UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

LASKIE DRAW QUADRANGLE,

JOHNSON AND CAMPBELL COUNTIES, WYOMING

BY

INTRASEARCH INC.

ENGLEWOOD, COLORADO

OPEN FILE REPORT 79-175
1980

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

MAPS | PLATES

TABLE OF CONTENTS (continued)

MAPS | PLATES

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 Laskie Draw Quadrangle, Johnson and Campbell Counties, Wyoming. This CRO and CDP map series includes 45 plates (U. S. Geological Survey Open-File Report 79-175). 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 Laskie Draw Quadrangle is located in Johnson and Campbell Counties in northeastern Wyoming. It encompasses all or parts of Townships 48 and 49 North, Ranges 76 and 77 West, and covers the area: 44°07'30" to 44°15' north latitude; 106°00' to 106°07'30" west longitude.

Main access to Laskie Draw Quadrangle is provided by Interstate Highway 90 which extends east-to-west across the northern portion of the study area. A maintained gravel road (Schoonover Road) extends east-to-west across the southern part of the quadrangle. Minor roads and trails branch from these maintained roads and provide access to the more remote areas. The closest railroad is the Burlington Northern trackage approximately 14 miles (23 km) to the northeast near Echeta, Wyoming.

Primary drainage is provided by westward-flowing Dead Horse Creek in the northern half of the quadrangle, and by Van Houten Draw and Burger Draw in the southern portion of the study area. These intermittent streams flow westward and are part of the Powder River drainage system. Minor streams supplement this drainage throughout the quadrangle. Elevations attain heights of 4,740 feet (1,445 m) above sea level in the southeast quarter of the quadrangle, where hills rise 700 to 750 feet (213 to 229 m) above the valley floors.

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

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

The Coal Resource Occurrence and Coal Development Potential program pertains to unleased federal coal and focuses upon the delineation of lignite, subbituminous coal, bituminous coal, and anthracite at the surface, and in the subsurface. In addition, the program identifies total tons of coal in place (resources), as well as recoverable tons (reserves). These coal tonnages are then categorized in measured, indicated, and inferred parts of identified 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 12.7 billion tons (11.5 billion metric tons) of total, unleased federal coal-in-place resources in the Laskie 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 overlying 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 Laskie Draw Quadrangle is located in an area where surface rocks are classified within the Wasatch Formation. Although the Wasatch Formation is reportedly up to 1,800 feet (549 m) thick (Denson and Horn, 1975), Olive (1957) mapped 700 to 800 feet (213 to 244 m). Only 700 to 750 feet (213 to 229 m) of Wasatch Formation are exposed in the quadrangle. Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the northward extension of the Sheridan coal field, Montana (Baker, 1929), and Gillette coal field, Wyoming (Dobbin and Barnett, 1927), and with coal beds in the Ashland coal field (Bass, 1932) in southeastern Montana. This report utilizes, where possible, the coal bed nomenclature used in previous reports.

The Felix coal bed was named by Stone and Lupton (1910). Taff (1909) named the Smith coal bed, and the Wall coal bed was named by Baker (1929). The Pawnee coal bed was named by Warren (1959). IntraSearch (1978b, 1979, 1978a) informally assigned names to the Wildcat, Moyer, and Oedekoven coal beds.

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 and Canyon coal beds (Baker, 1929), and all, or part, of the Cook (Bass, 1932) and Wall coal beds to the north and west of Gillette Wyoming. The Wyodak coal zone of the Laskie Draw Quadrangle is equivalent to the Anderson, Canyon and Cook coal beds in Somerville Flats East Quadrangle to the north and Morgan Draw Quadrangle to the east. The Lower Wall coal bed in Laskie Draw Quadrangle is equivalent to the Wall coal zone to the north in Somerville Flats East Quadrangle, and to the Wall coal bed to the west in Juniper Draw Quadrangle. This coal bed correlates to the Lower Wall coal bed of the Wall coal zone to the east in Morgan Draw Quadrangle, and to the Wall coal bed to the south in the Negro Butte Quadrangle. Due to problematic correlations outside the Gillette area, the Wyodak has been informally used by previous authors to represent coal beds in the area surrounding the Wyodak coal mine.

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

The dominant structural feature present within the quadrangle is a northwest-plunging anticline in the southern portion of the study area. The thicker coal beds are warped into a synclinal feature in the northern half of Laskie Draw Quadrangle.

