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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE THE IRON SPRINGS QUADRANGLE, MOFFAT COUNTY, COLORADO

[Report includes 24 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence and Coal Development Potential Maps of the Iron Springs quadrangle, Moffat County, Colorado. This report was compiled to support the land-planning work of the Bureau of Land Management (BLM) and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. This investigation was undertaken by Dames & Moore, Denver, Colorado, at the request of the U.S. Geological Survey under contract number 14-08-0001-15789. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished public information was used as the data base for this study. No new drilling or field mapping was performed as a part of this study, nor was any confidential data used.

Location

The Iron Springs quadrangle is located in east-central Moffat County in northwestern Colorado, approximately 13 airline miles (21 km) northwest of Craig and 41 airline miles (66 km) north of Meeker. The area within the quadrangle is unpopulated except for local ranches.

Accessibility

U.S. Highway 40 passes east-west through Lay, Colorado, approximately 8 miles (13 km) south of the quadrangle. A light-duty, all-weather road runs north from Lay into the south-central part of the quadrangle and traverses the quadrangle in a northerly direction. Other light-duty, all-weather roads connect the quadrangle with Maybell, Colorado, 25 miles (40 km) to the west and with Craig to the east. Numerous unimproved dirt roads provide access to the remainder of the quadrangle.

Railway service for the Iron Springs quadrangle is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig. The rail line generally parallels U.S. Highway 40 terminating approximately 13 miles (21 km) southeast of the quadrangle, and is the major transportation route for coal shipped east from northwestern Colorado.

Physiography

The Iron Springs quadrangle lies in the southern part of the Wyoming Basin physiographic province as defined by Howard and Williams (1972). The quadrangle lies approximately 17 miles (27 km) northwest of the Williams Fork Mountains and approximately 57 miles (92 km) west of the Continental Divide.

Approximately 850 feet (259 m) of relief is present in the Iron Springs quadrangle. Altitudes range from approximately 7,300 feet (2,225 m) in the northeastern corner of the quadrangle to approximately 6,450 feet (1,966 m) in the southwestern corner of the quadrangle.

The Iron Springs quadrangle is characterized by hill and valley topography. The landscape is dominated by broad, gentle to moderate slopes and wide valleys.

In general, the Iron Springs quadrangle is drained by a dendritic pattern of numerous intermittent creeks and streams that flow mainly in response to snowmelt in the spring. Lay Creek and Bord Gulch are the primary drainages and flow in a southerly direction before joining approximately 2 miles (3 km) south of the quadrangle. Lay Creek then flows westward and empties into the Yampa River approximately 13 miles (21 km) southwest of the quadrangle.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail with large daily temperature variations in the Iron Springs area. Daily temperatures typically range from 0° to 35°F (-18° to 2°C) in January and from 42° to 80°F (6° to 27°C) in July. Annual precipitation in the area averages approximately 14 inches (36 cm). Snowfall during the winter months accounts for the major part of the precipitation in the area; but rainfall from thundershowers during the summer months also contributes to the total. Winds averaging approximately 3 miles per hour (4.8 km per hour) are generally from the west, but directions tend to vary greatly depending on the local terrain (U.S. Bureau of Land Management, 1977).

Principal types of vegetation in the Iron Springs area include sagebrush, small semiarid shrubs, and scattered trees, mostly juniper and pinyon varieties. Several areas in the southern half of the quadrangle are used for agriculture (U.S. Bureau of Land Management, 1977).

Land Status

The Iron Springs quadrangle lies on the northwestern boundary of the Yampa Known Recoverable Coal Resource Area (KRCRA). Only about the southern one-third of the quadrangle lies within the KRCRA, and the Federal government owns the coal rights for approximately 85 percent of that area as shown on plate 2. There are no active coal leases in the quadrangle.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Iron Springs quadrangle is located was reported by Emmons (1877) as part of a Survey of the Fortieth Parallel. The decision to build a railroad into the region stimulated several investigations of coal between 1886 and 1905, including papers by Hewett (1889), Hills (1893), and Storrs (1902). Tweto (1976) compiled a generalized regional geologic map which included this quadrangle. Muller (1976) reported lithologic descriptions and geophysical logs of holes drilled by the U.S. Geological Survey in the Yampa and Danforth Hills coal fields during 1975.

