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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE BRIDGER QUADRANGLE, UINTA COUNTY, WYOMING

[Report includes 11 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

By

DAMES & MOORE

DENVER, COLORADO

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Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Bridger quadrangle, Uinta County, Wyoming. This report was compiled to support the land planning work of the Bureau of Land Management 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 Published and unpublished public information available through April, 1978, was used as the data base for this study.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 Bridger quadrangle is located in the north-central part of Uinta County, Wyoming, approximately 20 airline miles (32 km) northeast of the town of Evanston and 4 airline miles (6.4 km) west of the town of Carter, Wyoming. The quadrangle is unpopulated.

Accessibility

U.S. Highway 189, a paved heavy-duty road, crosses north-south along the northwestern edge of the quadrangle connecting the town of Kemmerer, located approximately 23 miles (37 km) to the north of the quadrangle, with Interstate Highway 80, approximately 11 miles (18 km) to the southwest. The Carter Cutoff, an improved light-duty road, crosses the northeastern corner of the quadrangle connecting the town of Carter to the east of the quadrangle with U.S. Highway 189 to the north. A second improved light-duty road parallels the Union Pacific Railroad and Big Muddy Creek southwesterly through the southern half of the quadrangle. Numerous unimproved dirt roads and trails provide access through the remainder of the quadrangle (U.S. Bureau of Land Management, 1971; Wyoming State Highway Commission, 1978).

The main east-west line of the Union Pacific Railroad passes through the southern half of the quadrangle and provides railway service across southern Wyoming connecting Ogden, Utah, to the west with Omaha, Nebraska, to the east. Bridger, located near the southern edge of the quadrangle, is a loading station on the railroad (U.S. Bureau of Land Management, 1978).

Physiography

The Bridger quadrangle lies on the western edge of the Green River Basin and on the southeastern edge of the Wyoming Overthrust Belt. The landscape in the quadrangle is characterized by a narrow north-south trending ridge, The Hogsback (Oyster Ridge), along the western edge of the quadrangle, bordered on the west by the flat-lying Cumberland Flats and on the east by a rolling or undulatating topography cut by numerous gulches and ravines. Altitudes in the quadrangle range from less than 6,540 feet (1,993 m) on Big Muddy Creek on the eastern edge of the quadrangle to 7,443 feet (2,269 m) on The Hogsback (Oyster Ridge) in the northwestern part of the quadrangle.

Big Muddy Creek and its tributaries drain the quadrangle east of The Hogsback (Oyster Ridge), flowing easterly into the Blacks Fork and the Green River east of the quadrangle boundary. Albert Creek drains the quadrangle west of The Hogsback (Oyster Ridge). It flows northeasterly into Little Muddy Creek, also a tributary of Blacks Fork and the Green River. All streams in the quadrangle, with the exception of Big Muddy Creek which flows year-round, are intermittent and flow mainly in response to snowmelt in the spring (U.S. Bureau of Land Management, 1971 and 1978; Wyoming State Highway Commission, 1978).

Climate and Vegetation

The climate of southwestern 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 averages approximately 10 inches (25 cm) and is fairly evenly distributed throughout the year (Wyoming Natural Resources Board, 1966).

The average annual temperature of the area is 39° F (4° C). The temperature during January averages 17° F (-8° C) and typically ranges from 4° F (-16° C) to 30° F (-1° C). During July, the average temperature is 62° F (17° C), and the temperature typically ranges from 43° F (6° C) to 82° F (28° C) (Wyoming Natural Resources Board, 1966; U.S. Bureau of Land Management, 1978).

Winds are usually from the west and west-southwest with an average annual velocity of approximately 15 miles per hour (24 km per hr) (U.S. Bureau of Land Management, 1978).

Principal types of vegetation in the quadrangle include grasses, sagebrush, mountain mahogany, saltbush, greasewood, rabbitbrush, and juniper (U.S. Bureau of Land Management, 1978).

Land Status

The Bridger quadrangle lies in the east-central part of the Kemmerer Known Recoverable Coal Resources Area (KRCRA). Only the western and northwestern parts of the quadrangle, about 17 percent of the quadrangle's total area, lie within the KRCRA boundary. The Federal government owns the coal rights for approximately half of this area, as shown on plate 2. No outstanding Federal coal leases, prospecting permits, or licenses occur within the quadrangle.

