Resource Series 38

Availability of Coal Resources in Colorado: Somerset Coal Field, West-Central Colorado

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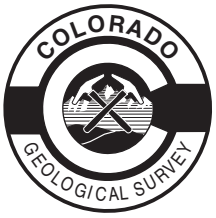

Colorado Geological Survey
Division of Minerals and Geology
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Foreword

The purpose of Colorado Geological Survey Resource Series 38 is to describe the amount of coal that is actually available for mining in the Somerset Coal Field of Gunnison and Delta Counties, Colorado. The staff of the Mineral Resources and Geological Mapping Section of the Colorado Geological Survey and DST & Associates, a consulting firm, performed the work from September 1998 to September 1999. The objective of this publication is to provide geological information to resource developers, government planners, and interested citizens.

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AGENCIES

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USGS—Mark Kirschbaum, Laura Roberts, and Bob Hettinger supplied information to support the project, including stratigraphic data. Laura Biewick provided GIS support.

MINES

Bowie No. 1 and No. 2 Mines-William Bear, Jr. (Bill) and Basil Bear; Jim Stover, their consultant, provided information on constraints to mining. Dan Bear provided stratigraphic data in the vicinity of the Bear Mine.

Sanborn Creek Mine (Oxbow Carbon and Minerals, Inc.)—Walt Wright, Mine Manager, and Tom Anderson, Environmental Manager, provided information on constraints to mining and a mine tour.

West Elk Mine (Mountain Coal Company)—Wendell Koontz, Geologist, and Jason Layton, Mining Engineer, provided information on constraints to mining and a mine tour. Mr. Koontz also provided drill hole data.

The format of these Coal Availability reports were used as guidance:

- Indiana Geological Survey Open-File Report 95-2, (Center Point Quadrangle), 1995
- Kentucky Geological Survey Information Circular 47 (Salyersville South Quadrangle), 1994
- Illinois State Geological Survey Minerals 114 (Mt. Carmel Quadrangle), 1996
- U.S. Geological Survey Open-File Report 97-469 (Hilight Quadrangle, WY), 1997
- Colorado Geological Survey Resource Series 36 (Somerset Quadrangle, CO), 1998

CONTENTS

FIGURES

TABLES

APPENDIX A (Tables)

Abstract

The Colorado Geological Survey, in cooperation with the U.S. Geological Survey Energy Resources Team Coal Availability/Recoverability Studies Cooperative Agreement, has concluded a study to determine of the amount of available coal in the five quadrangles which comprise the active and historical Somerset Coal Field in west-central Colorado. Available coal is defined as the quantity of the total coal resource that is accessible for mine development under current regulatory, land-use, and technologic constraints. This coal availability study evaluated only the Lower B, B, Lower D and D beds with the B and D beds being the primary producers. Based on this study approximately 5.1 billion tons of coal are available for development in the four seams evaluated, or 87 percent of the original 5.8 billions tons of in-place coal. As of January 1999, approximately 750 million tons of coal have either been mined out, lost in mining, or is unavailable due to technologic restrictions. All tonnage measurements in this report are in short tons.

Restrictions to coal development in the Somerset Coal Field include railroads, highways, rivers and lakes, cemeteries, towns, critical habitat for threatened and endangered species, and alluvial valley floors. While some of these factors could be mitigated so that coal mining could proceed, others could not be mitigated, and would prevent mining in that area. Technologic constraints that affect the availability of coal include mined-out areas, overburden thickness greater than 2,000 ft, thin interburden, and thin coal beds.

Background and Purpose of Study

Land-use, environmental, regulatory, technologic, and economic restrictions to coal resource recoverability have not been included in traditional Federal coal resource estimates. Many planners have thus overestimated the nation's future coal supply. In 1986, a pilot study was undertaken by the Kentucky Geological Survey and the U.S. Geological Survey (USGS) to develop and test a methodology for determining the quantity of coal resources available for mining under current mining conditions (Carter and Gardner, 1989; Eggleston and others, 1990). The concern for identifying the restrictions affecting coal mining has resulted in a collaborative program between the USGS and state geological surveys. The data generated from the coal availability studies is used by the USGS in their coal recoverability and assessments projects. In the recoverability studies, recovery and cost factors are applied to the estimated coal resources, resulting in estimates of economically recoverable coal that are usually far less than the amount available for development (Rohrbacher and others, 1994; Molnia and others, 1997).

The first coal availability studies were conducted in the Appalachian region of the eastern United States. The studies expanded into the Illinois Basin and more recently into the western United States in the Powder River Basin of Wyoming and Montana, the San Juan Basin of New Mexico, and the Wasatch Plateau of Utah. In 1998 the Colorado Geological Survey completed the first coal availability study in Colorado on the Somerset quadrangle (Eakins 1998a). This current study is an expansion from one to five quadrangles including the Somerset quadrangle and the surrounding areas that make up the entire Somerset Coal Field.

The effect of land-use and technologic factors on the availability of the remaining coal in Colorado's Coal Fields is not well known. Therefore, this study was designed to take into account the significant considerations and restrictions before calculating the amount of remaining coal that is actually available for development.

Location and Physiographic Setting

The Somerset Coal Field, located in west-central Colorado, is in the southeastern part of the Uinta Coal Region's Piceance Creek Basin in Gunnison and Delta Counties. The coal field is located in most of the Somerset, Bowie, and Paonia Reservoir quadrangles and the northern portions of the Minnesota Pass and West Beckwith Peak quadrangles. The town of Somerset is the only population center within the coal field. Colorado Highway 133 between the towns of Redstone and Paonia, bisects the coal field generally in an east-west direction. (Figure 1).

The North Fork of the Gunnison River forms at the junction of Coal Creek, Anthracite Creek and Muddy Creek at the Paonia Reservoir Dam and roughly delineates the eastern extent of the Somerset Coal Field. The steep narrow canyon of the North Fork of the Gunnison River separates the mesas in the southern part of the coal field from those in the northern part of the coal field. Tributaries of the North Fork have dissected these mesas.

Elevations within the coal field range from about 5,900 to 9,836 ft. (1,798 to 2,998 m) above sea level. The lowest elevation is along the North Fork at the western boundary of the Bowie quadrangle northeast of Paonia, while the highest elevation, Mt. Gunnison, at 12,719 ft. (3,877 m), defines the southern boundary of the coal field (Figure 2).

Surface land use in the Somerset Coal Field includes surface facilities for two relatively large operating underground mines, the town of Somerset, and dwellings along the North Fork valley. A rail line from the west, terminating near Somerset, parallels the river and highway providing access to the coal facilities. Fruit orchards are located on the alluvial terraces approximately 100–400 feet above the current valley floor, but below the coal outcrop in the Bowie quadrangle northeast of Paonia. Coal mining is the primary industry in the area with logging, ranching, and agriculture as secondary industries.

Over 50 percent the coal field is within the Gunnison National Forest. The U.S. Bureau of Land Management administers a large part of the remainder.

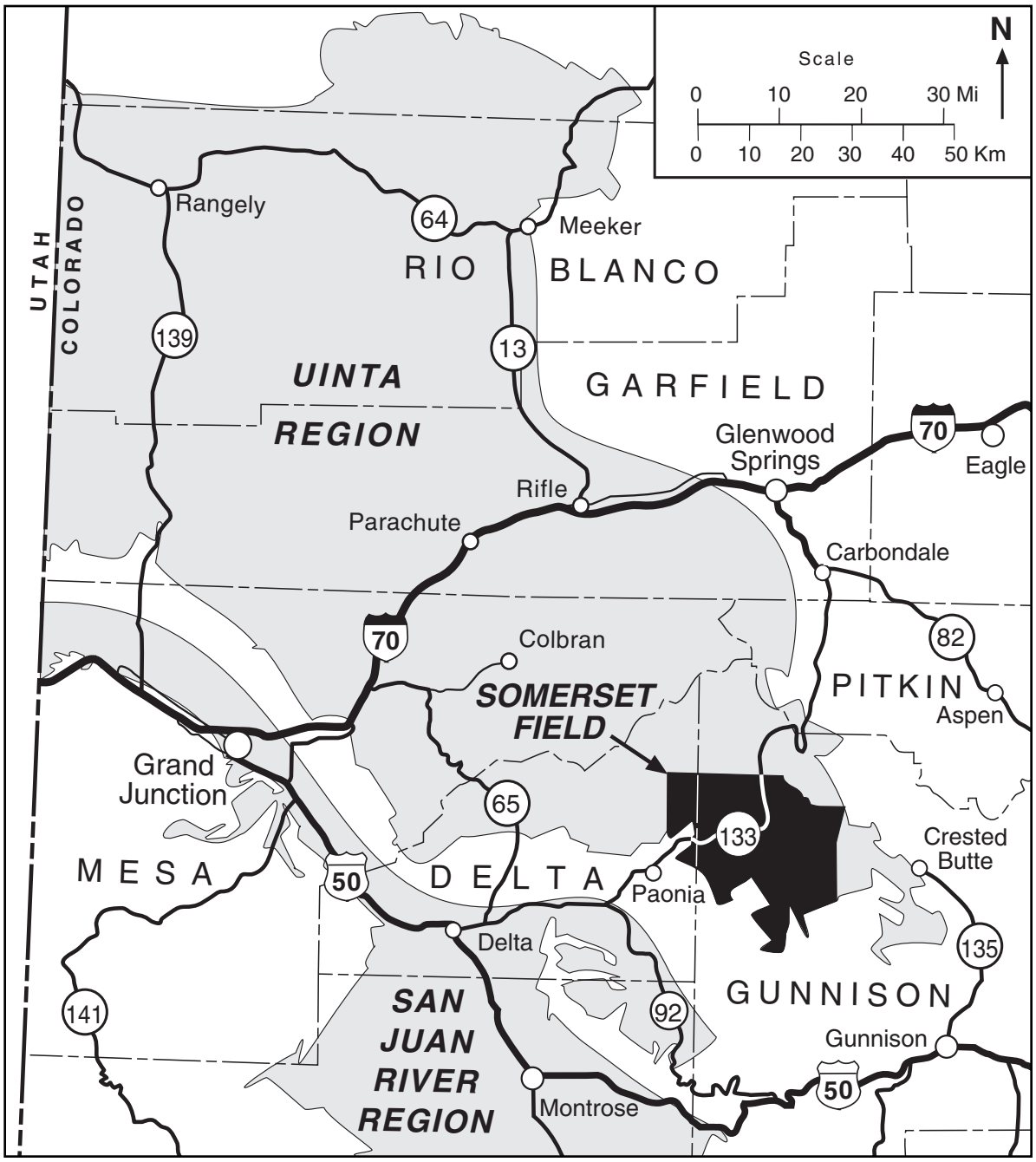


Figure 1. Map showing location of the Somerset Coal Field in the Uinta Region.

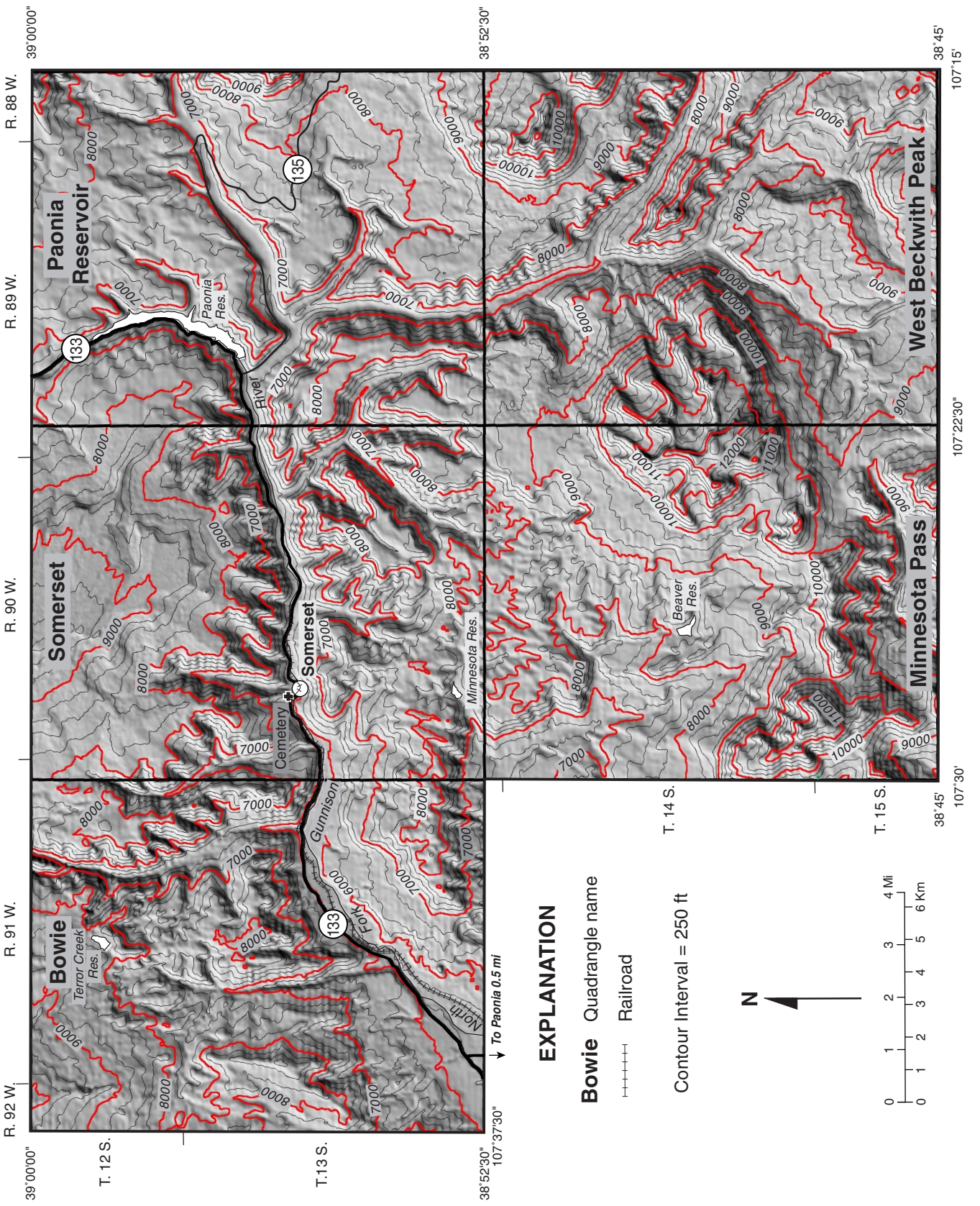


Figure 2. Simplified topographic map overlay on shaded relief map of the Somerset Coal Field.

Geology of the Somerset Coal Field and Surrounding Area

REGIONAL GEOLOGY

The Somerset Coal Field is located within the Uinta Coal Region. Approximately one-half of the Uinta Region lies in west-central Colorado; the remainder is the main coal-bearing region of eastern Utah. Most of the Colorado portion of the Uinta Region coincides with the Piceance Creek structural basin of Laramide age which is located in the eastern part of the Colorado Plateau physiographic province. The Uinta Region in Colorado is bounded by the Grand Hogback monocline to the east, the Axial Basin uplift to the north, the Utah state line to the west, Grand Valley and the Colorado River to the southwest and the North Fork Valley and Gunnison uplift to the south and southeast (Tremain and others, 1996).

The Piceance Creek Basin is the largest structural basin in western Colorado, covering an area exceeding 7,200 sq mi as defined by the base of the Upper Cretaceous Mesaverde Group. The basin is asymmetric in shape, with the steep flank on the east and its long axis trending northwest. This is one of the deepest basins in the Rocky Mountain region, with an estimated 25,000-plus ft of sediments at the north end of the basin in Rio Blanco County.

The southeastern part of the region, in Gunnison and Pitkin Counties, is bordered by the Elk and West Elk Mountains igneous intrusive complexes of Tertiary-age sills, laccoliths, dikes, and associated folds and faults. The high geothermal heat flow characteristic in this part of the region has increased the rank of much of the coal, creating large resources of coking coal. Original in-place identified coking coal resources in Colorado have been estimated at more than 4.2 billion tons. The Uinta Region contains an estimated 500 million tons of coking-coal resources (Goolsby and others, 1979). The southeastern third of the Uinta Region has produced the most desirable coke-oven feedstock in Colorado; however, thickness of overburden and/or relatively high methane content of the coals require additional planning before development of the resource in this area.

GEOLOGY OF THE SOMERSET COAL FIELD

Introduction

The Somerset Coal Field, in Delta and Gunnison Counties, lies in a valley cut by the North Fork of the Gunnison River and its tributaries. This correlates stratigraphically with the Lower Williams Fork Formation in other parts of the Piceance Basin. High-volatile B and C bituminous coals are up to 25 ft or more in thickness. The eastern part of the field, near the town of Somerset, contains coking coal of relatively good quality with fairly high levels of methane (Tremain and others, 1996).

The West Elk Mountains formed of intrusive and volcanic rock, intrude into or cover sedimentary rocks of Cretaceous and Tertiary age. The intrusive rocks have diverse and locally complex stratigraphic relationships with the sedimentary rocks. The magma that formed the intrusive rocks of the West Elk Mountains was injected into the strata at a relatively low temperature (Johnson, 1948a), so contact metamorphism is not extensive. Coal beds can be either partially intruded or replaced by intrusive rocks, and locally may be upgraded in rank.

Strata dip generally to the north-northeast at an average of about 3 to 5 degrees. Six major coal beds have been identified in the Mesaverde Formation (Johnson, 1948a). Although the geology of these coal beds (designated A through F), and their associated strata are shown in cross sections and tables throughout this report, due to study constraints

only the actively mined B and D beds and their adjacent splits, Lower B and Lower D, are evaluated in this report. Resources for the C and E beds were evaluated in the Somerset quadrangle study (Eakins and others, 1998a).

Surficial Geology

Surficial geology is depicted on a geologic map at a scale of 1:50,000 (Dunrud, 1989). The units described by Dunrud include Holocene alluvium (Qa) along the North Fork of the Gunnison River. Alluvium/colluvium along all drainages in the southern half of the of the field, two types of Pleistocene unconsolidated deposits, Pleistocene alluvial surfaces, Holocene and Pleistocene landslide deposits and artificial fill used to construct the Paonia Reservoir Dam are described in detail (Dunrud, 1989).

Bedrock Geology

Subsurface geologic information, which enabled inferred resources to be calculated, were available from 127 drill holes within the coal field. Abandoned oil and gas wells were the deepest drill holes identified, but were north of the study area. No oil or gas wells were located within the study area.

Bedrock units exposed in the Somerset Coal Field (Figures 3 and 4) range from Cretaceous Mancos Shale to Tertiary Wasatch Formation. Formation and member names are identified in order from oldest to youngest (Figure 3).

The **Mancos Shale** (Km) is the oldest exposed formation in the study area. As reported by numerous workers in the area, the Mancos Shale is composed of gray calcareous shale with sandy or carbonaceous intervals. The depositional environment was interpreted by Wellborn (1982a) as marine and a offshore facies of a delta system. Although the total thickness is about 5,000 ft (Young, 1982), locally the Mancos Shale is reported to be between 2,000 and 3,000 ft thick. Only the upper part of the Mancos Shale is exposed in the west-central Somerset Coal Field and in the extreme southwestern part of the study area along the North Fork of the Gunnison River.

The **Mesaverde Formation Undifferentiated** (Kmv). Many geologists who have worked in the area have subdivided the Mesaverde Formation into four members. They are from bottom to top: the Rollins Sandstone Member, the Bowie Shale (or the Lower Coal) Member, the Paonia Shale (or the Upper Coal) Member, and the Barren Member (Figures 3 and 5). Johnson and May (1980) and Dunrud (1989) include a fifth member, the Ohio Creek Member (Figure 4). The significant coals are within the Bowie Shale and Paonia Shale Members, or Lower Coal and Upper Coal Members respectively of the Mesaverde Formation, and are combined into a single unit (Kmvc) in Figure 3 (Dunrud, 1989). The Mesaverde Formation was deposited as part of a delta system that prograded to the southeast into the Late Cretaceous Western Interior Seaway (Wellborn, 1982a). The Mesaverde Formation where identified as "undifferentiated" sediments averages 2,500 ft thick.

a) The **Rollins Sandstone Member** (Kmvr) of the Mesaverde Formation, the basal member of the Mesaverde, is a conspicuous cliff-forming, white to buff sandstone, which contrasts sharply with the overlying coal-bearing members. Interpreted by Wellborn (1982a) as a delta-front facies, the Rollins Sandstone is 80–200 ft thick in the study area. The top of the Rollins Sandstone represents the lower boundary of the Bowie Shale Member.
b) The **Bowie Shale Member** (Kmvc), or the Lower Coal Member, used interchangeably, of the Mesaverde Formation is defined as a distinct series of sandstones and shales above the Rollins Sandstone.

    Dunrud (1989) combined the thickness of both coal bearing members with a thickness of approximately 160 ft in the eastern part of the coal field to 640 ft near the Terror Creek area in the western part of the coal field.

    The Bowie Shale Member unit reaches approximately 330 ft thick in the western part of the coal field, consisting of interbedded fine-grained sandstone, shale, carbonaceous shale, and coal representing lower delta-plain deposits (Wellborn, 1982a). The sediments were deposited in brackish-to fresh-water marshes and swamps, fresh-water lakes, occasional marine bays, and distributary channel systems. The coal-forming materials were deposited in interdistributary areas where water table levels were close to sea level and where conditions favored thick vegetation with little sediment inflow. The thickest and most extensive coals in the Lower Coal Member have been designated

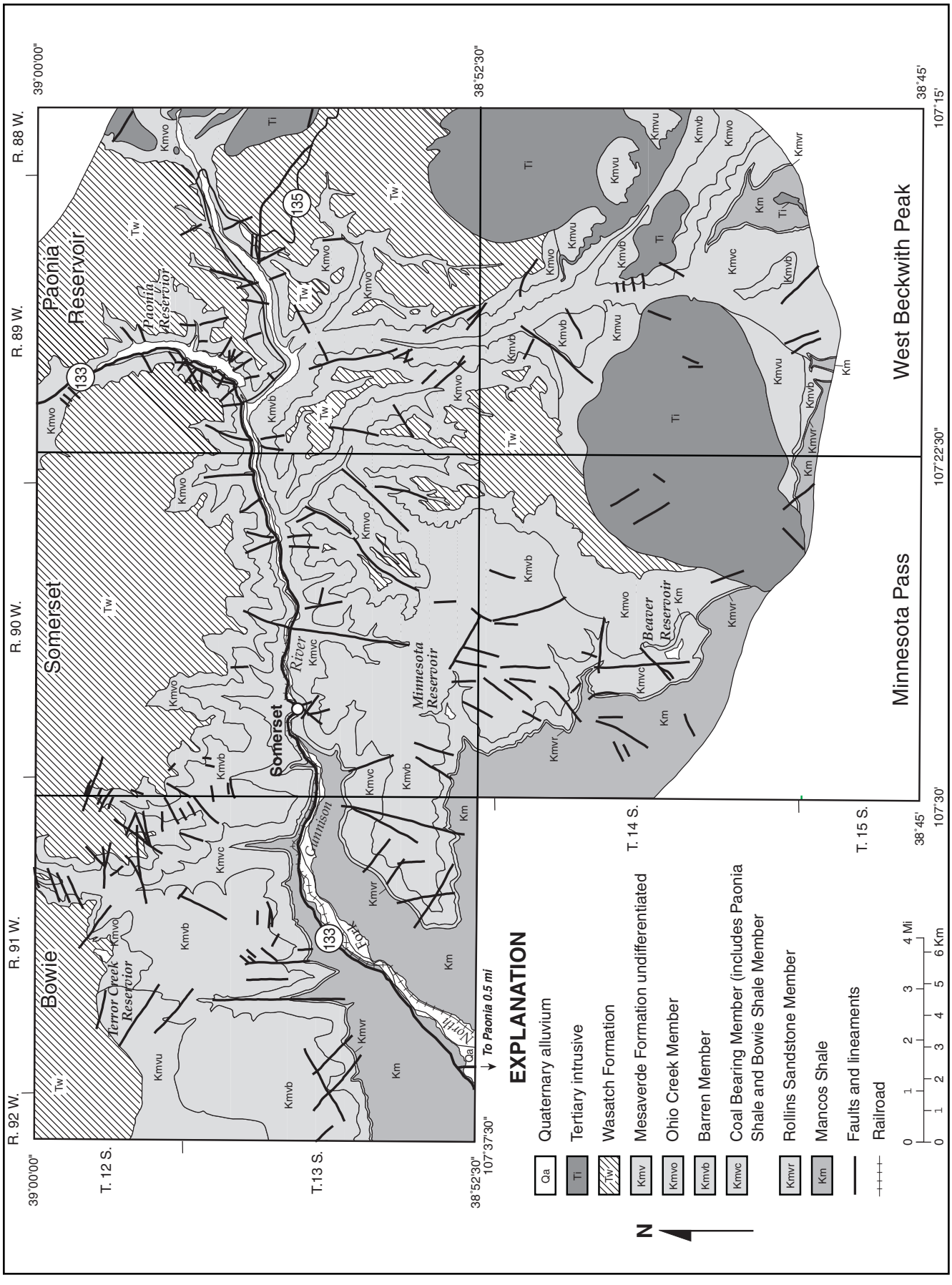


Figure 3. Simplified geologic map of the Somerset Coal Field (after Dunrud, 1989).

the A, B and C beds with A being the lowest bed. Nowak (1990) concluded from his investigations that the thickest beds in the lower part of the Bowie Member are parallel to the paleoshoreline, and are aligned in a north–south trend. The uppermost part of the Bowie Shale Member is an interval with several sandstone units from a distributary channel system (Wellborn, 1982a).

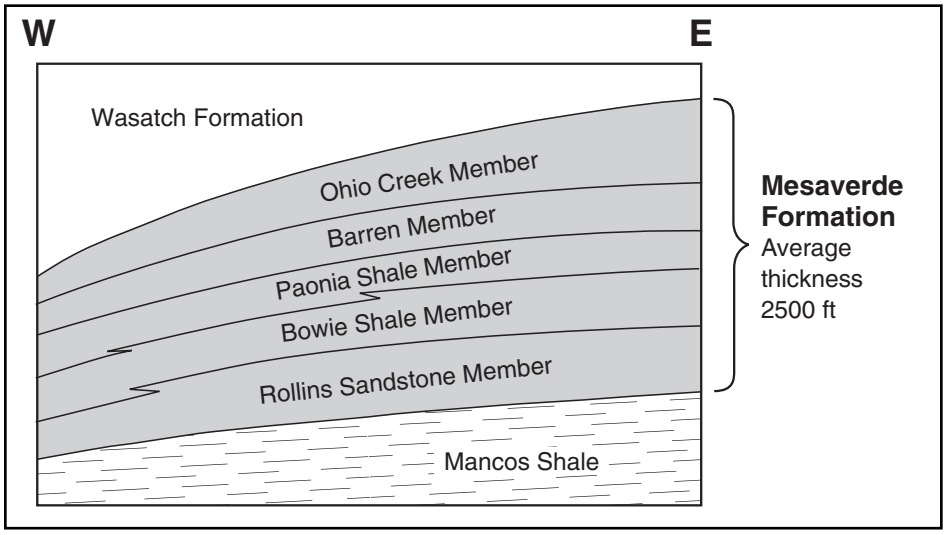


Figure 4. Lithofacies relationships of members of the Mesaverde Formation, Mancos Shale and Wasatch Formation in the Somerset Coal Field (Dunrud, 1989).

