UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

SOUTHEAST QUARTER OF TURNERCREST 15' QUADRANGLE,

CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-310

1979

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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 Southeast Quarter of Turnercrest 15' Quadrangle, Campbell County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-310) includes 34 plates. The project is compiled by Intra-Search Inc., 1600 Ogden Street, Denver, Colorado, under KRCRA Northeastern Powder River Basin, Wyoming Contract Number 14-08-0001-17180. This contract is a part of a program to provide an inventory of unleased federal coal in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States.

The Southeast Quarter of Turnercrest 15' Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses parts of Townships 41 and 42 North, Ranges 72 and 73 West, and covers the area: 43° 30' to 43°37'30" north latitude; 105° 30' to 105°37'30" west longitude.

Although there are no highways or maintained gravel roads present in the quadrangle, minor roads and trails provide access to even the remote regions of the study area. The closest railroad is the Burlington-Northern trackage 6 miles (10 km) to the east near the North Antelope coal mine.

Spring Creek, the West Prong of Spring Creek, Bates Creek, and Little Bates Creek provide the principal drainage in the quadrangle. The southeast flowing streams drain into the Cheyenne River system. Elevations attain heights of up to 5220 feet (1591 m) above sea level, 400 to 500 feet (122 to 152 m) above the valley floors.

The thirteen to fourteen inches (33 to 36 cm) of annual precipitation that falls in this semi-arid region accrues 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 Cheyenne, 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 5.7 billion tons (5.2 billion metric tons) of unleased federal coal resources, which includes approximately 9 million tons (8 million metric tons) of hypothetical coal resources in the Southeast Quarter of Turnercrest 15' Quadrangle.

The suite of maps that accompany this report portray the coal resource and reserve occurrence in detail. For the most part, this report supplements the cartographic information, with minimum duplication of the 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, that includes 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 Shale 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, east of the principal coal outcrops and associated clinkers (McKay, 1974), and 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 working with subsurface data, principally geophysical logs, in the basin are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts, 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 tropic to subtropic depositional environment included broad, inland flood basins with extensive swamps, marshes, freshwater lakes, and a sluggish but active northeastward discharging drainage system, 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 characteristic, 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 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 discrete balance between subsidence of the earth's crust and in-filling by trememdous 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 low land 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, and is considered to disconformably descend in the stratigraphic column to the top of the Wyodak-Anderson coal bed (Roland coal bed of Taff, 1909) along the eastern boundary of the coal measures. No attempt is made to differentiate the Wasatch and Fort Union Formations on geophysical logs or in the subsurface mapping program that is a part of this CRO-CDP 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 Turnercrest 15' Quadrangle is located in an area where surface rocks are classified into the Wasatch Formation.

Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the Sheridan coal field (Baker, 1929) and Gillette coal field (Dobbin and Barnett, 1927), Wyoming, and with coal beds in the Ashland coal field (Bass, 1932) in southeastern Montana. This report utilizes, where possible, the coal bed nomenclature used in previous reports. The Felix coal bed was named by Stone and Lupton (1910). The 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).

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. The Wildcat and Moyer coal beds were informally named by IntraSearch (1978 and 1979).

Local. The Southeast Quarter of Turnercrest 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 area, 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 Tongue River Member of the Fort Union Formation lies 750 to 1060 feet (229 to 323 m) beneath the surface and 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 Allen (1976).

The major source of subsurface control, particularly on deep coal beds, is the geophysical logs from oil and gas test bores and producing wells. 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 eighty percent of the logs include resistivity, conductivity, and self-potential curves. Occasionally the logs include 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, interpreted, and coal intervals annotated. Maximum accuracy of coal bed identification is accomplished where gamma, density, and resistivity curves are available. Coal bed tops and bottoms are picked on the logs at the midpoint between the minimum and maximum curve deflections. The correlation of coal beds within and between quadrangles is achieved utilizing a fence diagram to associate local correlations with regional coal occurrences.

