UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

SPOTTED HORSE QUADRANGLE

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-024
1979

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

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 per metric ton
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 Spotted Horse Quadrangle, Campbell County, Wyoming. This CRO and CDP map series includes 49 plates (U.S. Geological Survey Open-File Report 79-024). 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 federal coal in Known Recoverable Coal Resource Areas (KRCRA) in the western United States.

The Spotted Horse Quadrangle is located in Campbell County in northeastern Wyoming. It encompasses parts of Townships 54 and 55 North, Ranges 74 and 75 West, in Wyoming, and covers the area: 44°37'30" to 44°45' north latitude; 105°45' to 105°52'30" west longitude.

Access to the area is provided by U.S. Highway 14-16 which extends across the north-central part of the quadrangle. Minor roads and trails that branch from this highway provide access to most of the Spotted Horse Quadrangle. Gillette, Wyoming, is 32 miles (52 km) to the southeast on U.S. Highway 14-16. The closest railroad is the Burlington Northern trackage, 11 miles (18 km) to the west at Arvada, Wyoming.

Spotted Horse Creek bisects the quadrangle diagonally as it flows northwestward into the Powder River. Spotted Horse Creek and its tributaries drain most of the area. The valley floor of Spotted Horse Creek, at 3900 feet (1189 m) above sea level, is the lowest elevation in the area. The northern two-thirds of the quadrangle varies from 100 to 200 feet (31 to 61 m) above creek level, and the southern third includes narrow valleys bounded by steep terrain that attains maximum elevations of 4575 feet (1394 m) above sea level. The somber grays, yellows, and browns of outcropping shales and siltstones contrast strikingly with the brilliant reds, oranges, and purples of "clinker", and deep greens of the juniper and pine tree growth.

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 Arvada, Wyoming, average wintertime minimums and summertime maximums approach +5° to +15°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 with the state and federal surface generally leased to ranchers for grazing purposes. Details of surface ownership are available at the 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 ownership comprises both fee and state coal resources.

The Coal Resource Occurrence and Coal Development Potential program focuses upon: 1) the delineation of lignite, subbituminous, bituminous, and anthracite coal at the surface and in the subsurface on federal land; 2) the identification of total tons in place as well as recoverable tons; 3) categorization of these tonnages into measured, indicated, and inferred reserves and resources, and hypothetical resources; and 4) recommendations regarding the potential for surface mining, underground mining and in-situ gasification of the coal beds. This report evaluates the coal resources of all coal beds in the quadrangle which are five feet (1.5 m) or greater in thickness, and which occur at a depth up to 3000 feet (914 m).

Surface and subsurface geological and engineering extrapolations drawn from the current data base suggest the occurrence of approximately 9.8 billion tons (8.9 billion metric tons) of total coal-in-place in the Spotted Horse Quadrangle.

The suite of maps that accompany this report set forth and portray the coal resource and reserve occurrence in considerable detail. For the most part, this report intends to augment the cartographically displayed information with minimum word duplication of said 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 ager, 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 Lebo Member of the Fort Union Formation 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 working 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 member subdivisions 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 a near base level, emerging sea floor. Much of the vast areas 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 expremely 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 within the ancient stream channel system servicing 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 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, in northwestern Campbell County, Wyoming, the contact is positioned near the top of the Roland coal bed as mapped by Olive (1957) 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, and brown to black carbonaceous shales. These sediments are noticeably to imperceptibly coarser than the underlying Fort Union clastics.

The Spotted Horse Quadrangle is located in an area where surface rocks are classified into the Tongue River Member of the Fort Union Formation and the Wasatch Formation. Although the Tongue River Member is reportedly 1200 to 1300 feet (366 to 396 m) thick (Olive, 1957), only 600 to 700 feet (183 to 213 m) 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. Stone and Lupton (1910) named the Felix coal bed, and the Norfolk coal bed was named by Kent (1976). Taff (1909) named the Smith coal bed, and McKay and Maple (1973) named the Swartz coal bed. Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds. The Cook coal bed was named by Bass (1932), and the Pawnee and Cache coal beds were named by Warren (1959). The Oedekoven and Moyer coal beds were informally named by IntraSearch (1978a, 1979).