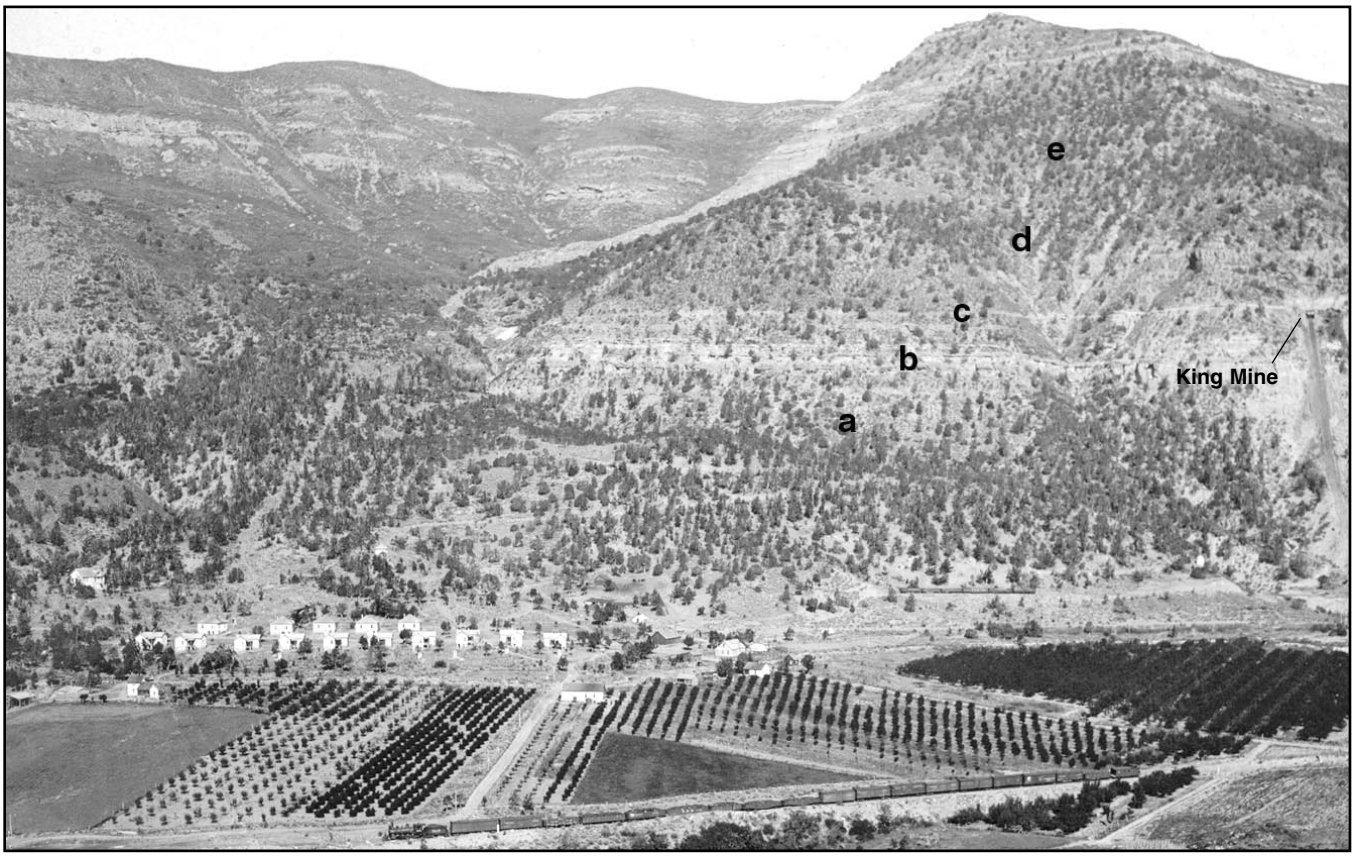


Figure 5. View of the town of Bowie around 1910 looking north across the North Fork valley showing outcrops of a) Mancos Shale, b) Rollins Sandstone, c) Bowie Shale, d) Paonia Shale, e) Upper Mesaverde (undifferentiated) (geology after Lee, 1912). View shows Juanita Coal and Coke Co. Mine (later King Mine), orchards and railroad in the foreground. Mine is 600 ft above the town. (Photo courtesy of Robert Bowie)

c) The **Paonia Shale Member** (Kmvc), or the Upper Coal Member, used interchangeably, of the Mesaverde Formation, is defined as the top of the uppermost sandstone unit of the Bowie Shale Member to the top of the F coal bed. This unit is composed of shale, minor carbonaceous shale, siltstone, and sandstone and ranges in thickness from approximately 200–400 ft in the Somerset Coal Field. The sediments were deposited in an interdistributary upper delta plain environment similar to that of the Bowie Shale Member, but were influenced more by fluvial processes, with an increase in channel and splay deposits (Wellborn, 1982a). Nowak (1990) observed that the thickest coal beds in the Paonia Shale Member are thinner than those in the Bowie Shale Member, and are generally not as laterally extensive. Distributary channel sandstones are also thinner and less extensive. The coal beds in the upper member are designated as D, E, and F beds.

d) The base of the **Barren Member** (Kmvb) is defined as the top of the F bed (Nowak, 1990). The Barren Member consists of alternating sandstone, shale, and siltstone beds but without continuous coal beds of commercial thickness (Wellborn, 1982a). There are few coals within the 100 ft above the F bed. The lower interval is primarily composed of coarse to fine-grained sandstones (Nowak, 1990).

e) The **Ohio Creek Member** (Kmvo) consists of interbedded sandstone, mudstone, and shales ranging from 500 to 900 ft thick (Dunrud, 1989). Most geologists working in the area prior to 1980 defined the Ohio Creek as a conglomeratic sandstone of Tertiary age (Wellborn, 1982a). Johnson and May (1980) redefined the Ohio Creek as a member of the Mesaverde Formation. The Ohio Creek Member is shown in this publication as the uppermost member of the Mesaverde Formation. The Ohio Creek Member is the boundary of the Cretaceous and Tertiary.

The **Tertiary Wasatch Formation** (Tw) is the uppermost rock unit (youngest age) in the study area consisting of varicolored claystone and mudstone with local lenses of sandstone, thin coal beds, and basal conglomerate (Dunrud, 1989). The Wasatch Formation is 200–400 ft thick in the study area. The formation is covered by Quaternary landsides and mudflows (Dunrud, 1989)

Principal Coal Beds

Coal beds in the Somerset Coal Field (Figure 6 and Table 1) designated with letters, and historically by names, are, in order from bottom to top, the A through F beds. Although all of the coal zones are primarily continuous, they may have significant splits or areas of nondeposition. Significant areas of unmined coal remain in these beds. Portions of the lower splits of the B and D beds are also minable. Thinner coals between the principal beds and beds A and F are not considered of minable thickness. Table 1 provides commonly used and alternative bed names for all beds with overall and typical thickness ranges of the principal coal beds. Mapping and resource calculations have been done in this study only for the principal beds being mined: the B and D, plus the splits of those beds: the Lower B and Lower D beds.

Table 1. Bed names and thickness ranges of the principal cool beds, Somerset Coal Field (Eakins, 1998).

Bed Name (Used in this report)	Lower B	B	C	Lower D	D	E
Common names and alternative names of beds used in this report	King B-1	Somerset B-1/ B-2	Bear	Lower Oliver D-1	Oliver Upper Oliver D–2	Hawks Nest
Thickness ranges (ft)	1.6–20	1.2–29	0–16	2.6–21	0–25	0–15
Typical thickness (ft)	5–10	15–25	6–8	6–15	8–20	5–8

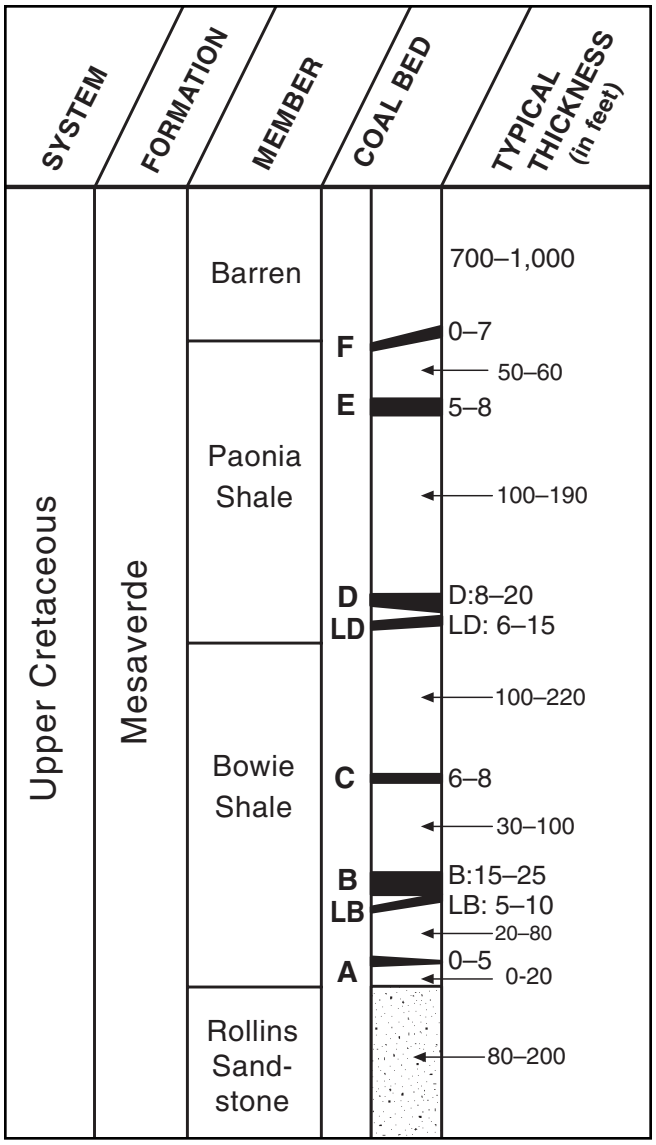


Figure 6. Generalized composite stratigraphic section showing coal beds and adjacent strata of the Somerset Coal Field.

Split beds, either the B and Lower B or the D and Lower D beds, occur where the thickness of the parting between the beds is thicker than the thickness of either coal bed (Figure 7). For example, if a coal bed consists of 12 ft of coal, 5 ft of non-coal parting, and 8 ft of coal, the bed is considered to be unsplit, with a coal thickness of 20 ft. The beds would, however, be considered split if the 8 ft and 5 ft beds of coal are separated by 12 ft of parting. The upper bed is then 8 ft thick and the lower bed is 5 ft thick (Figure 7).

Structure

The Somerset Coal Field dips typically about 200 to 300 ft per mi to the north-northeast based on structure maps derived from stratigraphic data used in this evaluation. Faults are steeply dipping, primarily west-northwest trending, and exhibiting several feet of stratigraphic separation where they offset coal beds in the mines. (Dunrud, 1976). No faults with more than 25 ft of throw were identified by structure mapping in the Somerset Coal Field; however, faults exceeding 25 ft of throw have been reported in some coal mines.

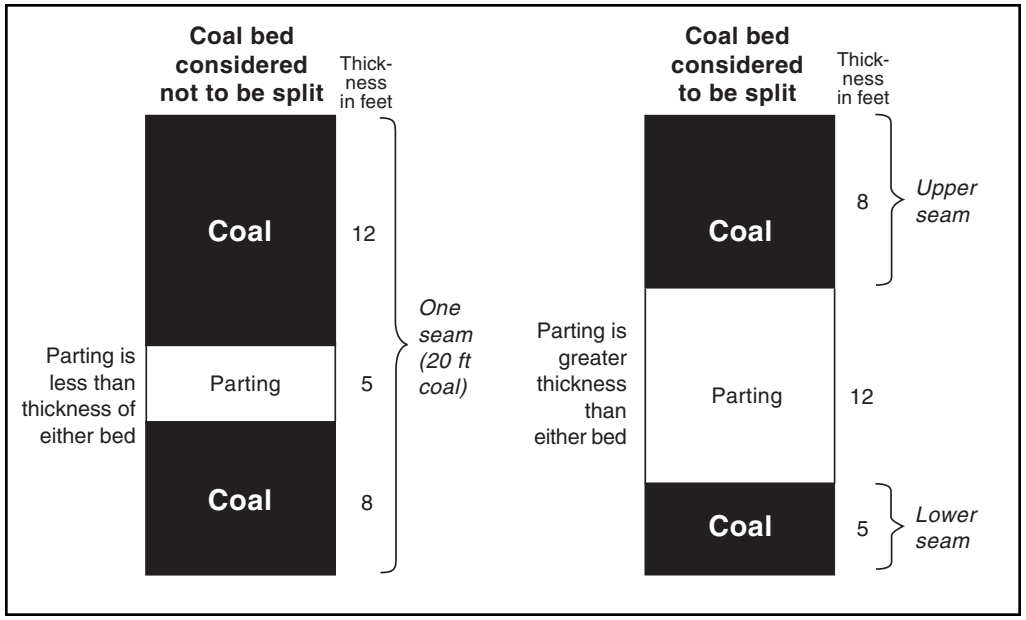


Figure 7. Explanation of what determines a coal bed to be considered split or not split.

COAL MINING

HISTORICAL PRODUCTION

Since the late 1880s, the Uinta Coal Region in Colorado has produced nearly 230 million short tons of coal from 300 mines. This production constitutes 26 percent of the total coal produced in Colorado. More than 16 million short tons of coal were produced in the Uinta Region in 1998, or 56 percent of the state's total output.

Table 2. Historic mines producing more than 100,000 short tons in the Somerset Coal Field.

Mine Name (Alternate Name)	Mine Map No.	Dates of Operation	Production (short tons)[1]	Bed(s) Mined	Reference/Comments[2]
Bear (Bear No. 1)	1	1932–1982	See Bear No. 3	C	Production combined with Bear No. 3 mine
Bear No. 2	2	1934–1982	See Bear No. 3	C	Production combined with Bear No. 3 mine
Bear No. 3	3	1934–1996	9,107,000	B(?),C	
Black Beauty (Hawks Nest No. 3)	4	1951–1976	1,400,000	E	Jones and Murray, 1976/ Metallurgical coal
Bowie No. 1 (Orchard Valley)	18	1976–1998 idle	16,059,000	D	Production is through 1997
Bowie No. 2	17	1997–present	2,713,322	D	First production in October 1997
Farmers (Paonia Farmers, Emmons)		1909–1966	255,000	C	
Hawks Nest East (Hawks Nest No. 2)	5	1975–1982	1,992,000	F (E)[3]	Kelso and others, 1981; Rushworth and others, 1984/Changed to E bed in Boreck and Murray, 1979
Hawks Nest No. 1	6	1931–1970	946,000	E	
Hawks Nest West	7	1970–1982	1,940,000	E	Kelso and others, 1981; Rushworth and others, 1984
King	16	1903–1974	2,996,000	A,B	Production was primarily from B bed
Lone Pine (Edwards)	8	1934–1965	505,000	B,C	Just west of Bear Mine entries
Mt. Gunnison No. 1	9	1982–1991	4,872,000	F (E)[3]	Rushworth and others, 1984/ Correlated as E bed in this report
Oliver No. 1	10	1923–1960	1,300,000	E	
Oliver No. 2	11	1945–1954	760,000	E (D)[3]	Correlated as D bed in this report
Oliver No. 3	12	1923–1960	See Oliver No. 1	D	Production combined with Oliver No. 1
Sanborn Creek	13	1992–present	8,692,226*	B,C	Zook and Tremain, 1997/Currently mining only the B bed; production is through 1998
Somerset	14	1903–1985	31,170,000	B,C	
West Elk	15	1992–present*	42,210,318	B	Zook and Tremain, 1997

1. Production through 1998 unless otherwise noted, rounded to nearest thousand tons
2. Reference is Boreck and Murray, 1979 unless otherwise cited. Post-1989 production from Colorado Division of Minerals and Geology files
3. Inicates differences in correlations

* Production through December 1999

Historical production from mines with total production exceeding 100,000 short tons in the Somerset Coal Field is shown on Table 2. For each mine, the dates of operation, total production, bed or beds mined, and references are provided. All mines operating in the coal field have been underground mines. Thirty-seven coal mines have operated in the Somerset Coal Field from 1903 to the present. Of the eighteen mines producing more than 100,000 short tons, fifteen are in the Somerset quadrangle and three are in the Bowie quadrangle (Table 2). Production numbers are through December 1999. Map numbers in Table 2 correspond to locations on Figures 16b and 16d.

Figure 8. Pickers and Diggers after blasting coal in mine around early 1900s. Smoke on roof is from the blast. Mine name is unknown. (Photo courtesy of the Colorado Historical Society)

Historic production records attribute all the coal produced from the Somerset Mine to Gunnison County (or the Somerset quadrangle) because the mine portal is in Gunnison County. Approximately half of the roughly 31 million tons mined from the Somerset Mine was actually mined in Delta County. About 80 percent of the coal mined from the Somerset Coal Field was produced from either the B or C bed. The remainder came from the D and E beds.

TIMELINES IN THE HISTORY OF COAL MINING IN THE NORTH FORK VALLEY

March 3, 1873

- A special act of congress provided for the disposal of coal lands by ordinary private entry or by preference right based on priority of possession and improvement. Under this act, tracts were limited to 160 acres for individuals and 320 acres for associations. The sale price was $10 per acre if more than 15 mi from a completed railroad and $20 per acre if within the 15 mi distance to the railroad.

  When it was disclosed that the Denver and Rio Grande Railroad intended to extend a railroad into the North Fork Valley where they owned a large block of land, many individuals flocked into the valley while land was available for $10 per acre.

1883

- Ira Quimby Sanborn, a geologist attempting to trace coal seams from Crested Butte, obtained the first patented mining claim. The coal was to be for smithing for the neighboring communities. Sanborn's business venture was unsuccessful. Sanborn abandoned his claim in 1893.

1894

- The Stucker Mine sold lump coal for $2.00/ton or $1.00 for all you could haul away in a wagon box.
- The Denver and Rio Grande Railroad completed their spur line to Somerset.

- A Denver & Rio Grande Railroad subsidiary, Colorado Fuel and Iron purchased the rights to Sanborn's Somerset Mine.

1902

- Utah Fuel and Iron acquired the Somerset Mine and began construction of the town of Somerset.
- From *The Rocky Mountain News*, August 20, 1902 (Courtesy of the Colorado Historical Society).
- Underground mine at turn of the century (Figure 8).

"COAL MINING STARTS NEW TOWN OF SOMERSET
Special to the News"

Gunnison, Colo., Aug. 19, 1902.—The new town of Somerset has been located in the western part of Gunnison county, on the North Fork river. It is at present a city of tents, but promises to grow to large proportions. Somerset has been established by the Denver and Rio Grande Railroad. The population is over fifty. The occasion for the existence of this new town is the opening of the great Coal Field of the North Fork valley at this point. A big entrance tunnel, 7-1/2 x 12 feet, is being driven on a twenty-foot vein of excellent bituminous coal, with four miles or more of this material ahead of it. The greatness of this coal deposit can hardly be realized. There have been probably, within the past eight months, full thirty thousand acres of this great Coal Field filed upon by the Colorado Fuel and Iron company and others. The Denver and Rio Grande Railway company has also become heavily interested, and is doing the work at the new town of Somerset. The company has the big tunnel in probably 160 feet, and is driving and timbering it at the rate of five feet per day. The work is under the management of A. E. Gibson.

1912

- Somerset had 600 residents, 85 cottages, a boarding house for single miners, a hospital and a post office. The coal field attracted mostly eastern European miners that gave the area its cultural diversity.
- Typical mine loadout (Figure 9).

1920s

- Miners were no longer paid in script and gold, nor were required to make purchases in the company store.
- Throughout the initial development of mining in the valley some mines became wagon mines operated as family enterprises while other larger operations required significant capital. Greater production from the Oliver Mine and the Juanita Coal & Coke Co (later the King Mine) required capital investment and the creation of more towns. The company town of Bowie was created. Figure 5 shows photo of Bowie. Figure 10 shows advertisement of Juanita Coal & Coke Co.
- Company regulations constrained miners political activities through restrictive regula-

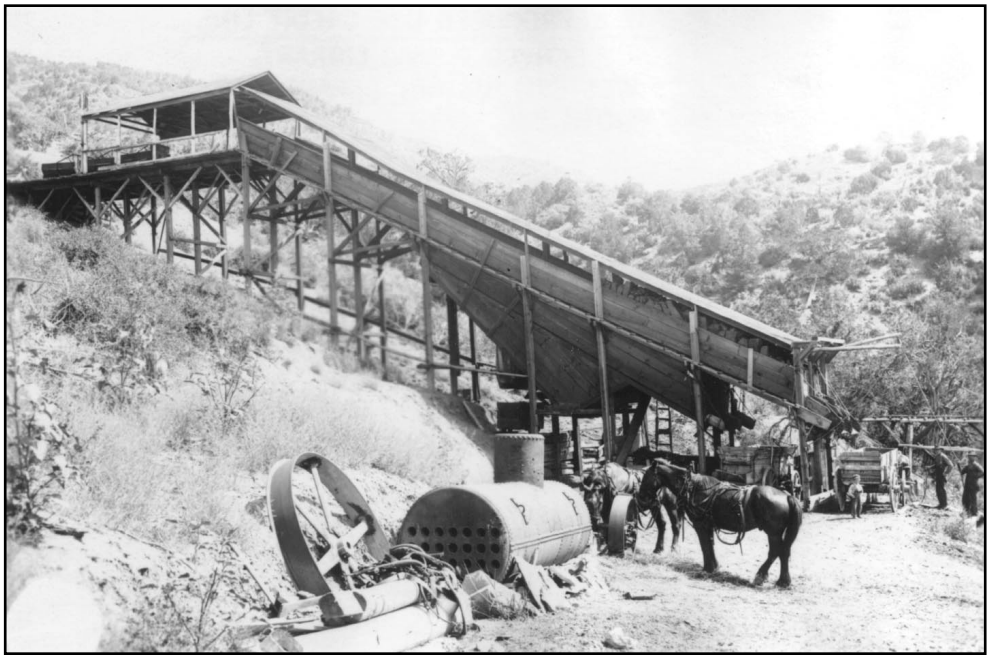
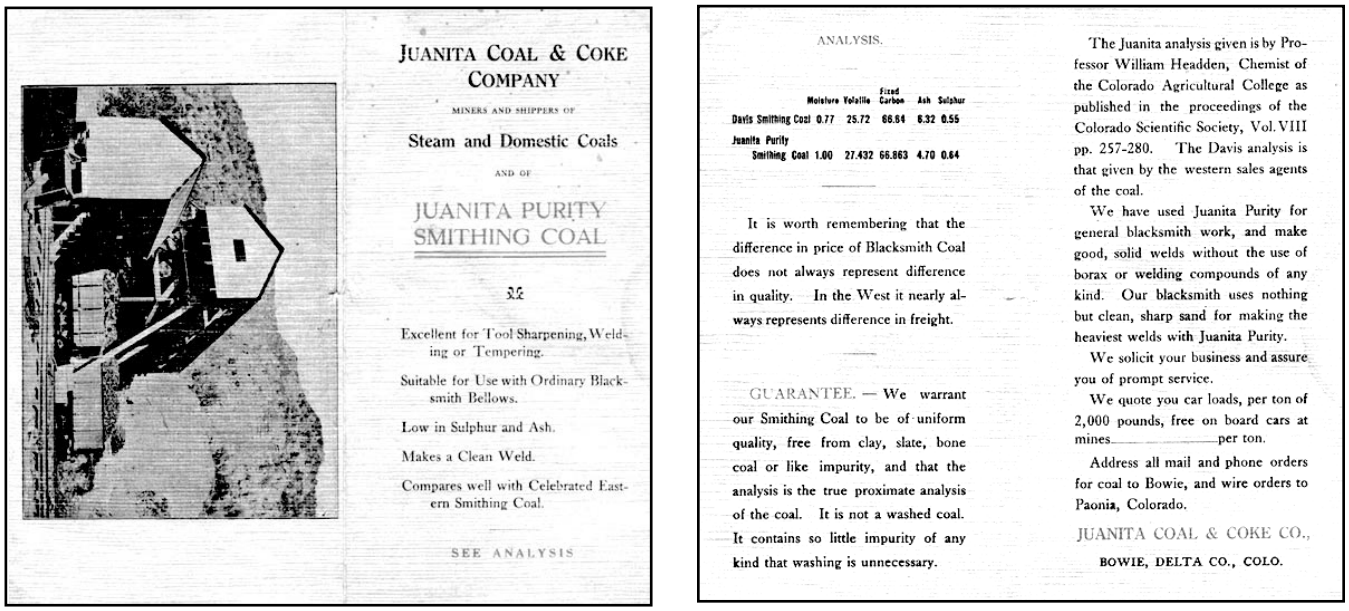


Figure 9. Converse Mine, Delta County between 1911 and 1918. Chute is full of coal to be loaded in horse drawn wooden wagon. (Photo courtesy of Denver Public Library, Western History Department).



JUANITA COAL & COKE COMPANY

MINERS AND SHIPPERS OF

Steam and Domestic Coals

AND OF

JUANITA PURITY SMITHING COAL

Excellent for Tool Sharpening, Welding or Tempering.

Suitable for Use with Ordinary Blacksmith Bellows.

Low in Sulphur and Ash.

Makes a Clean Weld.

Compares well with Celebrated Eastern Smithing Coal.

SEE ANALYSIS

ANALYSIS.

	Moisture	Volatile	Fixed Carbon	Ash	Sulphur
Davis Smithing Coal	0.77	25.72	66.64	6.32	0.55
Juanita Purity Smithing Coal	1.00	27.432	66.863	4.70	0.64

It is worth remembering that the difference in price of Blacksmith Coal does not always represent difference in quality. In the West it nearly always represents difference in freight.

GUARANTEE. — We warrant our Smithing Coal to be of uniform quality, free from clay, slate, bone coal or like impurity, and that the analysis is the true proximate analysis of the coal. It is not a washed coal. It contains so little impurity of any kind that washing is unnecessary.

The Juanita analysis given is by Professor William Headden, Chemist of the Colorado Agricultural College as published in the proceedings of the Colorado Scientific Society, Vol. VIII pp. 257-280. The Davis analysis is that given by the western sales agents of the coal.

