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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE NORTHWEST QUARTER OF THE BRIDGER PASS 15-MINUTE QUADRANGLE, CARBON COUNTY, WYOMING

[Report includes 32 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the northwest quarter of the Bridger Pass 15-minute 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 Published and unpublished public information was used as the data base for this study.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

In this report the term "quadrangle" refers only to the northwest quarter of the Bridger Pass 15-minute quadrangle which is located in south-central Wyoming in the west-central portion of Carbon County, approximately 8 miles (13 km) southwest of Rawlins and 26 miles (42 km) east of Wamsutter, Wyoming. The area is unpopulated. The Daleys Ranch loading station on the Union Pacific Railroad, located on the northwestern edge of the quadrangle, has been abandoned.

Accessibility

The main east-west line of the Union Pacific Railroad, providing railway service across southern Wyoming, passes through the northwestern corner of the quadrangle. The railway connects Ogden, Utah to the west, and Omaha, Nebraska to the east.

Interstate Highway 80 passes east-west through the region 1 to 3 miles (1.6 to 4.8 km) north of the quadrangle. The abandoned loading station of Daleys Ranch on the Union Pacific Railroad is accessible by an improved light-duty road from Interstate Highway 80. Twenty Mile road, connecting the city of Rawlins approximately 8 miles (13 km) to the northeast and Wyoming Highway 789 to the southwest, crosses the quadrangle through the valley between Red Rim hogback and Hogback Ridge. The remainder of the quadrangle is served by a network of unimproved dirt roads and trails.

Physiography

The northwest quarter of the Bridger Pass 15-minute quadrangle is located in the Red Desert region on the southeastern edge of the Great Divide Basin. The landscape in the northwestern three quarters of the quadrangle is characterized by northeast-trending hogbacks and valleys, and badland topography. Red Rim, a 200-foot (61-m) high hogback, and Hogback Ridge cut northeasterly across the quadrangle. The southeastern one quarter of the quadrangle grades upward into the 8,484-foot (2,586-m) high Separation Peak, the highest elevation in the quadrangle. The lowest elevation, approximately 6,680 feet (2,036 m), lies on Separation Creek near the Daleys Ranch station on the northwestern edge of the quadrangle. The eastern branch of the Continental Divide, which circles the Great Divide Basin, crosses the quadrangle from north to south, following along Hogback Ridge and crossing to the western flank of Separation Peak near the southern border of the quadrangle (Welder and McGreevy, 1966).

Separation Creek and its tributaries drain the northwestern one half of the quadrangle, flowing northward into the Great Divide Basin. The area southeast of Hogback Ridge is drained by Sugar Creek which flows northeastward, emptying into the North Platte River northeast of the quadrangle. All the streams in the area are intermittent, flowing mainly in response to snowmelt in the spring.

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). Approximately two thirds of the precipitation falls in the spring and summer months during a 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 wind 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 northwest quarter of the Bridger Pass 15-minute quadrangle lies along the northeastern edge of the Rawlins Known Recoverable Coal Resource Area. Approximately 95 percent of the quadrangle's total area is within the KRCRA boundary; only a small portion in the southeastern corner of the quadrangle is outside. The Federal government owns the coal rights for a little less than one half of this area, as shown on plate 2. No outstanding Federal coal leases, prospecting permits, or licenses occur within the KRCRA boundary in this quadrangle.

GENERAL GEOLOGY

Previous Work

Ball (1909) described the coal-bearing Mesaverde, Lance, and Fort Union Formations in his study of the western part of the Little Snake River coal field. Smith (1909) covered the northern portion of the quadrangle in his investigation of the eastern part of the Great Divide Basin coal field. Berry (1960) made a detailed investigation of the geology and ground-water resources of the Rawlins area, including the eastern two thirds of the quadrangle. Welder and McGreevy (1966) published a report on the geology and ground-water resources of the Great Divide Basin. Gill, Merewether, and Cobban (1970) described the stratigraphy of the Upper Cretaceous and Lower Tertiary age rocks in the quadrangle. Unpublished data from the Rocky Mountain Energy Company (RMEC), data from recent U.S. Geological Survey drilling, and reconnaissance mapping by Barclay (1978) and Edson (in press, b, 1977) provided coal outcrop and coal thickness information.

Stratigraphy

The formations exposed in the northwest quarter of the Bridger Pass 15-minute quadrangle range in age from Upper Cretaceous to Recent. All but the Pine Ridge Sandstone of the Mesaverde Group and the Lewis Shale are known to contain coal.

