTIAL MINE SUBSIDENCE REPORT
MADISONVILLE, KENTUCKY

SUBAREA: South Side REPORT #: 3

DATE RECEIVED: 7-30-82

NAME OF PERSON REPORTING: Ruth Patterson

ADDRESS: 1112 McLeodd Lane, Madisonville

TELEPHONE NUMBER: 821-2706

LOCATION OF REPORTED SUBSIDENCE [SAME AS ABOVE-YES/NO]:

Same.

DETAIL AND NATURE OF SUBSIDENCE AS REPORT BY CITIZEN:

None.

FOLLOW-UP DESCRIPTION AND COMMENTS BY OSMRE PERSONNEL:

INVESTIGATOR: G. C. Kelley

INVESTIGATED: 8-5-82 INTENSITY (1-5): 5,2 TIMING (a-c): c,a

House built in 1957. Started moving in 1961 and by 1963 was down 28 inches at east end. House was jacked and reblocked in 1965 but kept sloping basement floor. Reactivated and today Z-shaped and horizontal cracks have and are developing. Cracks in sheetrock--doors and windows stick and are out of alignment. Front wall has horizontal cracks. Patio has cracked. Garage has 1/2 inch open crack. West end has new cracks. Plumbing damaged.

Red Bud Mine below. In 60's, 10 inch wide crack crossed road and through house. Another house fell apart completely. Church across road, built within last 5 years, is right on old ground crack trace.

APPENDIX C - PILLAR STRENGTH CALCULATIONS

Analyses were performed to determine the compressive strength of the coal pillars left in place in order to assess their ability to support the overburden above the mine and to develop some ideas as to the depth at which pillar crushing is imminent. The theory behind this analysis is that the inherent compressive strength of the pillars will most likely be exceeded at some particular overburden thickness. Below this depth, crushing should have taken place shortly after mining is completed. Above this depth, pillars possess enough compressive strength to resist crushing.

The compressive strength of coal pillars can be computed using the following formula:

$$Cp = Cl[0.778 + 0.222(Wp/Hp)] \text{ (Hustrulid, 1976)}$$

Where Cp = compressive strength of a coal pillar

Cl = compressive strength of coal

Wp = pillar width (minimum)

Hp = pillar height

From data presented by Hustrulid (1976), the compressive strength of coal for a cube edge 30 inches long is approximately 900 psi. This value is used for Cl.

Wp is obtained from the mine map. If a pillar width is, for example, 12 feet, analytical methods require that 3 feet be subtracted from each face due to fracturing, weathering, etc. of the pillar that makes the outer part incompetent. A value of Wp = 6 feet is then used in the analysis.

Hp = Height of coal—The thickness of coal or void space observed in drill holes is used. If the mine is 6 feet high then:

$$Cp = 900 \text{ lb/in}^2[0.778 + (0.222)\ (6 \text{ ft}/6 \text{ ft})]$$

$$Cp = 900 \text{ psi}$$

It is now desired to determine the stresses on the pillar with variations in overburden thickness. This will enable the investigator to determine the depth at which pillars should crush because overburden pressures exceed those which can be tolerated by the remaining pillars.

The governing equation for pillar stresses is:

$$Sp = Sv(1/1-Ra) \text{ (Obert and Duvall, 1967)}$$

Where Sp = average pillar stress

Sv = stress due to overburden pressure

Ra = area extraction ratio

Sv is computed by multiplying the unit weight of rock by the overburden thickness. The average unit weight of rock is assumed to be 160 pcf. However, where several different strata may have different densities, the variations can be included in the computations.

$$Sv = D(144/UW)$$

Where UW = unit weight of the rock in pcf

(144/UW converts UW pcf to psi/ft of overburden)

D = depth or thickness of overburden

Computations are made for each 50-foot interval to the mine depth or level of pillar crushing.

Ra--is the ratio of the excavated-to-total area. This was computed from mine maps and found to range from approximately 55 percent in some entries to over 85 percent in some panels.

To determine the overburden thickness at which the compressive strength of the coal pillar will be exceeded:

$$Ra = Ae/At = At - Ap/At = 1 - Ap/At$$

Where Ae = excavated area

Ap = pillar area

At = Ae + Ap = total area

The average pillar stress Sp is related to the applied stress by:

$$SpAp = Sv(Ae + Ap)$$

and: $Sp = Sv(1/1-Ra)$

but: $Sv = D(144\ in^2/ft^2/UW)$

Where D = thickness of overburden

UW = unit weight of a cubic foot of overburden material

Crushing of pillars should occur when:

$$Sp > Cp$$

or $Sv(1/1-Ra) > Cp$

and depth of crushing Dc is found by:

$$Dc(144\ in^2/ft^2/UW][1/1-Ra) > Cp$$

or $Dc = (UW/144\ in^2/ft^2)(1-Ra)Cp$

SUBAREA 1 #11 COAL PANEL
DRILL HOLE NUMBER DH-1

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 16 ft
AREA EXTRACTION RATIO	= 83 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1008 psi
COAL SEAM BEGINS AT DEPTH	200 ft
PILLARS SHOULD CRUSH BELOW	172 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	293
100	586
150	879
200	1172
250	1465

PILLAR STRENGTH ANALYSIS

SUBAREA 1 #11 COAL ENTRY
DRILL HOLE NUMBER DH-1

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 13 ft
AREA EXTRACTION RATIO	= 79 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 915 psi
COAL SEAM BEGINS AT DEPTH	200 ft
PILLARS SHOULD CRUSH BELOW	193 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	237
100	474
150	711
200	949
250	1186

SUBAREA 2 #11 COAL PANEL
DRILL HOLE NUMBER DH-2

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 21 ft
AREA EXTRACTION RATIO	= 77 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1161 psi
COAL SEAM BEGINS AT DEPTH	223 ft
PILLARS SHOULD CRUSH BELOW	268 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	217
100	433
150	650
200	866
250	1083

