Text to accompany:

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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE COMO EAST QUADRANGLE, CARBON COUNTY, WYOMING

(Report includes 18 plates)

Prepared for:

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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[Plates are in pocket]

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INTRODUCTION

Purpose

This text is to be used along with the accompanying Coal Resource Occurrence (CRO) maps and the Coal Development Potential (CDP) map of the Como East quadrangle, Carbon County, Wyoming (18 plates; U.S. Geol. Survey Open File Report 78-049, prepared by Texas Instruments Incorporated under contract to the U.S. Geological Survey. This report was prepared to support the land planning work of the U.S. Bureau of Land Management's Energy Minerals Activities Recommendation System (EMARS) program, and to contribute to a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA) in the western United States. The Coal Resource Occurrence maps and the Coal Development Potential map for this quadrangle cover part of the northeast portion of the KRCRA of the Hanna coal field.

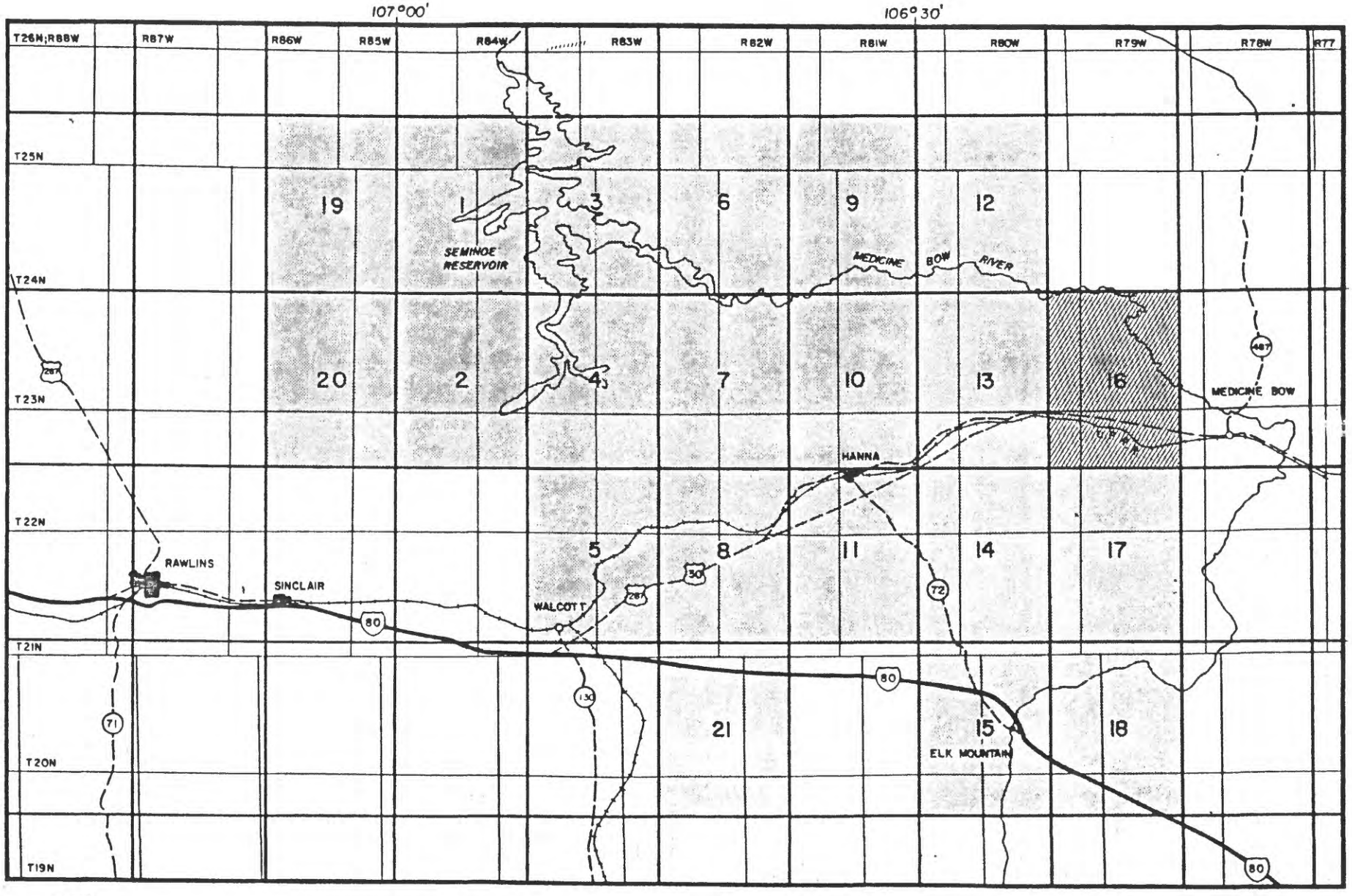
Acknowledgment

Texas Instruments Incorporated acknowledges the cooperation of the Rocky Mountain Energy Company, a wholly owned subsidiary of the Union Pacific Railroad Company, in supplying copies of survey sheets, drillers reports, electric logs, and coal analyses from the Union Pacific coal inventory program.

The Hanna and Carbon coal basins were studied as part of the inventory program and test drilling was conducted in 1970-1971. More than 650 Union Pacific coal drill holes have been evaluated as part of this contract study of 21 quadrangles in Carbon County, Wyoming; the results of this evaluation and 230 coal analyses have been incorporated into these reports.

