UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

# TEXT TO ACCOMPANY:

# COAL RESOURCE OCCURRENCE

# AND

# COAL DEVELOPMENT POTENTIAL

# MAPS

# OF THE

# SOUTHEAST QUARTER OF NORTH STAR SCHOOL 15' QUADRANGLE,

# CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-067
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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| 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 Southeast Quarter of North Star School 15' Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-067) includes 37 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 Southeast Quarter of North Star School 15' Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses parts of Townships 44 and 45 North, Ranges 72 and 73 West, and covers the area: 43°45' to 43°52'30" north latitude; 105°30' to 105°37'30" west longitude.

Access to the Southeast Quarter of North Star School 15' Quadrangle is provided by a network of minor roads and trails that are connected to Wyoming State Highway 59 approximately 2 miles (3.2 km) to the east and to Wyoming State Highway 387 which traverses the extreme southeast corner. The northern part of the area is accessible by a road that intersects Wyoming State Highway 59 east of the quadrangle. The southern part of the quadrangle is accessible by a road that intersects Wyoming State Highway 387 south of the area. The closest railroad is the Burlington Northern trackage 4 miles (6.4 km) east of the quadrangle near Wright, Wyoming.

Principal drainage for the quadrangle is provided by Hay Creek and the intermittent stream that occupies Rocky Butte Gulch. Hay Creek flows north-northeastward through the southeastern corner of the quadrangle. Rocky Butte Gulch trends northward along the western border of the quadrangle and receives drainage from the western half. The Belle Fourche River is in the extreme northwest corner and is the recipient of the intermittent drainage from the Southeast Quarter of North Star School 15' Quadrangle.

The terrain is fairly rugged and dominated by a divide that traverses the quadrangle from the southwest quadrant to the north-northeast. Total relief in the area is greater than 400 feet (122 m) between low elevations of less than 4800 feet (1463 m) above sealevel in the northeastern and northwestern corners to elevations in excess of 5200 feet (1585 m) above sealevel near the southwest corner.

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 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 10.9 billion tons (9.9 billion metric tons) of unleased federal coal resources in the Southeast 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 lightercolored 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 Southeast 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 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 suggest that the Anderson and Canyon coal beds equate with the upper 10 to 25 percent of the thick Wyodak coal bed, and the Cook and Wall, or Upper Wall, coal beds are equivalent to the major part of the Wyodak coal bed. Due to problematic correlations outside of the Gillette area, the name Wyodak has been informally used by many previous authors to represent the coal beds in the area surrounding the Wyodak coal mine.

Local. The Southeast 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.

## III. Data Sources

Areal geology of the coal outcrops and associated clinker is derived from Wegemann and others (1928), and from unpublished CRO-CDP mapping (Allen, 1977). The coal bed outcrops are adjusted to the current topographic map of 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. 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 Southeast Quarter of North Star School 15' Quadrangle include, in descending stratigraphic order, the Felix coal zone, the Smith, Upper Wyodak, Middle Wyodak, and Lower Wyodak, Wall, Pawnee, and unnamed local coal beds, and the Wildcat, Moyer and Oedekoven coal beds mapped together as a coal zone. A complete suite of maps (coal isopach, mining-ratio where appropriate, structure, overburden/interburden isopach, identified resources, and areal distribution of identified resources) is prepared for each of these coal beds except the Wall and local coal beds which are present in isolated locations. The Pumpkin Buttes coal field report (Wegemann and others, 1928) indicates a "D" coal bed outcrop that correlates with the Upper Felix coal bed outcrop, and "E" coal bed outcrop that is equivalent to the Lower Felix coal bed outcrop of this report.

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

| COAL BED NAME | | | ASH % | FIXED CARBON % | MOISTURE % | VOLATILES % | SULFUR % | BTU/LB |
|---|---|---|---|---|---|---|---|---|
| Upper Felix | (*) | | 6.2 | 29.7 | 35.5 | 30.5 | 1.2 | 7348 |
| Lower Felix | (*) | | 7.8 | 31.1 | 29.0 | 32.0 | 1.4 | 8215 |
| Smith | (U) | Hole 7312C | 6.167 | 33.340 | 29.610 | 30.883 | 1.068 | 8215 |
| Upper Wyodak | (U) | Hole 7544 | 4.501 | 32.688 | 24.337 | 38.450 | 0.201 | 8953 |
| Middle-Lower Wyodak | (U) | Hole 755 | 4.438 | 35.522 | 27.405 | 32.719 | 0.207 | 8568 |
| Pawnee | (U) | Hole 7424 | 7.880 | 31.029 | 31.910 | 29.183 | 0.386 | 7344 |

(*) - Wegemann and others, 1928
(U) - U. S. Geological Survey & Montana Bureau of Mines & Geology - 1973, 1974, 1976.