Three of the four formations included in the Upper Cretaceous-age Mesaverde Group crop out in the southeastern corner of the quadrangle, forming Separation Peak. These are, in ascending order, the Allen Ridge Formation, the Pine Ridge Sandstone, and the Almond Formation. The underlying basal unit of the Mesaverde Group, the Haystack Mountains Formation, is present in the subsurface.

The Haystack Mountains Formation consists primarily of marine and marginal marine shale and sandstone, approximately 790 feet (241 m) thick where measured in the Davis Oil Co. No. 1 Ram Canyon well in sec. 3, T. 19 N., R. 89 W. and in the El Paso Natural Gas Co. WDH-31-2 well in sec. 9, T. 19 N., R. 89 W.

The basal Deep Creek Sandstone Member of the Haystack Mountains Formation consists of pale yellowish-gray, fine- to medium-grained marine sandstone about 80 feet (24 m) thick. The Espy Tongue Member, immediately above, is a unit of dark-gray marine shale and lenticular sandstone averaging 220 feet (67 m) thick. The Espy Tongue Member grades into the overlying 135-foot (41-m) thick Hatfield Sandstone Member, which is thin-bedded to shaly at the base, and grades upward into a thick-bedded to massive, pale yellowish-gray sandstone at the top (Hale, 1961). Overlying the Hatfield Sandstone are approximately 355 feet (108 m) of interbedded sandstones, siltstones and shales forming the upper unnamed member of the Haystack Mountains Formation (Gill and others, 1970).

The Allen Ridge Formation consists of thick, brown and rusty-brown weathering, lenticular, fluvial channel sandstones with interbedded carbonaceous shale, siltstone, mudstone, and a few thin coal beds. The coals, commonly associated with the carbonaceous shale, are 1 to 4 feet (0.3 to 1.2 m) thick and are 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).

The Pine Ridge Sandstone is a blanket-like white to light-gray nonmarine sandstone unconformably overlying the Allen Ridge Formation. C. S. V. Barclay (written communication, 1974) indicates that the Pine Ridge Sandstone maintains its characteristic blanket-like form as far south as the Browns Hill quadrangle. The Pine Ridge Sandstone correlates with the Ericson Formation to the southwest and west.

Conformably overlying the Pine Ridge Sandstone is the Almond Formation, the uppermost unit of the Mesaverde Group. The Almond Formation, a thick sequence of marine and nonmarine rocks, 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 combined thickness of the Allen Ridge Formation, Pine Ridge Sandstone and Almond Formation, as indicated by the oil and gas wells drilled in this quadrangle, is approximately 1,755 feet (535 m).

The Upper Cretaceous-age Lewis Shale conformably overlies the Mesaverde Group. It crops out in a northeast-trending band between Hogback Ridge and Separation Peak. The Lewis Shale is composed of dark-gray to olive-gray fissile shale which grades into a buff-colored sandy shale (Berry, 1960). The middle or upper part of the Lewis Shale often 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). In sec. 7, T. 19 N., R. 89 W., in the southern portion of the quadrangle, the Lewis Shale is approximately 2,100 feet (640 m) thick as indicated by surface measurements and core from the El Paso Natural Gas Co. WDH-31-1 corehole (Hale, 1961, p. 136). The Lewis Shale contains no coal.

The Upper Cretaceous-age Fox Hills Sandstone 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 several 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 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 m) thick throughout the formation. Several fossiliferous zones are present in the upper portion of the formation. The Lance Formation is approximately 4,540 feet (1,384 m) thick where measured in the southwest quarter of the Rawlins Peak 15-minute quadrangle to the north (Berry, 1960). It thins to approximately 3,600 ft (1097 m) in the Riner quadrangle to the west. No information on the total thickness of the Lance Formation is available for this quadrangle. The only well drilled through the Lance Formation in the quadrangle, the Davis Oil Company No. 1 Mesa-Federal well, was collared in the Lance Formation and cuts only the lower 1,900 feet (579 m) of the formation.

Unconformably overlying the Lance Formation, the Paleocene-age Fort Union Formation crops out over the northwestern one-third of the quadrangle from the Red Rim hogback to Daleys Ranch. The Fort Union Formation is composed of dark-gray carbonaceous shale containing thick beds of coal and lignite interbedded with light-gray to brown, fine- to coarse-grained sandstone. The sandstone beds often contain lenses of light-brown to brown conglomerate composed of well-rounded, black, red, and gray chert pebbles, and pink and white quartz in a matrix of coarse- to medium-grained sandstone. Lenses of calcareous material are also present within the formation (Berry, 1960). Erosion of the formation since deposition has resulted in a wide variation in thickness. In the Rawlins area, the Fort Union Formation reaches a maximum thickness of approximately 2,450 feet (747 m) where it was measured about 22 miles (35.4 km) north of this quadrangle. No information is available on the thickness of the Fort Union Formation within this quadrangle.

