Text to Accompany:

Open-File Report 79-1404

1979

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE THE DEVILS HOLE GULCH QUADRANGLE, RIO BLANCO AND MOFFAT COUNTIES, COLORADO

[Report includes 22 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

By

DAMES & MOORE

DENVER, COLORADO

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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 Devils Hole Gulch quadrangle, Rio Blanco and Moffat Counties, 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 Published and unpublished public information available through November, 1978, was used as the data base for this study.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 Devils Hole Gulch quadrangle is located in northwestern Colorado. The southern three fourths of the quadrangle lies in north-central Rio Blanco County and the northern quarter lies in south-central Moffat County. The quadrangle is located approximately 25 airline miles (40 km) southwest of the town of Craig and approximately 6 airline miles (10 km) north of the town of Meeker. There are no major highways crossing the quadrangle, and with the exception of several ranches and the Wilson Creek Camp, the area within the quadrangle is unpopulated.

Accessibility

A paved medium-duty road crosses the southwest corner of the quadrangle along the Strawberry Creek valley, connecting Colorado Highway 64, approximately 6 miles (10 km) south of the quadrangle, with U.S. Highway 40, approximately 25 miles (40 km) to the north-northwest. An improved light-duty road, connecting the road along Strawberry Creek with Colorado Highway 13 (also known as Colorado Highway 789) approximately 8 miles (13 km) northeast of the quadrangle, crosses northeasterly through the quadrangle, following Devils Hole Gulch and Wilson Creek. It serves the Wilson Creek oil field in the central part of the quadrangle. The remainder of the quadrangle is accessible along a number of unimproved dirt roads and trails.

Railway service for the Devils Hole Gulch quadrangle is provided by the Denver and Rio Grande Railroad from Denver to the railhead at Craig. This railroad is the major transportation route for coal shipped east from northwestern Colorado (U.S. Bureau of Land Management, 1977).

Physiography

The Devils Hole Gulch quadrangle lies at the western edge of the Southern Rocky Mountain physiographic province as defined by Howard and Williams (1972). The quadrangle lies in the Danforth Hills, approximately 25 miles (40 km) southwest of the Williams Fork Mountains and approximately 68 miles (109 km) southwest of the Continental Divide.

The landscape throughout the quadrangle is characterized by moderate to steep slopes cut by numerous gulches. The topography becomes more gentle in the southwestern part of the quadrangle where Strawberry Creek forms a flat valley.

Altitudes range from 8,688 feet (2,648 m) on Devils Hole Mountain in the east-central part of the quadrangle to less than 6,320 feet (1,926 m) along Strawberry Creek in the southwestern corner of the quadrangle.

The northern half of the quadrangle is drained by a series of north-northeast-flowing streams which flow into the Yampa River approximately 15 miles (24 km) northeast of the quadrangle. The southern half of the quadrangle is drained by Strawberry Creek and Sulphur Creek. Strawberry Creek drains the southwestern area of the quadrangle and flows south-southeast into the White River approximately 8 miles (13 km) to the south of the quadrangle. Sulphur Creek drains the southeastern corner of the quadrangle and flows southward into the White River at Meeker.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail in the Devils Hole Gulch quadrangle area, with daily temperatures typically varying from 5° to 36°F (-15° to 2°C) in January and from 42° to 86°F (7° to 30°C) in July. Annual precipitation in the area averages approximately 16 inches (41 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 (5 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).

The dominant vegetation in the quadrangle is mountain shrub, including serviceberry, Gambel oak, and rabbitbrush. Sagebrush grows along Wilson Creek in the northeastern part and along the southern edge of the quadrangle. Aspen groves occur at higher elevations in the east-central part of the quadrangle and pinyon, Utah juniper, and Rocky Mountain juniper grow at lower elevations along Strawberry Creek in the southwestern part of the quadrangle (U.S. Bureau of Land Management, 1977).

Land Status

The Devils Hole Gulch quadrangle lies in the west-central part of the Danforth Hills Known Recoverable Coal Resource Area (KRCRA). Approximately four fifths of the quadrangle lies within the KRCRA boundary and the Federal government owns the coal rights for approximately 88 percent of this area. A Preference Right Lease Application (PRLA) area is located in the southeast corner of the quadrangle.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Devils Hole Gulch 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 1924, including papers by Hewett (1889), Hills (1893), Storrs (1902), Gale (1907 and 1910), and Sears (1924). A geologic map and report by Hancock and Eby (1930) included the Devils Gulch quadrangle. Tweto (1976) compiled a generalized regional geologic map of northwestern Colorado which includes this quadrangle. Results from reconnaissance drilling by the U.S. Geological Survey in the Devils Hole Gulch quadrangle area during 1977 and 1978 were reported by Reheis (1978a and 1978b).

