UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

# TEXT TO ACCOMPANY:

# COAL RESOURCE OCCURRENCE

# AND

# COAL DEVELOPMENT POTENTIAL

# MAPS

# OF THE

# NORTHWEST QUARTER OF HIGHLAND FLATS 15' QUADRANGLE,

# CONVERSE COUNTY, WYOMING

BY

INTRASEARCH INC.

DENVER, COLORADO

OPEN FILE REPORT 79-458

1979

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

# TABLE OF CONTENTS

## TABLE OF CONTENTS (continued)

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 Northwest Quarter of Highland Flats 15' Quadrangle, Converse County, Wyoming. This CRO and CDP map series (U. S. Geological Survey Open-File Report 79-458) includes 24 plates. The project is compiled by Intra-Search 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 Northwest Quarter of Highland Flats 15' Quadrangle is located in Converse County, in northeastern Wyoming. It encompasses all or parts of Townships 36, 37, and 38 North, Ranges 73 and 74 West, and covers the area: 43°07'30" to 43°15' north latitude; 105°37'30" to 105°45' west longitude.

Main access to the Northwest Quarter of Highland Flats 15' Quadrangle is provided by Ross Road which angles north to south across the western half of the quadrangle. A maintained road branches from Ross Road providing access to the eastern half of the study area. A light-duty road is located on the crest of the Cheyenne River Divide in the northern quarter of the map. Minor roads and trails that branch from these gravel roads provide additional access to the more remote areas. The closest railroads are the Burlington Northern and the Chicago and North Western trackage approximately 24 miles (39 km) to the southeast at Glenrock, Wyoming.

Drainage patterns generate from high, fairly rugged terrain in the southwest and northwest quarters of the study area. Elevations attain heights of 5640 feet (1719 m) above sea level, in the southwestern part of the area, 600 to 650 feet (183 to 198 m) above the valley floors. Eastward drainage is provided by Cheyenne River Draw and the Dry Fork of the Cheyenne River in the northern half of the quadrangle, just south of the Cheyenne River Divide. Brown Springs Creek in the southwest corner, drains northeastward. These intermittent streams drain into the Cheyenne River to the east.

The 10 to 12 inches (25 to 30 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 Glenrock, 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. State and federal lands are generally leased to ranchers for grazing purposes. Details of surface ownership are available at the Converse County Courthouse in Douglas, 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 belongs to both fee and state owners.

The Coal Resource Occurrence and Coal Development Potential program is restricted 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) subdivision of deposits into measured, indicated, and inferred reserve resource categories, and hypothetical resources; 3) the measurement of coal resources in place as well as reserves; and 4) the determination of the potential for surface or underground mining, and in-situ gasification of the coal beds. This report contains an evaluation of 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 1.4 billion tons (1.3 billion metric tons) of unleased federal coal resources in the Northwest Quarter of Highland Flats 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.

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 Northwest Quarter of Highland Flats 15' Quadrangle is located in an area where surface rocks are classified as the Wasatch Formation. This report utilizes, where possible, the coal bed nomenclature used in previous reports. The Smith coal bed was named by Taff (1909), and Baker (1929) assigned names to the Anderson and Canyon coal beds. The Wildcat and Moyer coal beds were informally named by IntraSearch (1978 and 1979).

Local. The Northwest Quarter of Highland Flats 15' Quadrangle lies on the eastern flank of the Powder River Basin near the basin axis. The Wasatch Formation crops out over the entire study 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.

## III. Data Sources

Areal geology of the coal outcrops is derived from Wegemann and others (1929), and Sharp and Gibbons (1964). The coal bed outcrops are adjusted to the current topographic maps in the area. Because the scale of the publication by Wegemann and others (1929) is 1:126,720, the outcrop configurations are enlarged. The structural elevation control points established on the outcrop configuration are considered to be plus or minus 50 to 100 feet (15 to 30 m) in accuracy. Numerous irregularities in outcrop elevations and the areal geology-topographic map relationship emphasize that these maps present a generalized configuration of the coal bed outcrop. Horizontal accuracy of the outcrop location is estimated plus or minus 1,000 feet (305 m).

Outcrop delineations for the Smith and Anderson coal beds from Wegemann and others (1929) are incomplete; therefore, an insufficient data line showing an approximation of the coal bed outcrop line between mapped localities was projected onto recent topographic maps.

The source of subsurface control 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 occurrence.

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 Highland Flats 15' Quadrangle is published by the U. S. Geological Survey, compilation date, 1959. Land network and mineral ownership data are compiled from land plats available from the U. S. Bureau of Land Management in Cheyenne, Wyoming. This information is current to October 13, 1977.

