UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEXT TO ACCOMPANY:

COAL RESOURCE OCCURRENCE

AND

COAL DEVELOPMENT POTENTIAL

MAPS

OF THE

THE NIPPLE QUADRANGLE,

JOHNSON AND CAMPBELL COUNTIES, WYOMING

BY

INTRASEARCH INC.

ENGLEWOOD, COLORADO

OPEN FILE REPORT 79-179
1980

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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/ metric ton
acre-feet	0.12335	hectare-meters
British thermal units/pound (Btu/lb)	2.326	kilojoules/kilogram (kj/kg)
British thermal units/pound (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 Nipple Quadrangle, Johnson and Campbell Counties, Wyoming. This CRO and CDP map series includes 55 plates (U. S. Geological Survey Open-File Report 79-179). 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 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 Nipple Quadrangle is located in Johnson and Campbell Counties, in northeastern Wyoming. It encompasses all or parts of Townships 45, 46 and 47 North, Ranges 76 and 77 West, and covers the area: 43°52'30" to 44°00' north latitude; 106°00' to 106°07'30" west longitude.

Access to The Nipple Quadrangle is provided by unimproved roads which extend throughout much of the area. Minor trails provide additional access to the more remote areas. U. S. Highway 109 runs north to south approximately 14 miles (23 km) to the east. The closest railroad is the Burlington Northern trackage approximately 32 miles (51 km) to the northeast at Gillette, Wyoming.

The most significant drainage is provided by westward-flowing Willow Creek and northwestward-flowing Pumpkin Creek. These creeks meander

across the southwest and northeast quarters of the quadrangle, respectively. Windmill Draw and other minor streams supplement the drainage through the remainder of the study area. The Powder River flows northward across the adjacent Hoe Ranch Quadrangle about 1 to 3 miles (1.6 to 4.8 km) west of The Nipple Quadrangle. Elevations attain maximum heights of 4,980 feet (1,518 m) above sea level in the southeast quarter of The Nipple Quadrangle, 600 to 700 feet (183 to 213 m) above the valley floor.

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 Arvada, Wyoming, average wintertime minimums and summertime maximums range from +5° to +15°F (-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 Johnson and Campbell County Courthouses in Buffalo and Gillette, Wyoming, respectively. 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 (resources), as well as recoverable tons (reserves). These coal tonnages are then categorized in measured, indicated, and inferred parts of identified 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 3,000 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 9.0 billion tons (8.2 billion metric tons) of total, unleased federal coal-in-place resources in The Nipple Quadrangle.

The suite of maps that accompanies 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 overlying Wasatch Formation. Approximately 3,000 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 the 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. The Lebo Member is east of the principal coal outcrops and associated clinkers (McKay, 1974), and it presumably projects into the subsurface beneath much of the basin. One of the principal characteristics for separating the Lebo and Tullock Members (collectively referred to as the Ludlow Member east of Miles City, Montana) from the overlying Tongue River Member is the color differential between the lighter-colored

upper portion and the somewhat darker lower portion (Brown, 1958). Although geologists are trying to develop criteria for subsurface recognition of the Lebo-Tullock and Tongue River-Lebo contacts through 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 member subdivisions 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 2 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 and in-filling of these areas 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 of 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 servicing 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 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 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 noticably to imperceptibly coarser than the underlying Fort Union clastics.

The Nipple Quadrangle is located in an area where surface rocks are classified within the Watsatch Formation. Although the Wasatch Formation is reportedly up to 1,800 feet (549 m) thick (Denson and Horn, 1975), Olive (1957) mapped 700 to 800 feet (213 to 244 m). Only 600 to 700 feet (183 to 213 m) of Wasatch Formation are exposed in the quadrangle.

Olive (1957) correlated coal beds in the Spotted Horse coal field with coal beds in the northward extension of the Sheridan coal field, Montana (Baker, 1929), and Gillette coal field, Wyoming (Dobbin and Barnett, 1927), 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 assigned the name to the Wall coal bed, and the Pawnee coal bed was named by Warren (1959). IntraSearch informally named the Wildcat, Moyer, and Oedekoven coal beds (1978b, 1979, 1978a).