Location

The Como East 7½-minute quadrangle is in the northeastern part of Carbon County, Wyoming. The center of the quadrangle is approximately 7 miles (11 km) northwest of Medicine Bow and 14 miles (23 km) northeast of Hanna, Wyoming (Figure 1).



Como East quadrangle (16)

Scale 1:446,000

Figure 1. - Map of the Hanna and Carbon Basins Study Area

Accessibility

U.S. Highway 30/287 crosses the southern half of the quadrangle from east to west. To the east, it connects at Medicine Bow with State Highway 487 from Casper, and to the west it joins U.S. Interstate Highway 80 near Walcott.

The quadrangle has four light-duty roads, as follows:

- An access road from State Highway 487, immediately east of the quadrangle, that runs west to the settlement of Oil Springs, in the northeast corner of the quadrangle.
- The Medicine Bow-Seminoe Dam access road that leaves U.S. Highway 30/287 at the southeast border of the quadrangle, runs northwesterly to the northwest corner of the quadrangle, crosses the Medicine Bow River, and continues west-northwesterly a further 35 miles (56 km) to the site of Seminoe Dam on the North Platte River.
- A local road in secs. 22 and 27, T. 23 N., R. 79 W. that leaves the Medicine Bow-Seminoe Dam access road and runs north to the Cronberg Ranch on the west bank of the Medicine Bow River.
- A road that leaves U.S. Highway 30/287 immediately west of this quadrangle, runs south for 1 mile (1.6 km), then turns east to enter this quadrangle, turns south, and continues to Elk Mountain, 16 miles (26 km) to the south of the Como East quadrangle.

Numerous unimproved dirt roads provide local access from the above highways and light-duty roads to the remaining areas of the quadrangle.

The main east-west tracks of the Union Pacific Railroad cross the quadrangle parallel to and south of U.S. Highway 30/287. The original main tracks from Medicine Bow westward through the towns of Carbon, Dana, and Walcott followed the valleys of First Sand and Carbon Creeks near the southern border of the quadrangle, leaving the quadrangle immediately west of South Reservoir. Coal to supply the railroad locomotives was first mined in the Hanna Basin in 1868, at Carbon. Good railroad-quality coal was subsequently discovered at Hanna and, with the opening of underground mines there in 1889, the main-line tracks were rerouted farther north between Medicine Bow and Dana to pass through Hanna. The coal mines at Carbon ceased production in 1902, and the original railroad location was abandoned about that time. An abandoned railroad spur that serviced the Carbon No. 4 and No. 5 mines, west of No. 5 Ridge in the southwest corner of the quadrangle, leaves the abandoned main line location southwest of Pynchin Lake.

Physiography

The quadrangle is on the extreme eastern edge of the Hanna structural basin and on the northern edge of the Carbon structural basin. The topography is high plains grasslands with poorly integrated drainage in the southern part of the quadrangle. The most notable topographic features are several ridges in the northeast quarter with a maximum relief of 240 feet (73 m). Fossil Ridge and Slate Ridge and their extensions form two parallel arcuate bands east of the meandering Medicine Bow River. Elevations within the quadrangle range from about 6,490 feet (1,978 m) in the northwest corner along the Medicine Bow River to about 7,040 feet (2,146 m) on No. 5 Ridge in the southwest corner.

The Medicine Bow River flows from the east-central part of the quadrangle in a northerly direction, and then westward along the northern border. The river has two principal tributaries in the area: the Little Medicine Bow River, a perennial stream flowing from the east, and an intermittent stream flowing from the northwest quarter called Pine Draw. There are numerous intermittent lakes in the south and west; some of these occupy abandoned meander scars adjacent to the Medicine Bow River.

Climate

Climate data for the Como East quadrangle were obtained from the nearby Medicine Bow weather station. Since no figures on snowfall were available at Medicine Bow, data from Elk Mountain station were used. The Medicine Bow station is located 7 miles (11 km) east-southeast of the center of the quadrangle at an elevation of 6,570 feet (2,003 m); precipitation and temperature records are available for 23 years to 1970. The Elk Mountain station is located 18 miles (29 km) south of the center of the quadrangle at an elevation of 7,270 feet (2,216 m); snowfall records are available for 29 years to 1960.

The climate is semiarid with a mean annual temperature of $42^{\circ}F$ ($6^{\circ}C$) and extremes ranging from 97° to $-46^{\circ}F$ (36° to $-43^{\circ}C$). July is the warmest month with a mean monthly temperature of $65^{\circ}F$ ($18^{\circ}C$) and January is the coldest month with $21^{\circ}F$ ($-6^{\circ}C$). For seven months of the year, April to October, the mean monthly temperature exceeds $32^{\circ}F$ ($0^{\circ}C$). Average annual precipitation is 10 inches (25 cm) with 51 percent of this total falling in the four

months of April to July. Part of the precipitation in March, April, and May is in the form of snow. Average annual snowfall is 108 inches (274 cm) with 64 percent falling in the four months of January to April. Snow rarely falls in July and August but an inch or more of snow may fall in any other month. March is the month of maximum snowfall (18 inches or 46 cm).

