Open-File Report 00-12

Demonstrated Reserve Base for Coal in Colorado: Yampa Coal Field

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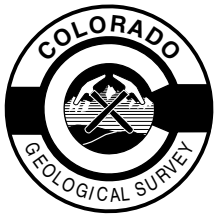

Colorado Geological Survey
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FOREWORD

The purpose of Colorado Geological Survey Open File Report 00-12, *Demonstrated Reserve Base for Coal in Colorado: Yampa Coal Field*, is to describe the amount of coal in the Yampa Coal Field, Moffat and Routt Counties, which is either measured or indicated by drill hole data or outcrop measurements. The staff of the Mineral Resources and Geological Mapping Section of the Colorado Geological Survey completed the work on this project from February 1999 to December 1999. The objective of this publication is to provide geological information to resource developers, government planners, and interested citizens.

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EXECUTIVE SUMMARY

The new demonstrated reserve base (DRB) estimate of coal for the Yampa Coal Field of Colorado is 9.88 billion short tons. This compares with 5.10 billion short tons for the same area according to the United States Geological Survey (USGS) coal resources study (Landis, 1959). The new estimates are derived from revised resource calculations based on a significantly larger drill hole database and adjustments for depletion due to past mining through November 1999. Bituminous reserves of the DRB are 8.35 billion short tons. Sub-bituminous reserves are 1.53 billion short tons. Most of the resource is in the middle coal group of the Williams Fork Formation (7.36 billion short tons).

The accessible reserve base (ARB), which excludes coal restricted by land use or technological considerations, is estimated to be 6.86 billion short tons. Using a 200 ft surface minable limit of depth to coal, the ARB can be differentiated for both surface and underground minable coal estimates. The surface minable accessible reserve base is 1.05 billion short tons, and the underground minable accessible reserve base is 5.81 billion short tons.

Estimated recoverable reserves (ERR) were calculated from the ARB figures to determine the volume of coal that can be feasibly recovered. The recoverable factor is calculated from known production records in the Yampa Coal Field from 1980 to 1995. Using 90 percent of the ARB for surface mining, and 64 percent for underground mining (longwall mining method) the ERR for surface mining in the Yampa Coal Field is 0.95 billion short tons, and for underground mining the ERR is 3.72 billion short tons. The combined ERR for the entire Yampa Coal Field is 4.67 billion short tons.

Two coal groups in the Cretaceous Williams Fork Formation were evaluated: the middle coal group and the upper coal group. The Twentymile Sandstone separates these two coal groups. The middle coal group is essentially bituminous while the upper coal group is both subbituminous and bituminous. From the original 9.88 billion tons in the DRB, 7.37 billion tons are estimated in the middle coal group and 2.52 billion tons are in the upper coal group. The middle coal group is mined both at the surface and underground while the upper coal group is currently only surface mined. Limitations of the reserve base include partial penetrating drill hole data which limit coal correlations and volumetric calculations, and structural limits such as faults and steeply dipping beds which constrict minability. Other technological restrictions beyond this project further limit the ERR as the values calculated do not take all minable technological restrictions into place. Future considerations to model are the significant technological restrictions to mining such as steeply dipping strata, groundwater, and the areal extent of the Twentymile Sandstone as a barrier to surface mining of the middle coal group.

The Colorado Geological Survey is currently conducting a multiyear study supported by the USGS to assess the availability of coal for mining in various parts of Colorado. The Yampa Coal Field coal availability will be studied in 2000, and the findings will provide additional adjustments to the reserve base.

INTRODUCTION

Background

The Coal Reserves Data Base (CRDB) program is a cooperative data base development program sponsored by the U.S. Department of Energy—Energy Information Administration (EIA). The objective of the CRDB program is to update the nation's coal reserves data.

The Colorado Geological Survey (CGS) entered into Cooperative Agreement DE-FC01-96EI29138 with the EIA to update coal resource estimates for the Somerset and Yampa Coal Fields. The project began in October 1996. The report on the Somerset coal field was completed in June 1998 and was released as CGS Open File Report 98-5 in 1999.

Purpose

The CRDB data are used in coal supply analyses and to support analyses of policy and legislative issues. They will be available to both government and non-government analysts. The data will also be part of the information used to supply United States energy data for international databases and for inquiries from private industry and the public.

The EIA recognizes that coal resource area maps, drilling records, historical mine boundaries, and site-specific analytical and geologic data are critical for reliable calculations of coal resource quantities. Such information has been used to various degrees in the present study. Most of the data was derived from the U.S. Geological Survey (USGS) drilling program in the 1970s, particularly in the Yampa Coal Field.

