UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE CALF CREEK QUADRANGLE, CAMPBELL COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

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

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CONVERSION TABLE

TO CONVERT	MULTIPLY BY	TO OBTAIN
inches	2.54	centimeters (cm)
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
cubic yards/ton	0.8428	cubic meters per metric ton
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 Calf Creek Quadrangle, Campbell County, Wyoming. This CRO and CDP map series includes 40 plates (U. S. Geological Survey Open-File Report 79-031. The project is compiled by IntraSearch 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 (KRCRA) in the western United States.

The Calf Creek Quadrangle is located in Campbell County, in northeastern Wyoming. It encompasses all or parts of Townships 52, 53 and 54 North, Ranges 72 and 73 West, and covers the area: 44° 30' to 44° 37' 30" north latitude; 105° 30' to 105° 37' 30" west longitude.

U. S. Highway 14-16, connecting Sheridan and Gillette, Wyoming, traverses the extreme southwestern portion of the Calf Creek Quadrangle. A maintained gravel road angles north-south through the central part of the study area, intersecting another maintained road which parallels Wildcat Creek in the northern portion of the quadrangle. Numerous minor roads and trails that branch from the aforementioned roads provide adequate access to the Calf Creek Quadrangle. The closest railroad is the Burlington Northern trackage near the Rawhide coal mine approximately 6 miles (10 km) south of the quadrangle boundary.

Wildcat Creek, approximately 3900 feet (1189 m) above sea level, flows northeastward through the northern portion of the quadrangle, and eventually drains into the Little Powder River. Wildcat Creek and its intermittent tributaries, Mamara Draw, Calf Creek, and Boxelder Creek, drain semi-rugged terrain that attains a maximum elevation of 4407 feet (1343 m) above sea level. Minimum elevations of 3840 feet (1170 m) above sea level occur in the valley floor of Wildcat Creek in the northeastern portion of the study area. 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 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 six inches (15 cm) or less generally characterize winter precipitation. Although temperatures ranging from less than -25°F (-32°C) to more than 100°F (38°C) have been recorded near Arvada, Wyoming, average wintertime minimums and summertime maximums approach +5° to +15°F (-15° and -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: 1) the delineation of lignite, subbituminous coal, bituminous coal and anthracite at the surface and in the subsurface on federal land; 2) the identification of total tons in place as well as recoverable tons; 3) categorization of these tonnages into measured, indicated, inferred reserves and resources, and hypothetical resources; and 4) recommendations 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 3.3 billion tons (3.0 billion metric tons) of total unleased federal coal-in-place in the Calf Creek Quadrangle.

The suite of maps that accompany this report set forth and portray 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, 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 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 Lebo Member of the Fort Union Formation 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 member subdivisions 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 a near base level, emerging sea floor. Much of the vast areas 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 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 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 of 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, in northwestern Campbell County, Wyoming, the contact is positioned near the top of the Roland coal bed as mapped by Olive (1957) 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 Calf Creek Quadrangle is located in an area where surface rocks are classified into the Tongue River Member of the Fort Union Formation and the Wasatch Formation. Although the Tongue River Member is reportedly 1200 to 1300 feet (366 to 396 m) thick (Olive, 1957), only 400 to 500 feet (122 to 152 m) are exposed in this area. Approximately 100 feet (30 m) of the Wasatch Formation crop out in this quadrangle. 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.

Kent (1976) named the Norfolk coal bed, and the Smith coal bed was named by Taff (1909). The Swartz coal bed was designated by McKay and Mapel (1973), and Baker (1929) assigned names to the Anderson and Canyon 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. Due to problematic correlations outside of the Gillette area, the name Wyodak has been informally used by many previous authors to represent the coal beds in the area surrounding the Wyodak coal mine. The Wildcat, Moyer, and Oedekoven coal beds were informally named by IntraSearch (1978b, 1979, and 1978a).

