Illinois Coal Reserve Assessment and Database Development: Final Report

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FIGURES

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EXECUTIVE SUMMARY

The new demonstrated reserve base estimate of coal for Illinois is 105 billion short tons*. This estimate is an increase from the 78 billion tons in the Energy Information Administration's demonstrated reserve base of coal, as of January 1, 1994. The new estimate arises from revised resource calculations based on recent mapping in a number of counties, as well as significant adjustments for depletion due to past mining. The new estimate for identified resources is 199 billion tons, a revision of the previous estimate of 181 billion tons.

The new estimates incorporate the available analyses of sulfur, heat content, and rank group appropriate for characterizing the remaining coal resources in Illinois. Coal-quality data were examined in conjunction with coal resource mapping. Analyses of samples from exploration drill holes, channel samples from mines and outcrops, and geologic trends were compiled and mapped to allocate coal resource quantities to ranges of sulfur, heat content, and rank group. The new allocations place almost 1% of the demonstrated reserve base of Illinois in the two lowest sulfur categories, in contrast to none in the previous allocation used by the Energy Information Administration (EIA). The new allocations also place 89% of the demonstrated reserve base in the highest sulfur category, in contrast to the previous allocation of 69% in the highest category.

Depletion of reserves as calculated from maps of mined areas was compared to reported production and recovery rates. The comparison demonstrated some potential pitfalls of estimating depletion based on reported production and suggested the need for local knowledge of mine operations. Problems included production data that were reported on the basis of tipple location rather than point of extraction, depletion of surface-minable reserves by underground mines, and inability to estimate on the basis of reported data the destruction of reserves by preferential mining of lower seams.

The accessible reserve base is estimated to be 70 billion tons. The previous estimate of 56 billion tons excluded surface-minable coal under prime farm land, an exclusion that is no longer valid. The new estimate excludes reserves under towns, interstate highways, and public land; underground-minable reserves thinner than 42 inches; reserves in small, irregular blocks between mines; and an allowance for coal left for barriers and small blocks in future mines. The Illinois State Geological Survey (ISGS) is currently conducting a multiyear study supported by the U.S. Geological Survey (USGS) to assess the availability of coal for mining. When complete, the findings from the coal availability studies are expected to lead to additional adjustments in the accessible reserve base.

Recoverable reserves, estimated to be 38 billion tons, were calculated using recoverability rates of 50% for underground-minable reserves and 70% to 85% (depending upon location and thickness) for surface-minable reserves. These percentages were selected after examining data on reserve depletion and mine production from January 1979 to January 1996. The recovery rates account for coal that will be lost in cleaning and handling or left as pillars or barriers in mines.

ACKNOWLEDGMENTS

The Illinois State Geological Survey entered into Cooperative Agreement DE-FC01-94EI24855 with the Energy Information Administration (EIA) of the U.S. Department of Energy to update coal reserve estimates for Illinois.

The assistance of several people was critical to the completion of this report. Richard Harvey (ISGS) spent much of his career compiling and editing the database of coal analyses that provided the basis for our coal quality allocations. Jennifer Hines (ISGS) supervised the entry of the production and stratigraphic data used to calculate cumulative production and to revise resource maps. Richard Bonskowski (EIA) provided quality, production, and recovery data and helped to develop and refine the methodology for this project.

* All tonnages reported are in short tons (2,000 pounds).

This project would not have been possible without the coal resource database developed for many years by ISGS staff with the financial and technical support of the Coal Branch of the U.S. Geological Survey. In particular, the National Coal Resources Data System and coal availability studies have been invaluable in advancing our knowledge of coal resources and reserves in Illinois.

INTRODUCTION

The Coal Reserves Data Base (CRDB) program involves authorities from regions with major coal resources in EIA's effort to update the national coal reserve data. This report describes the results of a two-part study in Illinois. It is the fifth study in EIA's program to update state-level reserve estimates in cooperation with a state geological survey.

The project ran from July 5, 1994, to January 3, 1997, and used funds furnished by the EIA and ISGS. EIA's funding was administered within two separate project periods. An interim report, *Final Report for Part 1*, was supplied to EIA in December 1995 and published by the ISGS as Open File Report 1995-11. The data in that report were used in updated demonstrated reserve base (DRB) and estimated recoverable reserve data released in EIA's report *U.S. Coal Reserves: A Review and Update* (EIA 1996).

The CRDB uses an updated set of criteria designed to be consistent nationally but flexible locally to accommodate variations in geology and mining practices. The CRDB program is needed because the traditional source of EIA coal reserve estimates, the DRB, was adapted from older published studies from various contributors, many of whom followed criteria somewhat different from those preferred for the DRB.

Purpose of Coal Reserves Database Studies

The CRDB data, intended for use in analyses of coal supply and to support analyses of policy and legislative issues, will be available to both government and nongovernment analysts. The data will also be part of the information used to supply U.S. energy data for international databases and to answer inquiries from private industry and the public.

The EIA recognizes that coal resource area maps, drilling records, historical mine boundaries, and site-specific analytical and geologic data are critical for reliable calculations of coal resource quantities. Such information has been used to various extents in the present study. In accordance with the terms of the CRDB program, the supporting data files and detailed documentation will remain at the ISGS, where they will be the basis for future updates and revisions, amplification with new data, or modification for other ISGS objectives. The EIA will maintain copies of the detailed database for counties and coal beds and selected source files.

The information in this report was compiled under guidelines that emphasize utilization of previously unexploited coal resource and coal analytical data that are immediately available and can be assimilated during a short-term project. Priority was given to revising seams with potential reserves of low to medium sulfur content or areas with significant new data.

Geology and Mining Practices of the Illinois Coal Field

Illinois has the second largest DRB of coal and largest DRB of bituminous coal in the nation (EIA 1996). The Illinois coal field in the Interior Region of the country consists of the western two-thirds of the Illinois Basin (or Eastern Interior Coal Field), which covers most of Illinois and western parts of Indiana and Kentucky (fig. 1).

Minable coal is found in the Pennsylvanian-age strata of the basin. The rank of these coals is high volatile bituminous, ranging from the A rank group at the extreme southern margin of the basin to rank groups B and C in the southern, central, and northern parts of the basin. The major coal seams crop out along the margins of the basin and dip gently to depths of more than 1,000 feet at the center of the basin in southeastern Illinois. Although the state has more than 60 named coal

Figure 1 Illinois Basin, or Eastern Interior Coal Field.

seams, this study reports on resources for 27 seams; 96% of the resources are concentrated in seven seams: the Danville (No. 7), Herrin (No. 6), Springfield (No. 5), Colchester (No. 2), Seelyville, Dekoven, and Davis Coals (fig. 2). A few other coals have been mined locally by small operations, but none of these resources have been mapped because of their limited extent.

Since the development of modern surface mining equipment, coals up to about 150 feet deep have commonly been mined by surface methods. Large dragline and shovel mining or small truck and shovel operations are the primary forms of surface mining. Augers and highwall miners are sometimes used to recover additional coal from the final cut of a surface mine.

Surface mine production peaked in Illinois in 1969 at almost 35 million tons (Illinois Department of Mines and Minerals [IDMM] 1994). Subsequently, production declined almost steadily to 7 million tons in 1995. Although stricter reclamation requirements and weak demand for high-sulfur coal have contributed to this decline, the major factor is believed to be depletion of low-cost reserves.

Shafts and slopes are the most common means of access to underground mines; but in a few cases, underground mines use a box cut or a drift entrance constructed at a surface mine highwall. Partial and high-extraction room-and-pillar mining and longwall mining methods are used.

During the past 10 years, production has shifted from entirely room-and-pillar mining to more than 30% from longwall operations. Annual production from underground mines rose from the 30- to 40-million-ton range in the 1970s and 1980s to a peak of 47 million tons in 1992. This production rate is expected to drop during the next few years as markets are lost as a result of Phase I restrictions of the 1990 Amendment to the Clean Air Act and increasing price competition from western coals.

Previous Investigations of Illinois Coal Resources and Reserves

A report in 1913 (Campbell) estimated the original coal resources of Illinois to be 200 billion tons. This estimate was based on very limited information and does not conform to current DRB criteria. Coincidentally, the 200-billion figure is remarkably close to the latest calculation of identified resources. Campbell's estimate, however, was based on a minimum thickness of 14 inches and did not use a minimum drill hole spacing. Using criteria comparable to Campbell's today, the original estimate of resources in the state would have exceded 300 billion tons.

In the early 1950s, Jack Simon and other members of the ISGS Coal Section staff under the general supervision of Gilbert Cady completed the first comprehensive survey of coal resources in the state (Cady 1952). This landmark report provided a framework and format generally followed in subsequent resource assessments. In particular, the report established categories of coal

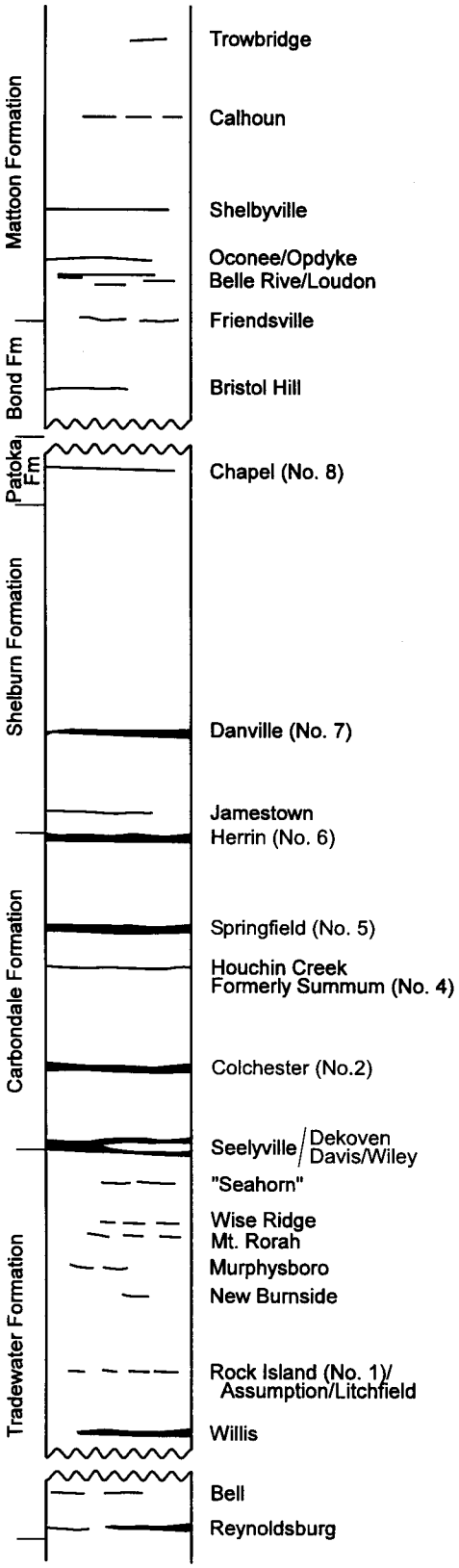

Figure 2 Stratigraphic position of coals mined or mapped as resources in Illinois.

resources adapted to reflect the lateral continuity of most coals found in Illinois (table 1). This report is also the only source of resource and reserve estimates for a few seams in some counties that have not attracted sufficient interest to warrant revised mapping.

Although there were no agreed upon criteria for the concept of a DRB at the time of Cady's report, the criteria used in his study are compatible with current DRB definitions and indicated a DRB of 61 billion tons. Results from additional mapping since 1950 (minus depletions) raised the DRB to 78 billion tons (EIA 1995).

Prior to inclusion of any data from this present project, EIA's most recent DRB estimate for Illinois was based on a compilation of coal resources as of January 1, 1979 (Treworgy and Bargh 1982). Subsequent resource studies incorporated into this update are Jacobson (1983), Jacobson (1985), Jacobson (1993), and Treworgy (1995).

METHODOLOGY AND ASSUMPTIONS

The primary task of this project was to use existing data to update the DRB and allocate coal reserves by depth and quality of the resource. Coal resources were revised for seams in counties where significant new data were available.

Coal Resource Quantities

Coal resource quantity data were compiled from published and unpublished maps developed by ISGS geologists from several sources: drilling logs, core descriptions, and geophysical logs obtained from companies, as well as descriptions of mine and outcrop exposures made by ISGS geologists. Appendix 1 documents the information sources used for resources for each seam in each county.

Mapping procedures Past ISGS studies have demonstrated the utility of computers and digital databases for reserve assessments (e.g., Treworgy and Bargh 1982). Computers expedite merging coal thickness data with data on coal depth, sulfur, rank, heat content, and mined areas, and with other information such as calculation of depletion, accessibility, and recoverability of reserves. Future updates, revisions, and accessibility adjustments can also be made more efficiently with a digital database.

Table 1 Categories of coal resources (modified from Cady 1952).

Class	Maximum distance from data points*	Accepted data points	Remarks
I-A Proved (Measured)	0.5 mile	Mined-out areas Diamond drill holes Outcrops Coal test geophysical logs	Approximately equivalent to *measured* category of the U.S. Geological Survey
I-B Probable (Indicated)	2 miles	All points of class I-A plus coal-test churn drill holes	Approximately equivalent to *indicated* category of the U.S. Geological Survey
II-A Strongly Indicated (Inferred)	4 miles	All points of classes I-A and I-B plus churn drill holes drilled for oil or water with unusually good records, control rotary drill holes, and oil-test geophysical logs	Approximately equivalent to *inferred* category of the U.S. Geological Survey

* Distances modified in practice by geological considerations.

Many of the coal resource maps needed for this study were already in some digital format. All data were combined into a single digital map database designed to facilitate processing for this study, as well as to provide a suitable foundation for future updates and revisions. All remaining paper maps were digitized into this common database.

When this digital database was created, a number of changes that were made to the data resulted in variations of the tonnages calculated from the original paper maps, even in cases for which no mining or new mapping has taken place. For example, most of the coal resource maps created or published before the 1980s were based on USGS 15-minute topographic maps, which are less accurate than current 7.5-minute base maps. In constructing the digital database, all maps were converted to a 7.5-minute base. Because the area and shape of each county is slightly different on each of the base maps, the conversion from one base to another inevitably results in a small increase or reduction in area and therefore in coal tonnage.

Adjustments were commonly necessary where areas covered by two studies met or overlapped. A number of studies mapped either surface-minable or underground-minable coal, separating surface- from underground-minable coal at a depth of 150 feet. The 150-foot-depth line used to form the boundary for underground- or surface-minable coals often varied slightly among studies of adjacent or common areas. The 150-foot-depth line had to be modified to combine the results from the studies and create a seamless digital database. In most cases, the 150-foot-depth line used in the surface-minable resource studies was more detailed and accurate. This line was retained, and data from the adjoining study of deeper coal were modified.

Mining categories Resources and reserves are divided into categories on the basis of the mining method most likely to be used to extract the coal. The two categories used for this study are surface minable and underground minable. A few companies use augering or highwall mining to extract coal beyond the last cut of a surface mine, and at least one company has used augering in an underground mine. Highwall mining, as recently practiced in Illinois, uses a remote-controlled continuous miner and a "train" of conveyor belts to mine straight, unsupported entries for about 800 feet in from a highwall. Because augering and highwall mining are not widely practiced in Illinois and their use is largely dependent upon circumstances at individual mines (e.g., the location of their lease boundary relative to the last practical highwall position), no separate category of resources could be defined for these mining methods.

The surface-minable category consists of coals most likely to be mined by removing the overburden to expose and mine the coal. In Illinois, this is commonly done by some combination of draglines, shovels, bucket wheel excavators, trucks, and scrapers. The underground-minable category consists

of resources that will be extracted by underground methods such as room-and-pillar or longwall mining. Access to the seam may be by drift, highwall exposure, box cut, slope, or shaft.

The factors that determine the method used to mine a particular deposit are commonly economic rather than technical. The main factors are thickness and depth of the coal, average stripping ratio of the mine block, nature of the overburden material (which may determine the amount of blasting required), surface ownership and land use, proximity to other surface features, and the capital and previous mining experience of the company.

In Illinois, the 150-foot-depth line, although arbitrary, is a workable delimiter between surface-minable and underground-minable resources. A few surface mines have mined small areas of deeper coal. More commonly, underground mines have mined shallower areas. In most cases, these underground mines are located where the greater portion of the reserve block is deeper than 150 feet, where surface land use or ownership makes surface mining impractical, or where existence of an abandoned highwall provides inexpensive access to a small, otherwise inaccessible block of coal. These exceptions are determined by local conditions, land ownership, company policy, and other circumstances that cannot be considered in regional assessments such as this study.

Surface-minable resources are defined by ISGS convention to have a minimum thickness of 18 inches. Underground-minable resources are defined to have a minimum thickness of 28 inches. These minimum thicknesses have been used by the ISGS since the 1950s and are based on historical mining practice in the state. For economic reasons, seams less than 42 inches thick have not been extensively mined underground in Illinois for the past three decades or more; however, reserves less than 42 inches thick have been retained in the DRB for this study in order to be comparable with current DRB estimates of other midwestern states. As explained below, these thin reserves are excluded from the accessible reserve base.

No maximum depth was established for underground-minable reserves. The deepest mapped resources in the state are slightly more than 1,500 feet deep. Interviews with representatives of mining companies indicated that this depth does not prevent mining of the coal.

Categories of coal thickness In Illinois, coal resources have commonly been mapped and reported in categories of 1-foot increments of seam thickness (table 2). The two thinnest categories, 18–28 and 28–42 inches, deviate from the 1-foot increment in order to correlate more closely with national reporting categories of 14–28 and 28–42 inches used by the EIA and the USGS. In practice at the ISGS, consistent 1-foot increments (18–30 and 30–42 inches) have been used for most mapping of surface-minable coal and most recent mapping of underground-minable coal. The 1-foot increments are preferred by the ISGS because their consistency facilitates the use of computers to map resources. For comparability with national reporting categories, these 1-foot-increment tonnages are reported as the 18–28 and 28–42-inch categories.

Table 2 Categories of coal seam thickness

Category in inches	Average thickness in feet
18–28	2*
28–42	3
42–54	4
54–66	5
66–78	6
78–90	7
90–102	8
102–114	9
>114	10

* Surface-minable coal only.

The most recent mapping, completed for this report, contoured resources on 6-inch increments (e.g., 30-, 36-, 42-, and 48-inch contours, etc.). For reporting purposes in this report, these data are aggregated to EIA's 12-inch categories, but the 6-inch thickness categories are retained in the digital database that accompanies this report.

Some surface-minable resources and resources from older studies of underground-minable coal are mapped using categories of average thickness that do not correspond to the standard 12-inch increments; for example, an area of resources may be classified as "averages 20 inches." The original thickness categories mapped have been retained in the digital database produced for this study.

Clean coal thickness (coal only, with partings excluded, as opposed to raw coal thickness or total seam thickness) was mapped in the areas revised for this study. It has been standard USGS practice for many years to exclude partings thicker than ⅜ inch from seam thicknesses used to calculate tonnages (Averitt 1969, Wood et. al. 1983). Many older ISGS resource studies do not document whether clean coal or raw seam thickness was mapped. However, all ISGS studies have used a density of 1,800 tons per acre foot (the standard density for clean bituminous coal), which indicates that the thickness for clean coal was mapped.

A more serious problem is that information on thin partings is not available from many logs. Many drilling logs report only major partings (e.g., 2 inches or more thick). Thin partings are sometimes difficult to recognize in cores and may even be undetectable on the types and scales of geophysical logs commonly run on coal test holes. Only major partings have been excluded from thickness measurements from oil test geophysical logs (because of the type and scale of log commonly used). Resources based on these data are assigned to the class II (inferred) category.

Mitigating this measurement problem somewhat is the fact that the major Illinois coals tend to be relatively free of partings. Errors in thickness caused by lack of information about partings should amount to no more than 2% or 3% and are on the same order of magnitude as other uncertainties in measuring thickness (e.g., loss of core material, determination of bed boundaries on geophysical logs, or rounding of measurements by drillers). Given these uncertainties as well as the uncertainties and assumptions associated with contouring and calculating tonnages, the lack of detailed data on partings is not a significant influence on the reserve tonnages calculated for this report.

Depth of coal Coal resources in Illinois have been mapped to depths of more than 1,500 feet. Surface-minable coals are found throughout the state (fig. 3). The major seams such as the Herrin Coal crop out and remain at shallow depths at the margins of the basin and dip toward the center of the basin in southeastern Illinois (fig. 4).

Information on the depth of resources was compiled in one of three ways. (1) Depth of surface-minable resources was digitized from maps prepared for previous studies. (2) Depth of underground-minable resources was taken from generalized, statewide maps created from point-source data. (3) For coal seams that were revised in the second year of this study (the majority of which were greater than 150 feet deep), depth was mapped using all available point-source data (e.g., drill holes and mine shafts).

Surface-minable resources are classified into three categories with 50-foot increments of overburden (0–50, 50–100, and 100–150 ft). Underground-minable resources (coal deeper than 150 feet) are classified into even 100-foot increments, except for the shallowest category of 150–200 feet. The depths of coals revised for this project were mapped using 25-foot increments. For reporting purposes, these have been aggregated into the broader categories given in table 3. The digital data supplied to EIA retain the more detailed depth categories.

The surface-minable depth categories, which were digitized from previous studies, are more accurate than the underground-minable categories. The shallow categories were mapped manually by overlaying a structure map of the coal seam with a topographic map of the land surface. The depth measurements reflect relatively detailed variations in surface topography and are suitable for calculating stripping ratios.

Table 3 Categories of overburden thickness

Underground mining in feet	Surface mining in feet
150–500	0–50
500–1,000	50–100
1,000–2,000	100–150

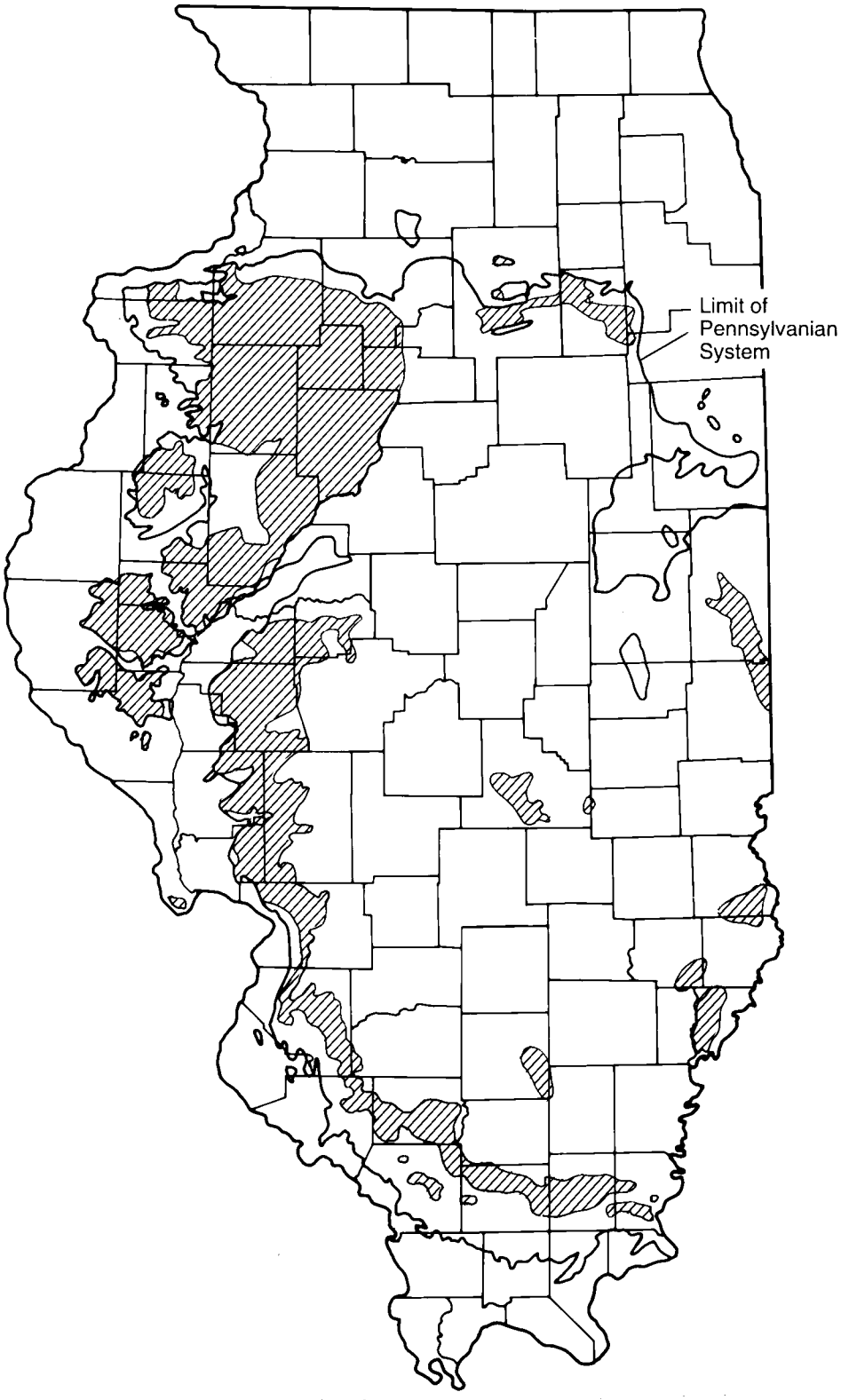

Figure 3 Areas with surface-minable coal resources.

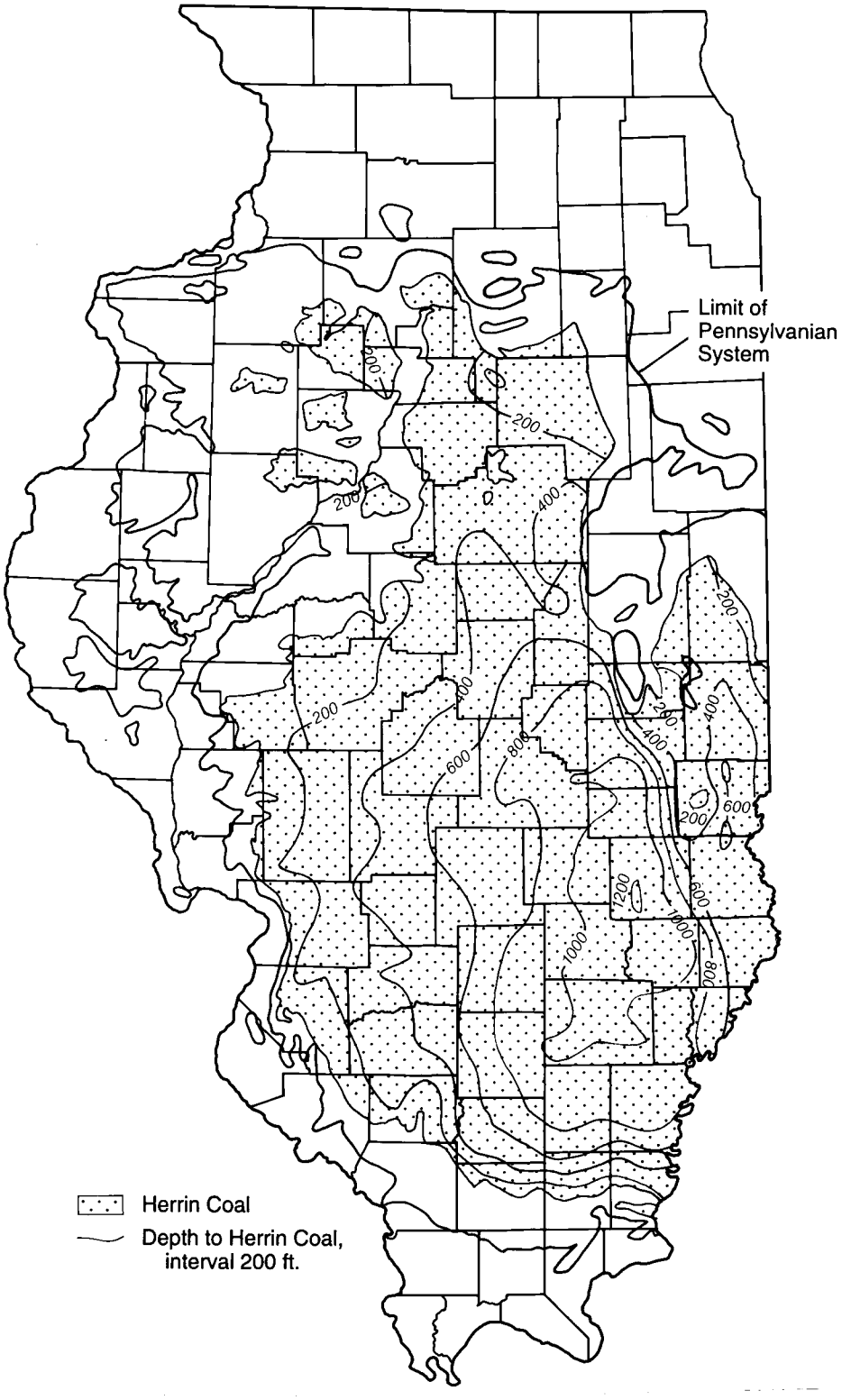

Figure 4 Depth of the Herrin Coal (from Smith and Stall 1975).