Recent deposits of alluvium cover the stream valleys of Separation Creek and Sugar Creek.

Upper Cretaceous-age sediments in the Bridger Pass area 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.

The marine, shallow-water marine, and nonmarine beds of the Mesaverde Group were 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 (Gill and others, 1970, and Hale, 1961).

The upper unnamed member of the Haystack Mountains Formation contains marine shale, beach deposits of sandstone and lagoonal deposits of sandstone and mudstone indicating a widespread regression of the sea. The Allen Ridge Formation is predominately non-marine fluvial in the lower portion while the upper portion of the formation contains brackish-water or tidal flat-lagoonal deposits reflecting the westward movement of the shoreline (C. S. V. Barclay, written communication, 1979).

The Pine Ridge Sandstone is a non-marine tongue reflecting the eastward retreat of the shoreline. The lower portion of the Almond Formation of the Mesaverde Group consists of fluviatile and coastal swamp sandstones, shales, and coals. The upper portion consists of marine shales, shallow-water marine sandstones, lagoonal, and brackish-water deposits (Gill and others, 1970).

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 Bridger Pass 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 northwest quarter of the Bridger Pass 15-minute quadrangle is located on the southeastern rim of the Great Divide structural basin. Throughout most of the quadrangle, the beds strike northeasterly and dip 12° to 20° to the northwest into the Great Divide Basin.

A north-northwesterly plunging anticline and syncline are located in the southeastern corner of the quadrangle, folding the Mesaverde Group beds forming Separation Peak. One minor fault associated with the folding was mapped on Separation Peak (Barclay, 1978).

COAL GEOLOGY

Three major coal zones have been identified in the northwest quarter of the Bridger Pass 15-minute quadrangle (plate 1). The thin coals of the Almond Formation are the lowest, stratigraphically, of the identified coal beds in the quadrangle. The Lance-Fox Hills Coal Zone lies approximately 2,000 feet (610 m) above the top of the Almond Formation with coal beds in both the Fox Hills Sandstone and in the base of the Lance Formation. The Lower Fort Union Coal Zone, uppermost of the coal zones in this quadrangle, is separated from the Lance-Fox Hills Zone by approximately 2,800 feet (853 m) of interbedded sandstones, shales, and thin coals of the Lance Formation.

Chemical analyses of coal.--Chemical analyses for some of the Lower Fort Union coal beds are located in table 1 (RMEC, no date). No information on coal quality was found for the Almond Formation or Lance-Fox Hills Zone coals within the quadrangle. However, an analysis of a sample from the old Nebraska Mine (Ball, 1909) in the Lance-Fox Hills coal zone 1 mile (1.6 km) east of the quadrangle was included in table 1. The sampled coal beds of this quadrangle are subbituminous A, B, or C in rank and low in sulfur. Almond Formation coal is believed to be either subbituminous B or C in rank and low in sulfur.

Coal Beds of the Almond Formation

From the information available, the coal beds of the Almond Formation appear to be lenticular and of limited areal extent, occurring randomly throughout an interval approximately 600 feet (183 m) thick. The coal beds are thin, rarely exceeding 5 feet (1.5 m) in thickness, both within this quadrangle and where they are traced to the northeast beyond this quadrangle boundary. In the southwest quarter of the Bridger Pass 15-minute quadrangle, four mappable coal beds are found, ranging in thickness from 3 to 9 feet (0.9 to 2.7 m). An anticline and a syncline located near the southeast corner of the quadrangle (plate 1) cause beds to dip from 12° to 19° in a westerly to northeasterly direction.

The Lance-Fox Hill Coal Zone

Coal beds of the Lance-Fox Hills Coal Zone crop out near the center of the quadrangle, trending northeast along the transitional contact between the marine sandstone of the Fox Hills Formation and the fluvial deposits of the Lance Formation. Within the zone, drill hole data revealed three distinct coal beds, the A, B, and C as named by RMEC. The zone is found in the quadrangles to the north (the southwest and southeast quarters of the Rawlins Peak 15-minute quadrangle), but the three, well-developed coal beds are not discernable. Dips taken along the outcrops in this quadrangle range from 12° to 25° to the northwest with overburden thickness increasing accordingly.