Stratigraphy

Rock formations which occur within 3,000 feet (914 m) of the surface in the Iron Springs quadrangle include the Lewis Shale, the Fox Hills Sandstone, and the Lance, Fort Union, Wasatch, and Green River

Formations. Of these, only the Fort Union, Wasatch, and Green River Formations crop out in the quadrangle.

The Lewis Shale of Late Cretaceous age is present in the subsurface in the quadrangle and consists of dark-gray to bluish, homogeneous, micaceous marine shale interbedded with a few sandstone layers (Bass and others, 1955). Where measured in oil and gas test wells drilled in the southern third of the Iron Springs quadrangle, the formation ranges from about 1,480 to 2,030 feet (451 to 619 m) in thickness.

The Fox Hills Sandstone of Late Cretaceous age intertongues with the underlying marine Lewis Shale and with the overlying brackish-water and fluviatile sandstone and shale of the Lance Formation (Haun, 1961). It consists of gray to white fine-grained fossiliferous sandstone interbedded with gray to dark-gray sandy shale, shale, and, sometimes, coal. Where interpreted from geophysical logs of oil and gas wells drilled in this quadrangle, the Fox Hills Sandstone ranges in thickness from approximately 80 feet (24 m) to a maximum of 115 feet (35 m) where penetrated in the Moore and Gilmore, et al No. 1 Kern well drilled in sec. 13, T. 8 N., R. 93 W. (Haun, 1961).

The Lance Formation of Late Cretaceous age is also present in the subsurface and conformably overlies the Fox Hills Sandstone. The formation consists of a non-marine sequence of sandstone, siltstone, carbonaceous shale, and occasional coal beds (Haun, 1961). It ranges in thickness from about 520 feet (158 m) in the North American Exploration No. 1-19 Peroulis well in sec. 19, T. 8 N., R. 92 W., to approximately 745 feet (227 m) in the No. 1 Kern well (Haun, 1961; Whitley, 1962).

Unconformably overlying the Lance Formation, the Fort Union Formation of Paleocene age crops out in the southeastern part of the quadrangle (Tweto, 1976). The formation is composed of medium- to coarse-grained brown sandstone interbedded with light- to dark-gray silty shale and coal beds. The sandstone is conglomeratic near the base of the formation. Drill-hole information from this quadrangle indicates that the formation is at least 1,100 feet (305 m) thick, but Bass and others

(1955) measured the formation to be about 1,400 feet (427 m) several miles east of the quadrangle. Several coal beds, including the Emerson and Blevins, occur within the Fort Union Formation in the Iron Springs quadrangle.

The Eocene-age Wasatch Formation unconformably overlies the Fort Union Formation and crops out throughout the Iron Springs quadrangle. According to Tweto (1976), the main body of the Wasatch Formation crops out in the southeastern three quarters of the quadrangle. In this quadrangle, only the basal 770 feet (235 m) of the Wasatch Formation have been identified from drill holes located within the KRCRA boundary. However, in the adjacent Craig NW quadrangle to the east, approximately 2,050 feet (623 m) of the Wasatch Formation has been identified. This formation consists of interbedded coarse gray sandstone, light-gray shale, sandy shale, gray siltstone and conglomerate (Bass and others, 1955). The Wasatch Formation is not known to contain coal in the Yampa KRCRA. However, coals have been identified in this formation in Wyoming, approximately 30 miles (51 km) north of the Iron Springs quadrangle.

The Eocene-age Tipton Tongue of the Green River Formation crops out in a thin northeast-trending belt in the northern third of the quadrangle, and is estimated by Tweto (1976) to range in thickness from approximately 50 to 300 feet (15 to 91 m). In general, the Tipton Tongue consists of interbedded brown to gray sandstone and intertongues with the Wasatch Formation (Fisher, 1962).

The Eocene-age Cathedral Bluffs Tongue of the Wasatch Formation is exposed in the northwestern part of the quadrangle. The Cathedral Bluffs Tongue ranges from 1,000 to 1,500 feet (305 to 457 m) in thickness and consists of variegated claystone, mudstone, and sandstone (Tweto, 1976).

Holocene deposits of alluvium cover the Lay Creek valley in the southern part of the quadrangle.

The Cretaceous-age rocks exposed in the Iron Springs quadrangle, including the Lewis Shale and the Lance Formation, accumulated close to the western edge of a Late Cretaceous epeirogenic seaway which covered part of the western interior of North America (O'Boyle, 1955). Several transgressive-regressive cycles caused the deposition of a series of marine, near-shore marine, and non-marine sediments in the Iron Springs area (Masters, 1959).