GENERAL GEOLOGY

Previous Work

Veatch (1907) mapped the geology and economic resources of a large part of Uinta and Lincoln counties in southwestern Wyoming, including the Bridger quadrangle. Cobban and Reeside described the stratigraphy of the coal-bearing Frontier Formation in the Kemmerer area in 1952. Hale (1960) described the stratigraphy of the Frontier Formation in southwestern Wyoming and Utah. Townsend described the Kemmerer coal field in 1960. Lawrence (1963) described the Wasatch and Green River Formations in the Cumberland Gap area. Oriel and Tracey (1970) described the stratigraphy of the Evanston and Wasatch Formations present in the Kemmerer area. Glass (1975) reported coal analyses and measured sections of Adaville coals from the Elkol and Sorensen mines located near the town of Elkol. The geology of the Kemmerer and Sage 15-minute quadrangles was mapped by Rubey and others (1975). Roehler and others (1977) described the geology and coal resources of the Hams Fork coal region including the Kemmerer coal field. Myers (1977) conducted a detailed study of the stratigraphy of the Frontier Formation in the Kemmerer area. Glass (1977) described the coal-bearing formations and coal beds present in the Hams Fork coal region. Schroeder mapped the geology and coal resources of the adjacent Meadow Draw (1976a), Ragan (1976b), and Elkol SW (1977) quadrangles. Schroeder and Lunceford mapped the surface geology of the Cumberland Gap (1976) and Bridger (1977) quadrangles. Unpublished data from Rocky Mountain Energy Company (RMEC) provided coal thickness information.

Stratigraphy

The formations cropping out in the Bridger quadrangle range in age from Early Cretaceous to Eocene. The Frontier Formation, trending north-northeast through the quadrangle, is coal-bearing.

The Bear River Formation of Early Cretaceous age is exposed in the western half of the quadrangle. It consists of interbedded claystone, fine-grained sandstone, and fossiliferous limestone (Rubey and others, 1975; Schroeder and Lunceford, 1977).

The Aspen Shale of latest Early Cretaceous age conformably overlies the Bear River Formation and is composed of dark-gray shale containing a few beds of gray sandstone and white to light-gray porcelanite. The upper formational contact is placed at the top of the highest prominent porcelanite bed. The Aspen Shale is exposed in the western half of the quadrangle. It is approximately 825 feet (251 m) thick where measured in the southeast quarter of the Kemmerer 15-minute quadrangle to the north (Rubey and others, 1975; Schroeder and Lunceford, 1977).

The Frontier Formation of early Late Cretaceous age crops out near the western edge of the quadrangle where it conformably overlies the Aspen Shale. Schroeder and Lunceford (1977) have divided the formation into two mappable units, each approximately 960 feet (293 m) thick. The lower unit consists mainly of sandstone, siltstone, mudstone, carbonaceous shale, minor limestone, and coal (Spring Valley coal zone). The upper unit contains sandstone, siltstone, shale and, near the top, the Kemmerer coal zone. This unit also contains the Oyster Ridge Sandstone Member, a ridge-forming sandstone that is characterized by the presence of *Ostrea soleniscus*, a long, slender oyster (Bozzuto, 1977). This member is approximately 135 feet (41 m) thick in the Cumberland Gap quadrangle to the north (Cobban and Reeside, 1952).

The Frontier Formation is overlain by the Hilliard Shale of early Late Cretaceous age and consists of a very thick sequence of dark-gray shale containing minor glauconitic sandstone beds (Cobban and Reeside, 1952). The formation is present in the northwestern corner of the quadrangle but is covered by Quaternary deposits (Schroeder and Lunceford, 1977). The formation ranges from 5,500 to 6,600 feet (1,676 to 2,012 m) in thickness (Rubey and others, 1975; Bozzuto, 1977).

The eastern half and much of the southwestern quarter of the Bridger quadrangle are covered by undifferentiated Eocene-age rocks of the Wasatch and Green River Formations. These formations intertongue with and unconformably overlie Cretaceous and older rocks.

Holocene deposits of alluvium cover Albert Creek in the northwestern part of the quadrangle. Landslides are especially common in the upper unit of the Frontier Formation where mapped by Schroeder and Lunceford (1977).

The Upper Cretaceous formations in the Elkol quadrangle indicate the transgressons and regressions of a broad, shallow north-south seaway that extended across central North America. These formations accumulated near the western edge of the Cretaceous sea and reflect the location of the shoreline (Weimer, 1960 and 1961).