SUBAREA 2 #11 COAL ENTRY
DRILL HOLE NUMBER DH-2

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 26 ft
AREA EXTRACTION RATIO	= 65 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1315 psi
COAL SEAM BEGINS AT DEPTH	223 ft
PILLARS SHOULD CRUSH BELOW	462 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	142
100	285
150	427
200	569
250	711

SUBAREA 2 #11 COAL PANEL
DRILL HOLE NUMBER DH-3

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 12 ft
AREA EXTRACTION RATIO	= 76 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 885 psi
COAL SEAM BEGINS AT DEPTH	192 ft
PILLARS SHOULD CRUSH BELOW	213 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	207
100	415
150	622
200	830

SUBAREA 2 #11 ENTRY
DRILL HOLE NUMBER DH-3

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 24 ft
AREA EXTRACTION RATIO	= 24 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1253 psi
COAL SEAM BEGINS AT DEPTH	192 ft
PILLARS SHOULD CRUSH BELOW	956 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	66
100	131
150	197
200	262

SUBAREA 2 #11 PANEL
DRILL HOLE NUMBER DH-4

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 14 ft
AREA EXTRACTION RATIO	= 85 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 946 psi
COAL SEAM BEGINS AT DEPTH	228 ft
PILLARS SHOULD CRUSH BELOW	142 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	332
100	664
150	996
200	1328
250	1660

SUBAREA 2 #11 ENTRY
DRILL HOLE NUMBER DH-4

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 12 ft
AREA EXTRACTION RATIO	= 60 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 885 psi
COAL SEAM BEGINS AT DEPTH	228 ft
PILLARS SHOULD CRUSH BELOW	355 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	124
100	249
150	373
200	498
250	622

SUBAREA 2 #11 COAL PANEL
DRILL HOLE NUMBER DH-5

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 8 ft
AREA EXTRACTION RATIO	= 84 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 762 psi
COAL SEAM BEGINS AT DEPTH	231 ft
PILLARS SHOULD CRUSH BELOW	122 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	311
100	622
150	934
200	1245
250	1556

SUBAREA 2 #11 COAL ENTRY
DRILL HOLE NUMBER DH-5

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 16 ft
AREA EXTRACTION RATIO	= 75 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1008 psi
COAL SEAM BEGINS AT DEPTH	231 ft
PILLARS SHOULD CRUSH BELOW	253 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	199
100	398
150	598
200	797
250	996

SUBAREA 2 #9 COAL PANEL
DRILL HOLE NUMBER DH-5

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 12 ft
AREA EXTRACTION RATIO	= 83 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 885 psi
COAL SEAM BEGINS AT DEPTH	307 ft
PILLARS SHOULD CRUSH BELOW	151 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	293
100	586
150	879
200	1172
250	1465
300	1758
350	2051

SUBAREA 2 #9 COAL ENRTY
DRILL HOLE NUMBER DH-5

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 18 ft
AREA EXTRACTION RATIO	= 73 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1069 psi
COAL SEAM BEGINS AT DEPTH	307 ft
PILLARS SHOULD CRUSH BELOW	290 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	184
100	369
150	553
200	738
250	922
300	1107
350	1291

SUBAREA 3 #11 COAL PANEL
DRILL HOLE NUMBER DH-10

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 13 ft
AREA EXTRACTION RATIO	= 80 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 915 psi
COAL SEAM BEGINS AT DEPTH	151 ft
PILLARS SHOULD CRUSH BELOW	184 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	249
100	498
150	747
200	996

SUBAREA 3 #11 COAL ENTRY
DRILL HOLE NUMBER DH-10

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 17 ft
AREA EXTRACTION RATIO	= 75 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1038 psi
COAL SEAM BEGINS AT DEPTH	151 ft
PILLARS SHOULD CRUSH BELOW	261 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	199
100	398
150	598
200	797

SUBAREA 4 #11 COAL PANEL
DRILL HOLE NUMBER DH-7

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 17 ft
AREA EXTRACTION RATIO	= 83 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1038 psi
COAL SEAM BEGINS AT DEPTH	227 ft
PILLARS SHOULD CRUSH BELOW	177 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	293
100	586
150	879
200	1172
250	1465

SUBAREA 4 #11 ENTRY
DRILL HOLE NUMBER DH-7

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 19 ft
AREA EXTRACTION RATIO	= 80 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1100 psi
COAL SEAM BEGINS AT DEPTH	227 ft
PILLARS SHOULD CRUSH BELOW	221 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	249
100	498
150	747
200	996
250	1245

SUBAREA 5 #11 COAL PANEL
DRILL HOLE NUMBER DH-18

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 16 ft
AREA EXTRACTION RATIO	= 77 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1008 psi
COAL SEAM BEGINS AT DEPTH	254 ft
PILLARS SHOULD CRUSH BELOW	233 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	217
100	433
150	650
200	866
250	1083
300	1299

SUBAREA 4 #11 ENTRY
DRILL HOLE NUMBER DH-18

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 13 ft
AREA EXTRACTION RATIO	= 71 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 915 psi
COAL SEAM BEGINS AT DEPTH	254 ft
PILLARS SHOULD CRUSH BELOW	266 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	172
100	343
150	515
200	687
250	859
300	1030

SUBAREA 5 #11 COAL PANEL
DRILL HOLE NUMBER DH-11

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 14 ft
AREA EXTRACTION RATIO	= 75 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 946 psi
COAL SEAM BEGINS AT DEPTH	283 ft
PILLARS SHOULD CRUSH BELOW	237 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	199
100	398
150	598
200	797
250	996
300	1195