In some parts of the Powder River Basin, additional subsurface control is available from U. S. Geological Survey open-file reports that include geophysical and lithologic logs of shallow holes drilled specifically for coal exploration. A sparse scattering of subsurface data points are shown on unpublished CRO-CDP maps compiled by the U. S. Geological Survey, and where these data are utilized, the rock-coal intervals are shown on the Coal Data Map (Plate 1). Inasmuch as these drill holes have no identifier headings, they are not set forth on the Coal Data Sheet (Plate 3). The geophysical logs of these drill holes were not available to IntraSearch to ascertain the accuracy of horizontal location, topographic elevation, and downhole data interpretation.

The reliability of correlations, set forth by IntraSearch in this report, vary 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 Turnercrest 15' Quadrangle is published by the U. S. Geological Survey, compilation date, 1960. Expansion of the topographic base of the Turnercrest Fifteen-Minute Quadrangle (1:62,500 scale) into seven and one-half minute quadrangle maps (1:24,000 scale) was performed by the U. S. Geological Survey for Coal Resource Occurrence-Coal Development Potential 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 Southeast Quarter of Turnercrest Quadrangle include, in descending stratigraphic order, the Felix, Smith, Anderson, Canyon, Cook,

Wall, Pawnee, Upper Wildcat, Lower Wildcat, local, and Moyer coal beds. A suite of maps consisting of structure, isopach, mining ratio, overburden, identified (and, where applicable, hypothetical) resources, and areal distribution of identified resources maps is prepared for the Felix, Smith, and Anderson coal beds, for a coal zone comprised of the Canyon, Cook, and Wall coal beds, for the Pawnee coal bed, and for a coal zone comprised of the Upper and Lower Wildcat, local and Moyer coal beds. In addition, interburden maps, presented with the overburden isopach maps, are prepared for the Anderson coal bed and the Canyon-Cook-Wall coal zone.

No physical and chemical analyses are known to have been published regarding the coal beds in the quadrangle. However, the general "as received" basis proximate analyses for central and southern Campbell County and northern Converse County coal beds are as follows:

COAL BED NAME			ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB
Felix	(U)	Hole 7324	6.993	35.200	25.010	37.798	0.628	8549
Smith	(U)	Hole 7312C	6.167	33.340	29.610	30.883	1.068	8215
Anderson	(U)	Hole 7546	9.227	34.495	23.469	32.810	0.382	8315
Canyon-Cook-Wall	(U)	Hole 757	6.024	32.831	26.907	34.237	0.336	8366
Pawnee	(U)	Hole 7424C	7.880	31.029	31.910	29.183	0.386	7344
Upper Wildcat	(*)	11447	4.3	29.4	27.8	29.4	0.27	8410

(*) - Winchester, 1912

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

The Coal Data Sheet, Plate 3, shows the downhole identification of coal beds within the quadrangle as interpreted from geophysical logs of 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 Canyon coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram.

The Canyon and Cook coal beds show the thickest single coal bed occurrence throughout the quadrangle. The Felix, Smith, and Anderson coal beds are relatively thin throughout most of the area. The Wall, Pawnee, Upper Wildcat, Lower Wildcat, local, and Moyer coal beds are relatively thin and deep, and display a very lenticular occurrence.

The Felix coal bed crops out in the northwestern quadrant and in a small part of the southwestern quadrant. It is eroded from approximatel eighty-five percent of the Southeast Quarter of the Turnercrest 15' Quadrangle. Some burning has occurred along the outcrop. The thickness of the Felix coal bed ranges from less than 5 feet (1.5 m) in the southernmost areas of occurrence to 13 feet (4 m) at a measured section in section 24, Township 24 North, Range 73 West (Plate 4). The structure contours drawn on top of the Felix coal bed indicate a slight northwest plunging syncline (Plate 5). The Felix coal bed occurs from 0 to greater than 100 feet (0 to 30 m) beneath the surface.

