Text to accompany:

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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE TL RANCH QUADRANGLE, CARBON COUNTY, WYOMING

(Report includes 13 plates)

Prepared for:

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used along with the accompanying Coal Resource Occurrence (CRO) maps and Coal Development Potential (CDP) maps of the TL Ranch quadrangle, Carbon County, Wyoming (13 plates; U.S. Geol. Survey Open-File Report 78-053), 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 maps for this quadrangle cover part of the southeastern portion of the KRCRA of the Hanna coal field.

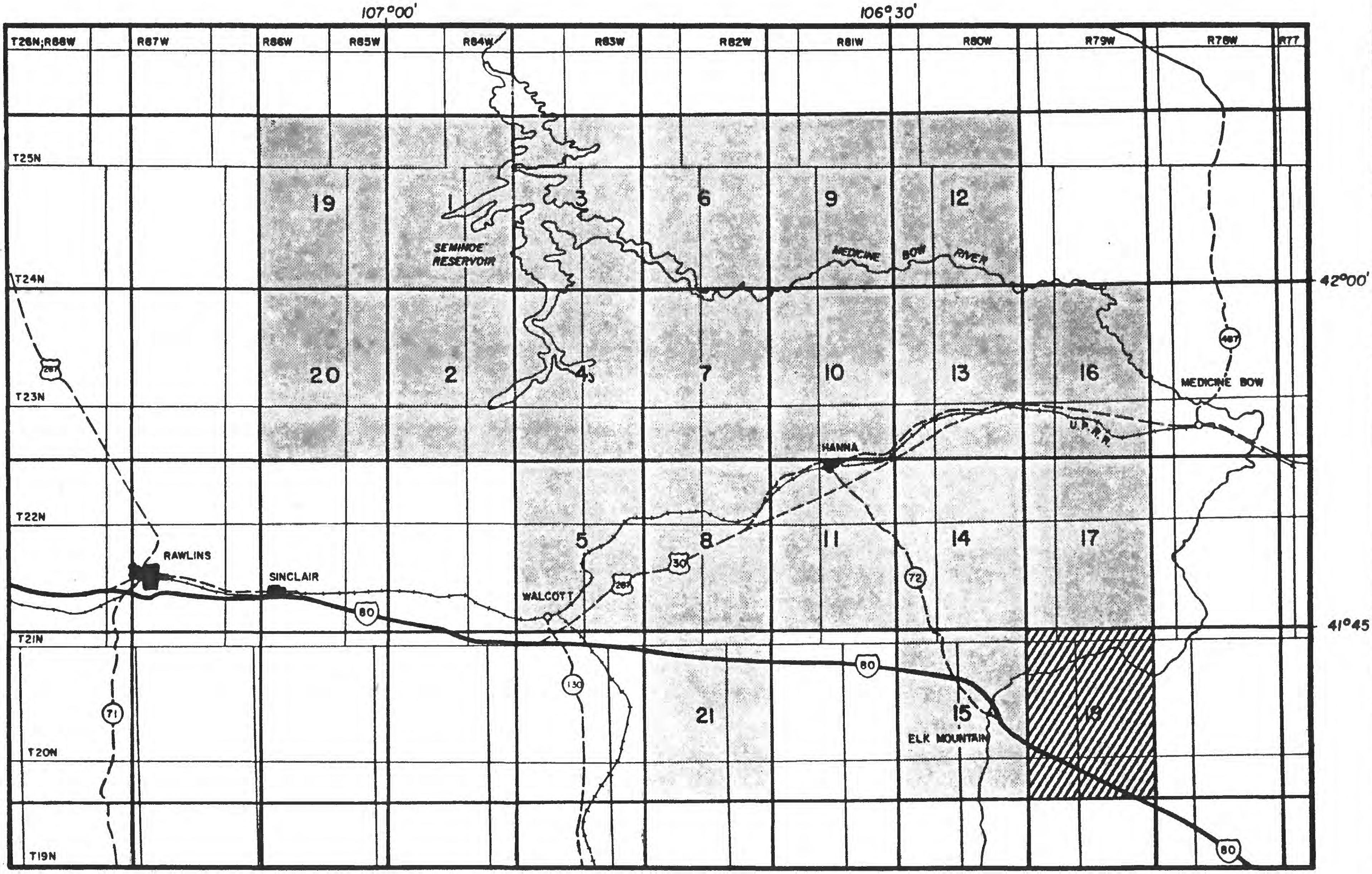
Acknowledgment

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, and the results and 230 coal analyses have been incorporated into these reports.

