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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE HUCKINS SCHOOL QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 41 plates]

By

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To convert	Multiply by	To obtain
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
short tons/acre-ft	7.36	metric tons/hectare-meter (t/ha-m)
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)

INTRODUCTION

Purpose

This text is for use in conjunction with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Huckins School quadrangle, Powder River County, Montana, (41 plates; U.S. Geological Survey Open-File Report 79-786). This set of maps was compiled to support the land-use planning work of the Bureau of Land Management in response to the Federal Coal Leasing Amendments Act of 1976 and to provide a systematic inventory of coal resources on Federal coal lands in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States. The inventory includes only those beds of subbituminous coal that are 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden and those beds of lignite that are 5 feet (1.5 m) or more thick and under less than 1,000 feet (305 m) of overburden.

Location

The Huckins School 7 1/2-minute quadrangle is in south-central Powder River County, Montana, about 18 miles (29 km) southwest of Broadus, a small town in the Powder River valley; about 80 miles (129 km) south of Miles City, a town in the Yellowstone River valley; about 58 miles (93 km) north of Gillette, Wyoming; and about 64 miles (103 km) northeast of Sheridan, Wyoming. Miles City is on U.S. Interstate Highway 94 and the main east-west routes of the Burlington Northern Railroad and the Chicago, Milwaukee, St. Paul and Pacific Railroad. Broadus is on the east-west U.S. Highway 212. Both Gillette and Sheridan are on U.S. Interstate Highway 90 and another branch of the Burlington Northern Railroad.

Accessibility

The quadrangle is accessible from Broadus by going southwest up the Powder River valley a distance of about 18 miles (29 km) on the graveled Powder River Road to the northern border of the quadrangle. A number of unimproved roads and

trails provide access to most of the quadrangle. The nearest railroad, the Burlington Northern Railroad, is located about 36 miles (58 km) southwest of the quadrangle up the Powder River valley near Kendrick, Wyoming.

Physiography

The Huckins School quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The Powder River and its flood plain are the most prominent land forms in the quadrangle. From the quadrangle the river flows northeastward to Broadus, Montana, and then generally northward until it meets the Yellowstone River about 104 miles (167 km) north-northeast of the quadrangle.

Most of the quadrangle lies southeast of the Powder River and drains northwestward into the river. The major northwestward-flowing tributaries are: Hell Creek, Bay Horse Creek, Buttermilk Creek, and Miller Creek. A few square miles (several square kilometers) of the quadrangle lie northwest of the Powder River where Pinto Creek drains southeastward into the river. The valleys of the larger tributary streams have relatively broad, gradual, lower slopes topped by steep upper slopes.

The highest point in the quadrangle, with an elevation of about 3,950 feet (1,204 m), is on an unnamed ridge on the divide between Bay Horse Creek and Buttermilk Creek near the southeast corner of the quadrangle. The lowest point in the quadrangle, with an elevation of about 3,185 feet (971 m), is along the Powder River at the north edge of the quadrangle. Topographic relief in the quadrangle is about 765 feet (233 m).

Climate

The climate of Powder River County is characterized by pronounced variations in seasonal precipitation and temperature. Annual precipitation in the region varies from less than 12 inches (30 cm) to about 16 inches (41 cm). The

heaviest precipitation is from April to August. The largest average monthly precipitation is during June. Temperatures in eastern Montana range from as low as -50°F (-46°C) to as high as 110°F (43°C). The highest temperatures occur in July and the lowest in January; the mean annual temperature is about 45°F (7°C) (Matson and Blumer, 1973, p. 6).

Land status

The Northern Powder River Known Recoverable Coal Resource Area (KRCRA) covers all of the quadrangle except an area along the Powder River. The Boundary and Coal Data Map (pl. 2) shows the location of the KRCRA tracts and the land ownership status. There are no National Forest lands within the Huckins School quadrangle. There was one outstanding Federal coal lease within the quadrangle recorded as of 1977.

GENERAL GEOLOGY

Previous work

Bryson and Bass (1973) mapped the entire Huckins School quadrangle as part of the East Moorhead coal field. Matson and Blumer (1973) mapped only State-owned sections of the quadrangle as part of the East Moorhead coal field.

Traces of coal bed outcrops shown by previous workers on planimetric maps which lack topographic control have been modified by us to fit the modern topographic map of the quadrangle.

Stratigraphy

The exposed bedrock units in this quadrangle belong to the Tongue River Member, the uppermost member of the Fort Union Formation (Paleocene).

The Tongue River Member is made up mainly of yellow to gray sandstone, sandy shale, carbonaceous shale, and coal. Much of the coal has burned, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds. The upper part of the Tongue River Member has been removed by erosion,

leaving about as much as 1,300 feet (396 m) of the member remaining in the quadrangle.