Deposition of the Lewis Shale marked a landward movement of the sea. The marine sediments of the Lewis Shale were deposited in water depths ranging from a few tens of feet to several hundred feet. Deposition of the Lewis Shale ended in the quadrangle with the regression of the sea (Kucera, 1959).

Final regression of the Cretaceous sea resulted from regional uplift of the Yampa Basin area. As the sea retreated to the northeast, the basal sandstone sequence of the Lance Formation (Fox Hills Sandstone) was deposited over the Lewis Shale in a littoral and near-shore environment. Following the regression of the Cretaceous sea, broad areas of estuarine, marsh, lagoonal, and coastal swamp environment resulted in deposits of carbonaceous shales, mudstones, and thin coal beds, characteristic of the Lance Formation (O'Boyle, 1955; Weimer, 1961).

After a period of erosion, the Fort Union Formation was deposited on the edge of the Larimide uplift after the final recession of the Cretaceous sea (Ritzma, 1955). The formation consists of thick conglomerate and sandstone beds which were deposited in fluvial and lacustrine environments. The thin sandstone, shale and coal beds of the Fort Union Formation are typical of deposits formed in fluvial, flood-plain and swamp environments (Ritzma, 1955).

Depositional environments fluctuated between fluvial and lacustrine during the Eocene Epoch. The main body and the Cathedral Bluffs Tongue of the Wasatch Formation are predominately fluvial deposits (Picard and McGrew, 1955), while the Tipton Tongue of the Green River Formation is mainly a lacustrine deposit (Fisher, 1962).

The coal beds, which have wide areal extent, were deposited near the seaward margins of the non-marine environments, probably in large brackish-water lagoons or swamps. The slow migration of this depositional environment is responsible for the wide distribution of the Fort Union [20], Emerson and Blevins coal beds in the Yampa study area. Coals of limited areal extent were generally deposited in environments associated with fluvial systems, such as back-levee and coastal plain swamps, interchannel basin areas, and abandoned channels.

Structure

The Yampa KRCRA lies in the southern extension of the Washakie/ Sand Wash structural basin of south-central Wyoming. The basin is bordered on the east by the Park Range, some 48 miles (77 km) east of the Iron Springs quadrangle, and on the southwest by the Axial Basin Anticline, approximately 14 miles (23 km) south of the quadrangle.

Two northwest-trending faults, shown on plate 1, cut the Cretaceous- and Tertiary-age rocks in the southeastern part of the quadrangle. The easternmost fault is from Tweto (1976); the westernmost fault is inferred by the authors, based on drill-hole data, and is postulated to have between 500 and 800 feet (152 and 244 m) of vertical offset. The dip of the strata between the faults ranges from 9° to 34° to the southwest while the average dip of the beds west and east of the faults average approximately 6° northwest and 9° north-northwest, respectively.

The structure contour maps of the isopached coal beds are based on the structure contour map of the base of the Fort Union Formation constructed by Brownfield (1979) in the Lay SE quadrangle to the south. These contours were then projected into the Iron Springs quadrangle. It is assumed that the structure of the coal beds duplicates that of the base of the Fort Union Formation. Modifications were made where necessary in accordance with drill-hole data.

COAL GEOLOGY

Several coal beds in the Lance and the Fort Union Formations have been identified in coal test holes and oil and gas test wells drilled in the Iron Springs quadrangle. In general, coals in the Lance Formation are thin, lenticular and of limited areal extent, whereas the Fort Union coals exceed Reserve Base thickness (5.0 feet or 1.5 meters) over large areas. Coal beds exceeding Reserve Base thickness that are not formally named have been given bracketed numbers for identification purposes.

Chemical analyses of coals.--Chemical analyses were not available for coals in the Lance and Fort Union Formations in this quadrangle, but representative analyses from Fieldner and others (1918) and George and others (1937) are listed in table 1. In general, these coals rank as subbituminous B on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Dotted lines shown on some of the derivative maps represent a limit of confidence beyond which isopach, structure contour, overburden isopach, and areal distribution and identified resources maps are not drawn because of insufficient data, even where it is believed that the coal beds may continue to be greater than Reserve Base thickness beyond the dotted lines.

Coal Beds in the Lance Formation and Fox Hills Sandstone

Coal beds in the Lance Formation and Fox Hills Sandstone have been penetrated by two oil and gas test holes in the southeastern part of the Iron Springs quadrangle at depths exceeding 2,000 feet (610 m). One of these coal beds, the Fox Hills [1], exceeds Reserve Base thickness and was encountered in only the King Resources and Imperial American Management No. 2 Lay Creek well. Therefore, this coal bed has been treated as an isolated data point (see Isolated Data Points section of this report).

