UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

RAWHIDE SCHOOL QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-036
1979

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

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CONVERSION TABLE

TO CONVERT	MULTIPLY BY	TO OBTAIN
inches	2.54	centimeters (cm)
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
cubic yards/ton	0.8428	cubic meters per metric 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 Rawhide School Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-036) includes 39 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 Rawhide School Quadrangle, is located in Campbell County, in northeastern Wyoming. It encompasses parts of Townships 51 and 52 North, Ranges 72 and 73 West, and covers the area: 44°22'30" to 44°30' north latitude; 105°30' to 105°37'30" west longitude.

Main access to the Rawhide School Quadrangle is provided by U. S. Highway 14-16, which traverses the area in a southeasterly direction from the northwest corner to the southeast quadrant at a point 6 miles (10 km) north of Gillette, Wyoming. A network of other highways, roads and trails that intersects with Highway 14-16 provides access to the more remote parts of the area. The closest railroad is the Burlington Northern trackage 6 miles (9.6 km) southward at Gillette, Wyoming.

Principal drainage for the area is provided by Rawhide Creek, which flows generally eastward through the south-central part of the quadrangle and exits near the midpoint of the eastern boundary. With the exception of small areas along the extreme west-central border, Rawhide Creek and its tributaries drain the entire quadrangle, producing a fairly rugged terrain. All of the drainage in the Rawhide School Quadrangle is a part of the Little Powder River system. Rawhide Creek flows into the

Little Powder River approximately 15 miles (24 km) northeast of the quadrangle. A total relief of about 600 feet (183 m) for the quadrangle is derived from low elevations of less than 4040 feet (1231 m) above sea-level in the northeast corner to high elevations of greater than 4660 feet (1420 m) above sealevel in the southwest quadrant.

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 Gillete, Wyoming, average wintertime minimums and summertime maximums range from +5° to +°15F (-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 7.5 billion tons (6.8 billion metric tons) of unleased federal coal resources in the Rawhide School 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 Mountain uplift. The structural configuration of the Powder River Basin originated in Late Cretaceous time, with episodic uplift thereafter. The Cretaceous Cordillera was the dominant positive land form throughout the Rocky Mountain area at the close of Mesozoic time.

Outcrops of the Wasatch Formation and the Tongue River Member of the Fort Union Formation cover most of the areas of major coal resource occurrence in the Powder River Basin. The Tongue River Member is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds. The Lebo 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 Rawhide School Quadrangle is located in an area where surface rocks are classified into the Tongue River Member of the Fort Union Formation and the Wasatch Formation. Although the Tongue River Member is reportedly 1200 to 1300 feet (366 to 396 m) thick (Olive, 1957), only 100 to 200 feet (30 to 60 m) are exposed in the area, and 450 to 550 feet (137 to 168 m) of the Wasatch Formation are exposed. 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 Daly coal bed was named by McLaughlin and Hayes (1973). The Felix coal bed was named by Stone and Lupton (1910), and the Smith coal bed was named by Taff (1909). The Swartz coal bed was designated by McKay and Mapel (1973), and 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.

The Wyodak coal bed in the Rawhide School Quadrangle includes coal bed intervals that equate with the Anderson, Canyon, and Cook coal beds to the west. South of this quadrangle, the Wyodak coal bed includes the Swartz coal bed in addition to the aforementioned suite of coal beds. IntraSearch's nomenclature departs from regional correlations and the nomenclature used by Mapel (1973). IntraSearch Inc. refers to divisions of the Wyodak coal bed as the Upper Wyodak and Lower Wyodak coal beds rather than designating them by individual names. In this report, the Cook coal bed of Mapel is equivalent to the Wall coal bed of IntraSearch Inc., and the Wall coal bed of Mapel is equivalent to the Pawnee coal bed of IntraSearch Inc. The Pawnee and Cache coal beds of Mapel are called the Wildcat and Moyer coal beds by IntraSearch Inc. The Oedekoven coal bed of IntraSearch Inc., is equivalent to the deepest unnamed coal bed of Mapel.

Local. The Rawhide School Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation covers approximately 90 percent of the quadrangle, and is comprised of friable, coarse-grained to gritty, arkosic sandstones, fine- to very fine-grained sandstones, siltstones, mudstones, claystones, brown-to-black carbonaceous shales, and coal beds. The Fort Union Formation crops out over the remaining area. The Fort Union Formation is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds.

III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from Mapel (1973).

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 indentification is accomplished where gamma, density, and resistivity curves are available. Coal bed tops and bottoms are picked on the logs at the midpoint between the minimum and maximum curve deflections. The correlation of coal beds within and between quadrangles is achieved utilizing a fence diagram to associate local correlations with regional coal occurrences.

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

The reliability of correlations, set forth by IntraSearch in this report, 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 Rawhide School 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 Rawhide School Quadrangle include, in descending stratigraphic order: the Daly, Felix, Smith, Swartz, Wyodak, Pawnee, Wildcat, Moyer, and Oedekoven coal beds. A complete suite of maps (coal isopach, mining ratio where needed, structure, overburden/interburden isopach, areal distribution of identified resources and identified resources) is prepared for each of these coal beds, except for the Wildcat and Moyer coal beds which are mapped as a zone, and the Daly coal bed where lack of data and areal extent preclude detailed mapping.