Stratigraphy

The rock formations cropping out in the Devils Hole Gulch quadrangle range in age from Late Cretaceous to Eocene and include the coal-bearing Iles and Williams Fork Formations of the Mesaverde Group.

The Mancos Shale of Late Cretaceous age does not crop out in this quadrangle but occurs in the subsurface. The formation is composed of gray to dark-gray marine shale with interbedded ledge-forming thin-bedded sandstone and sandy shale occurring locally in the upper part of the formation (Hancock and Eby, 1930). The Mancos Shale ranges in thickness from approximately 5,120 to 5,280 feet (1,561 to 1,609 m) where measured in the oil and gas wells drilled in the quadrangle.

The Mesaverde Group of Late Cretaceous age conformably overlies the Mancos Shale and contains two formations, the Iles and the Williams Fork.

The Iles Formation crops out in the central part of the quadrangle and consists of fine-grained, thick-bedded to massive sandstone interbedded with shaly sandstone, sandy shale, black carbonaceous shale, and coal (Hancock and Eby, 1930). It ranges in thickness from 1,460 to 1,560 feet (445 to 475 m) where measured in the oil and gas wells drilled in the quadrangle. The "rim rock" sandstone (Hancock and Eby, 1930; Konishi, 1959), the basal unit of the Iles Formation, consists of a light-brown massive sandstone interbedded with sandy shale (Hancock and

Eby, 1930). It ranges in thickness from approximately 30 to 60 feet (9 to 18 m) where measured in the oil and gas wells. The Trout Creek Sandstone Member caps the formation and averages about 80 feet (24 m) in the oil and gas wells. Hancock and Eby (1930) indicate that the Trout Creek ranges from 40 to 110 feet (12 to 34 m) in thickness in the Meeker areas and consists of massive white sandstone. Two coal-bearing sequences, the "lower" coal group and Black Diamond coal group (Hancock and Eby, 1930), occur in the Iles Formation below the Trout Creek Sandstone in this area. However, in this quadrangle only coal beds in the Black Diamond coal group have been identified.

With the exception of the southwestern and the central parts, the Williams Fork Formation crops out throughout most of the quadrangle, and it is approximately 5,050 feet (1,539 m) thick (Hancock and Eby, 1930) where measured in the vicinity of the Valentine Ranch near the head of Strawberry Creek. The formation is generally divided into three units: a lower coal-bearing unit, the Lion Canyon Sandtone Member, and an upper unit that also contains coal.

The lower unit extends from the top of the Trout Creek Sandstone Member of the Iles Formation to the base of the Lion Canyon Sandstone Member and is approximately 2,900 feet (884 m) thick in this quadrangle. It consists of interbedded sandstone, shale, sandy shale, carbonaceous shale, and coal. The sandstone is white to tan, light gray to brown, and fine to medium grained. Two coal groups, the Fairfield coal group and the Goff coal group, occur in the lower unit of the Williams Fork Formation (Hancock and Eby, 1930).

The Lion Canyon Sandstone Member is a thick-bedded light-yellowish-brown sandstone. It is estimated to be at least 100 feet (30 m) thick in this quadrangle (Hancock and Eby, 1930).

The upper unit of the Williams Fork Formation, which may be a Lance equivalent (Pipiringos and Rosenlund, 1977), is approximately 2,050 feet (625 m) thick and consists of interbedded light-gray to yellowish-brown, massive shaly sandstone, brown to black sandy and carbonaceous shale, and coal beds. Coal beds in this unit have been designated as the Lion Canyon coal group by Hancock and Eby (1930).

Unconformably overlying the Williams Fork Formation, the Wasatch Formation of Eocene age crops out in the southwestern part of the quadrangle. It consists mainly of a lower unit of sandstone and sandy shale with local layers and lenses of conglomerate and an upper unit of variegated shale (Hancock and Eby, 1930). The total thickness of the formation in this quadrangle is unknown, but the formation is approximately 2,300 to 3,300 feet (701 to 1,006 m) thick in the adjacent White Rock quadrangle to the west where mapped by Pipiringos and Rosenlund (1977).

Holocene deposits of alluvium cover the valleys and gulches in this quadrangle.