Coal Beds in the Fort Union Formation

The Fort Union Formation is the most important coal-bearing unit in this quadrangle. Outcrops of the coal beds have not been mapped, but have been penetrated by coal test holes and oil and gas wells drilled in the southern part of the quadrangle. Four of these coal beds, the Fort Union [2], Fort Union [3], Emerson (Brownfield, 1979), and Blevins, exceed Reserve Base thickness and have been isopached. Another coal bed exceeding Reserve Base thickness, the Fort Union [4], was encountered at one location only and has been treated as an isolated data point.

Fort Union [2] Coal Bed

The Fort Union [2] coal bed (plate 4) ranges in thickness from 2 to 6 feet (0.6 to 1.8 m) where penetrated by drill holes in the southeastern part of the quadrangle. This coal bed is lenticular and is not known to contain any rock partings.

Fort Union [3] Coal Bed

The Fort Union [3] coal bed (plate 8) lies 6 to 20 feet (1.8 to 6.1 m) above the Fort Union [2] coal bed and ranges in thickness from 3 to 10 feet (0.9 to 3.0 m) where measured in the oil and gas wells drilled in the southeastern part of the quadrangle The coal bed attains its maximum thickness in sec. 24, T. 8 N., R. 93 W., and is cut by the two northwest-trending faults.

Fort Union [20] Coal Bed

The Fort Union [20] coal bed (plate 12) was identified in only one of the coal test holes drilled in the southwest part of the quadrangle and is 7.0 feet (2.1 m) thick at that location. This coal bed extends into the Lay SE quadrangle to the south where it ranges in thickness from 4.5 feet (1.4 m) to a maximum of 17.8 feet (5.4 m), excluding a rock parting 5.6 feet (1.7 m) thick, where measured along the outcrop.

Emerson Coal Bed

The Emerson coal bed (Brownfield, 1979) is quite extensive and extends over a large area in the southern part of the quadrangle as shown on plate 15. Drill-hole data indicate that the coal bed ranges in thickness from 5 to 23 feet (1.5 to 7.0 m) in this quadrangle, the maximum reported thickness occurring in the coal test hole drilled in the NW 1/4 SW 1/4 sec. 21, T. 8 N., R. 93 W. In the Lay SE quadrangle, the

Emerson coal bed ranges from 5 to 28.9 feet (1.5 to 8.8 m) in thickness and appears to thicken to the west.

Blevins Coal Bed

The Blevins coal bed is another significant coal bed that has been penetrated by all the test holes drilled in the southern part of the quadrangle. It ranges from 2 to 12 feet (0.6 to 3.7 m) in thickness and contains a local cumulative rock parting 1.7 feet (0.5 m) thick that was recorded in one drill hole in SW 1/4 SE 1/4 sec. 15, T. 8 N., R. 93 W. This coal bed also extends into the Lay SE quadrangle where measured thicknesses range from 6.6 to 17.2 feet (2.0 to 5.2 m).

Isolated Data Points

In the instances where single or isolated measurements of coal beds thicker than 5.0 feet (1.5 m) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these beds limits the extent to which they can be reasonably projected in any direction and usually precludes correlation with other, better known beds. For this reason, isolated data points are included on a separate sheet (in U.S. Geological Survey files) for non-isopached coal beds. Descriptions and Reserve Base tonnages for the isolated data points occurring in this quadrangle are listed in table 5.

COAL RESOURCES

Data from oil and gas test wells and coal test holes drilled by the U.S. Geological Survey (Muller, 1976), as well as data projected into the Iron Springs quadrangle from the Lay SE quadrangle, were used to construct outcrop, isopach, and structure contour maps of the isopached coal beds. The source of each indexed data point shown on plate 1 is listed in table 6.

Coal resources were calculated using data obtained from the coal isopach maps (plates 4, 8, 12, 15, and 19) and the areal distribution and identified resources maps (plates 7, 11, 14, 18, and 22). The coal-bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed and by a conversion factor of 1,770 short tons of coal per acre-foot (13,018 metric tons per hectare-meter) for subbituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Coal beds thicker than 5 feet (1.5 m) that lie less than 3,000 feet (914 m) below the ground surface are included. These criteria differ somewhat from those used in calculating Reserve Base and Reserve tonnages as stated in U.S. Geological Survey Bulletin 1450-B which calls for a maximum depth of 1,000 feet (305 m) for subbituminous coal.

