UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

BOWMAN FLAT QUADRANGLE,

JOHNSON COUNTY, WYOMING

BY

INTRASEARCH INC.

ENGLEWOOD, COLORADO

OPEN-FILE REPORT 79-176
1980

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CONVERSION TABLE

TO CONVERT	MULTIPLY BY	TO OBTAIN
inches	2.54	centimeters (cm)
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
cubic yards/ton	0.8428	cubic meters/ metric ton
acre-feet	0.12335	hectare-meters
British thermal units/pound (Btu/lb)	2.326	kilojoules/kilogram (kj/kg)
British thermal units/pound (Btu/lb)	0.55556	kilocalories/kilogram (kcal/kg)
Fahrenheit	5/9 (F-32)	Celsius

I. INTRODUCTION

This report and accompanying maps set forth the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) of coal beds within the Bowman Flat Quadrangle, Johnson County, Wyoming. This CRO and CDP map series includes 40 plates (U. S. Geological Survey Open-File Report 79-176). The project is compiled by IntraSearch Inc., 5351 South Roslyn Street, Englewood, Colorado, under KRCRA Eastern Powder River Basin, Wyoming, Contract Number 14-08-0001-17180. This contract is a part of a program to provide an inventory of unleased federal coal in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States.

The Bowman Flat Quadrangle is located in Johnson County, in northeastern Wyoming. It encompasses all or parts of Townships 47 and 48 North, Ranges 77 and 78 West, and covers the area: 44°00' to 44°07'30" north latitude; 106°07'30" to 106°15' west longitude.

Access to the Bowman Flat Quadrangle is limited to unimproved roads which extend throughout the majority of the study area. Minor trails provide additional access to the more remote areas. Schoonover Road, the closest maintained road to the quadrangle, extends east to west approximately 1.2 miles (1.9 km) to the north of the quadrangle. The closest railroad is the Burlington Northern trackage approximately 27 miles (43 km) to the northeast near Echeta, Wyoming.

The primary drainage is provided by the northward-flowing Powder River, which meanders south to north throughout the eastern half of the quadrangle. Fourmile and Pumpkin Creeks flow into the Powder River

and drain the northwest and southeast quarters of the study area, respectively. Minor streams supplement the drainage throughout the remaining area. The terrain attains elevations of 4,640 feet (1,414 m) above sea level in the west-central part of the quadrangle, where hills rise 500 to 600 feet (152 to 183 m) above the valley floor.

The 13 to 14 inches (33 to 36 cm) of annual precipitation falling in this semi-arid region accrue principally in the springtime. Summer and fall precipitation usually originates from thunderstorms, and infrequent snowfalls of 6 inches (15 cm) or less generally characterize winter precipitation. Although temperatures ranging from less than -25°F (-32°C) to more than 100°F (38°C) have been recorded near Arvada, Wyoming, average wintertime minimums and summertime maximums range from +5° to +15°F (-15° to -9°C) and 75° to 90°F (24° to 32°C), respectively.

Surface ownership is divided among fee, state, and federal categories with the state and federal surface generally leased to ranchers for grazing purposes. Details of surface ownership are available at the Johnson County Courthouse in Buffalo, Wyoming. Details of mineral ownership on federal lands are available from the U. S. Bureau of Land Management in Cheyenne, Wyoming. Federal coal ownership is shown on plate 2 of the Coal Resource Occurrence maps. The non-federal coal ownership comprises both fee and state coal resources.

The Coal Resource Occurrence and Coal Development Potential program pertains to unleased federal coal and focuses upon the delineation of lignite, subbituminous coal, bituminous coal, and anthracite at the surface, and in the subsurface. In addition, the program identifies total tons of coal in place (resources), as well as recoverable tons (reserves). These coal

tonnages are then categorized in measured, indicated, and inferred identified reserves and resources, and hypothetical resources. Finally, recommendations are made regarding the potential for surface mining, underground mining, and in-situ gasification of the coal beds. This report evaluates the coal resources of all unleased federal coal beds in the quadrangle which are 5 feet (1.5 m) or greater in thickness and occur at depths down to 3,000 feet (914 m). No resources or reserves are computed for leased federal coal, state coal, fee coal, or lands encompassed by coal prospecting permits and preference-right lease applications.

Surface and subsurface geological and engineering extrapolations drawn from the current data base suggest the occurrence of approximately 8.3 billion tons (7.5 billion metric tons) of total, unleased federal coal-in-place in the Bowman Flat Quadrangle.