SUBAREA 5 #11 COAL ENTRY
DRILL HOLE NUMBER DH-11

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 15 ft
AREA EXTRACTION RATIO	= 73 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 977 psi
COAL SEAM BEGINS AT DEPTH	283 ft
PILLARS SHOULD CRUSH BELOW	265 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	184
100	369
150	553
200	738
250	922
300	1107

SUBAREA 5 #9 COAL PANEL
DRILL HOLE NUMBER DH-11

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 23 ft
AREA EXTRACTION RATIO	= 78 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1223 psi
COAL SEAM BEGINS AT DEPTH	372 ft
PILLARS SHOULD CRUSH BELOW	270 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	226
100	453
150	679
200	905
250	1132
300	1358
350	1585
400	1811

SUBAREA 5 #9 COAL ENTRY
DRILL HOLE NUMBER DH-11

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 27 ft
AREA EXTRACTION RATIO	= 72 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1346 psi
COAL SEAM BEGINS AT DEPTH	372 ft
PILLARS SHOULD CRUSH BELOW	378 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	178
100	356
150	534
200	711
250	889
300	1067
350	1245
400	1423

SUBAREA 6 #11 COAL PANEL
DRILL HOLE NUMBER DH-14

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 10 ft
AREA EXTRACTION RATIO	= 72 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 823 psi
COAL SEAM BEGINS AT DEPTH	267 ft
PILLARS SHOULD CRUSH BELOW	231 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	178
100	356
150	534
200	711
250	889
300	1067

SUBAREA 6 #11 ENTRY
DRILL HOLE NUMBER DH-14

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 15 ft
AREA EXTRACTION RATIO	= 71
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 977 psi
COAL SEAM BEGINS AT DEPTH	267 ft
PILLARS SHOULD CRUSH BELOW	284 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	172
100	343
150	515
200	687
250	859
300	1030

SUBAREA 6 #9 COAL PANEL
DRILL HOLE NUMBER DH-14

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 29 ft
AREA EXTRACTION RATIO	= 79 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1407 psi
COAL SEAM BEGINS AT DEPTH	350 ft
PILLARS SHOULD CRUSH BELOW	297 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	237
100	474
150	711
200	949
250	1186
300	1423
350	1660

SUBAREA 6 #9 COAL ENTRY
DRILL HOLE NUMBER DH-14

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 28 ft
AREA EXTRACTION RATIO	= 72 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1376 psi
COAL SEAM BEGINS AT DEPTH	350 ft
PILLARS SHOULD CRUSH BELOW	387 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	178
100	356
150	534
200	711
250	889
300	1067
350	1245

SUBAREA 6 #11 COAL PANEL
DRILL HOLE NUMBER DH-26

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 15 ft
AREA EXTRACTION RATIO	= 68 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 977 psi
COAL SEAM BEGINS AT DEPTH	253 ft
PILLARS SHOULD CRUSH BELOW	314 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	156
100	311
150	467
200	622
250	778
300	934

SUBAREA 6 #11 COAL ENTRY
DRILL HOLE NUMBER DH-26

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 20 ft
AREA EXTRACTION RATIO	= 63 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1131 psi
COAL SEAM BEGINS AT DEPTH	253 ft
PILLARS SHOULD CRUSH BELOW	420 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	135
100	269
150	404
200	538
250	673
300	808

SUBAREA 6 #11 COAL PANEL
DRILL HOLE NUMBER DH-13

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 16 ft
AREA EXTRACTION RATIO	= 81 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1008 psi
COAL SEAM BEGINS AT DEPTH	269 ft
PILLARS SHOULD CRUSH BELOW	192 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	262
100	524
150	786
200	1048
250	1310
300	1573

SUBAREA 6 #11 COAL ENTRY
DRILL HOLE NUMBER DH-13

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 11 ft
AREA EXTRACTION RATIO	= 76 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 854 psi
COAL SEAM BEGINS AT DEPTH	269 ft
PILLARS SHOULD CRUSH BELOW	206 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	207
100	415
150	622
200	830
250	1037
300	1245

SUBAREA 6 #9 COAL PANEL
DRILL HOLE NUMBER DH-13

PILLAR HEIGHT	= 5.5 ft
MINIMUM PILLAR WIDTH	= 16 ft
AREA EXTRACTION RATIO	= 81 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1063 psi
COAL SEAM BEGINS AT DEPTH	341 ft
PILLARS SHOULD CRUSH BELOW	203 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	262
100	524
150	786
200	1048
250	1310
300	1573
350	1835

SUBAREA 6 #9 COAL ENTRY
DRILL HOLE NUMBER DH-13

PILLAR HEIGHT	= 5.5 ft
MINIMUM PILLAR WIDTH	= 35 ft
AREA EXTRACTION RATIO	= 49 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1754 psi
COAL SEAM BEGINS AT DEPTH	341 ft
PILLARS SHOULD CRUSH BELOW	898 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	98
100	195
150	293
200	391
250	488
300	586
350	684

SUBAREA 6 #11 COAL PANEL
DRILL HOLE NUMBER DH-15

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 13 ft
AREA EXTRACTION RATIO	= 81 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 915 psi
COAL SEAM BEGINS AT DEPTH	269 ft
PILLARS SHOULD CRUSH BELOW	175 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	262
100	524
150	786
200	1048
250	1310
300	1573

SUBAREA 6 #11 COAL ENTRY
DRILL HOLE NUMBER DH-15

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 16 ft
AREA EXTRACTION RATIO	= 69 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1008 psi
COAL SEAM BEGINS AT DEPTH	269 ft
PILLARS SHOULD CRUSH BELOW	314 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	161
100	321
150	482
200	643
250	803
300	964