III. Data Sources

No significant coal outcrops or associated clinker in the Laskie Draw Quadrangle are mentioned in any known publications at the time of this report. It is possible that no significant coal outcrops or associated clinker exist in the Laskie Draw Quadrangle.

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 Laskie Draw Quadrangle is published by the U. S. Geological Survey, compilation date 1972. Land network and mineral ownership data are compiled from land plats available from the U. S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

IV. Coal Bed Occurrence

Wasatch Formation and Fort Union Formation coal beds that are present in all or part of the Laskie Draw Quadrangle include, in descending stratigraphic order: the Felix, Upper Smith, Lower Smith, Local, Wyodak, Upper Wall, Lower Wall, Pawnee, Wildcat, Moyer, Oedekoven, Local 1, and Local 2 coal beds. The several Wyodak coal beds are mapped as a coal zone. The Wildcat-Moyer-Oedekoven coal beds and the Local 1-Local 2 coal beds are mapped as composite coal beds. A suite of maps composed of: coal isopach and mining ratio, where appropriate; structure; overburden isopach; areal distribution of identified resources; identified resources and hypothetical resources, where applicable, was prepared for each of these coal beds or coal zones. Mining ratios are presented on the isopach maps of the Felix and Upper Smith coal beds. Interburden contours are presented on the overburden isopach map of the Wyodak coal zone. Insufficient thickness and areal extent preclude any detailed mapping of the Local coal bed beneath the Lower Smith coal bed.

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

COAL BED NAME		DATA SOURCE IDENTIFICATION	AS RECEIVED BASIS						MOIST, M-M-F BTU/LB	COAL RANK
			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB		
Felix	(**)	Lab.No. 6432	5.6	35.7	25.8	32.9	0.39	8465	9010	Subbtm. C
Smith	(**)	Lab.No. 6460	4.7	34.0	28.8	32.5	0.46	7862	8280	Lignite A
Upper Wyodak	(U)	Hole 7310	5.9	33.9	29.1	31.2	0.44	8172	8722	Subbtm. C
Middle-Lower Wyodak	(U)	Hole 7334	5.1	34.9	29.4	30.5	0.28	8329	8814	Subbtm. C
Pawnee	(U)	Hole 7424	7.9	31.0	31.9	29.2	0.39	7344	8025	Lignite A
"Wildcat"	(1)	Lab.No. 11447	4.3	29.4	27.8	29.4	0.27	8410	8818	Subbtm. C

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

** Stone and Lupton (1910).

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

(1) Winchester (1912).

The proximate analyses presented above are from core hole or outcrop locations in excess of 20 miles (32 km) from this quadrangle. In order to simplify tonnage computations, all coal beds in the Laskie Draw Quadrangle are tentatively classified as subbituminous C rank.

The Coal Data sheet, plate 3, shows the down-hole identification of coal beds within the quadrangle as interpreted from U. S. Geological Survey and Montana Bureau of Mines and Geology drill holes and geophysical logs from oil and gas test bores and from producing sites. This portrayal is schematic by design; hence, no structural or coal thickness implications are suggested by the dashed correlation lines projected through No Record (NR) intervals. Inasmuch as the Wyodak coal zone underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Wyodak coal zone and Pawnee coal zones show the thickest coal bed occurrence throughout the study area. The Felix, Upper Smith, Lower Smith, Lower Wall, Wildcat, Moyer, Oedekoven, Local 1 and Local 2 coal beds are relatively thin throughout the Laskie Draw Quadrangle.

The Felix coal bed maps in the Laskie Draw Quadrangle are derived from subsurface data to the north and east of the study area. Felix coal bed occurrence is limited to approximately 20 percent of the quadrangle along the northern and eastern edges. Felix coal bed thickness varies from 0 to 10 feet (0 to 3 m), with the maximum thickness along the northern edge of the quadrangle. Structure contours drawn on the Felix coal bed indicate a north-to-northeast dip interrupted by gentle folding. The coal bed lies approximately 100 to 600 feet (30 to 183 m) beneath the surface.

Where present, the Upper Smith coal bed occurs 500 to 650 feet (152 to 198 m) beneath the Felix coal bed. The Upper Smith coal bed varies in thickness from 0 to 18 feet (0 to 5 m) with the maximum thickness located in the northwest part of the area. The Upper Smith coal bed, absent from the east-central portion of Laskie Draw Quadrangle, is composed locally of two coal beds separated by a non-coal interval of 40 to 55 feet (12 to 17 m). The dominant structural configuration on the Upper Smith coal bed is a large, northeast-plunging anticline located in the center of the quadrangle. The Upper Smith coal bed occurs between 450 to 1,250 feet (137 to 381 m) beneath the surface.