The Cretaceous sedimentary rocks in the quadrangle accumulated close to the western edge of a Late Cretaceous epeirogenic seaway which covered part of the western interior of North America. Several transgressive-regressive cycles caused the deposition of a series of marine, near-shore marine, and non-marine sediments in the Devils Hole Gulch area (Ryer, 1977).

The Mancos Shale was deposited in an offshore marine environment which existed east of the shifting strand line. Deposition of the Mancos Shale in the quadrangle area ended with the eastward migration of the shoreline and the subsequent deposition of the Iles Formation (Konishi, 1959; Kucera, 1959).

The interbedded sandstone, shale, and coal of the Iles and Williams Fork Formations were deposited as a result of minor changes in the position of the shoreline. Near-shore marine, littoral, brackish tidal, brackish and fresh water supratidal, and fluvial environments existed during the deposition of the Iles and Williams Fork Formations in the area. The major sandstones of the Iles and Williams Fork Formations, including the "rim rock" sandstone, and the Trout Creek and Lion Canyon Sandstone Members, were deposited in shallow marine and near-shore marine environments as the shoreline fluctuated. Coal beds 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 (Konishi, 1959; Kucera, 1959).

The coarse sediments at the base of the Wasatch Formation were deposited in a fluvial environment and the upper sediments were deposited in alternating swamp, lake and stream environments (Beaumont, 1979).

Structure

The Danforth Hills KRCRA lies in the northern part of the Piceance structural basin of west-central Colorado (Howard and Williams, 1972). The Danforth Hills area is bordered on the northeast by the Axial Basin anticline, approximately 3 miles (5 km) northeast of the quadrangle, and on the west by the Yampa Plateau (Grose, 1972), approximately 24 miles (38 km) northwest of the quadrangle.

The southeast-trending Danforth Hills anticline crosses the central part of the quadrangle. This anticline is domelike in appearance in this quadrangle and is commonly called the Wilson Creek dome or Devils Hole dome. The Sulphur Creek syncline trends east-northeast across the southern part of the quadrangle (Hancock and Eby, 1930).

Dips in the northern part of the quadrangle on the northeastern flank of the Danforth Hills anticline range from 4° to 10° to the north. In the west-central part of the quadrangle, the beds dip from 4° to 20° to the southwest. In the southern part of the quadrangle, the beds dip from 10° to 45° southward on the northern limb of the Sulphur Creek syncline and from 8° to 15 northward on the southern limb (Hancock and Eby, 1930).

The structure contour maps of the isopached coal beds are based on a regional structure map of the Trout Creek Sandstone Member by Hancock and Eby (1930), and it is assumed that the structure of the coal beds nearly duplicates that of the Trout Creek Sandstone Member. Modifications were made where necessary in accordance with drill-hole and outcrop data.

COAL GEOLOGY

Numerous coal beds in the Iles and Williams Fork Formations have been identified in outcrops, coal test holes, and in oil and gas test wells drilled in the Devils Hole Gulch quadrangle. In general, coals in the Iles and Williams Fork Formations tend to be thin, lenticular, and of limited areal extent. None of the coal beds are formally named, but where coal beds exceed Reserve Base thickness (5.0 feet or 1.5 meters) they have been given bracketed numbers for identification purposes. In instances where coal beds have been identified at one location only and cannot be correlated, they are treated as isolated data points (see Isolated Data Points section of this report).

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.

<u>Chemical analyses of coals</u>.--Chemical analyses were not available for coals in the Iles and Williams Fork Formations in this quadrangle, but representative analyses from Hancock (1925), Hancock and Eby (1930), and George and others (1937) are listed in table 1. In general, these coals rank as high-volatile C bituminous on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Coal Beds in the Iles Formation

In the Meeker area, coal beds in the Iles Formation usually lie within the "lower" or Black Diamond coal groups. The "lower" coal group generally includes all coal beds between 100 and 250 feet (30 and 76 m) above the base of the Iles Formation, and the Black Diamond coal group includes all coal beds within the interval from 150 to 350 feet (46 to 107 m) below the top of the Trout Creek Sandstone Member (Hancock and Eby, 1930). Coal beds in the "lower" coal group have not been identified in this quadrangle and only one coal bed in the Black Diamond coal group has been identified in an outcrop in the NE 1/4 NE 1/4 sec. 13, T. 2 N., R. 94 W. However, this coal bed does not exceed Reserve Base thickness. Another coal bed in the Iles Formation, the Iles [13], was penetrated in the Texaco No. 45 Wilson Creek well and cannot be located in the stratigraphic section with enough accuracy to place the coal bed in either the "lower" or Black Diamond coal groups. Since this coal bed was encountered at one location only, it has been treated as an isolated data point.