Location

The TL Ranch $7\frac{1}{2}$-minute quadrangle is in the southeastern part of Carbon County, Wyoming. The center of the quadrangle is approximately 18 miles (28 km) southeast of Hanna and 16 miles (26 km) southwest of Medicine Bow, Wyoming (Figure 1).



TL Ranch quadrangle (18)

Scale 1:446,000

Figure 1. — Map of Hanna and Carbon Basins Study Area

Accessibility

Major access to the quadrangle is via U.S. Interstate Highway 80 between Rawlins and Laramie. This section of the highway crosses the southwestern part of the quadrangle from northwest to southeast.

Three light-duty roads traverse the quadrangle as follows:

- A road in the northeast corner provides access from the town of Medicine Bow to the TL Ranch on the south bank of the Medicine Bow River.
- A road between Medicine Bow to the northeast and Elk Mountain to the west, enters the quadrangle at the north-central border, continues south then southwest, passes the Johnson and Orton Ranches on the south bank of the Medicine Bow River, and leaves the quadrangle at the west-central border. A short fork from this road provides access to well sites and oil storage tanks in sec. 23, T. 20 N., R. 80 W.
- A road between Elk Mountain to the west and Arlington to the southeast, crosses the southern third of the quadrangle from the southwestern border to the southeast corner.

Numerous unimproved dirt roads provide access from the four major roads to the remaining areas of the quadrangle.

The main east-west tracks of the Union Pacific Railroad between Medicine Bow and Hanna, are 15 miles (24 km) north of the center of the quadrangle. A landing strip for light aircraft is located less than one mile (1.6 km) north of the northeast corner of the quadrangle and at the side of the light-duty road from Medicine Bow to the TL Ranch.

Physiography

The TL Ranch quadrangle is located in the southeastern part of the Carbon structural basin. Topography is the partially dissected high plains grasslands that is typical of southern Wyoming. The southern three-quarters of the quadrangle, south of the Medicine Bow River, is an upland area with a general slope northward from the Medicine Bow Range, to the south of the quadrangle, toward the center of the Carbon Basin. North of the Medicine Bow River the dip slopes of resistant Hanna sediments also gently descend toward the center of the Carbon Basin to the north of the quadrangle. Elevations range from less than 6,880 feet (2,097 m) where the Medicine Bow River leaves the quadrangle at the northeast border to 7,967 feet (2,428 m) at the summit of Sheepherder Hill in the southeast corner.

The most prominent topographic features in the quadrangle are the elongated crests of several asymmetric ridges which flank the alluvial-filled valley of the meandering Medicine Bow River. Local relief of these ridges is 300 feet (91 m) or less. In the southeast corner of the quadrangle, Sheepherder Hill has a local relief of over 400 feet (122 m).

Major drainage in the quadrangle is the easterly flowing Medicine Bow River and its three north-flowing tributaries of Bear, Wagonhound, and Willow Springs Creeks.

Climate

Climate data for the TL Ranch quadrangle were obtained from the Elk Mountain weather station located 5 miles (8 km) west of the center of the quadrangle at an elevation of 7,270 feet (2,216 m). Precipitation records are available for 65 years to 1970 and temperature records are available for 22 years to 1970.

The climate is semiarid with a mean annual temperature of 41°F (5°C) and extremes ranging from 95° to -42°F (35° to -41°C). July is the warmest month with a mean monthly temperature of 63°F (17°C) and January is the coldest month with 22°F (-6°C). For seven months of the year, April to October, the mean monthly temperature exceeds 32°F (0°C). Average annual precipitation is 15 inches (38 cm) with 50 percent of this total falling in the five months from March 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 early 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 southeast part of the KRCRA of the Hanna and Carbon Basins. The Federal Government owns approximately 20 percent of the coal rights in the quadrangle; the remaining 80 percent is non-federally owned. Approximately 9 percent of the area of the quadrangle is included in the KRCRA, and within this region about 6 percent of the land is federally owned. Plate 2 of the CRO maps illustrates the ownership status of the land in the quadrangle and the boundary of the KRCRA.