We have used Juanita Purity for general blacksmith work, and make good, solid welds without the use of borax or welding compounds of any kind. Our blacksmith uses nothing but clean, sharp sand for making the heaviest welds with Juanita Purity.

We solicit your business and assure you of prompt service.

We quote you car loads, per ton of 2,000 pounds, free on board cars at mines_____per ton.

Address all mail and phone orders for coal to Bowie, and wire orders to Paonia, Colorado.

JUANITA COAL & COKE CO.,

BOWIE, DELTA CO., COLO.

Figure 10. Marketing advertisement for the Juanita Coal and Coke Co. about 1915–1920. (Courtesy of Robert Bowie).

tions forbidding political or social gatherings opposed to the company. Bloody battles marked the struggles between management and labor in the coal field from the very moment the Utah Fuel and Iron Co. established the town of Somerset.

August 5, 1933

- United Mine Workers Local 6417 charter was issued.

1937

- First hydraulic cutting machine is used in the North Fork Valley mine at the King Mine (Figure 11).

1940s

- By the 1940s many coal producers were under union contract.
- The coal production boom produced by increased manufacturing during World

Figure 11. 1937—First hydraulic cutting machine, Sullivan 7AU with approximately a 9 ft blade. Man in photo is Wallace Bowie. (Photo courtesy of Robert Bowie).

War II was short lived and many miners, in order to supplement their income during the slow periods of coal production, worked in the orchards and ranches.

1950s

- By mid-century natural gas was becoming the fuel of choice for heating and the railroad began to power with diesel.
- Mechanization came to the valley mid-century and conveyor systems brought an end to the use of mules except for odd jobs. Although steam driven mechanization began as early as 1906, mules were not completely gone until the 1950s.

Early 1960s

- Introduction of continuous miners replaced picks and shovels.

December 15, 1976

- First women miners were hired at the Orchard Valley Mine.

1980s

- First longwall miner operated at the Hawk's Nest Mine, 1980–1982.

Figure 12. Longwall shearer at the West Elk Mine. (Photo courtesy of Carol Tremain Ambrose).

July 24, 1992

- Longwall miner began operations at the West Elk Mine (Figure 12).

Today

- Loadout and other facilities at West Elk Mine (Figure 13).

CURRENT PRODUCTION

Approximately 29 percent of Colorado's cumulative coal production through 1998 came from the Somerset Coal Field. In 1998 the three operating

Figure 13. View from Highway 133 of the Union Pacific rail load-out (on right), storage silos and stack tubes (on left) of the West Elk Mine, Somerset Coal Field

mines in the coal field, Sanborn Creek, West Elk and Bowie No. 2 Mines, produced a combined total of 8,677,147 short tons of coal, or 32 percent of the state's total production. Through the end of December 1999, the three mines produced 9,802,205 short tons of coal.

West Elk and Sanborn Creek Mines produced from the B bed; the Bowie No. 2 Mine produced from the D bed. All three mines have either installed a longwall operation or are in the process of developing longwall system.

Coal Quality

Available coal quality data for the Somerset Coal Field was transferred into a single database. The area covered by the database includes Townships 13–15 South and Ranges 89–93 West. A compilation of approximately 520 individual analyses at 68 locations were available for the Somerset Coal Field.

Coal quality data are presented in Table 3 as range of analyses for all beds in the Somerset Coal Field.

The first line of analyses for each coal bed gives the range of analysis collected from the entire coal field. The second line of analyses, where available, is the typical range of analysis and more closely represents the actual coal quality. For the currently mined B and D beds, these analyses were obtained from the mines and more recent sampling. All values were determined using ASTM standards.

The coal quality database (Tremain and others, 2000, in preparation) contains: point identifying numbers, sample dates, mine or corehole names, bed and coal zone names, coal rank, ash and sulfur percentages, Btu/lb, million Btu/lb per short ton, pounds of sulfur per million Btu, latitude, longitude, and section, township, and range of sample locations, and source database names. However, not all of the samples contain all of the above parameters, as certain analyses were not run on every sample.

Although the quality of coal is an important factor in determining the market demand for coal

Table 3. Range of analyses of the Somerset Coal Field coals, as received basis. (Source: Tremain and others, 2000, in prep. For additional analytical data see reference.)

Coal Field/ Bed	Moisture (%)	Volatile Matter (%)	Ash[1] (%)	Sulfur[1] (%)	Heating Value[1] (Btu/lb)	Ash Fusion Temperature (°F)	FSI[2]
F	9.1–10.2	38.4–40.2	4–5	0.4–0.6	11,950–12,090	2,300–2,760	Not Available
E	4.8–10.3	30.9–40.0	2–25 5–15	0.16–1.27 0.4–0.6	10,200–13,900	2,120–2,800	0–2.5
D	5.1–8.5	34.4–38.2	4–18 6–12	0.36–0.86 0.5–0.7	10,300–13,000 11,500–13,000	2,800	0–4.0
Lower D	7.1	39.7	11.3	2.4	11,470	1,980–2,310	Not Available
C	4.5–8.1	36.0–39.7	5-13 6–10	0.39–0.88 0.4–0.6	11,300–13,500 12,200–13,500	2,090–2,910+	1.5–4.5
B	4.4–8.2	33.4–36.4	6–13 8–12	0.32–1.02 0.4–0.6	11,200–13,400 11,500–13,000	2,595–2,800	0–0.5
Lower B	8.2	40.0	4	0.6	12,250	2,440–2,820	Not Available
A	6.2–7.1	36.8–39.4	10–23 10–15	0.62–2.26 0.8–1.5	10,870–11,830 11,200–12,000	1,980–2,800	3.5

1. Overall range is shown on first line and typical range on second line.
2. Free swelling index

from specific coal deposits, distribution of coal quality is not assessed in this study. The distribution of coal quality parameters across the coal field is not well understood and additional analytical data would be needed in order to map quality. Coal quality data is presented in Table 3 as range of analyses for all beds in the Somerset Coal Field.

The following were the sources of analytical and mine data:

- USGS coal analysis database [USALYT], USGS, National coal Resources Data System (NCRDS), unpublished data
- Two databases with data on mine samples; one originally developed by the U.S. Bureau of Mines (USBM) and the Energy Information Administration (EIA) [BMEIALYT] (USGS, NCRDS, unpub. data) and one digitized by the Colorado Geological Survey (CGS) from USBM technical paper 574 (U.S. Bureau of Mines, 1937)
- A database containing analyses of coal cores taken by the CGS as part of a late 1970s to early 1980s coalbed methane desorption program [COPET] (USGS, NCRDS, unpub. data)
- The USCHEM trace element database of mixed core and mine samples published in the USGS OFR 94-205

All the coal quality data was converted, if necessary, to an as-received basis.

Restrictions on Coal Availability in the Study Area

FACTORS AFFECTING AVAILABILITY OF COAL RESOURCES

The availability of coal for future mining in the Somerset Coal Field is limited by several factors. These were identified through interviews with mining engineers and geologists from four coal companies operating in the Somerset Coal Field, or in geologic and physiographic settings similar to those found in the coal field. Staff members from the Colorado Division of Minerals and Geology, the state agency responsible for permitting and inspecting mines, the U.S. Forest Service, and the U.S. Bureau of Land Mangement were also interviewed. The information from these interviews was used to develop restriction criteria for defining coal available for mining.

Availability of coal must be evaluated based on the mining method that will most likely be used for coal recovery. In the Somerset Coal Field, all historic mining has been by underground methods, as it is today. In the last several years, plans for expansion within existing mines and plans for new mines have involved longwall mining methods.

The availability of coal for development is affected by numerous factors. In general three groups of factors are considered: legal unsuitability criteria, potential land-use restrictions, and technologic factors.

A hierarchy was established for land-use and technologic restrictions to prevent double-counting of restrictions when they overlap. The hierarchy used for resolving overlapping applicable land-use restrictions were 1) streams, 2) highways, and 3) railroads. Technologic restrictions were considered in this order: 1) mined-out areas, 2) coalbed thickness, and 3) proximity to another bed.

Table 4 provides a complete listing of all factors considered within these three groups with the applicable factors for the Somerset Coal Field highlighted in bold letters (including the Federal Coal Management Regulations (43 CFR 3461.5).

Table 4. List of possible restrictions to coal mining. (Printed in bold if applicable to the Somerset Coal Field. Italicized items are those considered to possibly be applicable. Potential technologic restrictions would be evaluated for a specific development project. In some cases the potential restriction might be mitigated.)

A. Coal-leasing unsuitability criteria from the Federal Coal Management Regulations (43 CFR 3461.5)

1. Federal land systems
2. Rights of way and easements [i.e., railroad]
3. Dwellings, roads, cemeteries, and public buildings
4. Wilderness Study Areas
5. Lands with outstanding scenic quality
6. Lands used for scientific study
7. *Historic lands and sites*
8. Natural areas
9. *Critical habitat for threatened or endangered species*
10. *State listed threatened or endangered species*
11. *Bald or Golden Eagle nests*
12. *Bald and Golden Eagle roost and concentration areas*
13. *Federal lands containing active falcon cliff nesting site*
14. Habitat for migratory bird species
15. Fish and wildlife habitat for resident species
16. Floodplains
17. Municipal watersheds
18. National resource waters
19. Alluvial valley floors
20. State or Indian tribe criteria

Table 4. Continued.

B. Land-use restrictions
   1. Towns
   2. Pipelines
   3. *Powerlines*
   4. *Archaeological areas*
   5. Surface and coal ownership issues
   6. *Wetlands*
   7. Streams, lakes, and reservoirs

C. Technologic restrictions
   1. Coal quality
   2. Coal depth (<100 ft overburden for underground mining)
   3. Mined-out areas
   4. Limit of coal (including areas of burned coal)
   5. Subsidence over abandoned mines
   6. Subsidence is projected to cause material damage
   7. Active mines
   8. Abandoned mines
   9. Coal beds too close together (<40 ft)
   10. Coal beds too thin
   11. Coal bed discontinuities
   12. Roof or floor problems
   13. Barrier pillars
   14. *Oil and gas development*
   15. Steep slopes
   16. Steeply dipping beds
   17. Proximity to intrusives or faults
   18. Block size

LEGAL UNSUITABILITY CRITERIA DETERMINATIONS

Coal unsuitability criteria are listed in the Federal Regulations, Title 43, Subpart 3461 (43 CFR 34615). These 20 specific legal criteria are used to determine if an area can be mined by surface mining methods. Underground mining on Federal lands can be exempted from these criteria, except where the mining will include surface operations and have surface impacts on Federal lands that cannot be otherwise exempted (43 CFR 3461.1).

Land Use Restrictions

The unsuitability criteria that were evaluated to be restrictions to mining in the Somerset Coal Field are rights of way and easements (applicable to the railroad), roads (applicable to Colorado Highway 133) and cemeteries (the miner's cemetery north of Somerset) as shown on Figures 14 and 15. Dwellings and public buildings within the town of Somerset are also restrictions, although the entire town of Somerset is restricted under other land-use restrictions.

Coal beneath the town of Somerset, streams, lakes and reservoirs are also restrictions to coal mining. The North Fork of the Gunnison River and Minnesota Reservoir, Beaver Reservoir, Paonia Reservoir, and Terror Creek Reservoir are considered land-use restrictions; however, no restriction was applied to streams for coal more than 200 ft below the surface. The powerline along Terror Creek is currently being considered as a restriction. However, mining could occur under the powerline at yet to be determined depths.

Other potential land-use restrictions were considered; however, none were evaluated to be applicable to the Somerset Coal Field. No significant archaeological sites have been identified by the Colorado Historical Society. Small, isolated wetlands have been identified within areas permitted for coal mining; however, mining has not been restricted under these areas. Surface and coal ownership issues (Figures 14 and 15) are potential restrictions, but are considered on an individual or parcel basis.

Although it is conceivable that the cemetery, highway and railroad could potentially be relocated to allow mining to proceed, for the purposes of this study, they are considered restrictions to mining. No restriction was applied to highways for coal being mined more than 200 ft below the surface.

Other unsuitability criteria that are potential restrictions include critical habitat for threatened or endangered species, Bald or Golden Eagle nests, and alluvial valley floors. The Colorado Division of Wildlife has not identified any critical Bald Eagle nests within the coal field. Underground mining may be permitted beneath alluvial valley floors in some cases; therefore, alluvial valley floors were not considered as a restriction.

Although the above criteria could cause areas to be declared unsuitable for coal mining, detailed studies proposing mitigation measures could be made if an expression of interest for coal development was submitted to the proper agency.

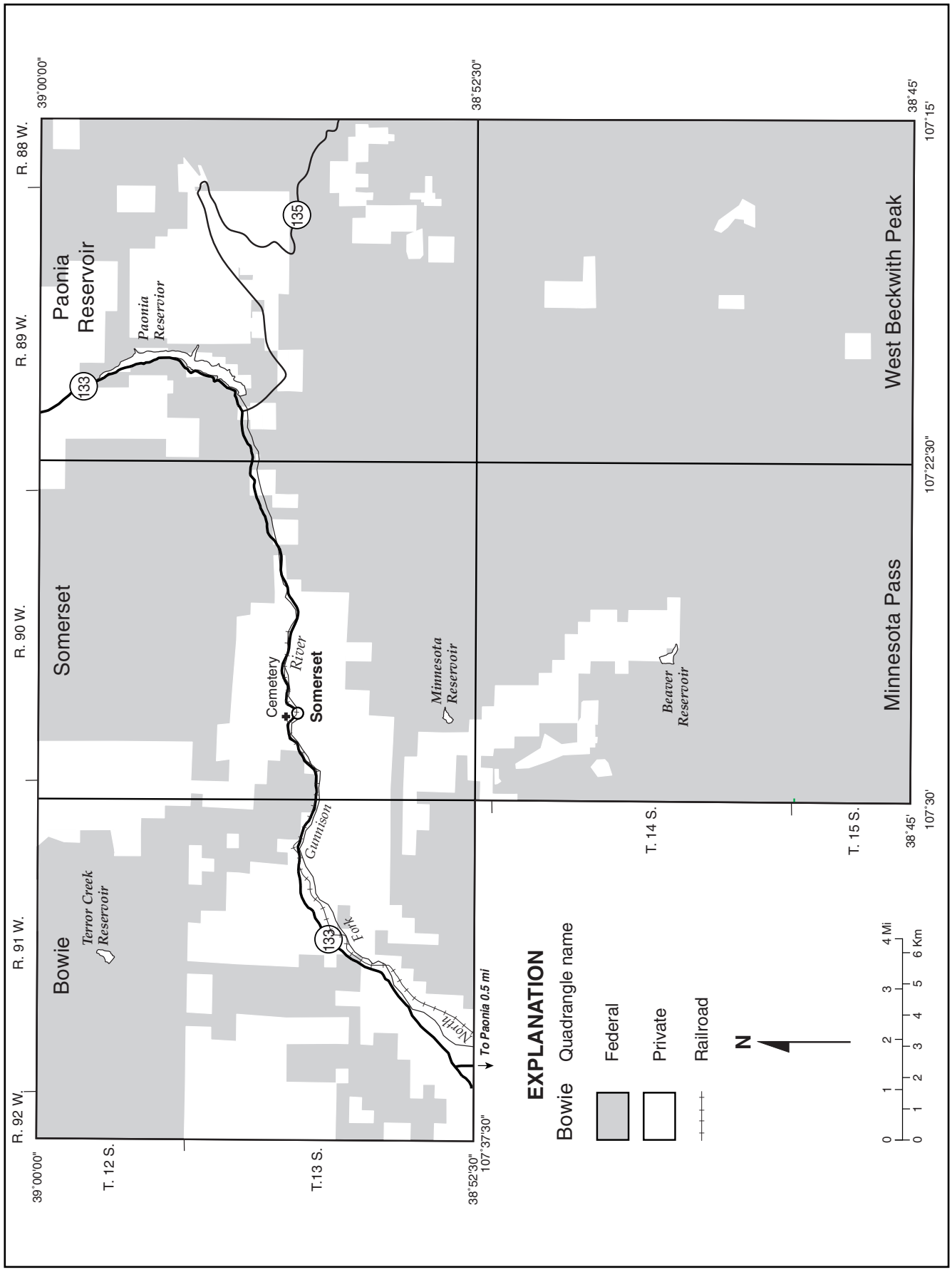


Figure 14. Map of surface ownership.

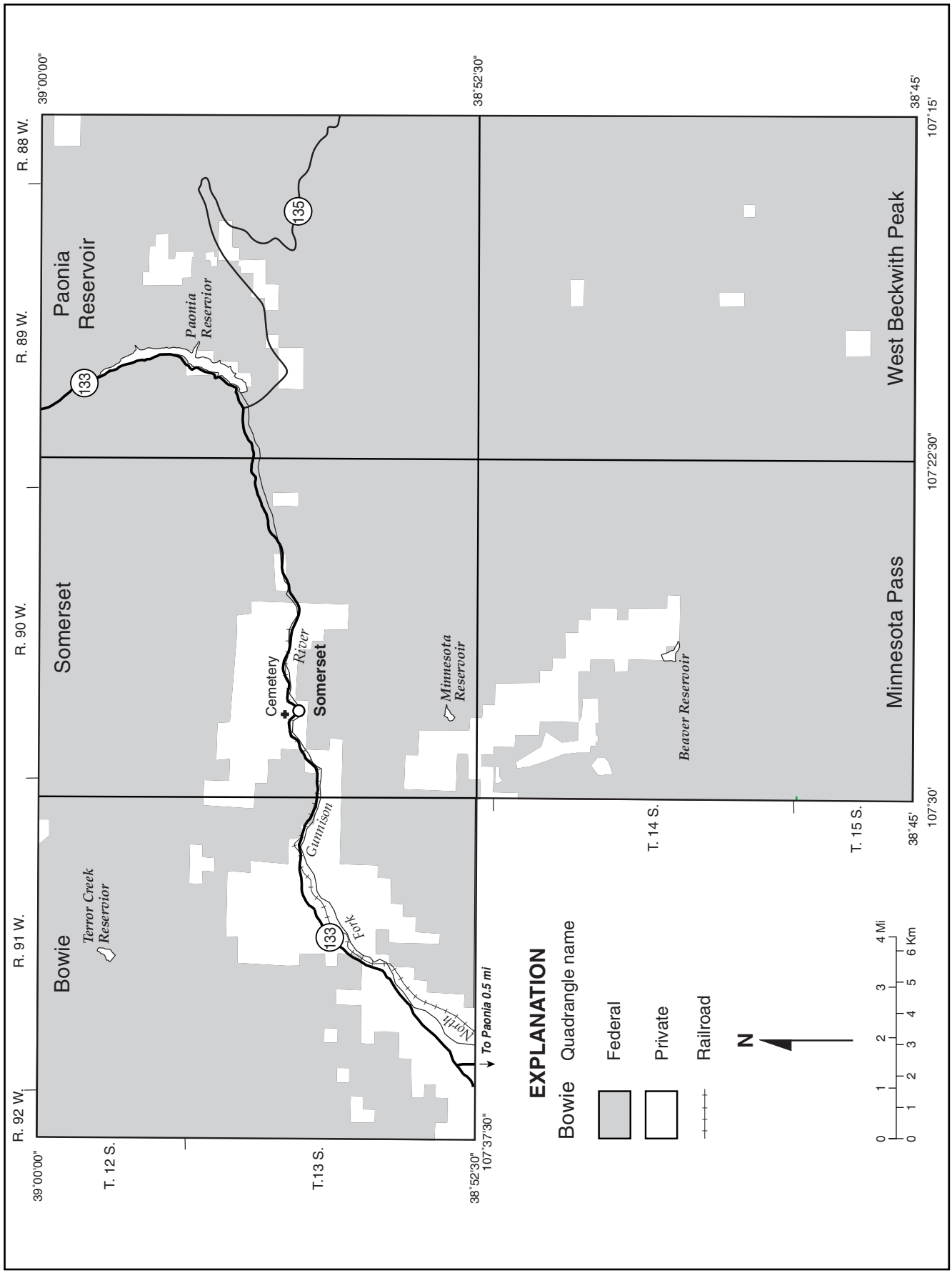


Figure 15. Map of coal ownership.

Table 5. Exclusions/Restrictions to Mining, Colorado Revised Statutes 34-33-101 and following sections: E—exclusions, R—restrictions

Restriction/ Exclusion	Explanation of Restriction or Exclusion	Rule No.
E	Lands within National Park system, National Wildlife Refuges, national system of trails, national wilderness preservation system, wild and scenic rivers, and national recreation areas	2.07.6(2)(d)(iii)(A)
E	Within 300 ft of public building (school, church, hospital, courthouse, government building ...) community or institutional building or any public park	2.07.6(2)(d)(iii)(B)
E	Within 100 ft of a cemetery	2.07.6(2)(d)(iii)(C)
E	Lands designated unsuitable for mining [CDMG comment: None have been designated in Colorado]	2.07.6(2)(d)(i)
E	Operations which affect the continued existence of threatened and endangered species	2.07.6(2)(n)
R	Mining on steep slopes (has to meet specific performance standards)	2.06.4
R	Lands within National Forest	2.07.6(2)(d)(iii)(D)
R	Will not adversely affect publicly owned park or place eligible to be included in the National Register of Historic Places	2.07.6(2)(e)(i)
R	Within 100 ft of public road right of way	2.07.6(2)(d)(iv)
R	Within 300 ft of an occupied dwelling (unless owner waives)	2.07.6(2)(d)(v)
R	500 ft, measured horizontally, from active or abandoned underground mines	4.19(1)
R	Beneath or adjacent to any perennial stream, or impoundment or other body of water >20 acre-ft	4.20.4
R	Mining in alluvial valley floors and prime farm land [CDMG comment: AVFs are identified during permitting process]	2.07.6(2)(K)
R	Operations where subsidence is projected to cause material damage [CDMG comment: Essentially must avoid or leave support pillars to protect aquifers, agricultural land, and occupied residential dwellings and noncommercial buildings]	2.05.6(6)(b)(iii) 4.20
R	Blasting within 1,000 ft of schools, churches, hospital and nursing facilities and within 500 ft of wells, pipelines, and storage tanks for oil, gas, or water	4.08.4(7)
R	Surface disturbance within 100 ft of perennial streams with biological communities in them	4.05.18

Technologic Factors

Technologic factors evaluated as restrictions to mining were coal depth, mined-out areas (both active and abandoned mines), insufficient interburden, thin coal beds, and areas of burned coal.

Overburden of less than 100 ft, interburden of less than 40 ft to the overlying or underlying bed, and bed thickness of less than 2.3 ft (28 in) were considered technologic restrictions to underground mining. Figures 16a through 16d show the areas for which each of the two coal beds B and D and the Lower B and Lower D splits are located in this study, and are technologically restricted.

Other technologic factors may apply to at least portions of the coal field, but were not evaluated due to insufficient data. For some factors, the basis of what would constitute a restriction was difficult to establish.

No oil and gas development has taken place within the Somerset Coal Field. A single well, drilled in 1981, was abandoned.

Coal quality is not considered to be a restriction to mining, although it could influence the specific areas of a bed that are selected to be mined. It is likely that subsidence over abandoned mines may preclude mining in some areas. Data to identify areas affected by such subsidence is not readily available. Also, areas with roof or floor

problems that would preclude mining, steep slopes, intrusives, and faults were not identified due to insufficient data.

Procedure for Determining Depleted Reserves

The CGS, with assistance from the USGS, established a digital database of the mined-out areas for the Somerset Coal Field. Information on the extent of mining was obtained from individual mine maps or previously-compiled 1:24,000 scale maps available at the CGS, from maps within mine permit documents at the CDMG, or from mine operators. Boundaries of active mines were updated to January 1, 1999, in part based on mine plans through the end of 1998.

Depleted reserves consist of the coal tonnage that was originally present in areas that have been mined out. These reserves have been extracted by mining or left as pillars within underground mines. The reserves from the mined out area plus coal left in the abandoned works were depleted from the individual bed. Coal that has been left in place as barrier pillars within 50 ft of mines has been excluded from resources. Colorado law requires that a barrier pillar at least 500 ft wide is left around active mines; however, once a mine becomes inactive, mining may be permitted within 50 ft of abandoned workings. The Mine Safety and Health Administration requires that a 50 ft barrier be left between inactive mines.

The Colorado Surface Coal Mining Reclamation Act also includes a number of potential exclusions or restrictions to underground coal mining, within Title 34, Article 33 as indicated in Table 5. Many of these overlap with Federal restrictions to mining. All were considered for inclusion in the factors affecting the availability of coal.

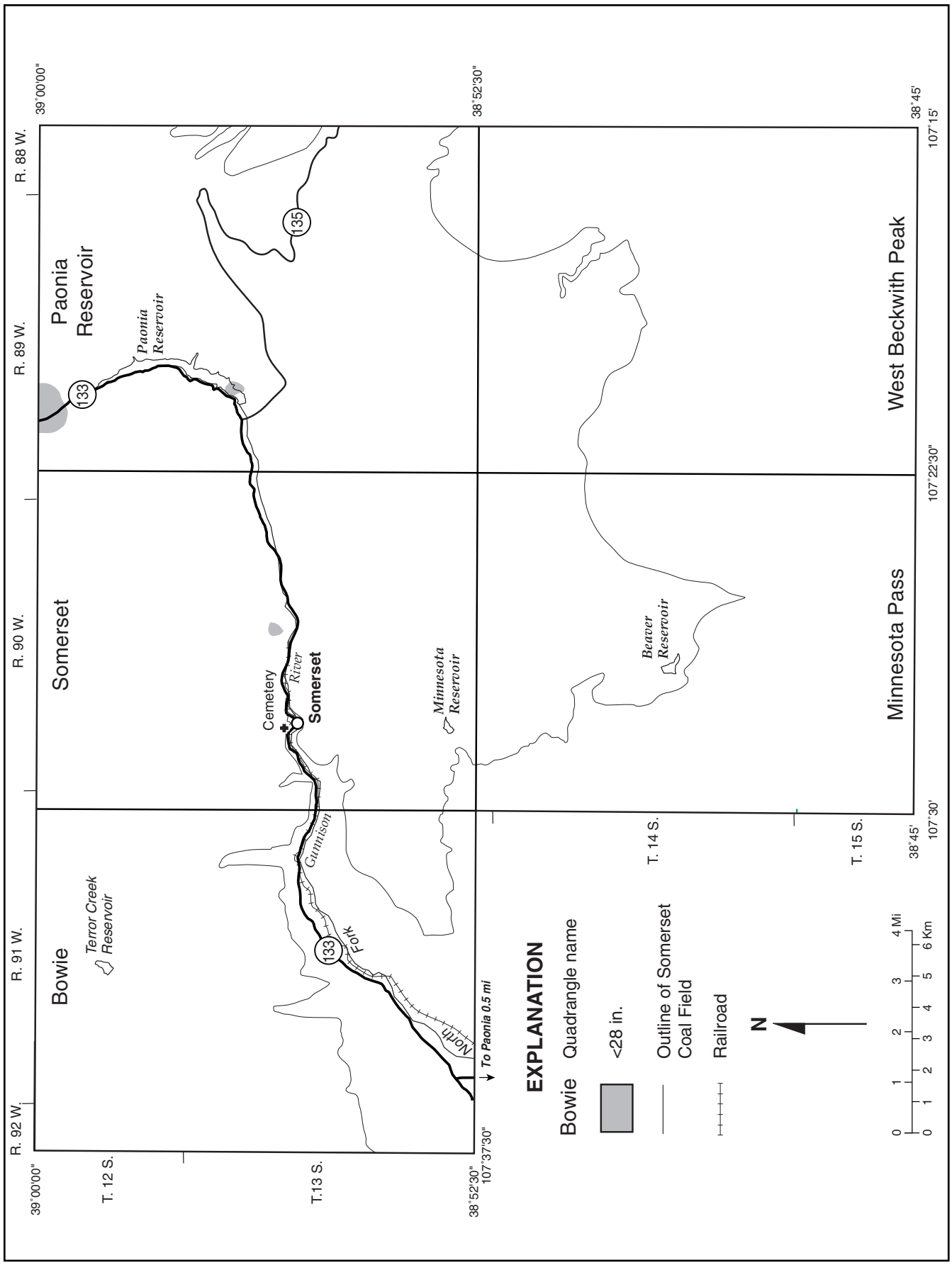


Figure 16a. Map of technologic restrictions of the Lower B coal bed, Somerset Coal Field.

