Text to accompany:

Open-File Report 79-610

1979

COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE GALLEGOS TRADING POST QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO

[Report includes 12 plates]

by

Dames & Moore

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GALLEGOS TRADING POST 7 1/2-MINUTE QUADRANGLE

INTRODUCTION

Purpose

This text is to be used in conjunction with the Coal Resource Occurrence (CRO) Maps and Coal Development Potential (CDP) Maps of the Gallegos Trading Post quadrangle, San Juan County, New Mexico. These maps were compiled to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) of the western United States. The work has been performed under contract with the Conservation Division of the U.S. Geological Survey (Contract No. 14-08-0001-17172).

The resource information gathered in this program is in response to the Federal Coal Leasing Amendments Act of 1976 and is a part of the U.S. Geological Survey's coal program. The information provides basic data on coal resources for land-use planning purposes by the Bureau of Land Management, state and local governments, and the public.

Location

The Gallegos Trading Post 7 1/2-minute quadrangle is located in central San Juan County, New Mexico. The area is approximately 10 miles (16 km) southeast of Farmington and 78 miles (126 km) northeast of Gallup, New Mexico.

Accessibility

The area is accessible by State Route 44 which crosses the northeastern corner of the quadrangle and joins State Route 17 at Bloomfield, 7 miles (11 km) to the north. Several light-duty roads intersect at Gallegos Trading Post near the western boundary of the area. Unimproved dirt roads diverge from the light-duty roads to provide access to the more remote regions. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 78 miles (126 km) to the southwest at Gallup, New Mexico, which connects Gallup with Grants and Albuquerque to the east.

Physiography

The quadrangle is located in the Central Basin area (Kelley, 1950) of the San Juan Basin, a structural depression in the Colorado Plateau physiographic province. Total relief in the quadrangle is 860 ft (262 m), with elevations which range from 5,570 ft (1,698 m) in an unnamed stream bottom near the northeast corner up to 6,430 ft (1,960 m) in the southwestern corner. A major part of the area forms a broad, southwesterly-sloping plain moderately dissected by intermittent streams. The northeastern corner is deeply dissected by streams incised up to 500 ft (152 m). In the southwest, a northwest-trending cuesta escarpment is exposed. Drainage into Gallegos Canyon has dissected the dip-slope of the cuesta and, with few exceptions, the tributary drainage of the area converges in Gallegos Canyon.

Climate

The climate of the San Juan Basin is arid to semi-arid. Annual precipitation is usually less than 10 inches (25 cm), with slight variations across the basin due to elevational differences. Rainfall is rare in the early summer and winter; most precipitation is received in July and August as intense afternoon thundershowers. Annual temperatures in the basin range from below 0°F (-18°C) to above 100°F (38°C). Snowfall may occur from November to April with an average of 18 inches (46 cm) in the southwestern part of the basin.

Land Status

The quadrangle is in the west-central portion of the San Juan Basin Known Recoverable Coal Resource Area, and the Federal Government owns the coal rights to the KRCRA land within the quadrangle as shown on Plate 2 of the Coal Resource Occurrence Maps. No Federal coal leases occur within the quadrangle.

GENERAL GEOLOGY

Previous Work

Reeside (1924) mapped the surficial geology of the area as part of a study of the Upper Cretaceous and Tertiary Formations of the San Juan

Basin. More recently, Fassett and Hinds (1971) made subsurface interpretations of the Fruitland Formation coals as part of a larger San Juan Basin coal study.

Geologic History

The San Juan Basin, an area of classic transgressive and regressive sedimentation, provided the ideal environment for formation of coals during Late Cretaceous time. At that time a shallow epeiric sea, which trended northwest-southeast, was northeast of the basin. The sea transgressed southwesterly into the basin area and regressed northeasterly numerous times; consequently, sediments from varying environments were deposited across the basin. Noncarbonaceous terrestrial deposition predominated during Paleocene and Eocene time.

