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Correlating Microfilm Mine Maps With Topographic Maps

By David C. Uhrin

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CORRELATING MICROFILM MINE MAPS WITH TOPOGRAPHIC MAPS

by

David C. Uhrin[1]

ABSTRACT

Two improved methods have been developed to transfer microfilmed mine maps to suitable base maps showing surface features. The methods provide for (1) positioning and orienting maps; (2) merging adjacent maps; and (3) plotting maps at a common scale.

One method produces an overlay mosaic of mine maps using an integrated camera-processor. This photographic method shows the details of mine workings and is most useful for specific limited-area projects. In the second method, outlines of mine maps are digitized, manipulated, and plotted as overlays using a computer. This computer method can plot mine outlines and spatially index large numbers of microfilmed maps.

Microfilmed mine maps used in this Bureau of Mines study are on file in the Mine Map Repository of the Eastern Field Operations Center. The base maps are U.S. Geological Survey 7.5-minute topographic maps. The demonstration area is located in the New Kensington East and West quadrangles, Pennsylvania.

INTRODUCTION

Since the Mine Map Repository at the Eastern Field Operations Center (EFOC) was established in 1970, a logical extension has been considered--developing a series of maps to indicate the extent of underground mining (2).[2] The Repository currently has more than 43,000 mine maps on microfilm, primarily from Ohio, Pennsylvania, and West Virginia. An estimated 500,000 mine maps for areas east of the Mississippi River are available from State agencies and private industry for inclusion in the system (2, p. 8). Typical users of the Repository range from potential homeowners concerned about mine subsidence to consultants or engineers requesting detailed information about mine workings for studies such as reserve assessments or abatement of acid mine drainage.

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[1]Geologist, Eastern Field Operations Center, Bureau of Mines, Pittsburgh, Pa.
[2]Underlined numbers in parentheses refer to items in the list of references preceding the appendixes.

Major difficulties in serving these users have been comparing, correlating, locating, and orienting the mine workings with regard to surface features. The purpose of this study is to address these difficulties by developing methods for using the microfilmed mine maps on file in the Repository to plot the extent of underground workings on suitable base maps showing surface features. Two methods--one photographic and the other computer--have been developed to plot underground workings as they relate to surface features.

ACKNOWLEDGMENTS

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NEEDS AND PROBLEMS

To develop a mine map transfer method that utilizes the microfilm maps in the Mine Map Repository and that best serves Repository users, it was necessary to identify both the needs of Repository users and the problems inherent in using the existing microfilm system.

The scale and format used for the demonstration area were based on information provided by Repository personnel, Repository users, and land use planning groups. This information indicated that Repository users needed: (1) index maps listing the microfilm required to obtain the best and most up-to-date coverage available for a selected area; (2) 7.5-minute topographic maps (U.S. Geological Survey [U.S.G.S.]) as base maps; (3) overlays of mine workings for topographic maps; (4) depth to mining or cover thickness; (5) dates of individual maps used to prepare the overlays; and (6) as much detail of mine workings as is possible to show on the topographic map overlays.

The problems in developing a method for mine map transfer were identified by examination of several hundred mine maps in the Repository. They are the same general problems for any geographic region included in the Repository, no matter what transfer method is employed. These problems relate to five categories: scale, surface control,[3] quality, duplication, and quantity of data available.

The most significant problems are related to map scale. There is no common scale on the original maps and in order to microfilm a given map in as few frames as possible, no attempt is made to bring the microfilm to a common

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[3]A glossary of terms used in the text is presented in appendix A.

scale. This creates a need for a transfer method to have a variable blowback capability. Also, some maps have no scale indicated.

A map lacking surface control is usually not usable. The presence of a north arrow and surface control on the mine maps is essential to correlating the mines to the land surface.

Mine map quality is determined by condition, readability, and adequacy of information such as coalbed names or dates of maps. Microfilm mine maps of poor quality cannot be used.

Duplication frequently makes the use of microfilm maps time consuming. Many of the maps in the Repository are updates of earlier maps or are duplicates from a different source or donor. Simple comparison resolves most duplication. But some maps must be carefully compared because each version may have certain areas that are more complete than those on another map.

Nearly 50 percent of all microfilmed maps cannot be used for mine map transfer because of factors such as lack of surface control, extremely poor quality, duplication, or unsuitable maps (for example, mine-fire maps). A listing of all duplicate and/or unusable maps should be prepared for each quadrangle.

The large number of microfilmed maps on file in the Repository and the fact that many of these documents consist of multiple frame sequences is an important consideration in the development of a mine map transfer method. The method developed must be capable of handling large quantities of data.

INVESTIGATIVE APPROACH

The New Kensington East and West quadrangles (fig. 1) were chosen for the demonstration area because (1) more than three-fourths of the area has been undermined; (2) surface control exists for approximately 80 percent of the mine maps; (3) mines extend into adjacent quadrangles; (4) mining has been confined primarily to one coalbed, and (5) WPA maps exist for testing the reliability of the mine map transfer method developed.[4]

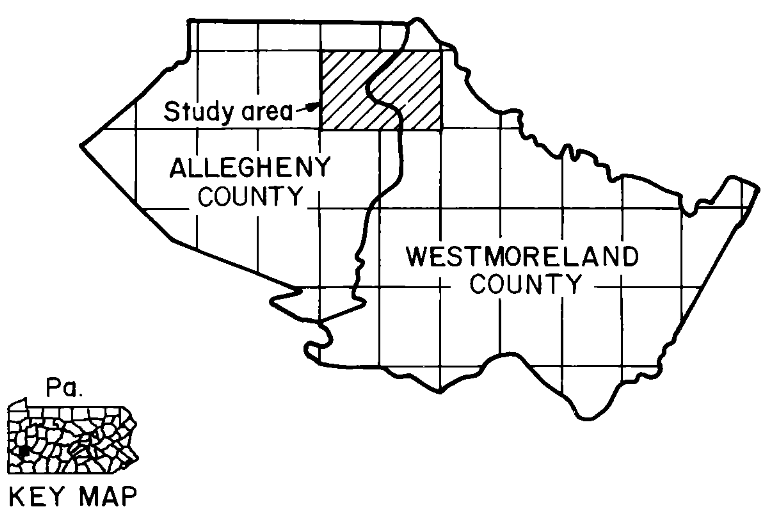

FIGURE 1. - Location of New Kensington East and West 7.5-minute quadrangles, Pennsylvania.

[4] WPA maps were prepared under a Works Progress Administration project in the 1930's and indicate the extent of coal mining in western Pennsylvania.

Mine maps for this area characterize most of the basic problems that occur with microfilm documents in the Repository.

Existing methods and equipment for map transfer were reviewed and persons currently attempting to solve the problems of mine map transfer and those who deal with similar problems were consulted. Methods currently used to transfer mine map data to a selected base map are hand transfer, pantograph, image projection and tracing, and photographic-darkroom processing A brief description of these methods is provided in appendix B. None of these methods proves entirely satisfactory for mine map transfer. Each has its drawbacks, such as being tedious and time consuming, failing to show sufficient details of mine workings, or requiring darkroom facilities. The review of methods did, however, indicate that if the need for darkroom facilities could be overcome, a photographic approach could address many of the problems of Repository microfilm transfer.

Prior to this study, another method--digitization-computer manipulation--had not been specifically used for the transfer of microfilm mine maps. Computer systems are used to manipulate various types of map information for such applications as land use analysis or environmental impact assessment. The techniques used in these systems are essentially the same as those needed for development of a system for manipulating and displaying mine maps. A computer approach also could provide a system for managing the large number of microfilm maps currently in the Repository.

PHOTOGRAPHIC METHOD

The photographic transfer method developed in this study consists of steps for (1) microfilm screening; (2) microfilm blowback; (3) mosaic assembly; (4) outlining areas of mine workings; and (5) overlay photography of the mosaic, mine outlines, and structure contour map.

The screening of microfilm was conducted to select the usable and most appropriate microfilm for blowback.[5] Selected microfilm maps were blown back to the project scale (1 inch = 2,000 feet) using an Itek Graphic Products integrated camera-processor.[6] This machine, a variable-focus camera, delivers either negative or positive images on film or paper in approximately 2-1/4 minutes. Depending on the blowback required, an aperture card is positioned either in the microfilm enlarger attachment or on the copyboard of the machine. The procedure for using the enlarger or the copyboard is similar. A photographic copy is made at the predetermined blowback number (see appendix D).