The Coal Data Sheet, Plate 3, shows the down hole identification of coal beds within the quadrangle as interpreted from geophysical logs, and 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-Lower Wyodak coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The combined Middle Wyodak and Lower Wyodak coal bed shows the thickest single coal bed occurrences throughout the quadrangle. The Felix, Smith, Upper Wyodak, Pawnee, Wildcat, Moyer and Oedekoven coal beds are relatively thin throughout most of the area.

The Felix coal zone is eroded from approximately 10 percent of the quadrangle and splits into upper and lower coal beds in the northern half. The total thickness ranges from 20 to 36 feet (6 to 11 m) with thickest coal concentrated in the northwest and southwest quarters of the area (Plate 4a). Where the coal zone splits, the Lower Felix coal zone has a thickness range of 20 to 31 feet (6 to 9 m), and the Upper Felix coal bed is from 4 to 15 feet (1.2 to 5 m) thick. In areas of the northwest quadrant, the Upper Felix coal bed is less than 5 feet (1.5 m) thick, hence, mining ratios were not computed in these areas. Plate 4b defines these areas and the mining ratio lines are drawn using only the Lower Felix overburden thickness and Lower Felix isopach thickness. The non-coal interval between the two Felix coal beds is usually less than 10 feet (3 m), but in the northwest area it attains a maximum thickness of 78 feet (24 m). The structure contours drawn on the tops of the Felix coal beds portray a north-plunging syncline and anticline in the southern half of the quadrangle, with the syncline dying in an enclosed low in the northwest quadrant (Plate 5). A northwest-plunging syncline is present in the northeast part of the quadrangle and it also dies in the closed low in the northwest quadrant. In the areas where the Felix coal zone is not eroded, it lies within 350 feet (107 m) of the surface (Plate 6).

The Smith coal bed is separated from the overlying Felix coal zone by 304 to 438 feet (93 to 134 m) of clastic debris. The thickness of the Smith coal bed is less than 10 feet (3 m) thick in an east-west trend through the central area and attains a maximum thickness of 21 feet (6 m) in the east-center of the quadrangle (Plate 9). Local non-coal partings are present within the Smith coal bed and attain 27 feet (8 m) in thickness. The structure contours drawn on top of the Smith coal bed portray a broad south-plunging syncline in the southwest half of the quadrangle and a northwest-plunging syncline in the northeast quarter of the quadrangle (Plate 10). A small, north-plunging anticlinal feature is present in the southeast corner. The Smith coal bed ranges approximately 290 to 800 feet (88 to 244 m) below the surface in approximately 60 percent of the quadrangle (Plate 11).

The Upper Wyodak coal bed is 100 to 174 feet (30 to 53 m) beneath the Smith coal bed. The Upper Wyodak coal bed varies in thickness from 10 to 25 feet (3 to 8 m). The thickest areas of the Upper Wyodak coal bed are in the northwest and southwest quadrants and it thins to the east-central region (Plate 14). The structure contour map (Plate 15) depicts a broad northwest-plunging syncline dominating the northern half of the quadrangle. An anticline parallels the syncline in the southwest with the anticlinal axis plunging from the southeast corner of the map and from the west-central area into Township 44 North, Range 73 West, sections 11 and 12. Another synclinal feature is located in the southwest corner of the quadrangle. The Upper Wyodak coal bed occurs approximately 425 to 1050 feet (130 to 320 m) beneath the surface throughout the study area. It is within the stripping limit of the coal bed in the west-central area, in the northeastern and southeastern corners and along the east boundary of the Southeast Quarter of North Star School 15' Quadrangle (Plate 16).

Between 55 to 291 feet (17 to 89 m) of clastic rocks separate the Middle-Lower Wyodak coal zone from the overlying Upper Wyodak coal bed. The Middle Wyodak and Lower Wyodak coal beds are mapped as a single coal zone because it is locally separated by 3 feet of interburden (0.9 m) within the quadrangle. The thickness of the coal zone varies from 70 to 135 feet (21 to 41 m) with the thinnest coal along the western border of the quadrangle and the thickest coal in the southeast corner and northeast quadrant. The Middle Wyodak and Lower Wyodak coal zone thins to 86 feet

(26 m) between the two thick coal areas (Plate 19). The structure contours drawn on the top of the Middle Wyodak and Lower Wyodak coal zone portrays a broad north-northwest-plunging syncline that dominates the entire quadrangle (Plate 20). A small north-northwest-plunging anticline parallels the syncline to the west and is located from the southwestern quadrant into the northwestern corner. The coal zone lies approximately 600 to 1100 feet (183 to 335 m) in depth beneath the surface over the entire quadrangle (Plate 21).

