

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

NORTHEAST QUARTER OF BETTY RESERVOIR 15' QUADRANGLE,

CONVERSE AND CAMPBELL COUNTIES, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

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This report is preliminary, and has not been edited or reviewed for conformity with United States Geological Survey standards or stratigraphic nomenclature.

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CONVERSION TABLE

<u>TO CONVERT</u>	<u>MULTIPLY BY</u>	<u>TO OBTAIN</u>
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 per metric tons
acre feet	0.12335	hectare-meters
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)
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 Northeast Quarter of Betty Reservoir 15' Quadrangle, Converse and Campbell Counties, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-319) includes 19 plates. The project is compiled by IntraSearch Inc., 1600 Ogden Street, Denver, Colorado, under KRCRA Northeastern 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 Areas (KRCRAs) in the western United States.

The Northeast Quarter of Betty Reservoir 15' Quadrangle is located in Campbell and Converse Counties in northeastern Wyoming. It encompasses parts of Townships 39, 40 and 41 North, Ranges 70 and 71 West, and covers the area: 43° 22' 30" to 43° 30' north latitude; 105° 15' to 105° 22' 30" west longitude.

Primary access to the study area is provided by two maintained gravel roads that enter the area from the west. These roads intersect Wyoming State Highway 59 from 1 to 2 miles (2 to 3 km) west of the quadrangle at points approximately 26 miles (42 km) south of the intersection of Wyoming State Highway 59 and Wyoming State Highway 387. The two maintained gravel roads and the minor roads and trails that branch from them provide access to all of the quadrangle. The closest railroad is the Chicago and Northwestern trackage 42 miles (68 km) to the south-southwest at Douglas, Wyoming. Proposed trackage of the Burlington Northern Railroad extends southward through the study area.

Complex drainage patterns and fairly rugged terrain characterize the topography of the Northeast Quarter of Betty Reservoir Fifteen-Minute Quadrangle. The principal drainage is provided by Antelope Creek, an intermittent stream that courses eastward across the northern part of the area. This stream is joined by northward flowing tributaries in East and West Logan Draws. The southern edge of the area is drained by Dugout and Woody Creeks and their tributaries. Maximum relief in the region is 600 feet (183 m) with maximum elevations exceeding 5000 feet (1524 m) above sea level in the southwest quadrant and minimum elevations of less than 4500 feet (1372 m) above sea level in the valley of Antelope Creek at the eastern boundary of the quadrangle.

The thirteen to fourteen inches (33 to 36 cm) of annual precipitation that falls in this semi-arid region accrues principally in the springtime. Summer and fall precipitation usually originates from thunderstorms, and infrequent snowfalls of six 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 Gillette, Wyoming, average wintertime minimums and summertime maximums approach $+5^{\circ}$ to $+15^{\circ}\text{F}$ (-15° and -9°C) and 75° to 90°F (24° to 32°C), respectively.

Surface ownership is divided among fee, state, and federal categories. State and federal lands are generally leased to ranchers for grazing purposes. Details of surface ownership are available at the Converse County Courthouse in Douglas, Wyoming and at the Campbell County Courthouse in Gillette, 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 belongs to both fee and state owners.

The Coal Resource Occurrence and Coal Development Potential program is restricted to unleased federal coal and focuses upon: 1) the delineation of lignite, subbituminous coal, bituminous coal, and anthracite at the surface and in the subsurface on federal land; 2) subdivision of deposits into measured, indicated, and inferred reserve resource categories, and hypothetical resources; 3) the measurement of coal resources in place as well as recoverable reserves; and 4) the determination of the potential for surface or underground mining, and in-situ gasification of the coal beds. This report contains an evaluation of 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 3000 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 1.9 billion tons (1.7 billion metric tons) of unleased federal coal resources in the Northeast Quarter of Betty Reservoir 15' Quadrangle.

The suite of maps that accompany this report portray the coal resource and reserve occurrence in detail. For the most part, this report supplements the cartographic information, with minimum duplication of the 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 3000 feet (914 m) of the Fort Union Formation,

that includes 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 major coal resource occurrence in the Powder River Basin. The Tongue River Member is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds. The Lebo Shale Member of the Fort Union Formation consists of light-to dark-gray very fine-grained to conglomeratic sandstone with interbedded siltstone, claystone, carbonaceous shale and thin coal beds. Thin bedded calcareous ironstone concretions interbedded with massive white sandstone and slightly bentonitic shale occur throughout the unit.