The properly scaled film is positioned and oriented (and affixed to a transparent overlay) with respect to the topographic map by matching surface control features such as roads, streams, or outcrop patterns. If a multiple

[5]A listing of the microfilm available for the New Kensington West 7.5-minute quadrangle, with comments on duplicate and unusable microfilm, is provided in appendix C.

[6]Reference to specific equipment does not imply endorsement by the Bureau of Mines.

frame document is being processed, a composite of scaled individual frames must first be pieced together. Scaled blowbacks for adjacent mines are then merged by piecing together a mosaic, thereby creating an overlay for the 7.5-minute topographic map (fig. 2).

Detail shown in figure 2 is not as clear as that in the actual overlay for the topographic map owing to reduction to page size. To illustrate detail that is available in the mosaic, a portion of the New Kensington West quadrangle and the corresponding portion of the mosaic of scaled mine maps are reproduced at actual scale (fig. 3).

General outlines of the mines in the Upper Freeport coalbed are shown in figure 4. This overlay includes mine names, document numbers of the microfilmed maps used for each specific area, and the mine closure or drafting dates. The overlay serves as an index of microfilm needed to view details of a mined area at an enlarged scale on a microfilm reader-printer. Also, it enables the user to properly orient a mine map.

A structure contour map on the top of the Upper Freeport coalbed was photographed to produce an overlay (fig. 5) for the New Kensington West quadrangle. This overlay is used with the mine mosaic overlay and the New Kensington West topographic map to indicate cover thickness over a mined area (by subtracting coal elevations from surface elevations).

For reproduction, the original overlays can be microfilmed and then printed on the reader-printer. They can also be duplicated on paper or on transparent material using a diazo-type process. To make periodic revisions, the blownback copy of the (microfilmed) revised area can be added to the original mosaic and rephotographed.

Maximum discrepancy observed during the study was found to be approximately 150 feet. When the mosaic of scaled mine maps is overlaid on the topographic map, there is usually a good match of surface features such as roads, streams, or outcrop patterns. (No reasonable method exists for checking how well the mine workings relate to surface features shown on the original maps.) Considering the age, storage conditions, and the number of generations for many of the original maps, little distortion is apparent in the mine maps when they are blown back to project scale.

Repository users needing mine details find the overlay mosaic of scaled mine maps extremely useful. They also indicate that the overlay showing general outlines of mines is especially valuable as a spatial index for selecting microfilm for further detailed examination.

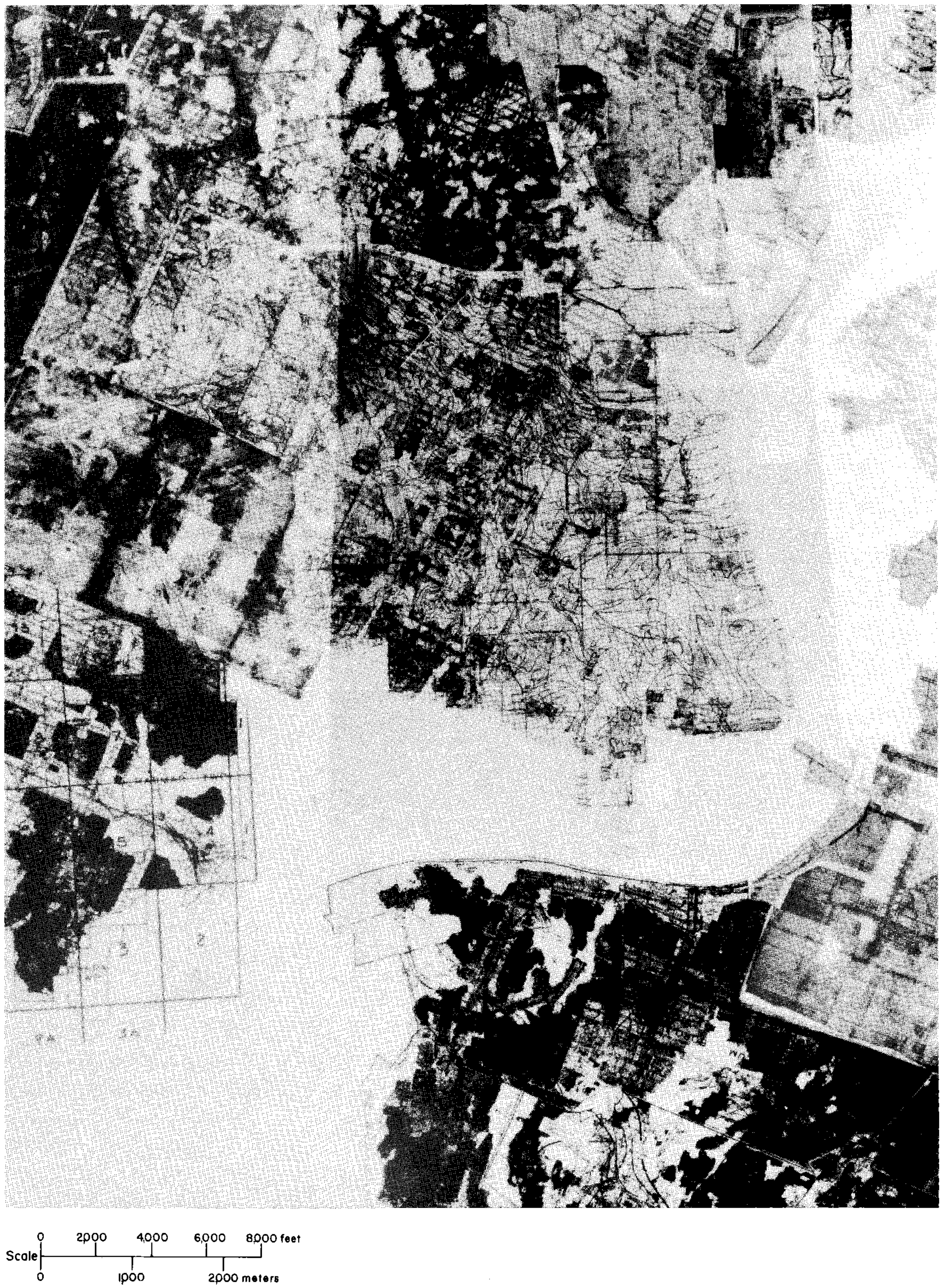

FIGURE 2. - Mosaic of scaled mine maps in the Upper Freeport coalbed, New Kensington West quadrangle.