The suite of maps that accompanies this report sets forth and portrays the coal resources and reserve occurrence in considerable detail. For the most part, this report supplements the cartographically displayed information with minimum verbal duplication of the CRO-CDP map data.

II. GEOLOGY

Regional. The thick, economic coal deposits of the Powder River Basin in northeastern Wyoming occur mostly in the Tongue River Member of the Fort Union Formation, and in the lower part of the Wasatch Formation. Approximately 3,000 feet (914 m) of the Fort Union Formation,

including the Tongue River, Lebo, and Tullock Members of Paleocene age, are unconformably overlain by approximately 700 feet (213 m) of the Wasatch Formation of Eocene age. These Tertiary formations lie in a structural basin flanked on the east by the Black Hills uplift, on the south by the Hartville and Casper Mountain uplifts, and on the west by the Casper Arch and the Big Horn Mountain uplift. The structural configuration of the Powder River Basin originated in Late Cretaceous time, with episodic uplift thereafter. The Cretaceous Cordillera was the dominant positive land form throughout the Rocky Mountain area at the close of Mesozoic time.

Outcrops of the Wasatch Formation and the Tongue River Member of the Fort Union Formation cover most of the areas of the major coal resource occurrence in the Powder River Basin. The Lebo Member of the Fort Union Formation is mapped at the surface northeast of Recluse, Wyoming. The Lebo Member is east of the principal coal outcrops and associated clinkers (McKay, 1974), and it presumably projects into the subsurface beneath much of the basin. One of the principal characteristics for separating the Lebo and Tullock Members (collectively referred to as the Ludlow Member east of Miles City, Montana) from the overlying Tongue River Member is the color differential between the lighter-colored upper portion and the somewhat darker lower portion (Brown, 1958). Although geologists are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts through use of subsurface data from geophysical logs, no definitive guidelines

are known to have been published. Hence, for subsurface mapping purposes, the Fort Union Formation is not divided into its member subdivisions for this study.

During the Paleocene epoch, the Powder River Basin tropical to subtropical depositional environment included broad, inland flood basins with extensive swamps, marshes, freshwater lakes, and a sluggish, but active, northeastward-discharging drainage system. These features were superimposed on an emerging sea floor, near base level. Much of the vast area where organic debris collected was within a reducing depositional environment. Localized uplifts began to disturb the near sea level terrain of northeastern Wyoming, following retreat of the Cretaceous seas. However, the extremely fine-grained characteristics of the Tongue River Member clastics suggest that areas of recurring uplift peripheral to the Powder River Basin were subdued during major coal deposit formation.

The uplift of areas surrounding the Powder River Basin created a structural basin of asymmetric character, with the steep west flank located on the eastern edge of the Big Horn Mountains. The axis of the Powder River Basin is difficult to specifically define, but it is thought to be located in the western part of the Basin, and to display a north-south configuration some 15 to 20 miles (24 to 32 km) east of Sheridan, Wyoming. Thus, the sedimentary section described in this report lies on the east flank of the Powder River Basin, with gentle dips of 2 degrees or less disrupted by surface structure thought to relate to tectonic adjustment and differential compaction.

Some coal beds in the Powder River Basin exceed 200 feet

(61 m) in thickness. Deposition of these thick, in-situ coal beds requires a delicate balance between subsidence of the earth's crust and and in-filling of these areas by tremendous volumes of organic debris. These conditions, in concert with a favorable ground water table, non-oxidizing clear water, and a climate amenable to the luxuriant growth of vegetation produce a stabilized swamp critical to the deposition of coal beds.

Deposition of the unusually thick coal beds of the Powder River Basin may be partially attributable to short-distance water transportation of organic detritus into areas of crustal subsidence. Variations of coal bed thickness throughout the basin relate to changes in the depositional environment. Drill hole data that indicate either the complete absence or extreme attenuation of a thick coal bed probably relate to location of the drill holes within the ancient stream channel system servicing this lowland area in Early Cenozoic time. Where thick coal beds thin rapidly from the depocenter of a favorable depositional environment, it is not unusual to encounter a synclinal structure over the maximum coal thickness due to the differential compaction between organic debris in the coal depocenter and fine-grained clastics in the adjacent areas.