Coal and other rocks comprising the Tongue River Member were deposited in a continental environment at elevations of perhaps a few tens of feet (a few meters) above sea level in a vast area of shifting rivers, flood plains, sloughs, swamps, and lakes that occupied the area of the Northern Great Plains in Paleocene (early Tertiary) time.

Representative samples of the sedimentary rocks overlying and interbedded with minable coal beds in the eastern and northern Powder River Basin have been analyzed for their content of trace elements by the U.S. Geological Survey, and the results have been summarized by the U.S. Department of Agriculture and others (1974) and by Swanson (in Mapel and others, 1977, pt. A, p. 42-44). The rocks contain no greater amounts of trace elements of environmental concern than do similar rocks found throughout other parts of the western United States.

Structure

The Huckins School quadrangle is on the eastern flank of the Powder River structural basin in Montana. Regionally the strata dip westward or southwestward at an angle of less than 1 degree. In places, the regional dip is modified by local folding (pls. 4, 7, 10, 13, 16, 19, 23, 26, 29, 32, 35, and 38). Some irregularities in dip may be caused by depositional variations as well as differential compaction, common in continental strata.

COAL GEOLOGY

The coal beds in the Huckins School quadrangle are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheet (pl. 3). All of the mapped coal beds occur in the Tongue River Member of the Fort Union Formation (Paleocene). No commercial coal beds are known to exist below the Tongue River Member.

The lowermost coal bed identified in the quadrangle is the Broadus coal bed which occurs about 100 feet (30 m) above the base of the Tongue River Member. The Broadus coal bed is successively overlain by a noncoal interval of about 60 feet (18 m), the Number 11 coal bed, a noncoal interval of about 45 to 175 feet (14 to 53 m), the Number 9c coal bed, a noncoal interval of about 20 to 35 feet (6 to 11 m), the Number 9b coal bed, a noncoal interval of about 20 to 100 feet (6 to 30 m), the Number 9a coal bed, a noncoal interval of about 50 feet (15 m), the Cache coal bed, a noncoal interval of about 25 to 55 feet (7.6 to 17 m), the Number 8a coal bed, a noncoal interval of about 15 to 50 feet (4.6 to 15 m), the Number 8 coal bed, a noncoal interval of about 45 to 65 feet (13.8 to 20 m), the Number 7 coal bed, a noncoal interval of about 5 feet (1.5 m), a local coal bed, a noncoal interval of about 30 feet (9.1 m), the Pawnee coal bed, a noncoal interval of about 10 to 15 feet (3 to 4.6 m), a local coal bed, a noncoal interval of about 45 to 90 feet (13.7 to 27 m), the Number 5 coal bed, a noncoal interval of 100 feet (30 m), and the upper split of the Cook coal bed.

The coal found along the eastern flank of the Powder River Basin in Montana increases in rank from lignite in the east to subbituminous in the deeper parts of the basin to the west. The rank of coal is controlled by the amount of compaction to which the coal is subjected. The compaction is a result of the original depth of burial of the coal (thickness of overburden) and of the degree of tectonic (mountain-building) activity to which the coal has been subjected. The eastern flank of the Powder River Basin has not been subjected to very much squeezing of sediments produced by tectonic activity so that the rank of coal there is primarily related to the original depth of burial (thickness of overburden) to which the coal has been subjected. Lignite A is a coal that has a heating value of 6,300 to 8,300 Btu per pound (14,654 to 19,306 kJ/kg) on a moist, mineral-matter-free basis. Subbituminous C coal has a heating value of

8,300 to 9,500 Btu per pound (19,306 to 22,097 kJ/kg) on a moist, mineral-matter-free basis.

At the start of this mapping contract, what appeared to us to be all of the available analyses of the Broadus coal bed, the stratigraphically lowermost coal bed of importance in this area, were considered in making our decision to assign a rank of subbituminous C to the Broadus coal within this quadrangle. Overlying coal beds in this quadrangle grade upward into increasingly lower ranks of coal (coal having lower Btu values per pound of coal on a moist, mineral-matter-free basis) as the coal is less and less compacted because of decreasing amounts of overburden. Several of the overlying coal beds in this quadrangle, which are stratigraphically higher than the Broadus coal bed, have been determined to be lignite in rank. However, early in this mapping project to expedite the calculation of resource tonnage and the evaluation of development potential for surface mining of the near-surface coal beds, it was arbitrarily decided by us to assign a rank of subbituminous C to all of the coal beds above the Broadus in this quadrangle. Consequently, we have used the 500-foot (152-m) stripping limit (which the USGS has arbitrarily assigned for multiple beds of subbituminous coal in this area of Montana) in this quadrangle for all of the coal beds above the Broadus even though our subsequent detailed work has indicated that the 200-foot (61-m) stripping limit assigned for lignite beds in this area should have been used for the lignite beds.