Six abandoned underground mines are shown on Plate 1. These are: the Black Diamond Nos. 1 and 2 mines (sec. 32, T. 21 N., R. 79 W.), the Johnson 1 mine (sec. 6, T. 20 N., R. 79 W.), the Kent Nos. 1 and 2 mines (sec. 2, T. 20 N., R. 80 W.), and an unnamed mine (sec. 24, T. 24 N., R. 80 W.). 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 quadrangle to the north and extended their mapping into the northwestern corner of TL Ranch quadrangle. Weitz and Love (1952) compiled a geological map of Carbon County which incorporates available data, published and unpublished, available to that date. Hyden and McAndrews (1967) mapped the geology of the TL Ranch quadrangle from 1963 to 1964. Hyden (1966) mapped the geology of the quadrangle east of TL Ranch; Hyden, King, and Houston (1967) mapped the quadrangle southeast of TL Ranch; and Hyden, Houston, and King (1968) mapped the geology of the quadrangle south of TL Ranch. Gill, Merewether, and Cobban (1970) defined and correlated the upper Cretaceous and lower Tertiary rocks of south-central Wyoming and their studies result in changes in the nomenclature and definition of several of the rock units in TL Ranch quadrangle.

Stratigraphy

Rocks exposed in the quadrangle range in age from Triassic to Quaternary. Older rocks, including Lower Triassic and Permian units, are known in the subsurface from the logs of oil wells. Coal beds are found in the

Mesaverde Formation of Late Cretaceous age and in the Hanna Formation of Paleocene age.

The oldest rocks exposed in the TL Ranch quadrangle are the upper 60 feet (18 m) of the Jelm Formation of Late Triassic age. The outcrop is of very limited extent, on the west bank of Wagonhound Creek at the south central boundary of the quadrangle. Overlying the Triassic are Upper Jurassic and Lower Cretaceous rocks exposed in the south-central part of the quadrangle. The outcrops of these units are extensively mantled by Quaternary deposits and in general they form discontinuous arcuate bands that outline the northwest-plunging Wagonhound anticline. Hyden and McAndrews (1967) show the Upper Jurassic as 515 feet (157 m) thick, including the Sundance and Morrison Formations; the Lower Cretaceous is 370 feet (113 m) thick and includes the Cloverly Formation, the Thermopolis Shale, and the Mowry Shale. The Upper Cretaceous Frontier Formation overlies the Lower Cretaceous and is 530 feet (161 m) thick in the TL Ranch quadrangle. The formation is exposed in the southern part of the quadrangle in three isolated outcrops, on the northeast and southwest flanks of the Wagonhound anticline, and east of Wagonhound Creek at Wick Lower Ranch. Overlying the Frontier is the Niobrara Formation of Late Cretaceous age, 890 feet (271 m) thick, and in one limited outcrop in the southwest part of the quadrangle on the north flank of the Wagonhound anticline.

Conformably overlying the Niobrara Formation is the Steele Shale of Late Cretaceous age. The formation is exposed in two small outcrops near the west-central border. Hyden and McAndrews (1967) quote a thickness of 2,980 feet (980 m) for the Steele Shale and describe it as consisting of interbedded and interlaminated shale and siltstone. The Steele Shale was deposited in a marine environment.

Conformably overlying the Steele Shale is the Mesaverde Formation of Late Cretaceous age. The Mesaverde is exposed in the west-central part of the quadrangle in a broad outcrop that defines the anticline of the Elk Mountain Oil Field, and in a broad band on the western flank of the Big Medicine Bow Oil Field, in the northeastern corner of the quadrangle. Hyden and McAndrews (1967) give a total thickness of 1,950 feet (594 m) for the Mesaverde Formation of which the upper 250 feet (76 m) constitutes their Pine Ridge Sandstone Member. They describe the formation as consisting of light-gray fine-grained sandstone, medium-gray carbonaceous siltstones, dark-gray micaceous carbonaceous shales, and lenticular coal beds that are interbedded and interlaminated with carbonaceous shales and siltstones. The Pine Ridge Sandstone Member consists of light-gray to white fine and very fine grained crossbedded sandstones, interbedded with carbonaceous shales, carbonaceous siltstones, and coal. In a recent study by Gill, Merewether, and Cobban (1970) the Mesaverde has been elevated to group status. In the Carbon and Hanna Basins to the north and west, four formations have been defined and described in the group while in the Laramie Basin to the southeast, two formations have been defined and described in the Mesaverde Group. These formational units have not been mapped in the TL Ranch quadrangle, however, and the group is consequently treated as a unit.