The underground-minable categories were mapped by contouring coal depths from point-source data. This procedure delineates broad, regional trends in depth, but ignores changes in depth caused by abrupt, localized changes in topography or coal structure (e.g., a deeply cut river valley or a fault). In Illinois, local changes in depths of seams due to topography and structure are relatively minor and need not be considered from the regional perspective of this study.

The point-source data were extracted from the ISGS stratigraphic database, a collection of logs obtained from companies and interpreted by ISGS geologists. The existing data are believed to be adequate for the accuracy needed for this study, and no new data were compiled for this purpose (table 4). The average density of data points for most seams was lower than one per square mile. However, the actual data density varied considerably across the state from tens of points per square mile to less than one point per tens of square miles. Contours were constructed using software from a commercial vendor (Earthvision version 3.0 by Dynamic Graphics, Inc. Alameda, CA) and carefully reviewed for accuracy by a geologist. A grid consisting of 5,000 x 5,000 foot cells (approximately 1 square mile) was used for contouring the statewide maps. This grid size represents regional trends, but generalizes areas with high data densities. The grids were contoured at a scale of 1:50,000. Although no paper maps were produced at this scale, the digital contour lines are smooth at this scale. Localized details that were not substantiated, given the data and assumptions used to create the final work maps, were eliminated by deleting contours enclosing areas less than about 9 square miles (map coordinates were in feet, so the actual value specified in the mapping procedure was 250 million square feet).

Information about the depth of overlying or underlying beds provided additional control for some coals. For example, the number and distribution of data points for the Herrin Coal were adequate to delineate the major structural features of the bed. However, fewer control points were available for the underlying Houchin Creek Coal, so the depth of the Houchin Creek resources was usually classified by adjusting the contours of the Herrin Coal by the approximate thickness of the stratigraphic interval between the two coals. Likewise, the Jamestown Coal is commonly 5 to 20 feet above the Herrin Coal, so its resources were assigned the same depth as the Herrin Coal.

The procedure for mapping depths of coals in counties where resources were revised in the second part of this project was similar to that described above. Because the amount of data available was generally greater in these counties and more time could be spent in verifying local anomalies, a grid of 1,000 x 1,000 foot cells was used and the minimum area enclosed by contours was about 90 acres (4 million square feet). The grids were contoured at a scale of 1:24,000.

Table 4 Construction of generalized, statewide depth maps for underground-minable reserves.

Coal	Number of points used	Data points per square mile	Additional control
Danville	9,185	0.4	Not allowed to be deeper than Herrin
Jamestown			Assigned same depth as Herrin
Herrin	17,371	0.7	
Springfield	10,106	0.4	Minimum 20 feet below Herrin
Houchin Creek			Depth assigned based on Herrin
Survant			Depth assigned based on Springfield
Colchester	6,794	0.3	Minimum 100 feet below Springfield
Seelyville	1,510	0.4	
Davis	2,659	1.2	Not allowed to be shallower than Colchester
Assumption			Not gridded; depth for this area estimated from three drill holes
Murphysboro	112	0.2	

Categories of resources The ISGS resource categories used for this study (table 1) are comparable to those defined by the USGS. Because of the considerable lateral continuity of most Illinois coals, however, the radius of influence assigned to each data point is larger than that used by the USGS. The ISGS categories of class I-A, I-B, and II-A are considered equivalent to the USGS categories of measured, indicated, and inferred resources, respectively. The ISGS categories were originally defined by Cady (1952) and were modified by Treworgy and Bargh (1982) to include oil test geophysical logs as accepted data points for class II-A.

The criteria are further modified by this study to include, at the geologist's discretion, coal test geophysical logs as acceptable data points for class I-A. The suite of logs run for coal exploration commonly includes single point resistivity, gamma, density, and caliper. The logs are typically plotted at a scale of 1 inch equals 20 feet, with expanded sections of 1 inch equals 1 foot for major coals.

Calculation of coal tonnages Coal tonnages are calculated using a density of 1,800 tons per acre per foot of coal thickness (equivalent to 1.32 specific gravity). This is the average density commonly used for bituminous coals (Wood et al. 1983). The mean value of the two contours defining an area is used for this calculation. For example, the area between the 5.5-foot and 6.5-foot isopachs is assumed to have an average thickness of 6 feet.

As noted previously, the coal thickness isopachs represent clean coal. Consequently, the tonnage calculated represents clean coal in the ground. This is the standard figure reported by the USGS, EIA, and state geological surveys and should not be confused with tonnages of raw coal reserves commonly reported in engineering studies or company reports.

Improved accuracy in the base maps used caused the coal tonnages calculated for seams in some areas to differ from previous reports, even where no mining or new resource mapping had taken place. Tonnages also changed because the procedures for calculating areas changed. Prior to the late 1970s, all areas were measured by planimeter or a point-counting method. The 1979 update of underground-minable resources used geographic information system (GIS) software to compute areas and volumes (Treworgy and Bargh 1982). The GIS software, developed by the ISGS specifically for that project, used 10-acre grid cells (660 × 660 ft) to represent areas, thus limiting resolution of features to 660 feet.

The present study used a commercial GIS package that represents features as vectors or polygons (Arc/Info version 7.04 by Environmental Systems Research Institute, Redlands, CA). Areas are calculated using a proprietary algorithm. Because of the differences in the way features are represented and the way algorithms are used to compute areas, the areas (and consequently volumes) calculated by the two methods differ by a few percent. The vector representation used for the present study is inherently more precise than the grid representation used by earlier software.

Coal stripping ratio Average and maximum stripping ratios (cubic yards of overburden per ton of coal) were calculated for the three depth categories of surface-minable resources (coals less than 150 feet deep). The formula for the ratios is given in appendix 7, and the ratios calculated are reported in the digital database produced for this project (see appendix 5).

The average stripping ratio was calculated by assuming that the coal tonnages in the 50–100 and 100–150 foot depth categories would be evenly distributed between the two extremes of depth and have average depths of 75 and 125 feet, respectively. The coal tonnage in the <50 foot depth category was assumed to be proportionally greater in the deeper half of the depth category, because most of the state is covered with glacial drift at least 20 feet thick. The average coal depth in the <50 foot category was assumed to be 35 feet.

These assumptions were confirmed by examining the coal depths in the ISGS database of drilling records. The averages in the three depth categories were 34, 75, and 125 feet. The points in the <50 foot depth category were examined for selected counties to see if the average coal depth varied by region. No significant difference in average depth was observed (table 5).

The maximum stripping ratio is the theoretical maximum ratio that could be encountered mining resources with a particular combination of thickness and depth. For example, resources in the 48-inch thickness and 50–100 foot depth categories can be as thin as 42 inches and as deep as 100 feet, which yields a maximum stripping ratio of 25.6 cubic yards per ton.

Table 5 Mean depths of coals less than 50 feet deep recorded in borings from selected counties.

County	Number of points	Mean depth in feet	Area of state
Brown	102	35.8	west
Fulton	492	34.3	west
Gallatin	53	34.6	southeast
Knox	130	34.0	northwest
Peoria	310	34.2	northwest
Perry	713	34.0	southwest
St. Clair	772	35.8	southwest
Saline	556	32.6	south
Schuyler	63	33.6	west
Stark	253	37.5	northwest
Vermilion	80	32.1	east

Revisions of coal resource maps The ISGS continually receives new data on coal thickness from coal companies, consultants, government agencies, and other sources. Resource estimates were revised for coal seams in selected counties where significant new data had become available since the latest coal resource maps were compiled. Project funding precluded revising all counties where new data were available. Priority was given to revising maps of seams that had lower sulfur contents or that would significantly add to the DRB. Resource calculations were revised for four seams in 18 counties (fig. 5). The procedures described in appendix 6 were used for all these revisions except for the Herrin Coal in Macoupin and Montgomery Counties. Because of time constraints, the Herrin Coal thickness was revised only in selected areas of these counties. In these counties, new points were posted on the existing resource map, and contours edited by a geologist to fit the new data. Appendix 1 also indicates those seams and counties for which new data are available, but whose resources have not yet been revised.

Depletion Adjustments

Information on mined areas and production was compiled to update the DRB to January 1, 1996, and to provide EIA with comparative statistics on reported production and depletion of reserves.

Mined areas Coal mining began in Illinois as early as 1810. Few maps exist of mines that operated prior to the late 1890s, but the undocumented area of depleted resources is believed to be relatively small. Through the efforts of the U.S. Bureau of Mines, Illinois Office of Mines and Minerals, and ISGS, a fairly complete record of major mining operations has been preserved. This record includes maps of mine workings or approximate areas of mining of more than 2,100 underground and 400 surface mines.

The ISGS maintains a digital database of the extent of these mined-out areas in Illinois (fig. 6). The database also contains point locations for an additional 2,500 mines for which no map of the extent of mining is available. These mines are believed to be mostly small, short-term operations that affected very small areas.

Information on the extent of mines is obtained from maps provided by mining companies or from secondary sources, such as private compilations made for banks or insurance companies. In the few cases for which no maps are available, the mined areas have been estimated from reported production. Prior to 1984, the exterior boundaries of mined areas were compiled on 1:62,500-scale base maps and then digitized. Since 1984, mine boundaries and large interior areas of unmined coal have been digitized directly from the original mine maps or obtained in a digital format directly from the mining company. In most cases, the newer outlines are at a scale of 1:12,000 or larger.

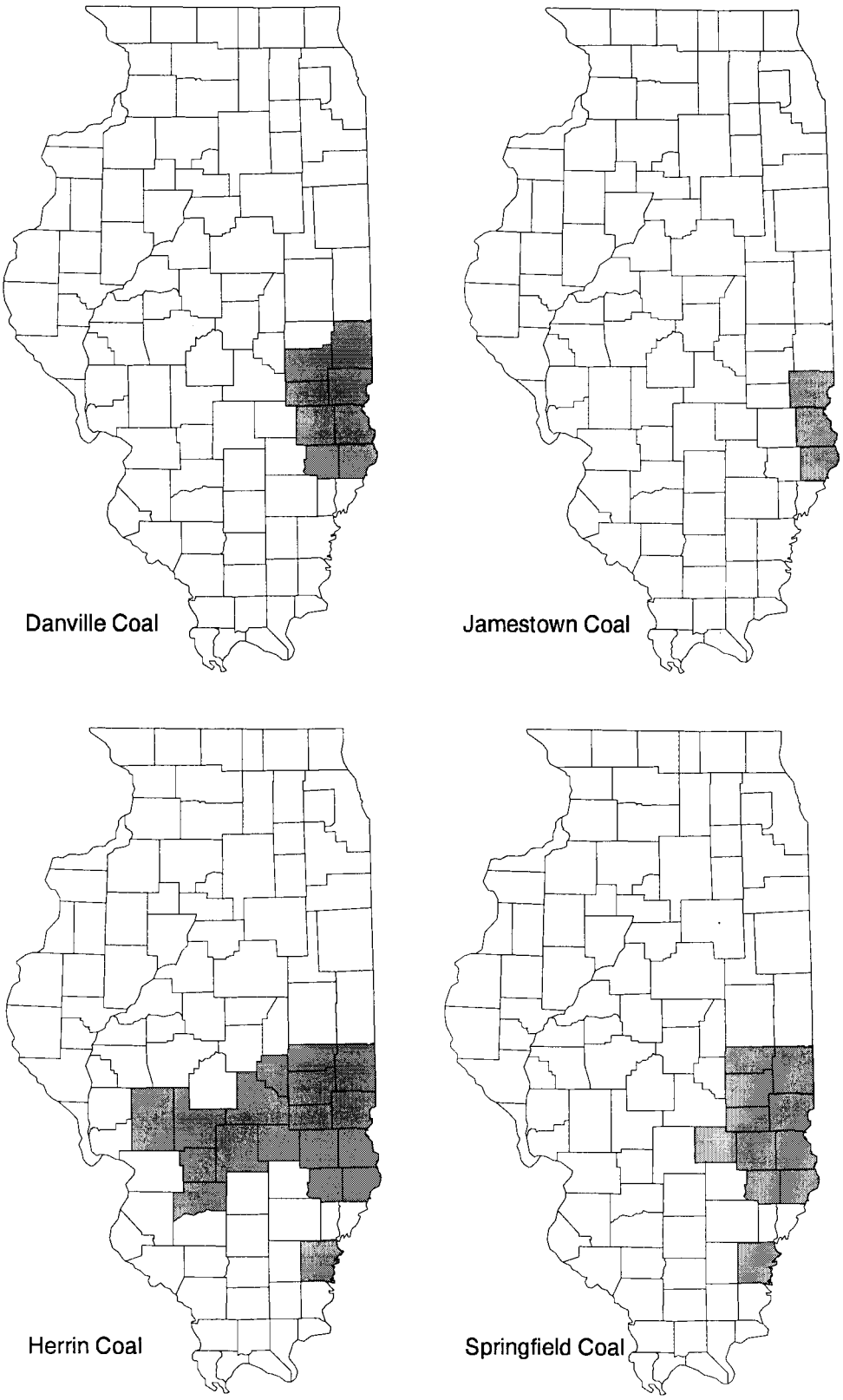

Figure 5 Areas of revised resource mapping.

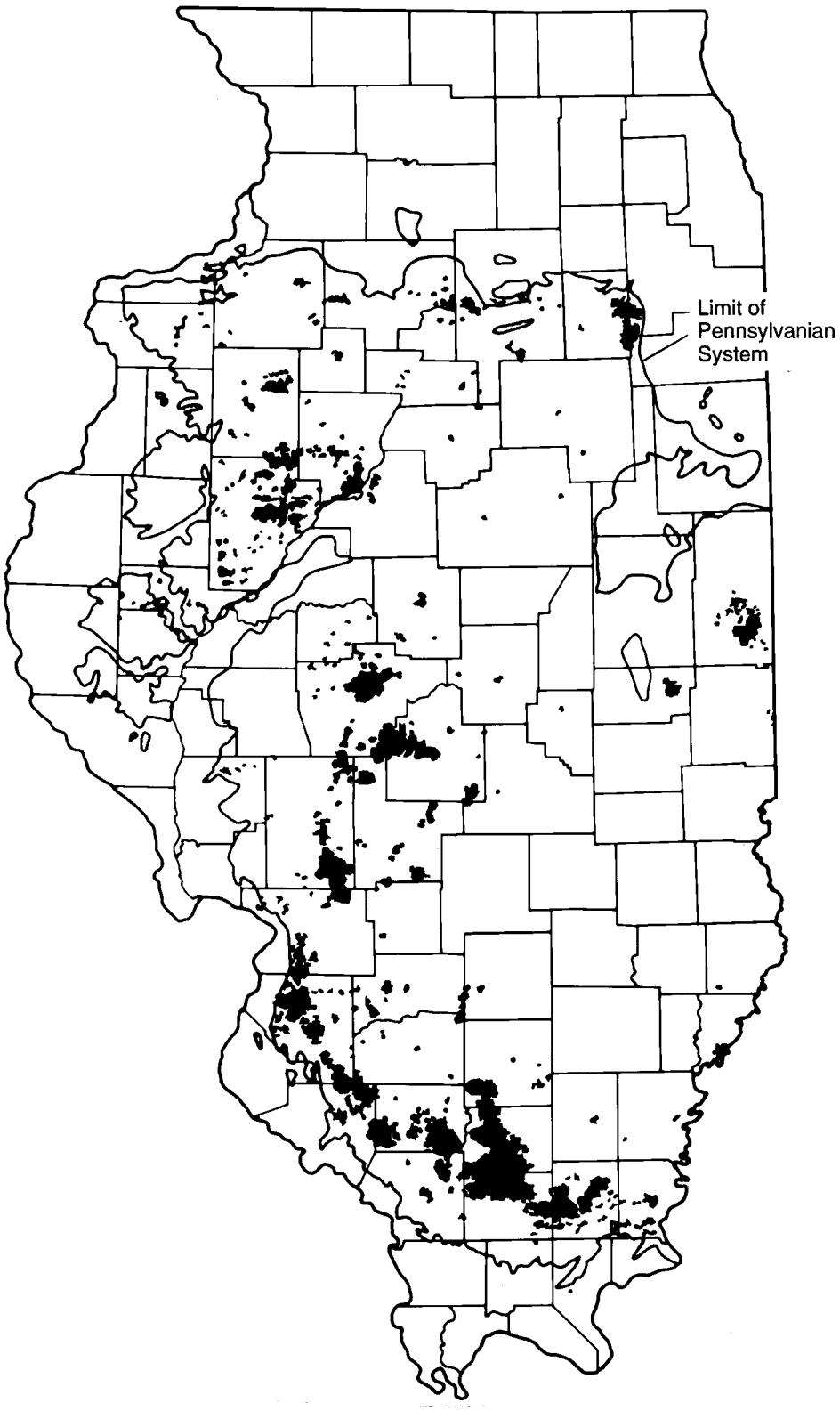

Figure 6 Locations of coal mines.

For this study, the database was updated using paper or digital maps obtained from mining companies. Boundaries of active mines were updated to January 1, 1996, and the boundaries of numerous abandoned mines were revised to incorporate corrections or additional detail.

Some coal left around abandoned mines has been excluded from resources because of mining laws or practical considerations. Illinois law requires that a barrier pillar at least 200 feet wide be left between mines. In many cases, larger blocks of unmined coal have been left because of geologic conditions, ownership issues, or the geometric layout required for face or pit operations. Although wider than 200 feet, these unmined blocks are often too small or convoluted to be extracted by an adjacent mine.

These blocks of unminable coal between underground mines were excluded from resource tabulations in the 1979 estimate; however, barrier pillars created between mines since 1979 are included in the estimate of resources or DRB—a measure taken to conform with the USGS and EIA definitions of resources and reserves. This tonnage has been excluded from the accessible reserve base (see Coal Accessibility Adjustments section below).

Production data Data on annual coal production were obtained from annual reports published by the Illinois Office of Mines and Minerals (IOMM) of the Department of Natural Resources. Prior to 1917, these reports were published as the biennial report of the Bureau of Labor Statistics and the annual coal report of Illinois of the State Mining Board. From 1917 to 1994, the reports were published by the Illinois Department of Mines and Minerals (IDMM). The reports list the annual production of each mine in the state, include the location and type of mine, and provide the name, average thickness, and depth of the seam mined.

Four problems were encountered in using the production data: (1) Production is commonly reported for the county where the mine tipple is located, which is not necessarily the county where the coal is mined. (2) Production is commonly reported by mine, not seam. If a mine operates in more than one seam, assumptions must be made as to how to allocate production to each seam. (3) Some underground mining recovers coal classified as surface minable. (4) The production data do not provide information on reserves destroyed or rendered unminable by mining of underlying or overlying seams.

To mitigate some of these problems, special effort was made to obtain unpublished production data by seam and county where the coal was mined in 1994 and 1995. After comparing production data with maps of mined areas, however, it appears that at least two out of 32 mines misreported the county from which they produced. This illustrates the importance of having local knowledge of mining operations when using production figures to calculate depletion.

Depleted underground-minable resources Depleted underground-minable resources consist of the tonnage of underground-minable resources that was originally present in areas that were mined between January 1, 1979, and January 1, 1996. These resources have been extracted by mining or left as pillars within the mines. The tonnage was calculated by combining maps of mines and resources as of 1979, 1994, and 1996 and calculating the tonnage of coal in the area mined since 1979 (fig. 7). Large blocks of unmined coal within mines, coal in barrier pillars between mines, or coal within 200 feet of mine boundaries have not been included in the depleted resources. These areas are, however, considered unminable and excluded from the accessible reserve base. The calculation of depleted underground resources is based entirely on the corrected digital map database compiled for this study. For the most part, the calculation is not influenced by the limitations of precision and accuracy of the base maps or software used for the 1979 study. The accuracy of the calculation is affected to a small extent by the accuracy of the 1979 mine boundaries, which were not drawn or digitized as accurately as the 1994 and 1996 boundaries. Many boundaries (for example, the east boundary of the mine shown in figure 7) are slightly offset. The effect of this offset on the calculation, however, is negligible.

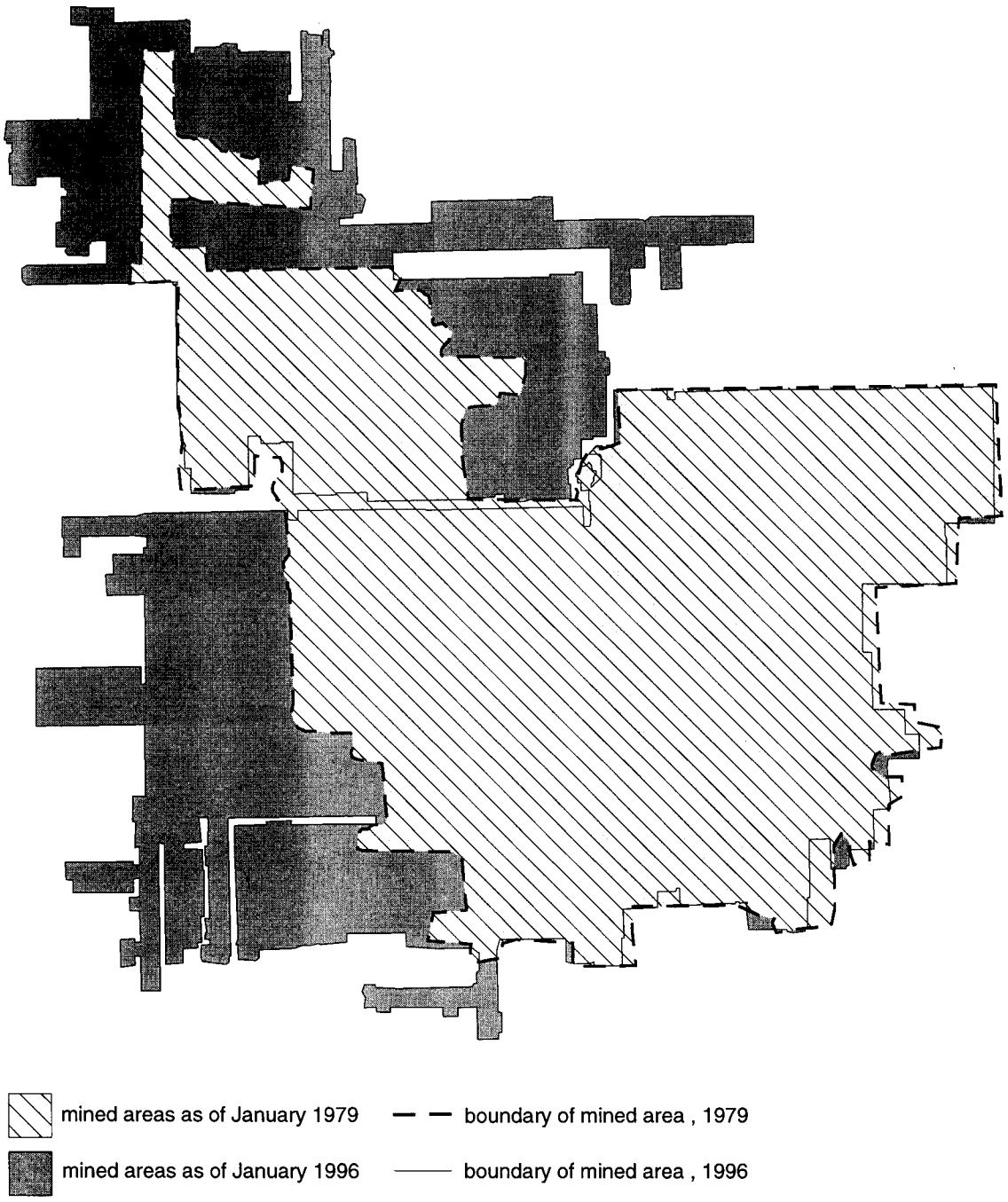

Figure 7 Examples of changes in mine boundaries of two mines, January 1, 1979, to January 1, 1996.

Cumulative production from surface mines The base year for mapping of surface-minable resources varies from county to county (fig. 8); for example, mapping in southern Illinois included mining to January 1956; mapping in western and northern Illinois counties included mining to July 1, 1959; and resources for all other counties were mapped as of January 1 of the year shown. Production from the base year of mapping through 1971 was available from a compilation made by the ISGS in 1973 (DeMaris, unpublished notes). Production of surface coal mines from 1972 to January 1, 1996, was compiled from the annual reports of the IDMM. These two sources were combined to arrive at cumulative production from surface mines in each seam and county from the base year of mapping to 1996. For Saline County, for example, cumulative surface mine production will be reported for each seam from the base year of 1956 to January 1, 1996.

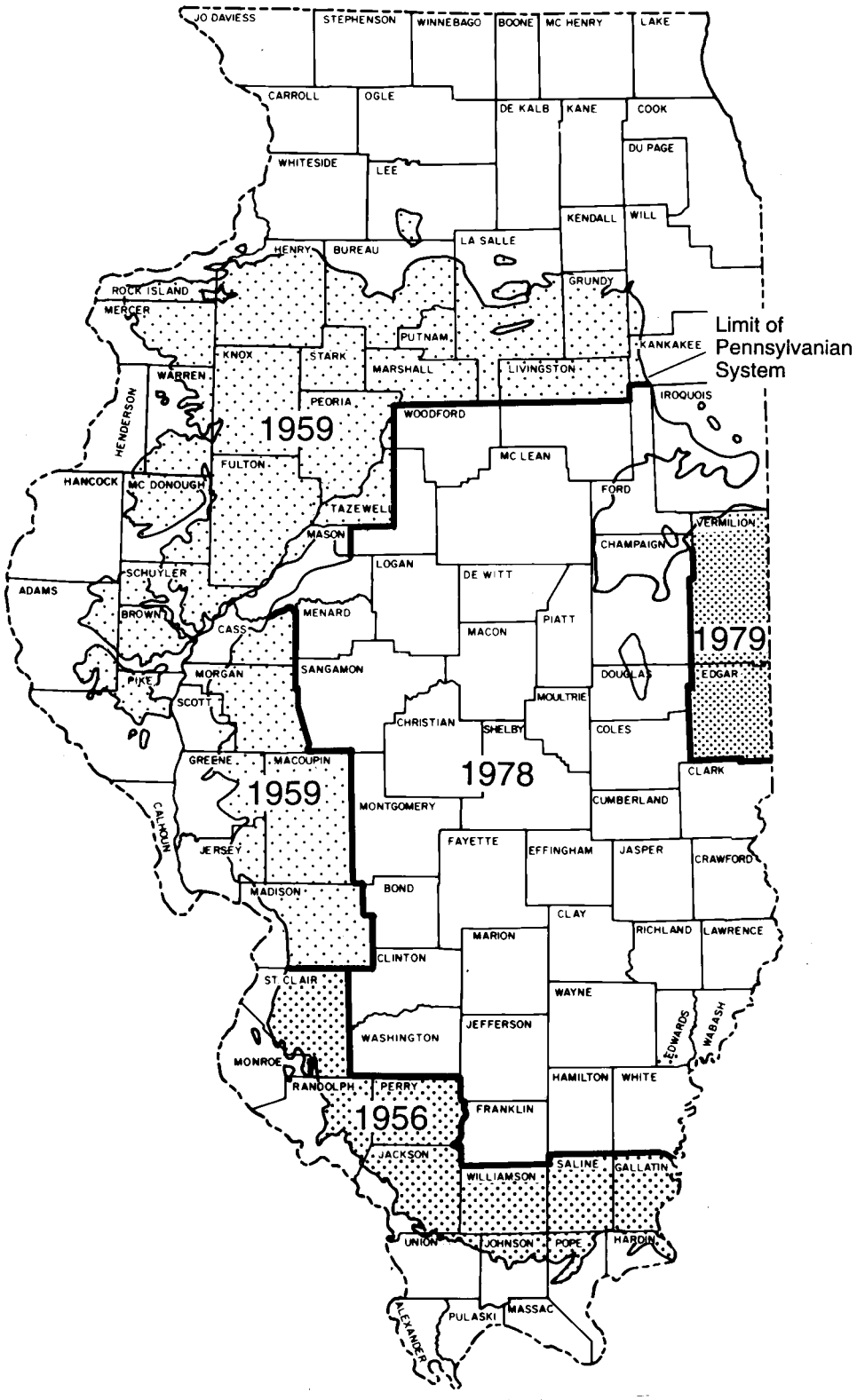

Figure 8 Base year of mapping of surface-minable coal resources.

Some mines operate pits in two or more counties and process coal at a central tipple. In most cases, the mine's production is listed in the annual coal report under the county where the tipple is located. Records that report production according to the county where the coal was mined are not readily available. The continuous production of large, multicounty operations distorts the apparent cumulative production of certain counties. No attempt was made in this study to reallocate production to the county in which it was mined.