Local. The Calf Creek Quadrangle lies on the eastern flank of the Powder River Basin, where the strata dip gently westward. The Wasatch Formation crops out in the southern portion of the study area and is comprised of friable, coarse-grained to gritty, arkosic sandstones, fine- to very fine-grained sandstones, siltstones, mudstones, brown-to-black carbonaceous shales, and coal beds. The Tongue River Member of the Fort Union Formation crops out over most of the quadrangle. The Fort Union Formation is composed of very fine-grained sandstones, siltstones, claystones, shales, carbonaceous shales, and numerous coal beds.

III. Data Sources.

Areal geology of the coal outcrops and associated clinker is derived from the Preliminary Geologic Map of the Calf Creek Quadrangle by McKay and Mapel (1973). IntraSearch correlates McKay and Mapel's (1973) Swartz coal bed outcrop with Kent's (1976) Norfolk coal bed outcrop in the adjacent Wildcat Quadrangle to the west. In this report, the Swartz coal bed outcrop of McKay and Mapel (1973) is labeled the Smith coal bed outcrop to correlate the surrounding quadrangles under study by IntraSearch.

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 upon: 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 nomenclature focuses upon the suggestion of a regional coal bed name 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 Calf Creek Quadrangle is published by the U. S. Geological Survey, compilation date, 1971. Land 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

Fort Union Formation coal beds that are present in all or part of the Calf Creek Quadrangle include, in descending stratigraphic order, the Norfolk, Smith, Swartz, Anderson, Canyon, Cook, Pawnee, Wildcat, Moyer, and Oedekoven coal beds. A complete suite of maps (structure, isopach, mining ratio, overburden/interburden, identified resources, and areal distribution of identified resources) is prepared for each of these coal beds or coal zones where coal beds are collectively mapped, except the Norfolk coal bed where insufficient data and the lack of areal extent precludes detailed mapping.

U. S. Geological Survey and Montana Bureau of Mines and Geology drill hole 738 in Section 5, T. 52 N., R. 72 W., provides an analysis of the Anderson coal bed in the Calf Creek Quadrangle. No physical and chemical analyses are known to have been published regarding other coal beds in the quadrangle. However, the general "as received" basis proximate analyses for northern Campbell County coal beds are as follows:

COAL BED NAME		ASH	FIXED CARBON	MOISTURE	VOLATILES	SULFUR	BTU/LB
Smith (U)	Hole 7340	3.505	38.036	29.980	28.474	0.309	8371
Swartz (U)	Hole 7336	5.224	33.326	33.242	28.029	0.999	7712
Anderson (U)	Hole 738	4.546	34.783	31.540	29.131	0.250	7770
Canyon (U)	Hole 744	4.290	32.852	35.100	27.758	0.307	7298
Cook (U)	Hole 7334	5.095	34.870	29.444	30.507	0.282	8329
Pawnee (U)	Hole 7424	7.880	31.029	31.910	29.183	0.386	7344

(U) - U. S. Geological Survey and Montana Bureau of Mines and Geology 1974, 1975.

All Analyses except BTU/LB are reported in percent.

The Coal Data Sheets, Plates 3a and b, show the downhole identification of coal beds within the quadrangle as interpreted from U. S. Geological Survey and Montana Bureau of Mines and Geology drill holes, and geophysical logs from oil and gas test bores and producing sites. Inasmuch as the Canyon-Cook coal zone underlies approximately ninety percent of the quadrangle, it is designated as datum for the correlation diagram. In a portion of T. 53 N., R. 72 W., and T. 54 N., R. 72 W. the datum is redesignated at the top of the Swartz-Anderson coal zone.

The Smith coal beds crop out in the Calf Creek Quadrangle and averages 20 feet (6 m) thick. Absent from the northern, eastern, and southern portions of the quadrangle, the Smith coal beds aggregate thickness ranges from 0 to 40 feet (0 to 12 m). Thicknesses for the Upper Smith coal bed vary from 0 to 27 feet (0 to 8 m), and the Lower Smith coal bed varies from 0 to 17 feet (0 to 5 m) in thickness. Non-coal intervals of 8 to 25 feet (2.4 to 8 m) thick separate the Smith coal beds. Structural contours on top of the Smith coal beds define a westward dip of less than one degree and a north-south trending closed synclinal feature in the northwest portion of the study area (Plate 5). The Smith coal beds lie less than 150 feet (46 m) beneath the surface throughout the Calf Creek Quadrangle (Plate 6).