IntraSearch's correlation of thick coal beds from the Spotted Horse coal field to Gillette points out that the Wyodak coal bed, named the "D" coal bed by Dobbin and Barnett (1927), is equivalent to the Anderson, Canyon, and all, or part, of the Cook coal beds to the north and west of Gillette, Wyoming. Correlation of this suite of coal beds with the Wyodak coal bed south and southwest of Gillette suggests that the Anderson and Canyon coal beds equate with the upper 10 to 25 percent of the thick Wyodak coal bed, and the Cook and Wall, or Upper Wall, coal beds are equivalent to the major part of the Wyodak coal bed. Due to problematic correlations outside of the Gillette area, the name Wyodak has been informally used by many previous authors to represent the coal beds in the area surrounding the Wyodak coal mine.

Local. The Nipple 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 composed 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

No significant coal outcrops or associated clinker in The Nipple Quadrangle are mapped in any publications known to IntraSearch at the time of this report. It is presumed and highly possible that no significant coal outcrops exist at the surface in The Nipple Quadrangle.

Geophysical logs from oil and gas test bores and producing wells compose 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 and its 3-mile perimeter area were scanned to select those with data applicable to Coal Resource Occurrence mapping. Paper copies of the logs were obtained and interpreted, and coal intervals were annotated. Maximum

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

The reliability of correlations, set forth by IntraSearch in this report, varies depending on: the density and quality of lithologic and geophysical logs; the details, 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 Nipple Quadrangle is published by the U. S. Geological Survey, compilation date 1953. 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

The Wasatch Formation and Fort Union Formation coal beds that are present in all or part of The Nipple Quadrangle include, in descending stratigraphic order: the Felix, Smith, local, Local "A", Upper Wyodak, Middle Wyodak, Lower Wyodak, Wall, local, Local "B", Pawnee, Wildcat, Moyer, and Oedekoven coal beds. A suite of maps composed of: coal isopach; structure; overburden isopach; areal distribution of identified resources; and identified resources was prepared for each of these coal beds or coal zones. Insufficient thickness and minimum areal extent preclude any detailed mapping of the local coal beds.

No physical or chemical analyses are known to have been published regarding the coal beds in The Nipple Quadrangle. For Campbell and eastern Johnson County coal beds, the "as received" proximate analysis; the Btu value computed on a moist, mineral-matter-free basis;* and the coal rank are as follows:

COAL BED NAME		DATA SOURCE IDENTIFICATION	AS RECEIVED BASIS: ASH %	FIXED CARBON %	MOISTURE %	VOLATILES %	SULFUR %	BTU/LB	MOIST, M-M-F BTU/LB	COAL RANK
Felix	(**)	Lab.No. 6432	5.6	35.7	25.8	32.9	0.39	8465	9010	Subbtm. C
Smith	(**)	Lab.No. 6460	4.7	34.0	28.8	32.5	0.46	7862	8280	Lignite A
Upper Wyodak	(U)	Hole 7310	5.9	33.9	29.1	31.2	0.44	8172	8722	Subbtm. C
Middle-Lower Wyodak	(U)	Hole 7334	5.1	34.9	29.4	30.5	0.28	8329	8814	Subbtm. C
Pawnee	(U)	Hole 7424	7.9	31.0	31.9	29.2	0.39	7344	8025	Lignite A
"Wildcat"	(1)	Lab.No. 11447	4.3	29.4	27.8	29.4	0.27	8410	8818	Subbtm. C

* The moist, mineral-matter-free Btu values are calculated in the manner stipulated in the publications by American Society for Testing and Materials (1971).

** Stone and Lupton (1910).

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

(1) Winchester (1912).

The proximate analyses presented above are from core hole or outcrop locations in excess of 20 miles (32 km) from this quadrangle. In order to simplify tonnage computations, all coal beds in The Nipple Quadrangle are tentatively classified as subbituminous C rank.