Several mines produce from more than one seam, sometimes as many as five. In most of these cases, the published production is not reported by seam. Allocating production to individual seams requires knowledge of the individual mining operation (including thickness and continuity of the seams), pit locations, and operating goals of the company. A seam may be the main target of a mining operation or merely part of the interburden mined in parts of the mine property. Allocation of production to individual seams has been based on our best knowledge of each situation. The assumptions used to allocate the production prior to 1971 are documented by DeMaris (unpublished notes, 1973). The assumptions used by this study to allocate production from 1972 to 1994 are listed in appendix 2. Actual totals on production by seam were obtained for 1994 and 1995.

Depleted surface-minable resources The boundaries of mined areas as of January 1, 1996, were merged with the surface-minable resource maps to calculate remaining resources. Cumulative depletion was calculated as the difference between the resources at the date of original mapping (referred to as the base year) and the new (January 1996) resource estimate. For example, depleted surface-minable resources for Saline County is the difference between resources reported for the base year 1956 and those reported as of January 1, 1996.

As explained in the Calculation of Coal Tonnages section above, changes in base maps and technology used (computer vs. planimeter) to calculate areas of coal between the base year and the present study caused increases or decreases of a few percent in reported tonnages (and therefore in cumulative depletion). This effect is most noticeable in counties with limited or no production from surface mines. The apparent depletion in these counties is largely due to these procedural factors rather than to actual mining.

To provide better data on depletion versus reported production, the boundaries of mined areas as of January 1, 1994, were merged with the digital database of coal resources as well. The 1994 and 1996 mine boundaries are comparable in precision and were posted on a common resource map. Therefore, the computation of resource depletion for this period is unaffected by the base map and procedural factors that distort the depletion calculated from base year of mapping to 1996.

Coal Quality Characterizations

Reserves were allocated to coal quality categories for sulfur, rank, and heat content as specified by EIA's Procedural Guidelines.

Data sources The ISGS has on file more than 4,000 analyses of Illinois coals. Most analyses are of face channel type samples; other sample types include column, bench, drill core, grid, run of plant, run of mine, and various float/sink fractions. The samples were collected and analyzed by ISGS staff, the U.S. Bureau of Mines, or coal companies. Face channel, column, composite bench, and drill core samples (table 6) were used in this study.

Standard face channel samples exclude partings greater than ⅜ inch, whereas column and drill core samples generally do not exclude any material. As a result, face channel samples will have lower ash contents and higher heat content than drill core or column samples taken in the same area. For example, the mean ash content of the Herrin Coal face channel samples was 11.2%, whereas the mean ash content from drill core samples of the Herrin Coal was more than 15%. This difference was taken into consideration in contouring the data (see following sections on sulfur, rank, and heat content).

The EIA provided copies of data collected by the Federal Energy Regulatory Commission on quality of coal shipped to electric power producers (FERC Form No. 423). These data were used to verify the mapped sulfur contents based on the ISGS analyses.

Quality of coal shipped by mines compared with that of face channel samples Nearly all the coal shipped by Illinois mines has been cleaned. The original concept of the face channel sampling technique (Holmes 1911), in particular the exclusion of mineral partings thicker than 3/8 inch, was intended to simulate the unsophisticated cleaning that prevailed at that time. Modern coal cleaning plants will remove more than just the prominent, visible mineral partings; therefore, in theory, channel samples may not be representative of the quality of the coal that will be produced from the resources in the ground.

In the early 1970s, an ISGS study (Helfinstine et al. 1971 and 1974) sought to determine how representative channel samples are of cleaned Illinois coal. Channel samples were generally found to be a good indicator of shipped coal quality. On the average, channel samples are equivalent to a recovery rate between 70% and 100% (averaging about 88%) of the combustibles from the full seam.

Current mining technologies generally extract all or most of a coal seam and commonly a small amount of roof and floor rock. To compare the 88% recovery rate of combustibles cited above with recovery rates from cleaning plants, it is necessary to adjust for partings and out-of-seam dilution that are typically included in the raw coal output from a mine. The ISGS study found that, compared with column samples (channel samples with inclusion of all mineral partings) from the same sites, a 90% recovery rate of combustibles corresponds to a 70% to 86% (averaging 80%) recovery of clean coal from the full seam. The mining process may add 5% out-of-seam dilution, which suggests an overall recovery rate from raw coal of about 65% to 81% (averaging 75%).

In 1993, by comparison, Illinois mines averaged 69% clean coal recovery from raw coal; recovery ranged between 51% and 84% (for mines producing more than 0.3 million tons per year; IDMM 1993). This lower percentage is not surprising because selection of sites for collecting channel and column samples generally avoids any anomalous seam, roof, or floor conditions that tend to raise the reject. Also, the assumed 90% recovery of combustibles probably is on the high side for the average of all mines in Illinois. However, for currently active mines for which we have data, the average ash and sulfur contents of shipped coal and of channel samples are nearly identical; face channel samples average only 3% to 5% (relative) higher ash and sulfur contents than the corresponding shipped coal. Overall, face channel samples still acceptably represent the quality of cleaned coal that can be produced from a resource.

Quality of coal producible from high- and low- to medium-sulfur reserves Recently the Illinois State Geological Survey (ISGS) collected and comprehensively characterized samples of as-shipped coal from all active Illinois mines (Demir et al. 1994). From 1968 to 1974, the ISGS also collected both run of mine and face channel samples from many active mines and studied their washability characteristics (Helfinstine et al. 1971, Helfinstine et al. 1974). These two sample sets provide insights into the quality of coal that can be produced from the two basic types of coal found in Illinois: high-sulfur and low- to medium-sulfur coal. Figures 9 and 10 show the distribution of sulfur and ash contents as a percentage of the sampled production for the two sampling periods for these two types of coal. For the 1968–1974 study, no analyses of as-shipped coal are available, but instead the 1.6 specific gravity floats can be used as a close approximation.

Table 6 Types of analyses used to assess sulfur, rank, and heat content.

Sample type	Number of analyses
Face channel	2,252
Composite face channel	384
Column	90
Composite column	7
Composite bench	11
Drill core	948
Composite drill core	5

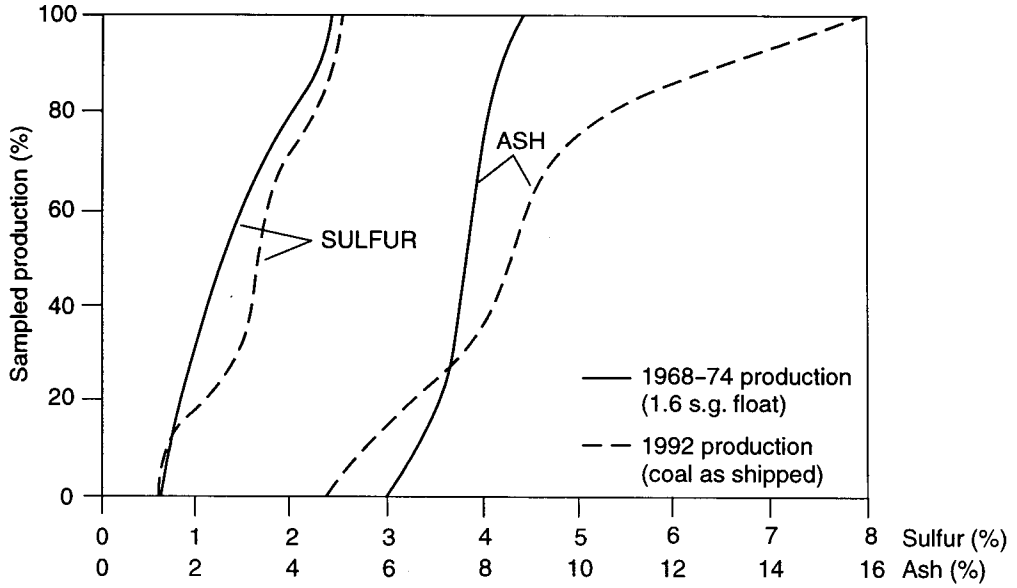

Figure 9 Sulfur and ash contents of low- to medium-sulfur coals.

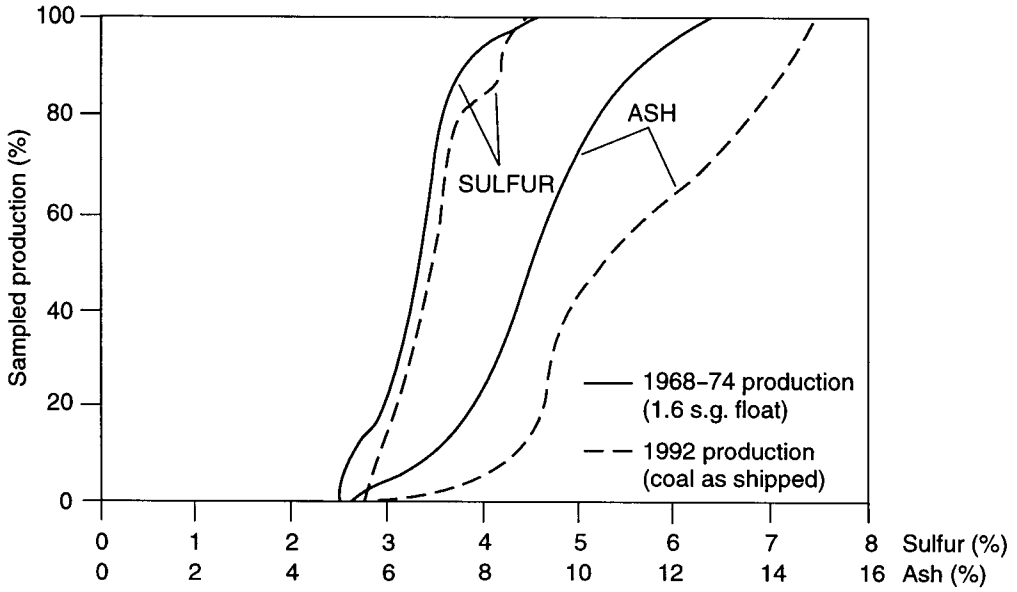

Figure 10 Sulfur and ash contents of high-sulfur coals.

For the low- to medium-sulfur coals, the bottom 20% of lowest sulfur of sampled production ranges between about 0.7% and 1.2% sulfur, and the top 20% ranges between about 2.1% and 2.6% sulfur; the median is about 1.3% to 1.7% sulfur. Most of these coals, about 60% of sampled production, range between 1.0% and 2.2% sulfur. The bottom 20% of lowest ash ranges between about 4.8% and 7.2% ash content; most of these coals, about 60% of sampled production, have ash contents between about 7% and 10.5%; the median is about 7.7% to 8.6% ash. The remaining 20% of sampled production has higher ash contents, depending on degree of cleaning, up to above 15%.

For the high-sulfur coals, the bottom 20% of sampled production ranges between about 2.5% and 3.1% sulfur; most of the sampled production (about 60%) ranges between about 3.1% and 3.7% sulfur; the remaining 20% of production exceeds 3.7% sulfur, reaching highs of about 4.5% sulfur.

The ash content of cleaned Illinois high-sulfur coal generally ranges between a little below 6% and up to 15%, depending upon the degree of cleaning applied and the characteristics of mined coal. The bottom 20% of ash content has ash contents between about 5% and 9.2%; most production (about 60%) ranges between about 8% and 13.6% percent ash; the median is about 9% to 10.5% ash.

The sulfur and ash distribution in these two sample sets is probably a good indication of what can be expected for future production from these two types of coal. Certainly, improved cleaning methods can push the cumulative production curves towards lower sulfur and ash values, but probably not far beyond the 1.6 specific gravity curves for the 1968–1974 sample set.

Sulfur content Sulfur content was mapped as pounds of sulfur per million Btu. The sample basis (as-received, dry, or ash-free) is inconsequential so long as the same basis is used for both sulfur and Btu. Theoretically, the drill cores and column samples could have higher sulfur contents than face channel samples because thick pyrite bands or concretions would be excluded from a face channel; however, this situation is expected to occur mostly in high-sulfur coals (greater than 2.5 pounds sulfur per million Btu). In areas of low to medium sulfur content (the areas contoured for this study), thick pyrite bands are not commonly present. Therefore, the use of drill hole and column samples is not believed to materially alter the allocation of coal within the categories used for this study.

Sulfur content of Illinois coals is related to the environments of deposition and burial associated with the coals. Understanding the geologic features associated with lower-sulfur coal and knowing their distribution aids in mapping these deposits. The approximate extents of areas of low- to medium-sulfur coal for the Danville, Herrin, Springfield, Colchester, and Murphysboro Coals in Illinois have been mapped on the basis of conceptual geologic models (Gluskoter and Simon 1968, Hopkins 1968, Gluskoter and Hopkins 1970, Jacobson 1983, Treworgy and Jacobson 1986). Lower-sulfur deposits of the Danville and Colchester Coals are associated with a silty to sandy facies in the overlying strata. Lower-sulfur deposits of the Herrin, Springfield, and Murphysboro Coals also correspond to areas where the marine black shale and limestone units that normally directly overlie these coals are displaced by silty to sandy non-marine units.

Mapping the sulfur content for each seam began with plotting the sulfur values from analyses along with the geologic boundaries (if any) of sediments normally associated with low-sulfur coals. Contours, hand-drawn by geologists, were based on the plotted analyses, supplemented by geologic interpretation. Contour intervals are those specified in EIA's Procedural Guidelines (table 7). For areas of limited data, it was necessary to confer with coal companies that had explored the areas to learn the general range and pattern of the coal's sulfur content. Because the geologic conditions associated with lower-sulfur coals seem to be relatively rare and the depositional environment at the time of peat deposition normally resulted in high sulfur contents, coals or areas of coals that lacked available analyses and geologic indicators associated with lower-sulfur coal were classified as high sulfur (greater than 2.5 pounds of sulfur per million Btu).

Data available for the Assumption Coal were not adequate to contour the sulfur content, but did indicate a range from 1.7 to 3.2 pounds of sulfur per million Btu. Two-thirds of the tonnage was assigned, on the basis of the number and distribution of data points, to the category of less than 2.5 pounds of sulfur per million Btu; and the remaining one-third was assigned to the category of greater than 2.5 pounds of sulfur per million Btu.

Rank All Illinois coals are high volatile bituminous A, B, or C. Coal rank changes systematically with distribution and depth of the deposit in the coal field (Damberger 1971). Rank was determined by calculating the heat content of samples on a moist, mineral-matter-free basis, according to formulas of ASTM Standard D388 (ASTM 1990). Because this calculation excludes mineral matter, all sample types provide equivalent results.

Table 7 Categories of sulfur content (lbs sulfur/million Btu).

≤0.40
0.41–0.60
0.61–0.83
0.84–1.24
1.25–1.67
1.68–2.5
>2.5

The Herrin Coal had the widest distribution of analyses of all seams (fig. 11). Analyses of the Herrin served as the primary control for

mapping trends in rank. Rank group isolines were drawn on the basis of the analyses for each coal as well as on the general trend of the Herrin Coal. In areas of good data control, rank paralleled certain geologic structures: the Shawneetown and Cottage Grove Fault Systems, the Du Quoin Monocline, the La Salle Anticlinal Belt, and the Marshall-Sidell Syncline (figs. 12 and 13). These structures were used to continue the trend of rank isolines across areas of limited control.

Ranks of the other seams were mapped on the basis of available analyses and the regional rank pattern indicated by the Herrin Coal. Coals that are 100 feet above (e.g., the Danville) or below (e.g., the Springfield) the Herrin Coal will have a heat content approximately 100 to 200 Btu per pound lower or higher than the Herrin, respectively (Damberger 1971). The data for the two coals stratigraphically above the Herrin, the Danville and Jamestown, were sparse and were insufficient to calculate a significant change in rank from the Herrin Coal, so the same rank lines were used for all three coals. The data for the Springfield Coal suggest a B/C rank group boundary that corresponds to the Herrin Coal along the east and west sides of the basin, but extends farther northward in the central part of the basin (fig. 13). The rank of the Seelyville (for which there are considerable resources, but few analyses) is based on analyses of the overlying Colchester Coal and a calculated increase in Btu per pound, based on depth of the Seelyville below the Herrin. Other coals were of limited extent and were assigned rank based on available analyses.

Heat content The analyses of the coals were used to map their heat content in million Btu per ton on an as-received basis, according to the categories specified in EIA's Procedural Guidelines (table 8). Because ash content affects the heat content, an adjustment is needed to compensate for the higher ash values of drill holes.

The mean ash content for all face channels of Herrin Coal (1,436 samples) is 11.2%, with a standard deviation of 2%. Aside from increases in ash content near channels contemporaneous with peat deposition, no pattern of ash distribution has been observed. The mean ash value was used to compute a normalized heat content for the drill core analyses. At this mean ash value, the 23- and 25-million-Btu-per-ton contours correspond closely to the B/C and A/B rank group boundaries, respectively. Given the distribution of available data, the same isolines were judged, for purposes of this study, to be suitable boundaries for both rank and heat content per ton.

Coal Accessibility Adjustments

The accessible reserve base is defined by the EIA (Richard Bonskowski, personal communication, September 1995) as the portion of the DRB that can be mined at present, when local or regional mining practice and technologies, physical or geologic conditions, and societal constraints are taken into account. Factors restricting accessibility are determined on a state-by-state basis and may include land use restrictions (towns, cemeteries, highways, railroads, oil and gas wells) and technological, geologic, and regulatory constraints (coal depth and thickness, geologic conditions, proximity to another coal seam or mine, or barrier coal left between mines), all of which may change with time. The EIA has expanded its original concept of accessibility to include, for new resource studies and revisions, the limiting effects of certain technological and geologic conditions. In the past, such adjustments were made in the resource database by the field investigator or within the DRB derivation, and were difficult to reassess. The EIA is taking advantage of the more detailed assessment capabilities of computerized resource mapping systems to enhance the comparability of coal accessibility and the USGS concept of coal availability (as presented below). The expanded definition has been incorporated into the Illinois study.

The USGS supports state geological surveys in their detailed investigations of selected small but representative sample areas (7.5-minute quadrangles) in order to identify and quantify factors that limit the availability of coal for future development (Eggleston et al. 1990). These coal availability studies define as "available" those resources not restricted by land use, geologic, or technological parameters.

Table 8 Categories of heat content (million Btu/short ton).

≥26
25–25.99
23–24.99
20–22.99
15–19.99

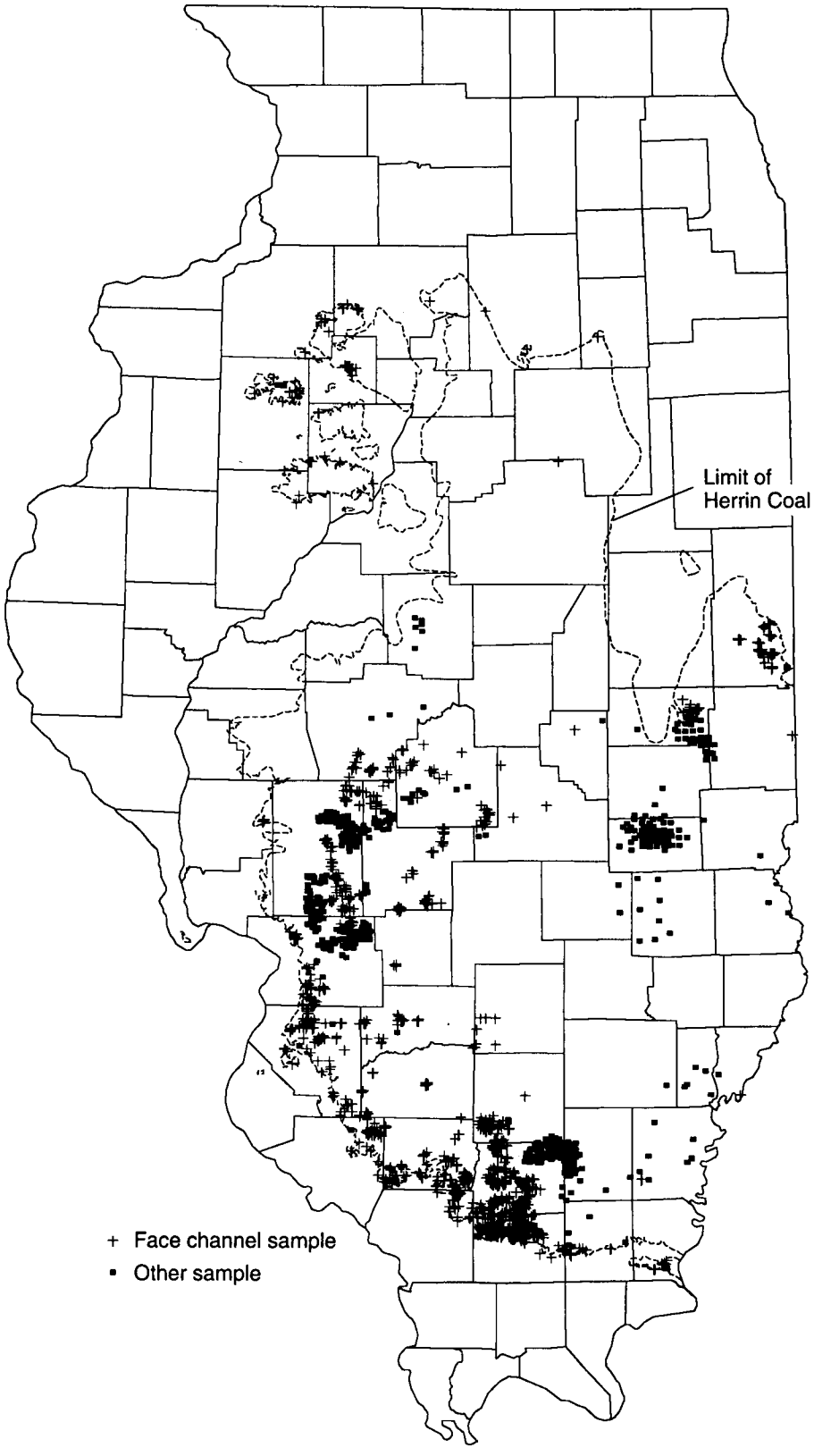

Figure 11 Locations of Herrin Coal samples analyzed to determine rank, sulfur content, and heat content.

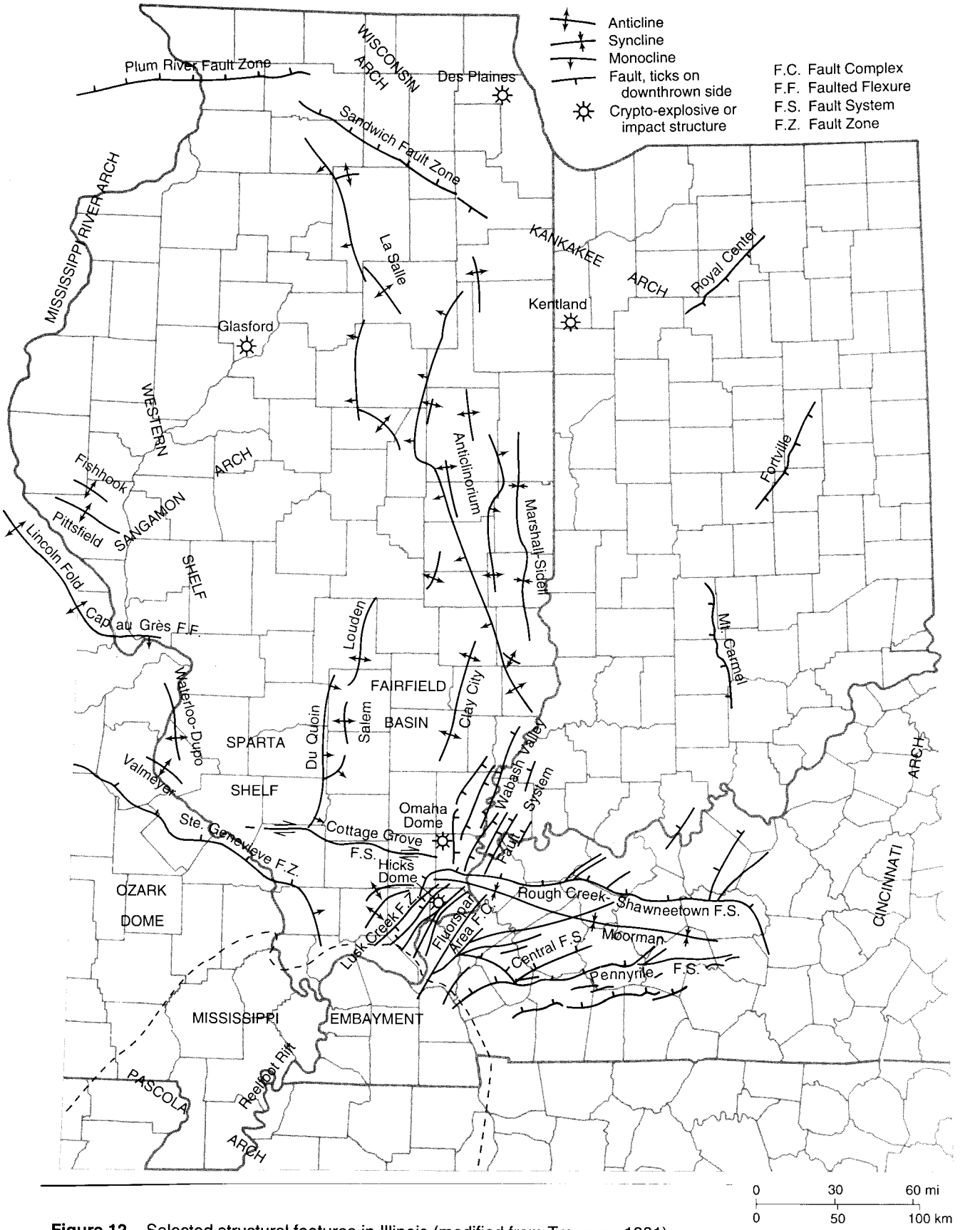

Figure 12 Selected structural features in Illinois (modified from Treworgy 1981).

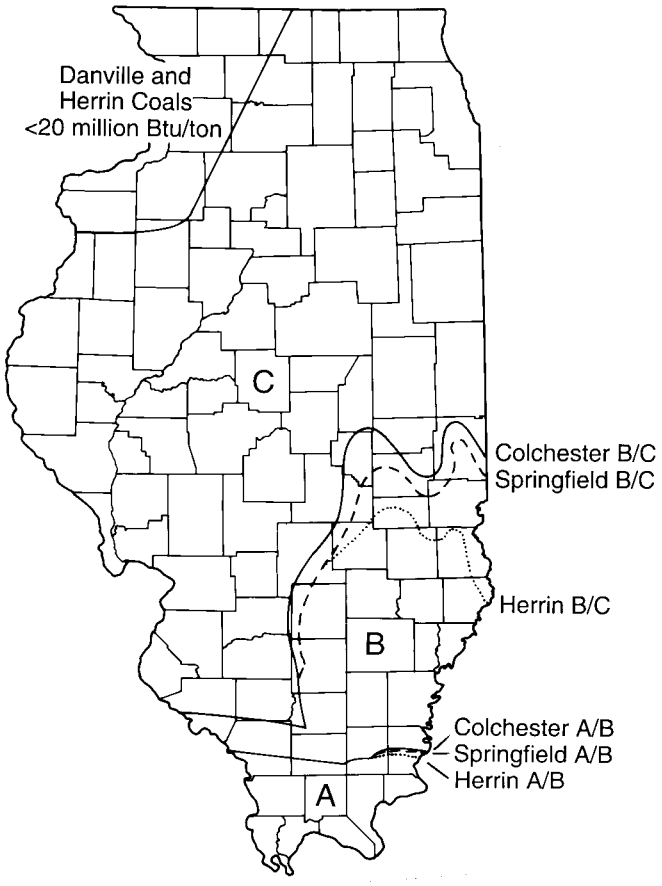

Figure 13 Rank of selected high volatile coals in Illinois. A = high volatile A bituminous rank; B = high volatile B bituminous rank; C = high volatile C bituminous rank.

Although available resources, as defined by the USGS, are currently too limited a sampling to support a national database, they do constitute an important source of information for EIA coal supply projections. While maintaining the integrity of the DRB as a nationally consistent database, the EIA is working to minimize the differences between the concepts of available and accessible resources. The accessible reserve base includes essentially the portion of available resources that would meet DRB criteria. For new resource updates, the EIA is coordinating data on coal accessibility and coal availability to the extent feasible.

The ISGS is in the fourth year of a multiyear study supported by the USGS to assess the availability of coal for mining (Treworgy et al. 1994, Treworgy et al. 1995, Jacobson et al. 1996, Treworgy et al. 1996a,b). At this point in the project, eight quadrangles have been evaluated, about 30% of the number needed to reliably assess the availability of all the resources in the state (fig. 14).

The amount of coal available for mining in the sample areas has ranged from 18% to 76% of the original resources (fig. 15). Technical factors such as thickness of the coal and overlying bedrock, roof and floor conditions, faults, and size of the mining block account for most of the restrictions on coal availability. Land use restricts from less than 1% to 22% of the resources in the quadrangles studied.

Although it is too early to apply most of the initial findings of this coal availability study, some preliminary observations have been incorporated into this estimate of accessible reserves. It is anticipated that the final findings of this study will significantly alter the accessible reserve base. The factors considered for estimating the accessible reserve base are listed in table 9.