DRILL HOLE NUMBER DH-15

PILLAR HEIGHT	= 5.5 ft
MINIMUM PILLAR WIDTH	= 21 ft
AREA EXTRACTION RATIO	= 64 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1281 psi
COAL SEAM BEGINS AT DEPTH	342 ft
PILLARS SHOULD CRUSH BELOW	463 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	138
100	277
150	415
200	553
250	692
300	830
350	968

SUBAREA 6 #9 COAL ENTRY
DRILL HOLE NUMBER DH-15

PILLAR HEIGHT	= 5.5 ft
MINIMUM PILLAR WIDTH	= 21 ft
AREA EXTRACTION RATIO	= 65 %
COMPRESSIVE STRENGTH OF COAL	= 800 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1107 psi
COAL SEAM BEGINS AT DEPTH	342 ft
PILLARS SHOULD CRUSH BELOW	389 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	142
100	285
150	427
200	569
250	711
300	854
350	996

SUBAREA 6 #11 COAL PANEL
DRILL HOLE NUMBER DH-31 (CUMBERLAND CHURCH)

PILLAR HEIGHT	= 5 ft
MINIMUM PILLAR WIDTH	= 14 ft
AREA EXTRACTION RATIO	= 80 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1020 psi
COAL SEAM BEGINS AT DEPTH	262 ft
PILLARS SHOULD CRUSH BELOW	205 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	249
100	498
150	747
200	996
250	1245
300	1494

SUBAREA 6 #11 COAL ENTRY
DRILL HOLE NUMBER DH-31 (CUMBERLAND CHURCH)

PILLAR HEIGHT	= 5 ft
MINIMUM PILLAR WIDTH	= 9 ft
AREA EXTRACTION RATIO	= 78 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1060 psi
COAL SEAM BEGINS AT DEPTH	262 ft
PILLARS SHOULD CRUSH BELOW	234 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	226
100	453
150	679
200	905
250	1132
300	1358

DRILL HOLE NUMBER DH-31 (CUMBERLAND CHURCH)

PILLAR HEIGHT	= 5 ft
MINIMUM PILLAR WIDTH	= 17 ft
AREA EXTRACTION RATIO	= 63 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1380 psi
COAL SEAM BEGINS AT DEPTH	349 ft
PILLARS SHOULD CRUSH BELOW	513 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	135
100	269
150	404
200	538
250	673
300	808
350	942

SUBAREA 6 #9 COAL ENTRY
DRILL HOLE NUMBER DH-31 (CUMBERLAND CHURCH)

PILLAR HEIGHT	= 5 ft
MINIMUM PILLAR WIDTH	= 18 ft
AREA EXTRACTION RATIO	= 61 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1419 psi
COAL SEAM BEGINS AT DEPTH	349 ft
PILLARS SHOULD CRUSH BELOW	556 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	128
100	255
150	383
200	511
250	638
300	766
350	894

SUBAREA 6C NUMBER 11 COAL PANEL
DRILL HOLE NUMBER DHM-1

PILLAR HEIGHT	= 7 ft
MINIMUM PILLAR WIDTH	= 15 ft
AREA EXTRACTION RATIO	= 78 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 957 psi
COAL SEAM BEGINS AT DEPTH	210 ft
PILLARS SHOULD CRUSH BELOW	211 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	226
100	453
150	679
200	905
250	1132

SUBAREA 6C NUMBER 11 COAL ENTRY
DRILL HOLE NUMBER DHM-1

PILLAR HEIGHT	= 7 ft
MINIMUM PILLAR WIDTH	= 15 ft
AREA EXTRACTION RATIO	= 85 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 957 psi
COAL SEAM BEGINS AT DEPTH	210 ft
PILLARS SHOULD CRUSH BELOW	144 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	332
100	664
150	996
200	1328
250	1660

Information from DHM-1 used for overburden thickness and size of void but percent coal extracted calculated from map information of entry just south of DHM-1.

SUBAREA 6C-MOORE SUBSIDENCE NUMBER 9 COAL PANEL
DRILL HOLE NUMBER DHM-1

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 25 ft
AREA EXTRACTION RATIO	= 77 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1284 psi
COAL SEAM BEGINS AT DEPTH	284 ft
PILLARS SHOULD CRUSH BELOW	297 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	217
100	433
150	650
200	866
250	1083
300	1299

SUBAREA 6C MOORE SUBSIDENCE NUMBER 9 COAL ENTRY
DRILL HOLE NUMBER DHM-1

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 25 ft
AREA EXTRACTION RATIO	= 61 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1284 psi
COAL SEAM BEGINS AT DEPTH	284 ft
PILLARS SHOULD CRUSH BELOW	503 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	128
100	255
150	383
200	511
250	638
300	766

SUBAREA 6C NUMBER 11 COAL PANEL
DRILL HOLE NUMBER DH-16

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 15 ft
AREA EXTRACTION RATIO	= 78 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1060 psi
COAL SEAM BEGINS AT DEPTH	224 ft
PILLARS SHOULD CRUSH BELOW	234 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	226
100	453
150	679
200	905
250	1132

SUBAREA 6 #11 COAL ENTRY
DRILL HOLE NUMBER DH-16 (MOORES)

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 18 ft
AREA EXTRACTION RATIO	= 70 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1069 psi
COAL SEAM BEGINS AT DEPTH	224 ft
PILLARS SHOULD CRUSH BELOW	322 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	166
100	332
150	498
200	664
250	830

SUBAREA 6C #9 COAL PANEL
DRILL HOLE NUMBER DH-16

PILLAR HEIGHT	= 5 ft
MINIMUM PILLAR WIDTH	= 14 ft
AREA EXTRACTION RATIO	= 74 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 980 psi
COAL SEAM BEGINS AT DEPTH	317 ft
PILLARS SHOULD CRUSH BELOW	256 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	192
100	383
150	575
200	766
250	958
300	1149
350	1341