The interbedded claystones, sandstones, and limestones of the Bear River Formation were deposited in a predominantly marine environment. According to Roehler and others (1977), the formation thickens to the north, where it was deposited in mixed fluvial, paludal, and marine environments.

Deposition of the Aspen Shale marked a westward or landward movement of the sea. According to Hale (1960), the marine shales and sandstones of the Aspen Shale were deposited in water depths up to 120 feet (37 m).

The Frontier Formation sediments were deposited during two major transgressions and regressions of the sea. The coal beds in the upper and lower parts of the formation were deposited in coastal swamps during periods when the sea retreated eastward. The Oyster Ridge Sandstone Member is a littoral or beach deposit marking the retreat of the Cretaceous sea from the area (Hale, 1960; Myers, 1977; Roehler and others, 1977).

The marine sequence of shales and sandstones of the Hilliard Shale were deposited during a transgression of the Cretaceous sea and indicate the fluctuations of the shoreline (Roehler and others, 1977).

The undifferentiated Wasatch and Green River Formations represent a complex variety of continental deposition. The Wasatch Formation was deposited mainly in fluvial (floodplain) environments while the Green River Formation was deposited primarily in lacustrine environments (Lawrence, 1963; Oriel and Tracey, 1970).

Structure

The Bridger quadrangle is located on the southeastern edge of the structurally complex Wyoming Overthrust Belt. Folded Paleozoic and Mesozoic rocks are thrust eastward over folded older-Cretaceous rocks with younger Cretaceous and Tertiary rocks resting unconformably on top of the older rocks. Coal-bearing strata crop out in eroded limbs of folds as long north-south trending belts bounded on the west by major thrust faults (Roehler and others, 1977).

In the Bridger quadrangle, the coal-bearing Frontier Formation crops out on the eastern limb of a major structural feature of the area, the Lazeart syncline. The axis of this asymmetrical fold lies a few miles west of the quadrangle. Coal-bearing strata in the quadrangle generally dip 22° to 36° to the west and northwest (Schroeder and Lunceford, 1977).

Three minor faults have been mapped in the western half of the quadrangle (plate 1), none of which offset mapped coal outcrop traces (Schroeder and Lunceford, 1977).

COAL GEOLOGY

The Frontier Formation in the Bridger quadrangle contains two major coal zones. The Spring Valley coal zone is located approximately 400 feet (122 m) above the base of the formation and the Kemmerer coal zone occurs near the top of the formation. Both coal zones crop out in the western half of the quadrangle, trending northeast-southwest.

Chemical analyses of coal.--Representative analyses of coal from the Kemmerer coal zone in the southeast quarter of the Kemmerer 15-minute quadrangle, and coal from the Spring Valley coal zone in the Ragan quadrangle are shown in table 1. In general, coals in the Spring Valley and the Kemmerer coal zones rank as high-volatile B bituminous. The coals are ranked on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Coal beds identified with bracketed numbers are not formally named, but have been given bracketed numbers for identification purposes in this quadrangle only.

Spring Valley Coal Zone

The Spring Valley coal zone, or Carter Coal Group (Veatch, 1907), contains several coal beds of variable thickness. In the Bridger quadrangle, measured coal beds average between 1 and 3 feet (0.3 and 0.9 m) thick. Spring Valley coal beds are thicker in the Kemmerer coal field (T. 20-19 N., R. 166 W.) and near Spring Valley Station (T. 15 N., R. 118 W.), where underground mines exploited Spring Valley coals in both areas during the late 1800's and early 1900's (Glass, 1977).

Spring Valley [1] Coal Bed

On the basis of information from this quadrangle and the adjacent Meadow Draw quadrangle to the west, a Spring Valley coal bed, informally identified as the Spring Valley [1] coal bed, has been isopached in the southwestern part of the Bridger quadrangle (plate 4). This coal bed is 4.5 feet (1.4 m) thick where measured in sec. 34, T. 17 N., R. 117 W., thickening to the southwest. It is approximately 7 feet (2.1 m) thick where measured in the Meadow Draw quadrangle, excluding rock partings 1 to 3 feet (0.3 to 0.9 m) thick.

Kemmerer Coal Zone

The Kemmerer coal zone overlies and is separated from the Oyster Ridge Sandstone Member by 220 to 280 feet (67 to 85 m) of mudstone, sandstone, and siltstone. This group of coal beds has been traced for more than 60 miles (97 km) in the Kemmerer coal field (Glass, 1977).