Local. The Spotted Horse Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Tongue River Member of the Fort Union Formation crops out over the northwest and northeast corners of the quadrangle. The Fort Union Formation is composed of very fine-grained sandstone, siltstone, claystone, shale, carbonaceous shale, and numerous coal beds. The Wasatch Formation crops out over the remainder of the quadrangle, and consists of friable, coarse-grained to gritty arkosic sandstones, fine to very fine-grained sandstones, siltstones, mudstones, claystones, brown to black carbonaceous shales, and coal.

Two small faults with less than 20 feet (6 m) of vertical displacement occur in the southern quarter of the quadrangle, with lateral extents of less than one mile (1.6 km). These faults displace the Felix coal bed outcrop, but do not noticeably alter other coal bed configurations.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from the Spotted Horse coal field Report (Olive, 1957). The coal bed outcrops are adjusted to the current topographic maps in the area.

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. A sparse scattering of subsurface data points are shown on unpublished CRO-CDP maps compiled by the U.S. Geological Survey, and where these data are utilized, the rock-coal intervals are shown on the Coal Data Map (Plate 1). Inasmuch as these drillholes have no identifier headings, they are not set forth on the Coal Data Sheet (Plate 3). IntraSearch cannot obtain geophysical logs of these drill holes to ascertain the accuracy of horizontal location, topographic elevation, and down-hole data interpretation.

The reliability of correlations, set forth by IntraSearch in this report, vary depending upon: 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. The thrust of the IntraSearch intent focuses upon the suggestion of a regional nomenclature 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 Spotted Horse Quadrangle is published by the U.S. Geological Survey, compilation date, 1971. Land ownership data is compiled from land plats obtained from the U.S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

The Felix coal bed is the only Wasatch Formation coal bed that is potentially recoverable in this quadrangle. Fort Union coal beds that are present in all or part of the Spotted Horse Quadrangle include, in descending stratigraphic order, the Norfolk, Smith, Swartz, Anderson, Upper and Lower Canyon, Upper and Lower Cook, Wall, Pawnee, Cache, Moyer, and Oedekoven. A complete suite of maps (structure, isopach, mining ratio, overburden/interburden, identified resources, and areal distribution of identified resources) is prepared for each of these coal beds, except for the Moyer and Oedekoven coal beds where insufficient data precludes detailed mapping.

No physical and chemical analyses are known to have been published regarding the coal beds in the Spotted Horse Quadrangle. However, the general "as received" basis proximate analyses for northern Campbell County, Wyoming coal beds are as follows:

COAL BED NAME		ASH	FIXED CARBON	MOISTURE	VOLATILES	SULPHUR	BTU/LB
Felix	Hole 7345	5.223	34.181	30.280	30.316	0.338	8111
Swartz	Hole 7338	5.713	34.106	31.241	28.940	0.664	7735
Smith (P)		6.440	31.390	35.370	26.800	0.450	7125
Anderson (U)	Hole 7406	6.317	31.113	32.583	29.986	0.327	7498
Canyon (P)		4.290	32.852	35.100	27.758	0.307	7298
Cook (P)		4.620	34.410	33.640	27.330	0.250	7766
Wall (U)	Hole 7426	9.542	29.322	32.150	28.985	0.500	7279
Pawnee (U)	Hole 7424	7.880	31.029	31.910	29.183	0.386	7344
Cache (U)	Hole 741	9.481	30.517	31.420	28.582	0.488	7271

(P) - Proprietary Data
(U) - U.S. Geological Survey & Montana Bureau of Mines & Geology - 1974

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 Canyon coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Wall and Pawnee coal beds are the thickest single coal bed occurrences in this quadrangle. Thicknesses of the Smith, Anderson, Canyon, and Cook coal beds average over 20 feet (6 m) throughout most of the area. The Norfolk, Swartz, Cache, Moyer, and Oedekoven coal beds average 10 feet (3 m) or less over much of the Spotted Horse Quadrangle.

