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

[Report includes 38 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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This report has not been edited
for conformity with U.S. Geological
Survey editorial standards or
stratigraphic nomenclature.

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Fillmore Ranch quadrangle, Carbon County, Wyoming. This report was compiled to support the land planning work of the Bureau of Land Management (BLM) 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 14-08-0001-17104. 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 Published and unpublished public information was used as the data base for this study.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, nor was any confidential data used.

Location

The Fillmore Ranch quadrangle is located in south-central Wyoming in western Carbon County, approximately 17 miles (27 km) southwest of Rawlins and 18 miles (29 km) southeast of Wamsutter, Wyoming. The area is unpopulated.

Accessibility

Twenty Mile road, an improved light-duty road, runs along the eastern edge of the quadrangle connecting Rawlins, Wyoming to the northeast with Wyoming Highway 789 to the southwest. Interstate Highway 80 runs east-west across southern Wyoming approximately 8 miles (13 km) north of the quadrangle. The remainder of the quadrangle is served by a network of unimproved dirt roads and trails.

The main east-west line of the Union Pacific Railroad lies approximately 7 miles (11 km) to the north of the quadrangle. This railway provides service across southern Wyoming, connecting Ogden, Utah to the west and Omaha, Nebraska to the east.

Physiography

The Fillmore Ranch quadrangle is located in the Red Desert region on the southeastern edge of the Great Divide Basin. The landscape within the quadrangle is characterized by gently rolling hills in the west, grading to a relatively rugged area of ridges in the southeast, and small, isolated areas of badland topography. The southern branch of the Continental Divide, which encircles the Great Divide Basin, cuts across the southern one third of the quadrangle. Altitudes in the quadrangle vary from approximately 6,910 feet (2,106 m) on one of the branches of Separation Creek on the north-central edge of the quadrangle to 8,160 feet (2,487 m) on a ridge north of Snowshoe Canyon in the southeastern corner of the quadrangle.

Separation Creek, running along the eastern edge of the quadrangle, is the major drainage for the southeastern portion of the Great Divide Basin. Its tributaries, Fillmore Creek, which cuts across the center of the quadrangle, and several other small streams in the northern portion of the quadrangle, drain the area north of the Continental Divide. The southern one quarter of the quadrangle, south of the Continental Divide, is drained by Alamosa Gulch and Olson Draw, both tributaries of Muddy Creek. All the streams in the area are intermittent, flowing mainly in response to snowmelt in the spring. Several small reservoirs and ponds are located on Fillmore Creek, Separation Creek, and Alamosa Gulch.

Climate and Vegetation

The climate of south-central Wyoming is semiarid, characterized by low precipitation, rapid evaporation, and large daily temperature variations. Summers are usually dry and mild, and winters are cold. The annual precipitation in the area averages 10.4 inches (26.4 cm) per year. Approximately two thirds of the precipitation falls in the spring and summer months during the seven-month period from April through October.

The average annual temperature in the area is 43°F (6°C). The temperature during January averages 21°F (-6°C) and ranges from 12°F

(-11°C) to 31°F (-0.6°C). During July the average temperature is 68°F (20°C), and the temperature ranges from 51°F (11°C) to 84°F (29°C) (Wyoming Natural Resources Board, 1966).

The winds are usually from the southwest and the west-southwest with an average velocity of 12 miles per hour (19 km per hr) (U.S. Bureau of Land Management, 1978).

The principal types of vegetation in the quadrangle include grasses, sagebrush, greasewood, saltbush, rabbitbrush, and other desert shrubs.

Land Status

The Fillmore Ranch quadrangle lies on the eastern edge of the Rawlins Known Recoverable Coal Resource Area (KRCRA). Only the southeastern corner of the quadrangle, approximately two percent of the quadrangle's total area, lies outside the KRCRA boundary. The Federal government owns the coal rights for approximately one half of the area inside the KRCRA boundary, as shown on plate 2. No outstanding Federal coal leases, prospecting permits, or licenses occur within the quadrangle.

GENERAL GEOLOGY

Previous Work

Ball (1909) described the coal-bearing Mesaverde Group, Lance Formation, and Fort Union Formation in his study of the western part of the Little Snake River coal field. Berry (1960) made a detailed investigation of the geology and ground-water resources of the Rawlins area to the northeast of the quadrangle. Haun (1961) and Hale (1961) described the stratigraphy of the Upper Cretaceous-age formations in the eastern Washakie Basin area including the Fillmore Ranch quadrangle. Welder and McGreevy (1966) included the quadrangle in a report published on the geology and ground-water resources of the Washakie and Great Divide Basins. Gill, Merewether, and Cobban (1970) described the stratigraphy of the Upper Cretaceous age- and Lower Tertiary-age rocks in the quadrangle. Sanders made a detailed investigation of the geology and coal resources of the adjacent Riner quadrangle to the north in 1974 and the Creston Junction quadrangle to the northwest in 1975. Edson and Curtiss (1976) published lithologic descriptions and geophysical logs of holes drilled by the U.S. Geological Survey in the Fillmore Ranch and adjacent quadrangles in 1975. Unpublished data from reconnaissance mapping by Edson (in press, a and b), and by Edson and Barclay (in press), drilling by the U.S. Geological Survey in 1976 and 1977, and data from the Rocky Mountain Energy Company (RMEC) provided the location of coal outcrops, coal analyses, and coal thickness information.

Stratigraphy

The formations present in the Fillmore Ranch quadrangle range in age from Upper Cretaceous to Recent. All but the Steele Shale, the Pine Ridge Sandstone, and the Lewis Shale are known to be coal-bearing in the Rawlins area.

The Steele Shale of Upper Cretaceous age is present in the subsurface of the Fillmore Ranch quadrangle. It consists of dark-gray marine shale with thin beds of very fine grained sandstone and siltstone, becoming more sandy near the top (Hale, 1961). The upper portion of the Steele Shale was encountered at a depth of over 2,200 feet (671 m) in two oil and gas wells drilled along the east-central edge of the quadrangle.