The objective of this project is to develop CRDB data for updated reserves estimates of the demonstrated reserve base (DRB), accessible reserve base (ARB), and estimates of recoverable reserves (ERR) allocated to specific ranges of sulfur and heat content. In accordance with the terms of the CRDB program, the supporting data files, detailed documentation, and reserve calculations will remain at the CGS, where they will be the basis for future updates and revisions. The EIA will maintain reserve calculation figures in their database.

The priority of this DRB update in Colorado is on coal groups currently being mined and perceived to contain coals that will be mined in the next several decades. Therefore, the DRB for the Yampa Coal Field was updated only for coals in the Cretaceous Williams Fork Formation coal groups. The Tertiary coals were not included in this update because of their lower coal quality.

EIA Coal Resource Terminology—Working Definitions

Demonstrated Reserve Base (DRB)

A collective term for the sum of selected coal resource data in measured and indicated geologic assurance categories; the DRB includes measured and indicated resources in place as of a December 1, 1999, in coalbeds thicker than specified minimums and within specified ranges of overburden thickness (depth); bed thickness and depth ranges vary by coal rank and region and may differ for surface and underground-minable resources; also includes thinner and/or deeper coalbed which may be feasibly mined. Note: the DRB concept was introduced in the early 1970s as part of a uniform set of national criteria for coal resource data compilation. The DRB is a baseline of qualified coal resources for calculating reserves that meet variable and specific mining criteria. The DRB does not equate to the coal economically recoverable from in-place resources. Rather, it includes reserves, along with coal that will be left in place or lost in the mining process or that may be left unmined for political, societal, or economic reasons.

Accessible Reserve Base (ARB)

A portion of the DRB in a state or region that is estimated would be available for mining at the present time based on information on land-use and/or environmental restrictions and information on technological restrictions.

Estimated Recoverable Reserves (ERR)

A portion of the accessible reserve base that is

estimated would be recoverable based on data on current recovery rates and/or anticipated changes in recovery rates; recoverable reserves can be estimated without reference to economic feasibility studies.

Previous Investigations

The current DRB for Colorado is primarily based on coal resource estimates compiled by the USGS. (Landis, 1959) and the U.S. Bureau of Mines (USBM) (Speltz, 1976). Coal resource estimates for the Yampa Coal Field can be extrapolated from the Landis data. While estimating the coal resources of Colorado in the late 1950s, Landis calculated 1.39 billion tons of demonstrated (measured and indicated) coal in the Moffat County part of the Yampa Coal Field to 2000 ft deep (see Appendix, Table 12). Landis also calculated 3.71 billion tons of demonstrated coal in Routt County to 2000 ft deep. CGS totals, using a much larger database of drill holes from the 1970s, are nearly twice that amount for the same area in Moffat County, but half the amount in Routt County due to depletion and a smaller drill hole database there.

The USBM published a study of strippable coal resources (Speltz, 1976) that was incorporated into the previous EIA estimates for the Yampa Coal Field. According to Speltz, the Colorado portion of the Green River Basin exceeds 300 billion tons above a depth of 6,000 ft. Speltz also estimates that nearly 1 billion tons of potentially surface-minable coal exists in the Yampa Coal Field, which is consistent with the CGS findings of strippable coal reserves (1.05 billion tons accessible reserve). The DRB value for surface minable is 2.59 billions tons surface minable, 1.2 billion tons of which is potentially surface minable from the middle coal group. The Twentymile Sandstone poses a significant technological restriction to surface mining the middle coal group, and may potentially lower the DRB value by up to 50 percent.

Regional Geology

The Yampa Coal Field lies in the southeastern part of the greater Green River Basin. The outcrop of the Trout Creek Sandstone (top member of the Iles Formation) defines the southern boundary for the Yampa Coal Field for this study (Figure 1). Structurally, this basin is defined as the Sand Wash Basin, which formed during the Laramide orogeny. The Axial Basin uplift divides the Yampa Coal Field from the Axial Basin to the south and southwest. The Williams Fork Formation coals outcrop in the Williams Fork Mountains along the southern part of the study area. These beds generally dip north at 10 degrees and, in the southeast part of the study area, are locally faulted and folded by a series of northwest-southeast trending faults. Igneous rocks have intruded the coals in the eastern part of the Yampa Coal Field. The northern study area boundary is a line representing the 2000 ft-depth to coal, which varies with regard to the upper and middle coal groups.

The main coal bearing intervals lie within the Iles, Williams Fork, Lance, and Fort Union Formations, with most of the coal mining occurring within the Williams Fork and Iles Formations. The coals for these two formations were subdivided into the lower, middle, and upper coal groups by Fenneman and Gale (1906). This project assesses the middle and upper coal groups of the Williams Fork Formation because all active mining occurs within those intervals.