Conformably overlying the Mesaverde is the Lewis Shale of Late Cretaceous age. The unit occurs in a broad band across the northern part of the quadrangle but the exposures are partially mantled by thick Quaternary deposits. Hyden and McAndrews (1967) give a thickness of 2,390 feet (728 m) for the Lewis Shale in this quadrangle. They describe the Lewis as consisting of interbedded and interlaminated gray and dark-gray shale and siltstone, with scattered lenses of light-gray very fine grained sandstone. The formation was deposited in a marine environment.

Overlying the Lewis Shale are two units which Hyden, McAndrews, and Tschudy (1965) named and described as the Foote Creek Formation and the Dutton Creek Formation. In the TL Ranch quadrangle, Hyden and McAndrews (1967) show thicknesses of 80 feet (24 m) for the Foote Creek and 180 feet (55 m) for the Dutton Creek. Later studies by Gill, Merewether, and Cobban (1970, p. 45, 46) have shown that in the TL Ranch quadrangle the Foote Creek Formation is a fine-grained facies of the Hanna Formation and the Dutton Creek Formation is a conglomeratic facies of the Hanna Formation, and both units are Paleocene in age. Gill, Merewether, and Cobban (1970) also state that the local unconformity recognized in the TL Ranch quadrangle at the base of the Foote Creek Formation is actually the regional unconformity at the base of the Hanna Formation. On the basis of their studies Gill, Merewether, and Cobban (1970) recommend abandoning the names Foote Creek and Dutton Creek as formal stratigraphic names and the reinstatement of the Hanna Formation. The Hanna Formation is exposed in the northwestern corner of the TL Ranch quadrangle on the southeastern margin of the Carbon Basin, and in a broad band from the center of the quadrangle to the southeastern border. The formation consists of a lower part of light-gray to white fine-grained sandstones interbedded with carbonaceous siltstones, shales, and coal beds; an upper part contains light-yellowish-gray coarse-grained conglomeratic sandstones interbedded with mudstones, shales, siltstones, and coal beds. The formation was deposited in a continental environment.

Extensive Quaternary colluvium and terrace gravels, as much as 40 feet (12 m) thick, cover large areas of the quadrangle. Quaternary alluvium occurs in the valley of the Medicine Bow River and in the valleys of its principal tributary streams.

Structure

The northwestern corner of the TL Ranch quadrangle lies on the southeastern edge of the Carbon structural basin. The northeastern corner of the quadrangle lies on the west flank of the Big Medicine Bow anticline which in turn is considered to lie on the western edge of the Laramie structural basin. The southern two-thirds of the quadrangle lies on the shelf area between the structural basins to the north and east and the Medicine Bow Range, two miles (3 km) to the south of the quadrangle. The basement structure contour map of Knight (1951) indicates that more than 9,000 feet (2,743 m) of sediments overlie crystalline basement in the central portion of the quadrangle.

In the southwest part of the TL Ranch quadrangle the Wagonhound anticline is a large structural feature which trends northwesterly and plunges to the northwest. Sediments as old as the Triassic are exposed on the northeast flank of the anticline. In the northwest part of the quadrangle a small anticline occurs in the Mesaverde Formation; the structure has been drilled for oil and the Elk Mountain Field contributes to Wyoming's production. The large exposure of the Hanna Formation south of the Medicine Bow River defines a shallow syncline that trends southeasterly and plunges to the southeast. Several small east-west folds have been mapped on the south edge of the syncline.

In the northeast part of the quadrangle Hyden and McAndrews (1967) have mapped a small anticline which is plunging southwest off the western flank of the Big Medicine Bow anticline, that lies east of the quadrangle boundary.

In the south-central part of the quadrangle a large northwest-trending fault, together with several short parallel fault segments, marks a fault zone which is upthrown to the southwest. This fault zone is the northern part of the Arlington Fault, a major thrust fault which extends south along the east edge of the Medicine Bow Mountains for more than 18 miles (29 km) southeast of this quadrangle. In the northern part of the quadrangle several small normal faults are mapped which show relatively little displacement; these faults are randomly oriented and displace both Upper Cretaceous and Tertiary rock units.

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 bed, 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 that are found in the 42 samples collected in six other Wyoming coal fields.