C Coal Bed

The lowermost of the three beds, the C bed, was mined at the old Nebraska Mine in sec. 6, T. 20 N., R. 88 W. just east of the quadrangle, and is locally called the Nebraska bed (Edson, in press, b). The bed is 8 feet (2.4 m) thick at the Nebraska Mine and 12 feet (3.7 m) thick inside the eastern quadrangle boundary 1 mile (1.6 km) to the west. It thins gradually to the southwest until the entire zone is no longer traceable (plate 4). Dips along the outcrop of the C bed average approximately 13° to the northwest except in and around sec. 29, T. 20 N., R. 89 W., where the dips range up to 25°.

B Coal Bed

The B bed lies approximately 100 to 140 feet (30.4 to 42.7 m) above the C bed. The B bed is generally less than 5 feet (1.5 m) thick except in secs. 11 and 29, T. 20 N., R. 89 W., where it attains a thickness of 10 feet (3.0 m) and 7 feet (2.1 m), respectively. Dips along the outcrop average approximately 18° to the northwest.

A Coal Bed

The A bed of the Lance-Fox Hills Coal Zone is, stratigraphically, above and separated from the B bed by approximately 130 feet (39.6 m) of sandstone. The A bed thickens locally to 10.1 feet (3.1 m) in sec. 23, T. 20 N., R. 89 W., but is believed to be rather thin throughout the rest of the area that has been drilled for Lance-Fox Hills coal. The bed dips toward the northwest at approximately 13°.

The Lower Fort Union Coal Zone

Outcrops of coal beds within the Lower Fort Union Coal Zone are found in the northwest quarter of this quadrangle. Dips taken in the coal bearing area (Edson, 1977) range from 12° to 20° in a northwesterly direction. Overburden thickness increases rapidly in the same direction.

Coal beds in the Lower Fort Union Coal Zone are often identified by two names. Both are used in this report and on the CRO maps where applicable. RMEC has drilled extensively in 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.

H Coal Bed

The H coal bed is, stratigraphically, the lowest identified bed of the Lower Fort Union Coal Zone in this quadrangle. The bed thickens to a maximum of 7 feet (2.1 m) in sec. 5, T. 20 N., R. 89 W., but averages approximately 5 feet (1.5 m) or less in the rest of the northwest portion of the quadrangle (plate 7). The H bed was not encountered in the southwest quarter of the Rawlins Peak 15-minute quadrangle to the north, nor was it found in the Riner quadrangle to the west. Since the bed dips northwest at approximately 10° to 15°, overburden thickness increases rapidly as shown on plate 8.

G (Daleys Ranch) Coal Bed

The G (Daleys Ranch) coal bed is, stratigraphically, above and separated from the H coal bed by a non-coal interval of variable thickness of up to 130 feet (39.6 m). This coal bed, designated G by RMEC, was named for Daleys Ranch located in sec. 32, T. 21 N., R. 89 W. (Edson, in press, a).

The G bed can contain considerable partings, although they are not as common here as they are in the southwest quarter of the Rawlins Peak 15-minute quadrangle to the north, where the bed has split into two seams separated by approximately 20 feet (6.1 m) of sandy shale and sandstone. Coal thicknesses shown on plate 10 are cumulative, excluding partings which may total 14 feet (4.3 m) or more. The G bed attains a maximum thickness of 13 feet (3.9 m) in this quadrangle but thins, with average thicknesses ranging from 3 to 6 feet (0.9 to 1.8 m), where traced southwest into the Riner quadrangle. Overburden thickness increases rapidly to the northwest due to a dip of approximately 9° to 13°.

F2 (Red Rim) Coal Bed

The F2 (Red Rim) coal bed lies approximately 230 feet (70 m) above the G bed. The name Red Rim, as used by Edson (in press, a), was applied to the coal bed because it crops out near Red Rim ridge in T. 20 N., R. 90 W. The coal thicknesses encountered in RMEC and U.S. Geological Survey drill holes are shown on plate 14, with a maximum of 11 feet (3.4 m) being recorded in sec. 13, T. 20 N., R. 90 W. Information from surrounding quadrangles indicates that the F2 bed is persistant laterally, and usually is greater than 5 feet (1.5 m) thick in all quadrangles which contain the Lower Fort Union Coal Zone. Dips derived from plate 15 range from 11° to 15° in a northwesterly direction.