Prime farm land Almost 60% of the 36 million acres of land in Illinois is classified as prime farm land. The percentage of surface-minable resources underlying prime farm land is not available. In 1978 the ISGS identified 6 billion tons of surface-minable reserves with the highest potential for development. Using the percentage of prime farm land in each county, the IDMM estimated that 58% of these reserves underlie prime farm land and that this represents 2.5% of the prime farm land in the state (IDMM 1993).

EIA's current estimate of accessible coal in Illinois excludes surface-minable reserves in areas of prime farm land. Illinois' surface mine regulations do not preclude the mining of prime farm land, and

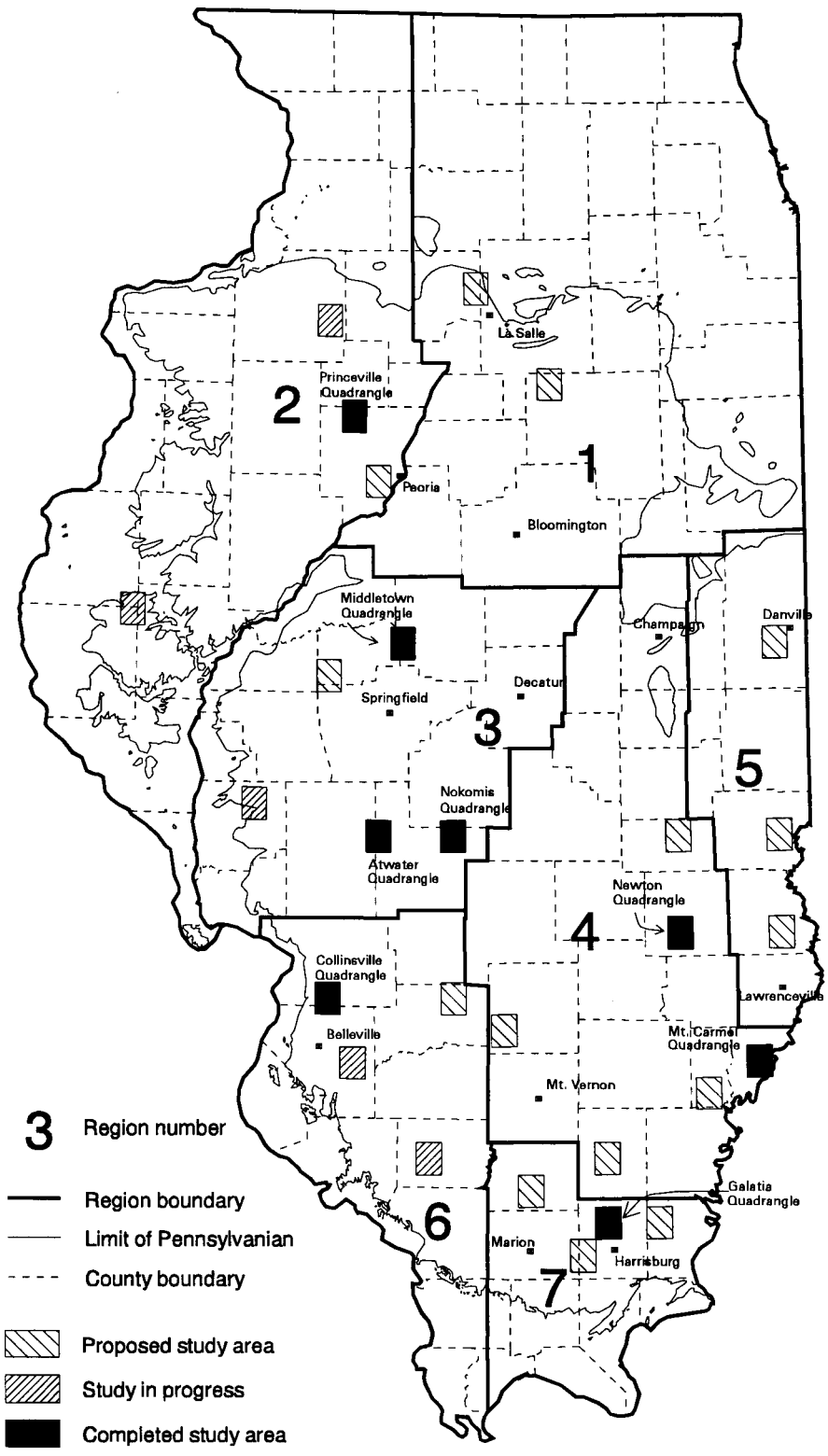

Figure 14 Quadrangles selected for coal availability studies.

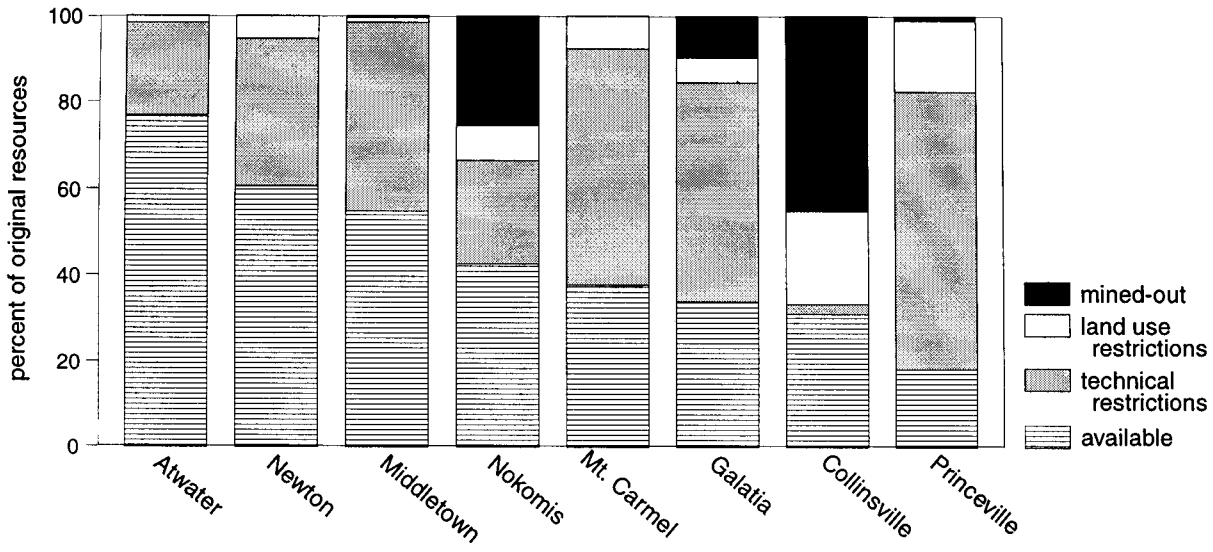

Figure 15 Availability of coal resources in eight quadrangles in Illinois.

Table 9 Factors considered and applied to the demonstrated reserve base to estimate the accessible reserve base.

Factor considered	Applied?	Remarks
Technical		
Prime farm land	No	There is no evidence that prime farm land restricts access.
Areas densely drilled for oil	No	The presence of wells does not raise costs enough to restrict access.
Barrier pillars and small blocks between mines	Yes	Tonnage of existing blocks and barriers was calculated from maps. Tonnage of blocks and barriers created by future mining was estimated to be 15% of reserves otherwise accessible.
Thin coal	Yes	Underground-minable reserves <42 inches thick excluded.
Land Use		The tonnage of underground-minable reserves restricted by all land use categories was estimated from previous mapping; 6% of all surface-minable reserves was assumed to be inaccessible because of land use.
Interstate highways	Yes	
Towns	Yes	
Cemeteries	Yes	
Public lands	Yes	

the coal availability studies do not indicate that operators consider areas of prime farm land to be unminable. Currently, surface mines in the state are mining and successfully reclaiming areas of prime farm land. In recent interviews with four surface mine operators conducted for a coal availability study involving prime farm land, none of the operators considered prime farm land to limit accessibility of the reserves. For these reasons, prime farm land was not used as a factor in estimating the accessible reserve base.

Areas densely drilled for oil Since Cady (1952), the ISGS has excluded areas densely drilled for oil from its calculation of coal reserves. Coal mining experts interviewed by Treworgy and Bargh (1982) confirmed this restriction, and the amount of coal excluded (9.6 billion tons) was documented for the first time. In theory, safety considerations prevented mining coal in such areas. Our recent coal availability studies found that mining companies no longer regard closely spaced oil wells as an absolute barrier to mining. Although regulations of the Mine Safety and Health Administration (MSHA) require

that a barrier pillar be left around wells, experienced mining companies have been allowed to reduce the size of the pillar. In many cases of abandoned wells, it has been feasible for the mining company to plug the well to MSHA specifications and mine through it. The decrease in the amount of coal recovered or the increase in the cost of mining is not severe enough to consider the reserves inaccessible.

Underground-minable coal less than 42 inches thick The eight quadrangles studied to date for coal availability in Illinois contain about 3% of the underground-minable resources in the state and include all the major seams. In assessing the availability of these resources, seven of the eight companies operating major underground mines in the state were interviewed. All seven companies identified coal thinner than 48 inches as too thin to mine economically by underground methods. Because the state lacks natural outcrops of coal, most underground mines require extensive exploratory and developmental drilling to obtain data for mine planning and permitting, and for the construction of slopes and shafts for the movement of air, men, materials, and coal. To justify these expensive and time-consuming pre-mining investments, mines must produce large tonnages of low-cost coal. Mining in thin seams requires more acreage, and the mining costs are higher. For these reasons, underground-minable reserves from thin seams have been excluded from the accessible reserve base. Because the 42-inch isopach was mapped for all reserves (the 48-inch isopach was mapped for only a portion of the reserves), 42 inches is used as the minimum thickness for accessible reserves. Reserves that were mapped as "average 42 inches" (which amounted to less than 350 million tons) were excluded from accessible reserves because it was assumed that at least half the deposit was less than 42 inches thick and that the coal greater than 42 inches is in blocks too small or irregular to mine.

Coal rendered inaccessible by mining A significant portion of inaccessible reserves consists of blocks of coal left as barrier pillars (Illinois law requires 200 feet between mines) or simply left out of the mining plan because of the geometry of the mine plan, early abandonment of a mine, inability to obtain land ownership or mineral rights, or unfavorable geology. Once surrounded by abandoned mines, these blocks are too small or irregular to be minable.

The approximate area of coal rendered inaccessible by mining was calculated by creating a 200-foot buffer around each mine (fig. 16). The buffer areas for each seam were examined and adjusted to include additional areas of coal considered to be unminable because of the small size of the mining area, convoluted geometry, or proximity to mined areas. The tonnage of coal in the adjusted buffer areas was calculated and excluded from the accessible reserve base.

Additional blocks will become inaccessible as mining continues. The amount of coal rendered inaccessible depends upon many variables. Studies conducted by the U.S. Bureau of Mines in selected quadrangles of West Virginia, Kentucky, and Illinois found that, even with optimal mine layouts, from 2% to 12% of the original resources will be left as barrier pillars (U.S. Bureau of Mines 1995). In reality, an optimal mine layout never occurs. Geologic conditions, availability of land and mineral rights, market conditions, and the desire of companies to maximize profits result in less than optimal placement of mines. This study found that, on a county-by-county basis, the amount of inaccessible coal ranged from 6% to more than 40% of the original resources in mined areas. On a statewide basis, the amount of inaccessible coal was roughly 20% of the original resources in mined areas. Some of this coal may have been left because of surface features, which are accounted for separately; thus it was assumed that 15% of the coal otherwise qualified for the accessible reserve base will be rendered inaccessible by future mining.

Other technical factors Other technical factors that restrict the accessibility of reserves include insufficient thickness of the bedrock overburden, insufficient thickness or strength of interburden between seams, other unfavorable roof or floor conditions, and partings in the coal seam. These factors are not understood well enough at this time to use them to adjust the accessible reserve base. At the completion of Illinois' coal availability assessment, the accessible reserve base should be adjusted to include as many of these factors as practical.

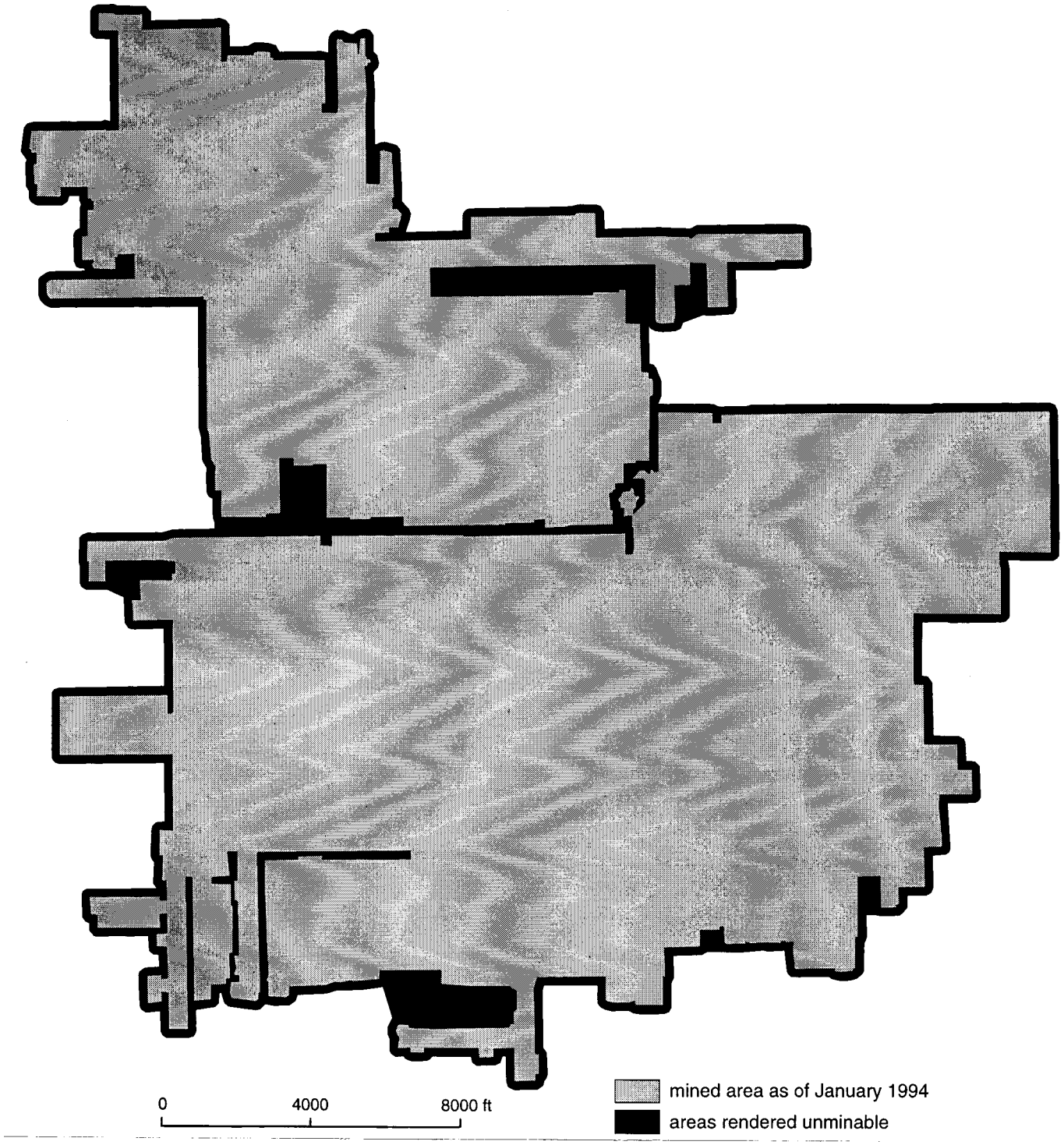

Figure 16 Typical areas of unminable coal between and adjacent to two mines.

Land use Earlier investigations identified land uses such as interstate highways, railroads, cemeteries, towns, and public lands as factors that limit the accessibility of coal (Treworgy et al. 1978, Treworgy and Bargh 1982). Current coal availability studies indicate that some refinements are needed in assessing these factors. For example, early results indicate that surface mining can

be conducted closer to towns in southern Illinois than in other parts of the state. County and township roads are serious obstacles to surface mining in some counties, but not in others. Additional quadrangle studies will help to define these factors and how they should be applied to the accessible reserve base.

The tonnage of underground-minable coal rendered inaccessible by surface features was mapped and calculated in the 1979 estimate of resources (Treworgy and Bargh 1982). The percentage of accessible coal varied from county to county; rural counties generally have 96% to 98% accessible, and counties with large urban areas have 78% to 92% accessible (appendix 3). The percentage of accessible coal for each seam in each county was applied to the underground-minable DRB (minus coal rendered inaccessible by mining) to obtain the underground-minable portion of the accessible reserve base.

Although the accessibility of surface-minable reserves has been considered in a previous study (Treworgy et al. 1978), changes in mining practice and findings from coal availability studies indicate that major changes in criteria used to evaluate accessibility are needed. For this preliminary assessment, a 94% rate of accessibility was applied in all counties to the new surface-minable DRB. This figure was chosen because it is the statewide average for the underground-minable reserves and it falls in the middle of the range measured for the surface-minable resources in the quadrangles studied to date for coal availability. When more data are available, the accessibility rate for surface-minable coal is expected to vary widely from county to county.

Recovery Rates

The EIA provided data on reported recovery rates from individual mines in Illinois for 1991 to 1993. These data were compared with regional recovery rates calculated from depletion (measured from resource maps) and production data (compiled from IDMM reports).

Underground mining Recovery rates for underground reserves were calculated by comparing depletion of underground resources (as indicated by maps of original resources and mined areas) with reported production. For those counties where a valid comparison could be made (representing 66% of the production and 72% of the depletion), recovery rates for 1979 to 1996 ranged from 36% to 58% on a county and seam basis and averaged 47% for all seams and counties combined (table 10). This rate compares favorably with EIA data for 1991 through 1993, which show a weighted average recovery rate of 50% for all underground mines. The higher rate

Table 10 Depletion, production, and calculated recovery rate of underground-minable resources in selected counties from January 1, 1979, to January 1, 1996, in millions of short tons.

County	Coal	Depletion	Production	In-mine recovery in percent
Christian, Montgomery, and Sangamon	Herrin	142	69	49
Clinton	Herrin	125	45	36
Douglas	Herrin	42	18	43
Franklin	Herrin	192	112	58*
Gallatin	Springfield	40	16**	39
Hamilton	Springfield	14	6	44
Jefferson	Herrin	133	68	51
Logan and Sangamon	Springfield	40	15	38
Macoupin	Herrin	146	61	42
Washington	Herrin	47	25	53
White	Herrin	36	16	44
TOTAL		957	451	47

* A significant portion of the production during this period came from longwall mines, hence the higher recovery rate.

** Excludes production of underground mines from surface-minable resources.

reported by the EIA probably reflects the increased use of longwall equipment over this period (32% of production in 1993 versus 15% in 1979). Based on these statistics, a factor of 50% was used to calculate remaining recoverable underground-minable reserves.

Some consideration was given to using a higher recovery rate in counties where longwall mining is being practiced. However, the EIA's data did not show a consistent relationship between mines operating longwalls and higher recovery rates. This probably reflects the influence of other factors such as geology, amount of coal preparation, and development stage of individual mines on recovery rates.

A valid comparison between depletion and production could not be made in several counties because reported production included production from outside the county, underground-minable reserves were depleted by surface mining, or production was too small to measure depletion at the scale of mapping (table 11).

Surface mining Data provided by the EIA for individual surface mines for 1991 to 1993 showed recovery rates from 60% to 90%, with a weighted average of 75%. These figures compare favorably with recovery rates for selected counties, as calculated from cumulative depletion (from base year of mapping to January 1996) of surface-minable resources and reported cumulative production from surface mines (table 12).

Both EIA data and ISGS depletion data from base year of mapping to 1996 suggest that recovery rates are lower for thinner seams (e.g., the Colchester Coal) or seams with many impurities (e.g., the Herrin Coal in Fulton and Peoria Counties). The Herrin Coal in northwestern Illinois commonly contains impurities in the form of a widespread parting known as the "blue band" and prevalent occurrences of "white top" and clay dikes (Smith and Berggren 1963, Damberger 1970).

Table 11 Depletion and production of underground-minable resources in selected counties from January 1, 1979, to January 1, 1996, in millions of short tons.

County	Coal	Depletion	Production	Remarks
Coles	Herrin	0	0.01	Area mined too small to measure at scale of mapping
Perry	Herrin	38	25	Considerable production from surface-minable reserves
Randolph	Herrin	74	63	Considerable production from surface-minable reserves
St. Clair	Herrin	4	14	Most production from surface-minable reserves
Saline	Herrin	61	31	Some production from surface-minable reserves, and some from Williamson County
Saline	Springfield	78	39	Some production from surface-minable reserves, and some from Williamson County
Sangamon	Springfield	7	2	Production reported under Logan County
Vermilion	Danville	0	0.2	Area mined too small to measure at scale of mapping
Vermilion	Herrin	0	0.3	All production from surface-minable reserves
Wabash	Springfield	74	46	About one-third of this production is from Indiana
Williamson	Herrin	28	9	Some production from surface-minable reserves, and some tonnage reported under Franklin and Saline Counties
Williamson	Springfield	11	1	Some production from surface-minable reserves, and most production reported under Saline County
TOTAL		375	231	

Table 12 Depletion, reported production, and calculated recovery rates for surface-minable resources from base year to January 1, 1996, in millions of short tons.

County	Seam	Resources as of base year	Current resources	Inferred depletion	Reported surface-mine production	Recovery rate*
Fulton	Springfield	702	576	126	101	80
Fulton	Colchester	1,105	1,070	35	20	57
Knox	Herrin	257	213	44	29	66
Peoria	Herrin	1,058	1,031	27	19	70
Peoria	Colchester	108	101	7	6.7	96
Perry	Herrin	897	614	282	242	86 (ug)
Randolph	Herrin	279	181	98	68	69 (ug)**
Randolph	Springfield	176	155	21	19	90
St. Clair	Herrin	1,241	1,091	150	117	78 (ug)**
Schuyler	Springfield	113	105	8	4	50
Will	Colchester	22	14	8	6	80
TOTAL				806	632	78

* ug = some surface-minable resources were depleted by underground mining.
** If depletion due to underground mining is exlcuded, the recovery rate rises to about 90%.

Based on these data, a recovery rate of 70% was used in this study to calculate recoverable surface-minable reserves for seams less than 48 inches thick and the Herrin Coal in northwestern Illinois. A recovery rate of 85% was used for all other surface-minable reserves. A valid comparison between depletion and production could not be made in several counties where reported production included production from outside the county, where reserves were destroyed by mining of lower seams, or where significant quantities of surface-minable reserves were mined by underground mines (table 13). Comparisons also could not be made in counties where reserves have been partially revised since the base year of mapping or where production from surface mines is small and the amount of depletion is masked by changes in the base map.

RESULTS

Demonstrated Reserve Base

The new demonstrated reserve base (DRB) for Illinois as of January 1, 1996, is 105 billion short tons (table 14). The previous estimate was 78 billion short tons. The new estimate arises from revised resource calculations based on recent mapping in a number of counties as well as significant adjustments for depletion due to past mining. Areas of coal reserves densely drilled for oil or gas exploration, excluded from the earlier DRB estimate, account for about 3 billion tons of the increase.

The new estimates incorporate analyses of available sulfur, heat content, and rank group data appropriate for characterizing the remaining coal resources in Illinois. Coal-quality data were examined in conjunction with coal resource mapping. Analyses of samples from exploration drill holes, channel samples from mines and outcrops, and geologic trends were compiled and mapped to allocate coal resource quantities to ranges of sulfur content and heat content. The new allocations place almost 1% of the DRB of Illinois in the two lowest sulfur categories (920 million tons), compared with none in the previous allocation used by the EIA. The new allocations place 89% of the reserve base in the highest sulfur category, compared with 69% in the earlier allocation.

Table 14 summarizes the new estimate of the DRB by mining method, sulfur content, and heat content. A complete listing of the DRB by county, seam, depth, heat content, and sulfur content is contained in appendix 4.

Accessible Reserve Base

The new estimate of the accessible reserve base is 70 billion tons, compared with the previous estimate of 56 billion tons (table 15). Unlike the previous estimate, the present compilation does not exclude surface-minable coal under prime farm land. However, underground-minable coal

Table 13 Mapped depletion and reported production of surface-minable resources from base year to January 1, 1996. Unless otherwise indicated under Remarks, production was statistically too small, relative to resources, to calculate a recovery rate. Tonnages are in millions of short tons.

County	Seam	Resources as of base year	Current resources	Inferred depletion	Reported surface-mine production	Remarks*
Adams	Colchester	619	616	3	0.3	
Brown	Colchester	386	363	23	0.4	Some production reported under Schuyler County
Bureau	Herrin	262	273		2	
Edgar	Danville	150	151		1	
Fulton	Danville	59	57	2	0	Destroyed by mining of lower seam
Fulton	Herrin	249	243	7	7	Some production probably from Knox County
Fulton	Rock Island	5	8		0.1	
Gallatin	Herrin	122	178		6	New mapping
Gallatin	Springfield	116	103	13	2	ug mining of sf resources
Greene	Colchester	501	503		0.1	
Grundy	Colchester	313	306	7	0.6	
Jackson	Herrin	149	79	70	33	Revised mapping
Jackson	Springfield	100	97	3	4	New mapping
Jackson	Murphysboro	130	135		1	New mapping
Jefferson	Opdyke	22	23		0.4	
Kankakee	Houchin Creek	16	15	1	0.1	
Kankakee	Colchester	12	12		3	Some production from Will or Grundy County
Knox	Danville	3	1	1	0	Destroyed by mining of lower seam
Knox	Springfield	627	621	5	3	Incomplete reporting
La Salle	Colchester	209	265		0.01	New mapping
McDonough	Colchester	584	579	6	6	
Mercer	Rock Island	55	54	1	0.5	
Peoria	Danville	283	276	6	0	Destroyed by mining of lower seam
Peoria	Springfield	726	737		1	
Perry	Springfield	209	108	101	92	Mining of unmapped reserves
Saline	Danville	78	69	10	0.4	Incomplete reporting; destroyed by mining
Saline	Herrin	285	215	70	38	ug mining of sf resources
Saline	Springfield	93	89	4	2	ug mining of sf resources
Saline	Dekoven	45	60		7	New mapping
Saline	Davis	44	71		9	Revised mapping
Schuyler	Colchester	606	600	6	6	
Stark	Herrin	442	439	3	8	New mapping
Vermilion	Danville	387	393		0.1	New mapping
Williamson	Danville	57	56		4	Some production from Saline County
Williamson	Herrin	291	235	56	70	Revised mapping
Williamson	Springfield	200	184	16	7	ug mining of sf resources
Williamson	Dekoven	41	51		8	New mapping
Williamson	Davis	26	47		11	New mapping

* ug = underground; sf = surface minable

Table 14 Summary of demonstrated reserve base in Illinois, as of January 1, 1996, in millions of short tons of bituminous coal.

Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu)							Total all sulfur categories
	<0.40	0.41–0.60	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	
Minable from surface								
<20	–	–	–	–	–	8.84	121.98	130.82
20–22.99	–	–	4.16	161.45	132.20	501.23	14,102.65	14,901.71
23–24.99	–	–	1.36	26.42	20.12	80.81	1,084.50	1,213.21
25–25.99	–	–	–	–	–	–	372.25	372.25
TOTAL			5.52	187.87	152.33	590.88	15,681.39	16,617.99
Minable underground								
20–22.99	199.42	683.74	1,089.46	1,660.13	1,220.92	2,439.41	48,028.67	55,321.75
23–24.99	2.44	34.08	255.55	874.93	650.75	1,509.48	28,712.89	32,040.12
25–25.99	–	–	–	–	–	–	1,167.04	1,167.04
>25.99	–	–	–	–	–	–	9.45	9.45
TOTAL	201.86	717.82	1,345.02	2,535.06	1,871.67	3,948.88	77,918.06	88,538.37
Minable total								
<20	–	–	–	–	–	8.84	121.98	130.82
20–22.99	199.42	683.74	1,093.63	1,821.58	1,353.12	2,940.64	62,131.33	70,223.46
23–24.99	2.44	34.08	256.91	901.35	670.87	1,590.28	29,797.40	33,253.33
25–25.99	–	–	–	–	–	–	1,539.30	1,539.30
>25.99	–	–	–	–	–	–	9.45	9.45
TOTAL	201.86	717.82	1,350.54	2,722.93	2,023.99	4,539.76	93,599.45	105,156.40

less than 42 inches thick, coal under surface features such as towns, interstate highways, and public lands, and coal rendered inaccessible (barrier pillars, small, irregular blocks between mines, and geologic constraints) by past and future mining have been excluded. Table 15 summarizes the new accessible reserve base estimate by mining method, heat content, and sulfur content.

Recoverable Reserves

The new estimate of recoverable reserves is 38 billion tons, compared with the previous estimate of 30 billion tons (table 16). Recoverable reserves were calculated from the accessible reserve base using recovery rates of 50% for underground-minable reserves, 70% for surface-minable reserves in seams less than 48 inches thick and the Herrin Coal in northwestern Illinois, and 85% for all other surface-minable reserves. Table 16 summarizes the estimates for recoverable reserves by mining method, heat content, and sulfur content.