General Features

In the TL Ranch quadrangle, 5 coal beds and 42 local coal lenses are mapped by Hyden and McAndrews (1967) and by Dobbin, Bowen, and Hoots (1929). Coal beds mapped in the Foote Creek and Dutton Creek Formations by Hyden and McAndrews (1967) are considered in this report to be Hanna coal occurrences (see preceding section, Stratigraphy). One published analysis of a sample from coal bed JB (the Johnson Bed) is shown in Appendix 3.

Mesaverde Coal Beds

In the Mesaverde Formation, coal bed 99 and 21 local coal lenses are mapped in the northeastern and west-central areas of the quadrangle. In the northeast on the west flank of the Big Medicine Bow anticline, coal bed 99 and short outcrops of several local coal lenses dip west, southwest, and south at 6° to 13°. In the west-central area, short outcrops of local coal lenses occur on the flanks of the anticline that is located south of the junction of Bear Creek and Medicine Bow River. Dip of the coal lenses varies from 10° to 14°, steepening south of Old Brooks Place on Bear Creek to 30° and vertical.

Measured thicknesses of coal bed 99 range from 1.3 to 2.5 feet (0.4 to 0.8 m) and average 1.7 feet (0.5 m); 21 measured sections of local coal lenses range from 1.0 to 9.5 feet (0.3 to 2.9 m) and average 3.1 feet (0.9 m). Four measurements of local coal lenses exceed the minimum Reserve Base thickness of 5 feet (1.5 m).

Hanna Coal Beds

Four coal beds and 21 local coal lenses are mapped in the Hanna Formation in the northwestern, central, and southeastern areas of the quadrangle. Coal beds 105 and 106 occur only in limited outcrops in the extreme northwest, but coal beds JB (the Johnson Bed) and FB (the Finch Bed) crop out in continuous outcrops of several thousands of feet in the northwestern and central areas. Dips of the coal beds and local coal lenses in the northwestern area are generally northerly toward the center of the Carbon Basin at 6° to 15°. Dips in the central and southeastern areas are 3° to 17°, generally southerly in the center of the quadrangle and northerly near the southeastern border.

Measured thicknesses of coal beds 105 and 106 range from 1.5 to 5.5 feet (0.5 to 1.7 m); the average thickness of coal bed 105 is 2.2 feet (0.7 m) and of coal bed 106, 3.8 feet (1.2 m). From 28 measured sections of coal bed JB, the coal content ranges from 1 to 14 feet (0.3 to 4.3 m), averaging 6.0 feet (1.8 m); from 29 measured sections of coal bed FB, the range is 1 to 7 feet (0.3 to 2.1 m) and the average thickness is 2.9 feet (0.9 m). Twenty-six sections have been measured on local coal lenses. Lens thicknesses range from 1 to 12 feet (0.3 to 3.7 m) and the average thickness is 2.9 feet (0.9 m). Only two measurements of local coal lenses exceed minimum Reserve Base thickness of 5 feet (1.5 m).

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), Hyden and McAndrews (1967), 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 coal data sheet (Plate 3). U.S. Geological Survey reviewed these two plates and on the basis of Reserve Base criteria, selected two coal beds for the calculation of coal resources in the TL Ranch 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 4-6, 9-11). 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.

Plates 4-6 and 9-11 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 the instructions provided by U.S. Geological Survey on approval of these 6 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 the coal beds JB and FB, and the resources defined by isolated or non-correlatable data points.

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

- 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°; 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 (0.4 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 miles (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) cut-off 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 7 for the coal bed JB. Evaluation of the coal bed FB showed that all coal resources which meet Reserve Base criteria are located beneath non-federal land. Consequently, a plate showing areal distribution and identified resources of coal bed FB was not compiled.

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 tonnages calculated for coal bed JB are 0.76 million short tons (0.69 million t) assigned to measured, indicated, or inferred categories as shown on Plate 7 and included in the coal Reserve Base totals shown on Plate 2. No Reserve Base tonnage from isolated or noncorrelatable coal beds 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 TL Ranch quadrangle, is 0.76 million short tons (0.69 million t).

Coal reserves for the quadrangle are calculated by applying recovery factors to the measured, indicated, and inferred resources of coal bed JB. For strippable resources, a recovery factor of 0.85 is used; for non-strippable resources, the recovery factor is 0.50. Reserve tonnages, to the nearest ten thousand short tons, are shown on Plate 7. Total coal reserves for unleased Federal land within the KRCRA in the TL Ranch quadrangle, are 0.39 million short tons (0.35 million t), consisting of 0.07 million short tons (0.06 million t) recoverable by strip mining or by underground mining, and 0.32 million short tons (0.29 million t) recoverable by underground mining only.