After its first basin-wide retreat, the Late Cretaceous sea reversed the direction of movement. As a result, the transgressive sequence of paludal Menefee Formation, nearshore Cliff House Sandstone, and marine Lewis Shale was deposited in the quadrangle. Swamps (Menefee) formed southwest (shoreward) of the transgressing beaches (Cliff House). Organic matter deposited in these swamps ultimately formed the coal beds in the Menefee Formation. A thin sand (Cliff House Sandstone) was deposited over the Menefee Formation. Subsequently, several hundred feet of beach sands of the La Ventana Tongue (Cliff House Sandstone) were deposited over the basal sand.

Onlap continued as the sea moved southwestward across the basin area. The marine facies which developed northeast of the strandline as it moved to the southwest is the Lewis Shale. This thick sequence which thins to the southwest, overlies the La Ventana Tongue and marks the last advance of the Late Cretaceous sea.

The first depositional evidence of the final retreat of the Late Cretaceous sea is the nearshore regressive Pictured Cliffs Sandstone. Southwest (shoreward) of the beach deposits, swamps, which were dissected by streams, accumulated organic matter which became coals of the Fruitland Formation. Deposition of organic material was influenced by the strandline as shown by both the continuity of the coal beds parallel to the northwest-southeast strandline and their discontinuity perpendicular to it to the northeast. The less continuous Fruitland coals appear to be noncorrelative, but are lithostratigraphically equivalent in terms of their relative position within the Fruitland Formation.

The brackish-water swamp environment of the Fruitland moved farther to the northeast as the regression continued in that direction. Terrestrial freshwater sediments covered the quadrangle as indicated by the lacustrine, channel, and floodplain deposits of the Kirtland Shale. This sequence of events is evidenced by both an upward decrease in occurrence and thickness of Fruitland coals and a gradational change to noncarbonaceous deposits of the Kirtland. Continuous deposition during Late Cretaceous time ended with the Kirtland. The sea then retreated beyond the limits of the quadrangle area, and modern basin structure began to develop. An erosional unconformity developed in a relatively short time as part of the Cretaceous Kirtland Shale was removed.

Terrestrial deposition resumed in the Paleocene as represented by the Ojo Alamo Sandstone and the overlying Nacimiento Formation. Alluvial plain and floodplain deposits of the Ojo Alamo were followed by the thick, lithologically varied floodplain deposits of the Nacimiento during continuous nonmarine deposition (Powell, 1973). The Nacimiento was later exposed to erosion.

The Eocene San Jose Formation was subsequently deposited over the Nacimiento erosional surface, reflecting various nonmarine environments which developed across the basin. Deposition and structural deformation of the basin then ceased, and the warped strata of the San Juan Basin have been exposed to erosional processes to the present time. A significant amount of erosion has occurred, as indicated by the removal of the San Jose Formation and some of the Nacimiento Formation from the area.

Stratigraphy

The formations studied in this quadrangle range from Late Cretaceous to Paleocene in age. They are, in order from oldest to youngest: the Menefee Formation and Cliff House Sandstone (two of the three formations of the Mesaverde Group); Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, Ojo Alamo Sandstone, and Nacimiento Formation. A composite columnar section on CRO Plate 3 illustrates the stratigraphic relationships of these formations and is accompanied by litholigic descriptions of the individual formations.

The oldest coal-bearing formation in the quadrangle is the Menefee Formation of the Mesaverde Group. In previous studies the Menefee has been divided into the Cleary Coal Member, the barren Allison Member, and an unnamed upper coal-bearing member (Beaumont and others, 1956). These three members were grouped together as undifferentiated Menefee Formation for the purposes of this report only. They were not differentiated due to the difficulty and inaccuracy in determining a consistent division between them on geophysical logs.

The Menefee Formation consists primarily of gray carbonaceous shale with local plant fossils and sandy stringers, interbedded thin sandstone, and lenticular coal beds. The formation has a total thickness of approximately 800 to 900 ft (243-290 m) in this area. Due to the regional dip of about 1° to the northeast, the Menefee Formation is more than 3,000 ft (914 m) deep (the overburden study limit) in all but the southwestern part of the quadrangle. In the southwestern corner of the area (in drill hole 5, sec. 3, T. 26 N., R. 12 W.), 883 ft (269 m) of the 920 ft (280 m) of the Menefee Formation have more than 3,000 ft (914 m) of overburden.

