UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

BLACK DRAW QUADRANGLE

CAMPBELL COUNTY, WYOMING

AND

POWDER RIVER COUNTY, MONTANA

REVISED TEXT, OCTOBER 1980

BY

INTRASEARCH INC.

ENGLEWOOD, COLORADO

OPEN-FILE REPORT 78-065
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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

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 Black Draw Quadrangle, Campbell County, Wyoming, and Powder River County, Montana. This CRO and CDP map series includes 39 plates (U. S. Geological Survey Open-File Report 78-065). 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 Black Draw Quadrangle is located on the Wyoming-Montana border in Campbell County, Wyoming, and Powder River County, Montana. It encompasses all or parts of Townships 57 and 58 North, Ranges 75 and 76 West, in Wyoming, and Township 9 South, Range 47 East, in Montana, and covers the area: 44°52'30" to 45°00 north latitude; 105°52'30" to 106°00' west longitude.

A maintained gravel road provides access to the Black Draw Quadrangle where it parallels the Powder River. Minor roads and trails that branch from this gravel road constitute an avenue of access to much of the area. The Powder River Road extends northeastward to Broadus, Montana, and to the south it joins U. S. Highway 14-16 adjacent to its crossing of the Powder River between Gillette and Sheridan, Wyoming.

The closest railroad is the Burlington Northern trackage, 15 miles (24 km) to the south at Leiter, Wyoming.

The Powder River flows northeastward through the north-central part of the quadrangle, and its valley floor is approximately 3,440 feet (1,049 m) above sea level. Fence Creek is tributary to the Powder River from the west, and drains fairly rugged terrain that attains elevations 700 feet (213 m) above river level. LX Bar Creek and SA Creek flow northwestward to join the Powder River in the central part of the quadrangle. 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 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 approach +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 Campbell County Courthouse in Gillette, Wyoming, and the Powder River County Courthouse in Broadus, Montana. 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 3.7 billion tons (3.4 billion metric tons) of total, unleased federal coal-in-place in the Black Draw Quadrangle.

The suite of maps that accompanies this report sets forth and portrays the coal resource 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 Black Draw Quadrangle is located in an area where surface rocks are classified into the Tongue River Member of the Fort Union Formation, except for small occurrences of basal Wasatch Formation

sediments on SA Peak, sections 29 and 30, T. 57 N., R. 75 W., and Tucker-Ross Flats, sections 27 and 34, T. 57 N., R. 76 W. Although the Tongue River Member is reportedly 1,200 to 1,300 feet (366 to 396 m) thick (Olive, 1957), only 700 to 800 feet (213 to 244 m) are exposed in this area. 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, where possible, the coal bed nomenclature used in previous reports. The Smith and Dietz No. 1 coal beds were named by Taff (1909). Baker (1929) assigned names to the Anderson, Canyon, and Wall coal beds. The Cook coal bed was named by Bass (1932), and the Pawnee coal bed was named by Warren (1959).

Local. The Black Draw Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. Except for minor Wasatch occurrences, the Tongue River Member of the Fort Union Formation crops out over the entire quadrangle. The Fort Union Formation is composed of very fine-grained sandstone, siltstone, claystone, shale, carbonaceous shale, and numerous coal beds.

Faults shown on the Black Draw Quadrangle are derived from the work of Olive (1957). Most of the faults develop minor displacement where they offset coal beds. The configuration of structural contours on the top of the Upper Canyon coal bed, plate 15, indicates 90 feet (27 m) of displacement on a northeast-trending fault in section 34, T. 58 N., R. 76 W. The magnitude of this displacement may be excessive

due to reconciliation of widely spaced subsurface structural control with structural elevations interpolated from Olive (1957) outcrop patterns adjusted to the recent U. S. Geological Survey topographic map compiled in 1971 .

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from the Spotted Horse coal field report (Olive, 1957). Coal bed correlations between Olive's Spotted Horse coal field publication and the Moorhead coal field publication (Bryson and Bass, 1973) are difficult due to the paucity of subsurface control and the difference in coal bed nomenclature between the two publications. The following table sets forth the coal bed nomenclature relationship between the Black Draw Quadrangle that relates to Olive's work, and the Bradshaw Creek Quadrangle, Montana, just north of the Black Draw Quadrangle, that utilizes Bryson and Bass' publication.

Black Draw Quadrangle	Bradshaw Creek Quadrangle
Anderson	Anderson west of Powder River and Canyon east of Powder River
Dietz No. 1	Dietz west of Powder River
Upper Canyon	Canyon west of Powder River and Upper Cook east of Powder River
Lower Canyon	Upper Cook west of Powder River and Lower Cook east of Powder River
Cook	Lower Cook and 5 west of Powder River and 4b and 5 east of Powder River
Wall	Pawnee
Pawnee	Cache

The coal bed outcrops are adjusted to the current topographic maps in the area.

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 Blaw Draw Quadrangle is published by the U. S. Geological Survey, compilation date 1971. 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 Black Draw Quadrangle include, in descending stratigraphic order: the Anderson, Dietz No. 1, Upper Canyon, Lower Canyon, Cook, Wall, and Pawnee. 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, is prepared for each of these coal beds.

