UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

NORTHEAST QUARTER OF NORTH STAR SCHOOL 15' QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-060
1979

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

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (Continued)

CONVERSION TABLE

TO CONVERT	MULTIPLY BY	TO OBTAIN
inches	2.54	centimeters (cm)
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
cubic yards/ton	0.8428	cubic meters 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 Northeast Quarter of North Star School 15' Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-060) includes 30 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 Northeast Quarter of North Star School 15' Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses all or parts of Townships 45, 46 and 47 North, Ranges 72 and 73 West, and covers the area: 43°52'30" to 44°00' north latitude; 105°30' to 105°37'30" west longitude.

Main access to the Northeast Quarter of North Star School 15' Quadrangle is provided by a maintained gravel road which extends east to west across the central portion of the study area. This gravel road intersects Wyoming State Highway 59 approximately 3 miles (4.8 km) to the east, 26 miles (42 km) south of Gillette, Wyoming. Minor roads and trails, that branch from this gravel road, provide additional access to the more remote areas throughout the quadrangle. The closest railroad is the Burlington Northern trackage, 8 miles (13 km) to the east.

The Belle Fourche River provides the most significant drainage in the quadrangle flowing southwest to northeast across the southern half of the study area. Eastward flowing Threemile Creek and Wild Horse Creek drain the northern half and southwest quarter of the quadrangle, respectively, and join the Belle Fourche River in the eastern half of the study area. Southeast flowing Rattlesnake Creek drains the northeast corner of the quadrangle and also flows into the Belle Fourche River east of the study area. Elevations of 5016 feet (1529 m) above sea level occur along the northern boundary of the quadrangle, 250 to 350 feet (76 to 107 m) above the valley floors of the eastern boundary. 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 +°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 11.3 billion tons (10.3 billion metric tons) of unleased federal coal resources in the Northeast Quarter of North Star School 15' 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 Northeast Quarter of North Star School 15' Quadrangle is located in an area where surface rocks are classified within 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), and the Smith coal bed was 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 Intra-Search (1978b, 1979, and 1978a).

IntraSearch's study of thick coal beds from the Spotted Horse coal field to Gillette suggest that the Wyodak coal bed, named the "D" coal bed by Dobbin and Barnett (1927), correlates with 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 correlation 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 Northeast Quarter of North Star School 15' 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, fine- to very fine-grained sandstones, siltstones, mudstones, claystones, 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.

The structural configuration of the various coal beds present within the quadrangle indicates a general regional dip to the west. A broad northwest-plunging syncline extends across the western and southern areas of the quadrangle separating two broad anticlinal features. These broad, northwest-plunging anticlines extend across the northern boundary and southwest corner of the quadrangle.

III. Data Sources

Areal geology of the coal outcrops is derived from Wegemann and others (1928), and from Allen (1976). The Upper and Lower Felix coal beds of this report are stratigraphically equivalent the "D" and "E" coal beds of Wegemann and others (1928). The coal bed outcrops are adjusted to the current topographic map in the area.

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. 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 North Star School 15' Quadrangle is published by the U. S. Geological Survey, compilation date 1959. Expansion of the topographic base of North Star School 15' Quadrangle (scale 1:62,500) into seven and one-half minute quadrangle maps (scale 1:24,000) was performed by the U. S. Geological Survey for Coal Resource Occurrence-Coal Development Mapping purposes. 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 Northeast Quarter of North Star School 15' Quadrangle include, in descending stratigraphic order, the Felix, local, Smith, Upper Wyodak, Middle Wyodak, Lower Wyodak, Wyodak, Wall, Pawnee, Wildcat, Moyer, local and Oedekoven coal beds. A complete suite of maps (coal isopach, mining ratio where necessary, structure, overburden/interburden isopach, areal distribution of identified resources and identified resources) was prepared for the Upper-Lower Felix and Smith coal beds, and for the Wyodak, Wall-Pawnee, and the Wildcat-Moyer-Oedekoven coal zones. Insufficient data, thickness, and areal extent preclude detailed mapping of the local coal beds.

No physical and chemical analyses are known to have been published regarding the coal beds in the Northeast Quarter of North Star School 15' Quadrangle. However, the general "as received" basis proximate analyses for northern and central Campbell County coal beds are as follows:

COAL BED NAME		ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Felix (U)	Hole 7315	6.623	32.727	28.925	31.726	0.595	8076
Smith (U)	Hole 7312C	6.167	33.340	29.610	30.883	1.068	8215
Wyodak (U)	Hole 755	4.438	35.522	27.405	32.719	0.207	8568
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

(U) - U. S. Geological Survey & Montana Bureau of Mines & 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 Middle Wyodak coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Middle and Lower Wyodak coal beds show the thickest single coal bed occurrences throughout the quadrangle.