The Cliff House Sandstone sequence conformably overlies the Menefee Formation. The thin, basal sand member referred to as "the Cliff House Sandstone" by Fassett (1977) correlates with the thin, undifferentiated Cliff House Sandstone to the northeast. It is about 60 ft (18 m) thick and consists of light gray sandstone and thin, interbedded shale. Overlying the basal member is the La Ventana Tongue. This member, present in the southern part of the area, is a 675-ft (206-m) thick sandstone sequence composed primarily of light gray, thinly-bedded, glauconitic and kaolinitic sandstone, with interbedded gray shale containing plant fossils and sandy stringers and interbedded gray siltstone, which are more common in the lower portion.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is comprised predominantly of gray fossiliferous shale with sandy stringers and siderite nodules with interbedded gray, calcareous siltstone. The Lewis averages 600 ft (183 m) in thickness throughout the quadrangle. The upper contact is gradational with the overlying Pictured Cliffs Sandstone and, therefore, a distinct contact is difficult to establish.

The Pictured Cliffs Sandstone consists of about 110 ft (34 m) of cream to light gray, kaolinitic sandstone with traces of glauconite and interbedded shale near the base of the formation where it grades into the Lewis. The upper contact is more sharply defined than the basal contact. Although intertonguing with the overlying Fruitland Formation results in minor variations in the formation top, the Pictured Cliffs Sandstone is fairly consistent throughout the basin. The authors have used the consistency and distinctive character of the formation on geophysical logs to designate the top of the Pictured Cliffs as a lithologic datum for correlation of Fruitland Formation coals.

Conformably overlying the Pictured Cliffs Sandstone is the Fruitland Formation, the major coal-bearing unit in the quadrangle. It consists of an average of 270 ft (82 m) of gray, carbonaceous shale, interbedded gray siltstone, and coal beds of varying thicknesses. The thickest and most continuous coal beds occur near the base of the formation, while discontinuous and lenticular coal beds are characteristic of the upper portion. The upper contact is gradational from nonmarine lower coastal plain deposits of the Fruitland to upper coastal or alluvial plain deposits of the Kirtland Shale (Molenaar, 1977). Many authors have used various criteria in establishing the upper contact, but, in general, for the purposes of this report the uppermost coal in the Fruitland Formation was used (after Fassett and Hinds, 1971).

The freshwater deposits of the Kirtland Shale are the youngest Cretaceous strata in the San Juan Basin. They average 775 ft (236 m) in thickness and consist of gray shale with local plant fossils and interbedded white to cream, friable, slightly kaolinitic sandstone. The Kirtland Shale has previously been divided into several members by various authors; however, for the purposes of this report the individual members were not differentiated.

Unconformably overlying the Upper Cretaceous strata is the Paleocene Ojo Alamo Sandstone. It consists primarily of about 100 ft (30 m) of white to cream, coarse-grained to conglomeratic sandstone.

The Nacimiento Formation gradationally overlies the Ojo Alamo. In this area only its basal portion is present and consists of gray to brown, locally silty shale, and interbedded buff to yellow sandstone and gray siltstone. The Nacimiento Formation crops out over most of the quadrangle area, except the southwestern and eastern parts where a thin band of Ojo Alamo Sandstone is exposed.

Structure

The Gallegos Trading Post quadrangle is located in the Central Basin area (Kelley, 1950) of the major structural depression known as the San Juan Basin. The axis of the basin is about 14 miles (23 km) northeast of the quadrangle area near Farmington, New Mexico, and trends in an arcuate pattern across the northern portion of the Central Basin area (Baltz, 1967). Reeside (1924) stated that the rocks in the area are "nearly horizontal".

COAL GEOLOGY

Two coal zones (Menefee, Fruitland) and two coal beds (Fruitland 1, Fruitland 2) were identified in the subsurface of this quadrangle (CRO Plate 1). The coals of the Menefee Formation are grouped together as the Menefee coal zone (Me zone). These coal beds are typically noncorrelative and less than reserve base thickness (5 ft [1.5 m]). Due to these characteristics, derivative maps were not constructed.