Coal Beds in the Williams Fork Formation

According to Hancock and Eby (1930), coal beds in the Williams Fork Formation occur in the Fairfield, Goff, and Lion Canyon coal groups. The Fairfield coal group includes the coal beds that occur in the basal 1,300 feet (396 m) of the formation. The Goff coal group generally includes the coal beds in the 700 feet (213 m) of coal-bearing strata below the Lion Canyon Sandstone Member, and the Lion Canyon coal group contains all coal beds in the 1,000 feet (305 m) of the Williams Fork Formation above the Lion Canyon Sandstone Member. Although many coal beds in the Fairfield coal group exceed Reserve Base thickness in this quadrangle, none have been recognized in the Goff coal group.

Fairfield Coal Group

The Fairfield coal group is the most important coal-bearing unit in this quadrangle and numerous, relatively thin coal beds in this group have been identified in drill holes and outcrops throughout the quadrangle. Thirty coal beds greater than Reserve Base thickness have been identified, but only seven of the coal beds can be correlated with enough accuracy to construct isopach maps of the individual coal beds in this coal group. The remaining 23 coal beds, including one located on non-Federal land, were treated as isolated data points. In addition, one coal zone and one coal bed that have not been identified in this quadrangle have been projected into the quadrangle based on geologic data in the adjacent Ninemile Gap and Axial quadrangles.

The Fairfield [15] coal bed (plate 10) crops out in the west-central part of the quadrangle and has thicknesses of 2.0 and 10.0 feet (0.6 and 3.0 m) where measured at two widely-spaced locations in secs. 20 and 30, T. 3 N., R. 94 W.

The Fairfield [36] coal bed (plate 13) ranges in thickness from 10.0 to 17.1 feet (3.0 to 5.2 m) where measured in two outcrops in the northeastern part of the quadrangle and is inferred to thin to the north because of the lack of data behind the outcrop.

The Fairfield [121] coal bed (plate 13) was identified in only one of the coal test holes drilled in the north-central part of the quadrangle. It is 8.0 feet (2.4 m) thick at that location and contains a rock parting 1.0 foot (0.3 m) thick. This coal bed extends into the Easton Gulch quadrangle to the north where it was penetrated by two drill holes and has measured thicknesses of 7.2 and 12.2 feet (2.2 and 3.7 m) in the south-central part of that quadrangle.

The Fairfield [122] coal bed (plate 7) is 13.8 feet (4.2 m) thick in the same drill hole that penetrated the Fairfield [121] coal bed. The coal bed was also identified in two drill holes in the south-central part of the Easton Gulch quadrangle where the coal-bed measurements are 7.5 and 8.9 feet (2.3 and 2.7 m). A rock parting 2.3 feet (0.7 m) thick was reported in one of the drill holes in that quadrangle.

The Fairfield [126] coal bed (plate 4) was identified in two coal test holes drilled in the north-central part of the quadrangle. Measured thicknesses of the coal bed were reported to be 9.0 feet (2.7 m) and 11.5

feet (3.5 m), excluding a rock parting 1.7 feet (0.5 m) thick. This coal bed has not been identified in the Easton Gulch quadrangle to the north, but it is believed to extend into that quadrangle and may be as much as 9 feet (2.7 m) thick along the quadrangle boundary in sec. 9, T. 3 N., R. 94 W.

The Fairfield [130] coal bed (plate 10) was identified in three coal test holes drilled in the northwestern part of the quadrangle. The coal bed ranges in thickness from 7.0 to 23.0 feet (2.1 to 7.0 m), the maximum reported thickness occurring in the coal test hole drilled in sec. 9, T. 3 N., R. 94 W. The coal bed is believed to extend into the Easton Gulch quadrangle where it may be at least 10 feet (3.0 m) thick.

The Fairfield [142] coal bed (plate 16) was identified in only one of the coal test holes drilled in the north-central part of the quadrangle. The coal bed is 8.0 feet (2.4 m) thick at that location in sec. 9, T. 3 N., R. 94 W. In the south-central part of the Easton Gulch quadrangle, this coal bed was penetrated by two drill holes and the coal bed was reported to be 5.6 feet (1.7 m) thick in both holes.