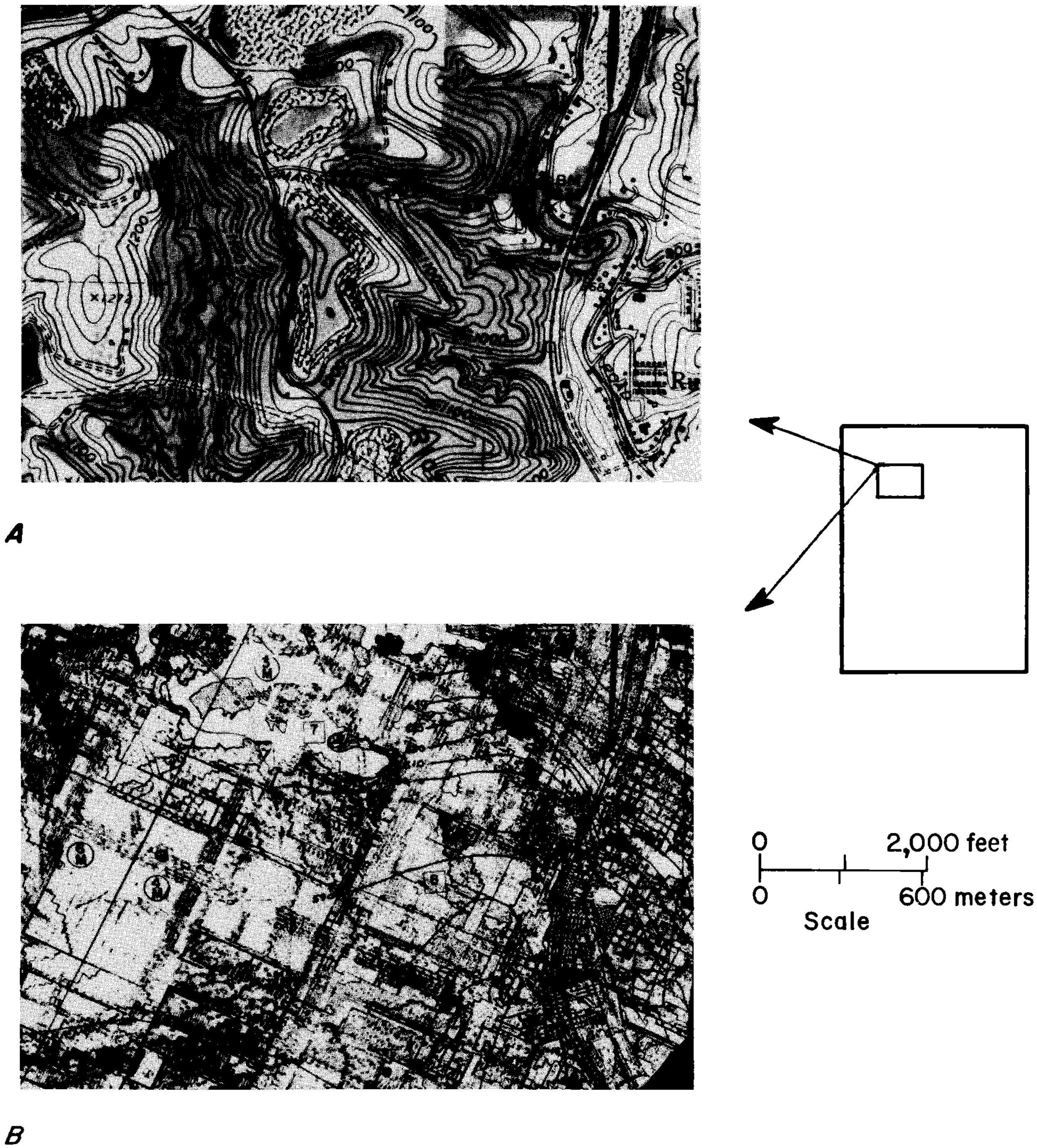

FIGURE 3. - Portion of the New Kensington West quadrangle (reproduced to actual size). *A*, Topographic map; *B*, corresponding portion of the mosaic of scaled mine maps.

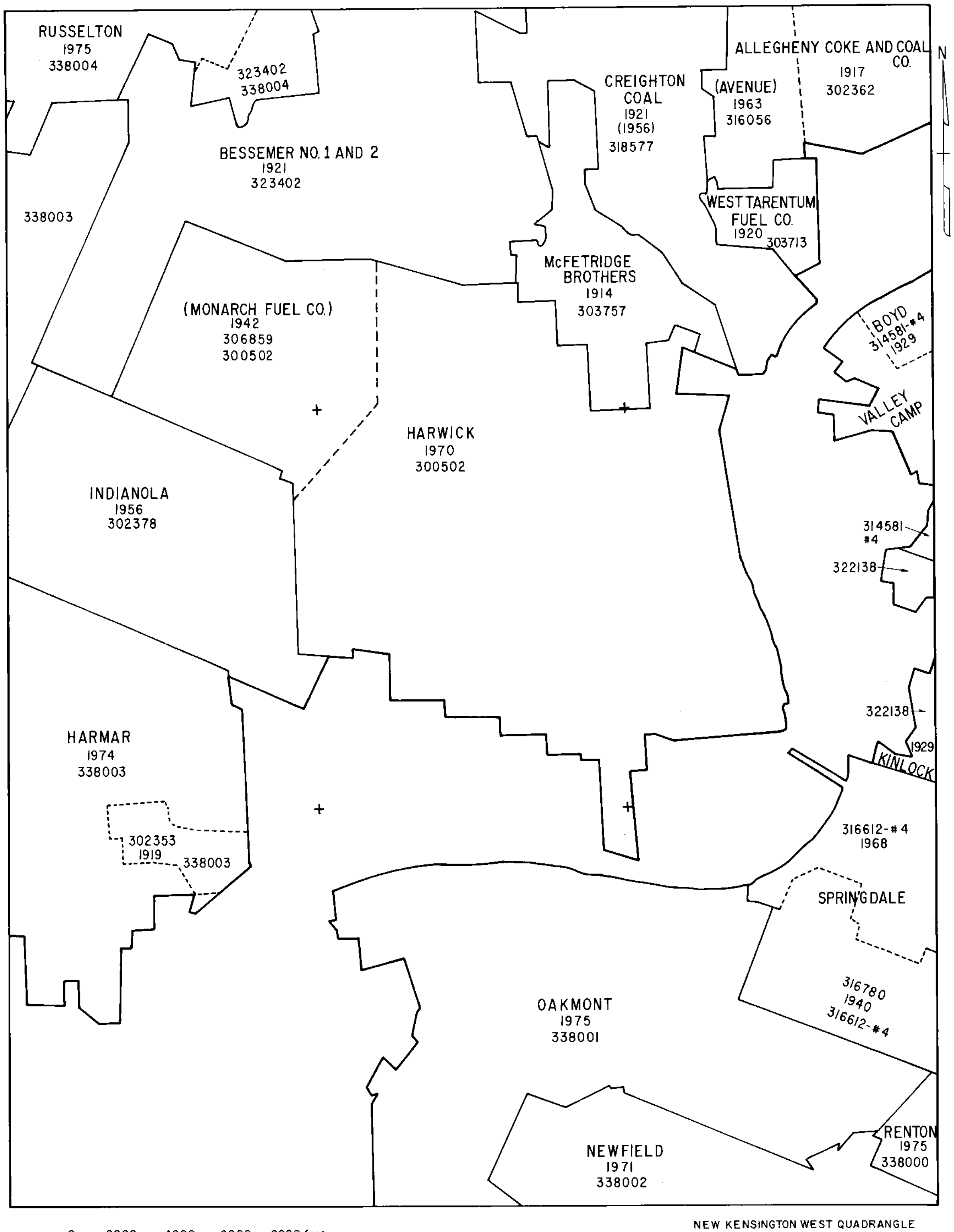

FIGURE 4. - General outlines for mines in the Upper Freeport coalbed, New Kensington West quadrangle (reduced to page size). Mine names, closure or drafting dates, and document numbers are indicated. Two documents were used for each area showing two document numbers and are set off by dashed lines.

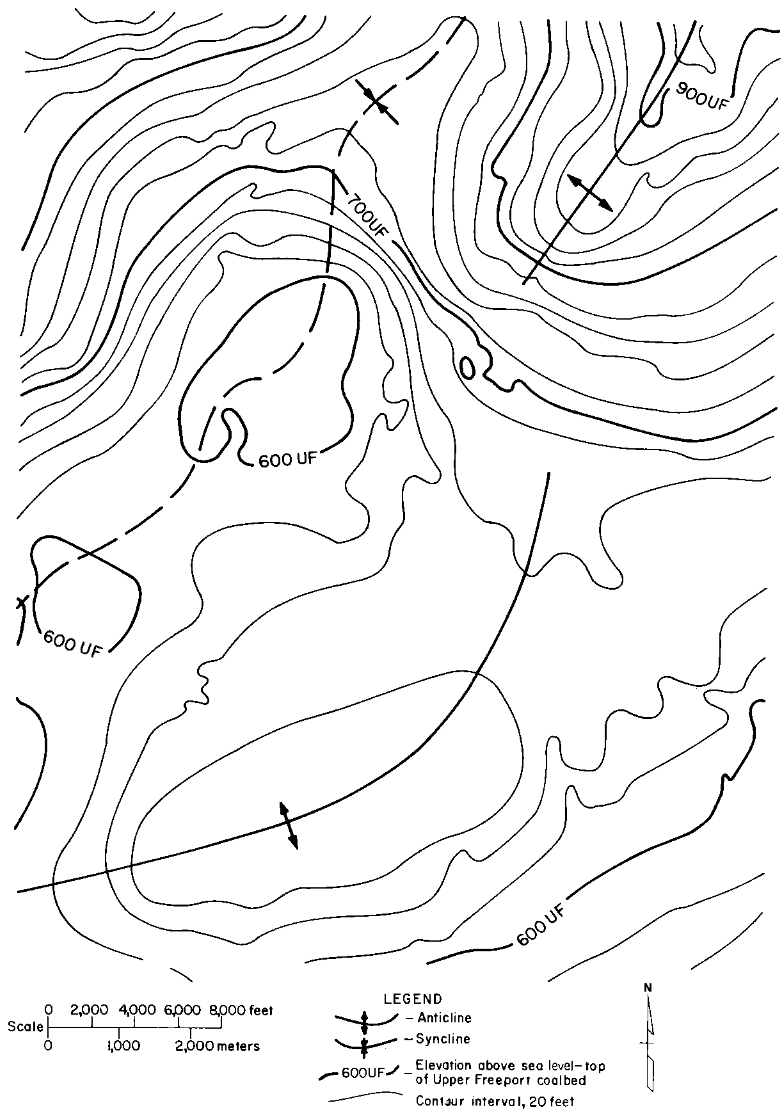

FIGURE 5. - Structure contour map—top of the Upper Freeport coalbed, New Kensington West quadrangle (5).