It is recommended that the 200-foot (61-m) stripping limit and the lignite weight-conversion factor should be used in any future revisions of the maps and coal tonnage calculations for the lignite beds in this quadrangle. The use of the 200-foot (61-m) stripping limit will produce a more conservative and realistic picture of the surface-mining potential of the various coal beds in this quadrangle.

The trace-element content of coals in this quadrangle has not been determined; however, coals in the Northern Great Plains, including those in the Fort Union Formation in Montana, have been found to contain, in general, appreciably lesser amounts of most elements of environmental concern than coals in other areas of the United States (Hatch and Swanson, 1977, p. 147).

Broadus coal bed

The Broadus coal bed, first described by Warren (1959, p. 570), was named from exposures in the Epsie NE quadrangle near the town of Broadus, about 14 miles (23 km) north-northeast of the Huckins School quadrangle. The isopach and structure contour map of the Broadus coal bed (pl. 38) shows that the Broadus coal bed ranges from about 3 to 8 feet (0.9 to 2.4 m) in thickness and has a general southwestward dip of less than one-half degree. Overburden on the Broadus coal bed (pl. 39) ranges from about 400 to 800 feet (122 to 244 m) in thickness.

A chemical analysis of the Broadus coal from the Peerless mine in sec. 23, T. 4 S., R. 50 E., in the Epsie NE quadrangle, located about 16 miles (26 km) north-northeast of the Huckins School quadrangle, shows ash 6.4 percent, sulfur 0.2 percent, and a heating value of 7,240 Btu per pound (16,840 kJ/kg) on an as-received basis (Gilmour and Dahl, 1967, p. 16). This heating value converts to about 7,735 Btu per pound (17,992 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Broadus coal at that location is lignite A in rank. Because of the proximity of that location to the Huckins School quadrangle, it is assumed that the Broadus coal in this quadrangle is similar and is also lignite A in rank.

Number 11 coal bed

The Number 11 coal bed was first described by Bryson and Bass (1973, p. 100) from exposures in the Moorhead coal field which includes the Huckins School quadrangle. The Number 11 coal bed occurs about 60 feet (18 m) above the Broadus

coal bed. The Number 11 coal bed does not crop out but was penetrated by several drill holes in the western part of the quadrangle. The isopach and structure contour map (pl. 35) shows that the coal bed ranges from about 5 to 7 feet (1.5 to 2.1 m) in thickness and has a general southwestward dip of less than 1 degree. Overburden on the Number 11 coal bed (pl. 36) ranges from about 200 to 600 feet (61 to 183 m) in thickness.

There is no known, publicly available chemical analysis of the Number 11 coal in the Huckins School quadrangle. Because other coals in this area are lignite A in rank, the Number 11 coal bed has also been assigned a rank of lignite A.

Number 9c coal bed

The Number 9c coal bed was first described by Bryson and Bass (1973, p. 91) from exposures in the Moorhead coal field which includes the Huckins School quadrangle. The Number 9c coal bed crops out in the northern part of the quadrangle and occurs about 45 to 175 feet (14 to 53 m) above the Number 11 coal bed. The isopach and structure contour map (pl. 32) shows that the Number 9c coal bed ranges from about 3 to 5 feet (0.9 to 1.5 m) in thickness and has a general northward dip of less than one-half degree. Overburden on the Number 9c coal bed (pl. 33) ranges from 0 feet at the outcrops to 400 feet (0-122 m) in thickness.

There is no known, publicly available chemical analysis of the Number 9c coal in the Huckins School quadrangle. Because other coals in the area are lignite A in rank, the Number 9c coal has also been assigned a rank of lignite A.

Number 9b coal bed

The Number 9b coal bed was first mapped by Warren (1959, pl. 24) as a local bed and later named the Number 9b coal bed by Bryson and Bass (1973, p. 91). The Number 9b coal bed occurs about 20 to 35 feet (6 to 11 m) above the Number 9c coal bed. The Number 9b coal bed crops out along the Powder River valley in the

northern part of the quadrangle. The isopach and structure contour map (pl. 29) shows that the Number 9b coal bed ranges from about 3 to 9 feet (0.9 to 2.7 m) in thickness and has a general westward to northwestward dip of less than 1 degree. Overburden on the Number 9b coal bed (pl. 30) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness.

There is no known, publicly available chemical analysis of the Number 9b coal in the Huckins School quadrangle. Because other coals in the area are lignite A in rank, the Number 9b coal has also been assigned a rank of lignite A.

Number 9a coal bed

The Number 9a coal bed was first described by Bryson and Bass (1973, p. 91) from outcrops in the Moorhead coal field which includes the Huckins School quadrangle. This coal bed is about 20 to 100 feet (6 to 30 m) above the Number 9b coal bed. The isopach and structure contour map (pl. 26) shows that the Number 9a coal bed ranges in thickness from 3.1 to 8 feet (0.9 to 2.4 m) and has a general southeastward dip of less than one-half degree. The general dip is modified by a southwest plunging anticline. Overburden on the Number 9a coal bed (pl. 17) ranges from 0 feet at the outcrops to about 290 feet (0-88 m) in thickness.