Physical and chemical analyses for the Swartz and Wyodak coal beds have been published for the Rawhide School Quadrangle. General proximate analyses performed on an "as received" basis for these coal beds, and other pertinent coal beds, in the northern Campbell County area are as follows:

COAL BED NAME			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Felix	(U)	Hole 7345	5.223	34.181	30.280	30.316	0.338	8111
Smith	(U)	Hole 7340	3.505	38.036	29.980	28.474	0.309	8371
Swartz	(U)	Hole 7334	6.442	34.001	29.260	30.297	0.707	7738
Wyodak	(U)	Hole 734	6.516	31.825	29.126	32.532	0.924	8167
Pawnee	(U)	Hole 7424	7.880	31.029	31.910	29.183	0.386	7344
"Wildcat"		Lab. No.* 11447	4.3	29.4	27.8	29.4	0.27	8410

(*) - Winchester (1912)
(U) - U. S. Geological Survey & Montana Bureau of Mines & Geology - 1973 and 1974.

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 Upper Wyodak coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram and shows the thickest single coal bed occurrence throughout the quadrangle.

The Felix coal bed is eroded from approximately 95 percent of the Rawhide School Quadrangle. It is present only on high terrain in the west-central portion and the southwestern quadrant of the quadrangle. Due to the absence of subsurface data for structure and isopach maps, mapping control is derived from outcrop elevations and surface measured sections. The Felix coal bed varies in thickness from 8 to 24 feet (2.4 to 7 m). Structure contours drawn on top of the Felix coal bed define a closed southwest trending anticline. The Felix coal bed lies less than 150 feet (46 m) beneath the surface.

The outcrop of the Smith coal bed extends north-south through the center of the quadrangle. The outcrop configuration is derived from subsurface data. The Smith coal bed is separated from the overlying Felix coal bed by 200 to 247 feet (61 to 75 m) of clastics. Coal bed thicknesses range from 5 to 20 feet (1.5 to 6 m), with maximum thickness occurring along the southern and western edges of the area. The Smith coal bed dips gently toward the west and it occurs at depths varying from 0 feet (0 m) to more than 450 feet (137 m) beneath the surface.

The Swartz coal bed is separated from the Smith coal bed by from 94 to 182 feet (29 to 55 m) of consolidated clastic particles. Erosion or nondeposition caused the Swartz coal bed to be absent over the eastern one-third of the quadrangle. The indicated range of thickness of the coal bed is between 0 to 20 feet (0 to 6 m) with an average thickness of approximately 12 feet (4 m). Maximum thickness of the Swartz coal bed occurs in the southwest quadrant. Structure contours drawn on the top of the Swartz coal bed delineate broad synclines in the northwest and southwest quadrants of the area superimposed upon a westward dip of one to two degrees. The Swartz coal bed lies at depths varying from 0 feet (0 m) to more than 550 feet (168 m) beneath the surface.

Approximately 10 to 116 feet (3 to 35 m) of interburden separate the Wyodak coal bed from the Swartz coal bed. The Wyodak coal bed has been eroded from approximately 2 percent of the quadrangle and some burning is indicated along the outcrop. The coal bed separates into upper and lower members in the western three quarters of the quadrangle. Where undivided, the Wyodak coal bed varies in thickness from 50 to 130 feet (15 to 40 m). Where the Wyodak coal bed is divided, the Upper Wyodak coal bed has a thickness range from 0 to 50 feet (0 to 15 m) with maximum thicknesses occurring in the central northwest to southeast diagonal of the quadrangle. The Lower Wyodak coal bed varies in thickness from 50 to 124 feet (15 to 38 m) with thick coal along the west-central border of the quadrangle.

The extreme variation in total thickness of the Wyodak coal beds in the southeastern part of the area leads to the postulation of conditions that resulted in compaction faulting in this area. (See Plate 19 for inferred position of faults). IntraSearch suggests that following deposition of most of the Wyodak coal bed, a major drainage invaded the area, scoured a channel into the thick semiconsolidated coal bed, and ultimately filled the channel with clastic sediments. Towards the end of Wyodak coal bed deposition the river channel apparently was diverted to some other location, and the Upper Wyodak coal bed was deposited throughout the area. Compaction fault displacement developed as the thick coal beds compressed to a greater degree than the channel clastics (Law, 1976). Geophysical logs define a clean, low ash, thick coal bed both north and south of the channel deposit and in close proximity to the compaction faults. The lack of shale and siltstone lenses in the coal bed plus the low ash content of the Wyodak coal bed suggest that the organic material collected in a swamp far removed from active river flow, overbank flooding, and clastic sediment deposition. Accumulation of the thick coal bed in a low-energy swamp environment followed by a drainage invasion and channel deposition develops a depositional model that accommodates the existing data base. The structure contour map of the Wyodak coal bed is dominated by a southward-plunging anticline in the west-central part of the area and a southward-plunging syncline in the east-central part. An enclosed high is associated with the anticline and enclosed lows with the syncline. Other smaller folds are also present. The Wyodak coal bed lies at depths varying from 0 feet (0 m) to more than 650 feet (198 m).