Cumberland Seam

The thickest and most persistent coal bed in the Kemmerer zone is the Cumberland seam (RMEC, no date). This coal bed is also called the Kemmerer No. 1 or Frontier No. 1 coal bed (Glass, 1977), or Main Kemmerer (Veatch, 1907). This coal bed crops out along the western side of Oyster Ridge and has a maximum measured thickness of 8.5 feet (2.6 m) in this quadrangle. In the Meadow Draw quadrangle, the coal bed is 11.7 feet (3.6 m) thick where measured in an abandoned subsurface mine in sec. 34, T. 17 N., R. 117 W. To the north in the adjacent Cumberland Gap quadrangle, the Cumberland coal bed (seam) has been mined extensively at the now abandoned Cumberland Mine Nos. 1 and 2. Coal thicknesses at these subsurface mines range from approximately 5 to 20 feet (1.5 to 6.1 m), with minor rock partings.

Kemmerer [1] Coal Bed

A coal bed encountered approximately 15 to 35 feet (4.6 to 10.7 m) below the Cumberland seam has been informally identified as the Kemmerer [1] coal bed. It may correlate with the "A" seam or Lower Kemmerer bed developed at the Frontier and Diamondville mines in the Kemmerer 15-minute quadrangle (Hunter, 1950). The Kemmerer [1] coal bed is thin, thickening to only 5.6 feet (1.7 m) in sec. 22, T. 17 N., R. 117 W. (plate 7).

COAL RESOURCES

Information from coal test holes drilled by RMEC and geologic mapping by Veatch (1907) and Schroeder and Lunceford (1977) were used to construct maps of the coal beds in the Bridger 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 derivative maps. However, data from these drill holes may have been used to construct the derivative maps. These data may be obtained by contacting RMEC. The source of each indexed data point shown on plate 1 is listed in table 4.

Coal resources were calculated using data obtained from the coal isopach maps (plates 4 and 7). The coal bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed, and by a conversion factor of 1,800 short tons of coal per acre-foot (13,238 metric tons per hectare-meter) for bituminous coal, yields the coal resources in short tons for each isopached coal bed. Reserve Base and Reserve tonnages for the isopached beds are shown on plates 6 and 9, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Coal beds of Reserve Base thickness (5 feet or 1.5 meters) or greater that lie less than 3,000 feet (914 m) below the ground surface are included. These criteria differ 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 minimum thickness of 28 inches (70 cm) and a maximum depth of 1,000 feet (305 m) for bituminous coal.

Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 2.62 million short tons (2.38 million metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface and in-situ mining methods are listed in tables 2 and 3.

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

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn so as to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-ha) parcels have been used to show the limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-ha) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 ha) within a parcel meet criteria for a high development potential, 25 acres (10 ha) a moderate development potential, and 10 acres (4 ha) a low development potential, then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Surface Mining Methods

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

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

where MR = mining ratio

t_o = thickness of overburden in feet

t_c = thickness of coal in feet

rf = recovery factor (85 percent for this quadrangle)

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

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

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

Areas where the coal data is absent or extremely limited between the 200-foot (61-m) overburden line and the outcrop are assigned unknown development potentials for surface mining methods. This applies to areas where coal beds 5 feet (1.5 m) or more thick are not known, but may occur.

The coal development potential for surface mining methods is shown on plate 10. Of the Federal land areas having a known development potential for surface mining methods, 60 percent are rated high, 13 percent are rated moderate, and 27 percent are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for surface mining methods.

Development Potential for Subsurface and In-Situ Mining Methods

Areas ordinarily considered to have a development potential for conventional subsurface mining methods include those areas where the coal beds of Reserve Base thickness are between 200 feet (61 m) and 3,000 feet (914 m) below the ground surface and have dips less than 15°. Areas of high, moderate, and low development potential for conventional subsurface mining are defined by the U.S. Geological Survey 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. Unknown development potentials are assigned to those areas where coal data is absent or extremely limited.

All Federal lands within the KRCRA boundary in this quadrangle have been classified as having an unknown development potential for conventional subsurface mining methods because the coal beds have dips greater than 15°.

Unfaulted coal beds lying between 200 and 3,000 feet (61 and 914 m) below the ground surface, dipping greater than 15°, are considered to have a development potential for in-situ mining methods. Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 35° and 90° with a minimum Reserve Base of 50 million short tons (45.4 million metric tons) for bituminous coal and 70 million short tons (63.5 million metric tons) for subbituminous coal have a moderate potential for in-situ development; coal beds dipping from 15° to 35°, regardless of tonnage, and coal beds dipping from 35° to 90° with less than 50 million short tons (45.4 million metric tons) of coal have a low development potential for in-situ mining methods. Coal lying between the 200-foot (61-m) overburden line and the outcrop is not included in the total coal tonnages available as it is needed for cover and containment in the in-situ process.