Menefee Formation coals in the central portion of the San Juan Basin are considered subbituminous A in rank. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values averaging 11,179 Btu's per pound (26,002 kj/kg) (Amer. Soc. for Testing and Materials, 1977). The coal is hard, brittle, and black with a bright luster. The coal readily slakes with exposure to weather; however, it stocks fairly well when protected. The "as-received" analyses indicate moisture content averaging 16.8 percent, ash content ranging from 6.6 to 13.0 percent, sulfur content varying from 0.6 to 1.4 percent, and heating values on the order of 9,947 Btu's per pound (23,137 kj/kg). No published analyses of Menefee coals from this area are known to be available. Analyses of several Menefee coals from the outcrop area to the southwest of this quadrangle are given in Table 1 (Bauer and Reeside, 1921; Dane, 1936; Shomaker, 1971). These coals are assumed to be similar in quality and character to the coals of this quadrangle.

The Fruitland 1 (Fr 1) coal bed is defined as the lowermost coal of the Fruitland Formation; it is generally directly above the Pictured Cliffs Sandstone. In areas where both coal beds are present, the Fruitland 2

TABLE 1

Analyses of coal samples from the Menefee Formation

(Form of analysis: A, as received; B, moisture free; C, moisture and ash free)

U.S. Bureau Mines Lab No.	Well or Other Source	Location			Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent					Heating Value (Btu)	Remarks
		Section	T.N.	R.W.			Mois-ture	Volatile matter	Fixed Carbon	Ash	Sulfur		
J-52142	Channel, Open Pit	SW¼ 27	25	17	-------------	A	17.4	35.5	40.5	6.6	0.6	10,410	Noncaking.
						B	----	43.0	49.1	7.9	0.7	12,600	Coal may have
						C	----	46.7	53.3	----	0.8	13,680	been slightly weathered.
J-61758	Core Sample	SW¼ 36	25	17	-------------	A	15.8	31.6	39.6	13.0	1.2	9,700	
						B	----	37.5	47.1	15.4	1.4	11,510	
						C	----	44.3	55.7	----	1.6	13,610	
J-61759	Core Sample	SW¼ 36	25	17	-------------	A	17.4	31.5	40.4	10.7	1.4	9,730	
						B	----	38.1	48.9	13.0	1.7	11,780	
						C	----	43.8	56.2	----	2.0	13,540	

To convert Btu's/lb to kj/kg, multiply Btu's/lb by 2.326.

(Fr 2) coal bed overlies the Fruitland 1, separated by a rock interval of 5 to 59 ft (1.5-18 m). The remaining coals of the Fruitland Formation are grouped together as the Fruitland coal zone (Fr zone). These coals are generally noncorrelative and less than reserve base thickness (5 ft [1.5 m]). Therefore, derivative maps were not constructed.

Fruitland Formation coals in the central portion of the San Juan Basin are considered high volatile A bituminous in rank. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values averaging 14,366 Btu's per pound (33,415 kj/kg) (Amer. Soc. for Testing and Materials, 1977). The coal is hard, brittle, and black with a bright luster. The coal readily slakes with exposure to weather; however, it stocks fairly well when protected. The "as-received" analyses indicate moisture content averaging 2.7 percent, ash content ranging from 12.0 to 19.3 percent, sulfur content less than one percent, and heating values on the order of 12,002 Btu's per pound (27,917 kj/kg). Analyses of several Fruitland Formation coals are given in Table 2 (Bauer and Reeside, 1921; Dane, 1936; Fassett and Hinds, 1971).

Fruitland 1 Coal Bed

The Fruitland 1 coal bed, informally named by the authors, generally represents the lowermost Fruitland Formation coal bed. Although the coal bed has been correlated and mapped as a consistent horizon, it may actually be several different coal beds that are lithostratigraphically equivalent, but not laterally continuous.