DIGITIZATION-COMPUTER MANIPULATION METHOD

To address the problems of mine map transfer, a geographical information system is the type of computer system needed. Such a system is capable of handling spatially related data such as maps (for example, political boundaries or isopachs). However, geographical information systems are in most instances relatively new and are still undergoing development (1, 3-4). Map output for these systems is generated by a plotting pen, a high-speed line printer, and/or a cathode ray tube display (CRT).

The digitization-computer manipulation method developed in this study consists of steps for (1) digitizing reader-printer copies of mine maps; (2) computer manipulation for scaling and orienting the digitized information; and (3) plotting the mine outline overlays. Experience gained from developing the photographic method made it unnecessary to repeat all the investigative steps for the computer method. For example, microfilm screening was not repeated.

A computer approach to mine map transfer requires that maps be converted into numerous groups of discrete values that can be read into a computer. This is called map digitization. Because of all the detail provided by any one mine map and the poor quality of many of the original maps, mining details cannot efficiently be digitized and utilized. Consequently, only the mine outlines were digitized in the study. A Numonics graphic digitizer, coupled to a Hewlett-Packard 9815 programable calculator, was used to digitize the mine outlines. A program to orient the planar map surface (X-Y plane of the digitizer) to the corresponding geographical coordinates (latitude and longitude) was used in the digitizing process.

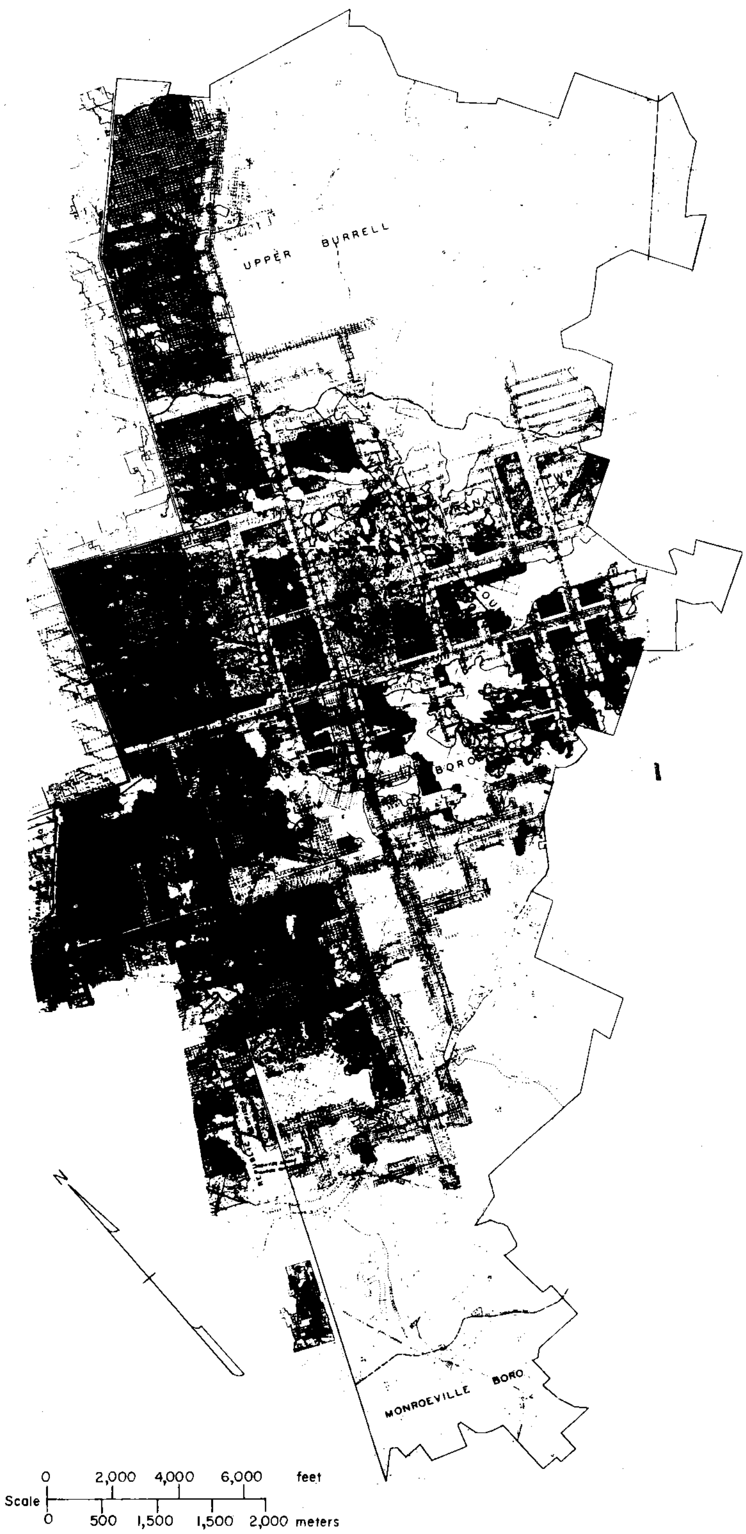

FIGURE 6. - Renton mine (reader-printer copy, reduced to page size).

Outlines of two mines were digitized from reader-printer copies made from microfilm (X 14.5 blowback). These two mines occur primarily within the New Kensington East quadrangle but extend into the New Kensington West quadrangle. One mine map, the Renton mine (fig. 6), is a single frame, with an original scale of 1 inch = 1,000 feet (microfilm reduction X 29); the other map, the Springdale mine (fig. 7), is four frames, with an original scale of 1 inch = 300 feet (microfilm reduction X 36). The outlines and three known points (lying on a right triangle) for each map were digitized relative to the southwest corner of the New Kensington East quadrangle.

Scaling routines were developed specifically for the study and standard software packages were utilized for graphing and plotting output. The routines manipulated the digitized map outlines to the project scale and to the correct position and orientation with respect to the topographic map. The scaling factor was determined by using the three known digitized points on both the mine and topographic map and comparing the hypotenuse of the triangle on the quadrangle map with the hypotenuse of the corresponding triangle on the mine map. Programs were run using a Tektronix 4010-1 CRT terminal through a time-sharing connection with a PDP-10