High winds are common throughout most of the year. The prevailing wind direction, as recorded at four weather stations around the perimeter of the Hanna and Carbon Basins, is westerly for all twelve months of the year. The growing season is restricted to less than 100 days between late May and September, which are the average times of the last killing spring frost and the first killing fall frost, respectively.

Land Status

The quadrangle is in the far eastern part of the KRCRA of the Hanna and Carbon Basins. The Federal Government owns approximately 40 percent of the coal rights in the quadrangle; the remaining 60 percent is non-federally owned. Approximately 5 percent of the area of the quadrangle is included in the KRCRA, and within this region about 15 percent of the land is federally owned. Plate 2 of the CRO maps illustrates land status and the KRCRA boundary.

There are two abandoned underground mines shown on Plate 1 in sec. 14, T. 22 N., R. 80 W. Glass (1972) states that Carbon No. 4 mine was opened on coal bed C4 but was never put into production. Carbon No. 5 mine was abandoned in 1881 after mining coal bed C5. There are no known active leases, permits, or licenses and no known active mining operations.

GENERAL GEOLOGY

Previous Work

Dobbin, Bowen, and Hoots (1929) mapped the Como East quadrangle as part of their study of the geology and coal and oil resources of the Hanna and Carbon Basins. Weitz and Love (1952) compiled a geologic map of Carbon County which incorporates available data, published and unpublished, to that date.

Stratigraphy

Rocks exposed in the Como East quadrangle range in age from Triassic to Quaternary. Coal occurrences mapped in the quadrangle include 2 coal beds in the Mesaverde Formation, 3 coal beds in the Medicine Bow Formation, 2 coal beds in the Ferris Formation, and 2 coal beds in the Hanna Formation.

The oldest rocks exposed in the quadrangle crop out in three anticlinal structures in the northeast and east-central areas. These west and northwest trending structures are, from north to south, the Oil Springs, Flat Top, and Allen Lake anticlines. The formations exposed include the Chugwater Formation of Triassic age; the Sundance and Morrison Formations of Late Jurassic age; the Cloverly Formation, Thermopolis Shale, and Mowry Shale of Early Cretaceous age; and the Frontier Formation, Carlile Shale, and Niobrara Formation of Late Cretaceous age. Dobbin, Bowen, and Hoots (1929) estimated the thickness of this sequence in the Hanna Basin to be about 4,300 feet (1,311 m); Barlow (1953), when describing the same sequence at the East Allen Lake dome, 1 mile (1.6 m) southwest of Medicine Bow, quotes a thickness of over 3,200 feet (975 m). Formation thicknesses compiled by Barlow (1953) are from oil wells drilled at the Flat Top anticline in this quadrangle, and at the Medicine Bow anticline, 13 miles (21 km) south-southeast of the center of this quadrangle.

The Steele Shale is a marine unit of Late Cretaceous age which conformably overlies the Niobrara Formation. The unit crops out in a broad belt immediately west and south of the Medicine Bow River; also east of the Medicine Bow River, in a narrow west plunging syncline between the Oil Springs and Flat Top anticlines, and in sec. 26, T. 23 N., R. 79 W. Dobbin, Bowen, and Hoots (1929) and Barlow (1953) each quote about 3,500 feet (1,067 m) for the thickness of the Steele Shale in this area. The unit is composed of dark-gray shales with intercalated beds of sandy shale and sandstone. Conspicuous ridge-forming glauconitic sandstones occur near the top of the formation.

Conformably overlying the Steele Shale is the Mesaverde Formation of Late Cretaceous age. The unit is exposed in the Como East quadrangle in a band 0.5 to 1 mile (0.8 to 1.6 km) wide that extends from the southeast part of the quadrangle to the northwest. Dobbin, Bowen, and Hoots (1929) measured a thickness of 2,200 feet (671 m) for the Mesaverde Formation in this

area. The lower part of the formation is of marine origin and consists of white to gray massive to thin-bedded sandstones alternating with thin beds of shale. The central part of the formation contains gray to brown sandstones alternating with gray carbonaceous shales and thin, irregular beds of coal. The upper part of the formation consists of white to gray sandstones interbedded with shales, carbonaceous shales, and coal beds. The central and upper parts of the Mesaverde Formation are of fresh to brackish-water origin.

Conformably overlying the Mesaverde is the Lewis Shale, which is a marine formation of Late Cretaceous age. It is exposed in the quadrangle in a band parallel to and west of the Mesaverde outcrop. The unit consists of dark-gray shales with numerous intercalated beds of sandy shale and sandstone. The thickness of the formation in this quadrangle is 3,000 feet (914 m).

The continental Medicine Bow Formation of Late Cretaceous age overlies the Lewis Shale with a conformable and gradational contact. The formation is exposed in a broad band approximately 1 mile (1.6 km) wide near the western border of the Como East quadrangle. In this area the Medicine Bow is 4,000 feet (1,219 m) thick. The formation consists of gray to brown massive to thin-bedded fine- to coarse-grained sandstones and light- to dark-gray carbonaceous shales, with numerous coal beds in the lower part.