Digital Data

A digital database of identified resources, the DRB, accessible reserves, and recoverable reserves has been provided to the EIA. This database contains more detailed thickness and depth categories than are shown in the tables of this report, as well as data on the average and maximum stripping ratio of surface minable resources. The format of the digital database is described in appendix 5.

Table 15 Summary of accessible reserve base in Illinois, as of January 1, 1996, in millions of short tons of bituminous coal.

Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu)							Total all sulfur categories
	<0.40	0.41–0.60	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	
Minable from surface								
<20	–	–	–	–	–	7.46	101.69	109.15
20–22.99	–	–	3.54	135.96	109.34	393.12	11,403.12	12,045.08
23–24.99	–	–	0.82	0.85	5.24	39.09	828.44	874.44
25–25.99	–	–	–	–	–	–	293.43	293.43
TOTAL			4.36	136.81	114.58	439.67	12,626.68	13,322.11
Minable underground								
20–22.99	91.17	353.50	651.21	900.59	712.67	1,393.41	30,360.59	34,463.14
23–24.99	1.07	16.58	160.36	633.11	452.48	1,108.46	18,871.96	21,244.02
25–25.99	–	–	–	–	–	–	533.51	533.51
TOTAL	92.24	370.08	811.57	1,533.70	1,165.15	2,501.87	49,766.07	56,240.68
Minable total								
<20	–	–	–	–	–	7.46	101.69	109.15
20–22.99	91.17	353.50	654.75	1,036.55	822.01	1,786.53	41,763.71	46,508.22
23–24.99	1.07	16.58	161.18	633.96	457.73	1,147.55	19,700.40	22,118.46
25–25.99	–	–	–	–	–	–	826.95	826.95
TOTAL	92.24	370.08	815.93	1,670.50	1,279.73	2,941.54	62,392.75	69,562.78

Table 16 Summary of recoverable reserve base in Illinois, as of January 1, 1996, in millions of short tons of bituminous coal.

Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu)							Total all sulfur categories
	<0.40	0.41–0.60	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	
Minable from surface								
<20	–	–	–	–	–	5.22	71.18	76.41
20–22.99	–	–	2.48	110.69	87.11	303.37	8,586.19	9,089.84
23–24.99	–	–	0.70	0.72	4.46	30.94	682.05	718.86
25–25.99	–	–	–	–	–	–	226.75	226.75
TOTAL			3.18	111.41	91.57	339.53	9,566.17	10,111.86
Minable underground								
20–22.99	45.58	176.75	325.61	450.29	356.33	696.70	15,180.30	17,231.57
23–24.99	0.54	8.29	80.18	316.55	226.24	554.23	9,435.98	10,622.01
25–25.99	–	–	–	–	–	–	266.76	266.76
TOTAL	46.12	185.04	405.79	766.85	582.58	1,250.93	24,883.03	28,120.34
Minable total								
<20	–	–	–	–	–	5.22	71.18	76.41
20–22.99	45.59	176.75	328.09	560.99	443.45	1,000.07	23,766.48	26,321.41
23–24.99	0.54	8.29	80.88	317.28	230.70	585.17	10,118.03	11,340.88
25–25.99	–	–	–	–	–	–	493.51	493.51
TOTAL	46.12	185.04	408.96	878.26	674.14	1,590.47	34,449.20	38,232.20

REFERENCES

Allgaier, G.J., and M.E. Hopkins, 1975, Reserves of the Herrin (No. 6) Coal in the Fairfield Basin in Southeastern Illinois: Illinois State Geological Survey Circular 489, 31 p.

ASTM, 1990, Annual Book of ASTM Standards, Section 5, Petroleum Products, Lubricants, and Fossil Fuels, Volume 5.05 Gaseous Fuels; Coal and Coke: American Society for Testing and Materials, Philadelphia, PA, 472 p.

Averitt, P.A., 1969, Coal Resources of the United States January 1, 1967, U.S. Geological Survey Bulletin 1275, 116 p.

Cady, G.H., 1952, Minable Coal Reserves of Illinois: Illinois State Geological Survey Bulletin 78, 138 p.

Campbell, M.R., 1913, The coal reserves of the United States, *in* The Coal Resources of the World, W. McInnes, D.D. Dowling, and W.W. Leach, editors: Toronto, Morang & Co., Ltd., v. 2, p. 525–539.

Damberger, H.H., 1970, Clastic dikes and related impurities in Herrin (No. 6) and Springfield (No. 5) Coals of the Illinois Basin, *in* W.H. Smith, R.B. Nance, M.E. Hopkins, R.G. Johnson, and C.W. Shabica, Depositional Environments in Parts of the Carbondale Formation—Western and Northern Illinois: Illinois State Geological Survey Guidebook 8, p. 111–119.

Damberger, H.H., 1971, Coalification pattern of the Illinois Basin: Economic Geology, v. 66, p. 488–494.

DeMaris, P.J., 1973, Illinois coal reserve data by county and coal seam: Illinois State Geological Survey, unpublished notes.

Demir, I., R.D. Harvey, R.R. Ruch, H.H. Damberger, C. Chaven, J.D. Steele, and W.T. Frankie, 1994, Characterization of Available (Marketed) Coals from Illinois Mines: Illinois State Geological Survey, Open File Series 1994-2, 26 p.

Eggleston, J.R., M.D. Carter, and J.C. Cobb, 1990, Coal Resources Available for Development—A Methodology and Pilot Study: U.S. Geological Survey Circular 1055, 15 p.

Energy Information Administration, 1995, Coal Data, A Reference: Office of Coal, Nuclear, Electric and Alternate Fuels, U.S. Department of Energy, 128 p.

Energy Information Administration, 1996, U.S. Coal Reserves—A Review and Update: Office of Coal, Nuclear, Electric and Alternate Fuels, U.S. Department of Energy, 105 p.

Gluskoter, H.J., and M.E. Hopkins, 1970, Distribution of sulfur in Illinois coals, *in* W.H. Smith, R.B. Nance, M.E. Hopkins, R.G. Johnson, and C.W. Shabica, Depositional Environments in Parts of the Carbondale Formation—Western and Northern Illinois: Illinois State Geological Survey Guidebook 8, p. 89–95.

Gluskoter, H.J., and J.A. Simon, 1968, Sulfur in Illinois Coals: Illinois State Geological Survey Circular 432, 28 p.

Helfinstine, R.J., N.F. Shimp, M.E. Hopkins, and J.A. Simon, 1974, Sulfur Reduction of Illinois Coals—Washability Studies, Part 2: Illinois State Geological Survey Circular 484, 32 p.

Helfinstine, R.J., N.F. Shimp, J.A. Simon, and M.E. Hopkins, 1971, Sulfur Reduction of Illinois Coals—Washability Studies, Part 1: Illinois State Geological Survey Circular 462, 44 p.

Holmes, J.A., 1911, The Sampling of Coal in the Mine: U.S. Bureau of Mines, Technical Paper 1, 18 p.

Hopkins, M.E., 1968, Harrisburg (No. 5) Coal Reserves of Southeastern Illinois: Illinois State Geological Survey Circular 431, 25 p.

Illinois Department of Energy and Natural Resources, 1982, Illinois Energy Plan, Volume IV, An Inventory of the Coal Resources of Illinois: IDENR, ILLDOE 82/13, 66 p.

Illinois Department of Mines and Minerals, 1993, Citizen's Guide to Coal Mining and Reclamation in Illinois: Illinois Department of Mines and Minerals, Land Reclamation Division, 31 p.

Illinois Department of Mines and Minerals, 1994, 1993 Annual Statistical Report: Illinois Department of Mines and Minerals, 29 p.

Jacobson, R.J., 1983, Murphysboro Coal, Jackson and Perry Counties—Resources with Low to Medium Sulfur Potential: Illinois State Geological Survey, Illinois Minerals Note 85, 19 p.

Jacobson, R.J., 1985, Coal Resources of Grundy, La Salle, and Livingston Counties, Illinois: Illinois State Geological Survey Circular 536, 58 p.

Jacobson, R.J., 1993, Coal Resources of the Dekoven and Davis Members (Carbondale Formation) in Gallatin and Saline Counties, Southeastern Illinois: Illinois State Geological Survey Circular 551, 41 p.

Jacobson, R.J., and L.E. Bengal, 1981, Strippable Coal Resources of Illinois, Part 7—Vermilion and Edgar Counties: Illinois State Geological Survey Circular 521, 24 p.

Jacobson, R.J., C.G. Treworgy, and C.A. Chenoweth, 1996, Availability of Coal Resources for Mining in Illinois—Mt. Carmel Quadrangle, Southeastern Illinois: Illinois State Geological Survey, Illinois Minerals 114, 39 p.
Nance, R.B., and C.G. Treworgy, 1981, Strippable Coal Resources of Illinois, Part 8—Central and Southeastern Counties: Illinois State Geological Survey Circular 515, 32 p.
Nelson, W.J., 1981, Faults and Their Effect on Coal Mining in Illinois: Illinois State Geological Survey Circular 523, 40 p.
Robinson, J.E., 1982, Computer Applications in Petroleum Geology: Stroudsburg, PA, Hutchinson Ross Publishing Company, 164 p.
Reinertsen, D.L., 1964, Strippable Coal Reserves of Illinois, Part 4—Adams, Brown, Calhoun, Hancock, McDonough, Pike, Schuyler, and the Southern Parts of Henderson and Warren Counties: Illinois State Geological Survey Circular 374, 32 p.
Smith, W.H., 1957, Strippable Coal Reserves of Illinois, Part 1—Gallatin, Hardin, Johnson, Pope, Saline, and Williamson Counties: Illinois State Geological Survey Circular 228, 39 p.
Smith, W.H., 1958, Strippable Coal Reserves of Illinois, Part 2—Jackson, Monroe, Perry, Randolph, and St. Clair Counties: Illinois State Geological Survey Circular 260, 35 p.
Smith, W.H., 1961, Strippable Coal Reserves of Illinois, Part 3—Madison, Macoupin, Jersey, Greene, Scott, Morgan, and Cass Counties: Illinois State Geological Survey Circular 311, 40 p.
Smith, W.H., 1968, Strippable Coal Reserves of Illinois, Part 6—La Salle, Livingston, Grundy, Kankakee, Will, Putnam, and Parts of Bureau and Marshall Counties: Illinois State Geological Survey Circular 419, 29 p.
Smith, W.H., and D.J. Berggren, 1963, Strippable Coal Reserves of Illinois, Part 5A—Fulton, Henry, Knox, Peoria, Stark, Tazewell, and Parts of Bureau, Marshall, Mercer, and Warren Counties: Illinois State Geological Survey Circular 348, 59 p.
Smith, W.H., and J.B. Stall, 1975, Coal and Water Resources for Coal Conversion in Illinois: Illinois State Water Survey and Illinois State Geological Survey, Cooperative Resources Report 4, 79 p., 3 pl.
Treworgy, C.G., 1981, The Seelyville Coal—A Major Unexploited Seam in Illinois: Illinois State Geological Survey, Illinois Mineral Notes 80, 11 p.
Treworgy, C.G., 1995, Thickness of the Herrin Coal in Moultrie County: Illinois State Geological Survey, unpublished work map.
Treworgy, C.G., and M.H. Bargh, 1982, Deep-Minable Coal Resources of Illinois: Illinois State Geological Survey Circular 527, 65 p.
Treworgy, C.G., L.E. Bengal, and A.G. Dingwell, 1978, Reserves and Resources of Surface-Minable Coal: Illinois State Geological Survey Circular 504, 44 p.
Treworgy, C.G., C.A. Chenoweth, and M.H. Bargh, 1995, Availability of Coal Resources for Mining in Illinois: Galatia Quadrangle, Saline and Hamilton Counties, Southeastern Illinois: Illinois State Geological Survey, Illinois Minerals 113, 42 p.
Treworgy, C.G., C.A. Chenoweth, and R.J. Jacobson, 1996a, Availability of Coal Resources for Mining in Illinois, Newton and Princeville Quadrangles, Jasper, Peoria, and Stark Counties: Illinois State Geological Survey, Open File Series 1996-3, 47 p.
Treworgy, C.G., C.A. Chenoweth, and M.A. Justice, 1996b, Availability of Coal Resources for Mining in Illinois, Atwater, Collinsville, and Nokomis Quadrangles, Christian, Macoupin, Madison, Montgomery, and St. Clair Counties: Illinois State Geological Survey, Open File Series 1996-2, 33 p.
Treworgy, C.G., G.K. Coats, and M.H. Bargh, 1994, Availability of Coal Resources for Mining in Illinois, Middletown Quadrangle, Central Illinois: Illinois State Geological Survey Circular 554, 48 p.
Treworgy, C.G., and R.J. Jacobson, 1986, Paleoenvironments and distribution of low-sulfur coal in Illinois, *in* Aureal T. Cross, editor, Economic Geology—Coal, Oil and Gas, Compte Rendu, v. 4, Ninth International Congress of Carboniferous Stratigraphy and Geology, Washington and Champaign–Urbana, May 1979: Southern Illinois University Press, Carbondale, p. 349–359.
Treworgy, J.D., 1981, Structural Features in Illinois—A Compendium: Illinois State Geological Survey Circular 519, 22 p., 1 plate.

U.S. Bureau of Mines, 1995, Coal Recoverability and Coal Reserve Analysis, Appalachian and Illinois Basins, 1994: U.S. Bureau of Mines Coal Recoverability Series Report 4, Open File Report 02-95, 41 p.

Wood, G.W., Jr., T.M. Kehn, M.D. Carter, and W.C. Culbertson, 1983, Coal Resource Classification System of the U.S. Geological Survey, U.S. Geological Survey Circular 891, 65 p.

APPENDIX 1 Source maps for coal resources

County	Seam	Source (ISGS publications)	Map year	Scale (×1000)	Subsequent mining *	Revision**
Adams	Colchester	Reinertsen 1964	1964	125		
Bond	Litchfield	Cady 1952	1950	62.5		
Bond	Herrin	This report	1996	50		C
Bond	Colchester	Cady 1952	1950	62.5		
Brown	Colchester	Reinertsen 1964	1964	125	S	
Bureau	Danville	Cady 1952, Smith and Berggren 1963, Smith 1968	1950	125		N
Bureau	Herrin	Cady 1952, Smith and Berggren 1963, Smith 1968	1950	125		N
Bureau	Colchester	Cady 1952, Smith and Berggren 1963, Smith 1968	1950	125		N
Calhoun	Colchester	Reinertsen 1964	1964	125		
Cass	Herrin	Smith 1961	1961	125		
Cass	Springfield	Nance and Treworgy 1981	1981	125		N
Cass	Colchester	Smith 1961	1961	125		
Champaign	Danville	Treworgy and Bargh 1982	1978	62.5		N
Champaign	Herrin	Treworgy and Bargh 1982	1978	62.5		N
Christian	Danville	Cady 1952	1950	62.5		
Christian	Herrin	Treworgy and Bargh 1982	1978	62.5	U	N
Christian	Springfield	Treworgy and Bargh 1982	1978	62.5		N
Christian	Assumption	Cady 1952	1950	62.5		
Clark	Danville	This report	1996	50		C
Clark	Jamestown	This report	1996	50		C
Clark	Herrin	This report	1996	50		C
Clark	Springfield	This report	1996	50		C
Clark	Seelyville	Treworgy 1981	1978	62.5		N
Clay	Herrin	Allgaier and Hopkins 1975	1975	125		
Clay	Springfield	Work map by CGT	1978	62.5		N
Clay	Seelyville	Treworgy 1981	1978	62.5		
Clinton	Herrin	This report	1996	50	U	C
Coles	Danville	This report	1996	50		C
Coles	Herrin	This report	1996	50		C
Coles	Springfield	This report	1996	50		C
Coles	Seelyville	Treworgy 1981	1978	62.5		C
Crawford	Bristol Hill	Nance and Treworgy 1981	1981	62.5		
Crawford	Danville	This report	1996	50		C
Crawford	Jamestown	This report	1996	50		C
Crawford	Herrin	This report	1996	50		C
Crawford	Springfield	This report	1996	50		C
Crawford	Seelyville	Treworgy 1981	1978	62.5		
Cumberland	Trowbridge	Nance and Treworgy 1981	1981	62.5		
Cumberland	Herrin	This report	1996	50		C
Cumberland	Springfield	This report	1996	50		C
Cumberland	Seelyville	Treworgy 1981	1981	62.5		N
De Witt	Springfield	Treworgy and Bargh 1982	1978	62.5		N
Douglas	Herrin	This report	1996	50		C
Douglas	Springfield	This report	1996	50		C
Edgar	Danville	This report	1996	50		C
Edgar	Herrin	This report	1996	50		C
Edgar	Springfield	This report	1996	50		C
Edgar	Survant	Work map by CGT	1978	62.5		
Edgar	Seelyville	Treworgy 1981	1981	62.5		

* Under "subsequent mining," U and S indicate whether underground or surface mining has occurred since the resources were last mapped.

** Under "revision," C indicates that the seam was revised for this project; N indicates that new data have become available since the date of mapping and the resource/reserve map should be revised.

APPENDIX 1 ***continued***

County	Seam	Source (ISGS publications)	Map year	Scale (x1000)	Subsequent mining *	Revision**
Edwards	Herrin	Treworgy and Bargh 1982	1978	62.5		N
Edwards	Springfield	Treworgy and Bargh 1982	1978	62.5		N
Effingham	Shelbyville	Nance and Treworgy 1981	1981	62.5		
Effingham	Herrin	This report	1996	50		C
Effingham	Springfield	This report	1996	50		C
Effingham	Seelyville	Treworgy 1981	1981	62.5		N
Fayette	Shelbyville	Nance and Treworgy 1981	1981	62.5		
Fayette	Louden	Nance and Treworgy 1981	1981	62.5		
Fayette	Danville	Cady 1952	1950	62.5		
Fayette	Herrin	This report	1996	50		C
Fayette	Springfield	Work map by CGT	1978	62.5		
Franklin	Belle Rive	Nance and Treworgy 1981	1981	62.5		
Franklin	Herrin	Treworgy and Bargh 1982	1978	62.5	U	N
Franklin	Springfield	Treworgy and Bargh 1982	1978	62.5		
Franklin	Dekoven	Cady 1952	1950	62.5		
Franklin	Davis	Cady 1952	1950	62.5		
Franklin	Mt. Rorah	Cady 1952	1950	62.5		
Fulton	Danville	Smith and Berggren 1963	1963	125	S	N
Fulton	Herrin	Smith and Berggren 1963	1963	125	S	N
Fulton	Springfield	Smith and Berggren 1963	1963	125	S	N
Fulton	Colchester	Smith and Berggren 1963	1963	125	S	N
Fulton	Rock Island	Smith and Berggren 1963	1963	125		
Gallatin	Herrin	Treworgy and Bargh 1982, Smith 1957	1957	62.5	US	N
Gallatin	Springfield	Circulars 527, 228	1957	62.5	US	N
Gallatin	Dekoven	Jacobson 1993	1993	62.5	S	
Gallatin	Davis	Jacobson 1993	1993	62.5	S	
Gallatin	Willis	Cady 1952	1950	62.5		
Greene	Herrin	Smith 1961	1961	125		
Greene	Colchester	Smith 1961, Cady 1952	1950	125		
Grundy	Herrin	Jacobson 1985	1985	62.5		
Grundy	Houchin Creek	Jacobson 1985	1985	62.5		
Grundy	Colchester	Jacobson 1985	1985	62.5	S	
Hamilton	Herrin	Treworgy and Bargh 1982	1978	62.5		
Hamilton	Springfield	Treworgy and Bargh 1982	1978	62.5	U	
Hamilton	Dekoven	Cady 1952	1950	62.5		
Hamilton	Davis	Cady 1952	1950	62.5		
Hancock	Colchester	Reinertsen 1964	1964	125		
Henderson	Colchester	Reinertsen 1964	1964	125		
Henry	Danville	Smith and Berggren 1963	1963	125		N
Henry	Herrin	Smith and Berggren 1963	1963	125		N
Henry	Colchester	Smith and Berggren 1963	1963	125		N
Henry	Rock Island	Searight and Smith 1969	1969	125		
Jackson	Seahorne	Smith 1957	1957	125		
Jackson	Herrin	Smith 1958	1958	125	S	N
Jackson	Springfield	Smith 1958, Treworgy and Bargh 1982	1958	125		
Jackson	Murphysboro	Jacobson 1983	1983	125		N
Jasper	Herrin	This report	1996	50		C
Jasper	Springfield	This report	1996	50		C
Jasper	Seelyville	Treworgy 1981	1981	62.5		N
Jefferson	Opdyke	Nance and Treworgy 1981	1981	62.5	S	
Jefferson	Belle Rive	Nance and Treworgy 1981	1981	62.5		
Jefferson	Herrin	Treworgy and Bargh 1982	1978	62.5	U	N
Jefferson	Springfield	Treworgy and Bargh 1982	1978	62.5		N
Jersey	Herrin	Smith 1961	1961	125		
Jersey	Colchester	Cady 1952, Smith 1961	1950	125		
Johnson	New Burnside	no mapped resources			S	

APPENDIX 1 ***continued***

County	Seam	Source (ISGS publications)	Map year	Scale (x1000)	Subsequent mining *	Revision**
Kankakee	Houchin Creek	Smith 1968	1968	125		
Kankakee	Colchester	Cady 1952, Smith 1968	1950	125		
Knox	Danville	Smith and Berggren 1963	1963	125	S	N
Knox	Herrin	Smith and Berggren 1963	1963	125	S	N
Knox	Springfield	Smith and Berggren 1963	1963	125	S	N
Knox	Colchester	Cady 1952, Smith and Berggren 1963	1950	125		N
Knox Rock	Island	Cady 1952	1950	62.5		
La Salle	Danville	Jacobson 1985	1985	62.5		
La Salle	Herrin	Jacobson 1985	1985	62.5		
La Salle	Houchin Creek	Jacobson 1985	1985	62.5		
La Salle	Colchester	Jacobson 1985	1985	62.5		
Lawrence	Danville	This report	1996	50		C
Lawrence	Jamestown	This report	1996	50		C
Lawrence	Herrin	This report	1996	50		C
Lawrence	Springfield	This report	1996	50		C
Lawrence	Survant	Cady 1952	1950	62.5		
Lawrence	Seelyville	Treworgy 1981	1981	62.5		
Livingston	Danville	Jacobson 1985	1985	62.5		
Livingston	Herrin	Jacobson 1985	1985	62.5		
Livingston	Houchin Creek	Jacobson 1985	1985	62.5		
Livingston	Colchester	Jacobson 1985	1985	62.5		
Logan	Danville	no mapped resources				N
Logan	Herrin	Work map by JDT	1983	62.5		N
Logan	Springfield	Treworgy and Bargh 1982	1978	62.5	U	N
McDonough	Colchester	Reinertsen 1964	1964	125	S	N
McLean	Danville	Cady 1952	1950	62.5		N
McLean	Springfield	Treworgy and Bargh 1982	1978	62.5		N
McLean	Colchester	Cady 1952	1950	62.5		N
Macon	Herrin	Treworgy and Bargh 1982	1978	62.5		
Macon	Springfield	Treworgy and Bargh 1982	1978	62.5		
Macoupin	Wiley	Cady 1952	1950	62.5		
Macoupin	Danville	Cady 1952	1950	62.5		
Macoupin	Herrin	Smith 1963, Treworgy and Bargh 1982	1963†	62.5	U	N
Macoupin	Houchin Creek	Cady 1952, Treworgy and Bargh 1982	1950	62.5		
Macoupin	Colchester	Cady 1952, Smith 1961	1950	62.5		
Macoupin	Litchfield	Cady 1952	1950	62.5		
Madison	Wiley	Cady 1952	1950	62.5		
Madison	Herrin	Smith 1963, Treworgy and Bargh 1982	1963	62.5		N
Madison	Colchester	Cady 1952, Smith 1961	1950	62.5		
Madison	Litchfield	Cady 1952	1950	62.5		
Marion	Herrin	Treworgy and Bargh 1982	1978	62.5		
Marion	Springfield	Work map by CGT	1978	62.5		
Marshall	Danville	Cady 1952, Smith and Berggren 1963	1950	62.5		
Marshall	Herrin	Cady 1952	1950	62.5		
Marshall	Colchester	Cady 1952	1950	62.5		
Mason	Springfield	Treworgy and Bargh 1982	1978	62.5		
Menard	Danville	no mapped resources				
Menard	Herrin	no mapped resources				N
Menard	Springfield	Treworgy and Bargh 1982	1978	62.5		N
Mercer	Colchester	Reinertsen 1964, Searight and Smith 1969	1964	125		N

† Minor revisions made for this report

APPENDIX 1 ***continued***

County	Seam	Source (ISGS publications)	Map year	Scale (x1000)	Subsequent mining *	Revision**
Mercer	Rock Island	Reinertsen 1964, Searight and Smith 1969	1964	125		
Monroe	Herrin	Smith 1958	1958	125		
Montgomery	Danville	Cady 1952	1950	62.5		
Montgomery	Herrin	Trewergy and Bargh 1982	1978†	62.5	U	N
Montgomery	Houchin Creek	Cady 1952	1950	62.5		
Montgomery	Colchester	Cady 1952	1950	62.5		
Montgomery	Litchfield	Cady 1952	1950	62.5		
Montgomery	Wiley	Cady 1952	1950	62.5		
Morgan	Herrin	Smith 1961, Trewergy and Bargh 1982	1961	125		
Morgan	Springfield	Smith 1961	1961	125		N
Morgan	Colchester	Smith 1961, Cady 1952	1950	125		N
Moultrie	Herrin	This report	1995	50		C
Peoria	Danville	Smith and Berggren 1963	1963	125	S	N
Peoria	Herrin	Smith and Berggren 1963	1963	125	S	N
Peoria	Springfield	Smith and Berggren 1963	1963	125		N
Peoria	Colchester	Smith and Berggren 1963, Cady 1952	1950	125		N
Perry	Danville	no mapped resources			S	
Perry	Herrin	Smith 1958, Trewergy and Bargh 1982	1958	62.5	US	
Perry	Springfield	Smith 1958, Trewergy and Bargh 1982	1958	62.5	S	
Perry	Murphysboro	Jacobson 1983	1983			
Piatt	Springfield	Trewergy and Bargh 1982	1978	62.5		
Pike	Colchester	Reinertsen 1964	1964	125		
Pope	Abbot Fm.	no mapped resources			S	
Putman	Danville	Cady 1952	1950	62.5		
Putman	Herrin	Trewergy and Bargh 1982	1978	62.5		
Putman	Colchester	Cady 1952	1950	62.5		
Randolph	Herrin	Smith 1958, Trewergy and Bargh 1982	1958	125	US	
Randolph	Springfield	Smith 1958	1958	125	S	
Richland	Calhoun	Nance and Trewergy 1981	1981	62.5		
Richland	Danville	Work map by CGT	1978	62.5		
Richland	Herrin	This report	1996	50		C
Richland	Springfield	This report	1996	50		C
Richland	Seelyville	Trewergy 1981	1981	62.5		
Rock Island	Rock Island	Searight and Smith 1969	1969	125		
St. Clair	Herrin	Circulars 260, 527	1958	125	US	
Saline	Danville	Smith 1957	1957	125	S	
Saline	Herrin	Smith 1957, Trewergy and Bargh 1982	1957	125	US	N
Saline	Springfield	Smith 1957, Trewergy and Bargh 1982	1957	125	US	N
Saline	Houchin Creek	Cady 1952	1950	62.5		
Saline	Dekoven	Smith 1957, Jacobson 1993	1957	125	S	N
Saline	Davis	Smith 1957, Jacobson 1993	1957	125	S	N
Sangamon	Herrin	Trewergy and Bargh 1982	1978	62.5		N
Sangamon	Springfield	Nance and Trewergy 1981, Trewergy and Bargh 1982	1978	62.5		N
Sangamon	Houchin Creek	Cady 1952	1950	62.5		N
Sangamon	Litchfield	Cady 1952	1950	62.5		

† Minor revisions made for this report

APPENDIX 1 ***continued***

County	Seam	Source (ISGS publications)	Map year	Scale (x1000)	Subsequent mining *	Revision**
Schuyler	Springfield	Reinertsen 1964	1964	125		
Schuyler	Colchester	Reinertsen 1964	1964	125	S	
Scott	Herrin	Smith 1961	1961	125		N
Scott	Colchester	Smith 1961, Cady 1952	1961	125		N
Shelby	Trowbridge	Nance and Trewergy 1981	1983	62.5		
Shelby	Shelbyville	Nance and Trewergy 1981	1983	62.5		
Shelby	Danville	Cady 1952	1950	62.5		
Shelby	Herrin	This report	1996	50		C
Shelby	Springfield	Work map by CGT	1978	62.5		
Shelby	Seelyville	Trewergy 1981	1981	62.5		
Shelby	Assumption	Cady 1952	1950	62.5		
Stark	Danville	Smith and Berggren 1963	1963	125		N
Stark	Herrin	Cady 1952, Smith and Berggren 1963	1950	125	S	N
Stark	Colchester	Smith and Berggren 1963	1963	125		N
Tazewell	Danville	Smith and Berggren 1963	1963	125		
Tazewell	Herrin	Smith and Berggren 1963, Trewergy and Bargh 1982	1963	125		
Tazewell	Springfield	Smith and Berggren 1963, Trewergy and Bargh 1982	1964	125		
Tazewell	Colchester	Cady 1952, Smith and Berggren 1963	1950	125		
Vermilion	Danville	Jacobson and Bengal 1981	1981	62.5	U	
Vermilion	Herrin	Jacobson and Bengal 1981	1981	62.5	US	N
Vermilion	Seelyville	Cady 1952	1950	62.5		
Wabash	Friendsville	Nance and Trewergy 1981	1983	62.5		N
Wabash	Herrin	Trewergy and Bargh 1982	1978	62.5		
Wabash	Springfield	Trewergy and Bargh 1982	1978	62.5	U	N
Warren	Springfield	Smith and Berggren 1963	1963	125		
Warren	Colchester	Smith and Berggren 1963	1963	125		
Warren	Rock Island	Searight and Smith 1969	1969	125		
Washington	Herrin	Trewergy and Bargh 1982	1978	62.5	U	
Wayne	Herrin	Trewergy and Bargh 1982	1978	62.5		
Wayne	Springfield	Trewergy and Bargh 1982, work map by CGT	1978	62.5		
White	Herrin	This report	1996	50	U	C
White	Springfield	This report	1996	50		C
White	Dekoven	Cady 1952	1950	62.5		
White	Davis	Cady 1952	1950	62.5		
Will	Colchester	Smith 1968	1968	125	S	
Williamson	Miscellaneous	Cady 1952, Smith 1957	1950	125	S	
Williamson	Danville	Smith 1957	1957	125	S	N
Williamson	Herrin	Smith 1957, Trewergy and Bargh 1982	1957	125	US	N
Williamson	Springfield	Smith 1957, Trewergy and Bargh 1982	1957	125	S	
Williamson	Dekoven	Cady 1952, Smith 1957	1950	125		
Williamson	Davis	Cady 1952, Smith 1957	1950	125		
Woodford	Danville	Cady 1952	1950	62.5		
Woodford	Springfield	Cady 1952	1950	62.5		
Woodford	Colchester	Cady 1952	1950	62.5		

* Under "revision," C indicates that the seam was revised for this project; N indicates that new data have become available since the date of mapping and the resource/reserve map should be revised.