The Swartz-Anderson coal zone crops out throughout the study area with extensive burning apparent along the outcrop. Occurring 69 to 174 feet (21 to 53 m) beneath the Smith coal beds, the Swartz-Anderson coal zone is absent from the southeastern and west-central portions of the quadrangle (Plate 9). Thicknesses for the Swartz-Anderson coal zone range from 0 to 58 feet (0 to 18 m), and average 43 feet (13 m) where the coal zone is present. Non-coal intervals from 3 to 43 feet (0.9 to 13 m) thick divide the Swartz-Anderson coal zone range from 0 to 58 feet (0 to 18 m), and average 43 feet (13 m) where the coal zone is present. Non-coal intervals from 3 to 43 feet (0.9 to 13 m) thick divide the Swartz-Anderson coal zone into two to five separate coal beds. Structural contours on top of the Swartz-Anderson coal zone portray a westward dip of less than one degree with a west-plunging synclinal feature in the west-central portion of the quadrangle (Plate 10). The Swartz-Anderson coal zone lies less than 300 feet (91 m) beneath the surface throughout the study area (Plate 11).

The Canyon-Cook coal zone crops out in the northeastern portion of the Calf Creek Quadrangle and lies 4 to 234 feet (1.2 to 71 m) beneath the Swartz-Anderson coal zone. Thicknesses for this coal zone range from less than 10 feet (3 m) in the northeast quadrant to 78 feet (24 m) in the southeast portion of the quadrangle (Plate 14). Although the Canyon-Cook coal zone is undivided in the southwest portion of the study area, non-coal intervals from 2 to 68 feet (0.6 to 21 m) separate the coal zone into two to four individual coal beds throughout the remainder of the quadrangle. Structural contours on top of the Canyon-Cook coal zone indicate a westward dip of less than one degree and two southwest-plunging synclinal features in the northwest and southeast portions of the study area (Plate 15). The Canyon-Cook coal zone lies less than 500 feet (152 m) beneath the surface throughout the quadrangle.

From 242 to 332 feet (74 to 101 m) of clastic sediment separate the Pawnee coal bed from the overlying Canyon-Cook coal zone. Absent from the eastern portion of the study, area, the Pawnee coal bed averages 9 feet (2.7 m) thick over the remainder of the quadrangle. Thicknesses for the Pawnee coal bed vary from 0 to 20 feet (0 to 6 m) (Plate 19). The Pawnee coal bed is undivided except in Sections 1 and 2, T. 52 N., R. 73 W., where non-coal intervals of 2 to 11 feet (0.6 to 3 m) are present. Structural contours on top of the Pawnee coal bed define a westward dip of less than one degree. The Pawnee coal bed lies less than 850 feet (259 m) below the surface throughout the Calf Creek Quadrangle.

The Wildcat coal bed lies 199 to 319 feet (61 to 97 m) beneath the Pawnee coal bed, and is absent from the northern and eastern portions of the quadrangle. Thicknesses for the Wildcat coal bed (Plate 24) vary from 0 to 8 feet (0 to 2.4 m), and average 5 feet (1.5 m). The Wildcat coal bed dips less than one degree westward (Plate 25) and lies 400 to 1200 feet (122 to 366 m) below the surface throughout the Calf Creek Quadrangle (Plate 26).

The Moyer coal bed lies 62 to 233 feet (19 to 71 m) beneath the overlying Wildcat coal bed, and averages 6 feet (1.8 m) thick. Absent from parts of the eastern portion of the quadrangle, the Moyer coal bed ranges from 0 to 15 feet (0 to 5 m) in thickness (Plate 29). Non-coal intervals from 8 to 67 feet (2.4 to 20 m) thick divide the Moyer coal bed into two units in the northeastern portion of the study area. The Moyer coal bed dips approximately one degree to the west (Plate 30) and lies 500 to 1400 feet (152 to 427 m) below the surface throughout the quadrangle (Plate 31).