The Smith coal bed lies approximately 300 to 400 feet (91 to 122 m) below the overlying Felix coal bed and is eroded from approximately ten percent of the quadrangle. Due to the lack of a complete outcrop configuration, an insufficient data line delimits the areal extent of the Smith coal bed. This insufficient data line is projected onto the topographic base as an approximate outcrop based on subsurface structural control points. The Smith coal bed varies in thickness from less than 5 feet (1.5 m) to over 10 feet (3 m). The maximum thickness occurs in the central portion of the quadrangle. The structure contour map drawn on the Smith coal bed shows minor folding superimposed upon a general northwest dip of two degrees or less.

The thickness of overburden above the Smith coal bed ranges from 0 to more than 500 feet (152 m). The Smith coal bed lies less than 500 feet (152 m) below the surface throughout approximately ninety-five percent of its area of occurrence in the quadrangle.

The Anderson coal bed occurs from 144 to 184 feet (44 to 56 m) beneath the Smith coal bed. Pinched out along the eastern quadrangle boundary, the Anderson coal bed attains maximum thicknesses of over 15 feet (5 m) in the northwestern corner and the southwestern quadrant. (Plate 14). The non-coal interburden within the Anderson coal bed varies from 0 to more than 50 feet (0 to more than 15 m) in thickness (Plate 16). The Anderson coal bed dips less than two degrees to the northwest, and lies at depths from less than 200 feet (61 m) to greater than 700 feet (213 m) beneath the surface. The Anderson coal bed lies within 500 feet (152 m) of the surface throughout approximately seventy percent of its area of occurrence.

The Canyon-Cook-Wall coal zone lies 111 to 288 feet (34 to 88 m) beneath the Anderson coal bed. The combined thickness of the coal beds in the Canyon-Cook-Wall coal zone ranges from less than 10 feet (3 m) in the southwestern corner to more than 90 feet (27 m) in the north-central portion of the quadrangle. The total non-coal interburden within the Canyon-Cook-Wall coal zone varies from 78 to 271 feet (24 to 83 m). The interburden increases from northeast to southwest. Structure contours drawn on top of the Canyon coal bed indicate a north plunging syncline through the central portion of the quadrangle and a northward plunging anticline along the eastern quadrangle boundary. The Canyon-Cook-Wall coal zone lies at depths greater than 500 feet (152 m) below the surface throughout approximately eighty percent of the Southeast Quarter of Turnercrest 15' Quadrangle.

The Pawnee coal bed occurs 234 to 303 feet (71 to 92 m) below the Wall coal bed and varies in thickness from 0 to 8 feet (0 to 2.4 m). Maximum thicknesses are found in the eastern half of the area. The Pawnee coal is absent from approximately fifty percent of the quadrangle. The westward dipping Pawnee coal bed lies greater than 500 feet (152 m) beneath the surface throughout the entire quadrangle.

A non-coal interval of approximately 366 to 372 feet (112 to 113 m) separates the Wildcat-Moyer coal zone from the Pawnee coal bed. The Wildcat-Moyer coal zone consists of the Upper and Lower Wildcat coal beds, the local coal bed where present, and the Moyer coal bed. The combined thickness of the coal beds varies from less than 10 feet (3 m) in the west-central region to more than 35 feet (11 m) in the southeastern corner. The total non-coal interburden within the Wildcat-Moyer coal zone ranges from 124 feet (38 m) where the Upper Wildcat coal bed is absent to 313 feet (95 m) in thickness. The westward dipping Wildcat-Moyer coal zone occurs at depths greater than 500 feet (152 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. Intra-Search Inc., plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed 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 Turnercrest 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 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 to a particular coal bed under study. Mining ratio maps for this quadrangle are constructed utilizing a ninety-five 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 ninety-five 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 two to three 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 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 potential map (Plate 34) is 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 is 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 potential is high for approximately twenty-five percent of the Southeast Quarter of Turnercrest 15' Quadrangle. The areas of high surface mining potential occur in the northwestern quadrant along the northern quadrangle boundary, in the east-central portion of the quadrangle, and in the south-central portion of the quadrangle. The high surface mining potential in the northwestern quadrant results from the less than 10:1 mining ratios for the Felix coal bed, which crops out in that area. Mining ratios of less than 10:1 for the Smith coal bed and the Canyon-Cook-Wall coal zone along the valley floor of Spring Creek are responsible for the high surface mining potential in the east-central portion of the quadrangle. Surface mining potential is high in the south-central region due to mining ratios of less than 10:1 for the Smith coal bed along the valley floor of Little Bates Creek.