The Wasatch Formation of Eocene age crops out over most of the central part of the Powder River Basin and exhibits a disconformable contact with the underlying Fort Union Formation. The contact has been placed at various horizons by different workers; however, for the

purpose of this report, the contact is positioned near the top of the Roland coal bed as mapped by Olive (1957) in northwestern Campbell County, Wyoming. It is considered to disconformably descend in the stratigraphic column to the top of the Wyodak-Anderson coal bed (Roland coal bed of Taff, 1909) along the eastern boundary of the coal measures. No attempt is made to differentiate the Wasatch and Fort Union Formations on geophysical logs or in the subsurface mapping program for this project.

Although Wasatch and Fort Union lithologies are too similar to allow differentiation in some areas, most of the thicker coal beds occur in the Fort Union section on the east flank of the Powder River Basin. Furthermore, orogenic movements peripheral to the basin apparently increased in magnitude during Wasatch time causing the deposition of friable, coarse-grained to gritty, arkosic sandstones, fine to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales, and coal beds. These sediments are noticably to imperceptibly coarser than the underlying Fort Union clastics.

The Bowman Flat Quadrangle is located in an area where surface rocks are classified within the Wasatch Formation. Although the Wasatch Formation is reportedly up to 1,800 feet (549 m) thick (Denson and Horn, 1975), Olive (1957) mapped 700 to 800 feet (213 to 244 m). Only 550 to 650 feet (168 to 198 m) of Wasatch Formation are exposed in the quadrangle. Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the northward extension of the Sheridan coal field, Montana (Baker, 1929), and Gillette coal field, Wyoming (Dobbin and Barnett, 1927), and with coal beds in the Ashland coal field (Bass, 1932) in

southeastern Montana. This report utilizes, were possible, the coal bed nomenclature used in previous reports.

The Dry Creek coal bed was named by Gale and Wagemann (1910). The Felix coal bed was named by Stone and Lupton (1910). Taff (1909) named the Smith coal bed, and the Pawnee coal bed was named by Warren (1959). IntraSearch informally assigned names to the Wildcat and Oedekoven coal beds (1978b, 1978a).

IntraSearch's correlation of the thick coal beds from the Spotted Horse coal field to Gillette points out that the Wyodak, named the "D" coal bed by Dobbin and Barnett (1927), is equivalent to the Anderson and Canyon coal beds (Baker, 1929), and all, or part, of the Cook (Bass, 1932) and Wall (Baker, 1929) coal beds to the north and west of Gillette, Wyoming. The Upper, Middle, and Lower Wyodak coal beds occurring in the Bowman Flat Quadrangle merge to form the massive Wyodak coal bed approximately 6 miles (10 km) to the east. Due to problematic correlations outside of the Gillette area, the name Wyodak has been informally used by many previous authors to represent the coal beds in the area surrounding the Wyodak coal mine.

Local. The Bowman Flat Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over the entire quadrangle and is composed of friable, coarse-grained to gritty, arkosic sandstones, fine to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales, and coal beds.

The Fort Union Formation underlies the Wasatch Formation, and is composed of fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds.

The dominant structural feature present within the quadrangle is a westward-plunging anticline extending across the northern third of the study area. A smaller, broader anticline is present in the southwest part of the quadrangle. These two anticlinal features are separated by a broad, shallow syncline.

III. Data Sources

No significant coal outcrops or associated clinker are mapped for this quadrangle in any publications known to IntraSearch at the time of this report. It is presumed and highly possible that no significant coal outcrops exist at the surface in the Bowman Flat Quadrangle. The thin Dry Creek coal bed outcrops in the northwest quarter of the quadrangle; however, insufficient thickness and areal extent preclude any detailed mapping.

Geophysical logs from oil and gas test bores and producing wells compose the source of subsurface control. Some geophysical logs are not applicable to this study, for the logs relate only to the deep, potentially productive oil and gas zones. More than 80 percent of the logs include resistivity, conductivity, and self-potential curves. Occasionally, the suite of geophysical logs includes gamma, density, and sonic curves. These logs are available from several commercial sources.

All geophysical logs available in the quadrangle and its 3-mile perimeter area were scanned to select those with data applicable

to Coal Resource Occurrence mapping. Paper copies of the logs were obtained and interpreted, and coal intervals were annotated. Maximum accuracy of coal bed identification was accomplished where gamma, density and resistivity curves were available. Coal bed tops and bottoms were identified on the logs at the midpoint between the minimum and maximum curve deflections. The correlation of coal beds within and between quadrangles was achieved utilizing a fence diagram to associate local correlations with regional coal occurrences.