Reserve Base and Reserve tonnages for the isopached coal beds are shown on plates 7, 11, 14, 18 and 22, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Only Reserve Base tonnages (designated as inferred resources) are calculated for areas influenced by isolated data points. Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 203.89 million short tons (184.97 million metric tons) for the entire quadrangle, including tonnages from the isolated data points.

Dames & Moore has not made any determination of economic recoverability for any of the coal beds described in this report.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn so as to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-ha) parcels have been used to show the limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-ha) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 ha) within a parcel meet criteria for 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 Surface Mining Methods

Areas where the coal beds of Reserve Base thickness are overlain by 200 feet (61 m) or less of overburden are considered to have potential for surface mining and were assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for surface mining of coal is shown below:

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

where MR = mining ratio

t_o = thickness of overburden in feet

t_c = thickness of coal in feet

rf = recovery factor (85 percent for this quadrangle)

cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:
0.911 for subbituminous coal
0.896 for bituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential for surface mining methods are defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15. These mining ratio values for each development potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey.

Areas where the coal data is absent or extremely limited between the 200-foot (61-m) overburden line and the outcrop are assigned unknown development potentials for surface mining methods. This applies to areas where coal beds 5 feet (1.5 m) or more thick are not known, but may occur, and to those areas influenced by isolated data points. Limited knowledge pertaining to the areal distribution, thickness, depth, and attitude of the coals in these areas prevents accurate evaluation of the development potential in the high, moderate, or low categories. The areas influenced by isolated data points in this quadrangle do not contain any coal that is available for surface mining.

The coal development potential for surface mining methods is shown on plate 23. Of those Federal land areas having a known development potential for surface mining methods within the KRCRA in this quadranlge, 44 percent are rated high, 4 percent are rated moderate, and 52 percent are rated low. The remaining Federal land areas within the KRCRA boundary are classified as having unknown development potential for surface mining methods. Reserve Base tonnages in the various development potential categories for surface mining methods are listed in table 2.

Development Potential for Subsurface and In-Situ Mining Methods

Areas considered to have a development potential for conventional subsurface mining methods include those areas where the coal beds of Reserve Base thickness are between 200 and 3,000 feet (61 and 914 m) below the ground surface and have dips of 15° or less. Unfaulted coal beds lying between 200 and 3,000 feet (61 and 914 m) below the ground surface, dipping greater than 15°, are considered to have a development potential for in-situ mining methods.

Areas of high, moderate, and low development potential for conventional subsurface mining methods are defined as areas underlain by coal beds at depths ranging from 200 to 1,000 feet (61 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m), respectively.

Areas where the coal data is absent or extremely limited between 200 and 3,000 feet (61 and 914 m) below the ground surface are assigned unknown development potentials. This applies to the areas influenced by isolated data points and to those areas where coal beds of Reserve Base thickness are not known, but may occur. The areas influenced by isolated data points in this quadrangle contain approximately 1.96 million short tons (1.78 million metric tons) of coal available for conventional subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 24. Of the Federal land areas classified as having known development potential for conventional subsurface mining methods, 90 percent are rated high and 10 percent are rated moderate. The remaining Federal land within the KRCRA boundary is classified as having unknown development potential for conventional subsurface mining methods. Reserve Base tonnages in the various development potential categories for conventional subsurface mining methods are listed in table 3.

Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 35° and 90° with a minimum Reserve Base of 50 million short tons (45.4 million metric tons) for bituminous coal and 70 million short tons (63.5 million metric tons) for subbituminous coal have a moderate potential for in-situ development; coal beds dipping from 15° to 35°, regardless of tonnage, and coal beds dipping from 35° to 90° with less than 50 million short tons (45.4 million metric tons) of coal have a low development potential for in-situ mining methods. Coal lying between the 200-foot (61 m) overburden line and the outcrop is not included in the total coal tonnages available as it is needed for cover and containment in the in-situ process.

Areas where faulted coal beds of Reserve Base thickness dip greater than 15° between 200 and 3,000 feet (61 and 914 m) below the ground surface are classified as having an unknown development potential for in-situ mining methods.

Coal development potential for in-situ mining methods is shown on plate 24. All of the Federal land areas classified as having known development potential for in-situ mining methods are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for in-situ mining methods. Reserve Base tonnages in the various development potential categories for in-situ mining methods are listed in table 4.