The Coal Data sheets, plates 3A and 3B, show the down-hole 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 from producing sites. This portrayal is schematic by design; hence, no structural or coal thickness implications are suggested by the dashed correlation lines projected through No Record (NR) intervals. Inasmuch as the Upper Wyodak coal bed underlies the entire quadrangle, it is designated as datum for the correlation diagram. The Middle Wyodak coal beds and combined Upper and Middle Wyodak coal beds show the thickest coal bed occurrence throughout the study area. The Lower Wyodak coal bed also shows a moderate coal bed thickness. The remaining coal beds are comparatively thin throughout The Nipple Quadrangle.

The Felix coal bed is a thin, lenticular coal bed ranging from 0 to 3 feet (0 to 0.9 m) in thickness. It occurs approximately 400 to 600 feet (122 to 183 m) beneath the surface in the east-central part of the study area. Insufficient thickness precludes detailed mapping.

The Smith coal bed occurs approximately 600 to 1,150 feet (183 to 351 m) beneath the surface throughout the quadrangle. The coal bed thickness ranges from 2 to 9 feet (0.6 to 2.7 m) with maximum thicknesses occurring in the eastern half of the study area. Structure contours drawn on top of the Smith coal bed indicate a northwest-plunging anticline in the east-central part of the study area. Separated by a

shallow syncline, another similarly-plunging anticline is evident in the southwest quarter of the quadrangle.

The Local "A" coal beds are comprised of one-to-two thin, lenticular coal beds occurring approximately 350 to 475 feet (107 to 145 m) below the Smith coal bed. The total coal thickness ranges from 0 to 13 feet (0 to 4 m), with maximum thicknesses occurring in the northwest quarter of the quadrangle. Approximately 26 to 81 feet (8 to 25 m) of clastic sediments separate the two Local "A" coal beds. Structure contours drawn on top of the Local"A" coal beds show a broad syncline in the northwest quarter of the study area. The Local "A" coal beds lie from 950 to 1,550 feet (290 to 472 m) beneath the surface of the quadrangle.

The Upper Wyodak coal beds lie approximately 25 to 225 feet (8 to 69 m) below the lenticular, Local "A" coal beds, and approximately 375 to 625 feet (114 to 191 m) beneath the Smith coal bed. Thickness of the coal beds ranges from 22 to 49 feet (7 to 15 m). Maximum thicknesses occur in the southern half of the quadrangle with thinning to the north. A clastic interval ranging from 0 to 130 feet (0 to 40 m) in thickness separates the Upper Wyodak coal bed throughout most of the western half of the study area. The dominant structural feature on these coal beds is a northwest-southeast-trending syncline through the central portion of the study area. A shallow anticline is located in the southwest quarter of the quadrangle. The Upper Wyodak coal beds lie approximately 900 to 1,650 feet (274 to 503 m) beneath the surface throughout the entire quadrangle.

The Middle Wyodak coal bed and the Upper Wyodak coal bed combine to form a single, thick coal bed throughout much of the eastern half of the quadrangle. The total Upper Wyodak and Middle Wyodak coal bed thickness averages approximately 95 feet (29 m) in this area. The Middle Wyodak coal bed ranges from 35 feet (11 m) along the western boundary to 75 feet (23 m) in the eastern two-thirds of the study area. The 35-foot isopach contour is projected from control points west of The Nipple Quadrangle. Minor, non-coal partings ranging from 0 to 19 feet (0 to 6 m) in thickness split the Middle Wyodak coal bed locally. Structure contours drawn on top of the Middle Wyodak coal bed depict a northwest-plunging syncline extending diagonally across the study area. The Middle Wyodak coal bed lies approximately 1,100 to 1,700 feet (335 to 518 m) beneath the surface of the entire quadrangle.