Conformably overlying the Medicine Bow Formation is the continental Ferris Formation, which is Late Cretaceous and Paleocene in age. The Ferris Formation is 2,600 feet (792 m) thick and crops out at the western border of the quadrangle. The formation consists of gray, brown, and yellow fine- to coarse-grained thin-bedded to massive lenticular sandstones, dark-gray partly carbonaceous shale, and numerous coal beds. In the lower part of the formation conglomerates are a major constituent and occur as pockets, lenses, and thin beds irregularly distributed throughout the sandstones.

The Hanna Formation of Paleocene age unconformably overlies the Ferris Formation. Hanna sediments crop out in the extreme southwestern corner of the quadrangle. Dobbin, Bowen, and Hoots (1929) give a total thickness of 7,000 feet (2,134 m) for the Hanna Formation, but Gill, Merewether, and Cobban (1970) state that it could be as thick as 13,000 feet (3,962 m). The formation consists of white, gray, and brown fine- to coarse-grained

thin-bedded to massive sandstones, yellow and dark-gray carbonaceous shales, conglomeratic sandstones, conglomerates, and numerous beds of coal. The Hanna was deposited in a continental environment.

Quaternary terrace gravels occur in the northwestern part of the Como East quadrangle. Here, near the south bank of the Medicine Bow River, they currently lie 200 to 250 feet (61 to 76 m) above the present level of the river. Quaternary alluvium is deposited in the valleys of the Medicine Bow River and the Little Medicine Bow River.

Structure

The western part of the Como East quadrangle lies on the extreme eastern edge of the Hanna structural basin. The eastern part of the quadrangle is in the border area between the Hanna Basin to the west and the Laramie structural basin to the east. The intermontane Hanna Basin is comparatively small in areal extent but very deep. The basin extends 40 miles (64 km) east-west, 25 miles (40 km) north-south, and in its central portion contains approximately 30,000-35,000 feet (9,140-10,670 m) of sediments overlying crystalline basement.

In the western part of the quadrangle, the Steele Shale and the successively younger formations form parallel arcuate bands that outline the eastern limit of the Hanna Basin. Dips in these rocks are from 25° to 65° to the west and southwest.

Three prominent anticlinal structures occur in the eastern part of the quadrangle. These structures are surrounded by outcrops of Steele Shale, with progressively older formations exposed in their central portions. In the northeast corner is the Oil Springs anticline, a long, narrow structure that trends west-northwest and plunges to the west. The anticline is asymmetric with steep dips (87°) on the north flank and moderately steep dips (56°) on the south flank. A mile (1.6 km) south of the Oil Springs anticline is the large Flat Top anticline, which trends east-west and plunges to the west. Flat Top anticline is exposed for approximately 3 miles (5 km) in Como East quadrangle but it can be traced for nearly 20 miles (32 km) to the east of the quadrangle. The structure is asymmetric with dips as steep as 85° on the north flank, and from 15° to 25° on the south flank. The tectonic map of Blackstone (1953) shows a high-angle

south-dipping reverse fault on the north flank of Flat Top anticline that is parallel to this fold structure. In the southeastern part of the quadrangle, the Allen Lake anticline trends northwest and plunges to the northwest. The Allen Lake structure is also asymmetric, with the axial plane dipping to the southwest.

Dobbin, Bowen, and Hoots (1929) have mapped a normal fault in the southern part of the quadrangle. This fault is exposed in the Mesaverde and Lewis Shale outcrops, trends northeast, is upthrown on the south, and has a horizontal displacement of approximately 1,000 feet (305 m).

COAL GEOLOGY

Previous Work

The coal deposits of the Hanna and Carbon Basins have been studied by Veatch (1907), Dobbin, Bowen, and Hoots (1929), Berryhill and others (1950), and Glass (1972 and 1975).

Twenty-six coal analyses have been published since 1913 for coal beds of the Mesaverde Group and the Medicine Bow, Ferris, and Hanna Formations within the Hanna and Carbon Basins (Appendices 1 and 2). Samples collected and analyzed prior to 1913 have not been considered in this report (American Society for Testing and Materials, 1977, p. 218). An average analysis and an apparent rank of coal beds in each of these four stratigraphic units have also been calculated for the 230 analyses from the Union Pacific coal inventory program (Appendices 1 and 2). A standard rank determination (ASTM, 1977, p. 216, sec. 6.2.2) cannot be made because (a) some of the published analyses are from weathered coal samples, and (b) the procedure and quality of sampling for the Union Pacific coal evaluation program are not known.

Glass (1975) and U.S. Department of Interior (1975) published not only proximate coal analyses for 17 samples collected in the Hanna Basin but also assays for 10 major and minor oxides, 12 major and minor elements, and up to 32 trace elements. Glass (1975, p. 1) stresses that his assay data are insufficient to characterize the chemical and physical properties of any individual coal beds but that this will be possible at a later date as the study continues. Assay results of the 17 Hanna Basin samples show that these coals contain no significantly greater amounts of trace elements of

environmental concern than is found in the 42 samples collected in six other Wyoming coal fields.

General Features

In the Como East quadrangle 13 coal beds and 30 local coal lenses either have been mapped by Dobbin, Bowen, and Hoots (1929) or have been identified in the subsurface (Plates 1 and 3). Derivative maps were compiled for coal bed 112-A in the Mesaverde Formation, coal bed CEL5 in the Ferris Formation, and coal beds C5 and C4 in the Hanna Formation. Analyses of samples from the four coal beds are shown in Appendix 3. These samples were collected during the Union Pacific coal inventory program.