Because the dips of the coal bed-bearing strata range from 22° to 36° and the total Reserve Base tonnage available for in-situ mining is less than 50 million short tons (only 970,000 short tons or 880,000 metric tons), all Federal land areas within the KRCRA boundary having known development potential for in-situ mining methods have been rated low as shown on plate 11. The remaining Federal lands are classified as having unknown development potential for in-situ mining methods.

Table 1. -- Chemical analyses of coals in the Bridger quadrangle, Uinta 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, NE¼, sec. 12, T. 21 N., R. 116 W., Kemmerer No. 1 Mine (U.S. Bureau of Mines, 1931)	Kemmerer No. 1	A	5.9	37.6	49.0	7.5	1.4	-	-	-	-	-	12,370
		C	0.0	39.9	52.1	8.0	1.5	-	-	-	-	-	13,140
NW¼, sec. 12, T. 15 N., R. 118 W., Richardson Mine (U.S. Bureau of Mines, 1931)	Spring Valley	A	6.9	35.6	43.8	13.7	0.9	-	-	-	-	-	11,350
		C	0.0	38.2	47.1	14.7	1.0	-	-	-	-	-	12,180

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

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

Table 2. Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Bridger quadrangle, Uinta County, Wyoming.

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Cumberland Seam	460,000	360,000	540,000	1,360,000
Kemmerer {1}	30,000	30,000	60,000	120,000
Spring Valley {1}	40,000	30,000	100,000	170,000
Totals	530,000	420,000	800,000	1,650,000

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

Table 3. Coal Reserve Base data for in-situ mining methods for Federal coal lands (in short tons) in the Bridger quadrangle, Uinta County, Wyoming.

Coal Bed	Moderate Development Potential	Low Development Potential	Total
Cumberland Seam	-0-	930,000	930,000
Kemmerer {1}	-0-	-0-	-0-
Spring Valley {1}	-0-	40,000	40,000
Totals	-0-	970,000	970,000

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	William G. Helis Estate	Oil/gas well No. 3-1 Bridger Station
2	Amoco Production Co.	Oil/gas well No. 1 Champlin-552-AMOCO-A
3	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1, Line A
4	Schroeder and Lunceford, 1977, U.S. Geological Survey, unpublished data	Measured Section No. 5
5	↓	Measured Section No. 10
6	↓	Measured Section No. 4
7	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1, Line B
8	Schroeder and Lunceford, 1977, U.S. Geological Survey, unpublished data	Measured Section No. 3
9	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 4, Line A
10	↓	Drill hole No. 5, Line A
11	↓	Drill hole No. 2, Line A
12	↓	Drill hole No. 1, Line A

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
13	Schroeder and Lunceford, 1977, U.S. Geological Survey, unpublished data	Measured Section No. 9
14	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 1, Line A
15	↓	Drill hole No. 1, Line A
16	Schroeder and Lunceford, 1977, U.S. Geological Survey, unpublished data	Measured Section No. 1
17	↓	Measured Section No. 2
18	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 4, Line A
19	↓	Drill hole No. 3, Line A
20	↓	Drill hole No. 2, Line A
21	↓	Drill hole No. 1, Line A
22	Veatch, 1907, U.S. Geological Survey Professional Paper 56, p. 128	Measured Section No. 112
23	Schroeder and Lunceford, 1977, U.S. Geological Survey, unpublished data	Measured Section No. 7

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
24	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 3, Line A
25	↓	Drill hole No. 1, Line A
26	↓	Drill hole No. 2, Line A
27	Veatch, 1907, U.S. Geological Survey Professional Paper 56, p. 128	Measured Section No. 113
28	Arrowhead Exploration Co.	Oil/gas well No. 1 Scully Gap-Gov't
29	Rocky Mountain Energy Co., unpublished data	Drill hole No.4 Line A
30	Schroeder and Lunceford, 1977, U.S. Geological Survey, unpublished data	Measured Section No. 6
31	Rocky Mountain Energy Co., (no date), unpublished data	Drill hole No. 3 Line A
32	↓	Drill hole No. 1 Line A
33	↓	Drill hole No. 2 Line A

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