The Steele Shale is conformably overlain by and laterally intertongues with the Mesaverde Group of Upper Cretaceous age. The Mesaverde Group is subdivided into four units which are, in ascending order, the Haystack Mountains Formation, the Allen Ridge Formation, the Pine Ridge Sandstone, and the Almond Formation (Hale, 1961).

The Haystack Mountains Formation, present in the subsurface of the quadrangle, consists primarily of gray to brownish-gray marine and marginal-marine shales and thick yellowish-gray sandstones. It is subdivided into four members, the basal Deep Creek Sandstone Member, the Espy Tongue Member, the Hatfield Sandstone Member, and, at the top, an unnamed member of interbedded sandstones, siltstones, and shales (Gill and others, 1970). The Haystack Mountains Formation ranges from approximately 640 to 860 feet (195 to 262 m) thick as indicated in the oil and gas wells drilled in the quadangle.

The basal Deep Creek Sandstone Member of the Haystack Mountains Formation consists of a pale yellowish-gray, fine- to medium-grained marine sandstone (Hale, 1961) approximately 54 feet (16.5 m) thick in the Fillmore Ranch quadrangle.

The Espy Tongue Member, immediately above, is a unit of dark-gray marine shale and lenticular sandstone ranging from 180 to 250 feet (55 to 72 m) in thickness in the quadrangle. It is a tongue of the Steele Shale included as part of the Haystack Mountains Formation (Hale, 1961).

The Espy Tongue Member grades into the overlying Hatfield Sandstone Member, which is thin-bedded to shaly at the base, and grades upward into a thick-bedded to massive sandstone at the top (Hale, 1961). The Hatfield Sandstone Member is approximately 150 to 190 feet (46 to 58 m) thick in the Fillmore Ranch quadrangle.

Overlying the Hatfield Sandstone Member are approximately 260 to 350 feet (79 to 107 m) of interbedded sandstones, siltstones, and shales forming the upper unnamed member of the Haystack Mountains Formation (Gill and others, 1970). Single beds of coal, 1 to 3 feet (0.3 to 0.9 m) thick, may occur in this interval (Barclay and others, 1978).

The marine sandstones of the Haystack Mountains Formation change abruptly into the non-marine carbonaceous shales and fluvial channel sandstones of the Allen Ridge Formation. The Allen Ridge Formation, present in the subsurface, consists of approximately 1,300 feet (396 m) of thick, brown, lenticular fluvial channel sandstones with interbedded non-marine carbonaceous shale, siltstone, mudstone, and a few thin coal beds. The upper 150 to 200 feet (46 to 61 m) of the Allen Ridge Formation contain some beds with marine affinities. C. S. V. Barclay (written commun., 1979) indicates that fossils, bedding and textures suggest lagoonal deposition was important in the upper Allen Ridge Formation.

The coals, commonly associated with the carbonaceous shale, are 1 to 4 feet (0.3 to 1.2 m) thick and may be found in the upper portion of the Allen Ridge Formation just below the overlying Pine Ridge Sandstone. A few thin coals may also be present in the lower portion of the Allen Ridge Formation (Barclay and others, 1978, and Gill and others, 1970).

The Pine Ridge Sandstone, present in the subsurface, is a white to light-gray non-marine sandstone unconformably overlying the Allen Ridge Formation (Gill and others, 1970) and is approximately 225 feet (69 m) thick as indicated by the oil and gas wells drilled in the quadrangle (Tyler, 1978).

Conformably overlying the Pine Ridge Sandstone is the Almond Formation, the uppermost unit of the Mesaverde Group. The Almond Formation, cropping out in the southeastern corner of the quadrangle, is a thick sequence of marine and non-marine rocks. It consists of thick marine sandstone, carbonaceous shale, coal, and interbedded clay-shale, mud-shale, and sandstone. The sandstones are pale yellowish-gray to dusky-yellow, which weather to various shades of brown, and are very fine-grained and thin-bedded.

The Almond Formation shales are of two types. The most typical shale is brownish-gray to brownish-black, carbonaceous to coaly, and contains many ironstone concretions and brackish-water fossils. The second type is a dark-gray to olive-gray shale which contains limestone concretions with marine fossils. The shales are tongues of the overlying Lewis Shale (Gill and others, 1970). Coal occurs in all parts of the Almond Formation, but is thickest and most abundant in the lower 200 feet (61 m) of the formation (Barclay and others, 1978). The Almond Formation, as indicated by the oil and gas wells drilled in the quadrangle, is approximately 320 to 330 feet (98 to 101 m) thick (Tyler, 1978).

The Lewis Shale of Upper Cretaceous age conformably overlies the Mesaverde Group. It crops out in a northeast-trending band across the eastern portion of the quadrangle. The Lewis Shale is composed of dark-gray to olive-gray fissile shale which grades into a buff-colored sandy shale (Berry, 1960). The upper part of the Lewis Shale contains a distinctive and widespread unit of interbedded sandstone and sandy shale called the Dad Sandstone Member, a tongue of the overlying Fox Hills Sandstone (Gill and others, 1970). It forms the bluffs present along the western side of Separation Creek and Alamosa Gulch (Edson and Barclay, in press). Oil and gas wells drilled in the quadrangle indicate the Lewis Shale is approximately 2,170 to 2,210 feet (661 to 674 m) thick (Tyler, 1978).

The Fox Hills Sandstone of Upper Cretaceous age intertongues with the underlying marine Lewis Shale and with the overlying brackish-water and fluvial sandstone and shale of the Lance Formation. The Fox Hills Sandstone is composed of thick units of pale yellowish-gray, very fine to fine-grained friable sandstone, and thin units of olive-gray to dark-gray sandy shale. The sandstone units are thin-bedded to massive, cross-bedded and ripple marked. They commonly contain fossiliferous sandstone concretions. Thin units of carbonaceous shale, containing brackish-water fossils and thin coal beds, also occur in the formation. The sandstone beds are generally nonresistant, but can locally be well-cemented and ridge-forming (Berry, 1960, and Gill and others, 1970). The Fox Hills Sandstone is approximately 210 to 240 feet (64 to 73 m) thick as indicated by the oil and gas wells drilled in the quadrangle (Tyler, 1978).