As illustrated by the structure contour map (CRO Plate 5), the coal bed dips less than 1° to the northeast. Consequently, overburden (CRO

TABLE 2

Analyses of coal samples from the Fruitland Formation

(Form of analysis: A, as received; B, moisture free; C, moisture and ash free)

U.S. Bureau Mines Lab No.	Well or Other Source	Location			Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent					Heating Value (Btu)	Remarks
		Section	T.N.	R.W.			Mois-ture	Volatile matter	Fixed carbon	Ash	Sulfur		
H-12706	Southwest Production Ted Henderson No. 1	NE¼ 5	26	11	1,700-1,705	A	3.6	40.6	39.3	16.5	0.7	11,540	
						B	---	42.1	40.8	17.1	0.7	11,970	
						C	---	50.8	49.2	----	0.8	14,430	
H-3031	Southwest Production Cambell No. 2	NE¼ 26	27	12	1,900-1,910	A	2.6	41.2	40.5	15.7	0.6	11,810	
						B	---	42.3	41.6	16.1	0.6	12,120	
						C	---	50.4	49.6	----	0.7	14,440	
H-5021	British-American Oil Fullerton No. 8	NE¼ 14	27	11	1,920-1,930	A	3.3	40.8	43.9	12.0	0.6	12,370	
						B	---	42.2	45.4	12.4	0.6	12,790	
						C	---	48.1	51.9	----	0.7	14,600	
H-15776	Aztec Oil & Gas Hanks No. 14-D	SW¼ 12	27	10	1,900-1,905	A	2.2	40.4	44.0	13.4	0.6	12,520	
						B	---	41.3	45.1	13.6	0.6	12,790	
						C	---	47.9	52.1	----	0.7	14,820	
H-5472	Aztec Oil & Gas Caine No. 13	NW¼ 16	28	10	1,842-1,853	A	1.6	38.4	40.7	19.3	0.6	11,760	
						B	---	39.0	41.4	19.6	0.6	11,950	
						C	---	48.5	51.5	----	0.8	14,870	
H-24567	Sunray Mid-Continent Gallegos No. 122	NW¼ 18	28	12	1,305-1,315	A	3.0	38.9	44.4	13.7	0.6	12,010	
						B	---	40.1	45.8	14.1	0.6	12,390	
						C	---	46.8	53.2	----	0.7	14,430	

To convert Btu's/lb to kj/kg, multiply Btu's/lb by 2.326.
To convert feet to meters, multiply feet by 0.3048.

Plate 6) increases from less than 1,200 ft (366 m) in the southwest to greater than 1,900 ft (579 m) in the northeast portion of the quadrangle. The isopach map (CRO Plate 4) shows the coal bed is greater than 15 ft (4.6 m) thick in the southwest. The thickness decreases in all directions, and the coal is absent in small areas in the northwest, northeast, and central parts of the quadrangle.

Chemical Analyses of the Fruitland 1 Coal Bed - Analyses of Fruitland Formation coal beds from this quadrangle and the surrounding area are given in Table 2 (Fassett and Hinds, 1971).

Fruitland 2 Coal Bed

The Fruitland 2 coal bed, informally named by the authors, has been correlated and mapped as a consistent horizon although it may, in fact, be several different coal beds that are lithostratigraphically equivalent, but not laterally continuous.

As illustrated by the structure contour map (CRO Plate 9), the coal bed dips less than 1° to the northeast. As a result, overburden (CRO Plate 10) increases from less than 1,200 ft (366 m) in the southwest to greater than 1,900 ft (579 m) in the northeast part of the quadrangle. As indicated by the isopach map (Plate 8), the coal bed is greater than 20 ft (6.1 m) thick in the east-central portion of the map. The thickness decreases in all directions, and the coal is absent throughout most of the western half of the quadrangle.

Chemical Analyses of the Fruitland 2 Coal Bed - Analyses of several Fruitland Formation coal beds from this quadrangle and the surrounding area are given in Table 2 (Fassett and Hinds, 1971).

COAL RESOURCES

Coal resource data from oil and gas wells and pertinent publications were utilized in the construction of isopach and structure contour maps of coals in this quadrangle. All of the coals studied in the Gallegos Trading Post quadrangle are more than 1,000 ft (305 m) deep and, thus, have no outcrop or surface development potential.