SUBARERA 6C #9 ENTRY
DRILL HOLE NUMBER DH-16

PILLAR HEIGHT	= 5 ft
MINIMUM PILLAR WIDTH	= 18 ft
AREA EXTRACTION RATIO	= 70 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1180 psi
COAL SEAM BEGINS AT DEPTH	317 ft
PILLARS SHOULD CRUSH BELOW	355 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	166
100	332
150	498
200	664
250	830
300	996
350	1162

SUBAREA 6C #11 COAL PANEL
DRILL HOLE NUMBER DH-17

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 15 ft
AREA EXTRACTION RATIO	= 73 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 977 psi
COAL SEAM BEGINS AT DEPTH	204 ft
PILLARS SHOULD CRUSH BELOW	265 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	184
100	369
150	553
200	738
250	922

SUBAREA 6C #11 COAL ENTRY
DRILL HOLE NUMBER DH-17

PILLAR HEIGHT	= 6.5 ft
MINIMUM PILLAR WIDTH	= 19 ft
AREA EXTRACTION RATIO	= 70 %
COMPRESSIVE STRENGTH OF COAL	= 900 psi
UNIT WEIGHT OF OVERBURDEN	= 143.42 pcf
COMPRESSIVE STRENGTH OF PILLAR	= 1100 psi
COAL SEAM BEGINS AT DEPTH	204 ft
PILLARS SHOULD CRUSH BELOW	331 ft

PILLAR LOADING

OVERBURDEN (ft)	PILLAR STRESS (psi)
0	0
50	166
100	332
150	498
200	664
250	830

APPENDIX D - ABANDONED MINE GAS

When underground mining is completed, the workings are usually sealed and mine ventilation is terminated. However, gas will continue to be emitted from remaining pillars and gob material into the open voids.

As subsidence proceeds, and if fractures propagate to the surface, a path for low-density gases to migrate from the mine voids to the surface is provided. The gas can collect in closed areas, at the surface, e.g., in or under buildings.

Gas Occurrence in Madisonville

Core drilling performed in the Madisonville area to establish the extent and character of subsidence episodes found numerous occurrences of gas emanating from drill holes; particularly following penetration into the mine voids. Analyses of the gas has established that methane and hydrogen sulfide gases are the main components, but other gases are also present (Table D-1). The presence of these methane (and other hydrocarbon gases) may create a fire or explosive environment, particularly when trapped in buildings. Hydrogen sulfide can be toxic and is an irritant to people upon contact.

The following information is provided to better understand the presence of these gases in the mine environment and how to cope with and control their emission for the safety of the general public.

Historical Background

From the earliest days of mining, the need for control of the mine atmosphere became evident. Emission of gases from the coal being mined created a serious potential hazard to health and safety in the work environment. Ventilation techniques were developed to maintain an acceptable working atmosphere. However, with the increased demand for energy, deeper and more gassy coalbeds have been mined, making ventilation an increasingly difficult problem.

Due to the very slow emission of gas from coal, considerable gas is retained in even the oldest coal pillars. However, if the overburden loads become too great and the pillars crush, all the gas may be abruptly released from the old workings. This gas can migrate along subsidence fractures and may eventually reach the surface.

Origin of Gases in Coal

The low molecular-weight hydrocarbons, methane, C_2 through C_5 hydrocarbons, and carbon dioxide gases, are byproducts of coalification of organic materials. Coalification involves the biochemical and geochemical processes which transform organic materials into a carbonaceous solid. The transformation goes through stages forming peat, lignite, bituminous and anthracite coals.

Table D-1. Gas Compositions of Several Samples of Appalachian Coalbeds

	Oxygen	Nitrogen	Carbon Dioxide	Carbon Monoxide	Hydrogen Sulfide	Argon	Methane	Ethane	Propane	Butane	Pentane
STANDARD AIR	20.95	78.08	0.03	--	--	0.93%	2ppm	---	---	--	--
NUMBER 11 COAL											
Hopkins County, KY											
Cumberland Subsidence	3.8	26.0	0.4	--	---	0.3	69.5	0.22	0.865	0.023	0.004
Gordon Subsidence	6.8	31.9	0.6	--	---	0.38	60.0	0.23	0.1	0.01	0.005
PITTSBURGH COAL											
Allegheny County, PA											
Thompsonville	0.9*	27.8	5.1	--	---		64.1	1.8	0.23	0.055	0.008
McClintock Subs.	2.4*	47.1	3.7	--	---		46.6	0.94	1.10	0.032	0.010
	11.3*	78.1	3.1	--	---		7.4	0.12	0.003	0.002	0.0005
Marion County, WV											
Barrackville Subs.	0.06	21.8	2.5	--	---	0.26	74.6	0.22	0.022	0.010	0.005
	1.1	57.2	4.6	--	---	0.68	36.1	0.29	0.03	0.01	0.002
FREEPORT COAL											
Upshur County, WV											
Hickleville	1.2*	61.6	1.6	--	---		35.5	0.06	0.001	0.00002	---
Glade Creek	13.3*	48.7	0.2	--	---		37.5	0.26	0.03	0.009	0.001
Adrain Mine	1.7*	59.8	0.46	--	---		38.0	0.06	----	---	---
COMMERCIAL GAS WELL	0.3*	1.5	0.1	--	---		88.4	6.05	2.54	0.87	0.27

* Analysis combines O_2 and Ar.

Carbon dioxide is formed by the oxidation of organic materials mostly in the early stages of coalification. Hydrogen may also be a product of coalification. Nitrogen and oxygen entrapped during the deposition of the organic sediments may also be introduced by ground water moving through the coal. Much of the oxygen in coal is used up by the oxidation of organic material forming carbon dioxide. Helium, a product of radioactive mineral decay, may be present in small amounts.