** Under "subsequent mining," U and S indicate whether underground or surface mining has occurred since the resources were last mapped.

APPENDIX 2 Assumptions used to allocate reported mine production to individual seams

Coals reported mined	Assumptions
Herrin and Springfield	Allocate production 60/40, *except* in Randolph County allocate 40/60.
Davis–Dekoven	Allocate production 50/50.
Nos. 2 and 3	Assume to be Davis and Dekoven; allocate production equally between seams.
Nos. 2 and 7 (Kankakee Co.)	No resources of Danville (No. 7) have been mapped and the coal is not known to be present; not sure which seam this might refer to. Allocate all production to Colchester (No. 2).
Nos. 2 and 5 (Fulton Co.)	Allocate 75% to Colchester, 25% to Springfield (No. 5) based on following year's production of Colchester only.
Nos. 5, 5A, and 6 (Gallatin Co.)	Allocate equally between Herrin and Springfield; no resources of Briar Hill (No. 5a) mapped.
Nos. 5 and 5A	Based on thickness and assumption that Briar Hill is not always present; allocate 20% to Briar Hill, 80% to Springfield.
Nos. 5, 6, and 7(Perry Co.)	Danville production assumed to be minimal. Allocate production 60% to Herrin, 40% to Springfield.
Nos. 6 and 7 (Delta Mine)	Danville production assumed to be minimal. Danville is 25% of total thickness, but not consistently present. Allocate 90% to Herrin, 10% to Danville.
Nos. 4 and 5 (Williamson Co.)	Allocate 20% to Houchin Creek (No. 4), 80% to Springfield based on average thickness and assumption that Houchin Creek was not mined in all areas of pit.
Nos. 3, 4, 5, 5A, and 6 (Gallatin Co.)	Allocate 10% to Briar Hill, 20% to Davis, Dekoven, Springfield, and Herrin.
Nos. 3, 4, 5, and 6 (Gallatin Co.)	Allocate 25% to each.
Nos. 3 and 4	Assume to be Davis and Dekoven; allocate 50/50.

APPENDIX 3 Factors used to calculate underground-minable reserves restricted by land use

The tonnage of underground-minable demonstrated reserves not restricted by land use was calculated with different accessibility factors for each county and each seam within a county. An accessibility factor of 94% was used for all surface-minable reserves.

County	Coal	% accessible
Bond	Herrin	94
Bond	Colchester	100
Bond	Litchfield	100
Bureau	Danville	85
Bureau	Herrin	90
Bureau	Colchester	94
Champaign	Danville	94
Champaign	Herrin	95
Christian	Danville	82
Christian	Herrin	95
Christian	Springfield	92
Christian	Rock Island	93
Clark	Danville	94
Clark	Jamestown	95
Clark	Herrin	67
Clark	Springfield	92
Clark	Seelyville	93
Clay	Herrin	81
Clay	Springfield	82
Clay	Seelyville	81
Clinton	Herrin	83
Coles	Danville	76
Coles	Herrin	75
Coles	Springfield	89
Coles	Seelyville	87
Crawford	Danville	58
Crawford	Jamestown	66
Crawford	Herrin	52
Crawford	Springfield	63
Crawford	Seelyville	62
Cumberland	Danville	97
Cumberland	Herrin	94
Cumberland	Springfield	95
Cumberland	Seelyville	93
De Witt	Springfield	90
Douglas	Herrin	94
Douglas	Springfield	96
Edgar	Danville	96
Edgar	Herrin	92
Edgar	Springfield	97
Edgar	Seelyville	95
Edwards	Herrin	87
Edwards	Springfield	85
Effingham	Danville	95
Effingham	Herrin	91
Effingham	Springfield	92
Effingham	Seelyville	93
Fayette	Danville	94
Fayette	Herrin	92
Fayette	Springfield	90
Franklin	Herrin	87
Franklin	Springfield	85
Franklin	Mt. Rorah	92
Franklin	Dekoven	79
Franklin	Davis	78
Fulton	Herrin	94

continued

County	Coal	% accessible
Fulton	Springfield	100
Fulton	Colchester	100
Fulton	Rock Island	94
Gallatin	Herrin	86
Gallatin	Springfield	87
Gallatin	Survant	100
Gallatin	Dekoven	94
Gallatin	Davis	94
Greene	Colchester	100
Grundy	Colchester	97
Hamilton	Herrin	88
Hamilton	Springfield	84
Hamilton	Dekoven	100
Hamilton	Davis	100
Henry	Colchester	100
Jackson	Springfield	97
Jasper	Danville	98
Jasper	Herrin	90
Jasper	Springfield	91
Jasper	Seelyville	92
Jefferson	Herrin	89
Jefferson	Springfield	90
Jersey	Colchester	100
Kankakee	Colchester	100
Knox	Colchester	100
Knox	Rock Island	100
La Salle	Danville	87
La Salle	Herrin	73
La Salle	Colchester	91
Lawrence	Danville	86
Lawrence	Jamestown	81
Lawrence	Herrin	84
Lawrence	Springfield	83
Lawrence	Survant	87
Lawrence	Seelyville	88
Livingston	Danville	95
Livingston	Herrin	98
Livingston	Houchin Creek	94
Livingston	Colchester	96
Logan	Herrin	91
Logan	Springfield	96
McLean	Danville	82
McLean	Springfield	92
McLean	Colchester	59
Macon	Herrin	93
Macon	Springfield	81
Macoupin	Danville	93
Macoupin	Herrin	96
Macoupin	Houchin Creek	100
Macoupin	Colchester	96
Macoupin	Wiley	82
Macoupin	Litchfield	91
Madison	Herrin	85
Madison	Colchester	99
Madison	Wiley	98
Madison	Litchfield	97

continued

APPENDIX 3 ***continued***

County	Coal	% accessible
Marion	Herrin	87
Marion	Springfield	84
Marshall	Danville	97
Marshall	Herrin	63
Marshall	Colchester	95
Menard	Springfield	95
Montgomery	Danville	95
Montgomery	Herrin	96
Montgomery	Houchin Creek	97
Montgomery	Colchester	94
Montgomery	Wiley	83
Montgomery	Litchfield	91
Morgan	Herrin	98
Morgan	Colchester	91
Moultrie	Herrin	85
Peoria	Springfield	100
Peoria	Colchester	100
Perry	Herrin	97
Perry	Springfield	93
Perry	Murphysboro	100
Piatt	Springfield	95
Putnam	Danville	94
Putnam	Herrin	86
Putnam	Colchester	95
Randolph	Herrin	90
Randolph	Springfield	94
Richland	Danville	88
Richland	Herrin	87
Richland	Springfield	88
Richland	Seelyville	100
St. Clair	Herrin	86
Saline	Herrin	87
Saline	Springfield	87
Saline	Survant	94
Saline	Dekoven	86
Saline	Davis	86
Sangamon	Herrin	88
Sangamon	Springfield	87
Sangamon	Houchin Creek	91
Sangamon	Litchfield	42
Scott	Colchester	100
Shelby	Danville	98
Shelby	Herrin	95
Shelby	Springfield	97
Shelby	Seelyville	95
Shelby	Assumption	100
Stark	Herrin	100
Tazewell	Herrin	80
Tazewell	Springfield	86
Tazewell	Colchester	52
Vermilion	Danville	97
Vermilion	Herrin	94
Vermilion	Seelyville	61
Wabash	Herrin	66
Wabash	Springfield	62
Washington	Herrin	94
Wayne	Herrin	79
Wayne	Springfield	80
White	Herrin	81
White	Springfield	80
White	Dekoven	72
White	Davis	66
Williamson	Herrin	95
Williamson	Springfield	89
Williamson	Survant	68
Williamson	Mt. Rorah	82
Williamson	Dekoven	88
Williamson	Davis	88
Williamson	Wise Ridge	94
Woodford	Danville	92
Woodford	Springfield	91
Woodford	Colchester	96

continued

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Adams County											
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							276.94	276.94
	Deep	150-500'	20-22.99							0.18	0.18
Adams Co., All Beds											
	Surface	0-150'	20-22.99							276.94	276.94
	Surface	Subtotal								276.94	276.94
	Deep	150-500'	20-22.99							0.18	0.18
	Deep	Subtotal								0.18	0.18
Adams Co. Totals										277.12	277.12
Bond County											
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99							2,251.62	2,251.62
		500-1000'	20-22.99							51.60	51.60
Bond Co., All Beds											
	Deep	150-500'	20-22.99							2,251.62	2,251.62
		500-1000'	20-22.99							51.60	51.60
	Deep	Subtotal								2,303.22	2,303.22
Bond Co. Totals										2,303.22	2,303.22

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Brown County											
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							256.03	256.03
	Deep	150-500'	20-22.99							8.11	8.11
Brown Co., All Beds											
	Surface	0-150'	20-22.99							256.03	256.03
	Surface	Subtotal								256.03	256.03
	Deep	150-500'	20-22.99							8.11	8.11
	Deep	Subtotal								8.11	8.11
Brown Co. Totals										264.14	264.14
Bureau County											
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							73.34	73.34
	Deep	150-500'	20-22.99							192.61	192.61
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							171.26	171.26
	Deep	150-500'	20-22.99							392.90	392.90
Colchester											
High Vol. C Bit.	Deep	150-500'	20-22.99							607.06	607.06
Bureau Co., All Beds											
	Surface	0-150'	20-22.99							244.60	244.60

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Surface	Subtotal								244.60	244.60
	Deep	150-500'	20-22.99							1,192.57	1,192.57
	Deep	Subtotal								1,192.57	1,192.57
Bureau Co. Totals										1,437.17	1,437.17
	Calhoun County										
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							12.21	12.21
Calhoun Co., All Beds											
	Surface	0-150'	20-22.99							12.21	12.21
	Surface	Subtotal								12.21	12.21
Calhoun Co. Totals										12.21	12.21
	Cass County										
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							79.09	79.09
	Deep	150-500'	20-22.99							4.87	4.87
Cass Co., All Beds											
	Surface	0-150'	20-22.99							79.09	79.09
	Surface	Subtotal								79.09	79.09
	Deep	150-500'	20-22.99							4.87	4.87

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Deep	Subtotal								4.87	4.87
Cass Co. Totals										83.96	83.96
	Champaign County										
Danville											
High Vol. C Bit.	Deep	150-500'	20-22.99							37.00	37.00
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99						19.09	134.85	153.95
Champaign Co., All Beds											
	Deep	150-500'	20-22.99						19.09	171.85	190.94
	Deep	Subtotal							19.09	171.85	190.94
Champaign Co. Totals									19.09	171.85	190.94
	Christian County										
Danville											
High Vol. C Bit.	Deep	150-500'	20-22.99							16.88	16.88
		500-1000'	20-22.99							44.46	44.46
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99			107.88	43.56	35.44	141.87	1,663.19	1,991.93
		500-1000'	20-22.99				12.55	10.62	85.94	723.01	832.12
Springfield											
High Vol. C Bit.	Deep	150-500'	20-22.99							495.38	495.38
		500-1000'	20-22.99							113.80	113.80

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
		500-1000'	23-24.99							27.93	27.93
Clark Co., All Beds											
	Surface	0-150'	20-22.99			0.45	18.17			3.63	22.25
	Surface	Subtotal				0.45	18.17			3.63	22.25
	Deep	150-500'	20-22.99	46.99	84.10	71.26	183.25	41.14	49.80	378.37	854.91
			23-24.99							356.26	356.26
		500-1000'	20-22.99	25.60	22.45	101.80	79.22	15.68	6.81	117.75	369.31
			23-24.99							560.01	560.01
	Deep	Subtotal		72.60	106.55	173.06	262.48	56.83	56.60	1,412.38	2,140.50
Clark Co. Totals				72.60	106.55	173.50	280.65	56.83	56.60	1,416.02	2,162.75
	Clinton County										
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99			7.17	12.32	42.06	21.91	2,634.33	2,717.78
		500-1000'	20-22.99							175.73	175.73
Clinton Co., All Beds											
	Deep	150-500'	20-22.99			7.17	12.32	42.06	21.91	2,634.33	2,717.78
		500-1000'	20-22.99							175.73	175.73
	Deep	Subtotal				7.17	12.32	42.06	21.91	2,810.06	2,893.51
Clinton Co. Totals						7.17	12.32	42.06	21.91	2,810.06	2,893.51

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
		500-1000'	23-24.99							27.93	27.93
Clark Co., All Beds											
	Surface	0-150'	20-22.99			0.45	18.17			3.63	22.25
	Surface	Subtotal				0.45	18.17			3.63	22.25
	Deep	150-500'	20-22.99	46.99	84.10	71.26	183.25	41.14	49.80	378.37	854.91
			23-24.99							356.26	356.26
		500-1000'	20-22.99	25.60	22.45	101.80	79.22	15.68	6.81	117.75	369.31
			23-24.99							560.01	560.01
	Deep	Subtotal		72.60	106.55	173.06	262.48	56.83	56.60	1,412.38	2,140.50
Clark Co. Totals				72.60	106.55	173.50	280.65	56.83	56.60	1,416.02	2,162.75
	Clinton County										
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99			7.17	12.32	42.06	21.91	2,634.33	2,717.78
		500-1000'	20-22.99							175.73	175.73
Clinton Co., All Beds											
	Deep	150-500'	20-22.99			7.17	12.32	42.06	21.91	2,634.33	2,717.78
		500-1000'	20-22.99							175.73	175.73
	Deep	Subtotal				7.17	12.32	42.06	21.91	2,810.06	2,893.51
Clinton Co. Totals						7.17	12.32	42.06	21.91	2,810.06	2,893.51

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Coles County											
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99			3.72	3.34				7.06
	Deep	150-500'	20-22.99								
		500-1000'	20-22.99			12.15	5.40	5.00	4.02	169.34	195.90
		>1000'	20-22.99			9.87	14.03	7.54	1.46	7.47	40.38
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99					4.32	1.46		5.77
	Deep	150-500'	20-22.99				2.65	74.63	33.34		110.61
		500-1000'	20-22.99				32.08	5.06	3.31		40.45
		>1000'	20-22.99			43.71	99.81	9.20	23.56		176.27
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99							11.82	11.82
		>1000'	23-24.99							210.56	210.56
High Vol. C Bit.	Surface	0-150'	20-22.99							0.91	0.91
	Deep	150-500'	20-22.99							11.91	11.91
		500-1000'	20-22.99							20.94	20.94
		>1000'	20-22.99							5.03	5.03
Coles Co., All Beds											
	Surface	0-150'	20-22.99			3.72	3.34	4.32	1.46	0.91	13.74
	Surface	Subtotal				3.72	3.34	4.32	1.46	0.91	13.74
	Deep	150-500'	20-22.99				2.65	74.63	33.34	11.91	122.53
		500-1000'	20-22.99			12.15	37.47	10.06	7.33	190.27	257.28
			23-24.99							11.82	11.82
		>1000'	20-22.99			53.58	113.84	16.73	25.03	12.50	221.68
			23-24.99							210.56	210.56
	Deep	Subtotal				65.73	153.96	101.42	65.70	437.06	823.87
Coles Co. Totals						69.45	157.31	105.73	67.15	437.96	837.61

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Crawford County											
Bristol Hill											
High Vol. B Bit.	Surface	0-150'	23-24.99						17.98		17.98
Danville											
High Vol. B Bit.	Deep	150-500'	23-24.99		5.08	56.83	48.97	20.44	2.49	2.07	135.88
		500-1000'	23-24.99	2.42	19.11	20.48					42.01
High Vol. C Bit.	Deep	150-500'	20-22.99	119.50	122.86	13.31					255.67
		500-1000'	20-22.99	7.32	0.96	0.30					8.58
Jamestown											
High Vol. B Bit.	Deep	150-500'	23-24.99							59.83	59.83
		500-1000'	23-24.99							126.20	126.20
High Vol. C Bit.	Deep	150-500'	20-22.99							294.19	294.19
		500-1000'	20-22.99							88.20	88.20
Herrin											
High Vol. B Bit.	Deep	150-500'	23-24.99							11.93	11.93
		500-1000'	23-24.99						0.04	18.99	19.03
High Vol. C Bit.	Deep	150-500'	20-22.99					0.68	6.94		7.62
		500-1000'	20-22.99				0.32	0.33	1.03		1.68
Springfield											
High Vol. B Bit.	Deep	150-500'	23-24.99							87.65	87.65
		500-1000'	23-24.99							331.37	331.37
Seelyville											
High Vol. B Bit.	Deep	500-1000'	23-24.99							210.60	210.60
Crawford Co., All Beds											
	Surface	0-150'	23-24.99						17.98		17.98
	Surface	Subtotal							17.98		17.98

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Deep	150-500'	20-22.99	119.50	122.86	13.31		0.68	6.94	294.19	557.47
			23-24.99		5.08	56.83	48.97	20.44	2.49	161.47	295.28
		500-1000'	20-22.99	7.32	0.96	0.30	0.32	0.33	1.03	88.20	98.47
			23-24.99	2.42	19.11	20.48			0.04	687.16	729.21
	Deep	Subtotal		129.24	148.02	90.92	49.29	21.45	10.50	1,231.02	1,680.44
Crawford Co. Totals				129.24	148.02	90.92	49.29	21.45	28.48	1,231.02	1,698.42
	Cumberland County										
Trowbridge											
High Vol. C Bit.	Surface	0-150'	<19.99						0.28		0.28
Danville											
High Vol. B Bit.	Deep	500-1000'	23-24.99							49.45	49.45
		>1000'	23-24.99							267.81	267.81
High Vol. C Bit.	Deep	150-500'	20-22.99							5.28	5.28
		500-1000'	20-22.99							120.34	120.34
		>1000'	20-22.99							36.61	36.61
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							1.24	1.24
		>1000'	23-24.99	0.02	6.51	20.53	46.47	14.81	12.00	426.01	526.34
High Vol. C Bit.	Deep	150-500'	20-22.99		6.01	1.69	7.09				14.80
		500-1000'	20-22.99		94.71	17.61	54.23	1.52	0.79	6.38	175.24
		>1000'	20-22.99		121.96	228.43	26.92	7.90	6.25	35.25	426.71
Springfield											
High Vol. B Bit.	Deep	150-500'	23-24.99							1.59	1.59
		500-1000'	23-24.99							94.08	94.08
		>1000'	23-24.99							738.81	738.81

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Seelyville											
High Vol. B Bit.	Deep	150-500'	23-24.99							3.81	3.81
		500-1000'	23-24.99							0.17	0.17
		>1000'	23-24.99							218.46	218.46
Cumberland Co., All Beds											
	Surface	0-150'	<19.99						0.28		0.28
	Surface	Subtotal							0.28		0.28
	Deep	150-500'	20-22.99		6.01	1.69	7.09			5.28	20.08
			23-24.99							5.40	5.40
		500-1000'	20-22.99		94.71	17.61	54.23	1.52	0.79	126.73	295.58
			23-24.99							144.94	144.94
		>1000'	20-22.99		121.96	228.43	26.92	7.90	6.25	71.86	463.31
			23-24.99	0.02	6.51	20.53	46.47	14.81	12.00	1,651.09	1,751.42
	Deep	Subtotal		0.02	229.19	268.25	134.71	24.23	19.04	2,005.29	2,680.73
Cumberland Co. Totals			0.02	229.19	268.25	134.71	24.23	19.32	2,005.29	2,681.01	
Douglas County											
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99				79.92	37.93	55.44		173.28
	Deep	150-500'	20-22.99				152.56	94.22	370.43		617.20
		500-1000'	20-22.99					2.13	125.13	48.01	175.27
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							7.06	7.06
	Deep	150-500'	20-22.99							59.18	59.18
		500-1000'	20-22.99							54.59	54.59

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Douglas Co., All Beds											
	Surface	0-150'	20-22.99				79.92	37.93	55.44	7.06	180.34
	Surface	Subtotal					79.92	37.93	55.44	7.06	180.34
	Deep	150-500'	20-22.99				152.56	94.22	370.43	59.18	676.38
		500-1000'	20-22.99					2.13	125.13	102.60	229.86
	Deep	Subtotal					152.56	96.35	495.56	161.78	906.24
Douglas Co. Totals							232.47	134.28	550.99	168.83	1,086.57
	Edgar County										
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99				2.25	6.47	1.92	124.69	135.33
	Deep	150-500'	20-22.99					1.25	0.68	836.26	838.20
		500-1000'	20-22.99							12.41	12.41
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99				54.18	67.24	20.97		142.39
	Deep	150-500'	20-22.99				250.03	303.85	112.13		666.01
		500-1000'	20-22.99						70.12		70.12
Springfield											
High Vol. B Bit.	Deep	150-500'	23-24.99							112.66	112.66
		500-1000'	23-24.99							44.64	44.64
High Vol. C Bit.	Surface	0-150'	20-22.99							20.28	20.28
	Deep	150-500'	20-22.99							278.74	278.74
Seelyville											
High Vol. B Bit.	Deep	150-500'	23-24.99							8.14	8.14
		500-1000'	23-24.99							371.42	371.42
High Vol. C Bit.	Deep	150-500'	20-22.99							158.28	158.28
		500-1000'	20-22.99							23.39	23.39

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Edgar Co., All Beds											
	Surface	0-150'	20-22.99				56.43	73.71	22.88	144.97	297.99
	Surface	Subtotal					56.43	73.71	22.88	144.97	297.99
	Deep	150-500'	20-22.99				250.03	305.10	112.81	1,273.28	1,941.23
			23-24.99							120.79	120.79
		500-1000'	20-22.99						70.12	35.80	105.92
			23-24.99							416.06	416.06
	Deep	Subtotal					250.03	305.10	182.93	1,845.93	2,583.99
Edgar Co. Totals							306.46	378.81	205.82	1,990.90	2,881.99
Edwards County											
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							208.52	208.52
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99					22.12	27.14	117.52	166.79
		>1000'	23-24.99						1.00	13.21	14.21
Edwards Co., All Beds											
	Deep	500-1000'	23-24.99					22.12	27.14	326.04	375.31
		>1000'	23-24.99						1.00	13.21	14.21
	Deep	Subtotal						22.12	28.14	339.25	389.52
Edwards Co. Totals								22.12	28.14	339.25	389.52

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Effingham County											
Shelbyville											
High Vol. C Bit.	Surface	0-150'	20-22.99							1.20	1.20
Danville											
High Vol. B Bit.	Deep	500-1000'	23-24.99							38.12	38.12
		>1000'	23-24.99							302.47	302.47
High Vol. C Bit.	Deep	500-1000'	20-22.99							0.13	0.13
		>1000'	20-22.99							0.18	0.18
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							45.13	45.13
		>1000'	23-24.99							468.59	468.59
High Vol. C Bit.	Deep	>1000'	20-22.99							0.40	0.40
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99							4.83	4.83
		>1000'	23-24.99							430.35	430.35
Effingham Co., All Beds											
	Surface	0-150'	20-22.99							1.20	1.20
	Surface	Subtotal								1.20	1.20
	Deep	500-1000'	20-22.99							0.13	0.13
			23-24.99							88.09	88.09
		>1000'	20-22.99							0.59	0.59
			23-24.99							1,201.40	1,201.40
	Deep	Subtotal								1,290.20	1,290.20
Effingham Co. Totals										1,291.40	1,291.40

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Fayette County											
Shelbyville High Vol. C Bit.	Surface	0-150'	20-22.99							0.55	0.55
Loudon High Vol. C Bit.	Surface	0-150'	20-22.99							1.37	1.37
Danville High Vol. C Bit.	Deep	500-1000'	20-22.99							306.68	306.68
Herrin High Vol. C Bit.	Deep	150-500'	20-22.99							49.45	49.45
		500-1000'	20-22.99							1,751.41	1,751.41
Springfield High Vol. C Bit.	Deep	500-1000'	20-22.99							125.56	125.56
Fayette Co., All Beds											
	Surface	0-150'	20-22.99							1.92	1.92
	Surface	Subtotal								1.92	1.92
	Deep	150-500'	20-22.99							49.45	49.45
		500-1000'	20-22.99							2,183.64	2,183.64
	Deep	Subtotal								2,233.09	2,233.09
Fayette Co. Totals										2,235.01	2,235.01
Franklin County											
Belle Rive High Vol. C Bit.	Surface	0-150'	20-22.99							1.75	1.75

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Herrin											
High Vol. B Bit.	Deep	150-500'	23-24.99				1.77	4.24	1.19	3.74	10.94
		500-1000'	23-24.99			4.01	24.09	9.70	15.71	1,321.97	1,375.49
High Vol. C Bit.	Deep	500-1000'	20-22.99				0.19	1.92	1.85	4.87	8.83
Springfield											
High Vol. B Bit.	Deep	150-500'	23-24.99							241.42	241.42
		500-1000'	23-24.99				0.03	17.30	254.33	1,237.44	1,509.11
		>1000'	23-24.99							25.54	25.54
High Vol. C Bit.	Deep	150-500'	20-22.99							71.02	71.02
		500-1000'	20-22.99							162.95	162.95
DeKoven											
High Vol. B Bit.	Deep	500-1000'	23-24.99							106.39	106.39
Davis											
High Vol. B Bit.	Deep	500-1000'	23-24.99							179.52	179.52
High Vol. C Bit.	Deep	500-1000'	20-22.99							5.71	5.71
Mt. Rorah											
High Vol. B Bit.	Deep	500-1000'	23-24.99							63.24	63.24
		>1000'	23-24.99							11.22	11.22
High Vol. C Bit.	Deep	500-1000'	20-22.99							0.75	0.75
Franklin Co., All Beds											
	Surface	0-150'	20-22.99							1.75	1.75
	Surface	Subtotal								1.75	1.75
	Deep	150-500'	20-22.99							71.02	71.02
			23-24.99				1.77	4.24	1.19	245.16	252.36
		500-1000'	20-22.99				0.19	1.92	1.85	174.27	178.24
			23-24.99			4.01	24.12	27.01	270.05	2,908.56	3,233.75
		>1000'	23-24.99							36.76	36.76

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Deep	Subtotal				4.01	26.09	33.17	273.09	3,435.77	3,772.12
Franklin Co. Totals						4.01	26.09	33.17	273.09	3,437.53	3,773.88
	Fulton County										
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							41.98	41.98
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							242.67	242.67
	Deep	150-500'	20-22.99							3.63	3.63
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							576.00	576.00
	Deep	150-500'	20-22.99							80.22	80.22
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							958.29	958.29
	Deep	150-500'	20-22.99							82.31	82.31
Rock Island											
High Vol. C Bit.	Surface	0-150'	20-22.99							8.03	8.03
	Deep	150-500'	20-22.99							0.15	0.15
Fulton Co., All Beds											
	Surface	0-150'	20-22.99							1,826.96	1,826.96
	Surface	Subtotal								1,826.96	1,826.96
	Deep	150-500'	20-22.99							166.30	166.30
	Deep	Subtotal								166.30	166.30
Fulton Co. Totals										1,993.26	1,993.26