The Felix coal beds have been eroded from approximately 15 percent of the quadrangle throughout the southern half and along the eastern boundary of the study area. The Felix coal beds occur as a single coal bed throughout the majority of the northern half of the quadrangle, separating into a thin Upper Felix coal bed overlying a moderately thick Lower Felix coal bed to the south. The combined coal bed thickness ranges from 10 to 37 feet (3.0 to 11 m) with maximum thickness occurring in the south-central part of the quadrangle. The Upper Felix coal bed thickness ranges from 4 to 10 feet (1.2 to 3.0 m) and the Lower Felix coal bed thickness varies from 10 to 31 feet (3.0 to 9 m). The clastic interval separating the Upper and Lower Felix coal beds varies from 0 to 53 feet (0 to 16 m). Structure contours drawn on the top of the Upper and Lower Felix coal beds indicate a synclinal low which extends into the quadrangle from the northwest and trends into the eastern and southern portions of the study area. This synclinal feature disrupts a northeast to southwest-trending anticline. Broad anticlinal highs remain in the northeast and southwest quarters of the quadrangle. The Felix coal beds lie less than 300 feet (91 m) in depth beneath the surface throughout the entire quadrangle.

The Smith coal bed occurs 320 to 384 feet (98 to 117 m) below the Lower Felix coal bed, and ranges in thickness from 10 to 25 feet (3.0 to 8 m). Maximum thicknesses occur along the northern boundary of the quadrangle, thinning to the southeast. Structure contours drawn on top of the Smith coal bed indicate a northwest-plunging syncline extending throughout the western half of the study area. The eastern half of the quadrangle shows a gentle westward dip with minor structural fluctuations. The Smith coal bed lies approximately 180 to 820 feet (55 to 250 m) in depth beneath the surface throughout approximately 40 percent of the quadrangle.

The Wyodak coal zone lies approximately 109 to 203 feet (33 to 62 m) beneath the Smith coal bed, and is composed primarily of a thin Upper Wyodak coal bed and thick Middle and Lower Wyodak coal beds. The total coal zone thickness ranges from 0 to 150 feet (0 to 46 m) with maximum thickness located in the northwest quarter and along the south-central boundary of the quadrangle. A localized absence of the Upper, Middle, and Lower Wyodak coal beds in the east-central portion of the quadrangle accounts for the total coal zone thickness thinning considerably in this area. The total clastic interval separating the various coal beds comprising the coal zone varies from 18 to 275 feet (5 to 84 m). A broad northwest-plunging syncline extends across the western half of the quadrangle and provides the most significant structural feature in the study area. Two northwest-plunging anticlines extend across the northern boundary and southwest corner of the quadrangle. The eastern half of the quadrangle shows a general regional dip to the west. The Wyodak coal zone lies approximately 380 to 950 feet (116 to 290 m) in depth beneath the surface throughout approximately 94 percent of the study area.

The Wall-Pawnee coal zone lies approximately 52 to 577 (16 to 176 m) below the Wyodak coal zone, and is composed of two thin, fairly uniform coal beds. The total coal zone thickness ranges from 5 to 40 feet (1.5 to 12 m) with maximum thicknesses occurring in the northwest quarter of the quadrangle. The Wall coal bed is absent from the eastern boundary of the quadrangle, which accounts for a significant thinning of the coal zone in that direction. The clastic interval separating the two coal beds varies from 138 to 151 feet (42 to 46 m). Structure contours drawn on the top of the Wall coal bed indicate a gentle regional dip to the west with a shallow syncline extending into the western half of the study area. The Wall-Pawnee coal zone lies approximately 925 to 1400 feet (282 to 427 m) beneath the surface throughout the entire quadrangle.