The Lower Smith coal bed occurs 160 to 200 feet (49 to 61 m) beneath the Upper Smith coal bed and, locally, it is divided into two coal beds that are separated by a clastic interval of 15 to 25 feet (5 to 8 m). The combined coal bed thickness ranges from 0 feet (0 m) in the southwest corner to 22 feet (7 m) in the southeast corner. Structure contours drawn on the top of the Lower Smith coal bed define a west-southwest-plunging syncline in the northern portion of the quadrangle, and a north-plunging anticline in the southeast corner. The Lower Smith coal bed lies from less than 750 feet (229 m) to greater than 1,300 feet (396 m) beneath the surface.

The Wyodak coal zone occurs 100 to 200 feet (30 to 61 m) beneath the Lower Smith coal bed, and 470 to 525 feet (143 to 160 m) beneath the Upper Smith coal bed where the Lower Smith coal bed is absent. Total coal thicknesses range from 75 to 200 feet (23 to 61 m) with the maximum thickness occurring in the northeast quarter of the study area.
The Wyodak coal zone separates into five or more coal beds, with a total, non-coal interval thickness ranging up to 233 feet (71 m). The five coal

beds composing the Wyodak coal zone converge into a single bed in the northeast corner of Laskie Draw Quadrangle. Structure contours drawn on the top of the Wyodak coal zone depict a closed, west-trending anticline that dominates the central portion of the quadrangle, and a closed syncline in the northern half of the study area. The Wyodak coal bed lies from less than 900 feet (274 m) to more than 1,600 feet (488 m) beneath the surface.

A clastic interval of approximately 130 to 410 feet (40 to 125 m) separates the Wyodak coal zone from the Lower Wall coal bed. The Lower Wall coal bed ranges in thickness from 0 to 80 feet (0 to 24 m) with maximum thickness occurring to the northeast. Subsurface data that control this mapped thickness are located north of the study area in the Somerville Flats East Quadrangle. The Lower Wall coal bed is absent in the southwest quadrant and along the western edge of the quadrangle. An east-west-trending anticline and a paralleling syncline are located in the northern and southern portions of the quadrangle, respectively. The Wall coal bed lies from less than 1,250 feet (381 m) to more than 2,100 feet (640 m) beneath the surface.

The Pawnee coal bed occurs approximately 180 to 290 feet (55 to 88 m) beneath the Lower Wall coal bed, and 420 to 485 feet (128 to 148 m) beneath the Wyodak coal zone where the Lower Wall coal bed is absent. The coal bed thickness ranges from 20 to 110 feet (6 to 34 m) with the maximum thickness occurring in the northeast quadrant. The Pawnee coal bed is projected to attain a thickness of

110 feet (34 m) on the Laskie Draw Quadrangle on the basis of subsurface control north of the mapped area. Locally, the Pawnee coal bed divides into two coal beds separated by a clastic interval ranging from 0 to 32 feet (0 to 10 m) in thickness. Structure contours drawn on the top of the Pawnee coal bed indicate a series of gentle, northwest folds. The Pawnee coal bed lies between 1,650 and 2,400 feet (503 and 732 m) beneath the surface.

The Wildcat-Moyer-Oedekoven coal bed composite lies approximately 200 to 300 feet (61 to 91 m) beneath the Pawnee coal bed. The Wildcat coal bed is separated from the Moyer coal bed by 40 to 140 feet (12 to 43 m) of clastic sediment. The observed clastic interval between the Moyer coal bed and the Oedekoven coal bed is 20 to 80 feet (6 to 24 m). Approximately 190 feet (58 m) of clastic interval separates the Wildcat and Oedekoven coal beds where the Moyer coal bed is absent. The total coal bed composite thickness ranges from 15 to 46 feet (5 to 14 m) with the maximum thickness in the southeast corner. The Wildcat coal bed is absent in the northwest quadrant, and the Moyer coal is absent along the western edge and in the northwestern quarter of the study area. Structure contours drawn on the top of the Wildcat coal bed indicate a north-northwest regional dip interrupted by gentle folding. Structure contours drawn on the top of the Oedekoven coal bed where the Wildcat and Moyer coal beds are absent indicate a gentle westward dip. The Wildcat coal bed lies from less than 2,000 feet (610 m) to more than 2,500 feet (777 m) beneath the surface. The Oedekoven coal bed occurs from less than 2,300 feet (701 m) to greater than 2,750 feet (838 m) beneath the surface.