There is no known, publicly available chemical analysis of the Number 9a coal in the Huckins School quadrangle. Because other coals in this area are lignite A in rank, the Number 9a coal has also been assigned a rank of lignite A.

Cache coal bed

The Cache coal bed, first named by Warren (1959, p. 572), derives its name from exposures along Cache Creek about 8 miles (13 km) north-northeast of the Huckins School quadrangle in the Lonesome Peak and Yarger Butte quadrangles. In the Huckins School quadrangle, the Cache coal bed is about 50 feet (15 m) above the Number 9a coal bed. The isopach and structure contour maps (pls. 22 and 23) show that the Cache coal bed ranges from about 4 to 23 (1.2 to 7.0 m) feet in

thickness and in general dips southeastward at an angle of less than 1 degree. Overburden on the Cache coal bed (pl. 24) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness.

A chemical analysis of the Cache (T) coal from a depth of 103 to 112 feet (32 to 34 m) in drill hole SH-713, sec. 6, T. 8 S., R. 51 E., in the Baldy Peak quadrangle about 6 miles (9.6 km) east of the Huckins School quadrangle, shows ash 4.601 percent, sulfur 0.741 percent, and heating value 7,208 Btu per pound (16,765 kJ/kg) on an as-received basis (Matson and Blummer, 1973, p. 93). This heating value converts to about 7,556 Btu per pound (17,575 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Cache coal at that locality is lignite A in rank. Because of the proximity of that location to the Huckins School quadrangle, it is assumed that the Cache coal in this quadrangle is similar and is also lignite A in rank.

Number 8a coal bed

The Number 8a coal bed was first described by Bryson and Bass (1973, p. 82) from exposures along the valley of Pinto Creek in the northwestern part of the Huckins School quadrangle. In this quadrangle, the Number 8a coal bed occurs about 25 to 55 feet (7.6 to 17 m) above the Cache coal bed. The isopach and structure contour map (pl. 19) shows that the Number 8a coal bed ranges from about 3 to 7 feet (0.9 to 2.1 m) in thickness and has a general southward dip of less than 1 degree. Overburden on the Number 8a coal bed (pl. 20) ranges from 0 feet at the outcrops to about 200 feet (0-61 m) in thickness.

There is no known, publicly available chemical analysis of the Number 8a coal in the Huckins School quadrangle. Because other coals in this area are lignite A in rank, the Number 8a coal has also been assigned a rank of lignite A.

Number 8 coal bed

The Number 8 coal bed was first described by Bryson and Bass (1973, p. 82) from exposures in the Bloom Creek quadrangle about 1 mile (1.6 km) west of the Huckins School quadrangle. The Number 8 coal bed occurs about 55 to 100 feet (17 to 30 m) above the Cache coal bed in the Huckins School quadrangle. The isopach and structure contour map (pl. 16) shows that the Number 8 coal bed ranges from about 3 to 8 feet (0.9 to 2.4 m) in thickness and in general dips southward at less than 1 degree. Overburden on the Number 8 coal bed (pl. 17) ranges from 0 feet at the outcrops to less than 100 feet (0-30 m) in thickness.

There is no known, publicly available chemical analysis of the Number 8 coal in the Huckins School quadrangle. Because other coals in this area are lignite A in rank, the Number 8 coal has also been assigned a rank of lignite A.

Number 7 coal bed

The Number 7 coal bed was first described by Bryson and Bass (1973, p. 82) from exposures on the divide between the Powder River and Bay Horse Creek to the east in the Huckins School quadrangle. In this quadrangle, the Number 7 coal bed occurs about 45 to 65 feet (13.8 to 20 m) above the Number 8 coal bed. The isopach and structure contour map (pl. 13) shows that the Number 7 coal bed ranges from about 2 to 7 feet (0.6 to 2.1 m) in thickness and has a general westward dip of less than 1 degree. In places the general dip is modified by low-relief folding. Overburden on the Numer 7 coal bed (pl. 14) ranges from 0 feet at the outcrops to about 200 feet (0-61 m) in thickness.

There is no known, publicly available chemical analysis of the Number 7 coal in the Huckins School quadrangle. Because other coals in the area are lignite A in rank, the Number 7 coal has also been assigned a rank of lignite A.