Approximately fifteen percent of the quadrangle is considered to have moderate surface mining potential. The areas of moderate surface mining potential are located adjacent to the high potential area along Spring Creek in the east-central portion of the quadrangle, adjacent to the high potential area along Little Bates Creek in the south-central portion of the quadrangle, and in the southwestern quadrant near the southern quadrangle boundary. The moderate surface mining potential in the east-central portion of the quadrangle is due to the mining ratios of less than 15:1 for the Smith coal bed along the valley slopes of Spring Creek. Mining ratios of less than 15:1 for the Smith coal bed along the valley slopes of Little Bates Creek are responsible for the moderate potential areas in the south-central portion of the quadrangle.

The moderate surface mining potential in the southwestern quadrant results from mining ratios of less than 15:1 for the Anderson coal bed along Bates creek.

Low development potential areas cover approximately fifty percent of the Southeast Quarter of Turnercrest 15' Quadrangle. The low development potential areas extend throughout the central portion of the quadrangle where the Felix coal bed is absent from the thick overburden above the Smith and Anderson coal beds and the Canyon-Cook-Wall coal zone has not been eroded by drainage. 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 Turnercrest 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 500 feet (152 m) to 3000 feet (914 m) beneath the surface, or 2) coal beds 5 feet (1.5 m) or more in thickness that lie 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 Turnercrest 15' 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 4.4 billion tons (4.0 billion metric tons) (Table 3). None of the coal beds in the quadrangle qualify for a moderate or high development potential rating.

Table 1.--Strippable Coal Reserve Base Data (in short tons) for Federal Coal Lands in the Southeast Quarter of Turnercrest 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	54,460,000	-----	-----	54,460,000
Smith	22,930,000	24,880,000	346,010,000	393,820,000
Anderson	-----	27,220,000	192,210,000	219,430,000
	(0-5:1 Mining Ratio)	(5:1-7:1 Mining Ratio)	(> 7:1 Mining Ratio)	
Canyon-Cook-Wall	-----	41,500,000	532,150,000	573,650,000
TOTAL	77,390,000	93,600,000	1,070,370,000	1,241,360,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESERVE BASE TONNAGE				
Smith	-----	-----	11,250,000	11,250,000
Anderson	-----	-----	168,220,000	168,220,000
Canyon-Cook-Wall	-----	-----	3,173,340,000	3,173,340,000
Pawnee	-----	-----	103,780,000	103,780,000
Wildcat-Moyer	-----	-----	942,350,000	942,350,000
TOTAL	-----	-----	4,398,940,000	4,398,940,000
HYPOTHETICAL RESOURCE TONNAGE				
Wildcat-Moyer	-----	-----	8,940,000	8,940,000
GRAND TOTAL	-----	-----	4,407,880,000	4,407,880,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
RESOURCE BASE TONNAGE				
Smith	-----	-----	11,250,000	11,250,000
Anderson	-----	-----	168,220,000	168,220,000
Canyon-Cook Wall	-----	-----	3,173,340,000	3,173,340,000
Pawnee	-----	-----	103,780,000	103,780,000
Wildcat-Moyer	-----	-----	942,350,000	942,350,000
TOTAL	-----	-----	4,398,940,000	4,398,940,000
HYPOTHETICAL RESOURCE TONNAGE				
Wildcat-Moyer	-----	-----	8,940,000	8,940,000
GRAND TOTAL	-----	-----	4,407,880,000	4,407,880,000

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