

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

FOUR BAR J RANCH QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-046
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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 Four Bar J Ranch Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-046) includes 55 plates. 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 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 Four Bar J Ranch Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses parts of Townships 48 and 49 North, Ranges 73 and 74 West, and covers the area: 44°07'30" to 44°15' north latitude; 105°37'30" to 105°45' west longitude.

Main access to the Four Bar J Ranch Quadrangle is provided by Interstate Highway 90 which extends east to west across the northern edge of the study area. A paved highway (Four J Road) extends northeast to southwest across the southern half of the quadrangle. Numerous gravel roads, minor roads and trails provide additional access to the more remote areas of the quadrangle. The closest railroad is the Burlington Northern trackage, 4 miles (6.4 km) to the north, near Gillette, Wyoming.

The primary drainage is provided by eastward-flowing Bluegate Creek which crosses the southern half of the Four Bar J Ranch Quadrangle, draining into the Belle Fourche River to the east. Significant drainage is also provided by northward-flowing Wild Horse Creek which flows through the northwest quarter of the study area, eventually draining into the

Powder River to the north. Bone Pile Creek, Benner Draw, Red Top Draw, and other intermittent streams supplement the drainage throughout the quadrangle. Elevations attain heights of 5140 feet (1567 m) in the southwest quarter of the quadrangle, 500 to 600 feet (152 to 183 m) above the valley floors. 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 12 to 14 inches (30 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 Gillette, Wyoming, average wintertime minimums and summertime maximums range from +5° to +15°F (-15° to -9°C) and 75° to 90°F (24° to 32°C), respectively.

Surface ownership is divided among fee, state, and federal categories with the state and federal surface generally leased to ranchers for grazing purposes. Details of surface ownership are available at the 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 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, as well as recoverable tons. These coal

tonnages are then categorized into units of measured, indicated, and inferred 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 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 9.5 billion tons (8.6 billion metric tons) of unleased federal coal resources in the Four Bar J Ranch Quadrangle.

The suite of maps that accompany 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 3000 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 Mountains 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 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 (Denson and Horn, 1975). The Lebo Member is mapped at the surface northeast of Recluse, Wyoming. Here, 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 the 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 members 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 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 delicate 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 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 descend disconformably 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 was 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 noticeably to imperceptibly coarser than the underlying Fort Union clastics.

The Four Bar J Ranch Quadrangle is located in an area where surface rocks are classified as part of the Wasatch Formation. 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. The Felix coal bed was named by Stone and Lupton (1910). The Ulm and Smith 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). The Wildcat, Moyer and Oedekoven coal beds were informally named by IntraSearch (1978b, 1979, and 1978a).

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

Wyodak coal bed south and southwest of Gillette suggests that the Anderson and Canyon coal beds equate with the upper 10 to 25 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.

Local. The Four Bar J Ranch Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out over the entire quadrangle, and is comprised of friable, coarse-grained to gritty, arkosic sandstones, brown-to-black carbonaceous shales, and coal beds. The Fort Union Formation unconformably underlies the Wasatch Formation, and is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds.

Structure contours drawn on top of the various coal beds and coal zones indicate a regional dip to the west-northwest showing a broad westward-plunging anticline extending across the northern portion of the quadrangle. A smaller similarly trending syncline is present along the southern third of the study area.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from Waring (1976).

Geophysical logs from oil and gas test bores and producing wells comprise 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 are scanned to select those with data applicable to Coal Resource Occurrence mapping. Paper copies of the logs are obtained and interpreted, and coal intervals are 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 drill holes have no identifier headings, they are not set forth on the Coal Data Sheet (Plate 3). The geophysical logs of these drill holes were not available to IntraSearch to ascertain the accuracy of horizontal location, topographic elevation, and downhole data interpretation.