The Local 1 - Local 2 coal bed composite occurs 180 to 250 feet (55 to 76 m) beneath the Oedekoven coal bed. Mapping of the Local 1 - Local 2 coal bed composite relies on subsurface data located in the Somerville Flats East Quadrangle to the north, and the Morgan Draw Quadrangle to the east. The Local 1 coal bed in the Laskie Draw Quadrangle correlates with the Local coal bed mapped beneath the Oedekoven coal bed in the Morgan Draw Quadrangle. Total coal bed composite thickness varies from 0 to 20 feet (0 to 6 m) with maximum thicknesses located along the northern boundary. Local 1- Local 2 coal bed occurrence is limited to the northern 30 percent of the quadrangle. Structure contours drawn on top of the Local 1 coal bed depict a gentle, south-southwest dip. The Local 1 - Local 2 coal bed composite lies from less than 2,500 feet (762 m) to more than 3,100 feet (945 m) beneath the surface.

V. Geological and Engineering Mapping Parameters

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

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

Subsurface mapping is based on geologic data within, and adjacent to, the Laskie 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 44) was prepared utilizing the following mining ratio criteria for coal beds 5 feet to 40 feet (1.5 to 12 m) thick:

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

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

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

The surface mining development potential is low for approximately 10 percent of the quadrangle. The area of low surface mining development potential is located in the extreme northeast corner and west-central part of Laskie Draw Quadrangle. The low development potential results from high-overburden-to-coal-thickness ratios for the Felix coal bed and the Upper Smith coal bed. The older coal beds occur greater than 500 feet (152 m) beneath the surface. Ninety percent of Laskie Draw Quadrangle includes areas classified as exhibiting no potential for surface mining development, or involving non-federal coal land. Table 1 sets forth the estimated strippable reserve base tonnages per coal bed for this quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining development potential throughout the Laskie 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 (plate 45) on the Laskie Draw Qudrangle is rated high over approximately 50 percent of the quadrangle. This potential relates to the thick Wyodak coal zone positioned more than 1,000 feet (305 m) beneath the surface. This high development potential rating occurs primarily in the central and northern portions of the quadrangle. Approximately 30 percent of the study area, classified as having moderate development potential, is located in the southwest quadrant. Thinning of the Wyodak coal zone causes the moderate development potential rating. A low development potential rating covers 10 percent of the quadrangle along the west-central edge. The area of low development potential occurs where the thick Wyodak coal zone is less than 1,000 feet (305 m) in depth. The remaining 10 percent of the quadrangle is classified as non-federal coal land. The coal resource tonnage totals for in-situ gasification are given on table 3.

Table 1.--Strippable coal Reserve Base data (in short tons) for Federal Coal Lands in the Laskie Draw Quadrangle, Johnson and Campbell Counties, Wyoming.

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

Coal Bed	High Development Potential (0-10:1 Mining Ratio)	Moderate Development Potential (10:1-15:1 Mining Ratio)	Low Development Potential (>15:1 Mining Ratio)	Total
Reserve Base Resources				
Felix	-	-	7,410,000	7,410,000
Upper Smith	-	-	5,020,000	5,020,000
TOTAL	-	-	12,430,000	12,430,000

Table 2.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Laskie Draw Quadrangle, Johnson and Campbell Counties, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resources				
Felix	-	-	5,020,000	5,020,000
Upper Smith	-	-	419,090,000	419,090,000
Lower Smith	-	-	504,870,000	504,870,000
Wyodak	-	-	7,249,340,000	7,249,340,000
Lower Wall	-	-	840,840,000	840,840,000
Pawnee	-	-	2,283,240,000	2,283,240,000
Wildcat-Moyer-Oedekoven	-	-	1,237,760,000	1,237,760,000
Local 1 - Local 2	-	-	133,860,000	133,860,000
Total	-	-	12,674,020,000	12,674,020,000
Hypothetical Resources				
Upper Smith	-	-	13,750,000	13,750,000
Lower Smith	-	-	13,240,000	13,240,000
Lower Wall	-	-	28,010,000	28,010,000
Total	-	-	55,000,000	55,000,000
GRAND TOTAL	-	-	12,729,020,000	12,729,020,000