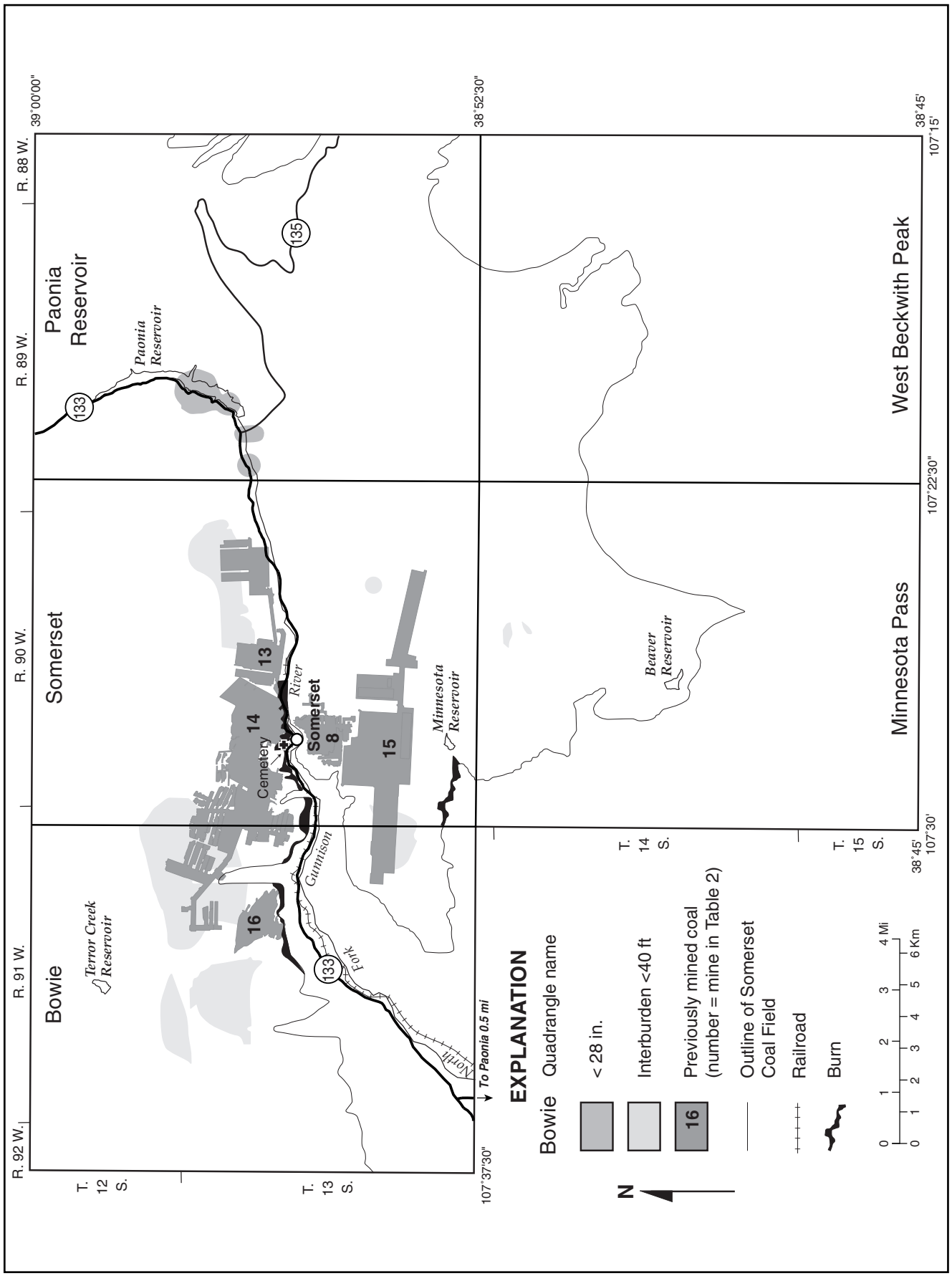


Figure 16b. Map of technologic restrictions of the B coal bed, Somerset Coal Field.

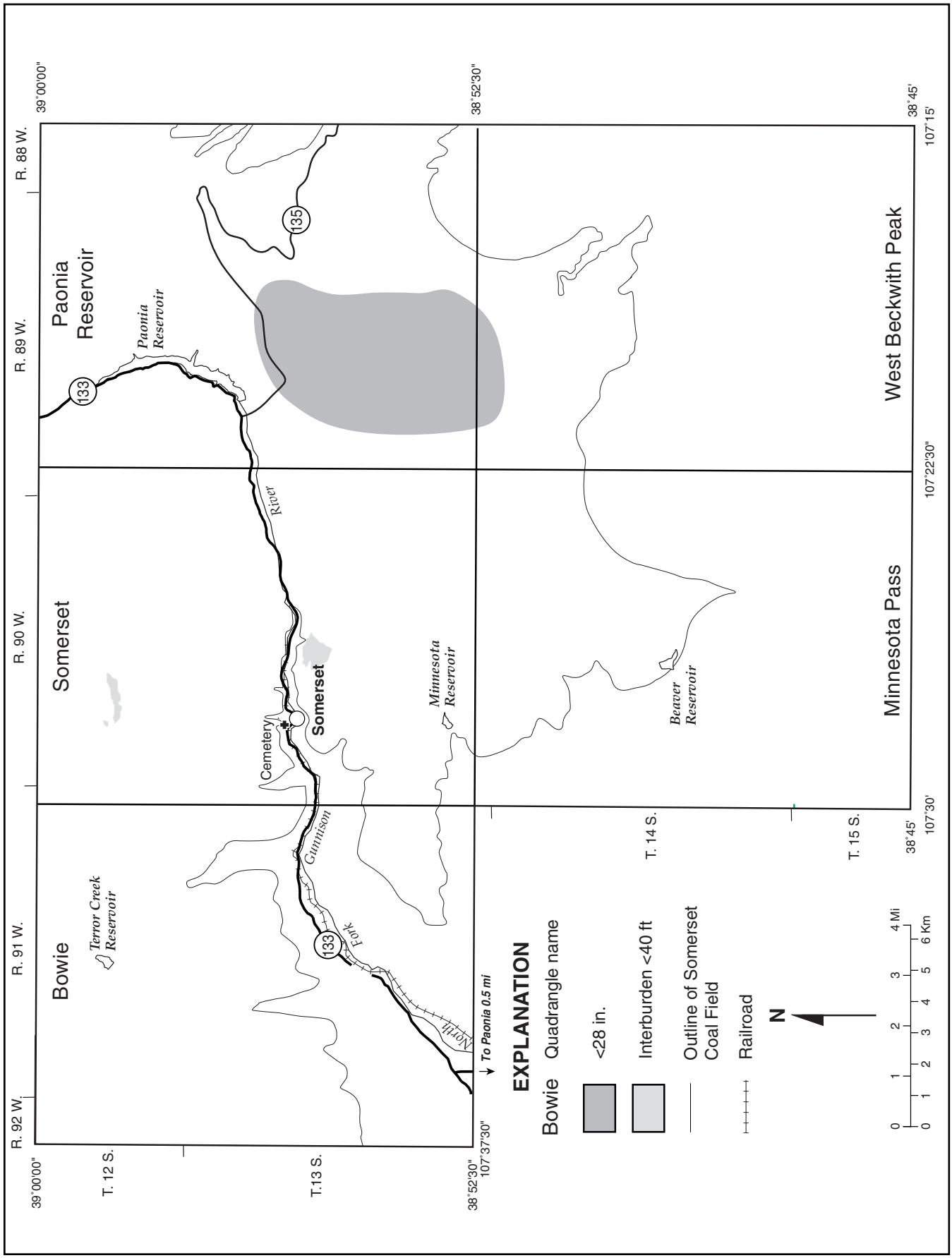


Figure 16c. Map of technologic restrictions of the Lower D coal bed, Somerset Coal Field.

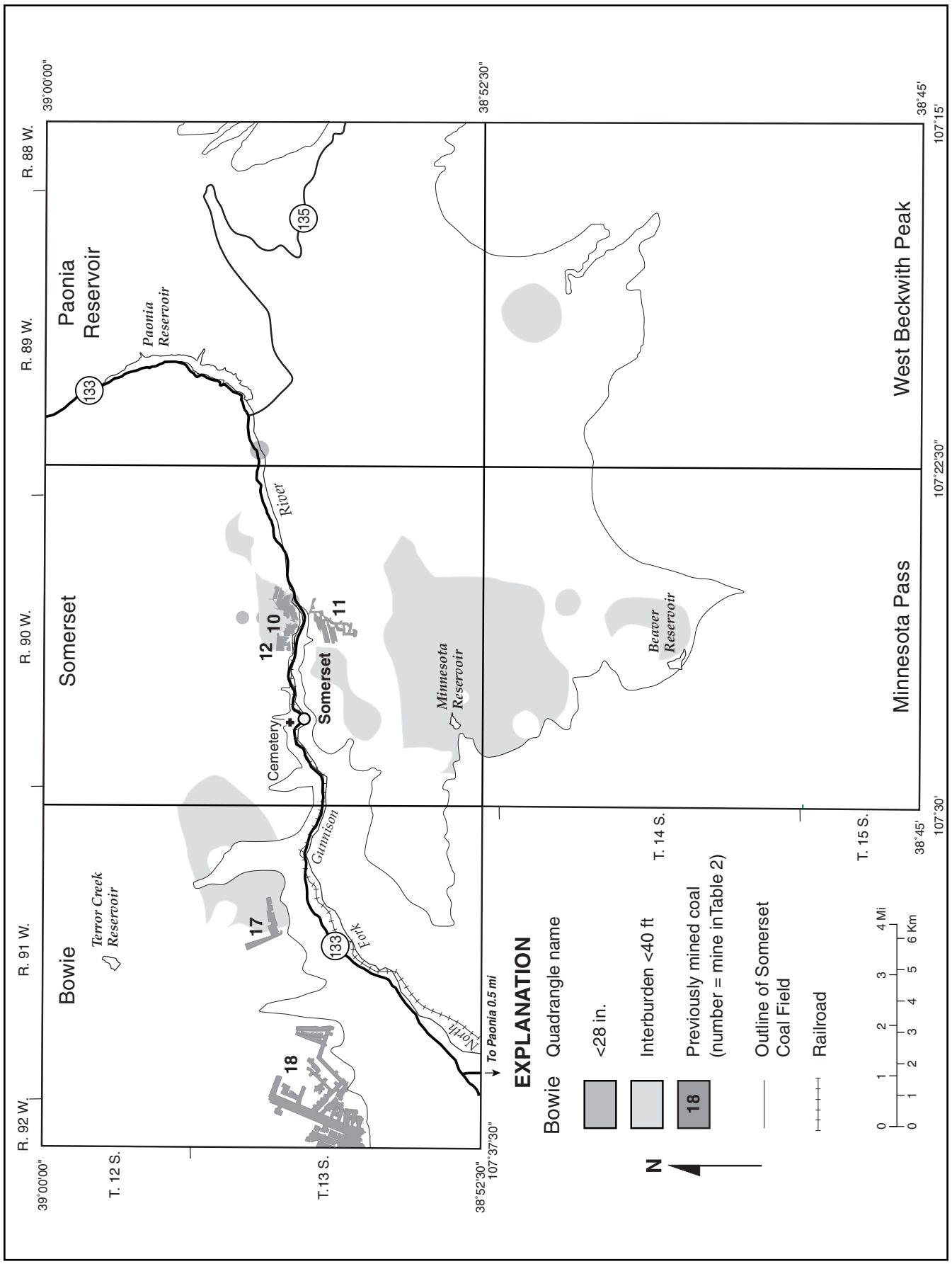


Figure 16d. Map of technologic restrictions of the D coal bed, Somerset Coal Field.

Preparation of Data for Resource Calculations

COLLECTION OF STRATIGRAPHIC DATA

Stratigraphic data sources used in determining coal resource quantities include drilling logs, core descriptions, and geophysical logs. Drill hole data were obtained from published sources, USGS databases, BLM files, Mountain Coal Company, and permit documents at the CDMG. The drill holes used, which represent all publicly available data for the coal field, are shown in Figure 16. Coal bed thicknesses were also scaled from cross sections published by the USGS (Dunrud, 1989).

Proprietary data were not used with the exception of confidential data loaned to CGS by Mountain Coal Company to fill in areas where drill holes were spaced more than 1.5 mi apart and no public data were available. These data were used only as specified by Mountain Coal Company. Logs of two additional drill holes were obtained from cross sections within permit documents filed with the CDMG.

CORRELATION OF COAL BEDS

Cretaceous coal beds of Colorado are highly lenticular and their minable thickness can extend relatively short distances. Because of this lenticularity, correlation of coal beds is sometimes difficult. Interpretations vary from publication to publication and geologist to geologist. Several previous studies, particularly Johnson (1948a) and Dunrud (1989), have covered a relatively large area, including areas both north and south of the North Fork of the Gunnison River. Their correlations do not agree in some instances.

1) In this report, previous correlations of geologists were used to a large extent; however, correlations in this study did not benefit directly from the proprietary data that was used by some of the geologists previously working in the area.
2) Historically, coal bed correlations across the North Fork valley were only rarely attempted with no conclusions being found in literature.

General coal bed correlations in the Somerset Coal Field are depicted in five coal correlation diagrams, the locations of which are shown on Figure 17 . Both Coal Correlation Diagrams A–A' and B–B' are in the Somerset quadrangle coal availability study (Eakins and others, 1998a). They have been used in this publication in an attempt to tie into the additional correlations made for the coal study of the entire Somerset Coal Field. Coal Correlation Diagram A–A' (Figure 18) trends east-west just north of the North Fork of the Gunnison River in the Somerset, Bowie and Paonia Reservoir quadrangles. Coal Correlation Diagram B–B' (Figure 19) trends north-south in the Somerset and Minnesota Pass quadrangles and ties in with coal correlation diagram A–A' at drill hole E-25A. Coal Correlation Diagram C–C' (Figure 20) trends north-south in the Paonia Reservoir and West Beckwith Peak quadrangles and ties into the coal correlation diagram D–D' drill hole PAO2. Coal Correlation Diagram D–D' (Figure 21) trends east-west in the Paonia Reservoir and Somerset quadrangles and ties into coal correlation diagram C–C' at drill hole PAO2. Coal Correlation Diagram E–E' (Figure 22) trends east-west in the Bowie quadrangle and ties into coal correlation diagram A–A' at the Bowie 10 drill hole.These correlation diagrams illustrates the lenticularity of the beds as well as the variability of bed thickness, splits, and bed position over a relatively short distance. Splits of the B and D beds, with a defined Lower B or Lower D bed occur in some drill holes but were not observed in others as illustrated in the coal correlation diagrams. Coals were correlated by lettered zones rather than by individual beds.

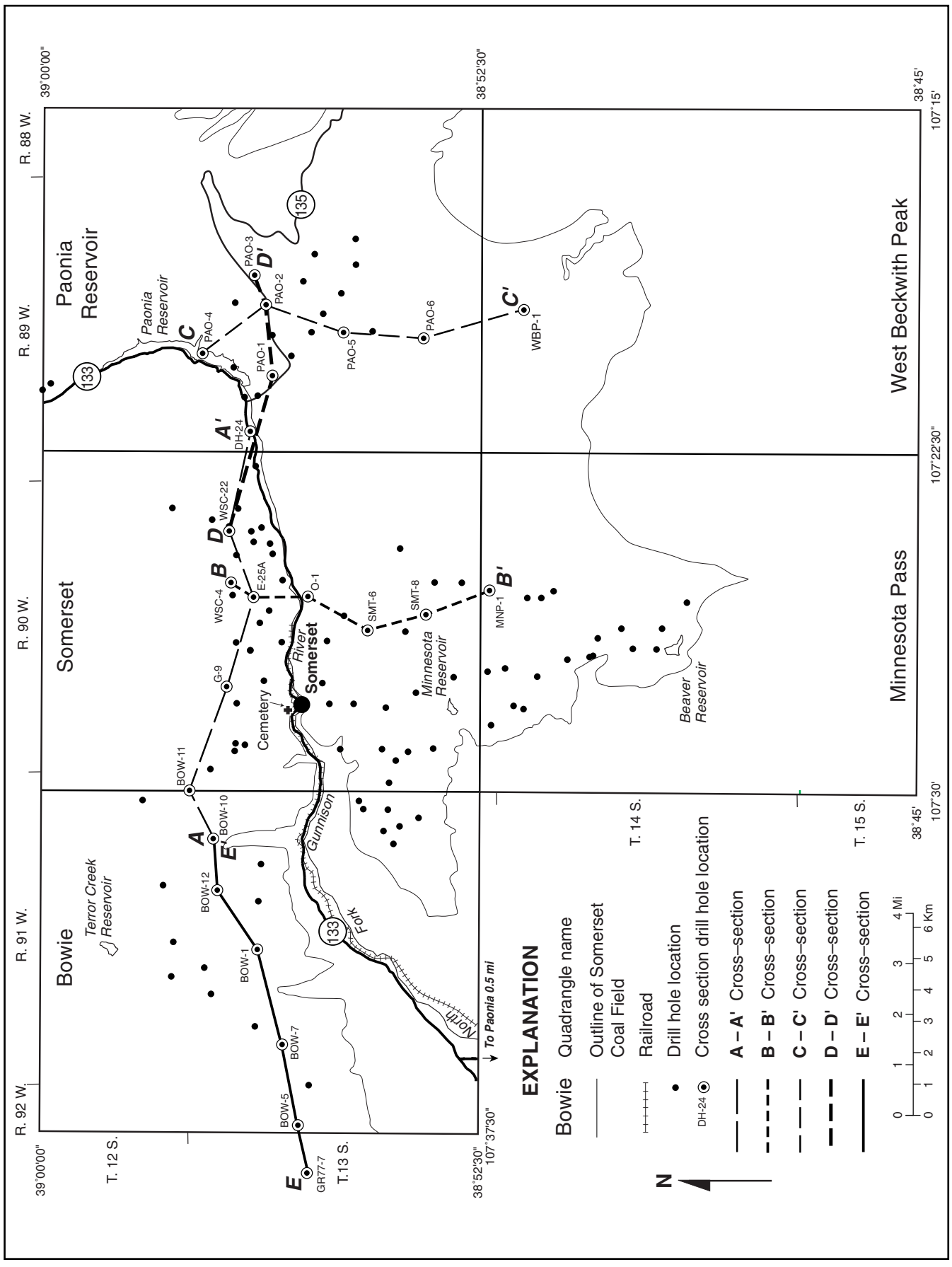


Figure 17. Map of data points and locations of coal correlation diagrams.

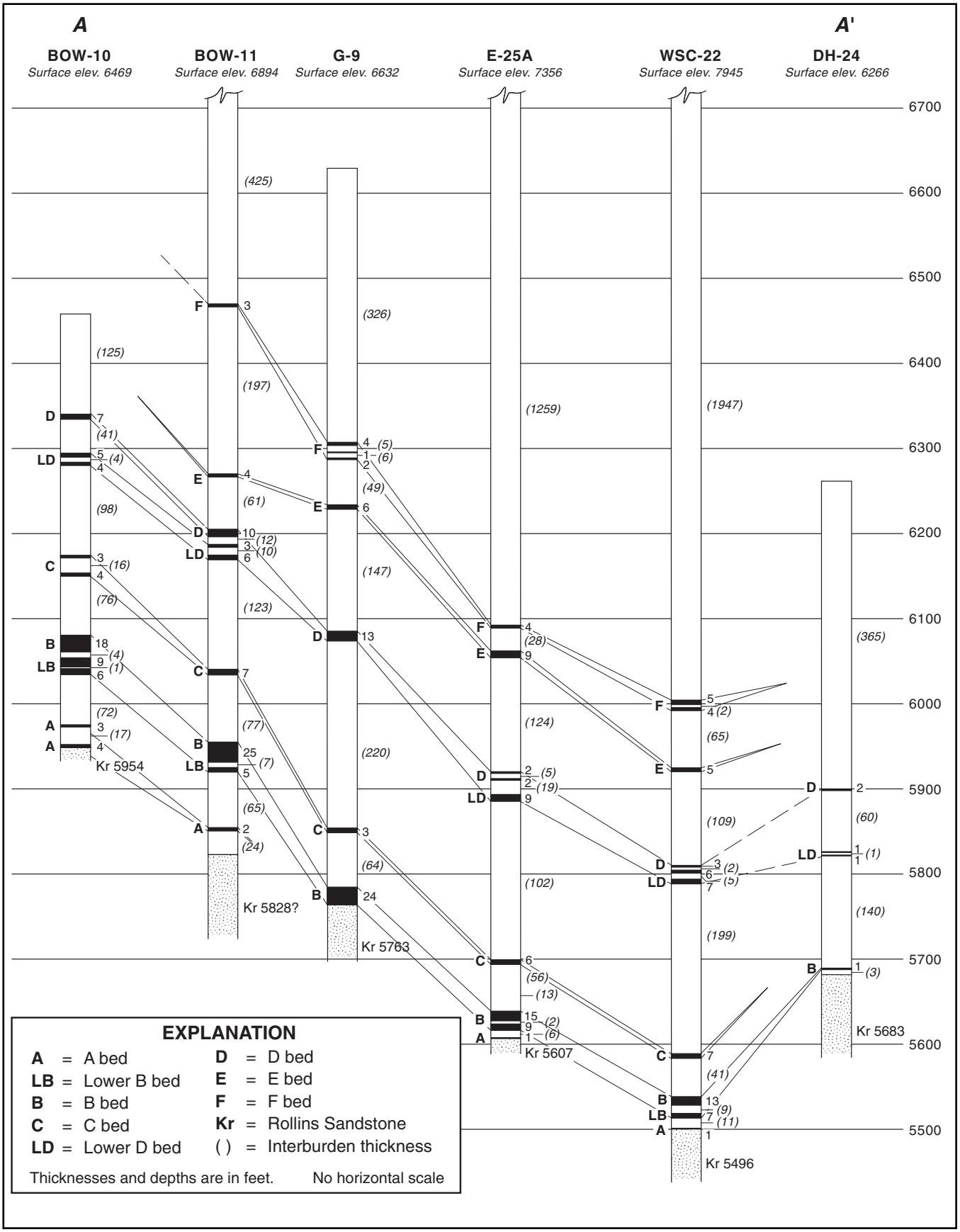


Figure 18. Coal Correlation Diagram A–A'.

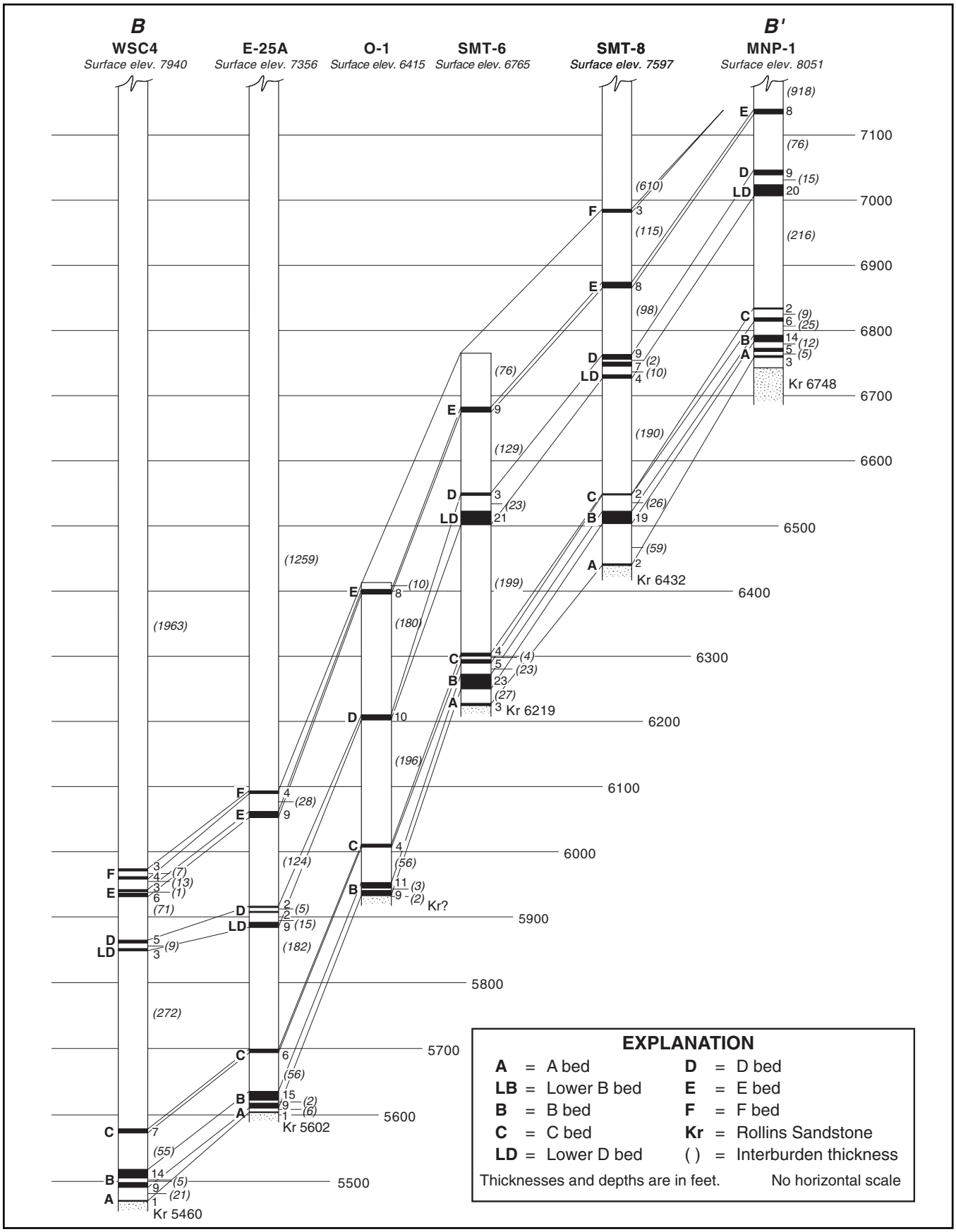


Figure 19. Coal Correlation Diagram B–B'.