The Felix coal bed is eroded from approximately 75 percent of the quadrangle, and burning is apparent along the outcrop. Thicknesses for the Felix coal bed range from 15 to 28 feet (5 to 9 m) and average 20 feet (6 m). The maximum coal bed thickness, attained in the southern part of the area, attenuates northward. The structure map of the Felix coal bed portrays a gentle westward dip of one to two degrees over most of the area. A northwest-trending syncline and anticline occur in the southeast corner of the quadrangle. Minor faulting vertically displaces the Felix coal bed outcrop approximately 20 feet (6 m) in the southern half of the study area.

The Norfolk coal bed lies 239 to 369 feet (73 to 113 m) beneath the Felix coal bed, and is eroded from approximately 20 percent of the quadrangle. Thicknesses for the Norfolk coal bed range from 4 to 14 feet (1.2 to 4 m) with a zone of thin coal traversing the quadrangle from the southwest corner to the eastern edge. The most prominent structural feature on the Norfolk structure contour map is a west-plunging syncline in the south central part of the area. This syncline is bounded on the north and south by anticlines plunging southwest and west respectively.

From 54 to 112 feet (16 to 34 m) of clastic debris separates the Smith coal bed from the overlying Norfolk coal bed. The Smith coal bed is eroded from approximately 10 percent of the quadrangle. Thicknesses for the Smith coal bed range from 13 to 39 feet (4 to 12 m), and average 30 feet (9 m). The Smith coal bed locally divides into two units separated by non-coal intervals 2 to 13 feet (0.6 to 4 m) thick. An east-west-trending syncline occurs in the northern part of the quadrangle, and a broad east-trending syncline is present in the southwest part of the area. A distinct, west-plunging anticline occurs in the center of the quadrangle. Two closed structural features are present along the southern edge of the study area; one is a structural high and the other is a structural low. A sharp increase in dip is apparent in the southeast corner of the quadrangle adjacent to the closed structural low.

Due to erosion, the Swartz coal bed is absent from 50 percent of the quadrangle. Where it is present, the Swartz coal bed lies 60 to 112 feet (18 to 34 m) beneath the Smith coal bed. Thicknesses for the Swartz coal bed range from 0 to 11 feet (0 to 3 m), and average 5 feet (1.5 m). An increase in degree of dip on the coal bed top occurs in Section 10, T. 54 N., R. 75 W. The Swartz coal bed is absent from the northern, eastern, and southwestern portions of the quadrangle.

The Anderson coal bed is separated from the overlying Swartz coal bed by 10 to 35 feet (3 to 11 m) of clastic sediments. Thicknesses for the Anderson coal bed range from 10 to 42 feet (3 to 13 m), and average 23 feet (7 m). The coal bed thins to the northeast and east. The two most notable structural features on the Anderson coal bed structure contour map are a southwest-plunging anticline traversing the quadrangle from the northeast corner to the west-central edge, and an adjacent syncline which parallels the anticline on the southeast. The Anderson coal bed portrays a westerly dip of approximately one degree.

The Canyon coal bed lies 28 to 205 feet (9 to 63 m) beneath the Anderson coal bed and averages 20 feet (6 m) thick. The Lower Canyon coal bed pinches out along a northwest-trending line that begins in the southeast corner of the quadrangle and continues to the northern portion of the western edge. The Lower Canyon coal bed thickens toward the southwest corner of the study area, and attains a maximum thickness of 30 feet (9 m) in this area. The Upper Canyon coal bed is less than 15 feet (5 m) thick in the southern half of the quadrangle, and thickens to 37 feet (11 m) in the northeastern corner where it is referred to as the Canyon coal bed. Two major west-plunging anticlines are depicted by the Upper Canyon structural contours. These anticlines are separated by an east-plunging syncline. The Lower Canyon structural contours define a northwest-plunging anticline in the west-central part of the quadrangle. The Canyon coal bed splits into the Upper and Lower Canyon coal beds in the southeast corner of the area, with a maximum interburden thickness of 218 feet (66 m).