Two underground mines were opened in the late 1800's to work coal beds C5 and C4 in sec. 14, T. 22 N, R. 80 W. Mining operations were never begun on the Carbon No. 4 mine. The Carbon No. 5 mine closed in 1881.

Mesaverde Coal Beds

In the Mesaverde Formation, two coal beds were mapped on the surface and two additional coal beds and 13 local coal lenses were identified in the subsurface. Coal beds 90 and 92 occur only in the subsurface and vary in thickness from 1 to 5 feet (0.3 to 1.5 m) with an average of 3 feet (1 m). Coal bed 112 occurs in the middle of the Mesaverde Formation, crops out in the southeast quadrant, dips southwest at 25°, is intersected in drill holes 8 and 9 (Plate 3), and averages 2 feet (0.6 m) in thickness.

Coal bed 112-A occurs at the top of the Mesaverde Formation; it crops out in the southeast quadrant and dips southwest at 25°. A measured thickness of 5 feet (1.5 m) was recorded at one surface location and in the subsurface 9 feet (3 m) of coal was intersected by drill hole 5.

Medicine Bow Coal Beds

In the Medicine Bow Formation, three coal beds crop out for distances of 1 mile (1.6 km) or less in the western half of the quadrangle. Coal beds 95 and 97 and one local coal lens occur only in the subsurface. The three surface coal beds, CEL 1, CEL 2, and CEL 3, dip southwest at about 45° and range in thickness from 1.5 to 13 feet (0.5 to 4 m), with an average of

4 feet (1.2 m). Coal beds 95, 97, and the local coal lens are 2 to 3 feet (0.6 to 1 m) thick.

Ferris Coal Beds

Two coal beds in the Ferris Formation were mapped at the surface. Eight local coal lenses were intersected in the subsurface in drill holes 11 and 12 (Plate 3). Coal bed CEL 5 crops out around the nose of a syncline in the southwest corner of the quadrangle. Dip along the west flank of the fold is 27° east and dip on the east flank is 40° southwest. To the south, on both flanks of the fold, coal bed CEL 5 is covered by the overlying Hanna Formation. Coal bed CEL 5 ranges in thickness from 5 to 14 feet (2 to 4 m), with an average thickness of 9 feet (3 m).

Hanna Coal Beds

Two coal beds, C5 and C4, crop out for a distance of 1 mile (1.6 km) in the extreme southwest corner of the quadrangle. Coal bed C5 is the Carbon No. 5 coal bed of Dobbin, Bowen, and Hoots (1929), and it is probably equivalent to the Johnson coal bed (Dobbin and others, 1929, pl. 10). Coal bed C4 is the Carbon No. 4 coal bed, and it is probably equivalent to the Finch coal bed. The Carbon No. 5 and No. 4 beds crop out near the base of the Hanna Formation, for about 2 miles (3.2 km) in the northwestern part of the Carbon Basin. The Johnson and Finch coal beds also crop out near the base of the Hanna Formation, but only in the western, southern, and southeastern parts of the Carbon Basin. Dobbin, Bowen, and Hoots (1929) map the Finch coal bed on the west side of the basin as far north as sec. 34, T. 22 N., R. 80 W. Outcrops of the Carbon No. 5 and No. 4 coal beds are mapped as far south as the center of sec. 22, T. 22 N., R. 80 W. Thus, west of the town of Carbon, the outcrops of the potentially correlatable coal beds are less than 2.3 miles (3.7 km) apart.

Coal beds C5 and C4 in this quadrangle dip south at 25°. Coal bed C5 varies in thickness from 10.3 to 13 feet (3 to 4 m). Coal bed C4 occurs about 50 feet (15 m) above coal bed C5, is 13.1 feet (4 m) thick at a measured outcrop, and is 5 feet (1.5 m) thick in the subsurface in drill hole 13.

Eight local coal lenses in the Hanna Formation are intersected in the subsurface by drill hole 13 (Plate 3).

COAL RESOURCES AND RESERVES

Previous Work

Coal reserves of the Hanna and Carbon Basins have been estimated or calculated by Dobbin, Bowen, and Hoots (1929), Berryhill and others (1950), and Glass (1972).

Method of Calculating Resources and Reserves

Data from Dobbin, Bowen, and Hoots (1929), oil and gas well logs, and coal drill holes (written communication, Rocky Mountain Energy Company, 1977) were used to construct a coal data map (Plate 1) and a coal data sheet (Plate 3). U.S. Geological Survey reviewed these two plates and on the basis of Reserve Base criteria, selected four coal beds for the calculation of coal resources in the Como East quadrangle. In addition, calculation of coal resources was requested for isolated or noncorrelatable data points.

The coal data map and coal data sheet were used to construct structure contour, coal isopach, and overburden isopach maps of the correlatable coal beds (Plates 4-9, 12-17). For single coal beds, the maps were drawn using, as control points, thicknesses measured at outcrop and subsurface data from drill hole information. Where coal beds are split, cumulative coal thicknesses were used, excluding non-coal partings. Control points were generated from surface data and from drill holes by combining outcrop or subsurface thicknesses of individual beds to produce a single, cumulative thickness of the entire zone.