The Fairfield [208] coal zone has not been identified in this quadrangle but has been projected into the northeast corner based on drill-hole data in the Ninemile Gap quadrangle to the east and the Axial quadrangle to the northeast. Individual coal beds in the Fairfield coal group zone [208] thicken, thin and split over short distances, ranging from 2.0 feet (0.6 m) to as much as 22.5 feet (6.9 m) in thickness in the Ninemile Gap quadrangle. Cumulative coal thicknesses range from 13.0 to 41.5 feet (4.0 to 12.6 m) and rock partings totalling from 2.0 to 17.0 feet (0.6 to 5.2 m) are included in the zone. In the Axial quadrangle, individual coal beds range from 2.0 to 16.0 feet (0.6 to 4.9 m) in thickness and cumulative coal thicknesses range from 11.6 to 41.0 feet (3.5 to 12.5 m). Total rock partings range from 1.8 to 24.8 feet (0.5 to 7.6 m) thick. Where the coal zone has been projected into the Devils Hole Gulch quadrangle, the cumulative coal thickness is inferred to be approximately 25 feet (7.6 m), as shown on plate 5, while the amount of rock partings is unknown.

The Fairfield [209] coal bed has also been projected into the northeast corner of the quadrangle based on drill-hole data in the Ninemile Gap and Axial quadrangles, and the coal bed is inferred to range from 5 to 11 feet (1.5 to 3.4 m) in thickness (plate 4). Where penetrated by drill holes in the Ninemile Gap quadrangle, measured thicknesses range from 4.5 feet (1.4 m) to a maximum of 16.0 feet (4.9 m), excluding a rock parting 2.5 feet (0.8 m) thick. The coal bed is 10.0 feet (3.0 m) thick where measured in a single drill hole in the Axial quadrangle.

Lion Canyon Coal Group

Coal beds in the Lion Canyon coal group have been identified in outcrops and in an oil and gas test well in the southern part of the quadrangle. Two coal beds, the Lion Canyon [4] and [5], exceed Reserve Base thickness and, since each bed was encountered at only one location, they are treated as isolated data points.

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 point maps are included on a separate sheet (in U.S. Geological Survey files) for non-isopached coal beds. Because of the extreme lenticularity of the coal beds in this quadrangle, it is assumed that these coal beds maintain their measured thickness for only 1,000 feet (305 m) in all directions from their points of measurement. Also, where the inferred limit of influence from the isolated data point is entirely within non-Federal land areas, an isolated data point map is not constructed for the coal bed. Descriptions and Reserve Base tonnages for the isolated data points occurring in this quadrangle are listed in table 4.

COAL RESOURCES

Data from outcrop measurements and coal test holes (Hancock and Eby, 1930; Reheis, 1978a and 1979b), as well as information from oil and gas test wells, 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 5.

Coal resources were calculated using data obtained from the coal isopach maps and the areal distribution and identified resources maps. The coal-bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed and by a conversion factor of 1,800 short tons of coal per acre-foot (13,238 metric tons per hectare-meter) for bituminous 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 minimum thickness of 28 inches (70 cm) and a maximum depth of 1,000 feet (305 m) for bituminous coal.

Reserve Base and Reserve tonnages for the isopached coal beds are shown on the areal distribution and identified resources maps, 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 141.91 million short tons (128.74 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 total approximately 5.52 million short tons (5.01 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 19. Of those Federal land areas having a known development potential for surface mining methods within the KRCRA in this quadrangle, 68 percent are rated high, 16 percent are rated moderate, and 16 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 4.45 million short tons (4.04 million metric tons) of coal available for conventional subsurface mining.

Areas classified as having coal deveopment potential for subsurface mining methods are shown on plate 20. The Federal land area having known development potential for conventional subsurface mining methods has been rated high. The remaining Federal lands are 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.

Coal beds lying between 200 feet (61 m) and 3,000 feet (914 m) below the ground surface, dipping greater than 15°, are considered to have a development potential for in-situ mining methods. 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) of bituminous 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 are not included in the total coal tonnages available because they are needed for cover and containment in the in-situ process.

All of the Federal lands where the dip of the coal beds exceeds 15° are rated as having unknown development potential because only approximately 2.20 million short tons (2.00 million metric tons) of coal, distributed through five isolated data points in secs. 4, 9, 16, and 17, T. 2 N., R. 94 W., are believed to be available for in-situ mining.