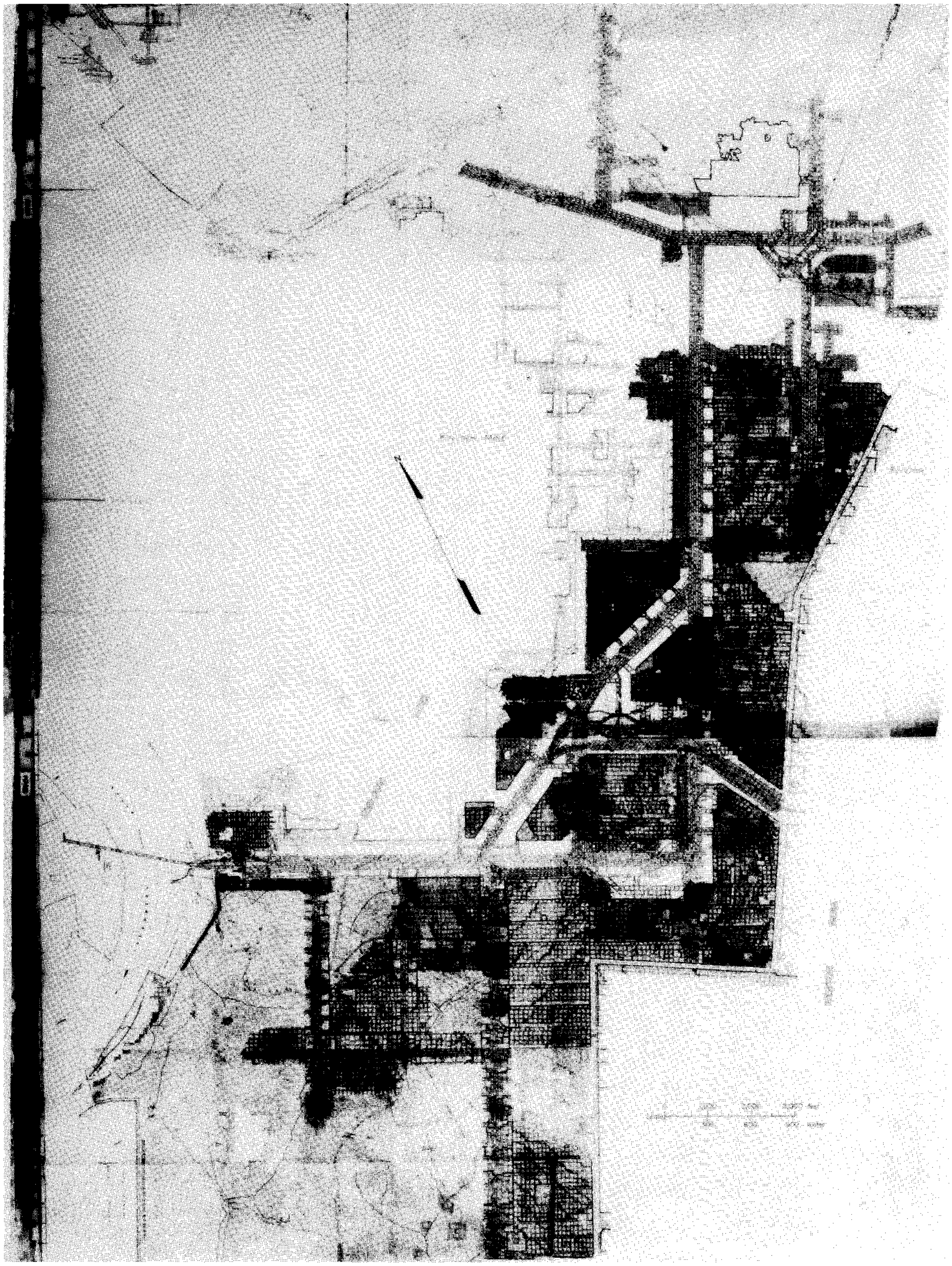

FIGURE 7. - Springdale mine (reader-printer copy, reduced to page size).

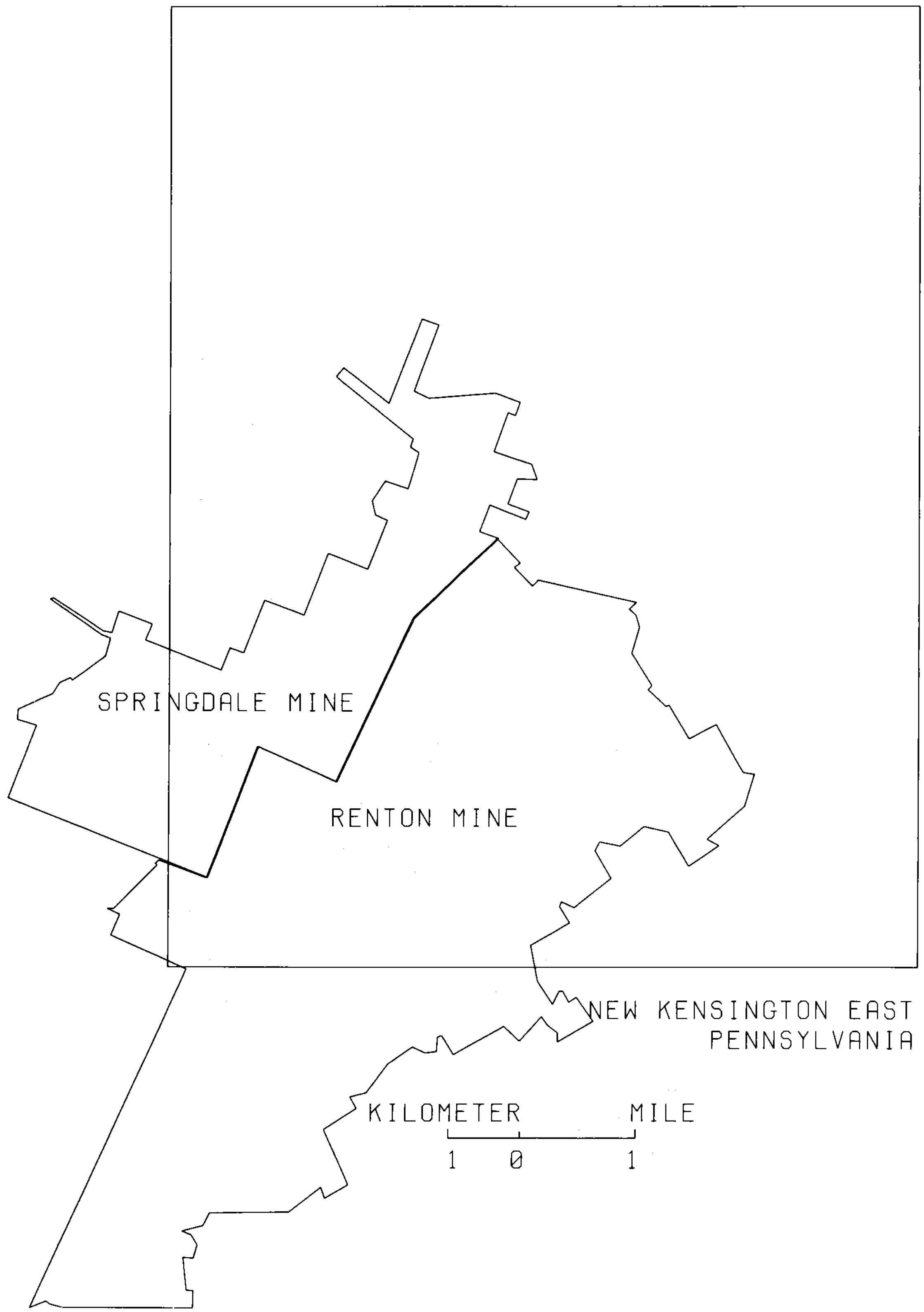

FIGURE 8. - CALCOMP plot of the Renton and Springdale mines (reduced to page size).