The Lebo Member is mapped at the surface northeast of Recluse, Wyoming, east of the principal coal outcrops and associated clinkers (McKay, 1974), and 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 work-

ing with subsurface data, principally geophysical logs, in the basin are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts, no definitive guidelines are known to have been published. Hence, for subsurface mapping purposes, the Fort Union Formation is not divided into its members for this study.

During the Paleocene epoch, the Powder River Basin tropic to subtropic depositional environment included broad, inland flood basins with extensive swamps, marshes, freshwater lakes, and a sluggish but active northeastward discharging drainage system, 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 characteristic, 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 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 two 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 discrete balance between subsidence of the earth's crust and in-filling 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 in 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 draining this low land 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, and 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 that is a part of this CRO-CDP 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 noticeably to imperceptibly coarser than the underlying Fort Union clastics.

The Northeast Quarter of Betty Reservoir 15' Quadrangle is located in an area where surface rocks are classified into the Wasatch and Fort Union Formations, and approximately 500 feet (152 m) of this sedimentary section are exposed in this area. Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the Sheridan coal field (Baker, 1929) and Gillette coal field (Dobbin and Barnett, 1927), Wyoming, and with coal beds in the Ashland coal field (Bass, 1932) in southeastern Montana. This report utilizes, where possible, the coal bed nomenclature used in previous reports. Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds. The Cook coal bed was named by Bass (1932).

IntraSearch's correlation of thick coal beds from the Spotted Horse coal field to Gillette points out that the Wyodak coal bed, named the "D" coal bed by Dobbin and Barnett (1927), is equivalent to the Anderson, Canyon, and all or part of the Cook coal beds to the north and west of Gillette, Wyoming. Correlation of this suite of coal beds with the Wyo-

dak coal bed south and southwest of Gillette suggests that the Anderson and Canyon coal beds equate with the upper ten to twenty-five percent of the thick Wyodak coal bed, and the Cook and Wall or Upper Wall coal beds are equivalent to the major part of the Wyodak coal bed. 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. The Wildcat and Moyer coal beds were informally named by IntraSearch (1978 and 1979).

Local. The Northeast Quarter of Betty Reservoir 15' Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently northwestward. The Wasatch Formation caps the higher elevations over approximately sixty percent of the quadrangle, and is comprised 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 crops out over the remaining area and is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from the CRO-CDP maps of the Northeast Quarter of Betty Reservoir 15' Quadrangle (Lingley, 1976). Additional adjustments to outcrop configurations are made from data derived by IntraSearch from the photo-geologic interpretations of 1:24,000 scale color aerial photography.

The major source of subsurface control, particularly on deep coal beds, is the geophysical logs from oil and gas test bores and producing wells. 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 eighty percent of the logs include resistivity, conductivity, and self-potential curves. Occasionally the logs include gamma, density, and sonic curves. These logs are available from several commercial sources.

All geophysical logs available in the quadrangle are scanned to select those with data applicable to Coal Resource Occurrence mapping. Paper copies of the logs are obtained, interpreted, and coal intervals annotated. Maximum accuracy of coal bed identification is accomplished where gamma, density, and resistivity curves are available. Coal bed tops and bottoms are picked on the logs at the midpoint between the minimum and maximum curve deflections. The correlation of coal beds within and between quadrangles is achieved utilizing a fence diagram to associate local correlations with regional coal occurrences.

In some parts of the Powder River Basin, additional subsurface control is available from U. S. Geological Survey open-file reports that include geophysical and lithologic logs of shallow holes drilled specifically for coal exploration.

The reliability of correlations, set forth by IntraSearch in this report, vary depending on: the density and quality of lithologic and geophysical logs; the detail, 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 Betty Reservoir 15' Quadrangle is published by the U. S. Geological Survey, compilation date, 1959. 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

Fort Union Formation coal beds that are present in all or part of the Northeast Quarter of Betty Reservoir 15' Quadrangle include, in descending stratigraphic order, the Middle Wyodak, Lower Wyodak, Wildcat, and Moyer coal beds. A complete suite of maps (structure, isopach, mining ratio, overburden and interburden, identified resources and areal distribution of identified resources) is prepared for the Middle Wyodak and Lower Wyodak coal beds and the Wildcat-Moyer coal zone.