Pawnee coal bed

The Pawnee coal bed was first named by Warren (1959, p. 572) from exposures in the Birney-Broadus coal field, which is about 1 mile (1.6 km) north of the Huckins School quadrangle. The Pawnee coal bed occurs about 15 to 75 feet (4.6 to 23 m) above the Number 7 coal bed in the Huckins School quadrangle. The isopach and structure contour map (pl. 10) shows that the Pawnee coal bed ranges from about 4 to 18 feet (1.2 to 5.5 m) in thickness and has a general westward dip of less than one-half degree. Overburden on the Pawnee coal bed (pl. 11) ranges from 0 feet at the outcrops to about 100 feet (0-30 m) in thickness.

There is no known, publicly available chemical analysis of the Pawnee coal in the Huckins School quadrangle. Because other coals in this area are lignite A in rank, the Pawnee coal has also been assigned a rank of lignite A.

Number 5 coal bed

The Number 5 coal bed was first described by Bryson and Bass (1973, p. 91) from exposures in the Moorhead coal field which includes the Huckins School quadrangle. In many places the Number 5 coal bed has been burned near the surface forming a thick clinker bed which caps the hills in the southern part of the quadrangle. The Number 5 coal bed occurs about 50 to 75 feet (15 to 23 m) above the Pawnee coal bed in the Huckins School quadrangle. The isopach and structure contour map (pl. 7) shows that the Number 5 coal bed ranges from about 7 to 10 feet (2.1 to 3 m) in thickness and has a general westward dip of less than 1 degree. In places, the general dip has been modified by low-relief folding. Overburden on the Number 5 coal bed ranges from 0 feet at the outcrops to 200 feet (0-61 m) in thickness.

There is no known, publicly available chemical analysis of the Number 5 coal in the Huckins School quadrangle. Because other coals in this area are lignite A in rank, the Number 5 coal has also been assigned a rank of lignite A.

Upper split of the Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 59) from exposures on Cook Mountain in the Cook Creek Reservoir quadrangle about 35 miles (56 km) northwest of the Huckins School quadrangle. Warren (1959, p. 573) recognized the upper split of the Cook coal bed in the Birney-Broadus coal field about 1 mile (1.6 km) north of this quadrangle. Bryson and Bass (1973, pl. 1) mapped the Cook (Number 4) coal bed in the Moorhead coal field which includes the Baldy Peak quadrangle. A preliminary regional isopach of the Cook coal bed shows that the Cook (Number 4) coal bed of Bryson and Bass (1973) is the upper split of the Cook coal bed. In the Huckins School quadrangle, the upper split of the Cook coal bed occurs about 100 feet (30 m) above the Number 5 coal bed. The isopach and structure contour map is based on limited data from within the quadrangle and projections of data from adjacent quadrangles. This map (pl. 4) shows that the upper split of the Cook coal bed ranges from 5.2 to 13.4 feet (1.6 to 4.1 m) in thickness and has a general southwestward or southeastward dip of about 1 degree. Overburden on the upper split of the Cook coal bed (pl. 5) ranges from 0 feet at the outcrops to less than 100 feet (0-30 m) in thickness.

There are no known, publicly available chemical analyses of the upper split of the Cook coal in the Huckins School quadrangle. However, the average of three chemical analyses of the Cook coal at depths of 115 to 125 feet (35 to 38.1 m), 125 to 133 feet (38.1 to 40.5 m), and 137 to 142 feet (41.8 to 43.3 m) in drill hole SH-7135 (Matson and Blumer, 1973, p. 99), sec. 29, T. 6 S., R. 48 E., in the Hodsdon Flats quadrangle, about 7 miles (11.3 km) west-northwest of the Huckins School quadrangle, shows ash 3.894 percent, sulfur 0.330 percent, and an average heating value of 7,739 Btu per pound (18,001 kJ/kg) on an as-received basis. This average heating value converts to about 8,053 Btu per pound (18,731 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Cook coal at that

location is high lignite A in rank. Because of the proximity of that location to the Huckins School quadrangle, it is assumed that the coal of the upper split of the Cook coal bed in this quadrangle is similar and is also high lignite A in rank.

COAL RESOURCES

Data from all publicly available drill holes and from surface mapping by others (see list of references) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle.

A coal resource classification system has been established by the U.S. Bureau of Mines and the U.S. Geological Survey and published in U.S. Geological Survey Bulletin 1450-B (1976). Coal resource is the estimated gross quantity of coal in the ground that is now economically extractable or that may become so. Resources are classified as either Identified or Undiscovered. Identified Resources are specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by specific measurements. Undiscovered Resources are bodies of coal which are surmised to exist on the basis of broad geologic knowledge and theory.

Identified Resources are further subdivided into three categories of reliability of occurrence: namely Measured, Indicated, and Inferred, according to their distance from a known point of coal-bed measurement. Measured coal is coal located within 0.25 mile (0.4 km) of a measurement point, Indicated coal extends 0.5 mile (0.8 km) beyond Measured coal to a distance of 0.75 mile (1.2 km) from the measurement point, and Inferred coal extends 2.25 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement point.