From 47 to 286 feet (14 to 87 m) of clastic sediments separate the Cook coal bed from the overlying Canyon and Lower Canyon coal beds. The Cook coal bed ranges from 13 to 48 feet (4 to 15 m) in thickness, and averages 26 feet (8 m). The major structural features on this coal bed are a southwest-plunging anticline which traverses most of the quadrangle from the northeast corner to the southwest, and two major synclines which trend northeast through the southern half of the study area. The Cook coal bed has a west to southwesterly dip of approximately one and one-half degrees. In the southwest quadrangle, a non-coal interval divides the Cook coal bed into two units. The thickness of the two coal beds totals less than the average thickness of the single Cook coal bed throughout the remainder of the quadrangle. The interburden between the Upper Cook and Lower Cook coal beds ranges from 2 to 66 feet (0.6 to 20 m).

The Wall coal bed lies 26 to 324 feet (8 to 99 m) beneath the Cook coal bed. Because it converges with the underlying Pawnee coal bed, the two coal beds are mapped together as the Wall-Pawnee coal zone. The structure contour map of the Wall-Pawnee coal zone (Plate 40) is drawn on top of the Wall coal bed. In the northern third of the quadrangle the Wall coal bed dips to the southwest, but in the southern two-thirds, it exhibits a westerly dip. Two major west-plunging synclines are separated by a west-plunging anticline in the southern half of the study area. The isopach map of the Wall-Pawnee coal zone (plate 39) represents the aggregate thickness of the individual coal beds excluding non-coal intervals. The Wall and Pawnee coal beds merge in four locations: Sections 12 and 14, T. 54 N., R. 75 W., Section 29, T. 55 N., R. 74 W., and Section 5, T. 54 N., R. 74 W. The thickness for the Wall-Pawnee coal zone ranges from 37 to 65 feet (11 to 20 m), and averages 49 feet (15 m). Non-coal intervals range from 2 to 94 feet (0.6 to 29 m), but frequently are less than 15 feet (5 m) thick. The Pawnee coal bed divides into two units in the eastern half of the quadrangle, with an average interburden of over 40 feet (12 m).

From 35 to 110 feet (11 to 34 m) of interburden separates the Cache coal bed from the overlying Pawnee coal bed. Thicknesses for the Cache coal bed range from 0 to 12 feet (0 to 4 m), and average 7 feet (2.1 m). The Cache coal bed attains the maximum thickness of 12 feet (4 m) in the southwest corner, thins to the north, and northeast, and pinches out in the northeast corner of the quadrangle.
A south-trending anticline influences the coal bed in the northern area and divides into two prominent south-plunging anticlines separated by a north-trending syncline in the center of the quadrangle. A prominent east-trending syncline occurs in the southwest corner of the study area adjacent to a closed structural high.

V. Geological and Engineering Mapping Parameters

Subsurface mapping is based on geologic data within and adjacent to the Spotted Horse 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 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. Structure contour maps are constructed on the tops of the main coal beds. Where subsurface data is 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 95% recovery factor. Contours on these maps identify the ratio of cubic yards of overburden to tons of recoverable coal. Where ratio controls 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.