The Pawnee coal bed is 180 to 380 feet (55 to 116 m) below the Middle Wyodak and Lower Wyodak coal zone and is absent along the west boundary of the southwest quadrant and in the south-central area. It has a maximum thickness of greater than 15 feet (5 m) in the northwest quadrant and the north-central area of the southeast quadrant (Plate 24). Non-coal intervals of 6 feet (1.2 m) are locally present in the Pawnee coal bed. The structure contours drawn on top of the Pawnee coal bed show a north-northwest to west-plunging syncline in the northern half and along the southeast boundary of the quadrangle. Two west-plunging anticlines flank the syncline to the north and southwest. Although no data are existent in the southwestern quadrant area, peripheral control suggets a minor folding superimposed on a regional west dip (Plate 25). The Pawnee coal bed occurs approximately 1000 to 1525 feet (305 to 465 m) in depth beneath the surface over the entire quadrangle (Plate 26).

The Wildcat-Moyer-Oedekoven coal zone is separated from the Pawnee coal bed by an interval of 308 to 419 feet (94 to 128 m). One to six coal beds comprise the Wildcat-Moyer-Oedekoven coal zone with a non-coal interval of zero, where only one coal bed is present, to 301 feet (92 m). The thickness of the coal zone is 3 to 65 feet (0.9 to 20 m) with the thicker coal projected from adjacent quadrangles. The total coal thickness increases from the southeast corner to the northwest corner (Plate 29). The individual coal beds rarely exceed 10 feet (3 m) in thickness in this quadrangle. A composite structure contour map (Plate 30) is drawn on the top of the Wildcat coal bed where it is present in the southern third of the map and northwest quadrant, and on the top of the Moyer coal bed over the remainder of the quadrangle. The structure contours show a gentle westward dip complicated by local folding especially in the southwest corner (Plate 30). The coal zone lies approximately 1400 to 1950 feet (427 to 594 m) in depth beneath the surface throughout the quadrangle (Plate 31).

## 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 Southeast 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 34) 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 considered high for the majority of the Southeast Quarter of North Star School 15' Quadrangle, except for small scattered areas throughout the study area. The moderately thick Felix coal zone, present at shallow depths, results in a high development potential for surface mining in approximately 87 percent of the quadrangle. In the southwest corner, increasing overburden thickness above the Felix coal zone creates an area of moderate development potential over 1 percent of the study area. Increased overburden thicknesses above the Smith and Upper Wyodak coal beds result in approximately 6 percent of the quadrangle being rated as low development potential for surface mining. These areas are located in the northwest, northeast and southeast corners and along the eastern boundary of the quadrangle. The remaining 6 percent of the study area is non-federal coal land. 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 Southeast 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).

The coal development potential for in-situ gasification within the Southeast Quarter of North Star School 15' Quadrangle is moderate over approximately 24 percent of the study area, because the combined coal thickness for the Middle-Lower Wyodak, Pawnee, Wildcat, Moyer and Oedekoven coal beds are greater than 100 feet (30 m) thick and are deeper than 1000 feet (305 m) beneath the surface (Plate 35). The area of moderate in-situ gasification development potential is located in the north-central, south-central, and along the southwest edge of the quadrangle. Seventy percent of the quadrangle is rated as having low development potential for in-situ gasification because the thick Middle-Lower Wyodak coal bed is not 1000 feet (305 m) deep and the deeper coal beds do not attain 100 feet (30 m) in combined thickness. The remaining 6 percent of the quadrangle is non-federal coal land. The coal resource tonnage for in-situ gasification totals approximately 8.8 billion tons (8.0 billion metric tons) (Table 3).

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Southeast 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 |
|---|---|---|---|---|
| Felix | ----- | ----- | 1,506,370,000 | 1,506,370,000 |
| Smith | ----- | ----- | 429,280,000 | 429,280,000 |
| Upper Wyodak | ----- | ----- | 60,130,000 | 60,130,000 |
| TOTAL | ----- | ----- | 1,995,780,000 | 1,995,780,000 |

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

| Coal Bed Name | High Development Potential | Moderate Development Potential | Low Development Potential | Total |
|---|---|---|---|---|
| Smith | ----- | ----- | 316,540,000 | 316,540,000 |
| Upper Wyodak | ----- | ----- | 820,810,000 | 820,810,000 |
| Middle and Lower Wyodak | ----- | ----- | 5,969,730,000 | 5,969,730,000 |
| Pawnee | ----- | ----- | 508,560,000 | 508,560,000 |
| Wildcat-Moyer-Oedekoven | ----- | ----- | 1,186,210,000 | 1,186,210,000 |
| TOTAL | ----- | ----- | 8,801,850,000 | 8,801,850,000 |

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

| Coal Bed Name | High Development Potential | Moderate Development Potential | Low Development Potential | Total |
|---|---|---|---|---|
| | ----- | 2,464,130,000 | 6,337,720,000 | 8,801,850,000 |
| TOTAL | ----- | 2,464,130,000 | 6,337,720,000 | 8,801,850,000 |

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