Undiscovered Resources are classified as either Hypothetical or Speculative. Hypothetical Resources are those undiscovered coal resources in beds that may reasonably be expected to exist in known coal fields under known geologic

conditions. In general, Hypothetical Resources are located in broad areas of coal fields where the coal bed has not been observed and the evidence of coal's existence is from distant outcrops, drill holes, or wells that are more than 3 miles (4.8 km) away. Hypothetical Resources are located beyond the outer boundary of the Inferred part of Identified Resources in areas where the assumption of continuity of the coal bed is supported only by extrapolation of geologic evidence. Speculative Resources are undiscovered resources that may occur in favorable areas where no discoveries have been made. Speculative Resources have not been estimated in this report.

For purposes of this report, Hypothetical Resources of subbituminous coal are in coal beds which are 5 feet (1.5 m) or more thick, under less than 3,000 feet (914 m) of overburden, but occur 3 miles (4.8 km) or more from a coal-bed measurement. Hypothetical Resources of lignite are in lignite beds which are 5 feet (1.5 m) or more thick, under less than 1,000 feet (305 m) of overburden, but occur 3 miles (4.8 km) or more from a coal-bed measurement.

Reserve Base coal is that economically minable part of Identified Resources from which Reserves are calculated. In this report, Reserve Base coal is the gross amount of Identified Resources that occurs in beds 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden for subbituminous coal or under less than 1,000 feet (305 m) of overburden for lignite.

Reserve Base coal may be either surface-minable coal or underground-minable coal. In this report, surface-minable Reserve Base coal is subbituminous coal that is under less than 500 feet (152 m) of overburden or lignite that is under less than 200 feet (61 m) of overburden. In this report, underground-minable Reserve Base coal is subbituminous coal that is under more than 500 feet (152 m), but less than 3,000 feet (914 m) of overburden, or lignite that is under more than 200 feet (61 m), but less than 1,000 feet (305 m) of overburden.

Reserves are the recoverable part of Reserve Base coal. In this area, 85 percent of the surface-minable Reserve Base coal is considered to be recoverable (a recovery factor of 85 percent). Thus, these Reserves amount to 85 percent of the surface-minable Reserve Base coal. For economic reasons coal is not presently being mined by underground methods in the Northern Powder River Basin. Therefore, the underground-mining recovery factor is unknown and Reserves have not been calculated for the underground-minable Reserve Base coal.

Tonnages of coal resources were estimated using coal-bed thicknesses obtained from the coal isopach map for each coal bed (see list of illustrations). The coal resources, in short tons, for each isopached coal bed are the product of the acreage of coal (measured by planimeter), the average thickness in feet of the coal bed, and a conversion factor of 1,770 short tons of subbituminous coal per acre-foot (13,018 metric tons per hectare-meter) or a conversion factor of 1,750 short tons of lignite per acre-foot (12,870 metric tons per hectare-meter). Tonnages of coal in Reserve Base, Reserves, and Hypothetical categories, rounded to the nearest one-hundredth of a million short tons, for each coal bed are shown on the Areal Distribution and Tonnage maps (see list of illustrations).

As shown by table 1, the total tonnage of federally owned, surface-minable Reserve Base coal in this quadrangle is estimated to be 715.92 million short tons (649.48 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 0.70 million short tons (0.64 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 42.25 million short tons (38.33 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 0 million short tons (0 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 758.17 million short tons (687.81 million t), and

the total of surface- and underground-minable Hypothetical coal is 42.25 million short tons (38.33 million t).

About 7 percent of the surface-minable Reserve Base tonnage is classed as Measured, 36 percent as Indicated, and 57 percent as Inferred. About 1 percent of the underground-minable Reserve Base tonnage is Measured, 15 percent is Indicated, and 84 percent is Inferred.

The total tonnages per section for both Reserve Base and Hypothetical coal, including both surface- and underground-minable coal are shown in the northwest corner of the Federal coal lands in each section on plate 2. All numbers on plate 2 are rounded to the nearest one-hundredth of a million short tons.

COAL DEVELOPMENT POTENTIAL

There is a potential for surface-mining in the Northern Powder River Basin in areas where subbituminous coal beds 5 feet (1.5 m) or more thick are overlain by less than 500 feet (152 m) of overburden (the stripping limit), or where lignite beds of the same thickness are overlain by 200 feet (61 m) or less of overburden (the stripping limit). This first thickness of overburden is the assigned stripping limit for surface mining of multiple beds of subbituminous coal in this area. Areas having a potential for surface mining were assigned a high, moderate, or low development potential based on their mining-ratio values (cubic yards of overburden per short ton of recoverable coal).