No physical or chemical analyses are known to have been published regarding the coal beds in the Black Draw Quadrangle. For northern Campbell County, Wyoming and southern Powder River County, Montana 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		
Anderson (U)	Hole 746	6.3	31.1	32.6	30.0	0.33	7498	8045	Lignite A
Canyon (U)	Hole 744	4.3	32.9	35.1	27.8	0.31	7298	7650	Lignite A
Cook (**)	Hole SH-64	3.1	36.2	30.8	29.9	0.15	7948	8223	Lignite A
Wall (U)	Hole 7426	9.5	29.3	32.2	29.0	0.50	7279	8108	Lignite A
Pawnee (U)	Hole 7424	7.9	31.0	31.9	29.2	0.39	7344	7674	Lignite A

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

** Matson, R. E., and Blumer, J. W. (1973).

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

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 Cook coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Anderson, Dietz No. 1, and Upper Canyon coal beds have been eroded from a major part of the Black Draw Quadrangle, and are extensively burned thoughout. The older the coal bed in this area, the less removal by erosion. CRO mapping of the Dietz No. 1 coal bed is restricted to the northwest corner of the quadrangle due to insufficient data throughout the remainder of the area.

The Anderson coal bed is eroded from more than 60 percent of the quadrangle and occurs in high terrain in the northwest, east-central, southeast, and southwest parts of the area. Coal bed thickness control is sparse; however, the existing data suggest the Anderson to range in thickness from 15 to 35 feet (5 to 11 m). Structural control on the top of the Anderson bed is also sparse; however, the projected contouring at the top of the Anderson appears to define a broad, synclinal axis plunging to the southwest in the central portion of the quadrangle. The Anderson coal bed attains a maximum depth of burial of 360 feet (110 m).

The Dietz No. 1 coal bed is restricted to the northwestern part of the Black Draw Quadrangle where the coal is approximately 100 feet (30 m) beneath the Anderson coal bed and appears to thin from a maximum of 8 feet (2.4 m) in the west to a pinchout line that exhibits a northeast-southwest trend across the northwest part of the area. Although

outcrop elevations show a rather gentle dip to the Dietz No. 1 coal bed in this part of the quadrangle, faulting, as well as synclinal folding, influence the steep degree of dip in the extreme northwest corner of the quadrangle. The Dietz No. 1 coal bed occurs from 0 to 280 feet (0 to 85 m) beneath the surface.

The Upper Canyon coal bed, 125 to 330 feet (38 to 100 m) beneath the Anderson coal bed, has been eroded from the valley of the Powder River and its principal tributaries in the Black Draw Quadrangle. The coal has burned extensively at the outcrop; however, unburned coal appears to be present throughout approximately 50 percent of the quadrangle. The Upper Canyon coal bed ranges in thickness from 10 feet (3 m) in the southern part of the quadrangle to more than 24 feet (7 m) in the northwestern corner of the area. A broadly defined coal thick trends north-south through the central part of the quadrangle, and is somewhat coincident with a synclinal axis of north-south to northeast trend in the south-central part of the quadrangle. The Upper Canyon coal bed exhibits minimal structural relief throughout most of the quadrangle; however, on the northwest flank of a northeast-southwest trending anticline in the northwestern corner of the area, the degree of dip increases dramatically to more than 160 feet (49 m) per mile. The Upper Canyon coal bed varies in depth from 0 to 530 feet (0 to 162 m).

The Lower Canyon coal bed is eroded from the lower reaches of the Powder River valley; however, it occurs throughout more than 70

percent of the Black Draw Quadrangle. The Lower Canyon coal bed ranges from a maximum thickness in excess of 14 feet (4 m) in the western part of the quadrangle to less than 8 feet (2.4 m) in the central and northern parts of the quadrangle, and is separated from the Upper Canyon coal bed by 167 feet (51 m) of clastics in section 2, T. 57 N., R. 76 W. The coal bed folds into a sinuous, south-plunging syncline that bisects the quadrangle. A closed anticline is located parallel and west of the syncline. Flank dips are less than 1 degree. The degree of dip increases in the northwestern part of the quadrangle where dips from 1 to 2 degrees in magnitude exist. The Lower Canyon coal bed ranges in depth from 0 to 730 feet (0 to 223 m).

The Cook coal bed underlies the entire Black Draw Quadrangle, and constitutes one of the principal coal resources in the total coal section. The Cook coal bed ranges from 11 feet (3 m) in thickness in the northern part of the quadrangle to more than 30 feet (9 m) along a maximum coal thickness, the axis of which trends generally west-northwestward through the central part of the area. Clastics ranging in thickness from 115 to 210 feet (35 to 64 m) separate the Lower Canyon and Cook coal beds. Structural configurations on the top of the Cook coal bed define a major south-plunging syncline and a closed syncline located in approximately the same positions as the previously discussed syncline on the Lower Canyon coal bed. Shallow dips less than 1 degree in magnitude are typical of structural relief throughout most of the area, however, steep dips

occur in the northwestern corner of the quadrangle. The overburden above the Cook coal bed ranges in thickness from 0 to 940 feet (0 to 287 m).