The U.S. Geological Survey designated the Fruitland 1 and Fruitland 2 coal beds for the determination of coal resources in this quadrangle. Coals of the Fruitland and Menefee zones were not evaluated because they are discontinuous, noncorrelative, and generally less than the reserve base thickness (5 ft [1.5 m]).

For Reserve Base and Reserve calculations, each coal bed was areally divided into measured, indicated, and inferred resource categories (CRO Plates 7 and 11) according to criteria established in U.S. Geological Survey Bulletin 1450-B. Data for calculation of Reserve Base and Reserves for each category were obtained from the respective coal isopach (CRO Plates 4 and 8) and areal distribution maps (CRO Plates 7 and 11) for each coal bed. The surface area of each isopached bed was measured by planimeter, in acres, for each category, then multiplied by both the average isopached thickness of the coal bed and 1,800 short tons of coal per acre-foot (13,239 tons/hectare-meter), the conversion factor for bituminous coal. This yields the Reserve Base coal, in short tons, for each coal bed.

In order to calculate Reserves, a recovery factor of 50 percent was applied to the Reserve Base tonnages for underground coal. However, in areas of underground coal exceeding 12 ft (3.7 m) in thickness, the Reserves (mineable coal) were calculated on the basis of a maximum coal bed thickness of 12 ft (3.7 m), which represents the maximum economically mineable thickness for a single coal bed in this area by current underground mining technology.

Reserve Base and Reserve values for measured, indicated, and inferred categories of coal for the Fruitland 1 and Fruitland 2 beds are shown on CRO Plates 7 and 11, respectively, and are rounded to the nearest hundredth of a million short tons. The total coal Reserve Base, by section, is shown on CRO Plate 2 and totals approximately 667 million short tons (605 million metric tons).

The coal development potential for each bed was calculated in a manner similar to the Reserve Base, from planimetered measurements, in acres, for areas of high, moderate, and low potential for subsurface mining methods. The Gallegos Trading Post quadrangle has development potential for subsurface mining methods only (CDP Plate 12).

COAL DEVELOPMENT POTENTIAL

Coal beds of 5 ft (1.5 m) or more in thickness which are overlain by 200 to 3,000 ft (61-914 m) of overburden are considered to have potential for underground mining and are designated as having high, moderate, or low development potential according to the overburden thickness: 200 to 1,000 ft (61-305 m), high; 1,000 to 2,000 ft (305-610 m), moderate; and 2,000 to 3,000 ft (610-914 m), low. Table 3 summarizes the coal development potential, in short tons, for underground coal of the Fruitland 1 and Fruitland 2 coal beds.

TABLE 3

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE GALLEGOS TRADING POST QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO

(To convert short tons to metric tons, multiply by 0.9072)

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Fruitland 2	--	200,500,000	--	200,500,000
Fruitland 1	--	466,330,000	--	466,330,000
TOTAL	--	666,830,000	--	666,830,000

Development Potential for Surface Mining Methods

All coals studied in the Gallegos Trading Post quadrangle are more than 1,000 ft (305 m) deep and, thus, they have no coal development potential for surface mining methods.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 coal bed has moderate development potential over most of the quadrangle (CDP Plate 12). The coal bed thickness varies from 5 to 16 ft (1.5-4.9 m) (CRO Plate 4) and the overburden increases from less than 1,200 ft (366 m) in the southwest to more than 1,950 ft (594 m) in the east (CRO Plate 6). The Fruitland 2 coal bed has moderate development potential in the eastern half of the quadrangle where the coal bed thickness ranges from 5 to 21 ft (1.5-6.4 m) (CRO Plate 8) and the overburden increases from 1,200 ft (366 m) in the southwest to more than 1,900 ft (579 m) in the northeast (CRO Plate 10).

Areas of unknown development potential occur in the west-central, central, and northeastern parts of the quadrangle where the coal beds are less than the reserve base thickness (5 ft [1.5 m]). A small area with no coal development potential is located in the west-central part of the quadrangle where no Fruitland 1 or Fruitland 2 coals are present.

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