Carbon monoxide, sulfur compounds and oxides of nitrogen are normally not found in gas from coalbeds. However, these gases are frequently associated with abandoned mines where there is decomposition of organic materials left in the mine or injected into old mine workings such as old timbers, sewage, etc. Carbon monoxide is also associated with, and may be a residual from, mine fires or explosions.

Storage of Gases in Coal

Coal is a porous carbonaceous material with two pore systems, macropores and micropores. The macropores are formed by the joint systems (cleats), cracks and fractures in the coal. The micropores are in the coal structure and have an average diameter of 5 to 20 Angstroms.

Free gas fills the macropore and moves through the coal fracture and joint system governed by Darcy's Law:

$$q = \frac{kA}{u} \cdot \frac{dP}{dL} \qquad (1)$$

which shows that the flow of gas, q, is proportional to the fracture permeability, k, and the cross-sectional area, A, and inversely proportional to the gas viscosity, u; the driving force is the pressure gradient, dP/dL, (the change in gas pressure), P, over the length, L. (In equation (1), gravitational effects have been neglected and gas flow is laminar.)

The bulk of the gas is adsorbed and stored in the coal in the micropores. The micropores provide a surface area for coal in the range of 200 to 300 square meters per gram of coal (2,150 to 3,230 square feet per gram of coal). This adsorbed gas in the micropores is transported through the coal governed by Fick's law of diffusion:

$$q' = -DA \cdot \frac{dC}{dL} \qquad (2)$$

which shows that the flow of gas, q', is proportional to the coal's diffusivity coefficient, D, and the cross sectional area, A; the driving force for this mode of transport is the concentration gradient dC/dL, the change in gas concentration, C, over length, L.

Although the two modes of transport are separate and distinct phenomena, they are interdependent. This interdependency can be expressed over a limited range of pressure as:

$$C_0 = bp^n \qquad (3)$$

where C_0 is the equilibrated concentration of methane in solid coal, p is the gas pressure, and b and n are constants.

Due to the enormous surface area of the micropores, very large volumes of gas are adsorbed in the coal. These gases migrate and are emitted very slowly from the coal. When gas saturated, coal can contain 21.34 cubic centimeters per gram of coal (684 cubic feet per ton) or 28 times the volume of coal at standard temperature and pressure. Therefore, 1 acre-foot of coal has the capability of containing up to 1.2 million standard cubic feet of methane. During the life of an active underground mine, large quantities of gas are generally removed; however, large amounts are retained in the remaining coal pillars when the mine is closed and sealed.

Post depositional history also affects the amount of gas in the coalbed. A primary control is how rapidly the original organic material was buried and how impermeable the overburden is to gas migration. The amount of gas in the coal also depends on this geologic history of temperature, pressure, and the degree of fracturing and permeability of the coal and superjacent strata since deposition. All of these factors control the degree of migration of gas from the coal (e.g., coal near the outcrop or with little overburden strata may have little to no gas retained).

Composition of Coal Gases in Abandoned Mine Atmospheres

The amount and compositions of gas associated with coal is highly variable. Table D-1 shows some average compositions of gas from several coalbeds. These samples were taken from virgin coal prior to mining or in advance of mining. Table D-1 also shows the composition of normal atmosphere gases found in abandoned coal mines consists chiefly of nitrogen, oxygen, carbon dioxide, carbon monoxide, methane, ethane, hydrogen sulfide and others in small or trace amounts.

The most important of these are:

1. Oxygen (O_2)-a colorless, odorless and tasteless gas necessary for the support of life. It actively reacts with (i.e., oxidizes) other elements. In combustion, oxidation is rapid with large amounts of heat energy released and in explosions, the oxidation is near instantaneous;

2. Nitrogen (N_2)-a colorless, odorless, tasteless, inactive or inert gas which is non-combustible. It comprises 4/5 of the atmospheric air;

3. Carbon dioxide (CO_2)-a colorless, odorless, non-toxic gas formed as a product of oxidation of carbon. It is heavier than air and will stratify lying at floor or ground level. High concentrations in enclosed areas can act as an asphyxiant. Carbon dioxide is known to the miner as "black damp;"

4. Carbon monoxide (CO)-a colorless, odorless, combustible to explosive gas, depending upon mixture of air. It is produced when carbon is burned in the presence of limited oxygen and is generally associated with mine fires, explosions, and gas fires. It is extremely toxic even in small quantities. It is known to the miner as "white damp;"

5. Methane (CH_4)-a colorless, odorless gas which is lighter than air. It is non-toxic but can serve as an asphyxiant when in high concentration. It will rise to the top of the mine or an enclosure and form an explosive mixture at 5 to 15 percent concentration in air. It is present in many coalbeds and may be associated with small amounts of other hydrocarbon gases such as ethane, propane, butane, and pentane. It is known to the miners as "fire damp;" and,

6. Hydrogen Sulfide (H_2S)-a colorless, flammable, highly-toxic gas. It has a strong odor resembling rotten eggs, and is heavier than air. This gas accumulates in low areas. It is a product of decomposition of sulfurous coal refuse and decaying organic matter, e.g., timbers left in abandoned mines. Hydrogen sulfide may also be indicative of sewage, e.g., leakage from septic tanks, that has migrated into abandoned mine workings.

Most underground abandoned mine gases are deficient in oxygen (Table D-1) and tend to have high concentrations of methane. Hydrogen sulfide and mercaptan gases are often present and are detected by a disagreeable odor.

Control of Methane During Active Mining

When the entrapped methane reaches a concentration of 5 to 15 percent in air, an explosive mixture is created requiring only a spark, lighted match or burning cigarette to ignite it. In concentrations greater than 15 percent, methane is flammable creating a potential fire hazard.

Ignition could start a destructive fire or explosion in an enclosure such as a building. With either mixture, the hazard for severe burns or death exists for occupants in the building.