No physical and chemical analyses are known to have been published regarding the coal beds in the Northeast Quarter of Betty Reservoir 15' Quadrangle. However, the following "as received", basis proximate analyses are available from quadrangles to the north, west and south of the Northeast Quarter of Betty Reservoir 15' Quadrangle:

COAL BED NAME		ASH	FIXED CARBON	MOISTURE	VOLATILES	SULFUR	BTU/LB
Middle and Lower Wyodak (U)	Hole 7544	4.442	33.082	24.843	37.633	0.188	8872
Middle Wyodak (U)	Hole 7546	9.227	34.495	23.469	32.810	0.382	8315
Wildcat (*)	11447	4.3	29.4	27.8	29.4	0.27	8410

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

(*) - Winchester, 1912

All analyses except BTU/LB are expressed as a percentage.

The Coal Data Sheet, Plate 3, shows the downhole identification of coal beds within the quadrangle as interpreted from geophysical logs from oil and gas test bores and producing sites.

Inasmuch as the Lower Wyodak coal bed is the thick coal bed that covers the greatest area, it is designated as datum for the correlation diagram (Plate 3). The Middle and Lower Wyodak coal beds show the thickest single coal bed occurrences in the quadrangle. For the most part, the individual Wildcat and Moyer coal beds are thinner than the Wyodak coal beds. Several thin local coal beds are identified (Plate 3) but their limited thickness and extent preclude mapping.

The Middle Wyodak coal bed is eroded from approximately seventy percent of the quadrangle. Minor areas of burning are shown by clinker at or near the outcrop. Where present, the Middle Wyodak coal bed varies in thickness from less than 10 feet (3 m) in the southwestern quadrant to 42 feet (13 m) in the northwestern quadrant. Total non-coal interburden within the Middle Wyodak coal bed varies from 0 to 4 feet (0 to 1.2 m). Structure contours drawn on top of the Middle Wyodak coal bed define a broad syncline with a northwest plunging axis trending through the northwestern corner of the quadrangle. The Middle Wyodak coal bed occurs at depths down to 260 feet (79 m) below the surface.

The Lower Wyodak coal bed occurs 44 to 112 feet (13 to 34 m) beneath the Middle Wyodak coal bed and crops out in the northeastern and southeastern corners of the study area. Pinched out in the southwestern quadrant, the Lower Wyodak coal bed attains a maximum thickness of 38 feet (12 m) along the northern boundary of the quadrangle. Total non-coal interburden within the Lower Wyodak coal bed attains a maximum thickness of 55 feet (17 m). The Lower Wyodak coal bed dips one to two degrees north-northwestward and exhibits minor folding in the northwestern

corner of the quadrangle. The maximum depth of occurrence of the Lower Wyodak coal bed is 278 feet (85 m).

The Wildcat-Moyer coal zone lies between 556 and 607 feet (169 to 185 m) below the Lower Wyodak coal bed. The Wildcat-Moyer coal zone consists of the Upper, Middle, and Lower Wildcat coal beds and the Moyer coal bed. The Wildcat coal beds individually have average thicknesses of less than 10 feet (3 m). The Moyer coal bed is the thickest coal bed within the zone with an observed average thickness of approximately 20 feet (6 m). The total thickness of coal beds in the Wildcat-Moyer coal zone varies from less than 15 feet (5 m) to more than 40 feet (12 m) from the southeastern to the northwestern corners of the area. Non-coal intervals within the zone vary from 70 to 315 feet (21 to 96 m). The structure contour map of the Wildcat-Moyer coal zone is drawn on top of the Upper Wildcat coal bed in the northwestern half and on top of the Middle Wildcat coal bed in the southern half of the quadrangle. The structure contours show a gentle dip of one to two degrees to the west-northwest with minor folding in the northwest quadrant. With the exception of minute areas along the eastern border, the Wildcat-Moyer coal zone lies greater than 500 feet (152 m) below the surface throughout the quadrangle.