F1 Coal Bed

The partially burned F1 coal bed has been located in the extreme northern part of the quadrangle, lying approximately 65 feet (20.7 m) above the F2 or Red Rim coal bed. Coal thicknesses shown on plate 18 were projected from the quadrangle to the north (the southwest quarter of the Rawlins Peak 15-minute quadrangle) where the coal bed attains a maximum thickness of 28 feet (8.5 m) excluding 6 feet (1.8 m) of partings. The coal bed thins dramatically southward from the quadrangle boundary and was not encountered in a single coal test hole within this quadrangle. The bed dips at 13° to the northwest, as shown on plate 18.

E2 Coal Bed

Approximately 140 feet (42.6 m) of thin sandstones and shale separate the F2 coal bed and the overlying E2 coal bed. The E2 bed is commonly split by an intervening shale layer 7 to 21 feet (2.1 to 6.4 m) thick. Where found, the lower coal split is very thin and of little importance in this quadrangle, and therefore is not used in coal thickness measurements. The E2 name has been applied only to the upper split on plate 20. The E2 bed thickens locally to 9.2 feet (2.8 m), but data shows that much of the bed is less than 5 feet (1.5 m) in thickness. Thicknesses of 5 to 6 feet (1.5 to 1.8 m) were measured in the southwest quarter of the Rawlins Peak 15-minute quadrangle to the north, while local thickenings of up to 12 feet (3.7 m) were encountered in the southern portion of the Riner quadrangle to the west. Dips calculated from plate 21 vary between 7° and 14° to the northwest.

E1 (Olson Draw) Coal Bed

The E1 (Olson Draw) coal bed lies approximately 60 to 90 feet (18.3 to 27.4 m) above the E2 coal bed. The bed is named for its occurrence near Olson Draw in the southwestern corner of the Fillmore Ranch quadrangle (T. 18 N., R. 91 W.). The bed is usually very trashy, with shale partings occurring throughout the coal. Coal thicknesses shown on plate 24 are cumulative, excluding partings. Thin coal beds, less than 5 feet (1.5 m) thick and separated from the main coal body by more than 10 feet (3.0 m) of shale, are not included in cumulative coal thickness. A maximum coal thickness of 18 feet (5.5 m), excluding 6 feet (1.8 m) of partings, was recorded in sec. 23, T. 21 N., R. 91 W. To the north, in the southwest quarter of the Rawlins Peak 15-minute quadrangle, 33 feet (10.1 m) of coal, with 7 feet (2.1 m) of partings, was found in the only RMEC drill hole to encounter the E1 coal bed. In the Riner quadrangle to the west, E1 thicknesses are similar to those found in this quadrangle. Dips calculated from plate 25 vary from 8° to 14° to the northwest.

FU[2] Coal Bed

The FU]2] coal bed lies approximately 260 feet (79.2 m) above the E1 coal bed. The name used for this coal bed is not formal but is used for identification purposes on this quadrangle only. Thicknesses greater than 5 feet (1.5 m) were only encountered in portions of secs. 11 through 14, T. 20 N., R. 90 W., as shown on plate 4. The bed can be traced southwest beyond the quadrangle boundary, where it rarely exceeds 5 feet (1.5 m) in thickness. The average dip of the bed is approximately 12° toward the northwest.

B (Fillmore Ranch) Coal Bed

The B (Fillmore Ranch) bed is located, stratigraphically, in the upper portion of the Lower Fort Union Coal Zone, approximately 30 to 50 feet (9.1 to 15.2 m) above the FU[2] bed and about 300 feet (91.4 m) above the E1 (Olson Draw) coal bed. It is named for its occurrence near Fillmore Ranch in sec. 6, T. 18 N., R. 90 W. The bed reaches a maximum thickness of 10 feet (3.0 m) in sec. 11, T. 20 N., R. 90 W., in this quadrangle. The outcrop of the B bed can be traced north into the next quadrangle, but thicknesses are minor. To the southwest, the bed is usually thicker than 5 feet (1.5 m), and is a prominent member of the Lower Fort Union Coal Zone. The bed dips, on the average, 11° to the northwest.