The formula used to calculate mining-ratio values for coal is:

$$MR = \frac{t_o(cf)}{t_c(rf)}$$

where MR = mining ratio
t_o = thickness of overburden, in feet
t_c = thickness of coal, in feet
rf = recovery factor = 0.85 in this area
cf = conversion factor = 0.911 cu. yds./short ton for subbituminous coal or 0.922 cu. yds./short ton for lignite

The mining-ratio values are used to rate the degree of potential that areas within the stripping limit have for surface-mining development. Areas having mining-ratio values of 0 to 10, 10 to 15, and greater than 15 are considered to have high, moderate, and low development potential, respectively. This grouping of mining-ratio values was provided by the U.S. Geological Survey and is based on economic and technological criteria. Mining-ratio contours and the stripping-limit overburden isopach, which serve as boundaries for the development-potential areas, are shown on the overburden isopach and mining-ratio contour plates. Estimated tonnages of surface-minable Reserve Base and Hypothetical coal resources in each development-potential category (high, moderate, and low) are shown in table 1.

Estimated tonnages of underground-minable coal resources are shown in table 2. Because coal is not presently being mined by underground mining in the Northern Powder River Basin for economic reasons, for purposes of this report all of the underground-minable coal resources are considered to have low development potential.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map included in this series of maps pertains only to surface mining. It depicts the highest coal development-potential category which occurs within each smallest legal subdivision of land (normally about 40 acres or 16.2 ha). For example, if such a 40-acre (16.2-ha) tract of land contains areas of high, moderate, and low development potential, the entire tract is assigned to the high development-potential category for CDP mapping purposes. Alternatively, if such a 40-acre (16.2-ha) tract of land contains areas of moderate, low, and no development potential, the entire tract is assigned to the moderate development-potential category for CDP mapping purposes. For practical reasons, the development-potential categories of areas of coal smaller

than 1 acre (0.4 ha) have been disregarded in assigning a development potential to the entire 40-acre (16.2-ha) tract.

In areas of moderate to high topographic relief, the area of moderate development potential for surface mining of a coal bed (area having mining-ratio values of 10 to 15) is often restricted to a narrow band between the high and low development-potential areas. In fact, because of the 40-acre (16.2-ha) minimum size of coal development-potential tracts, the narrow band of moderate development-potential area often does not appear on the CDP map because it falls within the 40-acre (16.2-ha) tracts that also include areas of high development potential. The Coal Development Potential (CDP) map then shows areas of high development potential abutting against areas of low development potential.

The coal development potential for surface-mining methods is shown on the CDP maps (pl. 41). Approximately 72 percent of the Federal land in this quadrangle has a high development potential for surface mining of coal because of the Cache and Pawnee coal beds.

The Broadus coal bed (pl. 39) has development potential for surface mining in the southeastern part of the quadrangle. High and moderate development potential is lacking, but relatively large areas of low development potential extend from the coal boundary to the 500-foot (152-m) overburden isopach. Areas of no development potential for surface mining extend from the 500-foot (152-m) overburden isopach under the crests of the hills.

The Number 11 coal bed (pl. 36) has development potential for surface mining in the eastern part of the quadrangle. Small areas of high development potential occur adjacent to the Powder River and Buttermilk Creek in the northern part of the quadrangle. Additional small areas of moderate development potential occur as narrow bands between the 10 and 15 mining-ratio contours. Very large areas of low development potential extend from the coal boundary or the 15 mining-ratio

contour to the 500-foot (152-m) overburden isopach. Minor areas of no development potential for surface mining extend from the 500-foot (152-m) overburden isopach under the crests of the hills.

The Number 9c coal bed (pl. 33) has development potential for surface mining in a small area in the northeastern part of the quadrangle. Small areas of high development potential occur along streams draining northwestward into the Powder River. Small areas of moderate development potential occur as narrow bands between the 10- and 15-foot mining-ratio contours. The remainder of the coal has low development potential.

The Number 9b coal bed (pl. 30) has development potential for surface mining in a small area in the northwestern part of the quadrangle. Small areas of high development potential occur along the valleys of the Powder River and the tributaries of Pinto Creek. Very narrow bands of moderate development potential occur as narrow bands between the 10 and 15 mining-ratio contours. Small areas of low development potential extend from the 15 mining-ratio contour up the slopes of the hills.

The Number 9a coal bed (pl. 27) has development potential for surface mining in three small, scattered areas in the northeastern part of the quadrangle. There, small areas of high development potential occur along streams draining northwestward into the Powder River. Very small areas of moderate development potential occur as narrow bands between the 10 and 15 mining-ratio contours. Small areas of low development potential occur between the 15 mining-ratio contour and the coal boundary.

The Cache coal bed (pl. 24) has development potential for surface mining over most of the Huckins School quadrangle. Very large areas of high development potential extend from the stream valleys up the slopes to the 10 mining-ratio contour. Large areas of moderate development potential occur as narrow bands

between the 10 and 15 mining-ratio contours. Areas of moderate development potential also extend from the 10 mining-ratio up the slopes of the lower hills. Large areas of low development potential occur between the 15 mining-ratio contour and the crests of the higher hills.