The Oedekoven coal bed occurs 93 to 167 feet (28 to 51 m) beneath the Moyer coal bed, and averages 6 feet (1.8 m) thick. Absent from the central portion of the quadrangle, the Oedekoven coal bed varies from 0 to 15 feet (0 to 5 m) in thickness (Plate 34). The Oedekoven coal bed dips one degree westward (Plate 35) and lies 600 to 1400 feet (183 to 427 m) below the surface throughout the Calf Creek Quadrangle (Plate 36).

V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. IntraSearch plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed 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 correctness. Inquiries to the companies who provided the oil and gas geophysical logs frequently reveal that corrections have been made in the original survey. If all horizontal location data sources have been checked and the information accepted as the best available data, the drillsite elevation on the geophysical log is modified to agree with the topographic map elevation. IntraSearch considers this agreement mandatory for the proper construction of most subsurface maps, but in particular, the overburden isopach, the ratio, and Coal Development Potential maps.

Subsurface mapping is based on geologic data within and adjacent to the Calf Creek Quadrangle area. Data from geophysical logs are used to correlate coal beds and control contour lines for the coal thickness, structure, and overburden maps. Isopach lines are also drawn to honor selected measured sections where there is sparse subsurface control Where 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 is 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 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 complex 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:

$$MR = \frac{t_o\ (0.911)\ *}{t_c\ (rf)}$$

where MR = mining ratio
t_o = thickness of overburden
t_c = thickness of coal
rf = recovery factor
0.911 = conversion factor (cu.yds./ton)

*Use (0.922) for lignite

A surface mining potential map (Plate 39) 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 ninety percent of the study area. This high potential relates to the thick Swartz-Anderson and Canyon-Cook coal zones occurring near the surface. Mining ratios for the Swartz-Anderson coal zone are less than 5:1 over most of the study area, and the Canyon-Cook coal zone mining ratios are less than 10:1. These circumstances create high development potentials for surface mining. Low potential areas cover the remainder of the quadrangle in the northeastern portion of the study area. The low potential areas relate to the absence of these thick coal zones and mining ratios for the Pawnee coal bed of greater than 15:1. 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 Calf Creek 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 buried 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 on the Calf Creek 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 552 million tons (501 million metric tons) (Table 3). None of the coal beds in the Calf Creek 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 Calf Creek 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
Smith	195,010,000	—	—	195,010,000
Canyon-Cook	1,341,180,000	40,070,000	3,870,000	1,385,120,000
Pawnee	—	—	5,350,000	5,350,000
Wildcat	—	—	—	—
Moyer	—	—	—	—
Oedekoven	—	—	—	—
	(0-5:1 Mining Ratio)	(5:1-7:1 Mining Ratio)	(>7:1 Mining Ratio)	
Swartz-Anderson	1,007,040,000	3,670,000	—	1,010,710,000
TOTAL	2,543,230,000	43,740,000	9,220,000	2,596,190,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	—	—	—	—
Anderson	—	—	—	—
Canyon	—	—	—	—
Pawnee	—	—	209,040,000	209,040,000
Wildcat	—	—	95,240,000	95,240,000
Moyer	—	—	161,170,000	161,170,000
Oedekoven	—	—	86,770,000	86,770,000
TOTAL	—	—	552,220,000	552,220,000

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

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Smith	———	———	———	———
Anderson	———	———	———	———
Canyon	———	———	———	———
Pawnee	———	———	209,040,000	209,040,000
Wildcat	———	———	95,240,000	95,240,000
Moyer	———	———	161,170,000	161,170,000
Oedekoven	———	———	86,770,000	86,770,000
Total	———	———	552,220,000	552,220,000

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