Isolated Data Points

In instances where isolated measurements of coal beds thicker than 5 feet (1.5 m) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not applicable. 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 data points used in this quadrangle are listed below. 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
RMEC	sec. 1, T. 20 N., R. 90 W.	FU[2]	6.0 ft (1.8 m)
RMEC	sec. 7, T. 20 N., R. 90 W.	FU[1]	6.0 ft (1.8 m)
Davis Oil Co.	sec. 20, T. 20 N., R. 90 W.	A1[2]	6.0 ft (1.8 m)
Union Pacific Coal Co.	sec. 35, T. 20 N., R. 90 W.	A1[1]	5.4 ft (1.6 m)

COAL RESOURCES

Data from coal test holes drilled by RMEC, Union Pacific Coal Company, and the U.S. Geological Survey, as well as oil and gas well information and surface mapping by Edson (in press,b, 1977) and Barclay (1978), were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle. At the request of RMEC, coal-rock data for some of their drill holes have not been shown on plate 1 or on the derivitive maps. However, data from these holes have been used to prepare the derivitive maps. These data may be obtained by contacting RMEC.

Coal resources were calculated using data obtained from the coal isopach maps (plates 4, 7, 10, 14, 18, 20, 24, and 28). 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 isopached beds are shown on plates 6, 9, 13, 17, 23, 27, and 30, 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 isolated data points in this quadrangle. Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 76.18 million short tons (69.11 million metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface and underground mining methods are shown in tables 2 and 3. The source of each indexed data point shown data used on plate 1 is listed in table 4.

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 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 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 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 5, 8, 12, 16, 19, 22, 26, and 29. 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, including areas influenced 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 1,160,000 short tons (1,050,000 metric tons).

The coal development potential for surface mining methods (less than 200 feet or 61 meters of overburden) is shown on plate 31.

High development potential for surface mining exists in 87 percent of of sec. 24, T. 20 N., R. 90 W., and 75 percent and 50 percent of those portions of secs. 14 and 26, respectively, that lie within the quadrangle boundaries. In T. 20 N., R. 89 W., high development potential occupies 31 percent of secs. 4, 6, 22, and 28, 50 percent of secs. 8 and 14, and 25 percent of that part of sec. 12 that lies within the quadrangle. In T. 21 N., R. 89 W., 55 percent of that portion of sec. 34 that falls within quadrangle boundaries is rated high for development potential.

Low, medium, and unknown potentials have been assigned to the remainder of the Federal lands within the quadrangle, based on the aforementioned criteria.

Development Potential for Subsurface and In-Situ Mining Methods

The coal development potential for subsurface mining is shown on plate 32. 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 exceed 15°. Reserve Base tonnages for these areas (>15°) are listed on table 3 in the unknown potential category.

High development potential for conventional subsurface mining exists in all of secs. 12 and 14, 25 percent of sec. 18, 63 percent of sec. 24, and 25 percent of that portion of sec. 26 that falls within the quadrangle boundaries. In T. 20 N., R. 89 W., high development potential areas include 6 percent of sec. 4, 75 percent of secs. 6 and 22, 23 percent of secs. 8 and 20, 94 percent of sec. 14, 12 percent of sec. 18, and 50 percent of that part of sec. 12 that lies within the quadrangle.

All of that portion of sec. 34, T. 21 N., R. 89 W. that falls within quadrangle boundaries has been rated high for subsurface development potential. Moderate or unknown potentials have been assigned to the remainder of the Federal lands within the quadrangle. Tonnages for the unknown (subsurface) development potential for isolated data points totals 5,310,000 short tons (4,820,000 metric tons).

All Federal lands within the KRCRA in this quadrangle have been rated low for in-situ development potential because of the limited areal extent of the coal beds and the low Reserve Base tonnages known to be available for in-situ mining.

Table 1. Chemical analyses of coals in the northwest quarter of the Bridger Pass 15-minute quadrangle, Carbon County, Wyoming

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, SW¼, SE¼, sec. 5, T. 20 N., R. 89 W. (RMEC, RR-4)	G	A	15.04	29.45	42.07	13.44	0.43	--	--	--	--	--	9,213
		C	0.0	34.66	49.52	15.82	0.51	--	--	--	--	--	10,844
NW¼, NE¼, NE¼, sec. 13, T. 20 N., R. 90 W., (RMEC, RR-10	E2	A	19.48	31.52	41.88	7.12	0.35	--	--	--	--	--	9,294
		C	0.0	39.14	52.06	8.84	0.43	--	--	--	--	--	11,543
NW¼, NE¼, SE¼, sec. 13, T. 20 N., R. 90 W. (RMEC, RR-47)	E1	A	21.97	28.27	35.13	14.63	0.36	--	--	--	--	--	7,943
		C	0.0	36.23	45.02	18.75	0.46	--	--	--	--	--	10,180
NW¼, NE¼, sec. 5, T. 20 N., R. 89 W. (RMEC, RR-125)	F2	A	16.01	30.04	42.83	11.12	0.32	--	--	--	--	--	9,345
		C	0.0	35.77	50.99	13.24	0.38	--	--	--	--	--	11,126
NE¼, SW¼, sec. 6, T. 20 N., R. 88 W. (Ball, 1909, old Nebraska Mine)	Lance-Fox Hills	A	19.20	36.46	40.56	3.78	0.34	5.74	58.88	1.34	29.92	5,401	9,722
		B	17.30	37.32	41.51	3.87	0.35	5.61	60.27	1.37	28.53	5,528	9,951