The Fox Hills Sandstone grades into the overlying Lance Formation of Upper Cretaceous age. The Lance Formation is composed of light-brown to dark-gray, sandy carbonaceous shale containing lignite and coal near the base, which grades upward into dark-gray, fissile carbonaceous shale. The shale is interbedded with brown to light-brown, very fine to fine-grained sandstone. The sandstone may occur in intervals up to 20 feet (6.1 m) thick throughout the formation. Several fossiliferous zones are present in the upper portion of the formation (Berry, 1960, and Haun, 1961). The Lance Formation is approximately 3,450 feet (1,052 m) thick in the Davis Oil Company No. 1 Elaine-Federal well located in sec. 14, T. 19 N., R. 91 W.

Unconformably overlying the Lance Formation, the Fort Union Formation of Paleocene age crops out over the northwestern one third of the quadrangle. The Fort Union Formation is approximately 4,000 feet (1,219 m) thick in the adjacent Seaverson Reservoir quadrangle. At the base of the formation are approximately 600 feet (183 m) of light-gray, thick-bedded to massive, medium- to coarse-grained, generally cross-bedded sandstones containing lenses of well-rounded chert pebbles, interbedded with dark-gray carbonaceous shale. These are overlain by approximately 1,300 feet (396 m) of interbedded light-brown to orange argillaceous siltstone, light-gray fine- to medium-grained sandstone, light- to dark-gray shale and thick coal. Above these are poorly exposed beds of arenaceous siltstone and carbonaceous shale (Edson and Barclay, in press, and Sanders, 1974 and 1975).

Recent deposits of alluvium cover the stream valleys of Separation Creek, Fillmore Creek, Alamosa Gulch and their tributaries. Gravel derived from older pediment deposits caps many hills and ridges in the quadrangle (Edson, in press, a).

The Upper Cretaceous-age sediments in the Fillmore Ranch quadrangle indicate the transgressions and regressions of a widespread Cretaceous sea. The sediments exposed in the quadrangle accumulated near the western edge of the sea and reflect the location of the shoreline.

Deposition of the marine Steele Shale indicates the westward transgression of the sea. The formations in the Mesaverde Group reflect the many fluctuations of the shoreline in a series of marine, shallow-water marine, and non-marine beds deposited on or near the Rawlins delta which extended northeastward into the Cretaceous sea (Weimer, 1961).

The Haystack Mountains Formation of the Mesaverde Group is composed of thick units of marine sandstone (the Deep Creek and Hatfield Sandstone Members) deposited in nearshore and offshore environments as marine beach or barrier bar deposits. These alternate with marine shale (the Espy Tongue Member) deposited in a deeper-water marine environment.

The upper unnamed member of the Haystack Mountains Formation contains open marine shale, beach sandstone and lagoonal sandstone and mudstone deposits. All of the Allen Ridge Formation except the uppermost 150 to 200 feet (46 to 61 m) was deposited in a non-marine fluvial environment. The upper portion contains lagoonal deposits (C. S. V. Barclay, written communication, 1979).

The Pine Ridge Sandstone is a major non-marine tongue reflecting the eastward retreat of the shoreline. The lower portion of the Almond Formation of the Mesaverde Group consists of some beach sandstones, fluvial and coastal swamp sandstones, shales, and coals. The upper portion consists of marine shales, shallow-water marine sandstones, and lagoonal or brackish-water deposits.

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.

The Fox Hills Sandstone represents a transitional depositional environment between the deeper-water marine environment of the Lewis Shale, and the lagoonal and continental environments of the Lance Formation. Deposition of the Fox Hills Sandstone sediments occurred in shallow marine, barrier bar, beach, estuarine and tidal channel environments.

During the gradual recession of the last Cretaceous sea, marking the close of Cretaceous time in the Fillmore Ranch area, the carbonaceous shales, mudstones, and coal beds of the Lance Formation were deposited in broad areas of estuarine, marsh, lagoonal, and coastal swamp environments.

After the final withdrawal of the Cretaceous sea, thick sections of detrital material, eroded from older deposits, were deposited as the coarse conglomerates and sandstones of the Paleocene-age Fort Union Formation. The sandstones, shales, and coals of the Fort Union Formation were deposited in stream, lake, and swamp environments.

Structure

The Fillmore Ranch quadrangle is located on the southeastern rim of the Great Divide structural basin. Throughout most of the quadrangle, the beds strike north-northeast and dip 10° to 20° to the northwest.

One normal fault with a displacement of about 800 feet (244 m) has been mapped passing east-west through secs. 14, 15, and 16, T. 18 N., R. 90 W., in the southeastern corner of the quadrangle (Edson and Barclay, in press).

COAL GEOLOGY

Three major coal zones have been identified in the Fillmore Ranch quadrangle (plate 1). The Almond Formation, lowest stratigraphically of the identified zones, includes four coal beds located in the lower portion of the formation just above the Pine Ridge Sandstone. The Lance-Fox Hills Coal zone lies approximately 2,300 feet (701 m) above the Almond beds with coal beds in both the Fox Hills Sandstone and the lower portion of the Lance Formation. The Lower Fort Union Coal Zone, uppermost of the zones in this quadrangle, lies approximately 500 feet (152 m) above the unconformable contact between the Fort Union and Lance Formations.

Chemical analyses of coal.--Chemical analyses for coals in the Lower Fort Union Coal zone are listed in table 1 (RMEC, no date). The Lower Fort Union coals are subbituminous C in rank. Analyses have not been obtained for either the Lance-Fox Hills or Almond coals, but they are believed to be low-sulfur, subbituminous B or C in rank, as are the majority of the coals tested in the Rawlins area (Barclay and others, 1978).

Coal Beds of the Almond Formation

Although no outcrop information was obtained, oil and gas wells and coal test holes (RMEC) revealed four major coal beds in the southeastern corner of the quadrangle (plate 1). These coal beds can be correlated with beds in the southwest quarter of the Bridger Pass 15-minute quadrangle, to the east, which are located in the lower portion of the Almond Formation just above the Pine Ridge Sandstone. The four coal beds are not known to possess formal names but have been given informal alpha-numeric names for the purposes of this report.