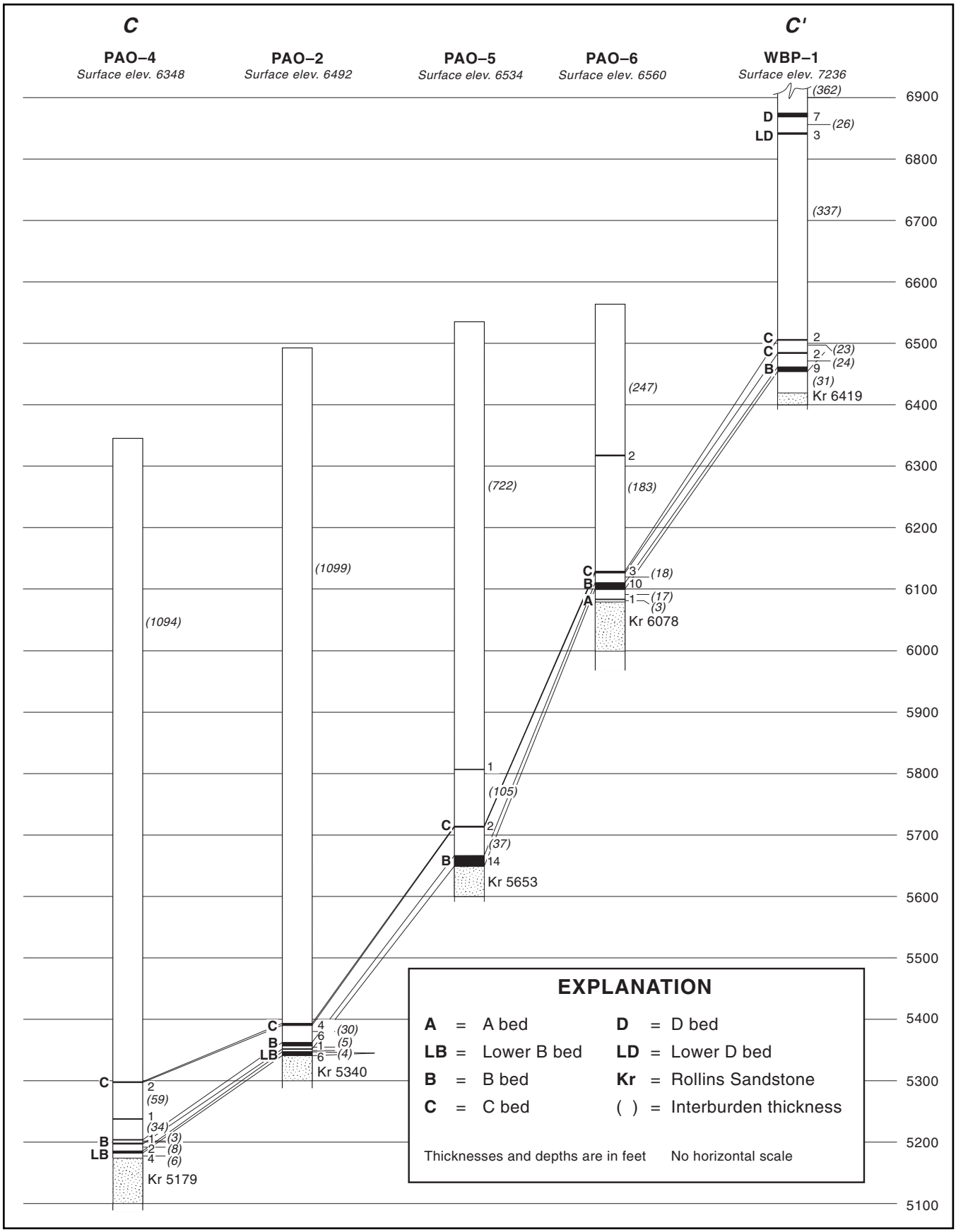


Figure 20. Coal Correlation Diagram C–C′.

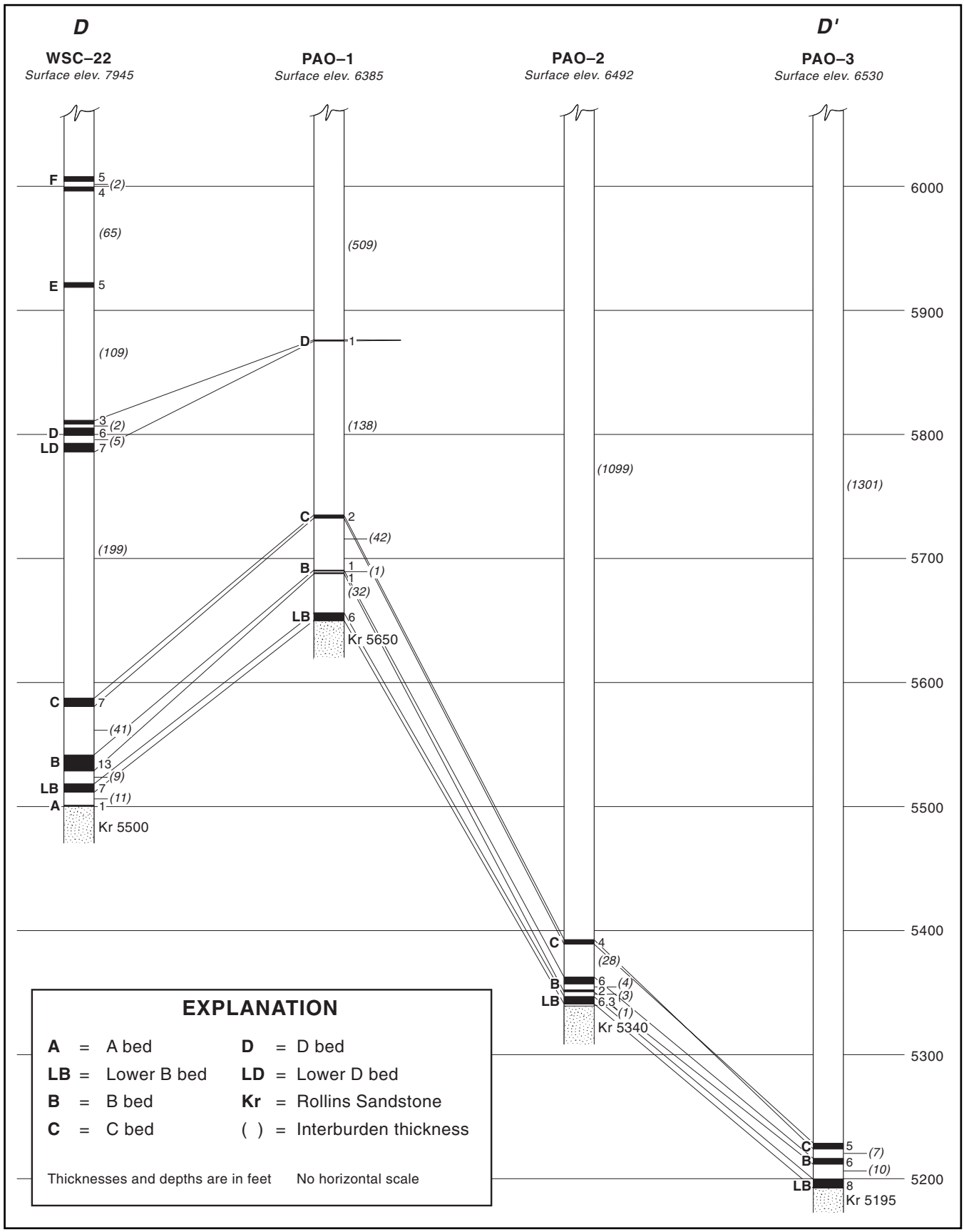


Figure 21. Coal Correlation Diagram D–D'.

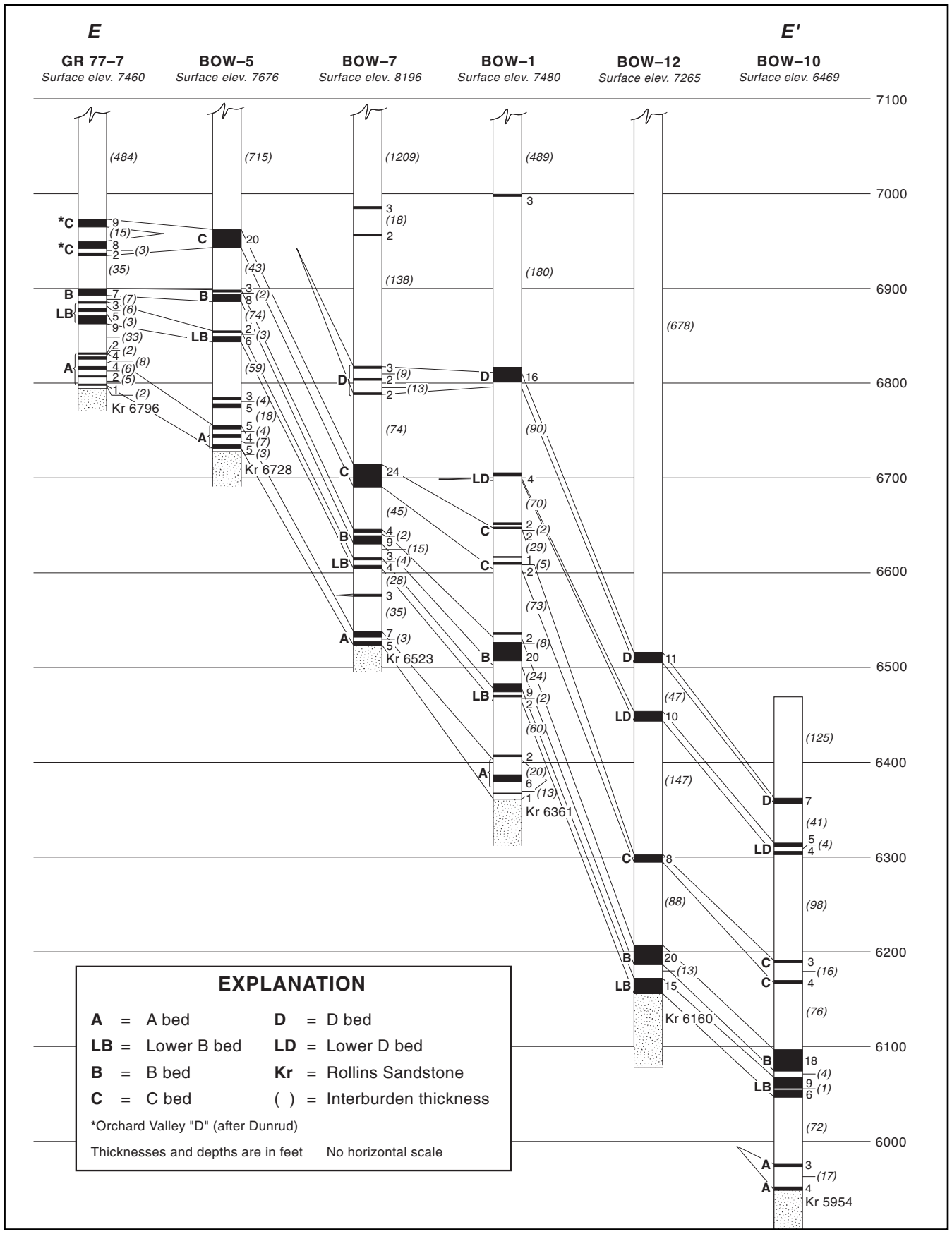


Figure 22. Coal Correlation Diagram E–E'.

COMPUTER TECHNIQUES

PREPARATION OF GEOLOGIC DATA

StratiFact™ program was used to assemble and manipulate the stratigraphic data. Correlations were made or modified in StratiFact™, then data were transferred into Microsoft Access™, where individual bed files were established. GIS coverages were digitized in ArcInfo:

- Drill hole locations were mapped and digitized.
- Land-use restrictions were digitized, or existing digital coverages were used where possible.
- Mine maps were assembled and digitized to produce a map of mined-out areas for each coal bed.
- Bed outcrops were constructed based on project data, geologic mapping (Dunrud, 1989), and topographic mapping and then digitized.
- Split lines for the B and Lower B beds and the D and Lower D beds were defined, mapped, and digitized.
- Burn areas shown on the geologic map by Dunrud (1989) were digitized.
- Bedrock geology in the five quadrangles of the coal field was modified from Dunrud's geologic map and digitized.
- The alluvial valley floor (Qa) was digitized and included on the bedrock geologic map.
- Existing coverages of surface and mineral ownership were obtained from the BLM and modified in the GIS for use in this project.

DST and Associates was responsible for producing most of the maps and all coal resource tables. The stratigraphic and GIS data generated by the CGS was transferred electronically to DST. The GRASS (Geographical Resource Analysis Support System) program was used by DST to produce maps of coal thickness (Figures 23a, 24a, 25a, and 26a), areas of reliability (Figures 23b, 24b, 25b, and 26b) coal depth (Figures 23c, 24c, 25c, and 26c); technologic restrictions (Figures 16a through 16d) and the required resource calculations (Appendix Tables A1a through A5c).

EXPLANATION OF GEOGRAPHIC RESOURCES ANALYSIS SUPPORT SYSTEM (GRASS)

The Somerset Coal Field study resource calculations were generated by raster maps using GRASS and reliability categories from Wood and others (1983). GRASS selects a data point (shown on Figure 27 as a circle representing one data point) which can be either coal thickness, overburden, interburden or elevation. Using a data point GRASS then extrapolates from a data point to the next data point creating a grid. For example: If one data point is 6 ft of coal and the next data point is 2 ft of coal, GRASS creates grid lines in increments of every 0.5 ft of coal thickness. A grid is created between adjacent data point creating a polygon. The resources are then calculated within each polygon for selected increments. If a larger or smaller distribution of data points is available for an identical area and two maps are generated for the same area using either a larger or smaller number of data points the griding sequence will change and GRASS will produce a different raster map. What may seem an inconsistency is simply the result of a different data set that creates a different griding sequence.

The edge of the polygon is sometimes determined by the boundary of the study area and the contour will end at the edge of that boundary.

COMPARISON BETWEEN DIFFERENT STUDY AREAS

In the instance of the Somerset quadrangle study, the boundary of the study area was extended 3 mi beyond the edge of the quadrangle for the purpose of extrapolating data and preventing a drop-off edge. In the case of the Somerset Coal Field study, which included the Somerset quadrangle, the boundaries have a different set of data points that extend beyond the 3 mi surrounding the Somerset quadrangle. The amount and density of data points for the Somerset Coal Field study varies greatly from one part of the field to the other as illustrated in Figure 17.

In the Somerset quadrangle study six seams were evaluated compared to four beds in the Somerset Coal Field study. In the field study the C seam was omitted between the B and Lower D resulting in a significant difference in the interburden calculations and therefore increasing available resources in both seams. Interburden between the B bed and the Lower D bed in some areas is as much as 250–300 ft.

Although comparison of resources from one study to the other would be ideal, each study needs to be evaluated individually by recognizing the focus of each study as well as the amount of data available. The Somerset quadrangle, in which the major mining has occurred, contained significantly more data points than any of the other quadrangles in the coal field study.

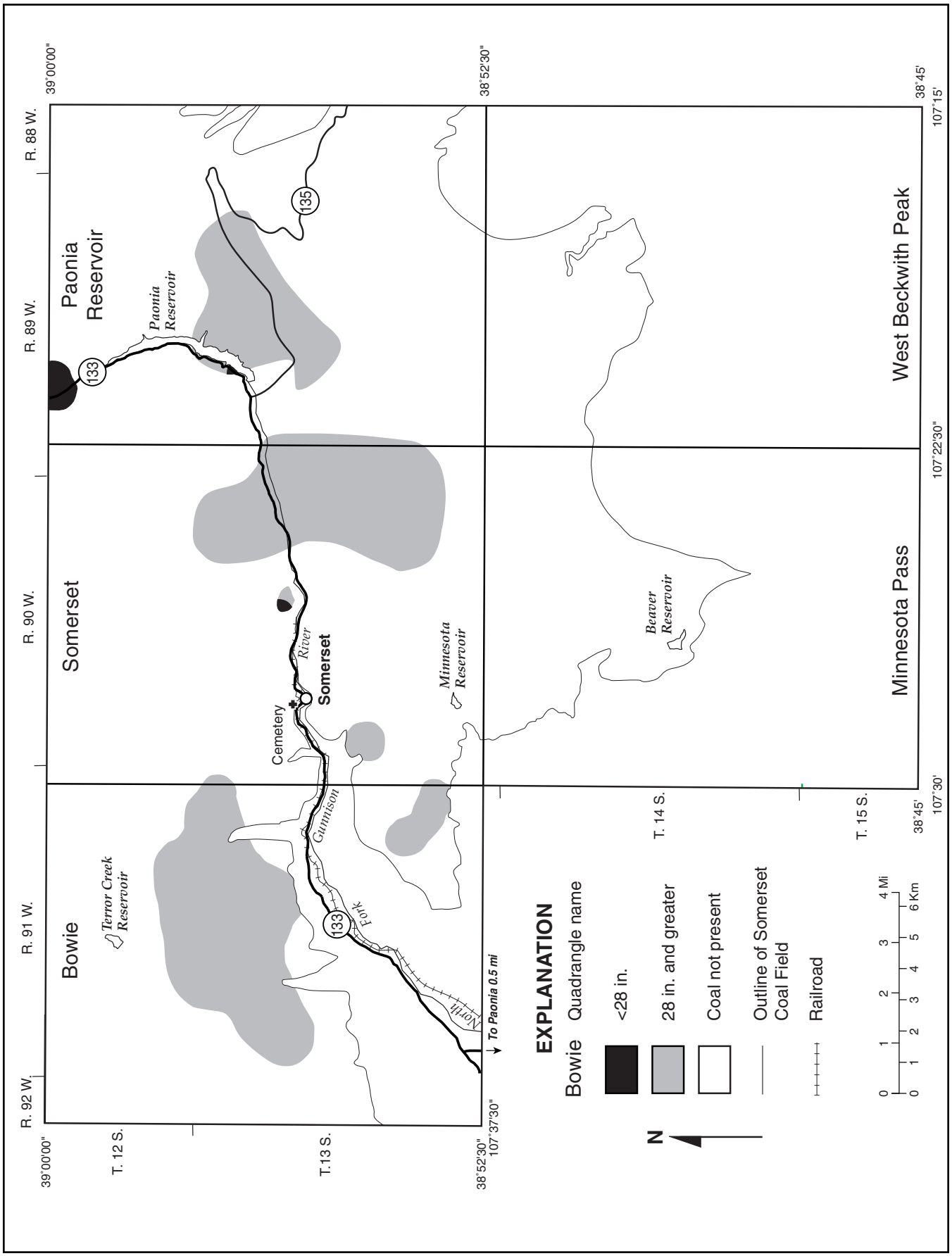


Figure 23a. Bed thickness (coal isopach) map of the Lower B coal bed, Somerset Coal Field.

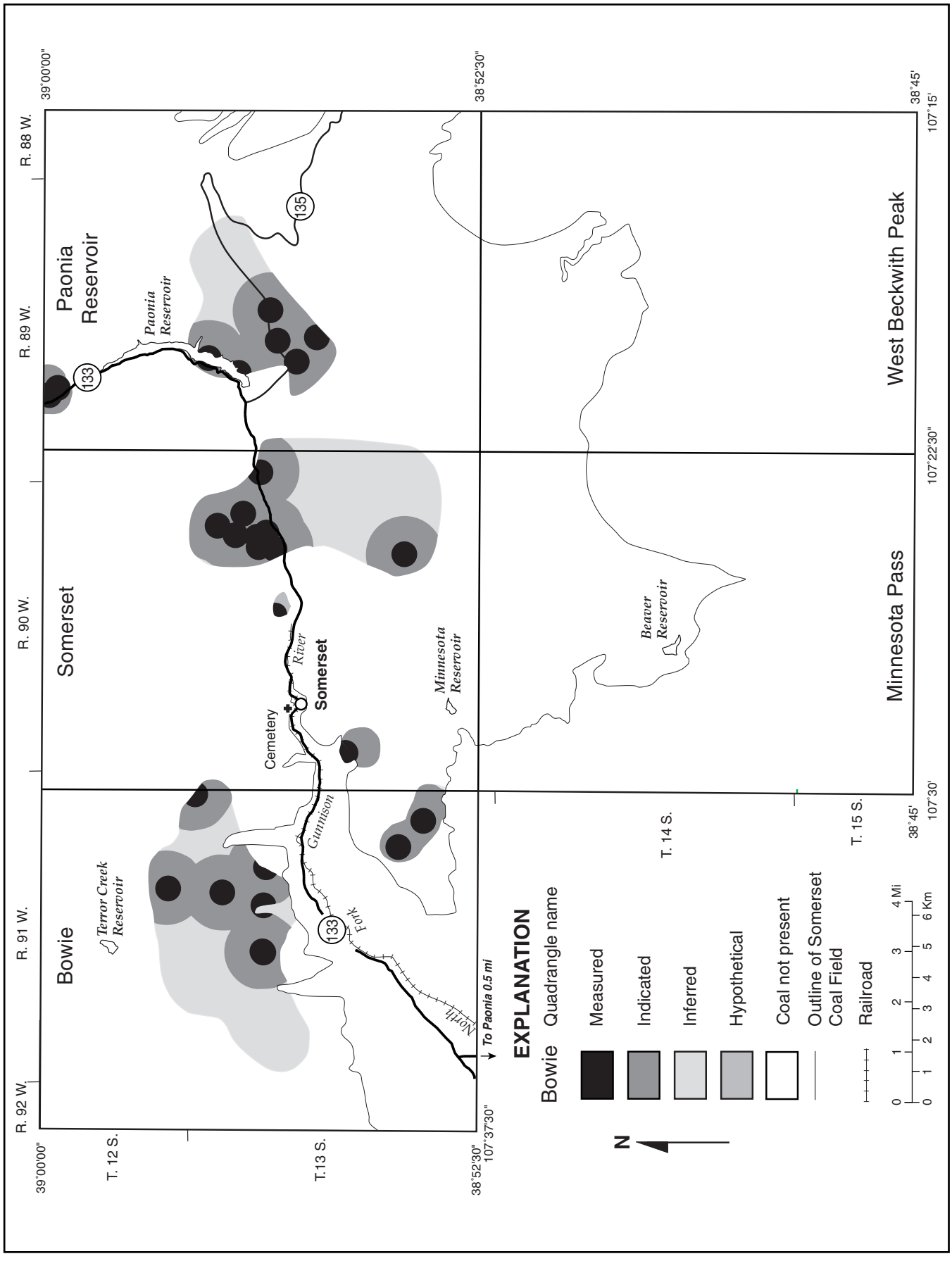


Figure 23b. Map showing areas of reliability of the Lower B coal bed, Somerset Coal Field.

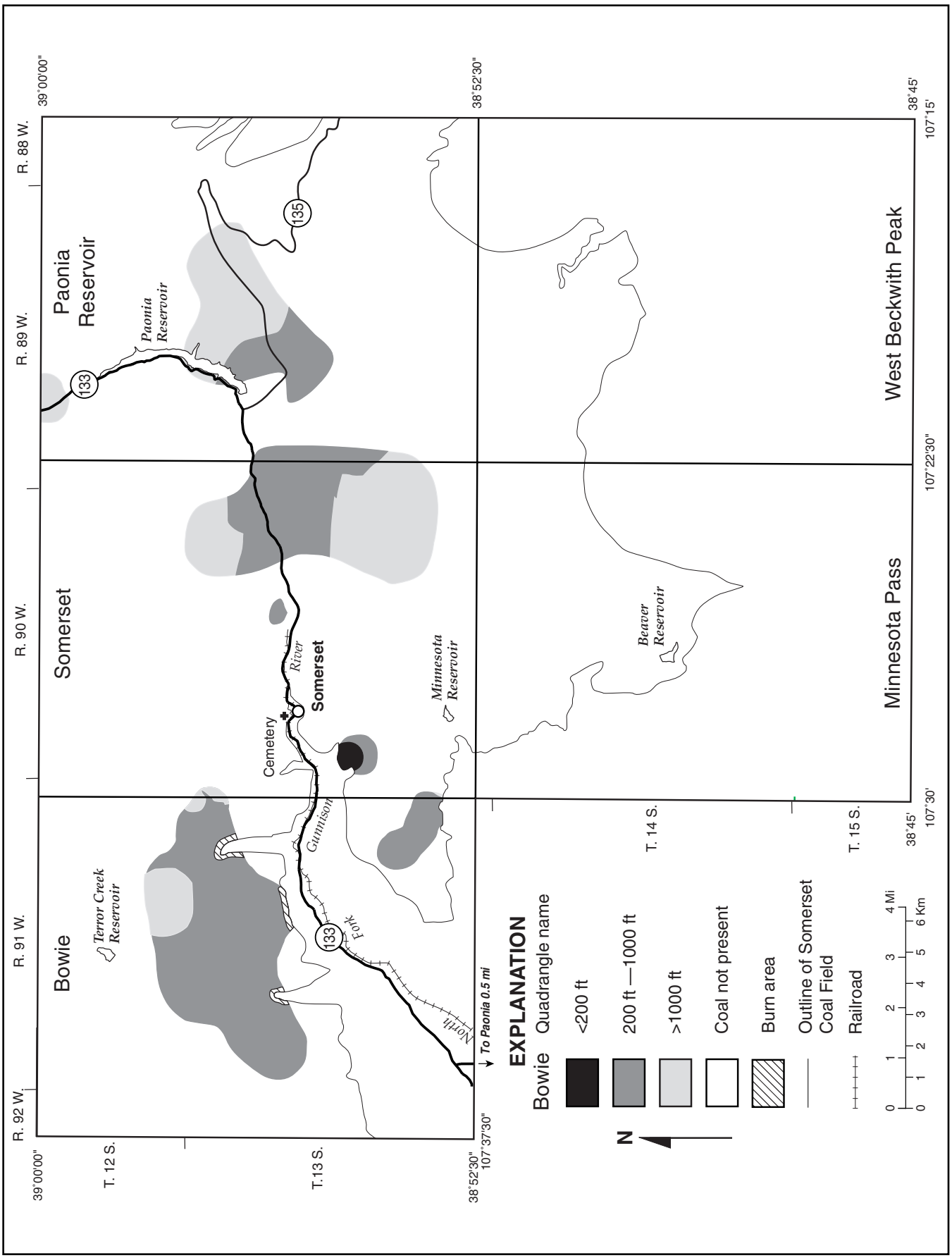


Figure 23c. Depth to coal (overburden isopach) map of the Lower B coal bed, Somerset Coal Field.