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. Strippable coal Reserve Base data for Federal coal lands (in short tons) in the northwest quarter of the Bridger Pass 15-minute quadrangle, Carbon County, Wyoming

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Total
B (Fillmore Ranch)	3,030,000	960,000	1,320,000	5,310,000
FU{2}	160,000	150,000	360,000	670,000
E1	500,000	200,000	1,170,000	1,870,000
E2	200,000	210,000	420,000	830,000
F1	10,000	30,000	20,000	60,000
F2	2,410,000	880,000	1,100,000	4,390,000
G	1,980,000	1,390,000	1,770,000	5,140,000
H	980,000	640,000	1,720,000	3,340,000
B (La-FH)	200,000	100,000	290,000	590,000
C (Nebraska)	1,770,000	690,000	660,000	3,120,000
Total	11,240,000	5,250,000	8,830,000	25,320,000

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 northwest quarter of the Bridger Pass 15-minute quadrangle, Carbon County, Wyoming

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential*	Total
B (Fillmore Ranch)	3,250,000	---	---	---	3,250,000
FU{2}	430,000	---	---	---	430,000
E1	4,650,000	---	---	---	4,650,000
E2	2,370,000	---	---	---	2,370,000
F1	---	---	---	---	---
F2	10,180,000	---	---	---	10,180,000
G	5,490,000	---	---	---	5,490,000
H	2,810,000	---	---	---	2,810,000
B (La-FH)	---	---	---	330,000	330,000
C (Nebraska)	12,200,000	1,150,000	---	940,000	14,290,000
Total	41,380,000	1,150,000		1,270,000	43,800,000

* For beds dipping $>15^{o}$

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	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 2AS
2	Davis Oil Co.	Oil/gas well No. 1 Ram Canyon
3	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. CD 29
4	El Paso Natural Gas Co.	Oil/gas well No. WDH-31-1
5	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 2AS
6	U.S. Geological Survey (no date), unpublished table	Drill hole No. BP-D17
7	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 125
8	↓	Drill hole No. RR 143
9	↓	Drill hole No. RR 3
10	↓	Drill hole No. RR 126
11	↓	Drill hole No. RR 1
12	↓	Drill hole No. RR 155
13	↓	Drill hole No. RR 156
14	↓	Drill hole No. RR 2
15	↓	Drill hole No. RR 158
16	↓	Drill hole No. RR 157

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Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
17	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 159
18	↓	Drill hole No. RR 4
19	U.S. Geological Survey, (no date), unpublished table	Drill hole No. BP-D18
20	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 163
21	↓	Drill hole No. RR 7
22	↓	Drill hole No. RR 123
23	↓	Drill hole No. 1AS
24	↓	Drill hole No. RR 164
25	↓	Drill hole No. RR 165
26	↓	Drill hole No. RR 6
27	↓	Drill hole No. RR 35
28	↓	Drill hole No. RR 8
29	↓	Drill hole No. RR 167
30	↓	Drill hole No. RR 166
31	↓	Drill hole No. RR 5
32	↓	Drill hole No. RR 34
33	↓	Drill hole No. RR 168
34	↓	Drill hole No. RR 169
35	↓	Drill hole No. RR 22

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Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
36	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 124
37	↓	Drill hole No. RR 11
38	U.S. Geological Survey, (no date), unpublished table	Drill hole No. BP-D19
39	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. CD 9
40	↓	Drill hole No. CD 8
41	↓	Drill hole No. CD 28
42	↓	Drill hole No. 1AD
43	U.S. Geological Survey, (no date), unpublished table	Drill hole No. BP-D20
44	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 130
45	Davis Oil Co.	Oil/gas well No. 1 Mesa-Federal
46	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. CD 18
47	↓	Drill hole No. CD 21
48	↓	Drill hole No. CD 16
49	↓	Drill hole No. CD 20
50	↓	Drill hole No. CD 19
51	↓	Drill hole No. CD 12