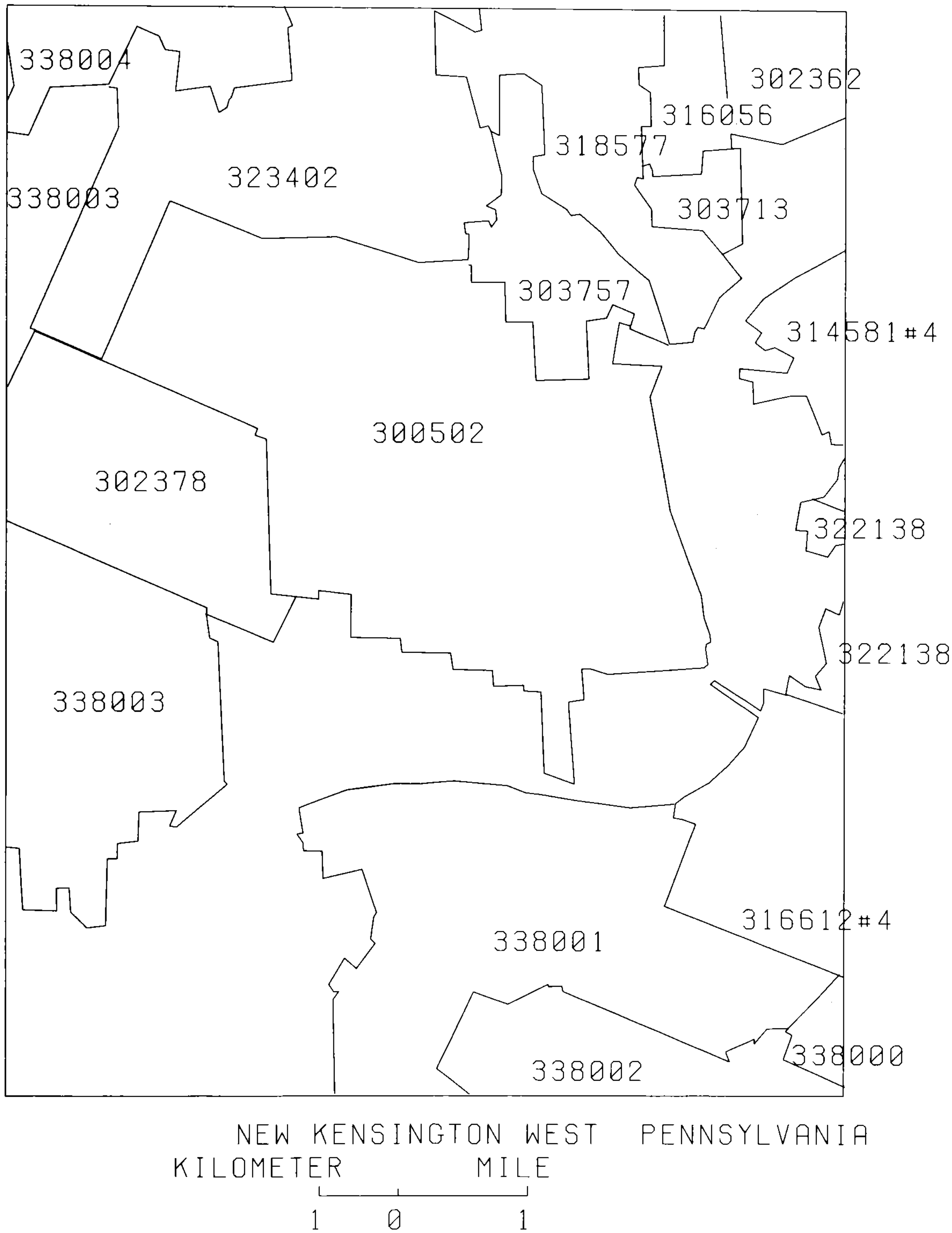

FIGURE 9. - CALCOMP plot showing general outlines of mines in the Upper Freeport coalbed, New Kensington West quadrangle (reduced to page size). Six-digit numbers are document identification numbers.

computer (Digital Equipment Corporation). The CRT display was used to check data input and to evaluate and refine the computer plots before a final plot was produced on a CALCOMP plotter. The CALCOMP plot, reduced to fit an 8- by 10-1/2-inch page, is shown in figure 8.

To illustrate how an overlay of an entire quadrangle can be computer generated, figure 4 produced by the photographic method was digitized and plotted. The CALCOMP plot, reduced to fit an 8- by 10-1/2-inch page, is shown in figure 9 (only the solid lines of fig. 4 were digitized).

Copies of computer overlays can be reproduced with a CALCOMP plotter. Or, as with the overlays produced by the photographic method, computer overlays can be microfilmed and printed on the reader-printer or reproduced using a diazo-type process.

The plot illustrated in figure 9, as well as that portion of figure 8 lying within the New Kensington West quadrangle, compare favorably with figure 4. Repository users indicate that figure 9 serves equally as well as figure 4, providing a spatial index for selecting microfilm for more detailed examination. The plots illustrated in figures 8 and 9 were produced on a system having an interactive capability. Thus, the user can interact with the system and can correct, add, or delete through a remote terminal. This capability is critical for rapid update and retrieval of information.

CONCLUSIONS

Either the photographic or the computer method can be used to bring mine maps to a common scale, merge adjacent maps (and frames), and properly position, orient, and plot the extent of mine workings relative to the overlying surface.

The two approaches provide different levels of detail. With the photographic method, most of the detail on the original mine map is reproduced. This method should be used when the configuration and details of mine workings and how they relate to the overlying surface (or adjacent beds) are needed. The method is time consuming and would be most useful and practical for specific, limited-area projects.

With the computer method, a system could be developed for plotting and indexing the large numbers of microfilmed maps in the Repository as they are spatially related to a standardized mapping system (such as the U.S.G.S. 7.5-minute topographic map series). An interactive computer system can index maps at a common scale and can permit rapid and repeated retrieval and display for correcting and updating data. The computer method can provide only an outline of mine workings at the present time.

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APPENDIX A.--GLOSSARY

Aperture card.--Tab card on which a 35-mm microfilm frame is mounted.

Blowback.--Process of enlarging or reducing a microfilm image.

Blowback number.--The number of times a microfilm image must be enlarged or reduced to produce a copy at a specified size or scale (reductions are expressed as a decimal).

Cathode ray tube (CRT).--Essentially a TV screen display device.

Character-print map.--A map prepared using a line printer to produce geometrical patterns by the proper placement of printer characters.

Composite.--Blownback copies of a multiple frame document that are pieced together to reproduce the original mine map.

Composite mapping.--A planning approach that utilizes various combinations of basic data maps as overlays to identify desirable and undesirable areas for development.

Diazo.--A method for producing blueprints, maps, and similar documents from a transparent or translucent original using an ammonia development process and providing a nonreversed copy.

Document.--Microfilmed mine map.

Frame.--One 35-mm microfilm chip.

Generation.--Designates whether a photograph is the original photograph or whether it is a subsequent reproduction of the original one.

Integrated camera-processor.--A unit that photographs a subject and develops the film automatically with no darkroom requirement.

Microfilm reduction.--The number of times a document is reduced when it is microfilmed.

Mosaic.--Single frame and composites blown back and pieced together to form an overlay of mine maps for a particular quadrangle.

Multiple frame document.--A mine map that is so large that it requires more than one frame to record the entire map.

Numerical factor.--The denominator of the numerical ratio of a map.

Numerical ratio.--Map scale expressed as a ratio.

Pantograph.--An instrument used for the mechanical copying of plans, maps, or similar documents to desired scale.

Printout listing.--Computer printout list generated by the Mine Map Repository computer indexing system.

Reader-printer.--A device that produces paper copies enlarged from a microfilm image.

Surface control.--Identifiable surface features such as roads or streams that relate underground mine workings to the ground surface above them.

APPENDIX B.--TRANSFER METHODS

Hand transfer.--A mine outline is transferred either from a reader-printer copy or an original map by scaling the distances and hand-plotting the outline onto a topographic map or an overlay. This method is tedious and time consuming; no details of mining are shown.

Pantograph.--A mine outline is transferred from either a reader-printer copy or the original map using a pantograph. This method is tedious and time consuming; no mining details are shown.

Image projection and tracing.--An image is projected to scale (using a standard darkroom enlarger) and the outline of the map is traced. This method is relatively fast if only a mine outline is wanted. However, sufficient light intensity for image projection presents a difficult problem. If mining details are wanted, the method is tedious and time consuming.

Photographic--darkroom processing.--The original map is photographed and either a darkroom negative or a microfilm is used in a conventional enlarger to produce a project scale map. The mine outline is traced or a film overlay is produced. A photographic approach can provide mine details. However, photographing the original map and using a negative does not rely on the Repository microfilm and would require regaining access to over 43,000 maps already in the system. This is impossible in most instances. Either technique would require a well-equipped darkroom setup or contracting for the work.