Plates 4-9, 12-17 provide the data for calculating the coal resources and reserves within the KRCRA boundary of the quadrangle in accordance with the classification system given in U.S. Geological Survey Bulletin 1450-B and in the instructions provided by U.S. Geological Survey upon their approval of these 12 plates. Calculation of the resources and reserves is in accordance with the following criteria:

- Identified coal resources of the quadrangle, as selected by U.S. Geological Survey, are contained within coal beds 112-A,

CEL 5, C5, and C4, and the resources defined by isolated or noncorrelatable data points.

- Coal bed thicknesses from surface mapping are true thicknesses; thicknesses from subsurface data are apparent thicknesses. Apparent thickness is corrected to true thickness if the dip of the selected coal bed exceeds 25^{o}.

- Strippable coal resources (the resources capable of being extracted by strip-mining methods) are composed of single coal beds at least 5 feet (1.5 m) thick and having 200 feet (61 m) or less of overburden, and of multiple coal beds at least 5 feet (1.5 m) thick and having 500 feet (152 m) or less of combined overburden and interburden.

- Nonstrippable coal resources (subsurface resources capable of being mined by underground methods) are single or multiple coal beds with a minimum thickness of 5 feet (1.5 m); a maximum dip of 15^{o}; an overburden, or combined overburden and interburden, thickness of 0 to 3,000 feet (914 m). To avoid duplicating strippable coal Reserve Base and reserve values, no nonstrippable coal Reserve Base and reserve values are calculated where a coal bed(s) occurs above the stripping limit. When calculating nonstrippable coal Reserve Base values, an average thickness for each coal bed is determined from the coal bed thicknesses at control points within a measured area. When calculating nonstrippable coal reserve values, the average thickness for each coal bed is determined in a like manner after coal bed thicknesses greater than 12 feet (3.7 m) have been reduced to 12 feet (3.7 m).

- All coal deeper than 3,000 feet (914 m) is excluded.

- Reliability or geologic assurance categories (measured, indicated, and inferred resources) are defined according to proximity of the coal to a data point. Measured resources occur within 0.25 mile (402 m) of a data point; indicated resources occur within an area that is 0.25 to 0.75 mile (402 m to 1.2 km) from a data point; inferred resources occur within an area that is 0.75 to 3 miles (1.2 to 4.8 km) from a data point. A data point is either a measured coal thickness in a drill hole or a measured coal thickness location on a mapped outcrop.

- Coal resources from isolated or noncorrelatable data points are calculated for a single coal bed at least 5 feet (1.5 m) thick or for an aggregate thickness of multiple coal beds each at least 5 feet (1.5 m) thick. The single coal bed, or the stratigraphically highest bed in an aggregate of coal beds, is locally projected up dip to the surface to establish an inferred outcrop. Strippable coal resources for the projected bed or beds are considered to occur from surface to a depth of 200 feet (61 m); nonstrippable coal resources are considered to occur from surface to a depth of 3,000 feet (914 m). Only the coal resources underlying an area within

0.5 mile (804 m) of a drill hole or a measured surface outcrop are considered, and they are assigned to the inferred category of reliability.

- Coal resources are calculated for unleased Federal land within the KRCRA boundary (Plate 2). Information pertaining to leased or fee acreage and to non-Federal land is considered proprietary and not for publication.

In preparing a map for evaluating the areal distribution of identified resources for the isolated or noncorrelatable coal beds, some data require a unique solution. For example:

- Where short segments of coal bed outcrop have data points that indicate a coal thickness of 5 feet (1.5 m) or more, an arc with a radius equal to half the outcrop length is drawn down dip from the outcrop, connecting to the ends of the outcrop. The resulting contained area defines the total coal resource, segmented into strippable and nonstrippable resource sections.

- Where a coal bed outcrop has data points with coal thicknesses less than 5 feet (1.5 m), a 5-foot (1.5-m) cutoff point is interpolated, and the resulting segments with values greater than 5 feet (1.5 m) are used to generate arcs (radii equal to half the outcrop length) for defining the extent of the coal resources. When several data points occur on the outcrop of a resource area, an average of their coal thickness values is used to calculate a tonnage of coal.

- Where areas within outcrop segment arcs and areas within 0.5 mile (804 m) of a drill hole coincide, the areas are combined and drill hole coal thickness values are averaged with outcrop coal thickness values.

- When evaluating multiple coal beds of an isolated or noncorrelatable data point, the interburden between subsurface coal beds may be too great to allow the aggregate thickness of coal to be considered as one planar unit. In such instances, a conservative judgment is made and the resources for each coal bed are calculated separately and then totaled.

Results

The areal distribution of leasable Federal coal resources within the KRCRA boundary is shown on Plate 10 for one of the four selected coal beds. Evaluation of coal beds 112-A, C5, and C4, showed that no mappable coal resources are present beneath unleased Federal land; therefore, these three selected coal beds are excluded from Reserve Base and reserve calculations.

The coal resource acreage within each area of unleased Federal land was determined by planimeter. Coal Reserve Base values are obtained by multiplying the coal resource acreage for the planimetric portion of each area of unleased Federal land by the average isopach value of the selected coal bed, times the conversion factor for subbituminous coal, 1,770 short tons (1,606 t) of coal per acre-foot. The coal Reserve Base tonnage for coal bed CEL 5 is 0.31 million short tons (0.28 million t); assigned to measured, indicated, or inferred categories; shown on Plate 10; and included in the coal Reserve Base totals shown on Plate 2. No Reserve Base acreage from isolated or noncorrelatable data points occurs on unleased Federal land within the KRCRA in the quadrangle.