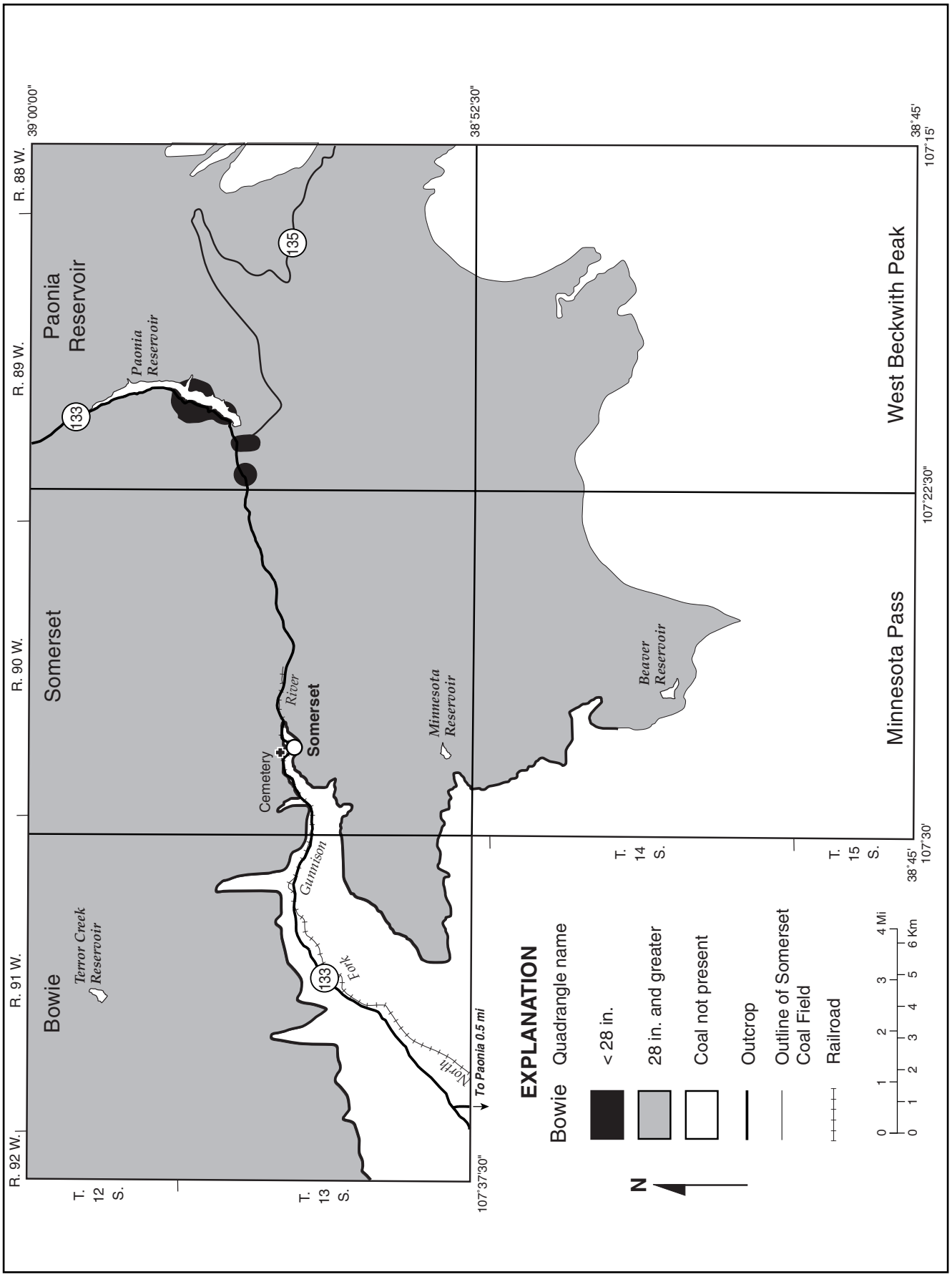


Figure 24a. Bed thickness (coal isopach) map of the B coal bed, Somerset Coal Field.

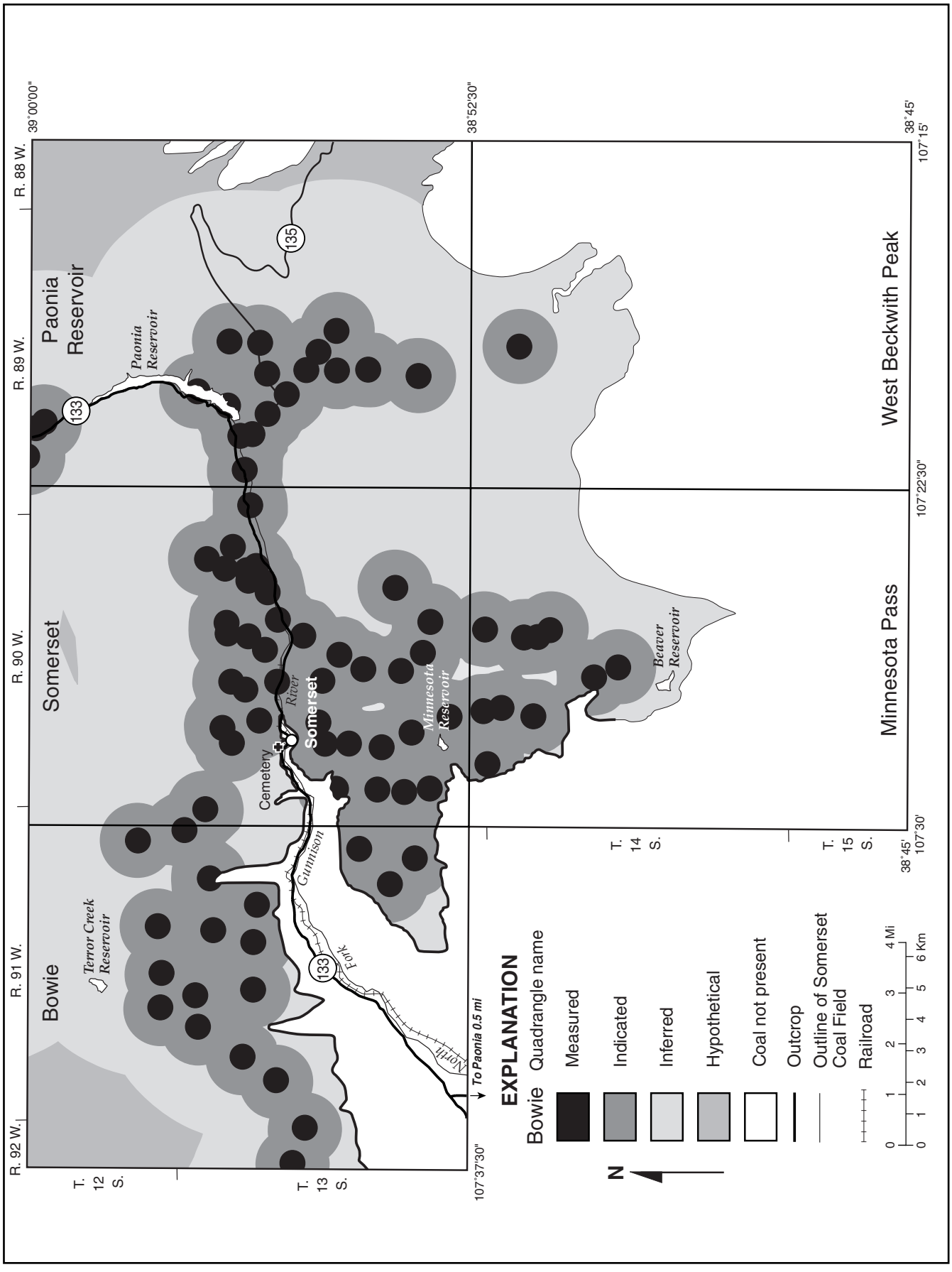


Figure 24b. Map showing areas of reliability of the B coal bed, Somerset Coal Field.

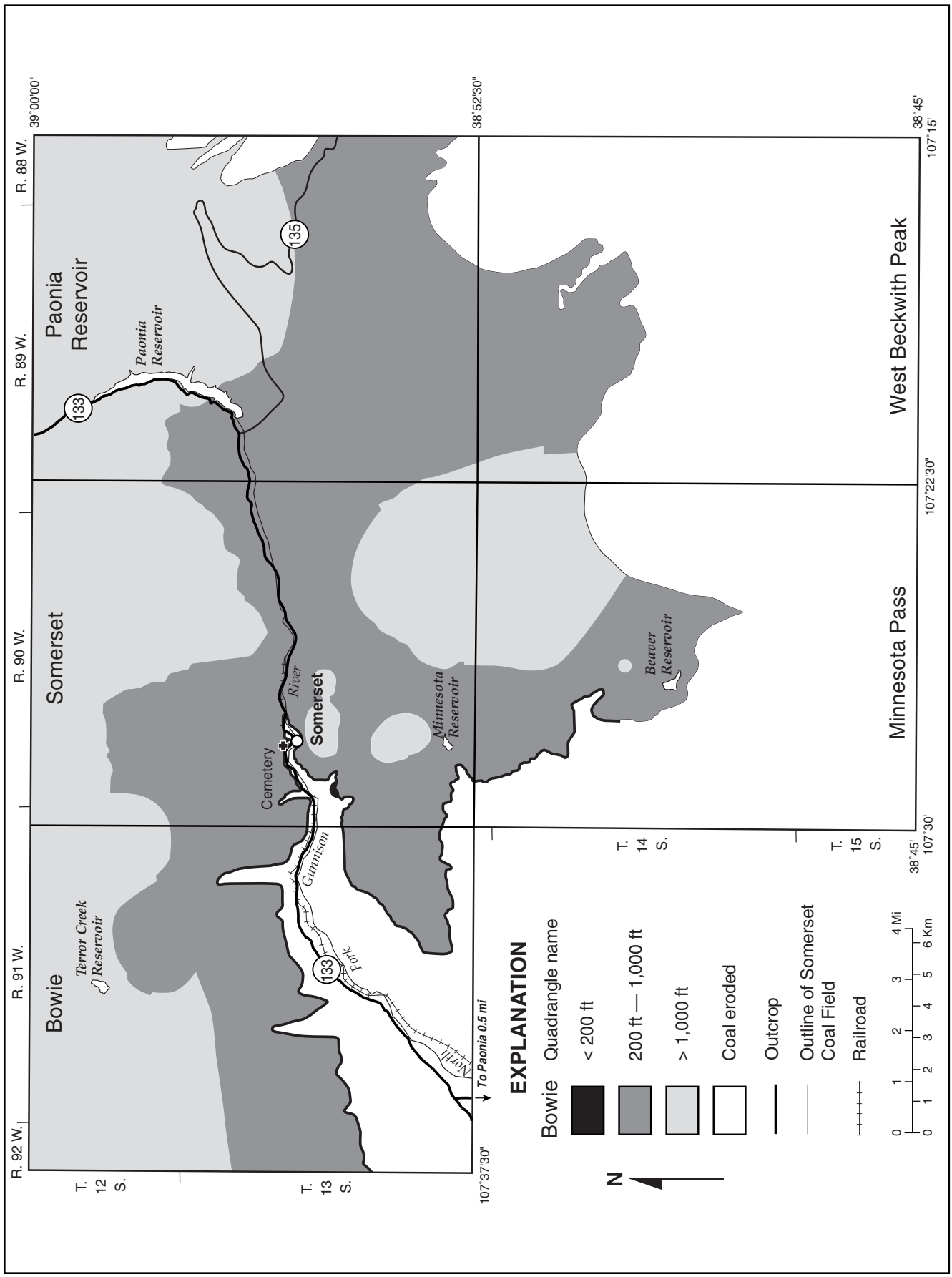


Figure 24c. Depth to coal (overburden isopach) map of the B coal bed, Somerset Coal Field.

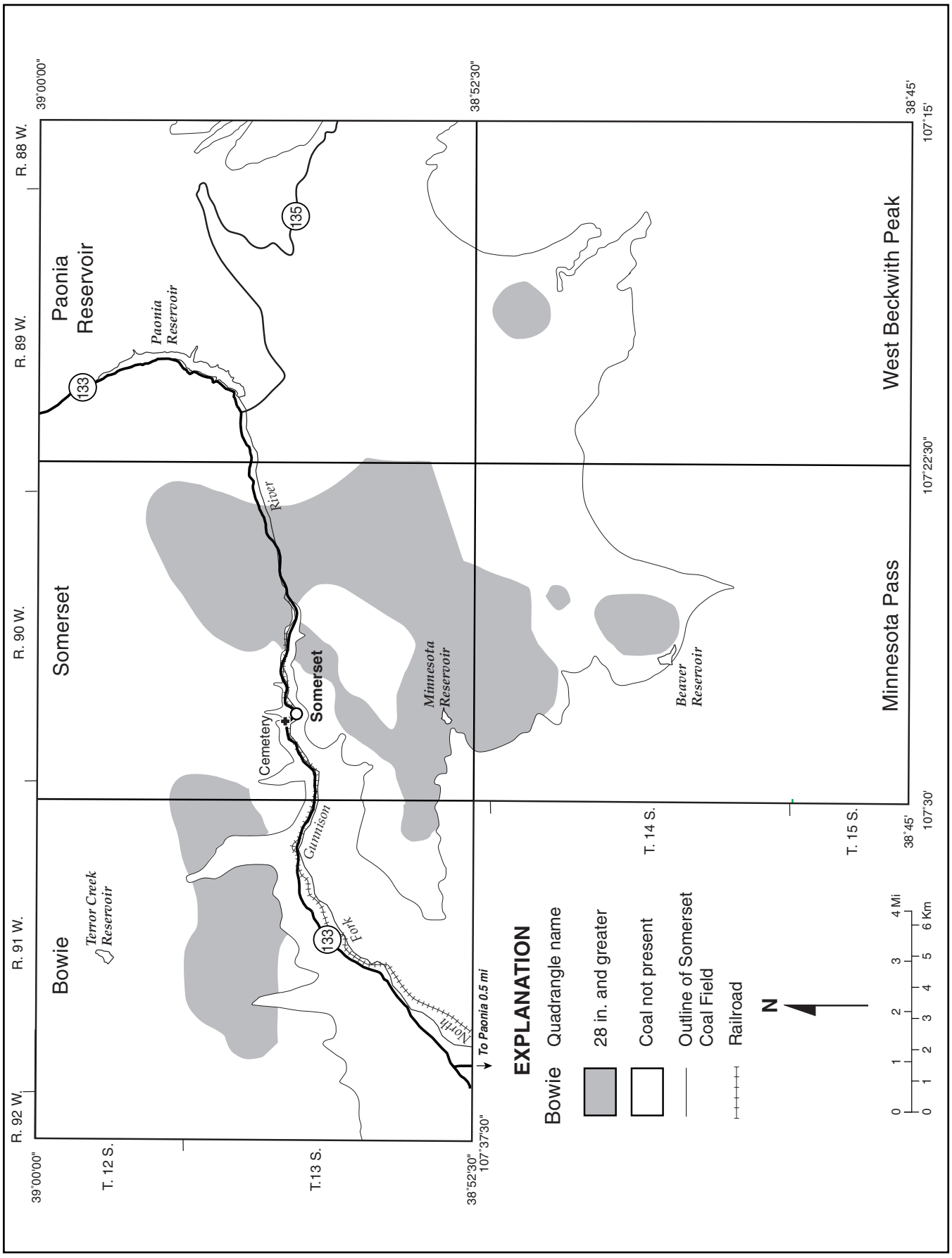


Figure 25a. Bed thickness (coal isopach) map of the Lower D coal bed, Somerset Coal Field.

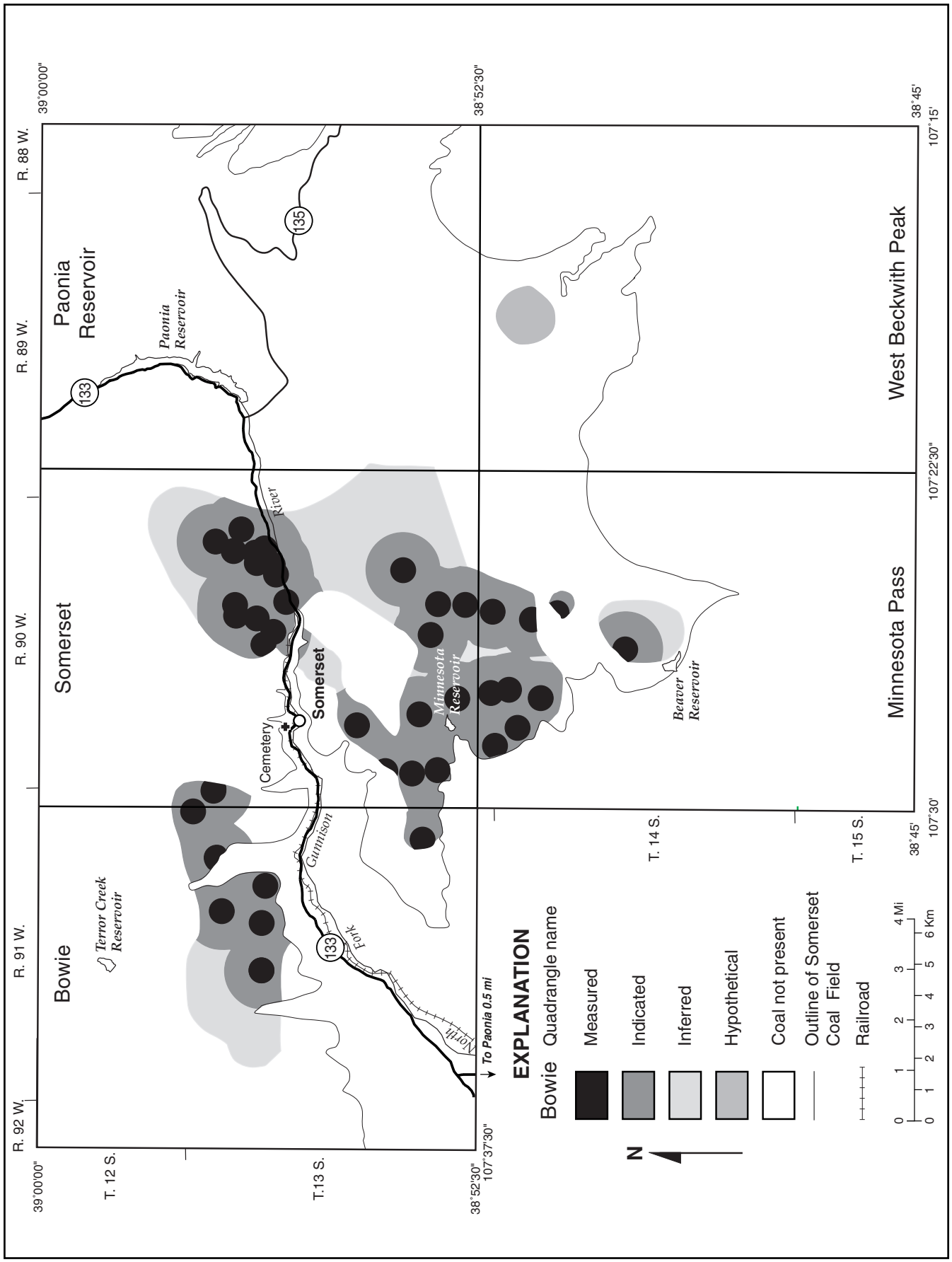


Figure 25b. Map showing areas of reliability of the Lower D coal bed, Somerset Coal Field.

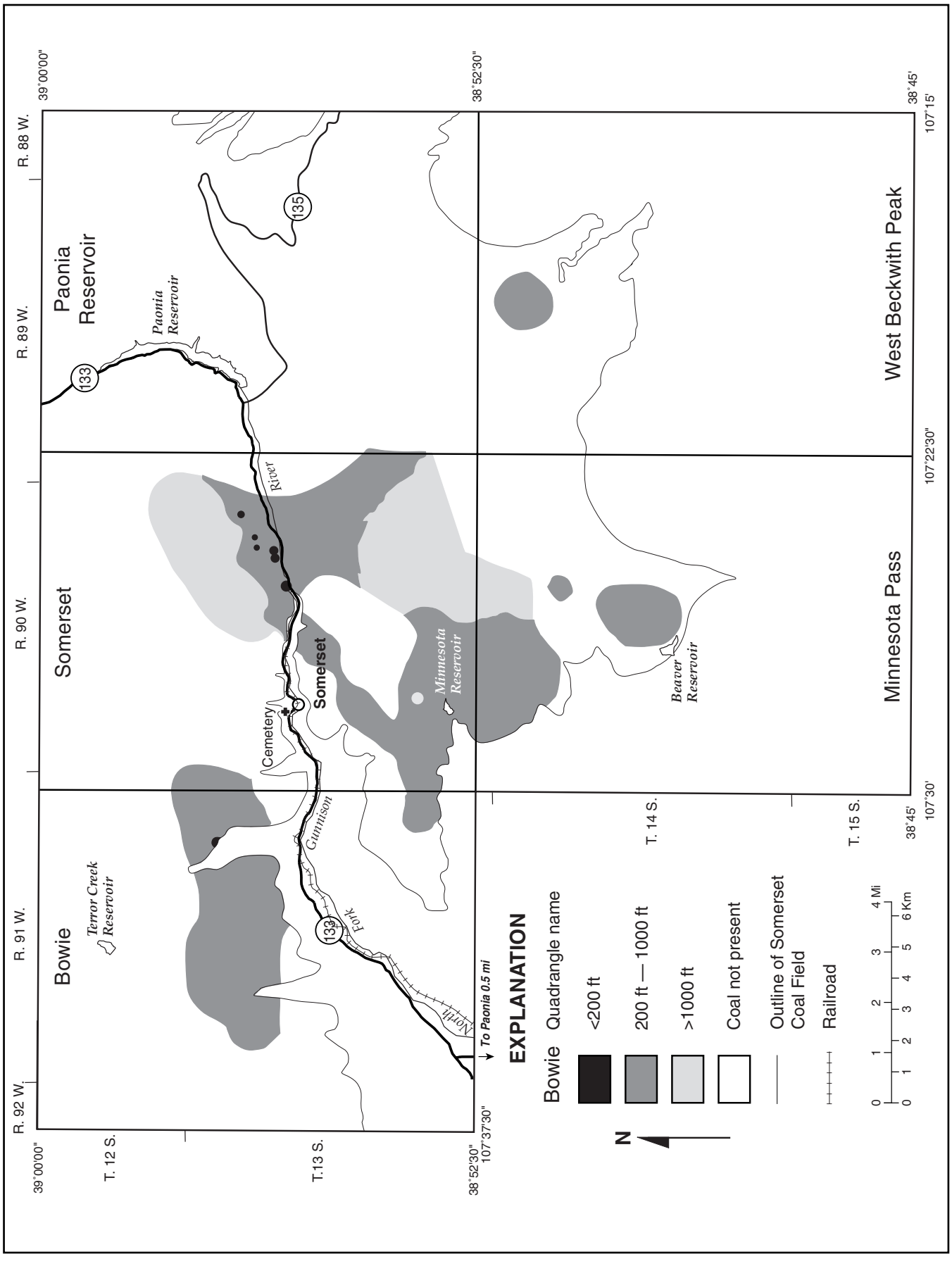


Figure 25c. Depth to coal (overburden isopach) map of the Lower D coal bed, Somerset Coal Field.

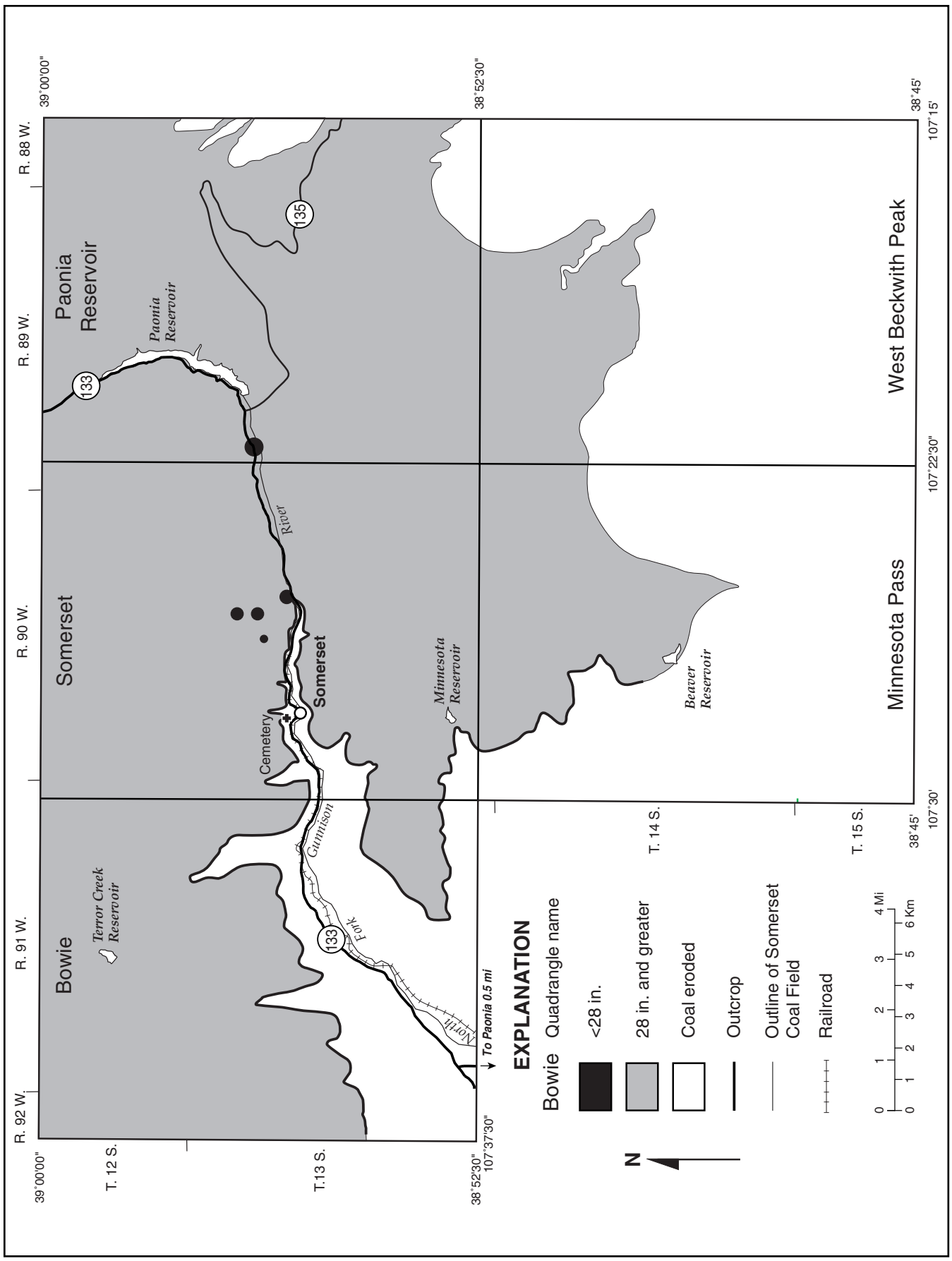


Figure 26a. Bed thickness (coal isopach) map of the D coal bed, Somerset Coal Field.