Table 1. -- Chemical analyses of coals in the Iron Springs quadrangle, Moffat County, Colorado.

Location	COAL BED NAME	Form of Analysis	Proximate				Ultimate					Heating Value	
			Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	Btu/Lb
Sec. 32, T. 7 N., R. 90 W., Kimberley Mine (Craig quadrangle)(George and others, 1937)	Lance Formation, Kimberley	A	22.1	31.6	42.0	4.3	0.7	-	-	-	-	-	9,300
		B	-	40.6	53.8	5.6	0.9	-	-	-	-	-	11,930
		C	-	43.0	57.0	-	1.0	-	-	-	-	-	12,640
NW¼ SE¼ sec. 27, T. 8 N., R. 93 W., Grassie Mine (Lay SE quadrangle)(George and others, 1937)	Fort Union (20)	A	15.9	32.5	46.6	5.0	0.5	-	-	-	-	-	10,140
		B	-	38.6	55.5	5.9	0.6	-	-	-	-	-	12,060
		C	-	41.0	59.0	-	0.6	-	-	-	-	-	12,820
Sec. 28, T. 8 N., R. 93 W., Blevins Mine (Lay SE quadrangle)(Fieldner and others, 1918)	Fort Union Formation, Blevins	A	18.94	30.41	44.36	6.29	0.64	-	-	-	-	-	9,722
		B	-	37.52	54.72	7.76	0.79	-	-	-	-	-	11,993
		C	-	40.68	59.32	-	0.86	-	-	-	-	-	13,001

Form of Analysis: A, as received
B, air dried
C, moisture free

Note: To convert Btu/pound to kilojoules/kilogram, multiply by 2.326

Table 2. -- Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Iron Springs quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Blevins	1,170,000	700,000	4,900,000	-	6,770,000
Emerson	260,000	190,000	740,000	-	1,190,000
Fort Union {3}	10,000	-	50,000	-	60,000
Totals	1,440,000	890,000	5,690,000	-	8,020,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 3. -- Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Iron Springs quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Blevins	42,230,000	5,150,000	-	-	47,380,000
Emerson	87,810,000	33,100,000	-	-	120,910,000
Fort Union {20}	1,900,000	1,750,000	-	-	3,650,000
Fort Union {3}	3,880,000	1,780,000	-	-	5,660,000
Fort Union {2}	1,100,000	2,240,000	-	-	3,340,000
Isolated Data Points	-	-	-	1,960,000	1,960,000
Totals	136,920,000	44,020,000	-	1,960,000	182,900,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 4. -- Coal Reserve Base data for in-situ mining methods for Federal coal lands (in short tons) in the Iron Springs quadrangle, Moffat County, Colorado.

Coal Bed	Moderate Development Potential	Low Development Potential	Total
Blevins	-	2,630,000	2,630,000
Emerson	-	6,090,000	6,090,000
Fort Union {20}	-	-	-
Fort Union {3}	-	3,490,000	3,490,000
Fort Union {2}	-	760,000	760,000
Isolated Data Points	-	-	-
Totals	-	12,970,000	12,970,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 5.--Descriptions and Reserve Base tonnages (in million short tons) for isolated data points

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Reserve Base Tonnages Subsurface
FU[4]	King Resources and Imperial American Management	sec. 14, T. 8 N., R. 93 W.	6.0 ft (1.8 m)	0	0.98
FH[1]	King Resources and Imperial American Management	sec. 14, T. 8 N., R. 93 W.	6.0 ft (1.8 m)	0	0.98

NOTE: To convert short tons to metric tons, multiply by 0.9072.

Table 6. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	U.S. Smelting, Refining, and Mining	Oil/gas well No. 1 Emily Nelson
2	↓	Oil/gas well No. 1 Federal-Peroulis
3	North American Exploration	Oil/gas well No. 1-19 Peroulis
4	Resources Exploration Ltd.	Oil/gas well No. 1 Morgan
5	Moore and Gilmore, et al	Oil/gas well No. 1 C. R. Kern
6	Humble Oil and Refining	Oil/gas well No. 1 North Lay Creek Unit
7	King Resources and Imperial American Management	Oil/gas well No. 2 Lay Creek
8	Muller, 1976, U.S. Geological Survey Open-File Report 76-383	Drill hole No. Y-3
9	↓	Drill hole No. Y-2
10	Belco Petroleum	Oil/gas well No. 1 Peroulis Fee

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