Table 1. -- Chemical analyses of coals in the Devils Hole Gulch quadrangle, Rio Blanco and Moffat Counties, 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
SW¼ sec. 24, T. 5 N., R. 91 W., Hamilton (Badger Creek) Mine (George and others, 1937) from Hamilton quadrangle	Iles Formation "Lower" coal group	A	12.5	29.7	48.0	9.8	0.8	-	-	-	-	-	10,650
		C	-	33.9	54.9	11.2	1.0	-	-	-	-	-	12,170
SW¼ sec. 15, T. 1 N., R. 94 W., Black Diamond Mine (Hancock, 1925) from Meeker quadrangle	Iles Formation Black Diamond coal group	A	10.8	37.2	44.0	7.98	0.49	-	-	-	-	-	11,220
		B	8.5	38.2	45.1	8.18	0.50	-	-	-	-	-	11,510
		C	-	41.8	49.3	8.95	0.55	-	-	-	-	-	12,580
SW¼ NE¼ sec. 2, T. 3 N., R. 93 W., Mount Streeter (Joseph Collum) Mine (Hancock and Eby, 1930) from Axial quadrangle	Fairfield coal group	A	11.9	40.6	45.3	2.2	0.32	-	-	-	-	-	11,610
		B	10.0	41.5	46.2	2.3	0.33	-	-	-	-	-	11,860
		C	-	46.1	51.4	2.5	0.36	-	-	-	-	-	13,180
NW¼ sec. 14, T. 3 N., R. 93 W., James Mine (George and others, 1937) from Ninemile Gap quadrangle	Goff coal group	A	12.1	35.8	47.5	4.6	0.5	-	-	-	-	-	11,360
		C	-	40.7	54.0	5.3	0.6	-	-	-	-	-	12,910
NW¼ sec. 29, T. 1 N., R. 94 W., Montgomery Mine (Hancock and Eby, 1930) from Meeker quadrangle	Lion Canyon coal group	A	12.4	38.6	42.9	6.1	0.71	-	-	-	-	-	10,790
		B	10.6	39.4	43.7	6.3	0.72	-	-	-	-	-	11,010
		C	-	44.1	48.9	7.0	0.81	-	-	-	-	-	12,320

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 Devils Hole Gulch quadrangle, Rio Blanco and Moffat Counties, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fairfield {126}	1,970,000	1,660,000	1,380,000	-	5,010,000
Fairfield {142}	-	70,000	330,000	-	400,000
Fairfield {130}	7,440,000	4,020,000	3,850,000	-	15,310,000
Fairfield {122}	-	-	90,000	-	90,000
Fairfield {121}	-	-	60,000	-	60,000
Fairfield {36}	4,530,000	2,530,000	2,700,000	-	9,760,000
Fairfield {15}	810,000	240,000	330,000	-	1,380,000
Fairfield {208}	540,000	-	-	-	540,000
Fairfield {209}	80,000	40,000	-	-	120,000
Isolated Data Points	-	-	-	5,520,000	5,520,000
Totals	15,370,000	8,560,000	8,740,000	5,520,000	38,190,000

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 Devils Hole Gulch quadrangle, Rio Blanco and Moffat Counties, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fairfield {126}	11,430,000	-	-	-	11,430,000
Fairfield {142}	4,060,000	-	-	-	4,060,000
Fairfield {130}	46,670,000	-	-	-	46,670,000
Fairfield {122}	7,930,000	340,000	-	-	8,270,000
Fairfield {121}	4,890,000	-	-	-	4,890,000
Fairfield {36}	13,020,000	-	-	-	13,020,000
Fairfield {15}	1,730,000	-	-	-	1,730,000
Fairfield {208}	5,830,000	-	-	-	5,830,000
Fairfield {209}	1,170,000	-	-	-	1,170,000
Isolated Data Points	-	-	-	6,650,000*	6,650,000
Totals	96,730,000	340,000	-	6,650,000	103,720,000

*Includes 2.20 million short tons dipping greater than 15 degrees.

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

Table 4.--Descriptions and Reserve Base tonnages (in million short tons) for isolated data points