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. Intra-Search Inc., plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed 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 Inc., 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 Northeast Quarter of Betty Reservoir 15' Quadrangle area. Data from geophysical logs are used to correlate coal beds and control contour lines for the coal thickness, structure, and overburden maps. Isopach lines are also drawn to honor selected surface measured sections where there is sparse subsurface control. Where isopach contours do not honor surface measured sections, the surface thicknesses are thought to be attenuated by oxidation and/or erosion, hence not reflective of total coal thickness. Isopach lines extend to the coal bed outcrops, the projections of coal bed outcrops, and the contact between porcellanite (clinker) and unoxidized coal in place. Attenuation of total coal bed thickness is known to take place near these lines of definition; however, the overestimation of coal bed tonnages that results from this projec-

tion of total coal thickness is insignificant to the Coal Development Potential maps. Structure contour maps are constructed on the tops of the main coal beds. Where subsurface data are scarce, supplemental structural control points are selected from the topographic map along coal outcrops.

In preparing overburden isopach maps, no attempt is made to identify coal beds that occur in the overburden to a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a ninety-five 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 at the intersections of coal bed and overburden isopach contours 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), where non-federal coal exists, or where federal coal leases, preference right lease applications, and coal prospecting permits exist.

Coal tonnage calculations involve the planimetry of areas of measured, indicated, inferred reserves and resources, and hypothetical resources to determine their areal extent in acres. 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 1770 (the number of tons of subbituminous C coal per acre-foot, 13,018 metric tons per hectare-meter), to determine total tons in place. Recoverable tonnage is calculated at ninety-five 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 planimetry 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 complexly curvilinear lines are discretely utilized, and resources and/or reserves are calculated within an estimated two to three 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 is as follows:

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

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 potential map (Plate 19) is prepared utilizing the following mining ratio criteria for coal beds 5 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 is 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 potential is high for approximately forty percent of the Northeast Quarter of Betty Reservoir 15' Quadrangle. The high surface mining potential exists where the thick Middle and Lower Wyodak coal beds occur at shallow depths along the northern and western edges of the study area and in the area immediately south of Antelope Creek. Approximately five percent of the quadrangle is rated as moderate potential and five percent is rated as low potential because the overburden over the Middle and Lower Wyodak coal beds is increasing. Twenty-five percent of the quadrangle contains no surface mining potential because the Middle and Lower Wyodak coal beds are either too deep or they are eroded. The remaining twenty-five percent of the study area is non-federal coal land. Table 1 sets forth the estimated strippable reserve base tonnages per coal bed for the quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Northeast Quarter of Betty Reservoir 15' 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 potential relates to the occurrence of coal beds more than 5 feet (1.5 m) thick buried from 500 to 3000 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 500 feet (152 m) to 3000 feet (914 m) beneath the surface, or 2) coal beds 5 feet (1.5 m) or more in thickness that lie 500 feet (152 m) to 1000 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 1000 to 3000 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 1000 to 3000 feet (305 to 914 m).

The coal development potential for in-situ gasification within the Northeast Quarter of Betty Reservoir 15' Quadrangle is low, hence no CDP map is generated for this map series. The coal resource base and hypothetical resource tonnage for in-situ gasification with low development potential totals approximately 1.2 billion tons (1.1 billion metric tons) (Table 3). None of the coal beds in the Northeast Quarter of Betty Reservoir 15' Quadrangle qualify for a moderate or high development potential rating.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Northeast Quarter of Betty Reservoir 15' Quadrangle, Converse and Campbell Counties, 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
Middle Wyodak	232,250,000	2,100,000	610,000	234,960,000
Lower Wyodak	332,640,000	59,760,000	38,820,000	431,220,000
Wildcat Moyer	-----	-----	5,900,000	5,900,000
TOTAL	564,890,000	61,860,000	45,330,000	672,080,000

Table 2.--Coal Resource Base and Hypothetical Resource Data (in short tons)
for Underground Mining Methods for Federal Coal Lands in the
Northeast Quarter of Betty Reservoir 15' Quadrangle, Converse
and Campbell Counties, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
<u>RESERVE BASE:</u>				
Wildcat-Moyer	-----	-----	1,101,240,000	1,101,240,000
TOTAL	-----	-----	1,101,240,000	1,101,240,000
<u>HYPOTHETICAL RESOURCES:</u>				
Wildcat-Moyer	-----	-----	94,310,000	94,310,000
TOTAL	-----	-----	94,310,000	94,310,000
GRAND TOTAL	-----	-----	1,195,550,000	1,195,550,000