COAL DEVELOPMENT POTENTIAL

Method of Calculating Development Potential

Following the calculation of Reserve Base values and coal reserves, the coal resources of the KRCRA of the TL Ranch 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:

Strippable Resources

- Assignment is based on calculated mining ratio values for subsurface data points (drill holes) and for points of intersection of coal isopachs (Plate 5) and overburden isopachs (Plate 6).

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

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

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 calculations.

- 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 prevents 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 8) was prepared for coal bed JB. A mining-ratio map is omitted for coal bed FB because of insufficient data within the unleased Federal land of the KRCRA in this quadrangle.

Development potential acreages were then blocked out, as shown on CDP Plates 12 and 13. Acreage for strippable and nonstrippable resources of selected coal beds is shown in Table 1 for each 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) within a parcel are assigned a high development potential, 25 acres (10 ha) a moderate development potential, and 10 acres (4 ha) a low development potential, then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Strippable Resources

Development potential for strippable coal resources within unleased Federal land in the KRCRA of this quadrangle, is shown in Table 1 for each selected coal bed. Plate 12 and Table 2 show the highest surface development potentials for the selected coal beds. The totals are obtained after assigning the highest assessed development potential for any coal bed within the smallest legal subdivision to that subdivision.

Table 1. — Development potential for identified resources of the selected coal beds within the KRCRA of the TL Ranch quadrangle

Coal bed	Development potential (acres)							
	Strippable resources			Nonstrippable resources			Unknown category	
	High	Moderate	Low	High	Moderate	Low	Strippable	Nonstrippable
JB	40	0	40	120	0	0	40	0
FB	0	0	0	80	0	0	120	40
Totals	40	0	40	200	0	0	160	40

To convert acres to hectares, multiply by 0.4046

Table 2. — Highest development potential for identified resources of the selected coal beds within the KRCRA of the TL Ranch quadrangle

Development potential (acres)							
Strippable resources			Nonstrippable resources			Unknown category	
High	Moderate	Low	High	Moderate	Low	Strippable	Nonstrippable
40	0	40	120	0	0	40	40

To convert acres to hectares, multiply by 0.4046

There are approximately 200 acres (80.9 ha) of unleased Federal land within the KRCRA of this quadrangle. Of this area, 120 acres (48.5 ha) or 60 percent of the total, are estimated to be underlain by coal resources, from the selected coal beds, with development potential for surface mining. Of the 120 acres (48.5 ha), a high development potential is assigned to 40 acres (16.2 ha), a low development potential to 40 acres (16.2 ha), and an unknown development potential to 40 acres (16.2 ha).

Development Potential for Nonstrippable Resources

Development potential for nonstrippable coal resources within unleased Federal land in the KRCRA of this quadrangle, is shown in Table 1 for each selected coal bed. Plate 13 and Table 2 show the highest subsurface development potentials for the selected coal beds. The totals are obtained after assigning the highest assessed development potential for any coal bed within the smallest legal subdivision to that subdivision.

Of the 200 acres (80.9 ha) of unleased Federal land within the KRCRA of this quadrangle, 120 acres (48.5 ha) or 60 percent of the total, are estimated to be underlain by coal resources, from the selected coal beds, with development potential for underground mining. A high development potential is assigned to all 120 acres (48.5 ha).

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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		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	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 Ft	Total footage 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	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, TL Ranch quadrangle

Sample number	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
22800	6	20	79	Johnson	-	-	-	-	5	5	13.3	6.9	37.9	41.9	10.9	10,810

Data for sample 22800 from USBM (1931).
[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 T.L. Ranch quadrangle, Carbon County, Wyoming.

Strippable coal Reserve Base data for Federal coal lands (in short tons) in the T.L. Ranch 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
JB	60,000	20,000	30,000	110,000
Total	60,000	20,000	30,000	110,000

Non-strippable coal Reserve Base data for Federal coal lands (in short tons) in the T.L. Ranch quadrangle, Carbon County, Wyoming. (To convert short tons to metric tons, multiply by 0.9072)

Coal Bed	High Development Potential (0-1000 ft of overburden)	Moderate Development Potential (1000-2000 ft of overburden)	Low Development Potential (2000-3000 ft of overburden)	Total
JB	480,000	0	0	480,000
Total	480,000	0	0	480,000