In summary, the total Reserve Base for all coal beds thicker than 5 feet (1.5 m), that lie less than 3,000 feet (914 m) below the ground surface of unleased Federal land within the KRCRA in the Como East quadrangle, is 0.31 million short tons (0.28 million t).

Coal reserves for the quadrangle are calculated by applying recovery factors to the measured, indicated, and inferred resources of the Como East Lens 5. For strippable resources, a recovery factor 0.85 is used; for nonstrippable resources, the recovery factor is 0.50. Reserve tonnages, to the nearest ten thousand short tons, are shown on Plate 10. Total coal reserves for unleased Federal land within the KRCRA in the Como East quadrangle, are 0.27 million short tons (0.24 million t) recoverable by strip mining or by underground mining.

COAL DEVELOPMENT POTENTIAL

Method of Calculating Development Potential

Following the calculating of Reserve Base values and coal reserves, the coal resources of the KRCRA of the Como East quadrangle are evaluated for their development potential in each of two mining-method categories, surface and subsurface.

Strippable and nonstrippable resources are assigned to one of four development potential categories (high, moderate, low, and unknown) according to the following criteria:

Stripping Resources

- Assignment is based on calculated mining ratio values for subsurface data points (wells and drill holes) and for points of intersection of coal isopachs (Plate 8) and overburden isopachs (Plate 9).

- The formula used to calculate mining ratios was provided by U.S. Geological Survey as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

where

MR = mining ratio

t_o = thickness of overburden, in feet

t_c = thickness of coal, in feet

rf = recovery factor (0.85 for strip mining)

0.911 = a constant

- If mining ratio is 0-10, resources have high development potential.

  If mining ratio is 10-15, resources have moderate development potential.

  If mining ratio is greater than 15, resources have low development potential.

- If insufficient data prevent the construction of mining ratio contours, the resources are assigned to unknown development potential category, provided that there is reasonable assurance the coal bed is present in that area.

Nonstrippable Resources

- Coal beds must be more than 5 feet (1.5 m) thick. Coal beds less than 5 feet (1.5 m) thick are excluded from the Reserve Base coal resources. Where coal beds are more than 12 feet (3.7 m) thick, only 12 feet (3.7 m) of the total thickness is used for Reserve Base calculation.

- If the overburden is between 0 and 1,000 feet (0 and 305 m), resources have high development potential; if the overburden is between 1,000 and 2,000 feet (305 and 610 m), resources have moderate development potential; if the overburden is between 2,000 and 3,000 feet (610 and 914 m), resources have low development potential.

- If insufficient data prevent the construction of coal isopachs or overburden isopachs, or if the correlatable coal bed in the area is located completely above the stripping limit,

the resources are assigned to the unknown development potential category, provided that there is reasonable assurance the correlatable coal bed is present in the area.

By applying the above criteria, a mining-ratio map (Plate 11) was prepared for the selected coal bed, CEL 5. Mining-ratio maps are omitted for coal beds 112-A, C5, and C4, because of insufficient data within the unleased Federal land of the KRCRA in this quadrangle.

Development potential acreages were blocked out for the selected coal bed, CEL 5, and then allocated to the two resource categories, strippable and nonstrippable. In addition, the acreages were assigned to one of the four development potential categories. In accordance with a constraint imposed by the U.S. Bureau of Land Management, the highest development potential affecting any portion of a 40-acre (16 ha) parcel is applied to the entire parcel. For example, if 5 acres (2 ha) in a parcel are assigned a high development potential, 10 acres (4 ha) a moderate development potential, and 25 acres (10 ha) a low development potential, then the entire 40 acres (16 ha) are assigned a high development potential.

Development potential acreages for the strippable resources of coal bed CEL 5 are shown on Plate 18. Due to the steep dips associated with this coal bed, nonstrippable resources could not be calculated, and therefore nonstrippable development potential acreages could not be generated.

Additionally, at the direction of the U.S. Geological Survey, an unknown development potential is assigned to coal resources calculated for any coal bed that, although not selected for coal resource evaluation, is (a) wholly or partly of Reserve Base thickness or (b) of unknown thickness.

Development Potential for Strippable Resources

Plate 18 shows the development potential for strippable coal resources of the selected coal bed, CEL 5, within unleased Federal land in the KRCRA of this quadrangle. Values are obtained after assigning the highest assessed development potential for any coal bed within the smallest legal subdivision to that subdivision.

There are approximately 320 acres (129 ha) of unleased Federal land in the KRCRA of this quadrangle. Of this area, 120 acres (48 ha) or 38 percent of the total, are estimated to be underlain by coal resources, from the

selected coal bed, with development potential for surface mining. Of the 120 acres (48 ha), a high development potential is assigned to 40 acres (16 ha) and low development potential to 80 acres (32 ha). Evaluation of all other coal beds in the quadrangle, whether selected for resource evaluation by U.S. Geological Survey or not, did not result in any further acreage being assigned development potential, either for surface or for subsurface mining.