The middle coal group is defined as all of the coal beds between the Trout Creek Sandstone and the Twentymile Sandstone Members. The principal coal beds are the Wolf Creek, Wadge, and Lennox (Figure 2). The Wadge coal seam is the best minable bed due to thickness, lateral continuity, and excellent quality characteristics. The upper coal group includes all coal beds between the Twentymile Sandstone and the base of the Lewis Shale. Main coal seams are labeled K through S, or as locally called the Dry Creek, Crawford, or Sleepy Cat seams. The Williams Fork coals in this area are generally high-volatile C bituminous to subbituminous B in rank. Thicknesses of the main coal beds range from 3 to 20 ft. Middle coal group coal beds are generally more laterally continuous and correlatable than those of the upper coal group, which tend to pinchout. Middle coal group coals are generally higher rank than upper coal groups coals as well.

In terms of Cretaceous stratigraphy, the top of the Mesaverde Group (upper Williams Fork Formation) is considered Maastrichtian within the Craig region (Figure 2). According to Robinson-Roberts and Kirschbaum (1995) the base of the Maastrichtian is the bottom of a distinct shale tongue beneath the Twentymile Sandstone. This implies that the middle coal group is uppermost Campanian in age. In the Yampa Coal Field the

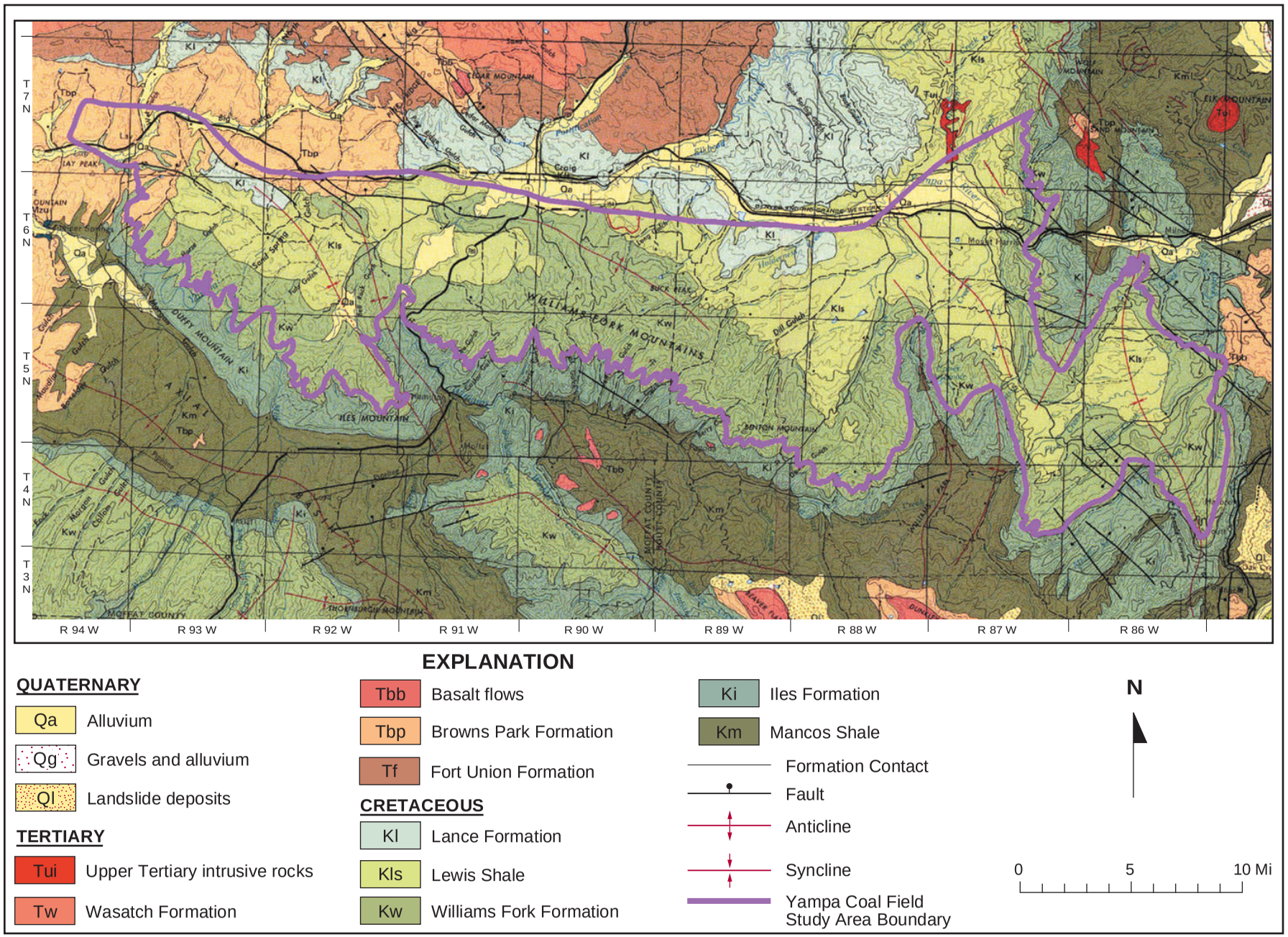

Figure 1. Map showing general location of the Yampa coal Field and geology (modified from Tweto, 1976).

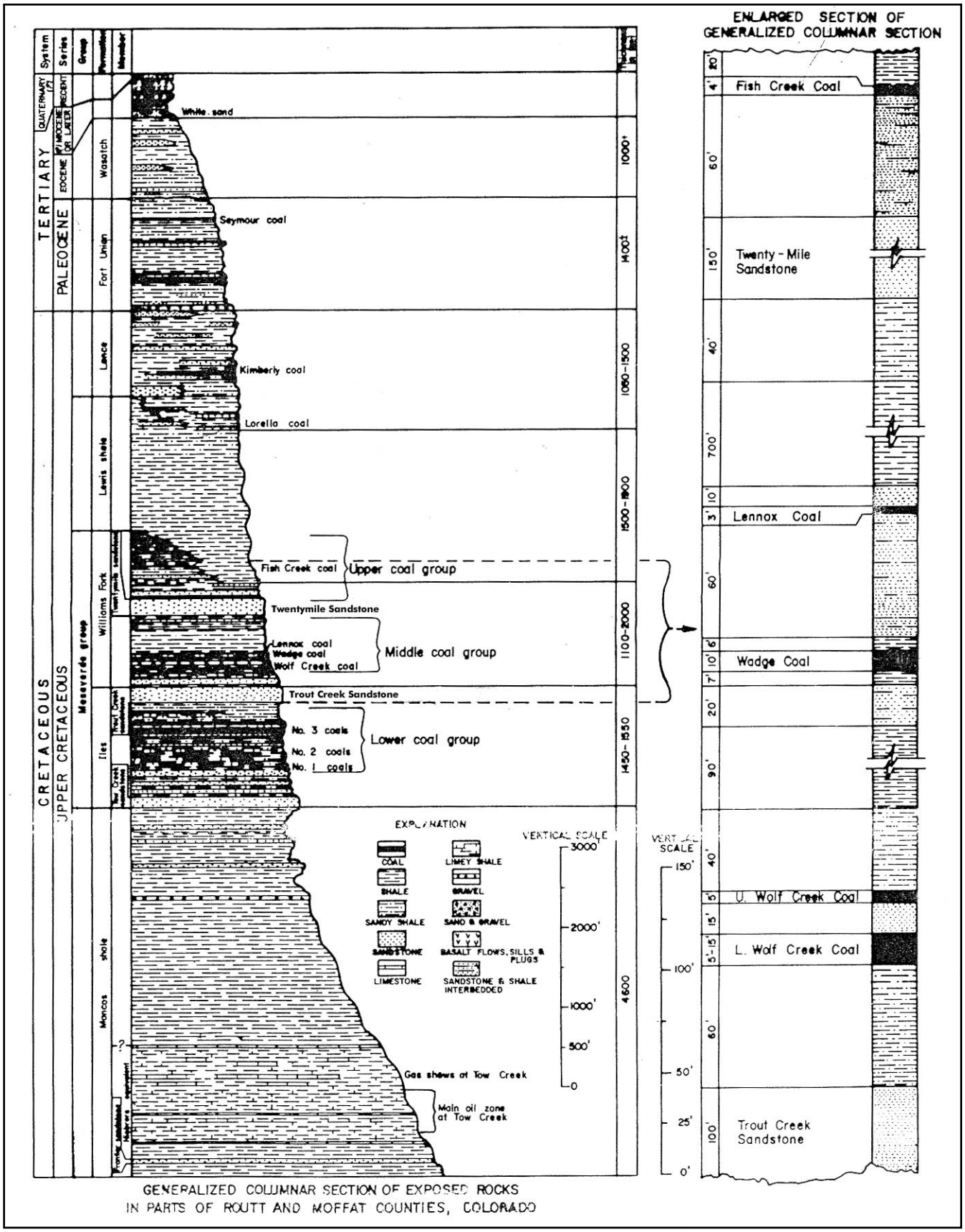

Figure 2. General stratigraphic column of the Yampa Coal Field.

base of the upper Campanian is in the Mancos Shale. All ages for Upper Cretaceous strata are based on faunal assemblages of *baculites* found within the members and also from correlations based on palynology on the Cretaceous/Tertiary sandstones higher in the section. The Mesaverde Group marks a time of major epicontinental sea invasion across North America composed of multiple eastward prograding near shore clastic wedges interfingering with westward transgressing marine tongues (Kauffman, 1977).