The reliability of correlations, set forth by IntraSearch in this report, varies depending on: the density and quality of lithologic and geophysical logs; the details, thoroughness, and accuracy of published and unpublished surface geological maps, and interpretative proficiency. There is no intent on the part of IntraSearch to refute nomenclature established in the literature or used locally by workers in the area. IntraSearch's nomenclature focuses upon the suggestion of regional coal bed names applicable throughout the eastern Powder River Basin. It is expected and entirely reasonable that some differences of opinion regarding correlations, as suggested by IntraSearch, exist. Additional drilling for coal, oil, gas, water, and uranium, coupled with expanded mapping of coal bed outcrops and associated clinkers will broaden the data base for coal bed correlations and allow continued improvement in the understanding of coal bed occurrences in the eastern Powder River Basin.

The topographic map of the Bowman Flat Quadrangle is published by the U. S. Geological Survey, compilation date 1972. Land network and

mineral ownership data are compiled from land plats available from the U. S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

The Wasatch and Fort Union Formation coal beds that are present in all or part of the Bowman Flat Quadrangle include, in descending stratigraphic order: the Dry Creek, Felix, Smith, Local, Upper Wyodak, Local, Middle Wyodak, Lower Wyodak, Pawnee, Wildcat, and Oedekoven coal beds. The Upper Wyodak coal beds are variable in coal bed occurrence and thickness, and are mapped as a coal zone. A suite of maps composed of: coal isopach and mining ratio, where appropriate; structure; overburden isopach; areal distribution of identified resources; identified resources and hypothetical resources, where applicable, was prepared for each of these coal beds or coal zones. Mining ratios are presented on the isopach map of the Felix coal bed. Insufficient thickness and areal extent preclude any detailed mapping of the Dry Creek or Local coal beds.

No physical or chemical analyses are known to have been published regarding the coal beds in the Bowman Flat Quadrangle, Campbell County and eastern Johnson County coal beds, the "as received" proximate analysis; the Btu value computed on a moist, mineral-matter-free basis;* and the coal rank are as follows:

COAL BED NAME	DATA SOURCE IDENTIFICATION	AS RECEIVED BASIS						MOIST, M-M-F BTU/LB	COAL RANK
		ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB		
Felix (**)	Lab.No. 6432	5.6	35.7	25.8	32.9	0.39	8465	9010	Subbtm. C
Smith (**)	Lab.No. 6460	4.7	34.0	28.8	32.5	0.46	7862	8280	Lignite A
Upper Wyodak (U)	Hole 7310	5.9	33.9	29.1	31.2	0.44	8172	8722	Subbtm. C
Middle-Lower Wyodak (U)	Hole 755	4.4	35.5	27.4	32.7	0.21	8568	8999	Subbtm. C
Pawnee (U)	Hole 7424	7.9	31.0	31.9	29.2	0.39	7344	8025	Lignite A
"Wildcat" (1)	Lab.No. 11447	4.3	29.4	27.8	29.4	0.27	8410	8819	Subbtm. C

* The moist, mineral-matter-free Btu values are calculated in the manner stipulated in the publications by American Society for Testing and Materials (1971).

** Stone and Lupton (1910).

(1) Winchester (1912).

(U) U. S. Geological Survey and Montana Bureau of Mines and Geology (1974 and 1976).

The proximate analyses presented above are from core hole or outcrop locations in excess of 20 miles (32 km) from this quadrangle. For simplification of tonnage computations, all coal beds in the Bowman Flat Quadrangle are tentatively classified as subbituminous C rank.

The Coal Data Sheet, plate 3, shows the down-hole identification of coal beds within the quadrangle as interpreted from U. S. Geological Survey and Montana Bureau of Mines and Geology drill holes and geophysical logs from oil and gas test bores and from producing sites. This portrayal is schematic by design; hence, no structural or coal thickness implications are suggested by the dashed correlation lines projected through No Record (NR) intervals. Inasmuch as the Middle Wyodak coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Middle-Lower Wyodak coal beds show the thickest coal bed occurrence throughout the study area. The remaining coal beds are relatively thin throughout the Bowman Flat Quadrangle.