Methane gas emissions in active mines are controlled by:

1. Dilution of the gas emitted from coal by large volumes of atmospheric air to reduce the concentration of flammable, explosive methane to safe levels - less than 1 percent. When the concentration of gas rises to over 1 percent, personnel are removed from the mine workings and ventilation is increased to dilute the gas to safe levels before mining can continue;

2. To clear the active mining faces, the ventilation air is directed through the mine entries with stoppings and curtains and is exhausted to the surface;

3. Auxiliary shafts and vertical vents may be employed to assist the ventilation system; and,

4. Mined-out and gobbed areas of the mine may be isolated from the actual workings by sealing the entries.

Control of Mine Gases

It is very important that personnel investigating mine subsidence occurrences be aware of the potential hazards early in the investigation. Early detection will allow application of safety procedures for protection against fire, explosion and exposure to toxic gases. There are two modes of controlling the gas emissions from abandoned mine subsidence areas:

1. Vents can be installed into the open abandoned mine to allow the mine gases to be dispersed into the atmosphere; and,

2. The abandoned mine workings can be sealed to prevent emissions at the surface.

Of the two methods, the installation of vents is the most successful, since complete sealing of underground workings cannot be assured. Important to installation of the vents is the positioning of slotted casing in the borehole. The slotted section of casing must be positioned to collect gas from the fractures occurring in the overburden immediately above the mine. If this gas is not intercepted, it may migrate up the subsidence-induced fractures. Therefore, a flame arrestor may need to be installed at the top of the vent so flame can not propogate down through the vent pipe to the mine level and cause an explosion or fire in the abandoned mine workings.

APPENDIX E - MINE SUBSIDENCE STABILIZATION TECHNIQUES

Listed below are factors which must be considered in the evaluation of techniques for stabilizing the surface after the beginning of a mine-related subsidence. For each type of problem, the abatement procedure is shown.

1. Roof fall - create a point support e.g., by grouting fallen material.

2. Pillar crushing - add point support at strategic locations to carry load.

3. Pillar punching - add broad-based support which will not sink into floor stratum.

4. Bending of the rocks which forms a sag depression on the surface - add support in the center of the depression and at locations along the axis of sag movement.

5. Creation of a hole or depression by piping - seal the zone of piping and redirect water away from zone.

6. Surface pit resulting from complete caving of overburden - fill the hole.

7. "Domino-effect" failure of adjacent pillars after an initial pillar failure - support the areas lateral to the existing failures and in the direction of domino movement.

For small areas of influence, build point supports with fly ash/cement mixes. For large areas of influence, areawide flushing using cheap materials is preferred. When the mine is flooded, the use of low slump concrete is recommended (pneumatic stowing and fly ash ruled out). If rooms are still standing, high volume backfilling or roof support can be utilized.

The availability of an accurate "as mined" mine map and the capability to correlate the mine map with the surface topography is important in lowering costs. The use of a borehole camera is also cost-effective in determining the optimum abatement technique for a particular site.

Types of Materials

The material available for use in a mine stabilization program is determined by local availability, transportation costs, and engineering properties desired e.g., to achieve a defined support strength. Common materials are waste rock, coal processing waste, fly ash and bottom ash from power plants, sand, gravel, and crushed rock.

Rock Processing Wastes

Many areas have local processing plants where rock is being crushed for aggregate. Large volumes of material are produced that are considered waste because they do not meet specifications. However, this waste may be very suitable for use in a mine stabilization program, as the primary bulk agent. If the rock being crushed is a limestone, the lime dust might be added to fly ash instead of cement to stimulate an increased pozzolanic (cementing) reaction.

Mine Refuse

Mine refuse is the waste product created by coal preparation plants. The waste consists of coal, clay, shale and/or other rock. If the waste pile has burned, a different material is produced which is referred to as "red dog."

The bearing strength of the material is low if it contains a high percentage of clay and clay shale. Use of this material is most applicable, therefore, to stabilize relatively shallow mines where roof fall is the major problem and overburden weight is low. Red dog is stronger than unburned coal refuse due to the baking of the clays, but it does not move freely once it is released from the end of the injection pipe. The material is also very abrasive on the pipe walls and on the pumps which creates an increased cost for injection equipment.

Fly ash/Bottom Ash

Fly ash and bottom ash are the noncombustible residue resulting when coal is burned. Fly ash is a fine-grained, light weight aggregate composed of small globules of glass-like material. When calcium is present in the ash, either as part of the original composition or added after burning, the ash can have a natural pozzolanic cementing action to form a solid; however there is generally not enough calcium present to cause this reaction to occur. Fly ash is easy to pump and as a slurry is capable of being transported long distances in mine voids. When strength to support overburden is one of the requirements, fly ash should have a cementing agent mixed with it.

Bottom ash has a high iron content, is coarser grained, and is heavier then fly ash. It is an excellent fill material for mine stabilization. This material is used by the construction industry for manufacture of block and other construction products, however, and is not normally available for subsidence abatement projects at cost-effective prices.

Other aggregates used in mine back-filling projects

Almost any aggregate can be used to back-fill abandoned mines. OSMRE has used crushed rock, slag, natural sand and gravel on a variety of projects. The selection of aggregate is based on availability and cost of materials and engineering requirements necessary to achieve the desired stabilization. Cement can be added to the mix where high strength is desired.

Areawide Flushing Techniques

1. Hydraulic back-filling-The process of mixing water with solids such as mine waste, fly ash, sand, or gravel, and pumping the mixture into the mine through vertical boreholes. Available techniques are in three forms.

a. High volume pumping-This process is normally used to pump mine refuse or other material into the mine voids and spread it over a large area. The high volume of water and the velocity at the injection point should assure a wider spread of material. This method requires the capability to pump 1000-5000 gallons of water per minute (gpm) with a solid-to-liquid ratio of 15-25 percent.