The Number 8a coal bed (pl. 20) has development potential for surface mining in a very small area near the center of the quadrangle. This area has high and moderate development potential.

The Number 8 coal bed (pl. 17) has development potential for surface mining in a relatively large area in the southern part of the quadrangle and a very small area in the northwestern part of the quadrangle. Relatively large areas of high development potential occur along Bay Horse Creek and its tributaries. Small areas of moderate development potential occur between the 10 and 15 mining-ratio contours. Large areas of low development potential extend from the 15 mining-ratio contour under the crests of the hills.

The Number 7 coal bed (pl. 14) has development potential for surface mining in several scattered small tracts in the southwestern part of the quadrangle. Small areas of high development potential extend from the coal boundary to the 10 mining-ratio contour. Very narrow bands of moderate development potential occur between 10 and 15 mining-ratio contours. Small areas of low development potential extend from the 15 mining-ratio contour under the crests of the hills.

The Pawnee coal bed (pl. 11) has development potential for surface mining in isolated tracts scattered throughout the quadrangle. Large areas of high development potential extend from the coal boundary to the 10 mining-ratio contours. Small areas of moderate development potential occur as narrow bands between the 10 and 15 mining-ratio contours. Very small areas of low development potential extend from the 15 mining-ratio contour under the crests of the higher hills.

The Number 5 coal bed (pl. 8) has development potential for surface mining in widely scattered tracts in the southern part of the quadrangle. Relatively large areas of high development potential extend from the coal boundary up the slopes to the 10 mining-ratio contour. Small areas of moderate development potential occur as narrow bands between the 10 and 15 mining-ratio contours. Very limited areas of low development potential extend from the 15 mining-ratio contour under the crests of the hills.

The upper split of the Cook coal bed (pl. 5) has development potential for surface mining in several very small isolated tracts in the southern part of the quadrangle. These tracts have high and moderate development potential.

About 72 percent of the Federal lands in the Huckins *School* quadrangle has a high development potential for surface mining, 3 percent has a moderate development potential, 5 percent has a low development potential, and 20 percent has no development potential for surface mining.

Development potential for underground mining and in-situ gasification

Subbituminous coal beds 5 feet (1.5 m) or more in thickness lying more than 500 feet (152 m) but less than 3,000 feet (914 m) below the surface and lignite beds of the same thickness lying more than 200 feet (61 m) but less than 1,000 feet (305 m) below the surface are considered to have development potential for underground mining. Estimates of the tonnage of underground-minable coal are listed in table 2 by development-potential category for each coal bed. Coal is not currently being mined by underground methods in the Northern Powder River Basin because of poor economics. Therefore, the coal development potential for underground mining of these resources for purposes of this report is rated as low, and a Coal Development Potential map for underground mining was not made.

In-situ gasification of coal on a commercial scale has not been done in the United States. Therefore, the development potential for in-situ gasification of coal found below the surface-mining limit in this area is rated as low, and a Coal Development Potential map for in-situ gasification of coal was not made.

Table 1.--Surface-minable coal resource tonnage (in short tons) by development-potential category for Federal coal lands in the Huckins School quadrangle, Powder County, Montana

[Development potentials are based on mining ratios (cubic yards of overburden/short ton of recoverable coal). To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Reserve Base tonnage				
Upper Cook	2,800,000	70,000	0	2,870,000
Number 5	11,500,000	1,550,000	960,000	14,010,000
Pawnee	75,930,000	6,450,000	590,000	82,970,000
Number 7	3,050,000	1,780,000	2,750,000	7,580,000
Number 8	14,160,000	6,790,000	22,120,000	43,070,000
Number 8a	660,000	320,000	550,000	1,530,000
Cache	188,240,000	93,170,000	82,590,000	364,000,000
Number 9a	4,770,000	2,440,000	4,490,000	11,700,000
Number 9b	8,850,000	3,020,000	6,210,000	18,080,000
Number 9c	2,900,000	2,400,000	14,580,000	19,880,000
Number 11	5,590,000	3,670,000	115,490,000	124,750,000
Broadus	0	0	25,480,000	25,480,000
Total	318,450,000	121,660,000	275,810,000	715,920,000
Hypothetical Resource tonnage				
Upper Cook	190,000	0	0	190,000
Pawnee	180,000	0	0	180,000
Number 11	0	0	330,000	330,000
Total	370,000	0	330,000	700,000
Grand Total	318,820,000	121,660,000	276,140,000	716,620,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Huckins School quadrangle, Powder River County, Montana

[To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High Development potential	Moderate development potential	Low development potential	Total
Reserve Base tonnage				
Number 11	0	0	11,350,000	11,350,000
Broadus	0	0	30,900,000	30,900,000
Total	0	0	42,250,000	42,250,000

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