The Felix coal bed is relatively thin and ranges in thickness from 0 to 7 feet (0 to 2.1 m). Maximum thicknesses occur in the central part of the quadrangle, and the coal bed thins to the northeast and south. The Felix coal bed is absent from approximately 15 percent of the study area in the northeast and southern quadrants. Structure contours drawn on top of the Felix coal bed show a broad, northwest-plunging syncline extending from the northwest corner into the central part of the quadrangle. A broad, northwest-plunging anticline occurs in the southwest quarter of the quadrangle. The Felix coal bed is positioned approximately 50 to 650 feet (15 to 198 m) beneath the surface.

The Smith coal bed lies approximately 450 to 550 feet (137 to 168 m) beneath the overlying Felix coal bed. The coal bed thickness ranges from 0 to 12 feet (0 to 4 m) with maximum thickness occurring

in the northeast corner of the quadrangle. The Smith coal bed thins to the southwest and is absent from approximately 6 percent of the quadrangle in this area. Structure contours drawn on top of the Smith coal bed depict a gentle, westward dip and a narrow westward-plunging anticline in the northwest quarter of the study area. The Smith coal bed occurs between 520 to 1,260 feet (158 to 384 m) beneath the surface.

The Upper Wyodak coal zone occurs approximately 200 to 350 feet (61 to 107 m) below the Smith coal bed, and is composed of as many as four thin, lenticular coal beds. The coal zone thickness ranges from 0 to 31 feet (0 to 9 m) with maximum thickness occurring in the southeast corner and along the eastern quadrangle boundary. The coal zone thins to the west and is absent from a small area in the northwest quarter. A clastic interval ranging from 0 to 108 feet (0 to 33 m) separates the various coal beds composing the coal zone. The most significant structural feature occurring within the study area is a westward-plunging anticline which extends across the northern half of the quadrangle. The Upper Wyodak coal zone lies approximately 800 to 1,540 feet (244 to 469 m) beneath the surface.

The Middle and Lower Wyodak coal beds, that lie approximately 80 to 425 feet (24 to 130 m) below the Upper Wyodak coal zone, are the thickest coal beds in the quadrangle. The total coal thickness ranges from 70 to 144 feet (21 to 44 m). Maximum thickness occurs in the northern half of the quadrangle. The Middle and Lower Wyodak coal beds

merge to form a massive coal bed throughout the majority of the study area. A clastic interval ranging from 0 to 131 feet (0 to 40 m) locally separates the Middle and Lower Wyodak coal beds in the northwest and southwest quarters of the quadrangle. Structure contours drawn on top of the Middle Wyodak coal bed indicate a westward-plunging anticline extending across the northern third of the study area. Another smaller, broader, westward-plunging anticline is also present in the southern half of the quadrangle. The two anticlines are separated by a broad, westward-plunging syncline through the central portion of the quadrangle. The Middle-Lower Wyodak coal beds occur between 1,100 and 1,900 feet (335 and 579 m) beneath the surface.

The Pawnee coal bed occurs approximately 400 to 600 feet (122 to 183 m) below the overlying Lower Wyodak coal bed. The coal bed thickness varies from 0 to 20 feet (0 to 6 m). Maximum coal bed thickness occurs in the southeast quarter and extreme northeast corner of the study area. The coal bed thins to the west. The Pawnee coal bed is absent from approximately 15 percent of the quadrangle along the western boundary. Structure contours drawn on top of the Pawnee coal bed define a gentle, westward dip. A small, westward-plunging anticline extends across the northern half of the study area. The Pawnee coal bed lies between 1,700 and 2,450 feet (518 and 747 m) beneath the surface.

The Wildcat coal bed lies approximately 250 to 300 feet (76 to 91 m) below the Pawnee coal bed, and ranges in thickness from 0 to

10 feet (0 to 3 m). Maximum thickness occurs along the eastern boundary of the study area. The coal bed pinches out to the west, where it is absent from approximately 30 percent of the quadrangle. Structure contours drawn on top of the Wildcat coal bed indicate a gentle dip to the west. The Wildcat coal bed occurs between 1,975 and 2,700 feet (602 and 823 m) beneath the surface.

The Oedekoven coal bed occurs approximately 200 to 250 feet (61 to 76 m) beneath the overlying Wildcat coal bed. The coal bed thickness ranges from 5 to 17 feet (1.5 to 5 m) with maximum thickness occurring in the eastern half of the study area. Structure contours drawn on top of the Oedekoven coal bed indicate a gentle, west dip. A minor, west-plunging anticline extends westward across the northern half of the quadrangle. The Oedekoven coal bed occurs between 2,200 and 2,950 feet (671 and 899 m) in depth beneath the surface.