The traces of the outcrops shown on the isopach and structure contour maps have been projected from the available data. Dips taken in the southeastern quarter of the quadrangle range from 10° to 18° to the west (Edson and Barclay, in press). Overburden thicknesses increase toward the west.

Z Coal Bed

The Z coal bed, lowermost of the Almond coals, occurs as a single bed with a maximum thickness of 18 feet (5.5 m) as shown on plate 4. The bed thins to the north and splits into two beds as it enters the southwest quarter of the Bridger Pass 15-minute quadrangle to the east. In the northeast quarter of the Doty Mountain 15-minute quadrangle to the south, the Z coal bed maintains a thickness of 16 to 18 feet (4.9 to 5.5 m).

Y Coal Bed

The Y coal bed lies approximately 40 feet (12.2 m) above the Z coal bed, averaging 13.5 feet (4.1 m) in thickness as shown on plate 8. The bed thins to 9 feet (2.7 m) or less in the southwest quarter of the Bridger Pass 15-minute quadrangle to the east but is 14 feet (4.3 m) thick a few miles south of the southern boundary of the Fillmore Ranch quadrangle.

X Coal Bed

The X coal bed is, stratigraphically, above and separated from the Y coal bed by 30 to 45 feet (9.1 to 13.7 m) of shale. The bed gradually thins northward from a maximum thickness of 9.5 feet (2.9 m) located in sec. 28, T. 18 N., R. 90 W. Local thickenings of 9 feet (2.7 m) were recorded in the southwest quarter of the Bridger Pass 15-minute quadrangle to the east in secs. 1 and 11, T. 18 N., R. 90 W. To the south, the coal bed averages approximately 6 feet (1.8 m) thick.

W Coal Bed

The W coal bed, uppermost of the four coal beds in the Almond Formation, lies approximately 20 feet (6.1 m) above the X coal bed. It averages 5 feet (1.5 m) thick in this quadrangle, 4 feet (1.2 m) thick in the southwest quarter of the Bridger Pass 15-minute quadrangle to the east, but pinches out to the south in the northeast quarter of the Doty Mountain 15-minute quadrangle.

Lance-Fox Hills Coal Zone

The Lance-Fox Hills Coal Zone, as mapped by Edson and Barclay (in press) crops out along a line trending northeast-southwest across the quadrangle, as shown on plate 1. The coal zone encompasses both the lower portion of the fluvial Lance Formation and the transitional beach sands of the Fox Hills Formation. The coal beds are usually lenticular and thin (Edson, personal communication) although a 10-foot (3.0-m) thickness was recorded in sec. 25, T. 18 N., R. 91 W. Approximately 1 mile (1.6 km) east of Fillmore Ranch, a local bed within the zone was mapped that attains a thickness of 6.1 feet (1.9 m) as shown on plate 20. The bed, informally named La-FH[2], dips to the northwest at approximately 19°. To the north, in the northwest quarter of the Bridger Pass 15-minute quadrangle, drill hole data has revealed three distinct coal beds within the zone. To the south, a single bed of the Lance-Fox Hills Zone has been mapped and thicknesses of 8 and 16 feet (2.4 and 4.9 m) were recorded. Dips along the outcrops range from 20° to 25° to the northwest.

Lower Fort Union Coal Zone

Coal beds within the Lower Fort Union Coal Zone crop out in the western portion of the quadrangle as shown on plate 1. These coal beds are commonly identified by two names, both of which are used in this report and on the CRO maps where applicable. Rocky Mountain Energy Company has extensively drilled this area and has identified the coal beds by using an alpha-numeric designation (e.g., G). Generic names (e.g., Daleys Ranch) have been used by Edson (in press, a) to designate some of the same coal beds. Dips are to the northwest, with overburden thickness increasing toward the northwest.

G (Daleys Ranch) Coal Bed

The G or Daleys Ranch coal bed is, stratigraphically, the lowest identified bed of the Lower Fort Union Coal Zone in this quadrangle. The bed, designated G by RMEC, is named for Daleys Ranch (Edson, in press, a) located in sec. 32, T. 21 N., R. 89 W. The bed thickens locally to 14 feet (4.3 m) in sec. 25, T. 19 N., R. 91 W., including a shale parting 2 feet (0.6 m) thick. It pinches out to the south and to the north, but measurements down-dip, in the Seaverson Reservoir quadrangle to the west, indicate that the bed is usually thicker than 10 feet (3.0 m) with the numerous shale partings excluded. Dips calculated from plate 5 range from 13° along the projected outcrop trace to 8° or less down-dip to the northwest.

F2 (Red Rim) Coal Bed

The F2 (Red Rim) coal bed lies approximately 200 feet (61 m) above the G bed. The Red Rim coal bed is named for Red Rim (Edson, in press, a) located in T. 20 N., R. 90 W. Plate 23 shows the variable thickness of the bed in this quadrangle. A maximum thickness of 28.5 feet (8.7 m) was recorded in sec. 13, T. 18 N., R. 90 W., excluding the shale partings which usually are present within this bed and may range from 1 to 15 feet (0.3 to 4.6 m) in thickness. Surrounding information indicates that the F2 coal bed is prominent and widespread, usually 10 feet (3.0 m) or more thick. Dips derived from plate 24 indicate a gradual decrease in dip with distance away from the outcrop. Dips of 14° to the northwest along the outcrop are common while dips of 5° or less prevail down-dip along the quadrangle's western boundary.

F1 Coal Bed

The F1 coal bed was mapped by Edson and Barclay (in press) in sec. 19, T. 19 N., R. 90 W. It lies approximately 20 to 50 feet (6.1 to 15.2 m) above the F2 coal bed and attains a maximum thickness of only 8 feet (2.4 m). The bed pinches out to the south and to the west but is present locally in the Riner quadrangle to the north, with thicknesses up to 8 feet (2.4 m). The F1 coal bed dips approximately 12° to the northwest.