The Middle Wyodak and the Lower Wyodak coal beds converge locally to form a single, thick coal bed along the extreme northern boundary of the quadrangle. A non-coal interval from 0 to 200 feet (0 to 61 m) in thickness separates the Middle Wyodak and Lower Wyodak coal beds throughout the remainder of the study area, and averages approximately 50 to 100 feet (15 to 30 m) thick, with maximum thickness occurring in the north-central portion of the quadrangle. The Lower Wyodak coal bed ranges in thickness from 24 to 54 feet (7 to 16 m). Maximum coal bed thicknesses occur in the northwest quarter of the quadrangle. A broad, shallow, northwest-plunging syncline extends diagonally across the central part of the quadrangle. The Lower Wyodak

coal bed occurs from 1,150 to 1,800 feet (351 to 549 m) beneath the surface of the quadrangle.

The Wall coal bed lies approximately 20 to 80 feet (6 to 24 m) below the Lower Wyodak coal bed. The coal bed thickness ranges from 0 to 12 feet (0 to 4 m). Maximum thickness occurs in the southern and east-central parts of the study area, with thinning to the northwest. The Wall coal bed is absent from approximately 20 percent of the quadrangle along the northern boundary. The uppermost Wall coal bed, that exhibits the areal extent of the three Wall coal beds, in underlain by two, thin, lenticular coal beds that are positioned from 0 to 50 feet (0 to 15 m) beneath the principal horizon. Structural contours drawn on top of the Wall coal bed define a northwest-plunging syncline extending diagonally across the central part of the study area. The Wall coal bed lies between 1,350 and 1,950 feet (411 to 504 m) beneath the surface of the study area.

The Local "B" coal beds occur approximately 40 to 200 feet (12 to 61 m) below the Wall coal bed. The total thickness of these coal beds ranges from 0 to 12 feet (0 to 4 m) with maximum thickness occurring in the central part of the quadrangle. The Local "B" coal beds are absent along the eastern boundary in the southeastern quarter. Structure contours drawn on top of the uppermost coal bed depict a northwest-plunging syncline extending diagonally across the study area. The non-coal interval separating the two-to-three, thin coal beds ranges from 0 to 60 feet (0 to 18 m) in thickness. The Local "B" coal beds occur

between 1,400 to 2,050 feet (427 to 625 m) beneath the surface of the quadrangle.

The Pawnee coal bed occurs approximately 175 to 350 feet (53 to 107 m) below the Local "B" coal beds. The coal bed thickness ranges from 0 to 21 feet (0 to 6 m) with maximum thickness occurring in the northwest quarter of the quadrangle. The Pawnee coal bed thins to the southeast, and is absent from approximately 3 percent of the quadrangle in the southeast quarter. A minor non-coal interval ranging in thickness from 0 to 30 feet (0 to 9 m) locally separates the Pawnee coal bed. Structure contours drawn on top of the Pawnee coal bed show a shallow syncline extending across the south-central part of the study area. Minor anticlinal highs are present in the northeast and southwest quarters of the quadrangle. The Pawnee coal bed occurs between 1,700 and 2,300 feet (518 and 701 m) beneath the surface of the quadrangle.

The Wildcat-Moyer coal zone lies approximately 145 to 325 feet (44 to 99 m) below the Pawnee coal bed, and is composed of one-to-two, thin Wildcat coal beds, plus one-to-two, lenticular Moyer coal beds. The total coal zone thickness ranges from 0 to 20 feet (0 to 6 m). Maximum thickness occurs along the northern boundary of the study area, with thinning to the south. The Wildcat-Moyer coal zone is absent from approximately 28 percent of the quadrangle, primarily in the southwest quarter. The most dominant structural feature is a broad, northwest-plunging anticline that trends across the northern half of the quadrangle. A shallow, northwest-plunging syncline also extends across the southern

half of the study area. The non-coal intervals separating the coal beds within the Wildcat-Moyer coal zone range from 0 to 220 feet (0 to 67 m) in thickness. The Wildcat-Moyer coal zone ranges from 1,900 to 2,550 feet (579 to 777 m) beneath the surface throughout approximately 72 percent of the study area.