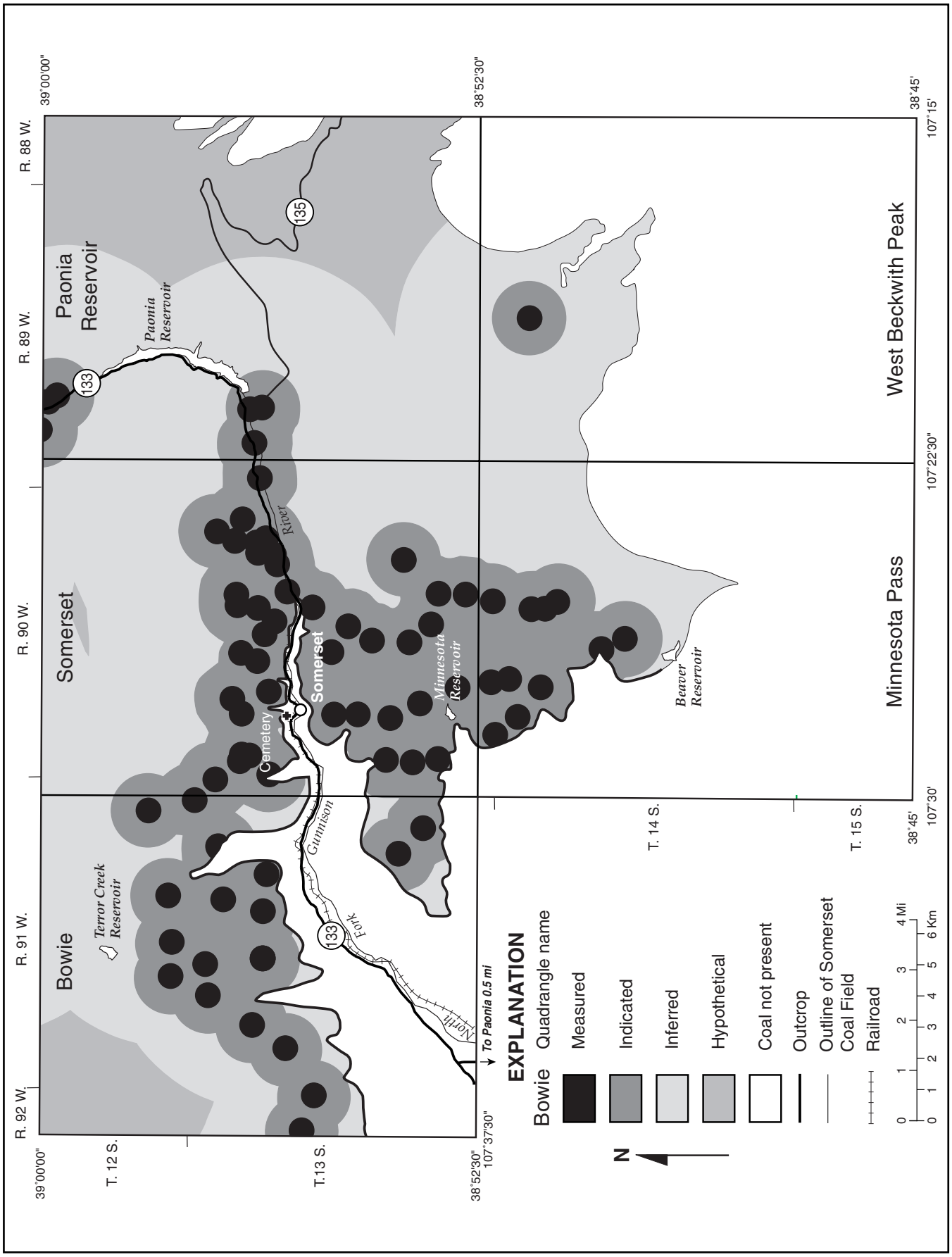


Figure 26b. Map showing areas of reliability of the D coal bed, Somerset Coal Field.

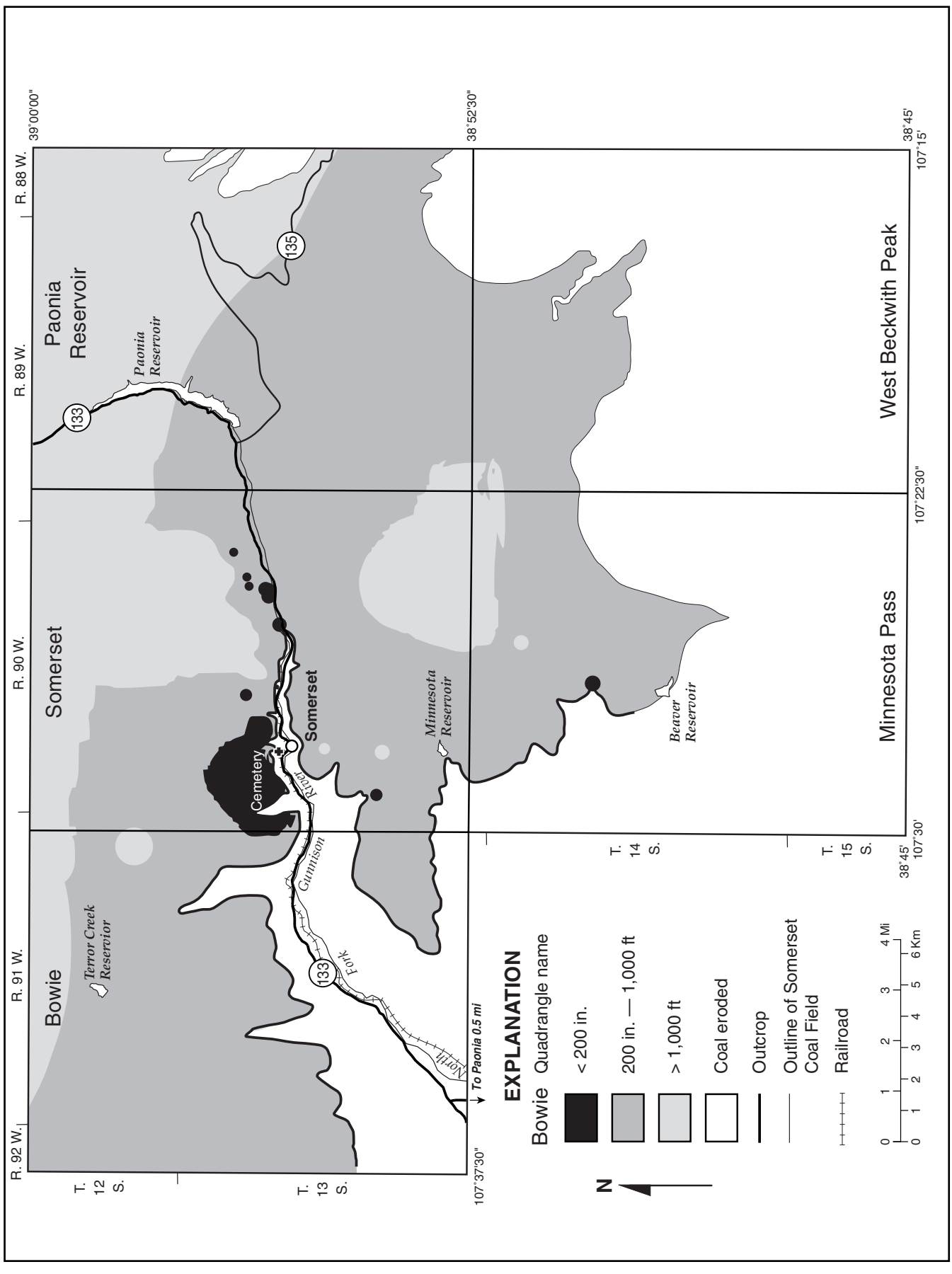


Figure 26c. Depth to coal (overburden isopach) map of the D coal bed, Somerset Coal Field.

Results: Coal Resources and Available Coal in the Somerset Coal Field

The Somerset Coal Field contains almost 5.8 billion tons of total original resources in the Lower B, B, Lower D and D. Approximately 286 million tons have been removed by mining or lost in the mining process, leaving 5.5 billion tons of remaining resources, or 95 percent of the original

Table 6. Summary of original, restricted, and available coal resources in the Paonia Reservoir, Somerset, Bowie, Minnesota Pass, West Beckwith Peak quadrangles, Somerset Coal Field for the Lower B, B, Lower D, and D by bed (millions of short tons) for beds >28 in.

Resource Category	Lower B	B	Lower D	D	Total
Original resources	287.0	2,974.1	424.4	2,112.3	5,797.7
Mined or lost in mining	0*	261.7	0*	24.7	286.4
Remaining	287.0	2,712.4	424.4	2,087.5	5,511.3
Land-use restrictions	0	0.1	0.7	0.4	1.2
Technologic restrictions	1.4	150.4	3.5	282.9	438.2
Available	285.7	2,561.9	420.1	1,804.2	5,071.9

*Probably reported as production in the B or D beds.

Table 7. Summary of restricted coal resources of the Somerset Coal Field by bed (thousands of short tons). All restricted tonnages, regardless of whether they overlap with other restrictions, are included. Figures do not necessarily coincide with those in Table 6 because adjustments have been made for overlapping restrictions in the overall summary totals in Table 6.

Resource Category	Lower B	B	Lower D	D	Total
		Land-use Restrictions			
Railroads	0	24	0	0	24
Streams	0	48	711	319	1,078
Towns	0	26	0	0	26
Roads	0	6	0	85	91
Total land-use restrictions	0	104	711	404	1,219
		Technologic Restrictions			
Interburden < 40 ft	0	140,775	3,542	282,447	426,764
Burn	0	7,259	0	0	7,259
Too thin (<28 in)	1,352	2,296	0	502	4,150
Total technologic restrictions	1,352	150,330	3,542	282,949	438,173
Total restrictions	1,352	150,434	4,253	283,353	439,392

resources still available for mining based on the study criteria of coals greater than 2.3 ft. Additionally, 429 million tons have been eliminated from the remaining coal due to technological restrictions leaving 5.07 billion tons of available coal in the Lower B, B, Lower D, and D, or 87 percent of the original resource (Table A5a).

In addition to the available resources contained in the Lower B, B, Lower D, and D beds, the study area also contains coals in the C and E beds, which were evaluated in the Somerset quadrangle study only (Eakins, 1998). These C and E beds were not evaluated for the entire coal field due to study constraints.

The C bed contains 402,938 short tons of available coal and the E bed contains 402,938 short tons of available coal in the Somerset quadrangle only for a combined additional resource of 793,590 short tons in the C and E beds.

Using today's underground mining methods coals from 7 ft to 14 ft are considered minable. Coal thicknesses greater than 14 ft in a bed currently being mined are also lost to future mining using today's mining methods. This does not mean that the remaining beds less than 7 ft or greater than 14 ft will not be minable at some time in the future.

The coal resources of the Somerset Coal Field, summarized in Tables A1a,b,c through A4a,b,c, provide detailed information on the coal resources of each of the four beds evaluated, and Tables A5a,b,c provide total resource information for the coal beds combined. Coal resources for the C and E beds in the Somerset quadrangle study are summarized in the Colorado Geological Survey Resource Series 36 (Eakins and others, 1998a).

Less than 0.01 percent of the original resource for the Lower B, B, Lower D, and D beds is between 1.2 and 2.3 ft thick. More than 86 percent of the original coal resource falls within a reliability category of either measured, indicated, or inferred (Figure 28). Coal within the measured category represents 8.7 percent of the total original resource, the indicated category represents 29.3 percent of the total original resource, the inferred category represents 48.2 percent of the total original resource and the hypothetical category represents 13.8 percent of the total original resource.

OVERVIEW—RESOURCE CATEGORIES

Original, remaining, and available coal resources calculated for the Somerset Coal Field are presented in Table A5a in the appendix. Original resources represent the amount of coal resources in the ground before production (Wood and others, 1983). Remaining resources are the coal resources in the ground after coal mined and lost-in-mining has been subtracted from the original resources (Carter and Gardner, 1989). Available resources are the resources that are available for development after coal restricted by land-use or technologic restrictions has been subtracted from the remaining resource (Carter and Gardner, 1989).

Resource estimates are subdivided into categories of overburden thickness (depth), coal thickness, and reliability of estimate. Overburden categories used were: 0–200 ft, 200–1000 ft, and >1000 ft. Two coal thickness categories were used: 1.2–2.3 ft (14–28 in.) and >2.3 ft (>28 in.). Reliability categories used were: Measured (coal within 0.25 mi of a data point); indicated (coal ranging from 0.25 to 0.75 mi from a data point); inferred (coal ranging from 0.75 to 3 mi from a data point); and hypothetical (coal more than 3 mi from a data point) (Figure 27) (Wood and others, 1983).

ORIGINAL RESOURCES

For the beds evaluated: the Lower B, B, Lower D, and D, approximately 3.5 billion tons, or 60.1 percent, of the original resource is less than 1000 ft deep, while approximately 2.3 billion tons, or 39.9 percent, is greater than 1000 ft deep. Almost all of the original resource is greater than 2.3 ft thick.

MINED-OUT AND REMAINING RESOURCES

Of the approximately 286 million tons of coal mined or lost-in-mining, approximately 94 percent is from the B bed and 6 percent is from the D bed. No coal was ever reported being mined in either the Lower B or Lower D beds specifically. Coal lost in mining includes coal unavailable to be mined due to previous mining of adjacent beds or mining of coal within the same bed. The amount

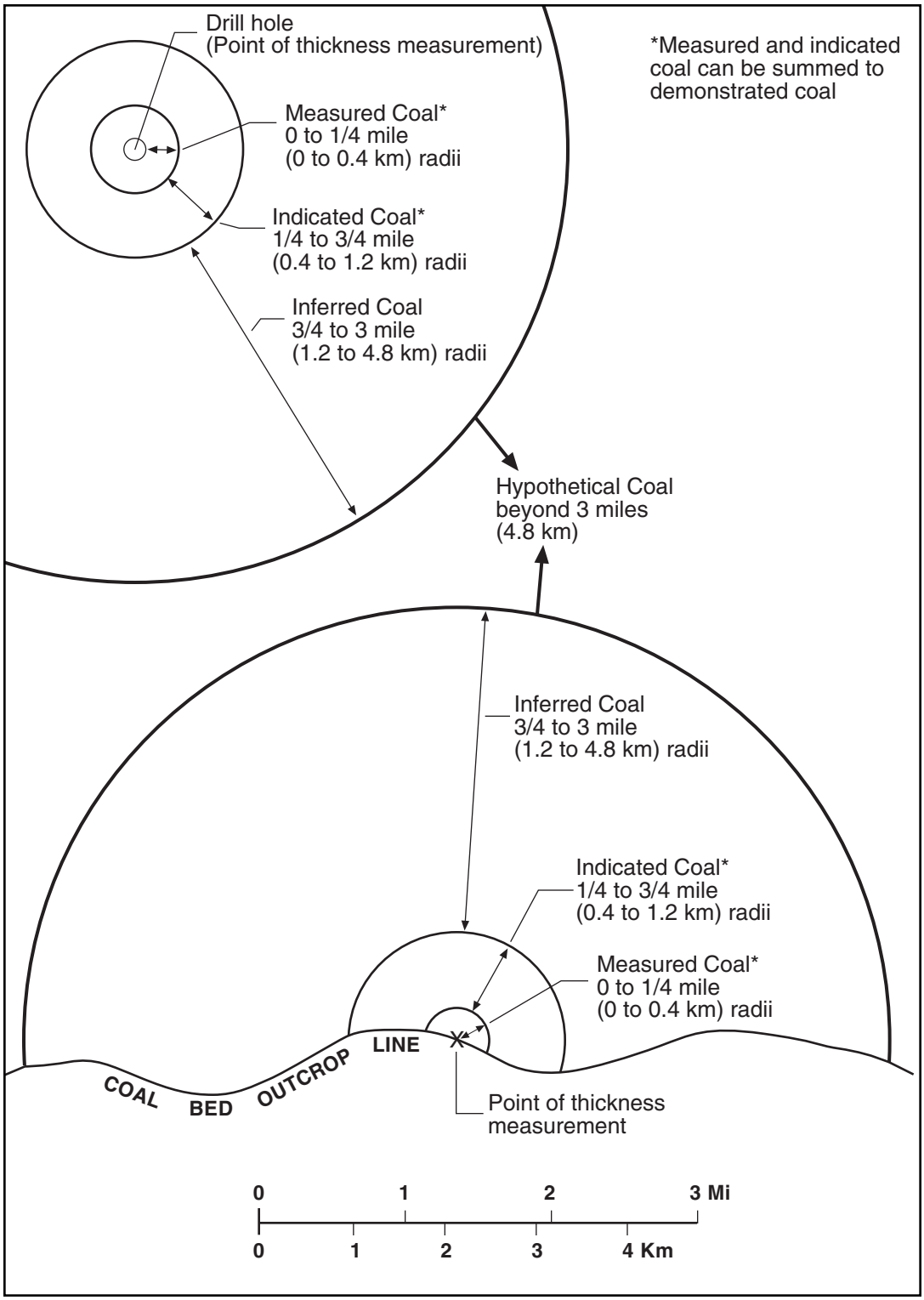


Figure 27. Diagram showing reliability categories based solely on distance from point of measurement (from Wood and others, 1983).

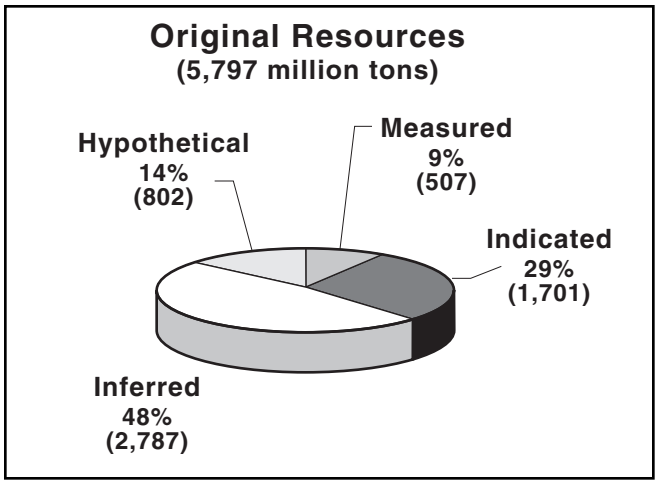


Figure 28. Chart showing reliablility categories of original resources (in millions of tons) in the Somerset Coal Field.

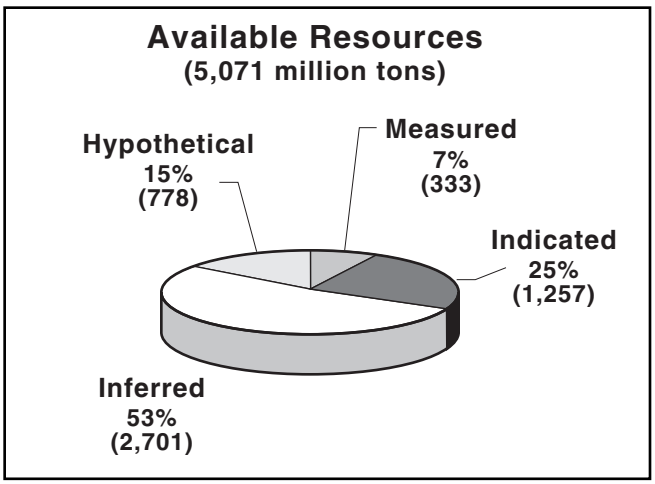


Figure 29. Chart showing reliability categories of available resources in millions of tons in the Somerset Coal Field.

of coal resource mined or lost-in-mining represents about 4.9 percent of the original resource of 5.79 billion tons. Remaining resources are, therefore, about 95.1 percent of the original resource, or 5.51 billion tons. Land-use restrictions and technologic restrictions further reduce the amount of available coal to 5.07 billion tons (Figure 29).

RESTRICTIONS AND AVAILABLE RESOURCES

Land-use restrictions limit the availability of only 1.2 million tons of coal, or much less than .01 percent of the original resource. Technologic restrictions, however, limit the availability of approximately 438 million tons, or 8.7 percent of the original resource. In cases where both land-use and technologic restrictions might apply, the technologic restrictions have been applied, based on the established hierarchy. The primary technologic restriction that has been applied is too thin interburden thickness. Beds less than 2.3 ft thick were considered a technologic restriction and therefore eliminated from the available coal resource. Thin beds account for about 0.9 percent of the total technologic restrictions for all beds.

As reported in the Somerset quadrangle study (Eakins and others, 1998a) the B bed has burned near the outcrop in the west-central and southwest parts of the Somerset quadrangle. The burned areas also extend into the Bowie quadrangle. This technologic restriction was estimated to be approximately 2.3 million tons in the Somerset Coal Field based on earlier mapping (Dunrud, 1989). No additional information or estimates of resources lost due to burn or the depth of the burn were found in either literature or in interviews.

Table 8. Comparison of original coal resources of the Somerset Coal Field and available coal resources (thousands of short tons). Coals less than 2.3 ft were eliminated in the original resource category calculations. Totals may differ from Tabel 6 due to rounding.

Coal Bed	Original Resource	Percentage of Original	Available Resource Remaining	Percentage of Total Available Resource
Lower B	286.7	5.0	285.7	5.6
B	2,971.1	51.3	2,561.9	50.5
Lower D	424.4	7.3	420.1	8.3
D	2,112.3	36.4	1,804.2	35.6
Total	5,794.5	100.0	5,071.9	100.0

Comparison to Other Coal Availability Studies

This coal availability study indicates that about 88 percent of the original coal resources in the coal field is available for mining. Studies in the Appalachian coal region indicate that approximately 50 percent of the original coal resource in that region is available for development (Carter and Gardner, 1994). The major differences between Appalachian and Uinta Basin coal development include land and mineral ownership patterns, population density, environmental regulations, mining methods, topography and land-management policies.

USGS and former USBM coal recoverability studies of the Appalachian region have shown that less than 10 percent of the original resource can be mined and marketed at a profit (Rohrbacher and others, 1994). The coal recoverability study of the Somerset Coal Field will be conducted in the future by the USGS to determine what percent of available coal is economically recoverable through design of theoretical mine plans for the coal field. These mine plans will consider the restricted resources of the coal field and mining practices of the Somerset Coal Field.

Comparison to Previous Coal Resource Calculations

The Somerset Coal Field study area includes all of Township13 and 14 South, Ranges 89, 90 and 91 West, however, the study includes only portions of Township 12 South and Ranges 89, 90, and 91 West. The focus of this particular study was to determine the resources of the Lower B, B, Lower D, and D beds as outlined in Tables A1a through A5c; with the geology determining the outline or the extent of the coal field. Although a comparison study of resources in this publication and previous studies by township and range would have been interesting, this was not the focus of this study, therefore no attempt was made to make a comparison of resources exclusively by township and range.

Landis (1959) estimated that a 210 sq mi area in the coal field contains 5.5 billion tons of coal is up to 3,000 ft deep. In-place coal resources to a depth of 6,000 ft in a 320-sq-mi area of the Somerset Coal Field (in both Delta and Gunnison Counties) were estimated at more than 8 billion tons (Landis, 1959). An unpublished draft report written by Vard Johnson on the geology and coal resources of the Paonia coal area, Delta and Gunnison Counties (Johnson, 1948a) indicates that more than 4.8 billion tons of reserves are within his area of study, of which 1.9 billion tons may be recoverable. The reserves were segregated into measured, indicated, and inferred reserves and also classified as original, remaining, and recoverable. There is not good agreement between the Johnson and Landis estimates. For two of the townships Johnson shows considerably more recoverable reserves than Landis indicates for coal resources. Johnson also estimates that 12 million tons of coal in Township 13 South, Ranges 90 and 91 West are strippable.

Landis provided resources for the Somerset Coal Field by county, township and range, overburden thickness, and coal thickness. Coal tonnage estimates given for the two townships and three ranges that occur within the Somerset Coal Field are provided in Table 9.

These estimates of original resources, which total more than 1.9 billion tons, are for beds greater than 14-in or 1.2-ft thick and overburden less than 3,000 ft. They include measured, indicated and, inferred resource estimates for each township.

Differences in total resources reported is to be expected as different data were available at the time Johnson (1948a) and Landis (1959) conducted their resource studies. Also differences in methodology applied, especially using computer techniques not available 40 years ago to either author, are applicable.

The coal resources for six beds in the Somerset Coal Field, were calculated by Eakins and others (1998b). Considerably different general parameters and assumptions were used in that study for the Energy Information Administration.

The resource calculations for Somerset Coal Field coal availability study did not include beds greater than 3,000 ft deep.

Table 9. Coal resource estimates for townships and ranges included in the Somerset Coal Field (Landis, 1959).

Township and Range	Estimated Coal Resources (million short tons)
T. 12 S., R. 89 W.	24
T. 12 S., R. 90 W.	136
T. 12 S., R. 91 W.	6
T. 13 S., R. 89 W.	458
T. 13 S., R. 90 W.	1,279
T. 13 S., R. 91 W.	27
Total	1,930

SUMMARY

Coal has been mined in the Somerset coal field dating back to the late 1800s. The coal was utilized initially for home heating, but was also recognized for its coking quality. With the 1902 completion of the Denver and Rio Grande Railroad spur line to Somerset, the coal field's opportunity for expanded markets, plus the high quality of the coal and the coking quality of the coal, encouraged increased production and larger mining operations.

The coal-bearing members of the Mesaverde Formation (Figure 3) lie on top of the distinctive cliff-forming Rollins Sandstone Member. The Bowie Shale Member, which lies directly on top of the Rollins Sandstone Member contains coal beds designated as A, B, and C, with the A bed being the lowest in the section. The Paonia Shale Member lies directly above the Bowie Shale Member and contains the D, E, and F beds. The A and F beds are not considered economically minable today; however, all the beds have been mined at one time or another.

Of the three active mines in the area, the Sanborn Creek and West Elk Mines are producing from the B seam; the Bowie No. 2 is mining in the D seam. The currently idle Bowie No. 1 was mining in the D seam.