The Wall coal bed underlies the Black Draw Quadrangle in its entirety, and ranges from less than 5 feet (1.5 m) in thickness in the west-central and northern parts of the area to 23 feet (7 m) in the southeast quarter. The axis of the maximum coal thickness in the central part of the quadrangle is semiparallel to, and slightly displaced from the axis of the overlying Cook coal bed maximum thickness. The Wall coal bed underlies the Cook coal bed from 56 feet (17 m) to 164 feet (50 m). Structure on the top of the Wall coal bed defines a major southwest-plunging syncline that approximately underlies synclines on overlying coal beds. The degree of dip on the Wall coal bed increases from southeast to northwest. From 20 to 1,020 feet (6 to 311 m) of overburden overlie the Wall coal bed.

The Pawnee coal bed, the lowest coal bed of widespread occurrence in this quadrangle, ranges from 5 feet (1.5 m) in thickness in the southwest part of the Black Draw Quadrangle to more than 22 feet (7 m) in the central part of the quadrangle. The axis of the maximum coal thickness is positioned approximately beneath the axes of coal maximums in the overlying Wall and Cook coal beds. From 30 to 99 feet (9 to 30 m) of sediments separate the overlying Wall coal bed from the Pawnee coal bed, which is split into upper and lower members by clastics ranging in thickness from 0 to 50 feet (0 to 15 m). The structural configurations

drawn on the top of the Pawnee coal bed are somewhat similar to folds expressed on overlying coal seams in that a major syncline dominates structure in the central part of the quadrangle and the degree of dip and fold contortion increase toward the northwest corner of the quadrangle. The overburden above the Pawnee coal bed ranges from 140 to 1,140 feet (43 to 347 m) in thickness.

A few local coal beds are shown beneath the Pawnee coal bed on the Coal Data Sheet, plate 3; however, the data are too minimal to allow correlation with pre-Pawnee coal beds occurring in quadrangles to the south.

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 Black Draw 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 measured sections where there is sparse subsurface control. Where coal isopach contours do not honor surface measured sections, the surface thicknesses are thought to be attenuated by oxidation and/or erosion: hence, they are 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 projection 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 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 surface mining development potential is high for approximately 80 percent of the quadrangle. These high development potential areas relate to the valleys of the Powder River and SA, LX Bar, and Fence Creeks that cut deeply into the Tongue River Member of the Fort Union Formation on Black Draw Quadrangle. The lower coal beds in the Tongue River Member, the Cook, Wall, and Pawnee coal beds, underlie these valleys at shallow depths less than 500 feet (152 m) in magnitude. Conversely, the inter-drainage, high, mesa-like terrain is underlain by the upper suite of coal beds in the Tongue River Member; the Smith, Anderson and Upper and Lower Canyon coal beds. These coal beds are less than 500 feet (152 m) beneath the surface and justify the high development potential for surface mining in this rugged terrain. Scattered areas of moderate development potential cover approximately 8 percent, and low development potential covers approximately 2 percent of the quadrangle. The remaining 10 percent of the study area is non-federal coal land. Table 1 sets forth the strippable reserve tonnages per coal bed for this quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining development potential throughout the Black Draw 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 the Black Draw 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 996,980,000 tons (904,460,260 metric tons - table 3). None of the coal beds in the Black Draw Quadrangle qualify for a moderate or high development potential rating for "in-situ" development.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Black Draw Quadrangle, Campbell County, Wyoming, and Powder River County, Montana.

[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				
Anderson	101,490,000	7,910,000	1,940,000	111,340,000
Dietz	15,050,000	6,390,000	6,740,000	28,180,000
Upper Canyon	412,930,000	50,260,000	36,810,000	500,000,000
Lower Canyon	115,980,000	107,380,000	193,230,000	416,590,000
Cook	250,950,000	327,420,000	313,540,000	891,910,000
Wall	22,310,000	41,300,000	349,540,000	413,150,000
Pawnee	-	9,470,000	190,230,000	199,700,000
Total	918,710,000	550,130,000	1,092,030,000	2,560,870,000
Hypothetical Resources				
Upper Canyon	-	-	700,000	700,000
Total	-	-	700,000	700,000
GRAND TOTAL	918,710,000	550,130,000	1,092,730,000	2,561,570,000

Table 2.--Coal Reserve Base Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Black Draw Quadrangle, Campbell County, Wyoming, and Powder River County, Montana.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Lower Canyon	-	-	11,790,000	11,790,000
Cook	-	-	195,380,000	195,380,000
Wall	-	-	311,260,000	311,260,000
Pawnee	-	-	478,550,000	478,550,000
TOTAL	-	-	996,980,000	996,980,000

Table 3.--Coal Reserve Base Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Black Draw Quadrangle, Campbell County, Wyoming, and Powder River County, Montana.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Lower Canyon	-	-	11,790,000	11,790,000
Cook	-	-	195,380,000	195,380,000
Wall	-	-	311,260,000	311,260,000
Pawnee	-	-	478,550,000	478,550,000
TOTAL	-	-	996,980,000	996,980,000

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