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
52	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1AS
53		Drill hole No. CD 11
54		Drill hole No. CD 15
55		Drill hole No. CD 10
56		Drill hole No. CD 14
57		Drill hole No. CD 13
58		Drill hole No. 3AS
59		Drill hole No. 2AS
60		Drill hole No. CD 24
61		Drill hole No. 115
62		Drill hole No. CD 23
63		Drill hole No. CD 22
64		Drill hole No. CD 26
65		Drill hole No. CD 25
66		Drill hole No. 1AS
67		Drill hole No. 2AS
68		Drill hole No. RR 160
69		Drill hole No. RR 161
70		Drill hole No. RR 162
71		Drill hole No. RR 25

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
72	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 64
73	↓	Drill hole No. RR 170
74	U.S. Geological Survey, (no date), unpublished table	Drill hole No. BP-D21
75	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 66
76	↓	Drill hole No. RR 10
77		Drill hole No. RR 9
78		Drill hole No. RR 172
79		Drill hole No. RR 171
80		Drill hole No. RR 26
81		Drill hole No. RR 24
82		Drill hole No. RR 13
83		Drill hole No. RR 19
84		Drill hole No. RR 12
85		Drill hole No. RR 15
86		Drill hole No. RR 173
87		Drill hole No. RR 174
88		Drill hole No. RR 23
89		Drill hole No. RR 14
90		Drill hole No. RR 18

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
91	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 175
92	↓	Drill hole No. RR 17
93	↓	Drill hole No. RR 21
94	↓	Drill hole No. RR 16
95	↓	Drill hole No. RR 49
96	↓	Drill hole No. RR 50
97	↓	Drill hole No. RR 29
98	↓	Drill hole No. RR 51
99	↓	Drill hole No. RR 48
100	↓	Drill hole No. RR 28
101	↓	Drill hole No. RR 47
102	↓	Drill hole No. RR 46
103	↓	Drill hole No. RR 27
104	↓	Drill hole No. RR 45
105	↓	Drill hole No. RR 176
106	U.S. Geological Survey, (no date), unpublished table	Drill hole No. BP-D23
107	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 44

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Table 4. -- Concluded

Plate 1 Index Number	Source	Data Base
108	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 43
109	U.S. Geological Survey, (no date), unpublished table	Drill hole No. BP-D24
110	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. RR 33
111	↓	Drill hole No. RR 154
112		Drill hole No. RR 142
113		Drill hole No. RR 141

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SELECTED 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 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., (in press), Preliminary geologic map of the northeastern part of the Rawlins (Little Snake River) KRCRA: U.S. Geological Survey Conservation Division, unpublished map, scale - 1:63,360.

______ 1978, Preliminary geologic map of the southeast part of the northwest quarter of the Bridger Pass 15-minute quadrangle, Carbon County, Wyoming: U.S. Geological Survey Conservation Division, unpublished map, scale 1:24,000.

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 Resource Area, Carbon and Sweetwater Counties, Wyoming, January 31, 1978: U.S. Geological Survey Conservation Division, unpublished report, 15 p.

Barclay, C. S. V., and Shoaff, L. A., 1978, Lithologic and geophysical logs of holes drilled in the Savery quadrangle and in the southeastern part of the Baggs quadrangle, Carbon County, Wyoming during 1977: U.S. Geological Survey Open-file report 78-660.

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 map, sheets 1 and 2, scale 1:63,360.

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

Selected References--Continued

______ 1977, Preliminary geologic map of the northwest part of the northwest quarter of the Bridger Pass 15-minute quadrangle, Carbon County, Wyoming: U.S. Geological Survey Conservation Division, unpublished map, 1:24,000.

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.

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

Rocky Mountain Energy Company, (no date), Unpublished drill hole data from the Red Rim and Continental Divide projects and the Union Pacific coal inventory of 1971-1973.

Smith, E. E., 1909, The eastern part of the Great Divide Basin coal field, Wyoming, in Coal fields of Wyoming: U.S. Geological Survey Bulletin 341-B, p. 220-242.

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.

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.

______ (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.

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

______ 1961, Uppermost Cretaceous rocks in central and southern Wyoming and northwest Colorado, in Symposium on the Late Cretaceous rocks of Wyoming and adjacent areas, Wyoming Geological Association Guidebook, 16th Annual Field Conference, 1961: p. 17-28.

Selected References--Continued

Welder, G. E., and McGreevy, L. J., 1966, Ground-water reconnaissance of the Great Divide and Washakie Basins and some adjacent areas, southwestern Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA-219.

Wyoming Natural Resources Board, 1966, Wyoming weather facts: Cheyenne, p. 14-15.