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. IntraSearch plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed on or near to a drillsite shown on the topographic map, and the topographic map horizontal location is utilized. If the ground elevation on the geophysical log does not agree with the topographic elevation of the drillsite, the geophysical log ground elevation is adjusted to conformance.

If there is no indication of a drillsite on the topographic map, the "quarter, quarter, quarter" heading location is shifted within a small area until the ground elevation on the heading agrees with the topographic map elevation. If no elevation agreement can be reached, the well heading or data sheet is rechecked for footage measurements and ground elevation accuracy. Inquiries to the companies who provided the oil and gas geophysical logs frequently reveal that corrections have been made in the original survey. If all horizontal location data sources have been checked and the information accepted as the best available data, the drillsite elevation on the geophysical log is modified to agree with the topographic map elevation. IntraSearch considers this agreement mandatory for the proper construction of most subsurface maps, but in particular, the overburden isopach, the mining ratio, and Coal Development Potential maps.

Subsurface mapping is based on geologic data within, and adjacent to, the Bowman Flat Quadrangle area. Data from geophysical logs are used to correlate coal beds and control contour lines for the coal thickness, structure, and overburden maps. Structure contour maps are constructed on the tops of the main coal beds.

In preparing overburden isopach maps, no attempt is made to identify coal beds that occur in the overburden above a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a 95 percent recovery factor. Contours of these maps identify the ratio of cubic yards of overburden to tons of recoverable coal. Where ratio control points are sparse, interpolated points are computed using coal structure, coal isopach, and topographic control. On the

Areal Distribution of Identified Resources Map (ADIR), coal bed reserves are not calculated where the coal is less than 5 feet (1.5 m) thick, where the coal occurs at a depth greater than 500 feet (152 m), and where non-federal coal exists, or where federal coal leases, preference-right lease applications, and coal prospecting permits exist.

Coal tonnage calculations involve the planimetering of areas of measured, indicated, and inferred parts of identified resources, and hypothetical resources to determine their areal extent in acres. An Insufficient Data Line is drawn to delineate areas where surface and subsurface data are too sparse for CRO map construction. Various categories of resources are calculated in the unmapped areas by utilizing coal bed thicknesses mapped in the geologically controlled area adjacent to the insufficient data line. Acres are multiplied by the average coal bed thickness and 1,750, or 1,770--the number of tons of lignite A or subbituminous C coal per acre-foot, respectively (12,874 or 13,018 metric tons per hectare-meter, respectively)--to determine total tons in place. Recoverable tonnages (reserves) are calculated at 95 percent of the total tons in place. Where tonnages are computed for the CRO-CDP map series, resources and reserves are expressed in millions of tons. Frequently, the planimetering of coal resources on a sectionized basis involves complexly curvilinear lines (coal bed outcrop and 500-foot stripping limit designations) in relationship with linear section boundaries and circular resource category boundaries. Where these relationships occur, generalizations of complex curvilinear lines are discretely utilized, and resources and/or reserves are calculated within an estimated 2 to 3 percent, plus or minus, accuracy.

VI. Coal Development Potential

Strippable Coal Development Potential. Areas where coal beds are 5 feet (1.5 m) or more in thickness and are overlain by 500 feet (152 m) or less of overburden are considered to have potential for surface mining and are assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for subbituminous coal is as follows:

$$MR = \frac{to\ (0.911)^*}{tc\ (rf)}$$

where MR = mining ratio
to = thickness of overburden
tc = thickness of coal
rf = recovery factor
0.911 = conversion factor (cu. yds./ton)

*A conversion factor of 0.922 is used for lignite.

A surface mining development potential map (plate 39) was prepared utilizing the following mining ratio criteria for coal beds 5 feet to 40 feet (1.5 to 12 m) thick:

1. Low development potential = 15:1 and greater ratio.
2. Moderate development potential = 10:1 to 15:1 ratio.
3. High development potential = 0 to 10:1 ratio.

The following mining ratio criteria are utilized for coal beds greater than 40 feet (12 m) thick:

1. Low development potential = 7:1 and greater ratio.
2. Moderate development potential = 5:1 to 7:1 ratio.
3. High development potential = 0 to 5:1 ratio.