Advantages are:

1. It can move a lot of fill material within a short period of time.

2. Uses low cost, locally available material.

Disadvantages are:

1. It takes a large water supply.

2. There must be sufficient space laterally in the mine for the displacement caused by the additional water and solids being injected into the mine.

3. The start-up costs are high due to size of the pumps and pipe required. Once in place, however, the system is relatively economical to operate.

4. If the mine is dry, addition of water can have adverse effects on the roof and pillar strength of the mine e.g., accelerating deterioration, lubricating under clays.

5. Erosion of pillars.

b. Low volume pumping-uses a combination of water mixed with solids and low-volume pumps to carry the material to the point of injection. The water volume requirements commonly range from 100-500 gpm using a solid-to-liquid ratio of 15-65 percent.

Advantages are:

1. Lower initial cost for water.

2. The pumping equipment required is generally available to construction companies.

3. The equipment is usually mobile and causes less obstruction within the project area.

Disadvantages are:

1. Slower injection rates which requires that equipment be in an area longer.

2. If the mine is dry, addition of water can have adverse effects on the roof and pillar strength of the mine.

3. Frequent movement of equipment is required because the material doesn't spread as far.

c. Gravity feed systems do not use mechanical pumps to transport the material. The solids are dumped into a hopper or on the ground. The material is then fed into a large funnel over the borehole and washed down the hole with a fire hose. The solid-to-liquid ratio is not controlled and the amount of water used is only the amount necessary to wash the material into the borehole.

Advantages are:

1. Low operating costs.

2. A minimum amount of equipment is required.

Disadvantages are:

1. The material is not transported very far in the mine.

2. Injection rates are very slow.

3. It requires active inspection and supervision since it is easy to block a hole with the fill material.

4. May not accomplish the desired support in the mine.

5. It is difficult to actually fill the void to achieve the desired column of support.

2. Pneumatic back-filling-A process of using air to assist the movement of solids into the mine void. Pneumatic methods can be subdivided into three main approaches; High pressure/low volume (100psi and less than 1000cfm); low pressure/high volume (less than 18psi and upto 4000cfm) and a combination of hydraulic injection methods with a high pressure air injection boost. In general the pneumatic system is most applicable to dry mine situation where there is a need to maintain the dry condition of the mine. Since all of the mines in the Madisonville area are flooded, the general details of the pneumatic systems will not be discussed.

Support Construction

Column supports are constructed to support the overburden by materials injected down a borehole to build a load-bearing column e.g., from the mine floor to the mine ceiling. Several kinds of supports can be built:

1. Gravel columns-Primarily used where heavy loads such as building construction are to be applied to the overburden. The columns are constructed in the mine void by pouring -3/8-inch gravel down a 6-inch borehole with an air jet located in the gravel pile at the bottom of the borehole to spread the gravel over a larger area. Normal design criteria specifies a roof contact area 6 feet in diameter. The gravel in the pile is after grouted with cement once the required roof contact is established.

   Advantages are:

   a. It requires a minimum abount of equipment that is readily available to local construction companies.

   b. The materials needed are also readily available ie. gravel and cement.

   Disadvantages are:

   a. It is difficult to obtain the desired roof contact with the gravel columns.

   b. It is very difficult to maintain that contact during the grouting phase since the gravel may move outward when the grout is injected which lowers the top of the pile.

   c. There is also a problem with achieving equal grout penetration throughout the pile. This makes it difficult to obtain the internal cementation of the pile necessary to support the overburden loads.

2. Injection of low-slump concrete-This technique has been used successfully on numerous subsidence abatement projects. Low-slump concrete is defined by using the ASTM tests Number 143-78. The material is placed in the mine void by extending the injection pipe to a point a few inches above the floor of the mine and pressure injecting the concrete to form a bulge around the bottom of the pipe. As the pressure builds up, the injection pipe is raised, continuing to keep the bottom of the pipe in the wet concrete. Pumping continues through a series of lifts until the desired roof contact is achieved.It is most important that the injection pipe remain in the wet mix pile in a flooded mine to keep the cement from washing out of the mix. The low-slump concrete injection method was used on the Continental Drive Emergency Project and on most of the other small OSMRE emergency projects in the Madisonville area.

   Advantages are:

   a. Low-slump concrete mixes can be used in both flooded and dry mines and the injection procedures are essentially the same.

   b. Gives strong roof support.

   c. The equipment necessary is readily available from local firms specilizing in highway and/or construction projects.

Disadvantages are:

a. The high cost of the concrete mix. It takes approximately 58 cubic yards of material to construct a 6 foot high cone with 6 feet of roof contact.

b. Project requires heavier equipment, and larger work crew to do the work.

c. Difficult to maintain the low-slump character of the mix. A thinner mix spreads out to a greater extent, causing a sharp increase in the amount of material required to build the support pile.

Barrier Construction

Barrier construction is a procedure used in dry mines to block openings into another part of the mine so as to isolate the area to be stabilized. Barrier construction methods are not applicable in the Madisonville study area because the mines are flooded. The discussion of the technique is included, however, because it may be applicable in some of the mines in western Kentucky where flooding has not taken place. The isolated area can them be injected with material at a lower cost than back flushing. The construction of a barrier system depends on the availability of accurate mine maps which are correlated with surface features. After deciding the most effective location for the barriers, the next step is to obtain a complete blockage of the mine openings. The normal procedure has been to gravity feed sand and gravel down a borehole drilled into the center of the void. Any unfilled area between the edge of the sloping pile and the wall of the mine can be reduced by injecting additional material through holes drilled between the prime injection hole and the edge of the pillar. Inspection of barriers is important and can be easily accomplished by drilling an observation borehole approximately 20 feet on either side of the proposed blockage and observing the progress with the borehole television camera.