E1 (Olson Draw) Coal Bed

The E1 (Olson Draw) coal bed overlies the F1 coal bed and is stratigraphically separated from it by approximately 160 feet (49 m) of interbedded sandstone, siltstone and shale. The bed is named for Olson Draw (Edson, in press, a), located in the southwestern corner of this quadrangle. A maximum thickness of 10 feet (3.0 m) was recorded in the northwest corner of the quadrangle. The E1 coal bed is persistant throughout the areas that contain the Lower Fort Union Coal Zone but is usually split by numerous partings ranging from 0 to 16 feet (0 to 4.9 m) in thickness. Dips derived from plate 32 are steep along the outcrop (up to 17°) but fall off rapidly down-dip to the northwest.

D1 (Separation Creek) Coal Bed

The D1 or Separation Creek coal bed is, stratigraphically, above and separated from the E1 coal bed by approximately 325 feet (99 m) of sandstone, siltstone and shale. The bed is named for Separation Creek (Edson, in press, a), located in the northeast corner of the quadrangle. Plate 35 indicates the D1 coal bed thickens southward to a maximum of 13.1 feet (4.0 m) in sec. 23, T. 18 N., R. 91 W. Carbonaceous shale partings within the coal bed are minor, 0 to 3 feet (0 to 0.9 m) thick, in this quadrangle. Information from surrounding areas indicates that the bed thins to the north but averages 5 feet (1.5 m) thick or greater as the bed is followed southward. Dips ranging from 11° to less than 5° were calculated from plate 9.

C (Muddy Creek) Coal Bed

The C (Muddy Creek) bed immediately overlies and is separated from the D1 coal bed by approximately 110 feet (34 m) of shale and thin coals. The coal bed is named for Muddy Creek (Edson, in press, a), located in the northeast corner of the northeast quarter of the Doty Mountain 15-minute quadrangle. The C coal bed thins northward from a maximum thickness of 12 feet (3.7 m) recorded in sec. 14, T. 18 N., R. 91 W. The coal thicknesses shown on plate 16 are cumulative, excluding partings which commonly split the coal bed (see plate 3, sheet 1). To the north in the Riner quadrangle, the C coal bed has been mapped but averages only 3 feet (0.9 m) thick. To the southwest, the average coal thickness is approximately 10 feet (3.0 m). From plate 17, it is indicated that dips of 7° or less occur along the outcrop and that the dip decreases down-dip to the northwest.

B (Fillmore Ranch) Coal Bed

The B or Fillmore Ranch coal bed is the uppermost of the isopached beds in the Lower Fort Union Coal Zone in this quadrangle. It crops out 100 to 200 feet (30.5 to 61 m) stratigraphically above the C coal bed, with the separation between the two increasing to the south. This important bed is named for Fillmore Ranch (Edson, in press, a), located in sec. 6, T. 18 N., R. 90 W. The B coal bed is usually quite thick, thickening southward to a maximum of 33 feet (10.1 m) in sec. 11, T. 18 N., R. 91 W. Partings in this quadrangle are relatively minor, but increase in importance to the south where the bed contains an average of 5 feet (1.5 m) of shale. Dips in the quadrangle are shallow, usually 7° or less, decreasing to the west.

Isolated Data Points

In instances where isolated measurements of coal beds of Reserve Base thickness (greater than 5 feet or 1.5 meters) 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 correlations 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-isopachable coal beds. The isolated points used in this quadrangle are listed on the next page. Coal beds identified by bracketed numbers are not formally named, but are used for identification purposes in this quadrangle only.

Source	Location	Coal Bed or Zone	Thickness
Edson	sec. 19, T. 18 N., R. 90 W.	La-FH [1]	9.6 ft (2.9 m)
Edson	sec. 26, T. 19 N., R. 91 W.	FU [1A]	6.0 ft (1.8 m)
RMEC	sec. 1, T. 18 N., R. 91 W.	FU [2]	6.6 ft (2.0 m)
Edson (1977)	sec. 18, T. 19 N., R. 90 W.	FU [4], FU [2] projected from Riner Quad	9.0 ft (2.7 m)
Edson (1977)	sec. 22, T. 19 N., R. 91 W.	A (Chicken Springs) of Lower Fort Union Coal Zone	9.0 ft (2.7 m)
Edson (1977)	sec. 34, T. 19 N., R. 91 W.	A (Chicken Springs) of Lower Fort Union Coal Zone	8.0 ft (2.4 m)

COAL RESOURCES

Information from oil and gas wells, and from coal test holes drilled by the U.S. Geological Survey and RMEC, as well as surface mapping by Edson and Barclay (in press) and Edson (in press, b), were used to construct outcrop, isopach, and structure contour maps of the coal beds in the Fillmore Ranch quadrangle. The source for each indexed data point used on plate 1 is listed in table 4. At the request of RMEC, coal-rock data for some of their drill holes have not been shown on plate 1 or on the derivative maps. However, data from these holes have been used to prepare the derivative maps. These data may be obtained by contacting RMEC.

Coal resources were calculated using data obtained from the coal isopach maps (plates 4, 8, 12, 16, 20, 23, 27, and 31). The coal bed acreage (measured by planimeter) multiplied by the average isopached 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. Reserve Base and Reserve tonnages for the Z, Y, X, W, La-FH, G, F2, F1, E1, D1, C and B beds are shown on plates 7, 11, 15, 19, 22, 26, 30, and 34, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Coal beds thicker than 5 feet (1.5 m) that lie less than 3,000 feet (914 m) below the ground surface are included although this criteria differs somewhat from that 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. Only Reserve Base tonnages (designated as inferred resources) are calculated for areas influenced by the isolated data points in this quadrangle. Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 347.80 million short tons (315.52 million metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface and subsurface mining methods are shown in tables 2 and 3.

Dames & Moore has not made any determination of economic recoverability for any of the coal beds 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 portions 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 portion 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 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 subbituminous coal is as follows:

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

where MR = mining ratio

t_o = thickness of overburden

t_c = thickness of coal

rf = recovery factor

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, as shown on plates 6, 10, 14, 18, 21, 25, 29, and 33. 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.