The Pawnee coal bed occurs 200 to 318 feet (61 to 97 m) beneath the Lower Wyodak coal bed and varies in thickness from 0 to 24 feet (0 to 7 m). Maximum thicknesses of the coal bed occur in the northwest quadrant. A pinchout of the Pawnee coal bed occurs over approximately the eastern one-third of the quadrangle. Structural configurations drawn on the top of the Pawnee coal bed indicate a one to two degree dip to the west. The Pawnee coal bed occurs at depths varying from less than 500 feet (152 m) to more than 1200 feet (366 m) beneath the surface.

The Wildcat-Moyer coal zone is 237 to 385 feet (72 to 117 m) below the Pawnee coal bed. The combined thickness of the coal beds in the Wildcat-Moyer coal zone ranges from 9 to 27 feet (2.7 to 8 m) with the thickest coal along the western boundary and through the center of the southern half of the quadrangle. The thinnest coal is in the northeast quadrant. Individually, the Wildcat coal bed varies from 6 to 15 feet (1.8 to 5 m), and the Moyer coal bed varies in thickness from 3 to 17 feet (0.9 to 5 m). Interburden between the Wildcat and Moyer coal beds ranges from 33 to 144 feet (9 to 44 m). The Moyer coal bed divides into an upper and lower member locally. Localized partings with the Moyer coal bed vary from 0 to 25 feet (0 to 8 m) thick. Structure contours drawn on top of the Wildcat coal bed depict a dip of two degrees or less to the west. The Wildcat-Moyer coal zone lies at depths varying from less than 650 feet (198 m) to more than 1500 feet (457 m).

The Oedekoven coal bed is separated from the Moyer coal bed by a sedimentary interval of 47 to 187 feet (14 to 57 m). The Oedekoven coal bed varies in thickness from 10 to 28 feet (3 to 9 m) with the thinnest coal in the northeast quadrant and gradual thickening through the remainder of the area. The Oedekoven coal bed sporadically divides into as many as three members with up to 38 feet (12 m) of non-coal interval separating them. Structure contours drawn on the top of the Oedekoven coal bed portray a gentle westward dip. The overburden above the Oedekoven coal bed varies from less than 750 feet (229 m) to more than 1750 feet (533 m) thick.

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 Rawhide School 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 planimetering 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 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 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 39) 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 most of the Rawhide School Quadrangle. The Wyodak coal bed accounts for most of the high surface mining potential in the study area. The Wyodak coal bed is a thick coal bed less than 500 feet (152 m) deep over 85 percent of the quadrangle. The Felix, Smith and Swartz coal beds also have large areas of high development potential for surface mining. Approximately 15 percent of the quadrangle is assigned a moderate or low surface mining development potential. This occurs mainly in the southwest quadrant where the Wyodak coal bed is thin, the Swartz coal bed is pinched out, the Felix coal bed is eroded, and the Smith coal bed has a greater than 10:1 mining ratio. Low surface mining development potential also exists where the terrain is steep in the west-central portion of the quadrangle. Table 1 sets forth the estimated strippable reserve base tonnages per coal bed for the quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Rawhide School 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).

The coal development potential for in-situ gasification within the Rawhide School Quadrangle is low, hence no CDP map is generated for this map series. The coal resource tonnage for in-situ gasification with low development potential totals approximately 2.4 billion tons (2.2 billion metric tons) (Table 3). None of the coal beds in the Rawhide School Quadrangle qualify for a moderate or high development potential rating for in-situ gasification.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Rawhide School Quadrangle, Campbell County, Wyoming.

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

Coal Bed	High Development Potential (0-10:1 Mining Ratio)	Moderate Development Potential (10:1-15:1 Mining Ratio)	Low Development Potential (>15:1 Mining Ratio)	Total
Felix	55,970,000	-----	-----	55,970,000
Smith	36,810,000	41,810,000	77,920,000	156,540,000
Swartz	50,900,000	46,120,000	207,290,000	304,310,000
Wyodak	4,026,920,000	207,130,000	24,800,000	4,258,850,000
TOTAL	4,170,600,000	295,060,000	310,010,000	4,775,670,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	-----	-----	-----	-----
Swartz	-----	-----	7,900,000	7,900,000
Wyodak	-----	-----	304,580,000	304,580,000
Pawnee	-----	-----	401,850,000	401,850,000
Wildcat-Moyer	-----	-----	769,600,000	769,600,000
Oedekoven	-----	-----	944,860,000	944,860,000
TOTAL	-----	-----	2,428,790,000	2,428,790,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	-----	-----	-----	-----
Swartz	-----	-----	7,900,000	7,900,000
Wyodak	-----	-----	304,580,000	304,580,000
Pawnee	-----	-----	401,850,000	401,850,000
Wildcat-Moyer	-----	-----	769,600,000	769,600,000
Oedekoven	-----	-----	944,860,000	944,860,000
TOTAL	-----	-----	2,428,790,000	2,428,790,000

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