APPENDIX C.--LISTING OF MICROFILMED MINE MAPS FOR NEW KENSINGTON WEST 7.5-MINUTE QUADRANGLE, BY MINE AND GEOGRAPHIC AREA

Document number	Comment	Document number	Comment
	Bessemer 1 and 2 mines		New Kensington area
338004[1]	Russelton mine.	314581 #4[1]	Boyd, Valley Camp, and Kinlock mines.
323402[1]	Bessemer 1 and 2 mines (Russelton).	322138[1]	The same as 314581 but is one frame.
302385	Less extensive than 323402.	316692	Includes plot and lot details for part of Valley Camp mine.
303816	Surface features only (shafts).	303850	Adds detail to Boyd mine.
302363	Property map.	303851	Less extensive than 314581.
		304969	Property map for general area of Kinlock mine.
	Creighton-Tarentum area	303560	Lot plan only at Kinlock.
303757[1]	McFetridge Brothers mine.	303597	Cragdale mine, essentially the same as 322137 #1.
316234	Essentially the same as 303757 with some additional detail.	322137 #1	Boyd mine, essentially the same as 303597.
318577[1]	Creighton Coal Works.	322137 #6	Adds detail to 314581 (Valley Camp mine).
302388	Less extensive than 318577 but adds some detail.	322137 #2-5, 7	Adds detail to 314581 (Kinlock mine).
306624	Less extensive than 318577.	303841	Property map for general area of Kinlock and Springdale mines.
302381	Property map for 318577.		
316056[1]	Allegheny Coal & Coke Co. mine.		Newfield mine
302362[1]	Less extensive than 316056 but clear detail.	338002[1]	Newfield mine.
303713[1]	West Tarentum Fuel Co. mine.	304671	Small section of 338002 at Milltown.
	Harmar mine	304970	Property map for 338002.
338003[1]	Harmar mine.		Oakmont mine
302353[1]	Early workings.	338001[1]	Oakmont mine.
306567	Ventilation plan.	322146	Less extensive than 338001.
300464	Small section of 338003.	302397	Early workings.
322125	.....do		Renton mine
302356	Property map for 338003.	338000[1]	Renton mine.
302405	Essentially the same as 302356.	314583	Only a small section of 314583 occurs on New Kensington West quadrangle.
304019	.....do		Springdale mine
304670	Early property map for 338003.	316612 #4[1]	Springdale mine.
	Harwick mine	316708[1]	Adds details to western section of 316612 #4.
300502[1]	Harwick mine.	322292	Less extensive than 316612.
306859[1]	Section of 300502.	316710	Large scale map of 316612.
314610	Small section of Cheswick.	306872	Mining in the Pittsburgh coalbed near Logans Ferry.
323414	Very large scale map of 300502 (39 frames).		General
322124	Section of 300502.	316239	Extent of "Thick Freeport" coalbed; small scale map; mine locations and coal contours.
302394	Property map (and small section of mining).	302679	Extent of "Thick Freeport" coalbed; small scale; mine locations.
316092	Small section of 300502.		
	Indianola mine		
302378[1]	Indianola mine.		
303943	Less extensive than 302378 but adds some detail.		
316519	Essentially the same as 302378.		
302408	Property map for northern section of 302378.		
302380	.....do		

#--Designates frame number.
[1]Designates the mine maps used to prepare the mosaic.

NOTE --This list is an example of how the mine maps for a given quadrangle should be grouped to assist the Repository users sort through duplicate and unsuitable documents.

APPENDIX D.--MICROFILM BLOWBACK

The term Blowback used in the study refers to the process of enlarging or reducing a microfilm image. The blowback number is the degree of enlargement a microfilm image must undergo to produce a copy at a specified scale (reductions are expressed as a decimal). For example,

$$\text{Blowback number} = \text{Numerical factor} \times \text{microfilm reduction factor} \times \text{numerical ratio},$$

$$= 2{,}400 \times 20 \times \frac{1}{24{,}000},$$

$$= 2.$$

Table D-1 was developed to establish the range of blowback needed to bring microfilm maps to the scale of 1 inch = 2,000 feet, given specific scales of original maps and specific microfilm reductions. The table, used in conjunction with the findings from a survey of Repository personnel on map scales and microfilm reduction numbers, helped to establish the blowback range requirements. Although the blowback number is used specifically in the photographic method, it is also useful as a general guide for the scaling factor in the computer method.

TABLE D-1. - Calculated blowback numbers for combinations of scales and microfilm reductions (for overlays at scale of 1 inch = 2,000 feet)[1]

Common scales of original mine maps	Numerical factor	Microfilm reduction (range)					
		14.5	16	20	25	30	36
		Blowback numbers					
1 inch = 50 feet	600	0.36	0.40	0.50	0.63	0.75	0.90
1 inch = 100 feet	1,200	0.73	0.80	1.00	1.25	1.50	1.80
1 inch = 200 feet	2,400	1.45	1.60	2.00	2.50	3.00	3.60
1 inch = 300 feet	3,600	2.18	2.40	3.00	3.75	4.50	5.40
1 inch = 500 feet	6,000	3.63	4.00	5.00	6.25	7.50	9.00
1 inch = 1,000 feet	12,000	7.25	8.00	10.00	12.50	15.00	18.00
1 inch = 2,000 feet	24,000	14.50	16.00	20.00	25.00	30.00	36.00
1 inch = 5,280 feet	63,360	38.28	42.24	52.80	66.00	79.20	95.04
1 inch ≈ 1 mile (U.S.G.S. 15-minute series)	62,500	37.76	41.67	52.08	65.10	78.12	93.75

[1]Dashed block indicates area of most common scales and reductions and therefore most common blowback numbers.

APPENDIX E.--ADDITIONAL INFORMATION ON COMPUTER METHODS

Two types of computer systems should be considered and distinguished when studying the problems of managing mine maps: Text-handling information systems and geographical information systems. A text-handling information system is currently used to index maps in the Mine Map Repository. Textual information on each map is machine-encoded and is retrievable as printout listings. This type of system can only provide a point location for each mine. As noted in the text, a geographical information system is the type of system needed to address the problems of mine map transfer, because such systems can handle spatially related data such as maps. A geographical information system would be capable of indexing maps and also would establish mathematically defined maps in a data base for future manipulation as additional data are entered into the system.

Digitizing map information is the most time-consuming aspect of computer mapping. Converting areal and line information into a computer compatible format can be accomplished in several ways, such as hand-coding sheets for keypunching or, more efficiently, using some type of digitizing device. Current optical scanners are not suitable for digitizing mine maps.

The CRT plot shown in figure E-1[1] is equivalent to the CALCOMP plot illustrated in figure 9. Frequently, when output that is properly scaled for plotting on the CALCOMP plotter is compressed and viewed on the CRT, it is difficult to read. It is possible, though, to "window-in" on a specific portion of the CRT image and enlarge that portion for display on the screen. An enlarged view of the northeast corner of figure E-1 is shown in figure E-2. This capability would be very useful in a computer system for managing the microfilm in the Repository.

The ability of a computer approach to provide an overlay as well as a composite mapping capability for handling mine map information is illustrated by the figures that follow.[2] A character-print map of the areas underlain by mine workings within the New Kensington West quadrangle is shown in figure E-3 (also see fig. 9). The legend for figure E-3 is given in figure E-4. Urban

[1]Figures E-1 and E-2 were drafted for publication clarity and are not actual computer plots.

[2]Because the computer programs that were available through time-sharing did not provide the capability needed to explore composite mapping, composite mapping was explored by using a system developed by the Ohio Department of Natural Resources. The Ohio Capability Analysis Program--OCAP--is a geographical information system for "...evaluation of the lands' inherent ability to accommodate various land uses...." An H. Dell Foster Coordinatograph is used for digitizing; the computer is an IBM 370; output character-print maps are generated by a high-speed line printer.

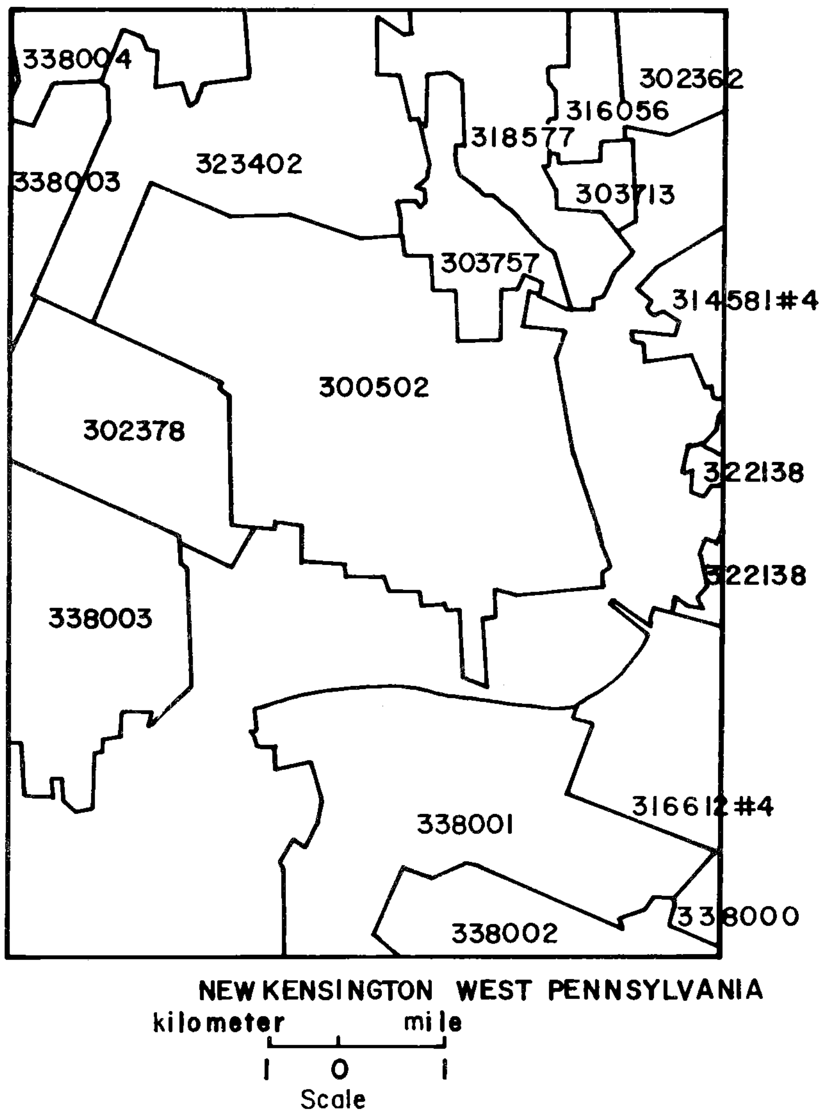


FIGURE E-1. - CRT plot (actual size; figure was drafted for publication clarity and is not actual computer plot). Outlines for mines in the Upper Freeport coalbed, New Kensington West quadrangle. Six-digit numbers are document numbers. (See discussion in text regarding clarity of numbers and letters.)