Unknown development potentials have been assigned to those areas where coal data is absent or extremely limited. This includes areas influenced only by isolated data points. Even though these areas contain coal thicker than 5 feet (1.5 m), limited knowledge of the areal distribution of the coal prevents accurate evaluation of development potential. Tonnages included in the unknown potential category for isolated data points total 870,000 short tons (789,000 metric tons).

The coal development potential for surface mining methods (less than 200 feet or 61 meters of overburden) is shown on plate 35.

Of the Federal land area having known development potential for surface mining methods, 81 percent is rated high, 6 percent is rated moderate, and 13 percent is rated low. The remaining Federal land within the KRCRA is classified as having unknown development potential, implying that no known coal beds 5 feet (1.5 m) or more thick, excluding isolated data points, occur within 200 feet (61 m) of the ground surface but that coal-bearing units are present.

Development Potential for Subsurface and In-Situ Mining Methods

The coal development potential for subsurface mining is shown on plate 36. Areas of high, moderate, and low development potential are defined as areas underlain by coal beds of Reserve Base thickness 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.

Reserve Base tonnages have been calculated for all areas where the coal beds are of Reserve Base thickness or greater. However, Reserves have been calculated for only that part of the Reserve Base considered to be suitable for subsurface mining. An arbitrary dip limit of 15° is assumed to be the maximum dip suitable for conventional subsurface mining methods, and Reserves have not been calculated for those areas where the dip of the coal beds exceeds 15°.

Of the Federal land areas having known development potential for conventional subsurface mining methods, 94 percent have high potential and 6 percent have moderate potential. Unknown potential is assigned to the remaining Federal land within the KRCRA, implying that no known coal beds 5 feet (1.5 m) or more thick, excluding isolated data points, occur between 200 feet (61 m) and 3,000 feet (914 m) below the ground surface but that coal-bearing units are present. Tonnages for the unknown (subsurface) development potential for isolated data points totals 7,430,000 short tons (6,740,000 metric tons).

Areas not rated for conventional subsurface mining that have coal beds dipping in excess of 15° have been evaluated for in-situ mining development. Because several coal beds are involved, the boundaries for in-situ development are uncertain and overlap considerably with the boundaries for conventional subsurface mining. For this reason, tonnages available for the in-situ process are difficult to determine under present criteria (but are known to be extremely low) and the areas in question have been rated as having unknown development potential.

Table 1. Chemical analyses of coals in the Fillmore Ranch quadrangle, Carbon County, Wyoming.

LOCATION	COAL BED NAME	Form of analysis	Proximate				Ultimate					Heating value	
			Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrocarbon	Carbon	Nitrogen	Oxygen	Calories	Btu/lb
SW¼, sec. 19, T. 19 N., R. 90 W. (RR-90-RMEC)	F2	A	27.81	32.30	34.63	5.26	0.19	-	-	-	-	-	7,473
		C	0.0	44.74	47.98	7.28	0.27	-	-	-	-	-	10,352
NW¼, NW¼, SE¼, sec. 35, T. 19 N., R. 91 W. (RR-92 RMEC)	B	A	27.00	29.26	37.62	6.12	0.30	-	-	-	-	-	8,194
		C	0.0	40.08	51.54	8.38	0.41	-	-	-	-	-	11,225
NE¼, NW¼, NE¼, sec. 25, T. 19 N., R. 91 W., (RR-96, RMEC)	C	A	26.91	27.90	31.49	13.70	1.31	-	-	-	-	-	7,319
		C	0.0	38.17	43.08	18.75	1.79	-	-	-	-	-	10,013
NE¼, NW¼, NE¼, sec. 25, T. 19 N., R. 91 W. (RR-96, RMEC)	D1	A	26.55	28.17	38.16	7.12	0.15	-	-	-	-	-	8,103
		C	0.0	33.35	51.95	9.70	0.21	-	-	-	-	-	11,032
SE¼, SW¼, SE¼, sec. 19, T. 19 N., R. 90 W. (RR-198 RMEC)	G	A	27.29	27.62	38.75	6.34	0.25	-	-	-	-	-	7,848
		C	0.0	37.98	53.30	8.72	0.34	-	-	-	-	-	10,794

Form of analysis: A, as received
C, moisture free

Note: To convert Btu/pound to kilojoules/kilgram, muptiply by 2.326.

Table 2. Strippable coal Reserve Base data for Federal coal lands (in short tons) in the Fillmore Ranch quadrangle, Carbon County, Wyoming

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Total
B (Fillmore Ranch)	9,300,000	1,070,000	560,000	10,930,000
C (Muddy Creek)	3,570,000	2,030,000	3,730,000	9,330,000
D1 (Separation Creek)	3,540,000	3,280,000	2,780,000	9,600,000
E1 (Olson Draw)	--	--	40,000	40,000
FU{1}	20,000	20,000	910,000	950,000
F1	120,000	70,000	150,000	340,000
F2 (Red Rim)	14,070,000	1,010,000	190,000	15,270,000
G (Daleys Ranch)	3,090,000	1,080,000	1,580,000	5,750,000
La-FH {2}	--	--	10,000	10,000
W	30,000	30,000	960,000	1,020,000
X	1,550,000	1,900,000	1,540,000	4,990,000
Y	3,580,000	2,200,000	2,400,000	8,180,000
Z	1,690,000	1,900,000	1,390,000	4,980,000
TOTAL	40,560,000	14,590,000	16,240,000	71,390,000

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 Fillmore Ranch quadrangle, Carbon County, Wyoming