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Subsurface	In-Situ
Iles [13]	Texaco, Inc.	sec. 4, T. 2 N., R. 94 W.	6.0 ft (1.8 m)	0	0	0.66
Fairfield [6]	Hancock and Eby (1930)	sec. 7, T. 2 N., R. 93 W.	10.4 ft (3.2 m)	0.04	0	0
Fairfield [7]	Hancock and Eby (1930)	sec. 11, T. 2 N., R. 94 W.	6.7 ft (2.0 m)	0.29	0	0
Fairfield [8]	Hancock and Eby (1930)	sec. 9, T. 2 N., R. 94 W.	5.3 ft (1.6 m)	0.30	0	0.16
Fairfield [9]	Hancock and Eby (1930)	sec. 9, T. 2 N., R. 94 W.	10.7 ft (3.3 m)	0.60	0	0.32
Fairfield [10]	Hancock and Eby (1930)	sec. 9, T. 2 N., R. 94 W.	8.3 ft (2.5 m)	0.40	0	0
Fairfield [14]	Hancock and Eby (1930)	sec. 4, T. 2 N., R. 94 W.	7.3 ft (2.2 m)	0.16	0	0
Fairfield [16]	Hancock and Eby (1930)	sec. 20, T. 3 N., R. 94 W.	5.3 ft (1.6 m)	0.14	0	0
Fairfield [17]	Hancock and Eby (1930)	sec. 36, T. 3 N., R. 94 W.	8.3 ft (2.5 m)	0.32	0	0
Fairfield [18]	Hancock and Eby (1930)	sec. 36, T. 3 N., R. 94 W.	9.9 ft (3.0 m)	0.38	0	0
Fairfield [19]	Hancock and Eby (1930)	sec. 36, T. 3 N., R. 94 W.	13.9 ft (4.2 m)	0.35	0	0

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

Table 4.--Continued

Coal Bed	Source	Location	Thickness	Reserve Base Tonnages Surface	Subsurface	In-Situ
Fairfield [20]	Hancock and Eby (1930)	sec. 2, T. 2 N., R. 94 W.	9.0 ft (2.7 m)	0.72	0	0
Fairfield [21]	Hancock and Eby (1930)	sec. 7, T. 3 N., R. 94 W.	6.0 ft (1.8 m)	0.10	0	0
Fairfield [27]	Reheis (1978a)	sec. 9, T. 3 N., R. 94 W.	7.5 ft (2.3 m)	0	0.64	0
Fairfield [28]	Reheis (1978a)	sec. 9, T. 3 N., R. 94 W.	7.7 ft (2.3 m)	0	0.66	0
Fairfield [29]	Reheis (1978b)	sec. 24, T. 3 N., R. 95 W.	8.0 ft (2.4 m)	0.01	1.02	0
Fairfield [31]	Reheis (1978a)	sec. 9, T. 3 N., R. 94 W.	8.1 ft (2.5 m)	0	0.70	0
Fairfield [32]	Reheis (1978a)	sec. 9, T. 3 N., R. 94 W.	5.6 ft (1.7 m)	0.29	0.18	0
Fairfield [33]	Reheis (1978a)	sec. 9, T. 3 N., R. 94 W.	5.5 ft (1.7 m)	0.28	0.18	0
Fairfield [35]	Hancock and Eby (1930)	sec. 15, T. 3 N., R. 94 W.	5.4 ft (1.6 m)	0.01	0	0
Fairfield [37]	Hancock and Eby (1930)	sec. 13, T. 3 N., R. 94 W.	11.1 ft (3.4 m)	0.35	0.07	0
Fairfield [38]	Hancock and Eby (1930)	sec. 4, T. 2 N., R. 94 W.	5.5 ft (1.7 m)	0.15	0	0.14
Fairfield [39]	Reheis (1978b)	sec. 24, T. 3 N., R. 95 W.	9.0 ft (2.7 m)	0.15	1.00	0
Lion Canyon [4]	Husky-Belco	sec. 17, T. 2 N., R. 94 W.	7.0 ft (2.1 m)	0	0	0.92
Lion Canyon [5]	Hancock and Eby (1930)	sec. 22, T. 2 N., R. 94 W.	8.1 ft (2.5 m)	0.48	0	0

Table 5. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 30	Measured Sections Nos. 477-481
2	Texaco, Inc.	Oil/gas well No. 43 Unit
3	The Texas Co.	Oil/gas well No. 39 Unit
4	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 27	Measured Section No. 147
5	The Texas Co.	Oil/gas well No. 28 Unit
6	↓	Oil/gas well No. 31 Unit
7	↓	Oil/gas well No. 38 Farmer's Unit
8	Texaco, Inc.	Oil/gas well No. 47 Wilson Creek Unit
9	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 27	Measured Section No. 169
10	↓	Measured Sections Nos. 166, 167
11	Texaco, Inc.	Oil/gas well No. 45 Wilson Creek Unit
12	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 27	Measured Section No. 171
13	↓	Measured Sections Nos. 172-178
14	↓	Measured Sections Nos. 264-268