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Appendix 1. — Average analyses of coal samples from the Hanna and Carbon Basins

Source of Data	Number of samples (1)	Total footage Ft	in	Average analyses — as-received basis, Percent: Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	Btu/lb	Calorific Value, Btu/lb Moist, mineral-matter-free basis (2)	Apparent rank of coal (3)
Published analyses	26	318	6	12.5	7.1	36.2	44.2	0.6	10,553	11,438	sub A or hvCb
Union Pacific coal inventory program	230	1,605	10	12.48	8.74	35.12	43.68	0.82	10,398	11,494	sub A or hvCb

Notes:

(1) Published data from USBM (1931, p. 40-45, sample nos. 2623, 2624, 22800, 22972, 93486, 93488, 93541, A14123, A14124); Glass (1975, p. 16-19, sample nos. 74-23 to 74-34, inclusive); Dept. of Interior (1975, p. 38, sample nos. D169597-99, D169607-08). Union Pacific coal inventory program data from company files, Rocky Mountain Energy Company (1977).

(2) Moist, mineral-matter-free Btu/lb calculated from average analyses, as-received basis, using Parr formula (ASTM, 1977, p. 216, sec. 8.2).

(3) Sub A — subbituminous A; hvCb — high volatile C bituminous (ASTM, 1977, p. 215, sec 4.2, and p. 217).

[To convert feet and inches to meters, multiply feet by 0.3048 and inches by 0.0254. To convert Btu/lb to kilojoule/kilogram, multiply by 2.326].

Appendix 2. — Average analyses of coal grouped by coal-bearing formations in the Hanna and Carbon Basins

Source of data	Formation or Group	Number of samples (1)	Total footage		Average analyses — as-received basis						Calorific Value, Btu/lb	Apparent rank of coal (3)
					Percent							
			Ft	in	Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	Btu/lb	Moist, mineral-matter-free basis (2)	
Published analyses	Mesaverde	1	4	0	14.1	7.8	36.5	41.6	1.1	10,290	11,251	sub A or hvCb
	Medicine Bow	2	10	1	12.8	3.8	33.3	50.2	0.8	11,050	11,534	hvCb
	Ferris	10	93	1	.13.0	8.3	34.3	44.3	0.4	9,970	10,956	sub A or hvCb
	Hanna	13	211	4	12.0	6.6	38.1	43.3	0.7	11,946	11,797	hvCb
Union Pacific coal inventory program	Mesaverde	13	70	5	9.45	8.41	35.42	46.72	0.77	11,112	12,237	hvCb
	Medicine Bow	16	93	4	13.09	4.03	35.46	47.42	0.80	10,927	11,446	sub A or hvCb
	Ferris	114	863	1	12.69	7.96	34.39	44.97	0.44	10,331	11,309	sub A or hvCb
	Hanna	87	579	0	12.51	10.67	35.96	40.85	1.33	10,280	11,640	hvCb

Notes:

(1) Published data from USBM (1931, p. 40-45, sample nos. 2623, 2624, 22800, 22972, 93486, 93488, 93541, A14123, A14124); Glass (1975, p. 16-19, sample nos. 74-23 to 74-34, inclusive); Dept. of Interior (1975, p. 38, sample nos. D169597-99, D169607-08). Union Pacific coal inventory program data from company files, Rocky Mountain Energy Company (1977).

(2) Moist, mineral-matter-free Btu/lb calculated from average analyses, as-received basis, using Parr formula (ASTM, 1977, p. 216, sec. 8.2).

(3) Sub A — subbituminous A; hvCb — high volatile C bituminous (ASTM, 1977, p. 215, sec. 4.2, and p. 217).

[To convert feet and inches to meters, multiply feet by 0.3048 and inches by 0.0254. To convert Btu/lb to kilojoule/kilogram, multiply by 2.326].

Appendix 3. — Coal analyses, Como East quadrangle

Drill hole	Location			Coal bed	Sample interval				Sample width		Analyses - as-received basis					
					From		To				Percent					
	Sec.	Twp.	Rge.		Ft	in	Ft	in	Ft	in	Moisture	Ash	Volatile matter	Fixed carbon	Sulfur	Btu/lb
5	9	22N	79W	112-A	81	0	91	1	10	1	11.29	13.56	34.00	41.15	1.85	9,953
11	13	22N	80W	CEL5	312	2	318	7	6	5	13.98	7.23	36.12	42.67	0.30	10,396
13	14	22N	80W	C4	316	0	322	0	6	0	10.53	10.40	34.95	44.12	0.54	10,564
13	14	22N	80W	C5	402	0	415	8	13	8	10.02	11.27	36.05	42.66	0.33	10,542

Data from Rocky Mountain Energy Company (1977).

[To convert feet and inches to meters (m), multiply feet by 0.3048 and inches by 0.0254.
To convert Btu/lb. to kilojoules/kilogram (kJ/Kg), multiply by 2.326.]

Appendix 4. — Coal Reserve Base Data for Federal coal lands (in short tons) in the Como East quadrangle, Carbon County, Wyoming.

Strippable coal Reserve Base data for Federal coal lands (in short tons) in the Como East quadrangle, Carbon County, Wyoming [Development potentials are based on mining ratios (cubic yards of overburden/ ton of underlying 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
CEL 5	60,000	150,000	0	210,000
Total	60,000	150,000	0	210,000