The reliability of correlations, set forth by IntraSearch in this report, varies 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 Four Bar J Ranch 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

Wasatch and Fort Union Formation coal beds that are present in all or part of the Four Bar J Ranch Quadrangle include, in descending stratigraphic order: the Ulm, local, local, Felix, Smith, Anderson, Canyon, Cook, Upper Wall, Lower Wall, Pawnee, Wildcat, local, Moyer, Oedekoven, and local coal beds. A complete suite of maps (coal isopach, mining ratio, where applicable, structure, overburden/interburden isopach, areal distribution of identified resources and identified resources) was prepared for each of these coal beds, except for the local coal beds, where insufficient data, thickness, and areal extent preclude detailed mapping.

No physical and chemical analyses are known to have been published regarding the coal beds in the Four Bar J Ranch Quadrangle. However, the proximate analyses performed on a general "as received" basis for Campbell

and Converse County coal beds are as follows:

COAL BED NAME			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Ulm	(U)	Hole 7331	8.224	30.181	31.753	29.842	1.807	7524
Felix	(U)	Hole 7335	7.384	33.777	26.162	32.670	0.797	8538
Smith	(U)	Hole 7340	3.505	38.036	29.980	28.474	0.309	8371
Anderson	(U)	Hole 7310	5.852	33.938	29.060	31.150	0.435	8172
Canyon	(U)	Hole 7310	5.852	33.938	29.060	31.150	0.435	8172
Cook	(U)	Hole 7310	5.852	33.938	29.060	31.150	0.435	8172
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
(Wildcat) "D"	(*)	Sample 11447	4.3	29.4	27.8	29.4	0.27	8410

(*) - Winchester, 1912

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

The Coal Data Sheet, Plate 3, shows the down hole identification of coal beds within the quadrangle as interpreted from geophysical logs from oil and gas test bores and producing sites. A datum coal bed is utilized to position columnar sections on Plate 3. 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 Anderson coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagrams.

The Ulm coal bed has been eroded from approximately 85 percent of the quadrangle, and is present primarily at the higher elevations of the western half of the study area. The coal bed lies from 0 to 190 feet (0 to 58 m) beneath the surface in the quadrangle, and ranges in thickness from less than 5 to 20 feet (1.5 to 6 m). Maximum thicknesses occur along

the southwestern edge of the quadrangle, with thinning to the east.

Structure contours drawn on top of the Ulm coal bed indicate a regional northwest dip showing minor anticlinal and synclinal features.

The Felix coal bed occurs 400 to 550 feet (122 to 168 m) below the Ulm coal bed, and ranges in thickness from 23 to 42 feet (7 to 13 m). Thicker coal occurs in the southeast quarter of the study area and extends northward into the central portion of the quadrangle. The Felix coal bed is locally absent, probably due to erosion and replacement of the coal by channel sandstones. Structure contours drawn on top of the Felix coal bed indicate a regional westward dip showing a small narrow, westward-plunging anticline in the northern half of the study area. The Felix coal bed lies from less than 200 feet (61 m) to greater than 500 feet (152 m) beneath the surface throughout the quadrangle.

The Smith coal bed lies 303 to 322 (92 to 98 m) beneath the Felix coal bed. The Smith coal bed thickness ranges from 0 to 22 feet (0 to 7 m) with maximum thicknesses extending northeast to southwest across the northern two-thirds of the study area. The coal bed thins to the south and is absent from 6 percent of the quadrangle, primarily in the southeastern corner. Structure contours drawn on top of the Smith coal bed indicate a broad westward-plunging anticline extending across the central portion of the quadrangle. The Smith coal bed is buried from less than 500 feet (152 m) to more than 1000 feet (305 m) beneath the surface of the quadrangle.

The Anderson coal bed occurs 76 to 333 feet (23 to 102 m) below the overlying Smith coal bed. The thickness of the Anderson coal bed ranges from 30 to 71 feet (9 to 22 m) with thickest occurrences extending north to south throughout the eastern half of the quadrant. A clastic interval locally separating the Anderson coal bed into Upper and Lower

Anderson coal beds varies from 0 to 229 feet (0 to 70 m). Structure contours drawn on top of the Anderson coal bed indicate a rolling surface with folds plunging northward, westward and southward from a central high. The Anderson coal bed lies less than 1000 feet (305 m) to more than 1250 feet (381 m) beneath the surface of the entire quadrangle.