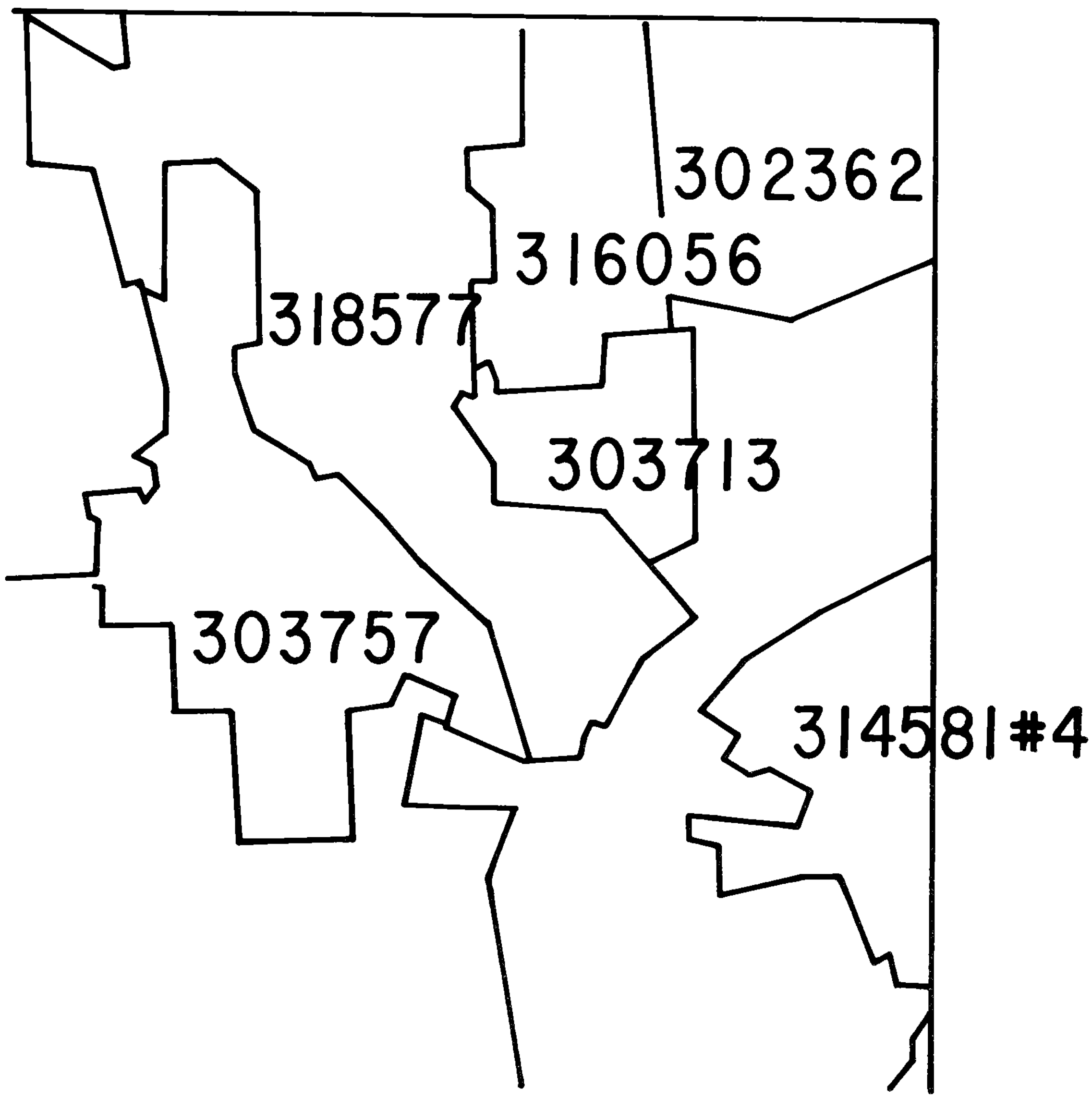
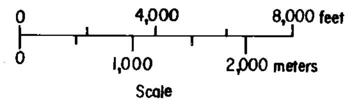


FIGURE E-2. - CRT plot (actual size; figure was drafted for publication clarity and is not actual computer plot). Enlargement of northeast corner of figure E-1.

FIGURE E-3. - Character-print map for mines in the Upper Freeport coalbed, New Kensington West quadrangle (reduced to page size).

LEGEND

Scale 1: 24000
Cell width : 200 feet
Cell height : 250 feet



Data code	Map symbol	Code description	
1		338004	Russelton (1975)
2		323402 338004	
3		323402	Bessemer No. 1 & 2 (1921)
4		338003	
5		318577	Creighton Coal (1921) (1956)
6		303757	McFetridge Brothers (1914)
7		316056	Allegheny Coke & Coal (1963)
8		302362	Allegheny Coke & Coal (1917)
9		303713	West Tarentum Fuel (1920)
10		Unmined areas	
11		300502	Harwick (1970)
12		306859 300502	Monarch Fuel (1942)
13		302378	Indianola (1956)
14		338003	Harmar (1974)
15		302353 338003	(1919)
16		314581	Boyd (1929)
17		314581	Valley Camp (1929)
18		314581	
19		322138	
20		322138	Kinlock (1929)
21		316612	Springdale (1968)
22		316780 316612	Springdale (1940)
23		338001	Oakmont (1975)
24		338002	Newfield (1971)
25		338000	Renton (1975)
26		Allegheny River	
Total	26		

FIGURE E-4. - Legend for figure E-3.

and rural areas within the New Kensington West quadrangle are shown in figure E-5. A composite map showing, for example, urban areas underlain by mines, was produced by having the computer composite or "overlay" figures E-3 and E-5. This character-print map is illustrated in figure E-6. Total areas in each category are indicated, as well as the total area of the quadrangles.[3] There are numerous applications for this overlay capability. Additional basic data maps such as cover thickness, mineral ownership, and coal thickness can be digitized and composite maps can be generated to focus on areas of potential conflict for development or potential subsidence.

[3]Note the symbol "NN" which demonstrates that the OCAP system has a routine to detect errors if individual component maps are not properly coded when compositing maps.

LEGEND

Scale 1:24000
Cell width : 200 feet
Cell height : 250 feet

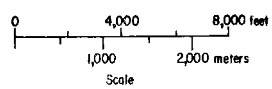
0 4,000 8,000 feet
1,000 2,000 meters
Scale

Data code	Map symbol	Code description
1		Rural areas
2		Urban areas
3		Allegheny River
Total	3	

FIGURE E-5. - Character-print map of urban and rural areas, New Kensington West quadrangle (reduced to page size).

LEGEND

Scale : 1:24000
Cell width : 200 feet
Cell height : 250 feet



Data code	Map symbol	Code description	Number of cells	Percent of study area	Area (acres)
1		—Mined land—Rural land use	20200	64.11	23259.5
2		—Mined land-Urban land use	3176	10.16	3686.4
3		—Unmined land-Rural land use	2259	7.17	2599.8
4		—Unmined land-Urban land use	4171	13.22	4796.1
5		—Allegheny River	1377	4.37	1586.7
6		—No match	302	0.97	350.4
Total	6		31485	100.00	36279.0

FIGURE E-6. - Composite character-print map produced by "overlaying" figures E-3 and E-5 (reduced to page size).

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