## IV. Coal Bed Occurrence

Wasatch and Fort Union Formation coal beds that are present in all or part of the Northwest Quarter of Highland Flats 15' Quadrangle include, in descending stratigraphic order, the Smith, Anderson, Canyon, Wildcat and Moyer coal beds. A complete suite of maps (structure, coal isopach, mining ratio, overburden isopach, identified resources and areal distribution of identified resources) is prepared for each of these coal beds, except the Wildcat and Moyer coal beds which are mapped together as a coal zone.

No physical and chemical analyses are known to have been published regarding the coal beds in the Northwest Quarter of Highland Flats 15' Quadrangle. However, the "as received" basis proximate analyses from samples of the Smith and Anderson coal beds taken in T. 36 N., R. 75 W., are as follows:

| COAL BED NAME | | ASH % | FIXED CARBON % | MOISTURE % | VOLATILES % | SULFUR % | BTU/LB |
|---|---|---|---|---|---|---|---|
| Smith | Sample No.* 74-37 | 9.68 | 29.48 | 26.41 | 34.43 | 0.52 | 7830 |
| Anderson | Sample No.* 74-35 | 8.48 | 28.47 | 29.02 | 34.03 | 0.41 | 7606 |

*Glass 1975b

The Coal Data Sheet, Plate 3, shows the downhole identification of coal beds within the quadrangle as interpreted from geophysical logs from oil and gas test bores and producing sites. A datum coal bed is utilized to position columnar sections on Plate 3. This portrayal is schematic by design; hence, no structural or coal thickness implications are suggested by the dashed correlation lines projected through no record (NR) intervals. Inasmuch as the Wildcat coal bed underlies the entire study area, it is designated as datum for the correlation diagram.

The Smith coal bed is eroded from approximately sixty percent of the quadrangle. Due to absence of subsurface data for structure and isopach maps, mapping control is derived from outcrop elevations and surface measured sections. The Smith coal bed varies from 1 to 11.9 feet (0.3 to 4 m) in thickness with maximum thickness occurring in the western quarter of the quadrangle (Plate 4). Inasmuch as there is no outcrop delineation in the southeast corner, an insufficient data line shows an approximation of the coal bed outcrop. Structure contours drawn on the Smith coal bed top define a broad, gentle, north-plunging anticline located in the central portion of the area with a companion syncline to the west (Plate 5). The Smith coal bed lies from 0 feet (0 m) to less than 400 feet (122 m) beneath the surface throughout the study area (Plate 6).

The Anderson coal bed crops out along the Dry Fork of the Cheyenne River in the northeast corner of the study area and is separated from the overlying Smith coal bed by approximately 100 to 350 feet (30 to 107 m) of clastic debris. Coal bed thicknesses range from 1.8 to 12 feet (0.5 to 4 m) with maximum thicknesses occurring in the northwest quarter of the area (Plate 9). Localized partings occur through the quadrangle with interburden 16 feet (5 m) thick observed. Inasmuch as there is a lack of outcrop delineation (Wegemann and others, 1929) in the northeast corner, an insufficient data line shows an approximation of the coal bed outcrop. A northeast plunging anticline is present in the central portion of the area with an adjacent syncline to the southeast (Plate 10). The Anderson coal bed lies from 0 feet to less than 500 feet (0 to 152 m) beneath the surface throughout the study area (Plate 11).

The Canyon coal bed lies approximately 220 to 400 feet (67 to 122 m) beneath the Anderson coal bed. The coal bed thickness varies from less than 5 feet to 7 feet (1.5 to 2.1 m) with maximum thickness occurring in the northwest corner of the area (Plate 14). The lack of subsurface data for the southern seventy-five percent of the quadrangle requires an insufficient data designation for this area. The structure contours on the coal bed top define a gentle northeast dip (Plate 15). The Canyon coal bed is less than 400 feet (122 m) to greater than 700 feet (213 m) beneath the surface along the Dry Fork of the Cheyenne River (Plate 16).

The Wildcat-Moyer coal zone lies approximately 1100 to 1200 feet (335 to 366 m) beneath the Canyon coal bed. Coal zone thicknesses range from 5 to 60 feet (1.5 to 18 m) with maximum thicknesses occurring in the northeast corner of the study area and minimum thickness in the southeast corner (Plate 19). The Wildcat coal bed varies from 2 to 24 feet (0.6 to 7 m) thick. The Moyer coal bed varies from 2 to 29 feet (0.6 to 9 m) thick with localized partings of up to 80 feet (24 m) occurring in the coal bed. Approximately 100 to 170 feet (30 to 52 m) of interburden separate the Wildcat and Moyer coal beds. Structure contours drawn on top of the Wildcat coal bed depict a broad north plunging syncline across the central portion of the quadrangle (Plate 20). The Wildcat-Moyer coal zone is less than 1500 feet (457 m) to greater than 1750 feet (533 m) beneath the surface (Plate 21).