The Canyon coal bed occurs 14 to 220 feet (4 to 67 m) below the Anderson coal bed, and ranges in thickness from 0 to 20 feet (0 to 6 m). Maximum thicknesses occur in the southeast quarter, extending northward throughout the eastern half of the quadrangle. The coal bed thickness thins to the west and is absent from approximately 13 percent of the quadrangle primarily in the southwest quarter. Structure contours drawn on top of the Canyon coal bed indicate a regional westward dip showing minor anticlinal and synclinal features in the northern half of the quadrangle. The Canyon coal bed lies less than 1000 feet (305 m) to greater than 1500 feet (457 m) beneath the surface throughout the quadrangle.

The Cook coal bed lies 61 to 140 feet (19 to 43 m) below the Canyon coal bed. The Cook coal bed thickness ranges from 0 to 25 feet (0 to 8 m) with maximum thicknesses occurring in the southwest quarter. The coal bed thins to the northeast and is absent from approximately 28 percent of the quadrangle, primarily in the eastern half. Structure contours drawn on top of the Cook coal bed indicate gentle westward dip with local structural variations across the northern two-thirds of the study area. A west-plunging syncline is present in the southern third of the quadrangle. The Cook coal bed lies from less than 1250 feet (381 m) to 1500 feet (457 m) beneath the surface of the quadrangle.

The Wall coal zone occurs 14 to 200 feet (4 to 61 m) below the Cook coal bed, and is comprised of two thin, lenticular coal beds. The total coal zone thickness ranges from 0 to 40 feet (0 to 12 m) with maximum thicknesses occurring in the southwest quarter of the quadrangle. The Wall coal zone is absent from approximately 13 percent of the quadrangle in the north-central portion of the study area. The clastic interval separating the two coal beds comprising the coal zone varies from 37 to 65 feet (11 to 20 m). Structure contours drawn on top of the Wall coal zone indicate a broad westward-plunging anticline extending across the central portion of the quadrangle and a similarly trending syncline extending across the southern part of the quadrangle. The Wall coal zone lies from less than 1250 feet (381 m) to greater than 1750 feet (533 m) beneath the surface of the quadrangle.

The Pawnee coal bed lies 66 to 183 feet (20 to 56 m) below the Wall coal zone, and ranges in thickness from 8 to 40 feet (2.4 to 12 m). Maximum thicknesses radiate from the west-central portion of the quadrangle and thins to the north, east, and south. A non-coal interval locally separates the Pawnee into two coal beds and varies in thickness from 0 to 116 feet (0 to 35 m). Structure contours drawn on top of the Pawnee coal bed indicate a regional westward dip showing minor structural anomalies. The Pawnee coal bed lies less than 1500 feet (457 m) to greater than 1750 feet (533 m) beneath the surface of the entire quadrangle.

The Wildcat-Moyer coal zone occurs 186 to 394 feet (57 to 120 m) beneath the Pawnee coal bed, and is comprised of two thin, somewhat lenticular coal beds. The total coal zone thickness ranges from 4 to 25 feet (1.2 to 8 m) with maximum thickness occurring in the southwestern edge of the quadrangle, and with thinner coal concentrated in the central part. The clastic interval separating the various coal beds comprising

the coal zone varies from 35 to 164 feet (11 to 50 m). Structure contours drawn on top of the Wildcat coal bed indicate a regional westward dip with a broad anticline plunging northeast to southwest across the northern half, and a northwest to southeast-trending syncline extending across the southern half of the quadrangle. The Wildcat-Moyer coal zone lies from less than 1500 feet (457 m) to greater than 2000 feet (610 m) beneath the surface of the quadrangle.