Table 3.--Coal Resource Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Northeast Quarter of Betty Reservoir 15' Quadrangle, Converse and Campbell Counties, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
<u>RESERVE BASE:</u>				
Wildcat-Moyer	-----	-----	1,101,240,000	1,101,240,000
TOTAL	-----	-----	1,101,240,000	1,101,240,000
<u>HYPOTHETICAL RESOURCES:</u>				
Wildcat-Moyer	-----	-----	94,310,000	94,310,000
TOTAL	-----	-----	94,310,000	94,310,000
GRAND TOTAL	-----	-----	1,195,550,000	1,195,550,000

SELECTED REFERENCES

- Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U. S. Geol. Survey Bull. 806-B, p. 15-67.
- Bass, N. W., 1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U. S. Geol. Survey Bull. 831-B, p. 19-105.
- Brown, R. W., 1958, Fort Union Formation in the Powder River Basin, Wyoming: Wyo. Geol. Soc. Guidebook, Thirteenth Annual Field Conf., p. 111-113.
- Dobbin, C. E., and Barnett, V. H., 1927, The Gillette coal field, northeastern Wyoming, with a chapter on the Minturn district and northwestern part of the Gillette field by W. T. Thom, Jr.: U. S. Geol. Survey Bull. 796-A, p. 150.
- Glass, G. B., 1975, Review of Wyoming coal field, 1975; Wyoming Geol. Survey Public Information circ. 4, p. 10.
- IntraSearch Inc., 1978, Coal resource occurrence and coal development potential of the Rocky Butte Quadrangle, Campbell County, Wyoming: U. S. Geol. Survey Open-File Report 78-830, 22 p.
- _____, 1979, Coal resource occurrence and coal development potential of the Larey Draw Quadrangle, Campbell County, Wyoming: U. S. Geol. Survey Open-File Report 79-023, 29 p.
- Jacob, A. F., 1973, Depositional environments of Paleocene Tongue River Formation: Am. Assoc. of Petroleum Geologists Bull, vol. 56, no. 6, p. 1038-1052.
- Lingley, Leslie, 1976, Preliminary coal resource occurrence and coal development potential maps of the Betty Reservoir NE quadrangle, Converse and Campbell Counties, Wyoming: U. S. Geol. Survey unpublished report, scale 1:24,000.

- McKay, E. J., 1974, Preliminary geologic map of the Bertha 2 NW (Rocky Butte) Quadrangle, Campbell County, Wyoming: U. S. Geol. Survey Open-File Report 74-173, scale 1:24,000.
- Olive, W. W., 1957, The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U. S. Geol. Survey Bull. 1050, 83 p.
- Schell, E. M., and Mowat, G. D., 1972, Reconnaissance map showing some coal and clinker beds in the Fort Union and Wasatch Formations in the eastern Powder River Basin, Campbell and Converse Counties, Wyoming: U. S. Geol. Survey Open-File Report, scale 1:63,360.
- Taff, J. A., 1909, The Sheridan coal field, Wyoming: U. S. Geol. Survey Bull. 341-B, p. 123-150.
- U. S. Bureau of Mines and U. S. Geological Survey, 1976, Coal Resource classification system of the U. S. Bureau of Mines and U. S. Geol. Survey Bull. 1450-B, 7 p.
- U. S. Geological Survey and Montana Bureau of Mines and Geology, 1976, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell and Sheridan Counties, Wyoming; Custer, Prairie, and Garfield Counties, Montana: and Mercer County, North Dakota: U. S. Geol. Survey Open-File Report 76-319, 377 p.
- Warren, W. C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U. S. Geol. Survey Bull. 1072-J, p. 561-585.
- Weimer, R. J., 1977, Stratigraphy and tectonics of western coals, in Geology of Rocky Mountain Coal, A Symposium, 1976: Colorado Geol. Survey Resource Series 1, p. 9-27.
- Winchester, D. E., 1912, The Lost Spring coal field, Converse County, Wyoming: U. S. Geol. Survey Bull. 471-F, p. 472-515.