The Oedekoven coal beds occur approximately 200 to 375 feet (61 to 114 m) beneath the Wildcat-Moyer coal zone. Total Oedekoven coal beds thickness range from 0 to 15 feet (0 to 5 m) with maximum thickness occurring along the northern boundary of the quadrangle. The Oedekoven coal beds are absent from approximately 65 percent of the quadrangle, primarily throughout the southern two-thirds of the study area. A non-coal interval, ranging from 0 to 35 feet (0 to 11 m) in thickness, locally separates the Oedekoven coal beds. Structure contours drawn on top of the Oedekoven coal beds indicate a westward-plunging anticline extending across the northern third of the quadrangle. The Oedekoven coal beds lie between 2,100 and 2,800 feet (640 and 853 m) beneath the surface throughout approximately 35 percent of the study area.

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 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 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 Nipple Quadrangle area. Data from geophysical logs are used to correlate coal beds and control contour lines for the coal thickness, structure, and overburden maps. Structure contour maps are constructed on the tops of the main coal beds.

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 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), and 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, and inferred parts of identified 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 1,750, or 1,770--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 tonnages (reserves) are 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 complex 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, when applicable, is prepared utilizing the following mining ratio criteria for coal beds 5 feet 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.

There is no development potential for surface mining in The Nipple Quadrangle. The coal beds present within the study area occur at depths that exceed the 500-foot (152-m) stripping limit for surface mining. For this reason, no surface mining development potential map was generated for this quadrangle.

Underground Mining Coal Development Potential. Subsurface coal mining development potential throughout The Nipple 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 1 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 development potential relates to the occurrence of coal beds more than 5 feet (1.5 m) thick buried from 500 to 3,000 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 1,000 feet (305 m) to 3,000 feet (914 m) beneath the surface, or 2)

a coal bed or coal zone 5 feet (1.5 m) or more in thickness that lies 500 feet (152 m) to 1,000 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 1,000 to 3,000 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 1,000 to 3,000 feet (305 to 914 m).

The coal development potential for in-situ gasification (plate 54) is moderate for approximately 95 percent of The Nipple Quadrangle. This moderate development potential rating is attributed primarily to the combined thickness of the Upper Wyodak, Middle Wyodak, and Lower Wyodak coal beds. These Wyodak coal beds compose nearly 85 percent of the total coal resources in the quadrangle, averaging 125 to 135 feet (38 to 41 m) thick throughout much of the study area. A low development potential rating covers approximately 1 percent of the quadrangle along the western boundary. In this area, the Upper Wyodak coal beds are positioned less than 1,000 feet (305 m) beneath the surface.

Table 1.--Coal Reserve Base Data (in short tons) for Underground Mining Methods for Federal Coal Lands in The Nipple Quadrangle, Johnson and Campbell County, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resource				
Smith	-	-	182,860,000	182,860,000
Local "A"	-	-	30,370,000	30,370,000
Upper Wyodak	-	-	1,855,250,000	1,855,250,000
Middle Wyodak	-	-	3,445,600,000	3,445,600,000
Lower Wyodak	-	-	2,009,540,000	2,009,540,000
Wall	-	-	242,620,000	242,620,000
Local "B"	-	-	184,470,000	184,470,000
Pawnee	-	-	573,870,000	573,870,000
Wildcat-Moyer	-	-	352,970,000	352,970,000
Oedekoven	-	-	117,190,000	117,190,000
TOTAL	-	-	8,994,740,000	8,994,740,000

Table 2.--Coal Reserve Base Data (in short tons) for In-Situ Gasification for Federal Coal Lands in The Nipple Quadrangle, Johnson and Campbell Counties, Wyoming.

Coal Bed Name	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Reserve Base Resource				
	-	91,830,000	8,902,910,000	8,994,740,000
TOTAL	-	91,830,000	8,902,910,000	8,994,740,000

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