Table 3.--Coal Reserve Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Laskie Draw Quadrangle, Johnson and Campbell Counties, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resources	9,040,340,000	3,316,530,000	317,150,000	12,674,020,000
Hypothetical Resources	-	-	55,000,000	55,000,000
TOTAL	9,040,340,000	3,316,530,000	372,150,000	12,729,020,000

SELECTED REFERENCES

American Society of Testing and Materials, 1971, Standard specifications for classification of coals by rank (ASTM Designation D 388-66) in Gaseous fuels, coal, and coke: American Society for Testing and Materials, pt. 19, p. 57-61.

Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U. S. Geological Survey Bull. 806-B, p. 15-67.

Bass, N. W., 1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U. S. Geological Survey Bull. 831-B, p. 19-105.

Brown, R. W., 1958, Fort Union Formation in the Powder River Basin, Wyoming: Wyoming Geological Association Guidebook, Thirteenth Annual Field Conf., p. 111-113.

Denson, N. M., and Horn, G. H., 1975, Geologic and structure map of the southern part of the Powder River Basin, Converse, Niobrara, and Natrona Counties, Wyoming: U. S. Geological Survey Miscellaneous Investigations Series, Map I-877, scale 1:125,000.

Dobbin, C. E., and Barnett, V. H., 1927 (1928), The Gillette coal field, northeastern Wyoming: U. S. Geological Survey Bull. 796-A, 50 p.

Glass, G. B., 1975, Review of Wyoming coal fields, 1975: Wyoming Geological Survey Public Information Circ. 4, p. 10.

IntraSearch Inc., 1978a, Coal resource occurrence and coal development potential maps of the Cabin Creek Northeast Quadrangle, Sheridan and Campbell Counties, Wyoming, and Powder River County, Montana: U. S. Geological Survey Open-File Report 78-064, 21 p.

IntraSearch Inc., 1978b, Coal resource occurrence and coal development potential maps of the Rocky Butte Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report 78-830, 22 p.

_____ 1979, Coal resource occurrence and coal development potential maps of the Larey Draw Quadrangle, Campbell County, Wyoming: U. S. Geological Survey Open-File Report 79-023, 29 p.

Jacob, A. F., 1973, Depositional environments of Paleocene Tongue River Formation: Am. Assoc. of Petroleum Geologists Bull., vol. 56, no. 6, p. 1038-1052.

McKay, E. J., 1974, Preliminary geologic map of the Bertha 2 NW (Rocky Butte) Quadrangle, Campell County, Wyoming: U. S. Geological Survey Open-File Report 74-173, scale 1:24,000.

Olive, W. W., 1957, The Spotted Horse coal field, Sheridan and Campbell Counties, Wyoming: U. S. Geological Survey Bull. 1050, 83 p.

Stone, R. W., and Lupton, C. T., 1910, The Powder River coal field, Wyoming, adjacent to the Burlington Railroad: U. S. Geological Survey Bull. 381-B, p. 115-136.

Taff, J. A., 1909, The Sheridan coal field, Wyoming: U. S. Geological Survey Bull. 341-B, p. 123-150.

U. S. Bureau of Mines and U. S. Geological Survey, 1976, Coal resource classification system of the U. S. Bureau of Mines and U. S. Geological Survey: U. S. Geological Survey Bull. 1450-B, 7 p.

U. S. Geological Survey and Montana Bureau of Mines and Geology, 1974, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell County, Wyoming: U. S. Geological Survey Open-File Report 74-97, 241 p.

U. S. Geological Survey and Montana Bureau of Mines and Geology, 1976, Preliminary report of coal drill-hole data and chemical analyses of coal beds in Campbell and Sheridan Counties, Wyoming: Custer, Prairie, and Garfield Counties, Montana; and Mercer County, North Dakota: U. S. Geological Survey Open-File Report 76-319, 377 p.

Warren, W. C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U. S. Geological Survey Bull. 1072-J, p. 561-585.

Weimer, R. J., 1977, Stratigraphy and tectonics of western coals in Geology of Rocky Mountain Coal, A Symposium, 1976: Colorado Geological Survey Resources Series 1, p. 9-27.

Winchester, D. E., 1912, The Lost Spring coal field, Converse County, Wyoming: U. S. Geological Survey Bull. 471-F, p. 472-515.