## V. Geological and Engineering Mapping Parameters

The correct horizontal location and elevation of drill holes utilized in subsurface mapping are critical to map accuracy. IntraSearch Inc., plots the horizontal location of the drill hole as described on the geophysical log heading. Occasionally this location is superimposed 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 Northwest Quarter of Highland Flats 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 <u>Insufficient</u>

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 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 potential map (Plate 24) 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 high surface mining potential, for approximately twelve percent of the Northwest Quarter of Highland Flats 15' Quadrangle is located in scattered areas in the northern and western parts of the quadrangle. The high potential areas occur in the valleys where the overburden is thin and the Smith and Anderson coal beds are greater than 5 feet (1.5 m) thick. About nine percent of the study area is rated as moderate and ten percent is rated as low surface mining potential. These areas are in the northern and western regions of the quadrangle. The remaining sixty-nine percent of the quadrangle is either non-federal coal land or has no surface mining potential. The areas of no surface mining potential are in the eastern half of the quadrangle where the Smith coal bed is eroded, where the Anderson and Canyon coal beds are less than 5 feet (1.5 m) thick, and where the Wildcat-Moyer coal zone is too deep.

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 Northwest Quarter of Highland Flats 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) a single coal bed or coal zone 5 feet (1.5 m) or more in thickness which lies 500 feet (152 m) to 1000 feet (305 m) beneath the surface.
2. Moderate development potential is assigned to a total coal section from 100 to 200 feet (30 to 61 m) thick, and buried from 1000 to 3000 feet (305 to 914 m) beneath the surface.
3. High development potential involves 200 feet (61 m) or more of total coal thickness buried from 1000 to 3000 feet (305 to 914 m).

The coal development potential for in-situ gasification within the Northwest Quarter of Highland Flats 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 1.2 billion tons (1.1 billion metric tons) (Table 3). None of the coal beds in the Northwest Quarter of Highland Flats 15' Quadrangle qualify for a moderate or high development potential rating.

Table 1.--Strippable Coal Reserve Base and Hypothetical Resource Data (in short tons) for Federal Coal Lands in the Northwest Quarter of Highland Flats 15' Quadrangle, Converse 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 |
|---|---|---|---|---|
| RESERVE BASE | | | | |
| Smith | 31,120,000 | 21,540,000 | 35,730,000 | 88,390,000 |
| Anderson | 210,000 | 2,090,000 | 57,510,000 | 59,810,000 |
| TOTAL | 31,330,000 | 23,630,000 | 93,240,000 | 148,200,000 |
| HYPOTHETICAL RESOURCE | | | | |
| Anderson | ----- | ----- | 38,000,000 | 38,000,000 |
| TOTAL | ----- | ----- | 38,000,000 | 38,000,000 |
| GRAND TOTAL | 31,330,000 | 23,630,000 | 131,240,000 | 186,200,000 |

Table 2.--Coal Resource Base and hypothetical Resource Data (in short tons) for Underground Mining Methods for Federal Coal Lands in the Northwest Quarter of Highland Flats 15' Quadrangle, Converse County, Wyoming.

| Coal Bed Name | High Development Potential | Moderate Development Potential | Low Development Potential | Total |
|---|---|---|---|---|
| RESERVE BASE | | | | |
| Canyon | ----- | ----- | 17,240,000 | 17,240,000 |
| Wildcat-Moyer | ----- | ----- | 840,770,000 | 840,770,000 |
| TOTAL | ----- | ----- | 858,010,000 | 858,010,000 |
| HYPOTHETICAL RESOURCE | | | | |
| Canyon | ----- | ----- | 3,580,000 | 3,580,000 |
| Wildcat-Moyer | ----- | ----- | 352,650,000 | 352,650,000 |
| TOTAL | ----- | ----- | 356,230,000 | 356,230,000 |
| GRAND TOTAL | ----- | ----- | 1,214,240,000 | 1,214,240,000 |

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

| Coal Bed Name | High Development Potential | Moderate Development Potential | Low Development Potential | Total |
|---|---|---|---|---|
| RESERVE BASE | | | | |
| Canyon | ----- | ----- | 17,240,000 | 17,240,000 |
| Wildcat-Moyer | ----- | ----- | 840,770,000 | 840,770,000 |
| TOTAL | ----- | ----- | 858,010,000 | 858,010,000 |
| HYPOTHETICAL RESOURCE | | | | |
| Canyon | ----- | ----- | 3,580,000 | 3,580,000 |
| Wildcat-Moyer | ----- | ----- | 352,650,000 | 352,650,000 |
| TOTAL | ----- | ----- | 356,230,000 | 356,230,000 |
| GRAND TOTAL | ----- | ----- | 1,214,240,000 | 1,214,240,000 |

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