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential*	Total
B(Fillmore Ranch)	4,930,000	--	--	--	4,930,000
C(Muddy Creek)	5,280,000	--	--	--	5,280,000
D1(Separation Creek)	16,640,000	--	--	--	16,640,000
E1(Olson Draw)	10,120,000	2,280,000	--	250,000	12,650,000
FU{1}	2,110,000	--	--	--	2,110,000
F1	390,000	--	--	--	390,000
F2(Red Rim)	75,900,000	33,970,000	--	--	109,870,000
G(Daleys Ranch)	11,970,000	22,830,000	--	--	34,800,000
La-FH{2}	--	--	--	700,000	700,000
W	2,510,000	--	--	1,770,000	4,280,000
X	12,690,000	--	--	2,720,000	15,410,000
Y	28,050,000	750,000	30,000	5,950,000	34,780,000
Z	23,820,000	--	--	3,400,000	27,220,000
TOTAL	194,410,000	59,830,000	30,000	14,790,000	269,060,000

*for beds dipping >15°

Note: To convert short tons to metric tons, multiply by 0.9072

Table 4. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	U.S. Geological Survey, 1978, unpublished table	Drill hole No. 33 (RME Drill hole No. 168)
2	Tenneco Oil Co.	Oil/gas well No. 3 Sugar Creek Unit
3	U.S. Geological Survey, 1978, unpublished table	Drill hole No. 38 (RME Drill hole No. 156)
4	↓	Drill hole No. 39 (RME Drill hole No. 155)
5	↓	Drill hole No. 41 (RME Drill hole No. 1AS)
6	↓	Drill hole No. 42 (RME Drill hole No. 169)
7	↓	Drill hole No. 43 (RME Drill hole No. 170)
8	↓	Drill hole No. 44 (RME Drill hole No. 2AS)
9	↓	Drill hole No. 45 (RME Drill hole No. ARW-5)
10	↓	Drill hole No. 46 (RME Drill hole No. 151)
11	Edson and Barclay (in press) U.S. Geological Survey, unpublished data	Measured Section
12	U.S. Geological Survey, 1978, unpublished table	Drill hole No. 47 (RME Drill hole No. 1AS)
13	↓	Drill hole No. 48 (RME Drill hole No. 2AD)
14	↓	Drill hole No. 49 (RME Drill hole No. 150)

Table 4. -- Continued.

Plate 1 Index Number	Source	Data Base
15	U.S. Geological Survey, 1978, unpublished table	Drill hole No. 50 (RME Drill hole No. 149)
16	↓	Drill hole No. 51 (RME Drill hole No. 1AD)
17	↓	Drill hole No. 52 (RME Drill hole No. 148)
18	↓	Drill hole No. 53 (RME Drill hole No. 147
19	↓	Drill hole No. 54 (RME Drill hole No. 146)
20	↓	Drill hole No. 56 (RME Drill hole No. 1AS)
21	↓	Drill hole No. 55 (RME Drill hole NO. 144)
22	↓	Drill hole No. 58 (RME Drill hole No. 145)
23	↓	Drill hole No. 59 (RME Drill hole No. ARW-6)
24	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. CB1
25	↓	Drill hole No. CB9
26	↓	Drill hole No. CB5
27	↓	Drill hole No. CB7
28	Edson and Curtiss, 1976, U.S. Geological Survey Open-File Report 76-272	Drill hole No. FR-D3

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Table 4. -- Continued.

Plate 1 Index Number	Source	Data Base
29	Edson and Barclay (in press) U.S. Geological Survey, unpublished data	Drill hole No. BS-145-1
30	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. CB13
31	↓	Drill hole No. CB15
32	↓	Drill hole No. CB17
33	↓	Drill hole No. CB20
34	↓	Drill hole No. CB22
35	↓	Drill hole No. CB27
36	↓	Drill hole No. CB24
37	U.S. Geological Survey, (no date), unpublished table and logs	Drill hole No. FR-D8
38	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. CB33
39	↓	Drill hole No. CB35
40	Edson and Curtiss, 1976, U.S. Geological Survey Open-File Report 72-272	Drill hole No. FR-D7
41	↓	Drill hole No. FR-D6
42	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. CB36
43	↓	Drill hole No. 2AS
44	↓	Drill hole No. 1AS

Table 4. -- Continued.

Plate 1 Index Number	Source	Data Base
45	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. CB43
46	↓	Drill hole No. CB49
47	↓	Drill hole No. CB44
48	↓	Drill hole No. CB51
49	↓	Drill hole No. CB52
50	↓	Drill hole No. CB53
51	Edson and Barclay (in press), U.S. Geological Survey, unpublished data	Measured section
52	↓	Measured section
53	Texas Oil and Gas Co.	Oil/gas well No. 1 State-331
54	Edson and Barclay (in press), U.S. Geological Survey, unpublished data	Drill hole No. SS-64-2
55	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 195
56	U.S. Geological Survey, (no date), unpublished table and logs	Drill hole No. FR-D1
57	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 85
58	↓	Drill hole No. RR 197
59	↓	Drill hole No. RR 87
60	↓	Drill hole No. RR 86
61	↓	Drill hole No. RR 116

Table 4. -- Continued.

Plate 1 Index Number	Source	Data Base
62	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 198
63	Tenneco Oil Co.	Oil/gas well No. 1 Trowbridge
64	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 98
65	Edson and Barclay (in press), U.S. Geological Survey, unpublished data	Drill hole No. SS-108-1
66	↓	Drill hole No. SS-108-2
67	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 114
68	Edson and Barclay (in press) U.S. Geological Survey, unpublished data	Measured Section
69	↓	Measured Section
70	↓	Measured Section
71	Tenneco Oil Co.	Oil/gas well No. 2 Sugar Creek Unit
72	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 97
73	↓	Drill hole No. RR 196
74	↓	Drill hole No. RR 117
75	Davis Oil Co.	Oil/gas well No. 1 Elaine-Federal
76	U. S. Geological Survey, (no date), unpublished table and logs	Drill hole No. FR-D2

Table 4. -- Continued.