The Upper-Lower Oedekoven coal zone lies 124 to 235 feet (38 to 72 m) below the Moyer coal bed, and is comprised of two thin, lenticular coal beds. The total coal zone thickness varies from 0 to 20 feet (0 to 6 m) with thickest occurrences located along the eastern boundary of the study area. Both coal beds are absent from the majority of the western half of the quadrangle. The clastic interval separating the coal beds of the coal zone varies from 63 to 113 feet (19 to 34 m). Structure contours drawn on top of the Upper Oedekoven and Lower Oedekoven coal beds indicate a gentle westward dip with local structural anomalies. The Oedekoven coal zone lies from less than 2000 feet (610 m) to 2500 feet (762 m) beneath the surface of 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 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 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 Four Bar J Ranch 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, 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 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. 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 1750, or 1770--the number of tons of lignite A or sub-bituminous C coal 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 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 complexly 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 54) was 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 are utilized for coal beds greater

than 40 feet (12 m) thick:

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

The surface mining development potential is high for approximately 40 percent of the Four Bar J Ranch Quadrangle. This high potential rating is attributed to low overburden to coal ratios for the Ulm and Felix coal beds. It occurs in areas of shallow coal bed occurrence, such as the Ulm coal bed in the southwest quarter of the quadrangle. High development potential also occurs in areas where erosion has decreased the overburden thickness overlying the Felix coal bed, primarily along the significant valleys throughout the quadrangle. A moderate development potential rating covers approximately 45 percent of the quadrangle primarily in the east-central area, and is attributed to increasing overburden-to-coal ratios for the Ulm and Felix coal beds. The low potential rating covers less than 5 percent of the quadrangle in localized areas where high overburden-to-coal ratios for the Ulm, Felix and Smith coal beds exist in the northwest and southwest portions of the study area. The remainder of the quadrangle is classified as non-federal coal land or as having no potential for surface mining.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Four Bar J Ranch 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 1000 feet (305 m) to 3000 feet (914 m) beneath the surface, or 2) a coal bed or coal zone 5 feet (1.5 m) or more in thickness which lies 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).

An in-situ gasification development potential map (Plate 55) was constructed using the above criteria. The coal development potential for in-situ gasification is moderate for approximately 50 percent of the quadrangle, primarily throughout the southern half. A low potential rating covers approximately 45 percent of the quadrangle, chiefly in the northern half of the study area. The remaining 5 percent is classified as non-federal coal land and not evaluated for in-situ gasification development. None of the Four Bar J Ranch Quadrangle qualifies for a high development potential for in-situ gasification. The coal resource tonnage totals for in-situ gasification with moderate and low development potentials are listed on Table 3.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Four Bar J Ranch 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
Ulm	92,010,000	8,810,000	3,620,000	104,440,000
Felix	361,210,000	902,890,000	26,370,000	1,290,470,000
Smith	-----	-----	12,550,000	12,550,000
TOTAL	453,220,000	911,700,000	42,540,000	1,407,460,000

Table 2.--Coal Resource Base and Hypothetical Resource Data (in short tons)
for Underground Mining Methods for Federal Coal Lands in the Four
Bar J Ranch Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
<u>RESOURCE BASE</u>				
Felix	-----	-----	369,730,000	369,730,000
Smith	-----	-----	782,140,000	782,140,000
Anderson	-----	-----	2,904,550,000	2,904,550,000
Canyon	-----	-----	583,680,000	583,680,000
Cook	-----	-----	387,290,000	387,290,000
Wall	-----	-----	572,660,000	572,660,000
Pawnee	-----	-----	1,592,530,000	1,592,530,000
Wildcat-Moyer	-----	-----	499,690,000	499,690,000
Oedekoven	-----	-----	329,060,000	329,060,000
TOTAL	-----	-----	8,021,330,000	8,021,330,000
<u>HYPOTHETICAL RESOURCE</u>				
Felix	-----	-----	1,090,000	1,090,000
GRAND TOTAL	-----	-----	8,022,420,000	8,022,420,000

Table 3.--Coal Resource Base and Hypothetical Resource Data (in short tons)
for In-Situ Gasification for Federal Coal Lands in the Four Bar J
Ranch Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESOURCE BASE	-----	3,126,350,000	4,894,980,000	8,021,330,000
HYPOTHETICAL RESOURCE	-----	-----	1,090,000	1,090,000
TOTAL	-----	3,126,350,000	4,806,070,000	8,022,420,000

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