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Gallatin County											
Herrin											
High Vol. A Bit.	Surface	0-150'	23-24.99							177.71	177.71
	Deep	150-500'	23-24.99							566.08	566.08
High Vol. B Bit.	Deep	500-1000'	23-24.99							112.12	112.12
Springfield											
High Vol. A Bit.	Surface	0-150'	25-25.99							66.13	66.13
	Deep	150-500'	25-25.99							137.17	137.17
		500-1000'	25-25.99							24.10	24.10
High Vol. B Bit.	Surface	0-150'	23-24.99							36.97	36.97
	Deep	150-500'	23-24.99							485.73	485.73
		500-1000'	23-24.99							445.38	445.38
DeKoven											
High Vol. A Bit.	Surface	0-150'	25-25.99							22.30	22.30
	Deep	150-500'	25-25.99							141.38	141.38
		500-1000'	25-25.99							54.27	54.27
High Vol. B Bit.	Deep	150-500'	23-24.99							0.31	0.31
		500-1000'	23-24.99							338.02	338.02
		>1000'	23-24.99							46.42	46.42
Davis											
High Vol. A Bit.	Surface	0-150'	25-25.99							33.33	33.33
	Deep	150-500'	25-25.99							209.85	209.85
		500-1000'	25-25.99							73.27	73.27
High Vol. B Bit.	Deep	150-500'	23-24.99							0.36	0.36
		500-1000'	23-24.99							447.80	447.80
		>1000'	23-24.99							67.69	67.69
Willis											
High Vol. A Bit.	Deep	150-500'	>25.99							5.98	5.98

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Gallatin Co., All Beds											
	Surface	0-150'	23-24.99							214.68	214.68
			25-25.99							121.76	121.76
	Surface	Subtotal								336.44	336.44
	Deep	150-500'	23-24.99							1,052.48	1,052.48
			25-25.99							488.40	488.40
			>25.99							5.98	5.98
		500-1000'	23-24.99							1,343.32	1,343.32
			25-25.99							151.64	151.64
		>1000'	23-24.99							114.10	114.10
	Deep	Subtotal								3,155.93	3,155.93
Gallatin Co. Totals										3,492.37	3,492.37
	Greene County										
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							75.00	75.00
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							377.99	377.99
	Deep	150-500'	20-22.99							17.93	17.93
Greene Co., All Beds											
	Surface	0-150'	20-22.99							452.99	452.99
	Surface	Subtotal								452.99	452.99
	Deep	150-500'	20-22.99							17.93	17.93
	Deep	Subtotal								17.93	17.93

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Greene Co. Totals										470.92	470.92
	Grundy County										
Herrin High Vol. C Bit.	Surface	0-150'	20-22.99							43.10	43.10
Houchin Creek High Vol. C Bit.	Surface	0-150'	20-22.99							113.11	113.11
Colchester High Vol. C Bit.	Surface	0-150'	20-22.99						42.64	260.86	303.50
	Deep	150-500'	20-22.99						8.16	260.02	268.18
Grundy Co., All Beds	Surface	0-150'	20-22.99						42.64	417.08	459.72
	Surface	Subtotal							42.64	417.08	459.72
	Deep	150-500'	20-22.99						8.16	260.02	268.18
	Deep	Subtotal							8.16	260.02	268.18
Grundy Co. Totals									50.80	677.09	727.90
	Hamilton County										
Herrin High Vol. B Bit.	Deep	150-500'	23-24.99							0.05	0.05
		500-1000'	23-24.99							1,827.43	1,827.43
		>1000'	23-24.99							217.60	217.60

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99			30.71	434.21	149.43	92.46	484.14	1,190.95
		>1000'	23-24.99				3.67	22.36	138.67	426.60	591.30
Hamilton Co., All Beds											
	Deep	150-500'	23-24.99							0.05	0.05
		500-1000'	23-24.99			30.71	434.21	149.43	92.46	2,311.57	3,018.39
		>1000'	23-24.99				3.67	22.36	138.67	644.20	808.90
	Deep	Subtotal				30.71	437.88	171.79	231.13	2,955.82	3,827.34
Hamilton Co. Totals						30.71	437.88	171.79	231.13	2,955.82	3,827.34
Hancock County											
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							28.73	28.73
Hancock Co., All Beds											
	Surface	0-150'	20-22.99							28.73	28.73
	Surface	Subtotal								28.73	28.73
Hancock Co. Totals										28.73	28.73
Henry County											
Danville											
High Vol. C Bit.	Surface	0-150'	<19.99							22.34	22.34
			20-22.99							34.49	34.49
Herrin											
High Vol. C Bit.	Surface	0-150'	<19.99							99.64	99.64
			20-22.99							91.68	91.68

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							112.97	112.97
	Deep	150-500'	20-22.99							3.24	3.24
Henry Co., All Beds											
	Surface	0-150'	<19.99							121.98	121.98
			20-22.99							239.14	239.14
	Surface	Subtotal								361.12	361.12
	Deep	150-500'	20-22.99							3.24	3.24
	Deep	Subtotal								3.24	3.24
Henry Co. Totals										364.36	364.36
	Jackson County										
Herrin											
High Vol. B Bit.	Surface	0-150'	23-24.99					5.35	11.88	46.03	63.26
High Vol. C Bit.	Surface	0-150'	20-22.99				0.20	0.75	1.61	13.46	16.03
Springfield											
High Vol. B Bit.	Surface	0-150'	23-24.99							90.94	90.94
	Deep	150-500'	23-24.99							99.46	99.46
High Vol. C Bit.	Surface	0-150'	20-22.99							5.59	5.59
	Deep	150-500'	20-22.99							41.34	41.34
Seahorne											
High Vol. B Bit.	Surface	0-150'	23-24.99							12.55	12.55
Jackson Co., All Beds											
	Surface	0-150'	20-22.99				0.20	0.75	1.61	19.05	21.61
			23-24.99					5.35	11.88	149.52	166.75

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Surface	Subtotal					0.20	6.10	13.49	168.57	188.37
	Deep	150-500'	20-22.99							41.34	41.34
			23-24.99							99.46	99.46
	Deep	Subtotal								140.80	140.80
Jackson Co. Totals							0.20	6.10	13.49	309.37	329.16
	Jasper County										
Danville											
High Vol. B Bit.	Deep	500-1000'	23-24.99							73.58	73.58
		>1000'	23-24.99							906.33	906.33
High Vol. C Bit.	Deep	500-1000'	20-22.99							20.45	20.45
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							111.92	111.92
		>1000'	23-24.99							1,798.94	1,798.94
High Vol. C Bit.	Deep	500-1000'	20-22.99							32.38	32.38
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99							58.06	58.06
		>1000'	23-24.99							1,352.95	1,352.95
Jasper Co., All Beds											
	Deep	500-1000'	20-22.99							52.83	52.83
			23-24.99							243.55	243.55
		>1000'	23-24.99							4,058.23	4,058.23
	Deep	Subtotal								4,354.61	4,354.61
Jasper Co. Totals										4,354.61	4,354.61

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Jefferson County											
Opdyke											
High Vol. C Bit.	Surface	0-150'	20-22.99							17.62	17.62
Belle Rive											
High Vol. C Bit.	Surface	0-150'	20-22.99							4.21	4.21
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99		3.38	4.38	94.98	41.76	31.49	1,000.30	1,176.29
High Vol. C Bit.	Deep	150-500'	20-22.99							54.13	54.13
		500-1000'	20-22.99		7.24	0.72	1.40	2.06	1.26	367.76	380.44
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99							892.35	892.35
		>1000'	23-24.99							89.72	89.72
High Vol. C Bit.	Deep	500-1000'	20-22.99							241.02	241.02
Jefferson Co., All Beds											
	Surface	0-150'	20-22.99							21.83	21.83
	Surface	Subtotal								21.83	21.83
	Deep	150-500'	20-22.99							54.13	54.13
		500-1000'	20-22.99		7.24	0.72	1.40	2.06	1.26	608.78	621.46
			23-24.99		3.38	4.38	94.98	41.76	31.49	1,892.65	2,068.64
		>1000'	23-24.99							89.72	89.72
	Deep	Subtotal			10.62	5.10	96.38	43.82	32.75	2,645.28	2,833.95
Jefferson Co. Totals					10.62	5.10	96.38	43.82	32.75	2,667.11	2,855.78

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Jersey County											
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							52.83	52.83
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							77.47	77.47
	Deep	150-500'	20-22.99							109.84	109.84
Jersey Co., All Beds											
	Surface	0-150'	20-22.99							130.30	130.30
	Surface	Subtotal								130.30	130.30
	Deep	150-500'	20-22.99							109.84	109.84
	Deep	Subtotal								109.84	109.84
Jersey Co. Totals										240.14	240.14
Kankakee County											
Houchin Creek											
High Vol. C Bit.	Surface	0-150'	20-22.99							14.89	14.89
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99						9.73	2.13	11.86
	Deep	150-500'	20-22.99							27.10	27.10
Kankakee Co., All Beds											
	Surface	0-150'	20-22.99						9.73	17.02	26.75
	Surface	Subtotal							9.73	17.02	26.75

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Deep	150-500'	20-22.99							27.10	27.10
	Deep	Subtotal								27.10	27.10
Kankakee Co. Totals									9.73	44.13	53.86
	Knox County										
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							1.17	1.17
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							212.64	212.64
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							464.78	464.78
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99						159.45	361.21	520.66
Rock Island											
High Vol. C Bit.	Deep	150-500'	20-22.99							43.78	43.78
Knox Co., All Beds											
	Surface	0-150'	20-22.99						159.45	1,039.80	1,199.25
	Surface	Subtotal							159.45	1,039.80	1,199.25
	Deep	150-500'	20-22.99							43.78	43.78
	Deep	Subtotal								43.78	43.78
Knox Co. Totals									159.45	1,083.58	1,243.03

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
La Salle County											
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							37.47	37.47
	Deep	150-500'	20-22.99							370.84	370.84
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							134.46	134.46
	Deep	150-500'	20-22.99							128.28	128.28
Houchin Creek											
High Vol. C Bit.	Surface	0-150'	20-22.99							47.15	47.15
	Deep	150-500'	20-22.99							13.95	13.95
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99						0.58	258.27	258.85
	Deep	150-500'	20-22.99						97.10	629.64	726.75
		500-1000'	20-22.99						13.88	203.60	217.48
LaSalle Co., All Beds											
	Surface	0-150'	20-22.99						0.58	477.35	477.93
	Surface	Subtotal							0.58	477.35	477.93
	Deep	150-500'	20-22.99						97.10	1,142.72	1,239.82
		500-1000'	20-22.99						13.88	203.60	217.48
	Deep	Subtotal							110.99	1,346.31	1,457.30
LaSalle Co. Totals									111.57	1,823.66	1,935.24

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Lawrence County											
Danville											
High Vol. C Bit.	Deep	150-500'	20-22.99	0.01	223.44	141.01	55.59	7.85	0.75	17.93	446.58
		500-1000'	20-22.99				0.92	2.63	0.01	28.85	32.42
Jamestown											
High Vol. C Bit.	Deep	150-500'	20-22.99							410.94	410.94
		500-1000'	20-22.99							203.55	203.55
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							22.95	22.95
High Vol. C Bit.	Deep	150-500'	20-22.99					42.71	49.26	75.00	166.96
		500-1000'	20-22.99							117.13	117.13
Springfield											
High Vol. B Bit.	Deep	150-500'	23-24.99							276.26	276.26
		500-1000'	23-24.99							259.06	259.06
		>1000'	23-24.99							12.88	12.88
Survant											
High Vol. B Bit.	Deep	500-1000'	23-24.99							95.64	95.64
		>1000'	23-24.99							0.20	0.20
Seelyville											
High Vol. B Bit.	Deep	500-1000'	23-24.99							33.83	33.83
		>1000'	23-24.99							0.44	0.44
Lawrence Co., All Beds											
	Deep	150-500'	20-22.99	0.01	223.44	141.01	55.59	50.56	50.00	503.88	1,024.49
			23-24.99							276.26	276.26
		500-1000'	20-22.99				0.92	2.63	0.01	349.53	353.10
			23-24.99							411.48	411.48
		>1000'	23-24.99							13.53	13.53

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Deep	Subtotal		0.01	223.44	141.01	56.51	53.19	50.01	1,554.68	2,078.85
Lawrence Co. Totals				0.01	223.44	141.01	56.51	53.19	50.01	1,554.68	2,078.85
	Livingston County										
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							93.42	93.42
	Deep	150-500'	20-22.99							212.52	212.52
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							102.76	102.76
Houchin Creek											
High Vol. C Bit.	Surface	0-150'	20-22.99							124.09	124.09
	Deep	150-500'	20-22.99							17.22	17.22
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99						4.94	1.89	6.84
	Deep	150-500'	20-22.99						4.53	179.88	184.41
Livingston Co., All Beds											
	Surface	0-150'	20-22.99						4.94	322.17	327.11
	Surface	Subtotal							4.94	322.17	327.11
	Deep	150-500'	20-22.99						4.53	409.61	414.15
	Deep	Subtotal							4.53	409.61	414.15
Livingston Co. Totals									9.48	731.78	741.26

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Logan County											
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99							658.16	658.16
Springfield											
High Vol. C Bit.	Deep	150-500'	20-22.99							1,448.29	1,448.29
Logan Co., All Beds											
	Deep	150-500'	20-22.99							2,106.45	2,106.45
	Deep	Subtotal								2,106.45	2,106.45
Logan Co. Totals										2,106.45	2,106.45
McDonough County											
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							348.35	348.35
McDonough Co., All Beds											
	Surface	0-150'	20-22.99							348.35	348.35
	Surface	Subtotal								348.35	348.35
McDonough Co. Totals									348.35	348.35	
McLean County											
Danville											
High Vol. C Bit.	Deep	150-500'	20-22.99							188.13	188.13
		500-1000'	20-22.99							35.51	35.51

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Springfield											
High Vol. C Bit.	Deep	150-500'	20-22.99							43.14	43.14
		500-1000'	20-22.99							140.43	140.43
Colchester											
High Vol. C Bit.	Deep	500-1000'	20-22.99							84.60	84.60
McLean Co., All Beds											
	Deep	150-500'	20-22.99							231.27	231.27
		500-1000'	20-22.99							260.54	260.54
	Deep	Subtotal								491.81	491.81
McLean Co. Totals										491.81	491.81
	Macon County										
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99							88.95	88.95
Springfield											
High Vol. C Bit.	Deep	150-500'	20-22.99							320.47	320.47
		500-1000'	20-22.99							248.60	248.60
Macon Co., All Beds											
	Deep	150-500'	20-22.99							409.43	409.43
		500-1000'	20-22.99							248.60	248.60
	Deep	Subtotal								658.03	658.03
Macon Co. Totals										658.03	658.03

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Macoupin County											
Danville											
High Vol. C Bit.	Deep	150-500'	20-22.99							14.06	14.06
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							265.51	265.51
	Deep	150-500'	20-22.99			116.67	134.44	76.86	109.94	2,826.02	3,263.93
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							13.08	13.08
	Deep	150-500'	20-22.99							194.93	194.93
		500-1000'	20-22.99							77.91	77.91
Wiley											
High Vol. C Bit.	Deep	150-500'	20-22.99							0.13	0.13
		500-1000'	20-22.99							43.90	43.90
Litchfield											
High Vol. C Bit.	Deep	500-1000'	20-22.99							70.72	70.72
Macoupin Co., All Beds											
	Surface	0-150'	20-22.99							278.59	278.59
	Surface	Subtotal								278.59	278.59
	Deep	150-500'	20-22.99			116.67	134.44	76.86	109.94	3,035.15	3,473.06
		500-1000'	20-22.99							192.53	192.53
	Deep	Subtotal				116.67	134.44	76.86	109.94	3,227.67	3,665.58
Macoupin Co. Totals						116.67	134.44	76.86	109.94	3,506.26	3,944.17

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Madison County											
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							406.91	406.91
	Deep	150-500'	20-22.99			102.44	212.47	150.44	42.56	894.43	1,402.33
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							116.78	116.78
	Deep	150-500'	20-22.99							17.49	17.49
Madison Co., All Beds											
	Surface	0-150'	20-22.99							523.69	523.69
	Surface	Subtotal								523.69	523.69
	Deep	150-500'	20-22.99			102.44	212.47	150.44	42.56	911.93	1,419.83
	Deep	Subtotal				102.44	212.47	150.44	42.56	911.93	1,419.83
Madison Co. Totals						102.44	212.47	150.44	42.56	1,435.62	1,943.52
Marion County											
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							84.84	84.84
High Vol. C Bit.	Deep	500-1000'	20-22.99							222.44	222.44
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99							110.72	110.72
High Vol. C Bit.	Deep	500-1000'	20-22.99							136.58	136.58
Marion Co., All Beds											
	Deep	500-1000'	20-22.99							359.02	359.02
			23-24.99							195.56	195.56

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Deep	Subtotal								554.58	554.58
Marion Co. Totals										554.58	554.58
	Marshall County										
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							115.45	115.45
	Deep	150-500'	20-22.99							95.70	95.70
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99							7.12	7.12
Colchester											
High Vol. C Bit.	Deep	150-500'	20-22.99						15.00	163.27	178.28
		500-1000'	20-22.99						104.21	24.91	129.11
Marshall Co., All Beds											
	Surface	0-150'	20-22.99							115.45	115.45
	Surface	Subtotal								115.45	115.45
	Deep	150-500'	20-22.99						15.00	266.09	281.10
		500-1000'	20-22.99						104.21	24.91	129.11
	Deep	Subtotal							119.21	291.00	410.21
Marshall Co. Totals									119.21	406.45	525.66
	Menard County										
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							506.78	506.78
	Deep	150-500'	20-22.99							731.70	731.70

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Menard Co., All Beds											
	Surface	0-150'	20-22.99							506.78	506.78
	Surface	Subtotal								506.78	506.78
	Deep	150-500'	20-22.99							731.70	731.70
	Deep	Subtotal								731.70	731.70
Menard Co. Totals										1,238.49	1,238.49
	Mercer County										
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							4.13	4.13
Mercer Co., All Beds											
	Surface	0-150'	20-22.99							4.13	4.13
	Surface	Subtotal								4.13	4.13
Mercer Co. Totals										4.13	4.13
	Monroe County										
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							7.13	7.13
Monroe Co., All Beds											
	Surface	0-150'	20-22.99							7.13	7.13
	Surface	Subtotal								7.13	7.13
Monroe Co. Totals										7.13	7.13

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Montgomery County											
Danville											
High Vol. C Bit.	Deep	500-1000'	20-22.99							51.61	51.61
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99			87.73	34.10	69.00	50.32	1,926.52	2,167.68
		500-1000'	20-22.99							1,615.88	1,615.88
Houchin Creek											
High Vol. C Bit.	Deep	150-500'	20-22.99							97.01	97.01
Colchester											
High Vol. C Bit.	Deep	500-1000'	20-22.99							176.31	176.31
Wiley											
High Vol. C Bit.	Deep	500-1000'	20-22.99							78.09	78.09
Litchfield											
High Vol. C Bit.	Deep	500-1000'	20-22.99							183.15	183.15
Montgomery Co., All Beds											
	Deep	150-500'	20-22.99			87.73	34.10	69.00	50.32	2,023.54	2,264.69
		500-1000'	20-22.99							2,105.04	2,105.04
	Deep	Subtotal				87.73	34.10	69.00	50.32	4,128.57	4,369.73
Montgomery Co. Totals					87.73	34.10	69.00	50.32	4,128.57	4,369.73	

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Morgan County											
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							95.70	95.70
	Deep	150-500'	20-22.99							65.89	65.89
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							162.46	162.46
	Deep	150-500'	20-22.99							43.17	43.17
Morgan Co., All Beds											
	Surface	0-150'	20-22.99							258.15	258.15
	Surface	Subtotal								258.15	258.15
	Deep	150-500'	20-22.99							109.05	109.05
	Deep	Subtotal								109.05	109.05
Morgan Co. Totals										367.21	367.21
Moultrie County											
Herrin											
High Vol. C Bit.	Deep	500-1000'	20-22.99							261.91	261.91
Moultrie Co., All Beds											
	Deep	500-1000'	20-22.99							261.91	261.91
	Deep	Subtotal								261.91	261.91
Moultrie Co. Totals										261.91	261.91

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Peoria County											
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							233.82	233.82
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							852.76	852.76
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							585.56	585.56
	Deep	150-500'	20-22.99							395.62	395.62
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							49.41	49.41
	Deep	150-500'	20-22.99							46.28	46.28
Peoria Co., All Beds											
	Surface	0-150'	20-22.99							1,721.55	1,721.55
	Surface	Subtotal								1,721.55	1,721.55
	Deep	150-500'	20-22.99							441.89	441.89
	Deep	Subtotal								441.89	441.89
Peoria Co. Totals										2,163.44	2,163.44
Perry County											
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99				3.40	13.81	6.90	590.38	614.49
	Deep	150-500'	20-22.99				5.45	3.92	0.77	1,224.75	1,234.90
		500-1000'	20-22.99				1.61	6.80	3.57	16.84	28.82

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							88.66	88.66
	Deep	150-500'	20-22.99							98.64	98.64
		500-1000'	20-22.99							52.86	52.86
Murphysboro											
High Vol. C Bit.	Deep	150-500'	20-22.99							409.28	409.28
		500-1000'	20-22.99							233.46	233.46
Perry Co., All Beds											
	Surface	0-150'	20-22.99				3.40	13.81	6.90	679.04	703.15
	Surface	Subtotal					3.40	13.81	6.90	679.04	703.15
	Deep	150-500'	20-22.99				5.45	3.92	0.77	1,732.68	1,742.82
		500-1000'	20-22.99				1.61	6.80	3.57	303.17	315.14
	Deep	Subtotal					7.06	10.72	4.34	2,035.84	2,057.97
Perry Co. Totals							10.45	24.54	11.24	2,714.88	2,761.12
Pike County											
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							116.62	116.62
Pike Co., All Beds											
	Surface	0-150'	20-22.99							116.62	116.62
	Surface	Subtotal								116.62	116.62
Pike Co. Totals										116.62	116.62

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Putnam County										
Danville											
High Vol. C Bit.	Deep	150-500'	20-22.99							206.68	206.68
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99							77.85	77.85
Colchester											
High Vol. C Bit.	Deep	150-500'	20-22.99							347.23	347.23
		500-1000'	20-22.99							27.54	27.54
Putnam Co., All Beds											
	Deep	150-500'	20-22.99							631.75	631.75
		500-1000'	20-22.99							27.54	27.54
	Deep	Subtotal								659.30	659.30
Putnam Co. Totals										659.30	659.30
	Randolph County										
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							180.90	180.90
	Deep	150-500'	20-22.99							81.55	81.55
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							139.24	139.24
	Deep	150-500'	20-22.99							23.88	23.88
Randolph Co., All Beds											
	Surface	0-150'	20-22.99							320.14	320.14

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Surface	Subtotal								320.14	320.14
	Deep	150-500'	20-22.99							105.43	105.43
	Deep	Subtotal								105.43	105.43
Randolph Co. Totals										425.57	425.57
	Richland County										
Calhoun											
High Vol. C Bit.	Surface	0-150'	20-22.99							6.60	6.60
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							28.09	28.09
		>1000'	23-24.99							180.76	180.76
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99							0.28	0.28
		>1000'	23-24.99							177.62	177.62
Richland Co., All Beds											
	Surface	0-150'	20-22.99							6.60	6.60
	Surface	Subtotal								6.60	6.60
	Deep	500-1000'	23-24.99							28.37	28.37
		>1000'	23-24.99							358.38	358.38
	Deep	Subtotal								386.75	386.75
Richland Co. Totals										393.35	393.35

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
St.Clair County											
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99					0.25	13.87	1,077.35	1,091.48
	Deep	150-500'	20-22.99			25.73	93.52	104.62	160.19	789.45	1,173.51
St.Clair Co., All Beds											
	Surface	0-150'	20-22.99					0.25	13.87	1,077.35	1,091.48
	Surface	Subtotal						0.25	13.87	1,077.35	1,091.48
	Deep	150-500'	20-22.99			25.73	93.52	104.62	160.19	789.45	1,173.51
	Deep	Subtotal				25.73	93.52	104.62	160.19	789.45	1,173.51
St.Clair Co. Totals						25.73	93.52	104.87	174.07	1,866.80	2,264.99
Saline County											
Danville											
High Vol. B Bit.	Surface	0-150'	23-24.99							68.68	68.68
Herrin											
High Vol. A Bit.	Surface	0-150'	25-25.99							8.21	8.21
High Vol. B Bit.	Surface	0-150'	23-24.99							206.38	206.38
	Deep	150-500'	23-24.99							762.72	762.72
		500-1000'	23-24.99							240.90	240.90
Springfield											
High Vol. A Bit.	Surface	0-150'	25-25.99							34.22	34.22
	Deep	150-500'	25-25.99							1.41	1.41
High Vol. B Bit.	Surface	0-150'	23-24.99			1.36	0.97	4.17	15.19	33.44	55.12
	Deep	150-500'	23-24.99			49.28	50.89	72.43	51.39	149.41	373.41
		500-1000'	23-24.99			69.33	65.73	94.42	6.81	123.23	359.52

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Houchin Creek											
High Vol. B Bit.	Deep	150-500'	23-24.99							12.69	12.69
		500-1000'	23-24.99							1.94	1.94
DeKoven											
High Vol. A Bit.	Surface	0-150'	25-25.99							47.45	47.45
	Deep	150-500'	25-25.99							187.10	187.10
		500-1000'	25-25.99							6.83	6.83
High Vol. B Bit.	Deep	150-500'	23-24.99							31.21	31.21
		500-1000'	23-24.99							209.12	209.12
Davis											
High Vol. A Bit.	Surface	0-150'	25-25.99							70.91	70.91
	Deep	150-500'	25-25.99							257.52	257.52
		500-1000'	25-25.99							10.15	10.15
High Vol. B Bit.	Deep	150-500'	23-24.99							45.15	45.15
		500-1000'	23-24.99							401.13	401.13
Saline Co., All Beds											
	Surface	0-150'	23-24.99			1.36	0.97	4.17	15.19	308.49	330.18
			25-25.99							160.79	160.79
	Surface	Subtotal				1.36	0.97	4.17	15.19	469.29	490.97
	Deep	150-500'	23-24.99			49.28	50.89	72.43	51.39	1,001.19	1,225.18
			25-25.99							446.03	446.03
		500-1000'	23-24.99			69.33	65.73	94.42	6.81	976.32	1,212.61
			25-25.99							16.99	16.99
	Deep	Subtotal				118.61	116.63	166.85	58.20	2,440.53	2,900.82
Saline Co. Totals						119.97	117.59	171.01	73.39	2,909.82	3,391.79

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Sangamon County											
Herrin											
High Vol. C Bit.	Deep	150-500'	20-22.99							1,763.90	1,763.90
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							278.17	278.17
	Deep	150-500'	20-22.99							1,965.64	1,965.64
Houchin Creek											
High Vol. C Bit.	Deep	150-500'	20-22.99							85.27	85.27
Litchfield											
High Vol. C Bit.	Deep	500-1000'	20-22.99							4.19	4.19
Sangamon Co., All Beds											
	Surface	0-150'	20-22.99							278.17	278.17
	Surface	Subtotal								278.17	278.17
	Deep	150-500'	20-22.99							3,814.81	3,814.81
		500-1000'	20-22.99							4.19	4.19
	Deep	Subtotal								3,819.00	3,819.00
Sangamon Co. Totals										4,097.18	4,097.18
Schuyler County											
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							96.38	96.38
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							516.76	516.76

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Deep	150-500'	20-22.99							6.65	6.65
Schuyler Co., All Beds											
	Surface	0-150'	20-22.99							613.14	613.14
	Surface	Subtotal								613.14	613.14
	Deep	150-500'	20-22.99							6.65	6.65
	Deep	Subtotal								6.65	6.65
Schuyler Co. Totals										619.79	619.79
	Scott County										
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							5.99	5.99
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							169.96	169.96
Scott Co., All Beds											
	Surface	0-150'	20-22.99							175.94	175.94
	Surface	Subtotal								175.94	175.94
Scott Co. Totals										175.94	175.94
	Shelby County										
Trowbridge											
High Vol. C Bit.	Surface	0-150'	<19.99						8.56		8.56
Shelbyville											
High Vol. C Bit.	Surface	0-150'	20-22.99							43.26	43.26