Coal tonnage calculations involve the planimetering of areas of measured, indicated, inferred reserves and resources, and hypothetical resources to determine their areal extent in acres. Acres are multiplied by the average coal bed thickness and 1750 or 1770 (the number of tons of lignite A or subbituminous C per acre-foot respectively; 12,874 or 13,018 metric tons per hectare-meter respectively) to determine total tons in place. Recoverable tonnage is calculated at 95% of the total tons in place. North of the Spotted Horse Quadrangle in the Montana portion of the Powder River Basin, a recovery factor of 85 percent is utilized because of the general northward thinning of economic coal beds. 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 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:

$$MR = \frac{t_o \,(0.922)}{t_c \,(rf)}$$

where MR = mining ratio
t_o = thickness of overburden
t_c = thickness of coal
rf = recovery factor
0.922 = conversion factor (cu.yds/ton)*

*Conversion factor of 0.911 is used for subbituminous coal; 0.922 is used for lignite.

A surface mining potential map was prepared utilizing the following mining ratio criteria:

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 surface mining potential is high for most of the Spotted Horse Quadrangle. The Felix, Norfolk, Smith and Anderson coal beds all have a high development potential. The Felix coal bed crops out in high terrain in the southern part of the quadrangle, and its thickness and shallow depth of burial create a high development potential for most of the area. In the northern two-thirds of the quadrangle, the Smith and Norfolk coal beds have a high development potential along the valley walls inside their respective outcrop configurations. Because of its greater thickness, the Smith coal bed has a high development potential over a larger area than the Norfolk coal bed. A high development potential for the Anderson coal bed occurs in the northwest corner of the quadrangle where erosion along Spotted Horse Creek has removed large amounts of overburden. Because of the occurrence of these thick coal beds near the surface, the Spotted Horse Quadrangle has a high development potential for surface mining. 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 Spotted Horse Quadrangle is considered low. 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 a total coal section less than 100 feet (30 m) thick, or coal beds 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 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 on the Spotted Horse Quadrangle is low, hence no CDP map is generated for this map series. The resource tonnage for in-situ gasification with low development potential totals approximately 6.8 billion tons (6.2 billion metric tons)(Table 3). None of the coal beds in the Spotted Horse 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 Spotted Horse Quadrangle, Campbell 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
Felix	306,430,000	11,820,000	-	318,250,000
Norfolk	179,580,000	76,310,000	63,880,000	319,770,000
Smith	890,610,000	279,810,000	119,240,000	1,289,660,000
Swartz	-	10,970,000	11,480,000	22,450,000
Anderson	37,750,000	233,400,000	365,010,000	636,160,000
Canyon	-	42,030,000	162,950,000	204,980,000
Cook	-	-	-	-
Wall-Pawnee	-	-	-	-
Cache	-	-	-	-
TOTAL	1,414,370,000	654,340,000	722,560,000	2,791,270,000

Table 2.--Coal Resource Base Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Spotted Horse Quadrangle, Campbell County, Wyoming

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Felix	-	-	-	-
Norfolk	-	-	10,470,000	10,470,000
Smith	-	-	233,640,000	233,640,000
Swartz	-	-	76,280,000	76,280,000
Anderson	-	-	639,580,000	639,580,000
Canyon	-	-	1,239,170,000	1,239,170,000
Cook	-	-	1,562,730,000	1,562,730,000
Wall-Pawnee	-	-	2,712,810,000	2,712,810,000
Cache	-	-	349,640,000	349,640,000
TOTAL	-	-	6,824,320,000	6,824,320,000

Table 3.--Coal Resource Base Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Spotted Horse Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Felix	-	-	-	-
Norfolk	-	-	10,470,000	10,470,000
Smith	-	-	233,640,000	233,640,000
Swartz	-	-	76,280,000	76,280,000
Anderson	-	-	639,580,000	639,580,000
Canyon	-	-	1,239,170,000	1,239,170,000
Cook	-	-	1,562,730,000	1,562,730,000
Wall-Pawnee	-	-	2,712,810,000	2,712,810,000
Cache	-	-	349,640,000	349,640,000
TOTAL	-	-	6,824,320,000	6,824,320,000

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