Plate 1 Index Number	Source	Data Base
77	Edson and Barclay (in press), U.S. Geological Survey, unpublished data	Drill hole No. BS-109-1
78	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 95
79	↓	Drill hole No. RR 199
80	Edson and Barclay (in press), U.S. Geological Survey, unpublished data	Drill hole No. BS-211-1
81	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 96
82	↓	Drill hole No. RR 109
83	↓	Drill hole No. RR 113
84	↓	Drill hole No. RR 200
85	↓	Drill hole No. RR 201
86	↓	Drill hole No. RR 110
87	↓	Drill hole No. RR 101
88	↓	Drill hole No. RR 112
89	↓	Drill hole No. RR 99
90	U.S. Geological Survey, (no date), unpublished table and logs	Drill hole No. FR-D5
91	Edson and Barclay (in press), U.S. Geological Survey, unpublished data	Drill hole No. BS-16-1
92	↓	Drill hole No. BS-52-1

Table 4. -- Concluded.

Plate 1 Index Number	Source	Data Base
93	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 100
94	↓	Drill hole No. RR 94
95	↓	Drill hole No. RR 93
96	↓	Drill hole No. RR 108
97	↓	Drill hole No. RR 106
98	↓	Drill hole No. RR 92
99	↓	Drill hole No. RR 107
100	↓	Drill hole No. RR 91
101	↓	Drill hole No. RR 105

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REFERENCES

American Society for Testing and Materials, 1977, Standard specification for classification of coals by rank, in Gaseous fuels; coal and coke; atmospheric analysis: ASTM Standard Specification D 388-77, pt. 26, p. 214-218.

Ball, M. W., 1909, The western part of the Little Snake River coal field, Wyoming, in Coal fields of Wyoming: U.S. Geological Survey Bulletin 341-B, p. 243-255.

Barclay, C. S. V., Jobin, D. A., and Storrs, J. P., 1978, Minutes for the revision of the Rawlins (Little Snake River) Known Recoverable Coal Resources Area, Carbon and Sweetwater Counties, Wyoming, January 31, 1978: U.S. Geological Survey Conservation Division, unpublished report, 15 p.

Berry, D. W., 1960, Geology and ground-water resources of the Rawlins area, Carbon County, Wyoming: U.S. Geological Survey Water-Supply Paper 1458, 74 p.

Bradley, W. H., 1964, Geology of Green River Formation and associated Eocene rocks in southwestern Wyoming and adjacent parts of Colorado and Utah: U.S. Geological Survey Professional Paper 496-A., p. A1-A10.

Edson, G. M., in press (a), Preliminary geologic map and coal sections of the Seaverson Reservoir quadrangle, Carbon County, Wyoming: U.S. Geological Survey Conservation Division, unpublished maps, sheets 1 and 2, scale 1:24,000.

______ in press (b), Preliminary geologic map of the northwestern part of the Rawlins (Little Snake River) Known Recoverable Coal Resources Area (KRCRA) : U.S. Geological Survey Conservation Division, unpublished map, scale 1:63,360.

Edson, G. M., and Barclay, C. S. V., in press, Preliminary geologic map and coal sections of the Fillmore Ranch quadrangle, Carbon County, Wyoming: U.S. Geological Survey Conservation Division, unpublished maps, tables, cross-sections, and field notes.

Edson, G. M., and Curtiss, G. S., 1976, Lithologic and geophysical logs of holes drilled in the High Point, Seaverson Reservoir, and Fillmore Ranch quadrangles, Carbon County, Wyoming: U.S. Geological Survey Open-File Report 76-272.

Gill, J. R., Merewether, E. A., and Cobban, W. A., 1970, Stratigraphy and nomenclature of some Upper Cretaceous and Lower Tertiary rocks in south-central Wyoming: U.S. Geological Survey Professional Paper 667, 53 p.

References--Continued

Hale, L. A., 1961, Late Cretaceous (Montanan) stratigraphy, eastern Washakie Basin, Carbon County, Wyoming, in Symposium on Late Cretaceous Rocks of Wyoming and adjacent areas, Wyoming Geological Association Guidebook, 16th Annual Field Conference, 1961: p. 129-137.

Haun, J. D., 1961, Stratigraphy of post-Mesaverde Cretaceous rocks, Sand Wash Basin and vicinity, Colorado and Wyoming, in Symposium on Late Cretaceous rocks, Wyoming Geological Association Guidebook, 16th Annual Field Conference, 1961: p. 116-124.

Rocky Mountain Energy Company, (no date), Unpublished drill hole data from the Red Rim and China Butte projects and the Union Pacific coal inventory of 1971.

Sanders, R. B., 1974, Geologic map and coal resources of the Riner quadrangle, Carbon and Sweetwater Counties, Wyoming: U.S. Geological Survey Coal Investigations Map C-68, scale 1:24,000.

______ 1975 Geologic map and coal resources of the Creston Junction quadrangle, Carbon and Sweetwater Counties, Wyoming: U.S. Geological Survey Coal Investigations Map C-73, scale 1:24,000.

Tyler, T. F., 1978, Preliminary chart showing electric log correlation section A-A' of some Upper Cretaceous and Tertiary rocks, Washakie Basin, Wyoming: U.S. Geological Survey Open-File Report 78-703.

U.S. Bureau of Land Management, 1978, Draft environmental statement, proposed domestic livestock grazing management program for the Seven Lakes area: U.S. Bureau of Land Management, Rawlins district, Wyoming, v. 1, pt. 2, p. 1-3.

U.S. Geological Survey, 1976, Coal resource classification system of the U.S. Bureau of Mines and U.S. Geological Survey: U.S. Geological Survey Bulletin 1450-B, 7 p.

______ 1978, Unpublished table of estimated depths and apparent thicknesses of coal beds in drill holes in the lower part of the Almond Formation in the eastern part of the Rawlins (Little Snake River) KRCRA, Carbon County, Wyoming: U.S. Geological Survey Conservation Division, unpublished table.

______ (no date), Holes drilled for classification and evaluation of lands in the Rawlins (Little Snake River) KRCRA, Carbon and Sweetwater Counties, Wyoming by the Conservation Division during 1975, 1976, and 1977: U.S. Geological Survey Conservation Division, unpublished table and logs.

Weimer, R. J., 1960, Upper Cretaceous stratigraphy, Rocky Mountain area: American Association of Petroleum Geologists Bulletin, v. 44, no. 1, p. 1-20.