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Danville											
High Vol. C Bit.	Deep	500-1000'	20-22.99							129.17	129.17
Herrin											
High Vol. C Bit.	Deep	500-1000'	20-22.99							1,702.13	1,702.13
Springfield											
High Vol. C Bit.	Deep	500-1000'	20-22.99							92.35	92.35
Shelby Co., All Beds											
	Surface	0-150'	<19.99						8.56		8.56
			20-22.99							43.26	43.26
	Surface	Subtotal							8.56	43.26	51.82
	Deep	500-1000'	20-22.99							1,923.65	1,923.65
	Deep	Subtotal								1,923.65	1,923.65
Shelby Co. Totals									8.56	1,966.91	1,975.47
	Stark County										
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							227.70	227.70
	Deep	150-500'	20-22.99							0.21	0.21
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							0.14	0.14
Stark Co., All Beds											
	Surface	0-150'	20-22.99							227.83	227.83
	Surface	Subtotal								227.83	227.83

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
	Deep	150-500'	20-22.99							0.21	0.21
	Deep	Subtotal								0.21	0.21
Stark Co. Totals										228.05	228.05
	Tazewell County										
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							4.59	4.59
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							63.12	63.12
	Deep	150-500'	20-22.99							54.26	54.26
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							29.67	29.67
	Deep	150-500'	20-22.99							199.87	199.87
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							12.66	12.66
	Deep	150-500'	20-22.99							33.20	33.20
Tazewell Co., All Beds											
	Surface	0-150'	20-22.99							110.03	110.03
	Surface	Subtotal								110.03	110.03
	Deep	150-500'	20-22.99							287.33	287.33
	Deep	Subtotal								287.33	287.33
Tazewell Co. Totals										397.36	397.36

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Vermilion County											
Danville											
High Vol. C Bit.	Surface	0-150'	20-22.99							375.84	375.84
	Deep	150-500'	20-22.99							1,465.71	1,465.71
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99					1.42	168.08	56.44	225.95
	Deep	150-500'	20-22.99				144.42	93.87	657.29	497.27	1,392.85
Seelyville											
High Vol. C Bit.	Deep	150-500'	20-22.99							29.37	29.37
Vermilion Co., All Beds											
	Surface	0-150'	20-22.99					1.42	168.08	432.28	601.79
	Surface	Subtotal						1.42	168.08	432.28	601.79
	Deep	150-500'	20-22.99				144.42	93.87	657.29	1,992.35	2,887.93
	Deep	Subtotal					144.42	93.87	657.29	1,992.35	2,887.93
Vermilion Co. Totals							144.42	95.30	825.38	2,424.63	3,489.72
Wabash County											
Friendsville											
High Vol. C Bit.	Surface	0-150'	20-22.99							48.56	48.56
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							418.11	418.11
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99				103.80	165.76	16.31	167.53	453.40

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Wabash Co., All Beds											
	Surface	0-150'	20-22.99							48.56	48.56
	Surface	Subtotal								48.56	48.56
	Deep	500-1000'	23-24.99				103.80	165.76	16.31	585.63	871.51
	Deep	Subtotal					103.80	165.76	16.31	585.63	871.51
Wabash Co. Totals							103.80	165.76	16.31	634.19	920.06
	Warren County										
Springfield											
High Vol. C Bit.	Surface	0-150'	20-22.99							0.79	0.79
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99							176.86	176.86
Warren Co., All Beds											
	Surface	0-150'	20-22.99							177.65	177.65
	Surface	Subtotal								177.65	177.65
Warren Co. Totals										177.65	177.65
	Washington County										
Herrin											
High Vol. C Bit.	Surface	0-150'	20-22.99							9.26	9.26
	Deep	150-500'	20-22.99							3,288.45	3,288.45
		500-1000'	20-22.99							384.01	384.01

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Washington Co., All Beds											
	Surface	0-150'	20-22.99							9.26	9.26
	Surface	Subtotal								9.26	9.26
	Deep	150-500'	20-22.99							3,288.45	3,288.45
		500-1000'	20-22.99							384.01	384.01
	Deep	Subtotal								3,672.46	3,672.46
Washington Co. Totals									3,681.72	3,681.72	
	Wayne County										
Herrin											
High Vol. B Bit.	Deep	500-1000'	23-24.99							183.71	183.71
		>1000'	23-24.99							18.21	18.21
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99						51.94	5.78	57.71
		>1000'	23-24.99						105.12	90.98	196.10
Wayne Co., All Beds											
	Deep	500-1000'	23-24.99						51.94	189.49	241.43
		>1000'	23-24.99						105.12	109.19	214.31
	Deep	Subtotal							157.05	298.68	455.73
Wayne Co. Totals									157.05	298.68	455.73

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
White County											
Herrin											
High Vol. B Bit.	Deep	150-500'	23-24.99							32.69	32.69
		500-1000'	23-24.99							1,597.15	1,597.15
		>1000'	23-24.99							0.70	0.70
Springfield											
High Vol. B Bit.	Deep	500-1000'	23-24.99					0.77	79.02	749.46	829.24
		>1000'	23-24.99						359.10	206.98	566.08
DeKoven											
High Vol. B Bit.	Deep	500-1000'	23-24.99							0.67	0.67
		>1000'	23-24.99							2.54	2.54
White Co., All Beds											
	Deep	150-500'	23-24.99							32.69	32.69
		500-1000'	23-24.99					0.77	79.02	2,347.28	2,427.06
		>1000'	23-24.99						359.10	210.22	569.32
	Deep	Subtotal						0.77	438.12	2,590.18	3,029.08
White Co. Totals								0.77	438.12	2,590.18	3,029.08
Will County											
Colchester											
High Vol. C Bit.	Surface	0-150'	20-22.99						13.64	0.22	13.86
Will Co., All Beds											
	Surface	0-150'	20-22.99						13.64	0.22	13.86
	Surface	Subtotal							13.64	0.22	13.86
Will Co. Totals									13.64	0.22	13.86

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Williamson County											
Danville											
High Vol. B Bit.	Surface	0-150'	23-24.99							55.83	55.83
Herrin											
High Vol. B Bit.	Surface	0-150'	23-24.99				25.45	10.61	25.74	173.26	235.07
	Deep	150-500'	23-24.99				0.29	4.10	12.17	264.61	281.17
		500-1000'	23-24.99							44.94	44.94
Springfield											
High Vol. B Bit.	Surface	0-150'	23-24.99						10.01	174.00	184.01
	Deep	150-500'	23-24.99					4.72	166.87	436.94	608.52
		500-1000'	23-24.99					6.38	84.23	5.34	95.95
Houchin Creek											
High Vol. B Bit.	Deep	150-500'	>25.99							3.47	3.47
DeKoven											
High Vol. A Bit.	Surface	0-150'	25-25.99							21.87	21.87
	Deep	150-500'	25-25.99							59.33	59.33
High Vol. B Bit.	Deep	150-500'	23-24.99							88.91	88.91
		500-1000'	23-24.99							63.70	63.70
Davis											
High Vol. A Bit.	Surface	0-150'	25-25.99							36.23	36.23
	Deep	150-500'	25-25.99							4.66	4.66
High Vol. B Bit.	Deep	150-500'	23-24.99							30.19	30.19
		500-1000'	23-24.99							39.64	39.64
Wise Ridge											
High Vol. B Bit.	Deep	150-500'	23-24.99							4.64	4.64
Mt. Rorah											
High Vol. B Bit.	Deep	150-500'	23-24.99							4.30	4.30

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed / Coal rank/type of mining		Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Murphysboro											
High Vol. A Bit.	Surface	0-150'	25-25.99							31.59	31.59
High Vol. B Bit.	Surface	0-150'	23-24.99							8.71	8.71
Williamson Co., All Beds											
	Surface	0-150'	23-24.99				25.45	10.61	35.75	411.80	483.61
			25-25.99							89.70	89.70
	Surface	Subtotal					25.45	10.61	35.75	501.50	573.31
	Deep	150-500'	23-24.99				0.29	8.82	179.04	829.58	1,017.73
			25-25.99							63.98	63.98
			>25.99							3.47	3.47
		500-1000'	23-24.99					6.38	84.23	153.62	244.23
	Deep	Subtotal					0.29	15.20	263.27	1,050.66	1,329.42
Williamson Co. Totals							25.74	25.81	299.02	1,552.16	1,902.73
Woodford County											
Danville											
High Vol. C Bit.	Deep	150-500'	20-22.99							30.04	30.04
Springfield											
High Vol. C Bit.	Deep	150-500'	20-22.99							45.72	45.72
Colchester											
High Vol. C Bit.	Deep	150-500'	20-22.99						0.47	63.38	63.85
		500-1000'	20-22.99						33.67	46.27	79.94
Woodford Co., All Beds											
	Deep	150-500'	20-22.99						0.47	139.14	139.61
		500-1000'	20-22.99						33.67	46.27	79.94

Appendix 4 Remaining demonstrated reserve base in Illinois, January 1, 1996 (million short tons)

Coal bed Coal rank/type of mining	Depth (ft)	Heat content (million Btu/ short ton)	Sulfur content (lbs sulfur/million Btu) ≤0.40	0.41–0.06	0.61–0.83	0.84–1.24	1.25–1.67	1.68–2.50	>2.50	Total all sulfur categories
Deep	Subtotal							34.14	185.41	219.55
Woodford Co. Totals								34.14	185.41	219.55

APPENDIX 5 Formats of digital files of demonstrated reserves provided to the Energy Information Administration

The EIA will be provided with three digital files, all with the same format and a fixed record length of 123 characters. The three files are (1) identified resources and demonstrated reserves, (2) accessible reserves, and (3) recoverable reserves. Data will be aggregated to the county level by seam. For each seam in a county, there will be one or more records, depending upon the different combinations of reliability, thickness, depth, Btu, and rank. The layout of each record is described below.

15 items: starting in position 1

Col	Item name	Width	Type	N. Dec	Explanation
1	COUNTY	3	I	–	County FIPS code
4	SEAM	4	I	–	ISGS seam code
8	RELIABILITY	1	I	–	ISGS reliability classification
9	THICK	3	I	–	Thickness in inches
12	DEPTH	4	I	–	Depth category
16	BTU	5	N	2	Btu category
21	RANK	1	C	–	Rank (A, B, or C)
22	S.40	10	I	–	Tonnage, lbs S <0.40/million Btu
32	S.60	10	I	–	Tonnage, lbs S 0.41–0.60/million Btu
42	S.83	10	I	–	Tonnage, lbs S 0.61–0.83/million Btu
52	S1.24	10	I	–	Tonnage, lbs S 0.83–1.24/million Btu
62	S1.67	10	I	–	Tonnage, lbs S 1.24–1.67/million Btu
72	S2.5	10	I	–	Tonnage, lbs S 1.67–2.5/million Btu
82	S2.5+	10	I	–	Tonnage, lbs S >2.5/million Btu
92	ALL-SUL	10	I	–	Tonnage, all sulfur categories
102	AVE-RATIO	4	N	1	Average stripping ratio
106	MAX-RATIO	4	N	1	Maximum stripping ratio
110	MIN-THICK	3	I	–	Minimum thickness in inches
113	MAX-THICK	3	I	–	Maximum thickness in inches
116	MIN-DEPTH	4	I	–	Minimum depth in feet
120	MAX-DEPTH	4	I	–	Maximum depth in feet

ISGS seam codes	
1670	Trowbridge
1750	Calhoun
1760	Shelbyville
1780	Opdyke
1790	Loudon
1800	Belle Rive
1910	Bristol Hill
2490	Danville
2610	Jamestown
2660	Herrin
2790	Springfield
2840	Houchin Creek
2940	Survant
3020	Colchester
3030	Mt. Rorah
3170	Seelyville
3210	Dekoven
3240	Wiley
3250	Davis
3370	Murphysboro
3490	Rock Island
3500	Litchfield
3510	Assumption

Item types	
I	= integer
N	= decimal
C	= character

Reliability codes	
3	= measured
1	= indicated
2	= inferred

Average depth categories (ft)	
50	= 0 to 50
100	= 50 to 100
150	= 100 to 150
200	= 150 to 200
250	= 200 to 300
350	= 300 to 400
450	= 400 to 500
	... etc.

Btu categories (million Btu/ton)	
19.00	= 15 – 19.99
21.50	= 20 – 22.99
24.00	= 23 – 24.99
25.50	= 25 – 25.99

APPENDIX 6 Procedures for revising estimates of coal resources

The ISGS maps and database on coal resources and reserves in Illinois have been organized by county and seam. For counties for which significant new data were available, resource estimates were also revised on a seam and county basis.

The ISGS has typically mapped coal resources at a scale of 1:62,500. In most cases, this scale is well suited for the amount of data available (generally only a few points per square mile) and the variability in seam thickness. (The thickness of major Illinois coals is consistent over wide areas.) The areas revised for this project were gridded using a 1,000-foot spacing (see discussion under section on contouring) and contoured at a scale of 1:24,000.

Computer databases and mapping software are used extensively in the mapping process, particularly for representing data, merging layers of information, and tabulating tonnages. Computers have not replaced the requirement for geologic expertise and careful work in compiling and interpreting resource data. This appendix outlines the procedures used to revise coal resources for this study. In practice, the process is not routine; its success depends upon the geologist's ability to recognize miscorrelations between seams, to identify and reject imprecise or spurious drilling records, and to distinguish between genuine geologic trends and localized anomalies.

Revising resource estimates proceeds in three basic steps: (1) selecting the data, (2) contouring the thickness and depth, and (3) merging the contours with other data layers and calculating volumes.

Selection of Data

The ISGS maintains paper files and a computer database of stratigraphic records from boreholes, outcrops, and mine exposures. The measurements and lithologies were recorded by coal companies or observed by ISGS geologists. Approximately half the records are proprietary and can only be used by ISGS staff as long as specific point locations and thickness measurements are not disclosed.

All stratigraphic correlations in the computer database have been made by ISGS staff. Although the computer database is not complete for all counties in the state, it was completed for the counties updated for this project.

Data selection begins by extracting from the database all points in and within approximately 4 miles of the county to be revised. The points outside the county boundary are used so that contours extending to the edge of the county will match with contours in the next county. If several adjacent counties are to be revised, the points for all of the counties are extracted together.

The data points extracted for each seam are plotted on base maps and compared with the previous base map used to plot the resources for that seam. Any points on the previous map missing from the new map are added to the database. The geologist must examine the extracted points to determine which are suitable for representing the seam isopach (thickness contour), and what the correct thickness of clean, minable coal is at each location.

Records from coal test holes, mines, and some engineering borings are generally categorized, in ISGS terminology, as class I points. Class I points are suitable for classifying deposits of coal as demonstrated reserves. Records from water wells and oil test holes are class II points, which provide useful information for areas otherwise devoid of data; they not sufficiently reliable for classifying deposits of coal as demonstrated reserves. In the Geographic Information system (GIS), buffer zones 2 miles in diameter are created around each class I point. Class II points are used for resource mapping only outside this buffer because thickness measurements from water wells and oil test holes are less accurate than those from coal test holes and mines. We have found that class II points reduce the accuracy of contouring areas for which class I data are ample.

The clean, minable thickness of the coal at each location is used to construct the seam isopach. Partings of shale and other rock materials within the seam are excluded from the contoured

thickness (Wood et al. 1983). If thick rock partings divide the seam into two or more benches, only the thicknesses of the bench(es) most likely to be mined are included in the contoured thickness. If the thickness and distribution of partings is so great that the coal is unlikely to be mined, that area of the seam is excluded from reserve calculations.

All the resources revised for this study were at depths that require underground mining. As a general rule in Illinois mines, 1 foot of parting material is the maximum considered feasible to mine for any extended area. Thinner partings are mined to recover separate benches of coal, if the tonnage of the clean coal recovered exceeds the tonnage of the parting material that must be handled (fig. A6-1a, Nokomis Coal no. 1). In this example, the resource would be mapped as the total thickness of coal (excluding the partings).

The log for the test hole, Christian County no. 857 (fig. A6-1b), shows a 9.5-foot seam that contains a 1-foot parting at 1.5 feet above the base of the seam. In this example, the parting and lower bench of coal are not likely to be mined because the tonnage recovered from the lower bench of coal would be less than the tonnage of the parting. (Parting material has a specific gravity of around 2.6; bituminous coal has a specific gravity of about 1.3.) The lower bench of coal would be minable if the parting were less than 0.8 feet thick. In this example, the resource would be mapped as 7 feet thick.

Only the upper two benches of coal, represented in the log for Christian County no. 2196 (fig. A6-1c), would be mined. The lower bench of coal would be left because the shale parting is too thick for mining; thus the mapped thickness of resources would be 5 feet. Figure A6-1d (Montgomery County no. 741) shows the entire seam to be unminable; the partings are too thick to mine, and none of the benches of coal is thick enough to mine alone. The area represented by this log would be excluded from resource calculations.

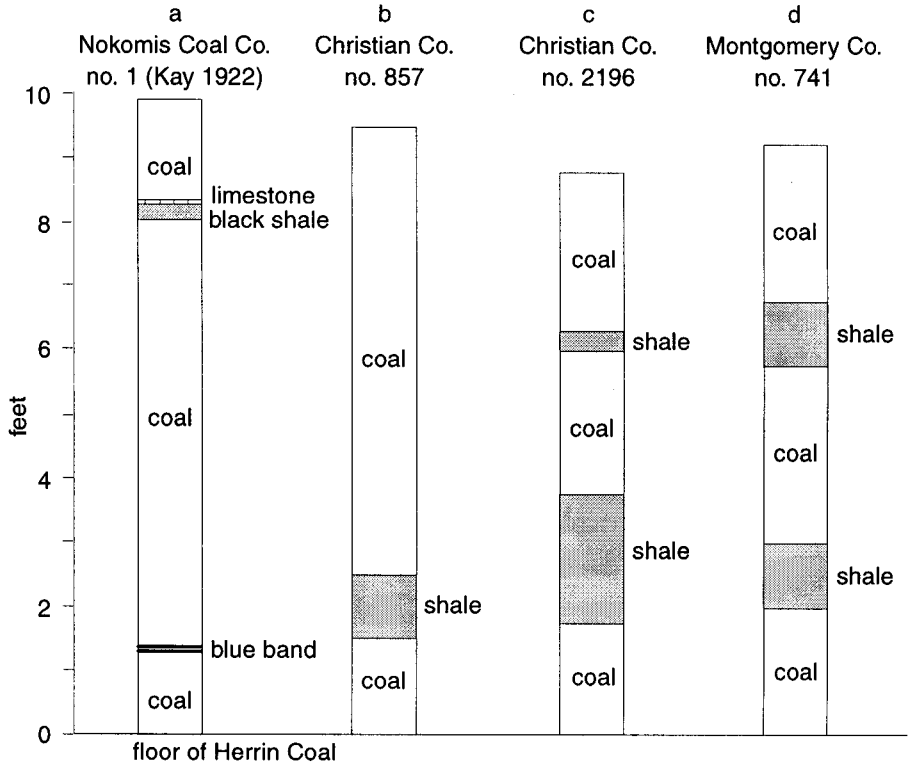

Figure A6-1 Examples of partings observed in mines or logs in the vicinity of the Nokomis Quadrangle (from Treworgy et al. 1996).

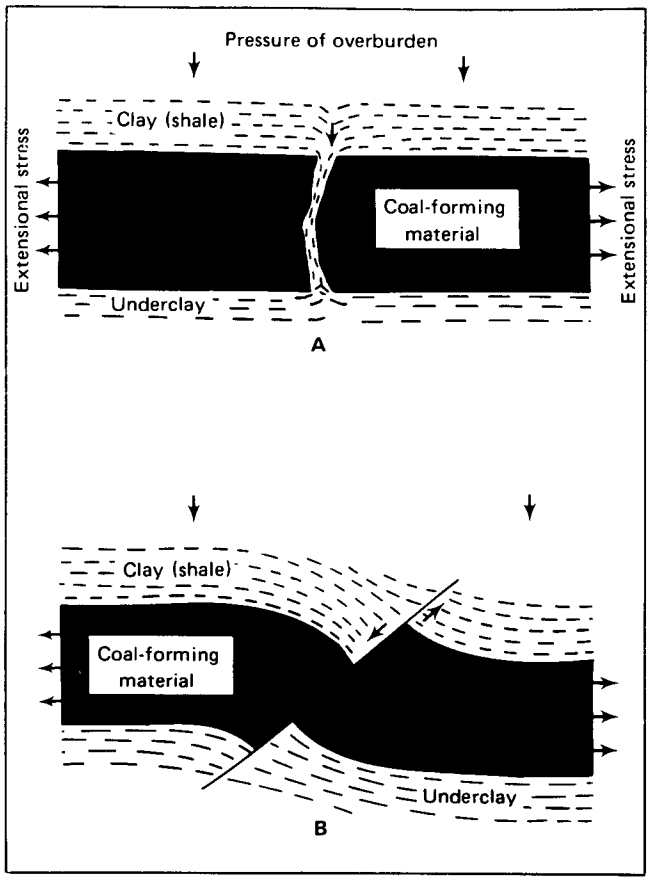

Figure A6-2 Examples of clay dikes and clay-dike faults (from Nelson, 1981).

Many drilling records report only total seam thickness and give no information on partings. Thin partings of noncoal material (<0.5 inches thick) are common in Illinois coals; however, the percentage of unreported noncoal material is believed to be an insignificant source of error in estimating coal resources.

Contouring of Data

The thickness, depth, and elevation contours for each seam are created from the selected data points by using a commercial software package for contouring (Earthvision version 3.0, Dynamic Graphics Inc., Alameda, California). This package operates like most contouring software in that a regularly spaced grid of nodes is superimposed on the data set, and an arithmetic function is used to extrapolate the values to be contoured from the data points to the surrounding nodes (Robinson 1982). As a final step, the software contours the area on the basis of the extrapolated values at the uniformly spaced nodes.

The results of this process vary depending upon the distance between grid nodes and the function used to extrapolate the data values to the grid. These parameters, specified by the geologist, depend upon the number and distribution of data points as well as the variability of the value being contoured. Too small a grid creates spurious detail, and too large a grid overgeneralizes the data. We experimented until we found settings that contoured our typical sets the way a geologist would have manually contoured the data. For our software, this setting was 2-D minimum tension gridding with normal tension, 1,000-foot grid spacing, and a multiple data point gridding level of four points. Thickness maps were contoured with a 0.5-foot interval at a resolution of 1:24,000. Depth maps were contoured with a 25-foot interval.

The initial set of maps must be carefully reviewed to distinguish between genuine geologic anomalies resulting from features such as faults, channels, and clay dikes, and data errors such as miscorrelations, data entry errors, and mislocation of data points. Data points indicating anomalous thickness or depth must be verified as genuine, or they are corrected or deleted. The geologist must decide whether to let the software contour geologic anomalies or to remove the data points so that these features may be contoured by hand later. Several iterations of mapping, reviewing, and modifying data may be required before a suitable set of maps is obtained.

Whether geologic anomalies are included in the resource estimate depends upon two decisions made by the geologist: (1) Are anomolies real or due to errors in the data? (2) If an anomalous feature is real and present, should it be represented on the map; that is, can it be reasonably represented at the scale of mapping? For example, abrupt thinning of a coal may indicate a local condition such as a clay dike or small fault that affects only the coal within a few feet of specific data points (fig. A6-2). These features cannot be accurately contoured at the scale of a regional resource assessment, and the affected data points should not be used by the computer in contouring

coal thickness. Data points that penetrate normal or reverse faults are also excluded from regional resource maps; displacement from such faults in Illinois typically affects an area that is less than 100 feet wide and can only be delineated by numerous, closely spaced holes (fig. A6-3).

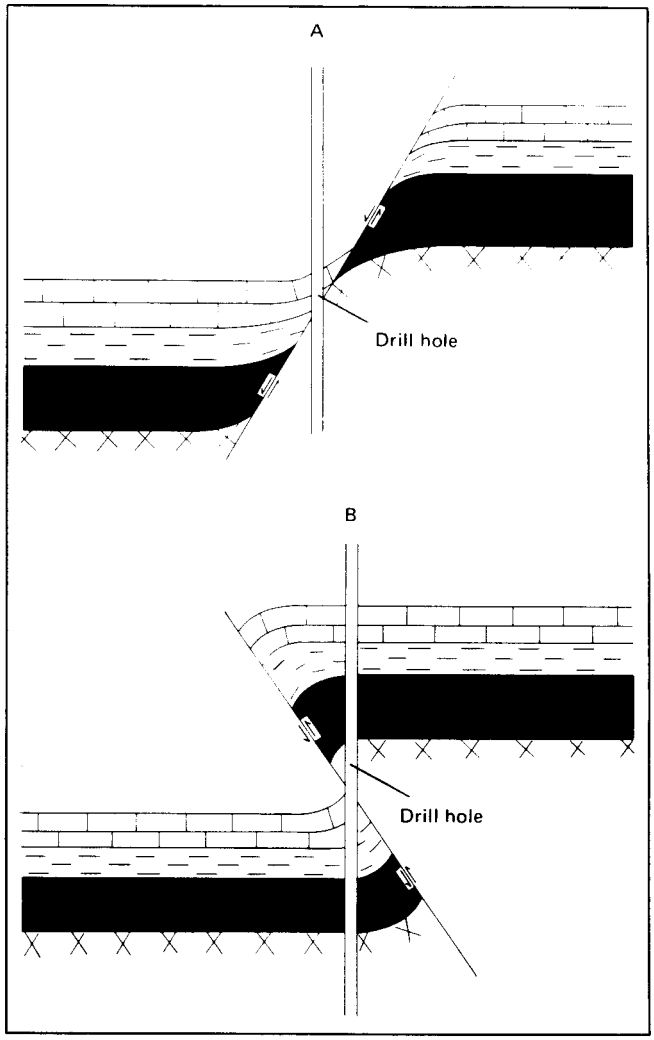

Figure A6-3 Displacement of coal by faults (from Nelson 1981).

Data points that encounter post-peat-swamp stream channels that eroded through the coal must also be excluded from the computer processing. In most cases, there are not enough points for the computer software to delineate the complete path of the channel. Because these channels eroded the coal after it was deposited, they did not influence the development of the peat swamp and the resulting trends in coal thickness. The geologist should first allow the computer to contour the coal thickness based on the trends derived from nonchannel points. In a later step, the geologist can manually superimpose his interpretation of the channel course on the final map.

Data points penetrating channel systems that formed contemporaneously with the peat may be included in the contouring, at the discretion of the geologist. Thickness patterns of coal deposits adjacent to peat-contemporaneous channels are often complex. In some areas, the coal thins toward the channel in a regular pattern. In other areas, the coal thickens significantly, then abruptly splits into multiple thin benches. The geologist must assess each area and judge whether the software has adequately contoured the data.

Merging of Data Layers and Calculating Volumes

In the final stage of processing, the computer-generated contour maps are converted from the grid format of the contouring software to another format used by GIS software. The GIS creates reliability zones for measured, indicated, and inferred resources. Within the GIS, maps of seam thickness, depth, and reliability are merged with maps of mined areas, rank, sulfur, and heat content. Tonnages are calculated from the merged layers and stored in the database of resource and reserve data on all seams.

APPENDIX 7 Formulas for calculating sulfur, heat content, rank, and stripping ratio

Results of coal analyses stored in the ISGS database are calculated on a dry basis. Standard formulas were used to convert to the units required for the Demonstrated Reserve Base (ASTM 1990, Wood 1983).

Sulfur

ISGS data were converted from percent sulfur to pounds of sulfur per million Btu. The basis of the Btu and total sulfur values does not matter, as long as it is the same for both (e.g, dry basis).

$$\text{Pounds sulfur/million Btu} = (10{,}000 \times \text{total sulfur}) / \text{Btu per pound}$$

Heat content

ISGS data were converted from Btu per pound (dry basis) to million Btu per ton (as-received basis).

$$\text{Million Btu/ton}_{\text{as received}} = ((100 - \text{moisture}) / 100) \times (\text{Btu per pound}_{\text{dry}} / 500)$$

Rank

Rank was determined by ASTM's classification (D388), which uses Btu/lb on a moist, mineral-matter-free basis (mmmf). All Illinois coals are high volatile bituminous. Coals above 14,000 Btu/lb (mmmf) are high volatile A bituminous; 13,000 to 14,000 are B; and less than 13,000 are C. Btu/lb data in the ISGS database are stored on a dry basis and were converted to a moist, mineral-matter-free basis, by using the following equation.

$$\text{Btu/lb}_{\text{mmmf}} = \frac{((\text{Btu/lb}_{\text{dry}} - (50 \times \text{total sulfur}_{\text{dry}})) \times (100 - \text{moisture})}{100 - ((100 - \text{moisture})/100) \times ((1.08 \times \text{ash}_{\text{dry}}) + (0.55 \times \text{total sulfur}_{\text{dry}}))}$$

Stripping ratio

The stripping ratio is expressed in cubic yards per ton and represents the amount of overburden material that must be moved to uncover a ton of coal. The calculation in this report is based on raw coal, exclusive of partings with no allowance made for additional losses in handling and cleaning.

$$\text{Cubic yards/ton} = \frac{(\text{thickness of overburden (ft)} \times \text{acres} \times 43{,}560\text{sq ft/acre}) / 27\text{sq ft/cu yd}}{\text{thickness of coal (ft)} \times \text{acres} \times 1{,}800\text{ tons/acre}}$$

This equation simplifies to

$$\text{Cubic yards/ton} = \frac{\text{thickness of overburden (ft)} \times 0.896296\text{ cu yd/ton}}{\text{thickness of coal (ft)}}$$