Table 5. -- Continued

Plate 1 Index Number	Source	Data Base
15	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 27	Measured Section Nos. 269-272
16	↓	Measured Section No. 263
17		Measured Section Nos. 259-261
18		Measured Section Nos. 153, 154
19		Measured Section Nos. 148-152
20		Measured Section Nos. 155-165
21		Measured Section Nos. 145
22		Measured Section No. 254
23	Husky-Belco	Oil/gas well No. 16-17 Bailey
24	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 27	Measured Sections Nos. 238-243
25	↓	Measured Sections Nos. 246-249
26		Measured Sections Nos. 250, 251
27		Measured Sections Nos. 275, 276
28	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 28	Measured Sections Nos. 367-369

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Table 5. -- Continued

Plate 1 Index Number	Source	Data Base
29	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 28	Measured Section No. 365
30	↓	Measured Sections Nos. 359-362
31	↓	Measured Sections Nos. 355-358
32	↓	Measured Section No. 354
33	Reheis, 1978a, U.S. Geological Survey Open-File Report No. 78-272	Drill hole No. D-52-D
34	↓	Drill hole No. D-54-D
35	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 28	Measured Section No. 345
36	↓	Measured Section No. 344
37	↓	Measured Section 342
38	↓	Measured Section No. 340
39	↓	Measured Section Nos. 338, 339
40	↓	Measured Section No. 337
41	↓	Measured Section Nos. 333-336
42	↓	Measured Section No. 329

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Table 5. -- Continued

Plate 1 Index Number	Source	Data Base
43	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 28	Measured Section No. 311
44	The Texas Co. and California Co.	Oil/gas well No. 40 Unit
45	Texaco, Inc.	Oil/gas well No. 50 Wilson Creek Unit
46	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 28	Measured Section No. 302
47	↓	Measured Section No. 316
48	↓	Measured Sections Nos. 313-315
49	↓	Measured Sections Nos. 317-319
50	↓	Measured Sections Nos. 324-327
51	The Texas Co. and California Co.	Oil/gas well No. 33 Wilson Creek Unit
52	The Texas Co.	Oil/gas well No. 29 Wilson Creek Unit
53	The Texas Co. and California Co.	Oil/gas well No. 10 Unit
54	Texaco, Inc.	Oil/gas well No. 58 Unit
55	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 28	Measured Section No. 296
56	↓	Measured Sections Nos. 293-295

Table 5. -- Continued

Plate 1 Index Number	Source	Data Base
57	The Texas Co. and California Co.	Oil/gas well No. 37 Wilson Creek Unit
58	Texaco, Inc.	Oil/gas well No. 49 Wilson Creek Unit
59	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 28	Measured Section No. 299
60	Texaco, Inc.	Oil/gas well No. 52 Wilson Creek Unit
61	California Co.	Oil/gas well No. 32 Wilson Creek Unit
62	The Texas Co.	Oil/gas well No. 11 Wilson Creek Unit
63	The Texas Co. and California Co.	Oil/gas well No. 15 Wilson Creek Unit
64	The Texas Co.	Oil/gas well No. 27 Wilson Creek Unit
65	↓	Oil/gas well No. 20 Wilson Creek Unit
66	California Co.	Oil/gas well No. 34 Wilson Creek Unit
67	The Texas Co.	Oil/gas well No. 13 Wilson Creek Unit
68	↓	Oil/gas well No. 14 Unit
69	The Texas Co. and California Co.	Oil/gas well No. 12 Wilson Creek Unit
70	The Texas Co.	Oil/gas well No. 26 Wilson Creek Unit

Table 5. -- Continued

Plate 1 Index Number	Source	Data Base
71	The Texas Co. and California Co.	Oil/gas well No. 30 Wilson Creek Unit
72	↓	Oil/gas well No. 7 Wilson Creek Unit
73	Texaco, Inc.	Oil/gas well No. 48 Wilson Creek Unit
74	The Texas Co.	Oil/gas well No. 24 Unit
75	Texaco, Inc.	Oil/gas well No. 46 Unit
76	The Texas Co.	Oil/gas well No. 21 Unit
77	Texaco, Inc.	Oil/gas well No. 56 Gov't-Wilson Creek Unit
78	The Texas Co.	Oil/gas well No. 41 Unit
79	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 28	Measured Sections Nos. 283-287
80	↓	Measured Section No. 307
81	↓	Measured Sections Nos. 371, 371A
82	Reheis, 1978b, U.S. Geological Survey Open-File Report 78-1031	Drill hole No. D-37-DH
83	↓	Drill hole No. D-43-DH

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