The surface mining development potential is low for approximately 35 percent of the quadrangle. This low development potential area

stretches across the central part of the quadrangle and results from high overburden to coal thickness ratios for the Felix coal bed. The coal beds older than the Felix coal bed occur greater than 500 feet (152 m) beneath the surface or are less than 5 feet (1.5 m) thick; hence, they are not considered to be surface mineable. Table 1 sets forth the estimated strippable reserve base tonnages per coal bed for this quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining development potential throughout the Bowman Flat Quadrangle is considered low. Inasmuch as recovery factors have not been established for the underground development of coal beds in this quadrangle, reserves are not calculated for coal beds that occur more than 500 feet (152 m) beneath the surface. Table 2 sets forth the estimated coal resources in tons per coal bed.

In-Situ Gasification Coal Development Potential. The evaluation of subsurface coal deposits for in-situ gasification development potential relates to the occurrence of coal beds more than 5 feet (1.5 m) thick buried from 500 to 3,000 feet (152 to 914 m) beneath the surface. This categorization is as follows:

1. Low development potential relates to: 1) a total coal section less than 100 feet (30 m) thick that lies 1,000 feet (305 m) to 3,000 feet (914 m) beneath the surface, or 2) a coal bed or coal zone 5 feet (1.5 m) or more in thickness that lies 500 feet (152 m) to 1,000 feet (305 m) beneath the

surface.

2. Moderate development potential is assigned to a total coal section from 100 to 200 feet (30 to 61 m) thick and buried from 1,000 to 3,000 feet (305 to 914 m) beneath the surface.

3. High development potential involves 200 feet (61 m) or more of total coal thickness buried from 1,000 to 3,000 feet (305 to 914 m).

The coal development potential for in-situ gasification (Plate 40) on the Bowman Flat Quadrangle is moderate over approximately 85 percent of the quadrange, and relates to the thick Middle and Lower Wyodak coal beds. The combined thickness for all coal beds positioned more than 1,000 feet (305 m) in depth exceeds 200 feet (61 m) along the eastern boundary of the quadrangle. This relationship suggests a high, in-situ gasification potential for this area that encompasses 2 percent of the quadrangle. Low development potential is mapped in approximately 3 percent of the study area, and is located along the western boundary of the quadrangle. This low rating is related to the westward thinning trend of all coal beds. The remaining area is classified as non-federal coal land, and is not evaluated in this study. Table 3 sets forth the total coal tonnage considered amenable to in-situ gasification.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Bowman Flat Quadrangle, Johnson County, Wyoming.

(Development potentials are based on mining ratios (cubic yards of overburden/ton of recoverable coal).

Coal Bed	High Development Potential (0-10:1 Mining Ratio)	Moderate Development Potential (10:1-15:1 Mining Ratio)	Low Development Potential (>15:1 Mining Ratio)	Total
Reserve Base				
Felix	-	-	126,300,000	126,300,000
Total	-	-	126,300,000	126,300,000
Hypothetical Resources				
Felix	-	-	3,430,000	3,430,000
Total	-	-	3,430,000	3,430,000
GRAND TOTAL	-	-	129,730,000	129,730,000

Table 2.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Bowman Flat Quadrangle, Johnson County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base				
Felix	-	-	9,460,000	9,460,000
Smith	-	-	169,600,000	169,600,000
Upper Wyodak	-	-	857,140,000	857,140,000
Middle-Lower Wyodak	-	-	5,770,740,000	5,770,740,000
Pawnee	-	-	482,240,000	482,240,000
Wildcat	-	-	168,360,000	168,360,000
Oedekoven	-	-	696,430,000	696,430,000
Total	-	-	8,154,210,000	8,154,210,000
Hypothetical Resources				
Smith	-	-	240,000	240,000
Upper Wyodak	-	-	580,000	580,000
Middle-Lower Wyodak	-	-	2,950,000	2,950,000
Total	-	-	3,530,000	3,530,000
GRAND TOTAL	-	-	8,157,740,000	8,157,740,000

Table 3.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Bowman Flat Quadrangle, Johnson County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base	299,690,000	7,388,580,000	465,940,000	8,154,210,000
Hypothetical Resources	-	-	3,530,000	3,530,000
GRAND TOTAL	299,690,000	7,388,580,000	469,470,000	8,157,740,000

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