In this study, only the B and D beds including their splits, the Lower B and Lower D, were evaluated. The Lower B and Lower D beds tend to be discontinuous, which is somewhat characteristic of all of the coal beds throughout the entire coal field as demonstrated in most coal correlation diagrams. Although it is possible to trace the coal zones, only the B, D and E seams are considered economically minable based on today's mining methods. Coals range in thickness from 2.3 ft (the minimum coal thickness considered in this report) to 24 ft.

The coals of the Somerset Coal Field are bituminous. Typical qualities for the B bed are: Moisture—4.4–8.2 percent, Volatile Matter—33.4–36.4 percent, Ash—8–12 percent, Sulfur—0.4–0.6 percent, Btu/lb—11,500–13,000, Free Swelling Index—0–0.5. Typical qualities for the D seam are: Moisture—5.1–8.5 percent, Volatile Matter—34.4–38.2 percent, Ash—6–12 percent, Sulfur—0.5–0.7 percent, Btu/lb—11,500–13,000, Free Swelling Index—0–4.0.

Land-use and technologic restrictions have not been considered in previous resource calculations except in the Somerset quadrangle study (Eakins and others, 1998a). In this study these factors were taken into consideration. Based on a hierarchy established by various agencies and the mining companies, land-use restrictions include (but are not limited to) the following: rights of way and easements, i.e. railroad; dwellings; roads; cemeteries; alluvial valley floors; reservoirs; and coal ownership. Technologic restrictions include (but are not limited to): coal depth, mined-out areas, burn, thin coal beds, or insufficient (less than 40 ft) interburden between coal beds. All of the resources affected by these factors have been subtracted from the total in-place coal resource estimates.

The digitized resource data was submitted to DST, a consulting company, along with drill hole information and an outline of the extent of the coal field that was based on geologic factors. The computer system, GRASS, was used for the resource calculations and then submitted to CGS in two different formats. The graphic format includes a bed thickness isopach map, reliability circles map, an overburden isopach map, and technologic restrictions map for each of the four seams. The tables format for each bed includes the original resources, mined-out resources and resources affected by technologic and land-use restrictions which have been subtracted from the original resources to determine the available resources.

Total original resource estimates identified 5,797 million tons. 286 million tons of coal were removed or lost in mining leaving 5,511 million tons remaining. Land-use restrictions eliminated 1.2 millions tons and technologic restrictions eliminated an additional 438 million tons leaving a total of 5,072 million tons of available coal resource in the Somerset coal field.

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APPENDIX A

Table A1a. Summary of estimated coal resources of the "Lower B" coal bed in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
ORIGINAL																
	0–200	0	614	614	0	266	266	0	0	0	0	0	0	0	880	880
	200–1000	317	21953	22270	0	50930	50930	0	15985	15985	0	0	0	317	88868	89185
	>1000	450	14118	14568	585	72260	72845	0	109528	109528	0	0	0	1035	195906	196941
	TOTAL	767	36685	37452	585	123456	124041	0	125513	125513	0	0	0	1352	285654	287006
MINED OUT**																
SURFACE	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DEEP	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REMAINING																
	0–200	0	614	614	0	266	266	0	0	0	0	0	0	0	880	880
	200–1000	317	21953	22270	0	50930	50930	0	15985	15985	0	0	0	317	88868	89185
	>1000	450	14118	14568	585	72260	72845	0	109528	109528	0	0	0	1035	195906	196941
	TOTAL	767	36685	37452	585	123456	124041	0	125513	125513	0	0	0	1352	285654	287006
RESTRICTIONS																
LAND–USE	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TECHNOLOGIC	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	317	0	317	0	0	0	0	0	0	0	0	0	317	0	317
	>1000	450	0	450	585	0	585	0	0	0	0	0	0	1035	0	1035
	TOTAL	767	0	767	585	0	585	0	0	0	0	0	0	1352	0	1352
TOTAL	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	317	0	317	0	0	0	0	0	0	0	0	0	317	0	317
	>1000	450	0	450	585	0	585	0	0	0	0	0	0	1035	0	1035
	TOTAL	767	0	767	585	0	585	0	0	0	0	0	0	1352	0	1352
AVAILABLE																
	0–200	0	614	614	0	266	266	0	0	0	0	0	0	0	880	880
	200–1000	0	21953	21953	0	50930	50930	0	15985	15985	0	0	0	0	88868	88868
	>1000	0	14118	14118	0	72260	72260	0	109528	109528	0	0	0	0	195906	195906
	TOTAL	0	36685	36685	0	123456	123456	0	125513	125513	0	0	0	0	285654	285654

**Mined and lost-in-mining, by surface and deep mining methods.

Note: Totals may not equal sum of components because of independent rounding.

Table A1b. Estimated coal resources of the "Lower B" coal bed in the Somerset Coal Field, Gunnison and Delta Counties, Colorado unavailable due to land use restrictions (in thousands of short tons)). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200–1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions
Note: Totals may not equal sum of components because of independent rounding.

Table A1c. Estimated coal resources of the "Lower B" coal bed unavailable due to technologic restrictions in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons).). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Interburden < 40 ft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200–1000																
	Interburden < 40 ft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	317	0	317	0	0	0	0	0	0	0	0	0	317	0	317
	TOTAL	317	0	317	0	0	0	0	0	0	0	0	0	317	0	317
>1000																
	Interburden < 40 ft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	450	0	450	585	0	585	0	0	0	0	0	0	1035	0	1035
	TOTAL	450	0	450	585	0	585	0	0	0	0	0	0	1035	0	1035
TOTAL																
	Interburden < 40 ft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	767	0	767	585	0	585	0	0	0	0	0	0	1352	0	1352
	TOTAL	767	0	767	585	0	585	0	0	0	0	0	0	1352	0	1352

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Table A2a. Summary of estimated coal resources of the "B" coal bed in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
ORIGINAL																
	0–200	0	2150	2150	0	0	0	0	0	0	0	0	0	0	2150	2150
	200–1000	1001	170416	171417	348	616304	616652	0	680425	680425	0	69223	69223	1349	1536368	1537717
	>1000	319	76485	76804	628	247418	248046	0	904661	904661	0	204679	204679	947	1433243	1434190
	TOTAL	1320	249051	250371	976	863722	864698	0	1585086	1585086	0	273902	273902	2296	2971761	2974057
MINED OUT**																
SURFACE	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DEEP	0–200	0	752	752	0	0	0	0	0	0	0	0	0	0	752	752
	200–1000	0	56518	56518	0	129791	129791	0	26460	26460	0	0	0	0	212769	212769
	>1000	0	21656	21656	0	26528	26528	0	0	0	0	0	0	0	48184	48184
	TOTAL	0	78926	78926	0	156319	156319	0	26460	26460	0	0	0	0	261705	261705
TOTAL	0–200	0	752	752	0	0	0	0	0	0	0	0	0	0	752	752
	200–1000	0	56518	56518	0	129791	129791	0	26460	26460	0	0	0	0	212769	212769
	>1000	0	21656	21656	0	26528	26528	0	0	0	0	0	0	0	48184	48184
	TOTAL	0	78926	78926	0	156319	156319	0	26460	26460	0	0	0	0	261705	261705
REMAINING																
	0–200	0	1398	1398	0	0	0	0	0	0	0	0	0	0	1398	1398
	200–1000	1001	113898	114899	348	486513	486861	0	653965	653965	0	69223	69223	1349	1323599	1324948
	>1000	319	54829	55148	628	220890	221518	0	904661	904661	0	204679	204679	947	1385059	1386006
	TOTAL	1320	170125	171445	976	707403	708379	0	1558626	1558626	0	273902	273902	2296	2710056	2712352
RESTRICTIONS																
LAND–USE	0–200	0	104	104	0	0	0	0	0	0	0	0	0	0	104	104
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	104	104	0	0	0	0	0	0	0	0	0	0	104	104
TECHNOLOGIC	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	1001	21687	22688	348	72048	72396	0	10616	10616	0	14	14	1349	104365	105714
	>1000	319	6684	7003	628	21996	22624	0	14985	14985	0	4	4	947	43669	44616
	TOTAL	1320	28371	29691	976	94044	95020	0	25601	25601	0	18	18	2296	148034	150330
TOTAL	0–200	0	104	104	0	0	0	0	0	0	0	0	0	0	104	104
	200–1000	1001	21687	22688	348	72048	72396	0	10616	10616	0	14	14	1349	104365	105714
	>1000	319	6684	7003	628	21996	22624	0	14985	14985	0	4	4	947	43669	44616
	TOTAL	1320	28475	29795	976	94044	95020	0	25601	25601	0	18	18	2296	148138	150434
AVAILABLE																
	0–200	0	1294	1294	0	0	0	0	0	0	0	0	0	0	1294	1294
	200–1000	0	92211	92211	0	414465	414465	0	643349	643349	0	69209	69209	0	1219234	1219234
	>1000	0	48145	48145	0	198894	198894	0	889676	889676	0	204675	204675	0	1341390	1341390
	TOTAL	0	141650	141650	0	613359	613359	0	1533025	1533025	0	273884	273884	0	2561918	2561918

**Mined and lost–in–mining, by surface and deep mining methods.

Note: Totals may not equal sum of components because of independent rounding.

Table A2b. Estimated coal resources of the "B" coal bed in the Somerset Coal Field, Gunnison and Delta Counties, Colorado unavailable due to land use restrictions (in thousands of short tons)). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	24	24	0	0	0	0	0	0	0	0	0	0	24	24
	Streams	0	48	48	0	0	0	0	0	0	0	0	0	0	48	48
	Roads	0	6	6	0	0	0	0	0	0	0	0	0	0	6	6
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	26	26	0	0	0	0	0	0	0	0	0	0	26	26
	TOTAL**	0	104	104	0	0	0	0	0	0	0	0	0	0	104	104
200–1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	24	24	0	0	0	0	0	0	0	0	0	0	24	24
	Streams	0	48	48	0	0	0	0	0	0	0	0	0	0	48	48
	Roads	0	6	6	0	0	0	0	0	0	0	0	0	0	6	6
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	26	26	0	0	0	0	0	0	0	0	0	0	26	26
	TOTAL	0	104	104	0	0	0	0	0	0	0	0	0	0	104	104

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Table A2c. Estimated coal resources of the "B" coal bed unavailable due to technologic restrictions in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons).). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Interburden < 40 ft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200–1000																
	Interburden < 40 ft	0	20686	20686	0	67577	67577	0	8829	8829	0	14	14	0	97106	97106
	Burn	0	1001	1001	0	4468	4468	0	1790	1790	0	0	0	0	7259	7259
	Too thin	1001	0	1001	348	0	348	0	0	0	0	0	0	1349	0	1349
	TOTAL	1001	21687	22688	348	72045	72393	0	10619	10619	0	14	14	1349	104365	105714
>1000																
	Interburden < 40 ft	0	6684	6684	0	21996	21996	0	14985	14985	0	4	4	0	43669	43669
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	319	0	319	628	0	628	0	0	0	0	0	0	947	0	947
	TOTAL	319	6684	7003	628	21996	22624	0	14985	14985	0	4	4	947	43669	44616
TOTAL																
	Interburden < 40 ft	0	27370	27370	0	89573	89573	0	23814	23814	0	18	18	0	140775	140775
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	1001	1001	0	4468	4468	0	1790	1790	0	0	0	0	7259	7259
	Too thin	1320	0	1320	976	0	976	0	0	0	0	0	0	2296	0	2296
	TOTAL	1320	28371	29691	976	94041	95017	0	25604	25604	0	18	18	2296	148034	150330

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Table A3a. Summary of estimated coal resources of the "Lower D" coal bed in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons).). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
ORIGINAL																
	0–200	0	2192	2192	0	0	0	0	0	0	0	0	0	0	2192	2192
	200–1000	0	47165	47165	0	143966	143966	0	88635	88635	0	8478	8478	0	288244	288244
	>1000	0	15761	15761	0	47759	47759	0	69644	69644	0	796	796	0	133960	133960
	TOTAL	0	65118	65118	0	191725	191725	0	158279	158279	0	9274	9274	0	424396	424396
MINED OUT**																
SURFACE	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DEEP	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
REMAINING																
	0–200	0	2192	2192	0	0	0	0	0	0	0	0	0	0	2192	2192
	200–1000	0	47165	47165	0	143966	143966	0	88635	88635	0	8478	8478	0	288244	288244
	>1000	0	15761	15761	0	47759	47759	0	69644	69644	0	796	796	0	133960	133960
	TOTAL	0	65118	65118	0	191725	191725	0	158279	158279	0	9274	9274	0	424396	424396
RESTRICTIONS																
LAND–USE	0–200	0	711	711	0	0	0	0	0	0	0	0	0	0	711	711
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	711	711	0	0	0	0	0	0	0	0	0	0	711	711
TECHNOLOGIC	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	75	75	0	2459	2459	0	0	0	0	2534	2534
	>1000	0	0	0	0	0	0	0	1008	1008	0	0	0	0	1008	1008
	TOTAL	0	0	0	0	75	75	0	3467	3467	0	0	0	0	3542	3542
TOTAL	0–200	0	711	711	0	0	0	0	0	0	0	0	0	0	711	711
	200–1000	0	0	0	0	75	75	0	2459	2459	0	0	0	0	2534	2534
	>1000	0	0	0	0	0	0	0	1008	1008	0	0	0	0	1008	1008
	TOTAL	0	711	711	0	75	75	0	3467	3467	0	0	0	0	4253	4253
AVAILABLE																
	0–200	0	1481	1481	0	0	0	0	0	0	0	0	0	0	1481	1481
	200–1000	0	47165	47165	0	143891	143891	0	86176	86176	0	8478	8478	0	285710	285710
	>1000	0	15761	15761	0	47759	47759	0	68636	68636	0	796	796	0	132952	132952
	TOTAL	0	64407	64407	0	191650	191650	0	154812	154812	0	9274	9274	0	420143	420143

**Mined and lost–in–mining, by surface and deep mining methods.
Note: Totals may not equal sum of components because of independent rounding.

Table A3b. Estimated coal resources of the "Lower D" coal bed in the Somerset Coal Field, Gunnison and Delta Counties, Colorado unavailable due to land use restrictions (in thousands of short tons)). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	711	711	0	0	0	0	0	0	0	0	0	0	711	711
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL**	0	711	711	0	0	0	0	0	0	0	0	0	0	711	711
200–1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	711	711	0	0	0	0	0	0	0	0	0	0	711	711
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	711	711	0	0	0	0	0	0	0	0	0	0	711	711

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Table A3c. Estimated coal resources of the "Lower D" coal bed unavailable due to technologic restrictions in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons).). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Interburden < 40 ft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200–1000																
	Interburden < 40 ft	0	0	0	0	75	75	0	2459	2459	0	0	0	0	2534	2534
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	75	75	0	2459	2459	0	0	0	0	2534	2534
>1000																
	Interburden < 40 ft	0	0	0	0	0	0	0	1008	1008	0	0	0	0	1008	1008
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	1008	1008	0	0	0	0	1008	1008
TOTAL																
	Interburden < 40 ft	0	0	0	0	75	75	0	3467	3467	0	0	0	0	3542	3542
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	75	75	0	3467	3467	0	0	0	0	3542	3542

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Table A4a. Summary of estimated remaining coal resources of the "D" coal bed in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons).). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
ORIGINAL																
	0–200	112	17645	17757	0	25642	25642	0	106	106	0	0	0	112	43393	43505
	200–1000	258	105361	105619	0	423431	423431	0	592318	592318	0	399643	399643	258	1520753	1521011
	>1000	271	30495	30766	0	71896	71896	0	325842	325842	0	119231	119231	271	547464	547735
	TOTAL	641	153501	154142	0	520969	520969	0	918266	918266	0	518874	518874	641	2111610	2112251
MINED OUT**																
SURFACE	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DEEP	0–200	40	16	56	0	0	0	0	0	0	0	0	0	40	16	56
	200–1000	27	2154	2181	0	2337	2337	0	11365	11365	0	8777	8777	27	24633	24660
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	67	2170	2237	0	2337	2337	0	11365	11365	0	8777	8777	67	24649	24716
TOTAL	0–200	40	16	56	0	0	0	0	0	0	0	0	0	40	16	56
	200–1000	27	2154	2181	0	2337	2337	0	11365	11365	0	8777	8777	27	24633	24660
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	67	2170	2237	0	2337	2337	0	11365	11365	0	8777	8777	67	24649	24716
REMAINING																
	0–200	72	17629	17701	0	25642	25642	0	106	106	0	0	0	72	43377	43449
	200–1000	231	103207	103438	0	421094	421094	0	580953	580953	0	390866	390866	231	1496120	1496351
	>1000	271	30495	30766	0	71896	71896	0	325842	325842	0	119231	119231	271	547464	547735
	TOTAL	574	151331	151905	0	518632	518632	0	906901	906901	0	510097	510097	574	2086961	2087535
RESTRICTIONS																
LAND–USE	0–200	72	332	404	0	0	0	0	0	0	0	0	0	72	332	404
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	72	332	404	0	0	0	0	0	0	0	0	0	72	332	404
TECHNOLOGIC	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	231	40310	40541	0	161878	161878	0	19063	19063	0	14322	14322	231	235573	235804
	>1000	271	19644	19915	0	27230	27230	0	0	0	0	0	0	271	46874	47145
	TOTAL	502	59954	60456	0	189108	189108	0	19063	19063	0	14322	14322	502	282447	282949
TOTAL	0–200	72	332	404	0	0	0	0	0	0	0	0	0	72	332	404
	200–1000	231	40310	40541	0	161878	161878	0	19063	19063	0	14322	14322	231	235573	235804
	>1000	271	19644	19915	0	27230	27230	0	0	0	0	0	0	271	46874	47145
	TOTAL	574	60286	60860	0	189108	189108	0	19063	19063	0	14322	14322	574	282779	283353
AVAILABLE																
	0–200	0	17297	17297	0	25642	25642	0	106	106	0	0	0	0	43045	43045
	200–1000	0	62897	62897	0	259216	259216	0	561890	561890	0	376544	376544	0	1260547	1260547
	>1000	0	10851	10851	0	44666	44666	0	325842	325842	0	119231	119231	0	500590	500590
	TOTAL	0	91045	91045	0	329524	329524	0	887838	887838	0	495775	495775	0	1804182	1804182

**Mined and lost–in–mining, by surface and deep mining methods.
Note: Totals may not equal sum of components because of independent rounding.

Table A4b. Estimated coal resources of the "D" coal bed in the Somerset Coal Field, Gunnison and Delta Counties, Colorado unavailable due to land use restrictions (in thousands of short tons)). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	43	276	319	0	0	0	0	0	0	0	0	0	43	276	319
	Roads	29	56	85	0	0	0	0	0	0	0	0	0	29	56	85
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL**	72	332	404	0	0	0	0	0	0	0	0	0	72	332	404
200–1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	43	276	319	0	0	0	0	0	0	0	0	0	43	276	319
	Roads	29	56	85	0	0	0	0	0	0	0	0	0	29	56	85
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	72	332	404	0	0	0	0	0	0	0	0	0	72	332	404

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Table A4c. Estimated coal resources of the "D" coal bed unavailable due to technologic restrictions in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons).). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Interburden < 40 ft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200–1000																
	Interburden < 40 ft	0	40310	40310	0	161878	161878	0	19063	19063	0	14322	14322	0	235573	235573
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	231	0	231	0	0	0	0	0	0	0	0	0	231	0	231
	TOTAL	231	40310	40541	0	161878	161878	0	19063	19063	0	14322	14322	231	235573	235804
>1000																
	Interburden < 40 ft	0	19644	19644	0	27230	27230	0	0	0	0	0	0	0	46874	46874
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	271	0	271	0	0	0	0	0	0	0	0	0	271	0	271
	TOTAL	271	19644	19915	0	27230	27230	0	0	0	0	0	0	271	46874	47145
TOTAL																
	Interburden < 40 ft	0	59954	59954	0	189108	189108	0	19063	19063	0	14322	14322	0	282447	282447
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	502	0	502	0	0	0	0	0	0	0	0	0	502	0	502
	TOTAL	502	59954	60456	0	189108	189108	0	19063	19063	0	14322	14322	502	282447	282949

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.
Note: Totals may not equal sum of components because of independent rounding.

Table A5a. Summary of estimated remaining coal resources of the Lower B, B, Lower D, and D coal beds in the Somerset Coal Field, Gunnison and Delta Counties, Colorado (in thousands of short tons). Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
ORIGINAL																
	0–200	112	22601	22713	0	25908	25908	0	106	106	0	0	0	112	48615	48727
	200–1000	1576	344895	346471	348	1234631	1234979	0	1377363	1377363	0	477344	477344	1924	3434233	3436157
	>1000	1040	136859	137899	1213	439333	440546	0	1409675	1409675	0	324706	324706	2253	2310573	2312826
	TOTAL	2728	504355	507083	1561	1699872	1701433	0	2787144	2787144	0	802050	802050	4289	5793421	5797710
MINED OUT**																
SURFACE	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DEEP	0–200	40	768	808	0	0	0	0	0	0	0	0	0	40	768	808
	200–1000	27	58672	58699	0	132128	132128	0	37825	37825	0	8777	8777	27	237402	237429
	>1000	0	21656	21656	0	26528	26528	0	0	0	0	0	0	0	48184	48184
	TOTAL	67	81096	81163	0	158656	158656	0	37825	37825	0	8777	8777	67	286354	286421
TOTAL	0–200	40	768	808	0	0	0	0	0	0	0	0	0	40	768	808
	200–1000	27	58672	58699	0	132128	132128	0	37825	37825	0	8777	8777	27	237402	237429
	>1000	0	21656	21656	0	26528	26528	0	0	0	0	0	0	0	48184	48184
	TOTAL	67	81096	81163	0	158656	158656	0	37825	37825	0	8777	8777	67	286354	286421
REMAINING																
	0–200	72	21833	21905	0	25908	25908	0	106	106	0	0	0	72	47847	47919
	200–1000	1549	286223	287772	348	1102503	1102851	0	1339538	1339538	0	468567	468567	1897	3196831	3198728
	>1000	1040	115203	116243	1213	412805	414018	0	1409675	1409675	0	324706	324706	2253	2262389	2264642
	TOTAL	2661	423259	425920	1561	1541216	1542777	0	2749319	2749319	0	793273	793273	4222	5507067	5511289
RESTRICTIONS																
LAND–USE	0–200	72	1147	1219	0	0	0	0	0	0	0	0	0	72	1147	1219
	200–1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	72	1147	1219	0	0	0	0	0	0	0	0	0	72	1147	1219
TECHNOLOGIC	0–200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	200–1000	1549	61997	63546	348	234001	234349	0	32138	32138	0	14336	14336	1897	342472	344369
	>1000	1040	26328	27368	1213	49226	50439	0	15993	15993	0	4	4	2253	91551	93804
	TOTAL	2589	88325	90914	1561	283227	284788	0	48131	48131	0	14340	14340	4150	434023	438173
TOTAL	0–200	72	1147	1219	0	0	0	0	0	0	0	0	0	72	1147	1219
	200–1000	1549	61997	63546	348	234001	234349	0	32138	32138	0	14336	14336	1897	342472	344369
	>1000	1040	26328	27368	1213	49226	50439	0	15993	15993	0	4	4	2253	91551	93804
	TOTAL	2661	89472	92133	1561	283227	284788	0	48131	48131	0	14340	14340	4222	435170	439392
AVAILABLE																
	0–200	0	20686	20686	0	25908	25908	0	106	106	0	0	0	0	46700	46700
	200–1000	0	224226	224226	0	868502	868502	0	1307400	1307400	0	454231	454231	0	2854359	2854359
	>1000	0	88875	88875	0	363579	363579	0	1393682	1393682	0	324702	324702	0	2170838	2170838
	TOTAL	0	333787	333787	0	1257989	1257989	0	2701188	2701188	0	778933	778933	0	5071897	5071897

**Mined and lost in mining, by surface and deep mining methods.

Table A5b. Estimated coal resources of the Lower B, B, Lower D, and D coal beds unavailable due to land use restrictions in the Somerset Coal Field, Gunnison and Delta Counties, Colorado. Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred, and hypothetical).

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	24	24	0	0	0	0	0	0	0	0	0	0	24	24
	Streams	43	1035	1078	0	0	0	0	0	0	0	0	0	43	1035	1078
	Roads	29	62	91	0	0	0	0	0	0	0	0	0	29	62	91
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	26	26	0	0	0	0	0	0	0	0	0	0	26	26
	TOTAL**	72	1147	1219	0	0	0	0	0	0	0	0	0	72	1147	1219
200–1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>1000																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Streams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL																
	Cemeteries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Railroads	0	24	24	0	0	0	0	0	0	0	0	0	0	24	24
	Streams	43	1035	1078	0	0	0	0	0	0	0	0	0	43	1035	1078
	Roads	29	62	91	0	0	0	0	0	0	0	0	0	29	62	91
	Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Towns	0	26	26	0	0	0	0	0	0	0	0	0	0	26	26
	TOTAL	72	1147	1219	0	0	0	0	0	0	0	0	0	72	1147	1219

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.

Table A5c. Estimated coal resources Lower B, B, Lower D, D coal beds unavailable due to technologic restrictions in the Somerset Coal Field, Gunnison and Delta Counties, Colorado. Resources are subdivided into categories of overburden thickness (0–200 ft, 200–1000 ft, and >1000 ft), coal thickness (1.2–2.3 ft and >2.3 ft), and reliability of estimate (measured, indicated, inferred and hypothetical

		MEASURED (ft)			INDICATED (ft)			INFERRED (ft)			HYPOTHETICAL (ft)			TOTAL (ft)		
		1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total	1.2–2.3	>2.3	Total
0–200																
	Interburden < 40 ft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200–1000																
	Interburden < 40 ft	0	60996	60996	0	229530	229530	0	30351	30351	0	14336	14336	0	335213	335213
	Burn	0	1001	1001	0	4468	4468	0	1790	1790	0	0	0	0	7259	7259
	Too thin	1549	0	1549	348	0	348	0	0	0	0	0	0	1897	0	1897
	TOTAL	1549	61997	63546	348	233998	234346	0	32141	32141	0	14336	14336	1897	342472	344369
>1000																
	Interburden < 40 ft	0	26328	26328	0	49226	49226	0	15993	15993	0	4	4	0	91551	91551
	Burn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Too thin	1040	0	1040	1213	0	1213	0	0	0	0	0	0	2253	0	2253
	TOTAL	1040	26328	27368	1213	49226	50439	0	15993	15993	0	4	4	2253	91551	93804
TOTAL																
	Interburden < 40 ft	0	87324	87324	0	278756	278756	0	46344	46344	0	14340	14340	0	426764	426764
	<100 ft overburden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Burn	0	1001	1001	0	4468	4468	0	1790	1790	0	0	0	0	7259	7259
	Too thin	2589	0	2589	1561	0	1561	0	0	0	0	0	0	4150	0	4150
	TOTAL	2589	88325	90914	1561	283224	284785	0	48134	48134	0	14340	14340	4150	434023	438173

**Not necessarily sum. Calculated separately to avoid double counting of overlapping restrictions.