The Wildcat-Moyer-Oedekoven coal zone lies approximately 247 to 394 feet (75 to 120 m) below the Pawnee coal bed, and is composed of a thin Wildcat coal bed, and moderately thick Moyer and Oedekoven coal beds. The total coal zone thickness ranges from 20 to 63 feet (6 to 19 m) with maximum thicknesses extending from the northeast quarter to the southwest quarter of the quadrangle. The Moyer and Oedekoven coal beds generally exceed 20 feet (6 m) in thickness and extend throughout the entire study area. The thin Wildcat coal bed averages approximately 5 to 6 feet (1.5 to 1.8 m) and is absent from most of the southeastern portion of the quadrangle. The total clastic interval separating the various coal beds comprising the coal zone varies from 190 to 311 feet (58 to 95 m). Structure contours drawn on top of the Wildcat and Moyer coal beds indicate a gentle regional dip to the west with only slight structural irregularities. The Wildcat-Moyer-Oedekoven coal zone lies approximately 1400 to 1950 feet (427 to 594 m) beneath the surface throughout the entire 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. IntraSearch 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 Northeast Quarter of North Star School 15' 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 29) 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.

A high surface mining development potential covers the majority of the quadrangle, except for scattered areas along the eastern boundary, the southwest quarter, the west-central boundary, and extreme northern portions. This high potential rating is attributed to low overburden to coal ratios for the Upper and Lower Felix coal beds and the Wyodak coal zone. A moderate development potential rating covers approximately 5 percent of the quadrangle, primarily in the eastern half and southwest quarter of the quadrangle. These moderate and low development potential ratings can be attributed to the moderate to low overburden to coal ratios for the Felix, Smith, and Wyodak coal beds. The remaining 5 percent of the area is classified as non-federal land and not evaluated for surface mining. Table 1 sets forth the estimated strippable reserve and hypothetical resources base tonnages per coal bed for the quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining potential throughout the Northeast Quarter of North Star School 15' 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).

A coal development potential map for in-situ gasification (Plate 30) was constructed using the above criteria. A low coal development potential for in-situ gasification covers 70 percent of the study area. The area of low development potential is located in the southwestern corner, in the northwestern area and most of the eastern half of the Northeast Quarter of North Star School 15' Quadrangle. A moderate development potential rating covers approximately 20 percent of the quadrangle along the western and northern boundaries of the study area. A high development potential rating covers only approximately 5 percent of the quadrangle in the northwest quarter. Non-federal coal land covers approximately 5 percent of the study area, occurring as small scattered areas throughout the quadrangle. The coal resource tonnage totals for in-situ gasification with low, moderate, and high development potentials are given on Table 3.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Northeast Quarter of North Star School 15' 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
RESOURCE BASE				
Felix	572,810,000	44,900,000	-----	617,710,000
Smith	-----	-----	361,030,000	361,030,000
	(0-5:1 Mining Ratio)	(5:1 - 7:1 Mining Ratio)	(> 7:1 Mining Ratio)	
Wyodak	47,170,000	37,510,000	119,960,000	204,640,000
TOTAL	619,980,000	82,410,000	480,990,000	1,183,380,000
HYPOTHETICAL RESOURCE				
Felix	-----	-----	284,370,000	284,370,000
Smith	-----	-----	2,290,000	2,290,000
TOTAL	-----	-----	286,660,000	286,660,000
GRAND TOTAL	619,980,000	82,410,000	767,650,000	1,470,040,000

Table 2.--Coal Resource Base and Hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Northeast Quarter of North Star School 15' Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESOURCE BASE				
Smith	-----	-----	563,910,000	563,910,000
Wyodak	-----	-----	5,149,220,000	5,149,220,000
Wall-Pawnee	-----	-----	1,279,630,000	1,279,630,000
Wildcat-Moyer-Oedekoven	-----	-----	2,762,650,000	2,762,650,000
TOTAL	-----	-----	9,755,410,000	9,755,410,000
HYPOTHETICAL RESOURCE				
Smith	-----	-----	26,500,000	26,500,000
Wildcat-Moyer-Oedekoven	-----	-----	2,430,000	2,430,000
TOTAL	-----	-----	28,930,000	28,930,000
GRAND TOTAL	-----	-----	9,784,340,000	9,784,340,000

Table 3.--Coal Resource Base and Hypothetical Resource Data (in short tons) for In-Situ Gasification for Federal Coal Lands in the Northeast Quarter of North Star School 15' Quadrangle, Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESOURCE BASE				
	478,460,000	2,764,410,000	6,512,540,000	9,755,410,000
HYPOTHETICAL RESOURCE				
	-----	-----	28,930,000	28,930,000
TOTAL	478,460,000	2,764,410,000	6,541,470,000	9,784,340,000

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