Coal Production

More than 42 percent of Colorado's total coal production was from the Yampa Coal Field in 1998. Historically, approximately 255 million tons of coal were produced from the Green River Region, or about 26 percent of Colorado's historic total (Keystone Coal Directory, 1999). The largest active mine in Colorado, in addition to other significantly active mines, are located in the Yampa Coal Field. The Foidel Creek Mine in Routt County produced 8.45 million tons of coal in 1998, a state coal production record. Most of the coal in the Yampa Coal Field is used today for electrical power generation at plants in Craig, Hayden, Denver, and Colorado Springs. Some coal is shipped out of state, and about one million tons is shipped to Mexico as well.

Production data for the coal mines in this area for 1998 are listed in Table 1.

Table 1. Production for coal mines in the Yampa Coal Field for 1998.

Coal Mine	Type of Mining	1998 Production (short tons)
Seneca (Seneca IIW and Yoast)	Surface	1,589,497
Trapper	Surface	2,187,356
Foidel Creek (Twentymile)	Underground	8,450,394

METHODOLOGY

Study Area

The coal reserve estimates updated by this study pertain only to Williams Fork Formation coals within the Yampa Coal Field. As stated previously, these coals consist of the upper and middle coal groups of the Williams Fork Formation and represent the only currently mined coal in the field. The DRB is updated for only these coal groups. Coals of the lower coal group in the Iles Formation have been mined in the past, but reserves have been significantly depleted and future mining is economically doubtful. Coals within the Tertiary Fort Union and Lance Formations were mined by small operations but are of even less economic value.

Coal Resource Quantity Factors

Six factors were used to determine the reserve base. These parameters were established with the assistance of the EIA.

Data Sources

Stratigraphic data sources used to determine the coal resource quantities include drilling logs, core descriptions, geophysical logs, and mine data. Data was obtained from published sources, coal companies, USGS databases, Burearu of Land Management (BLM) files, and permit documents at the Colorado Division of Minerals and Geology. The stratigraphic database was compiled by the USGS and converted to Microsoft Access format for calculations using Geographic Information Systems (GIS) software such as ESRI's Arcview and Arcinfo products.

Categories of Coal Rank

The Yampa Coal Field has both bituminous and subbituminous coal. The USGS criteria for density factors (Wood and others, 1983) were used for subbituminous and bituminous coals. Subbituminous coal was assigned a density factor of 1770 tons/acre-ft. Bituminous coal was assigned a density factor of 1800 tons/acre-ft.

Mining Categories

Resources and reserves are assigned to mining categories based on the most likely method of extracting the coal. The two mining categories used for this study are surface minable and underground minable.

The factor used to determine the mining category is depth to coal. In the Yampa Field, where significant coal reserves were mined or are currently being mined, minable coals at depths between 20 and 140 ft have been assigned to the surface-minable category. The DRB was calculated as surface minable for coal with depths less than 200 ft. Stripping ratios were not calculated. Previous investigations estimated that the ratio of surface to underground minable coal is less than 10:1. Typically the surface minable coal is between 6 and 8 percent of the total resource. DRB calculations for surface minable coal (<200 ft) in the Yampa Coal Field is 2.56 billion tons and 7.32 billion tons for underground minable coal.

Reliability Categories

Reliability estimates are based on USGS Circular 891 (Wood and others, 1983). Coals within the demonstrated category (measured and indicated) are within 0.75 mile of a data point (drill hole). Inferred coal is more than 0.75 mile but less than 3 miles from a data point (Figure 3). Cretaceous coal beds of Colorado are highly lenticular and their minable thicknesses frequently extend laterally for relatively short distances. Due to this lenticularity, correlation of individual beds is difficult and inferred resources and calculations are speculative.

Categories of Coal Thickness

Coal reserve estimates were itemized by USGS standard categories of coal thickness (Wood and others, 1983). These are shown in Table 2 below. Note that the bituminous coal beds are measured in inches and that the subbituminous coal beds are measured in feet.

Actual thickness cutoffs used for digital mapping of bituminous coal were in feet and tenths of a foot, rather than inches, as follows: 2.3 ft, 5.1 ft,

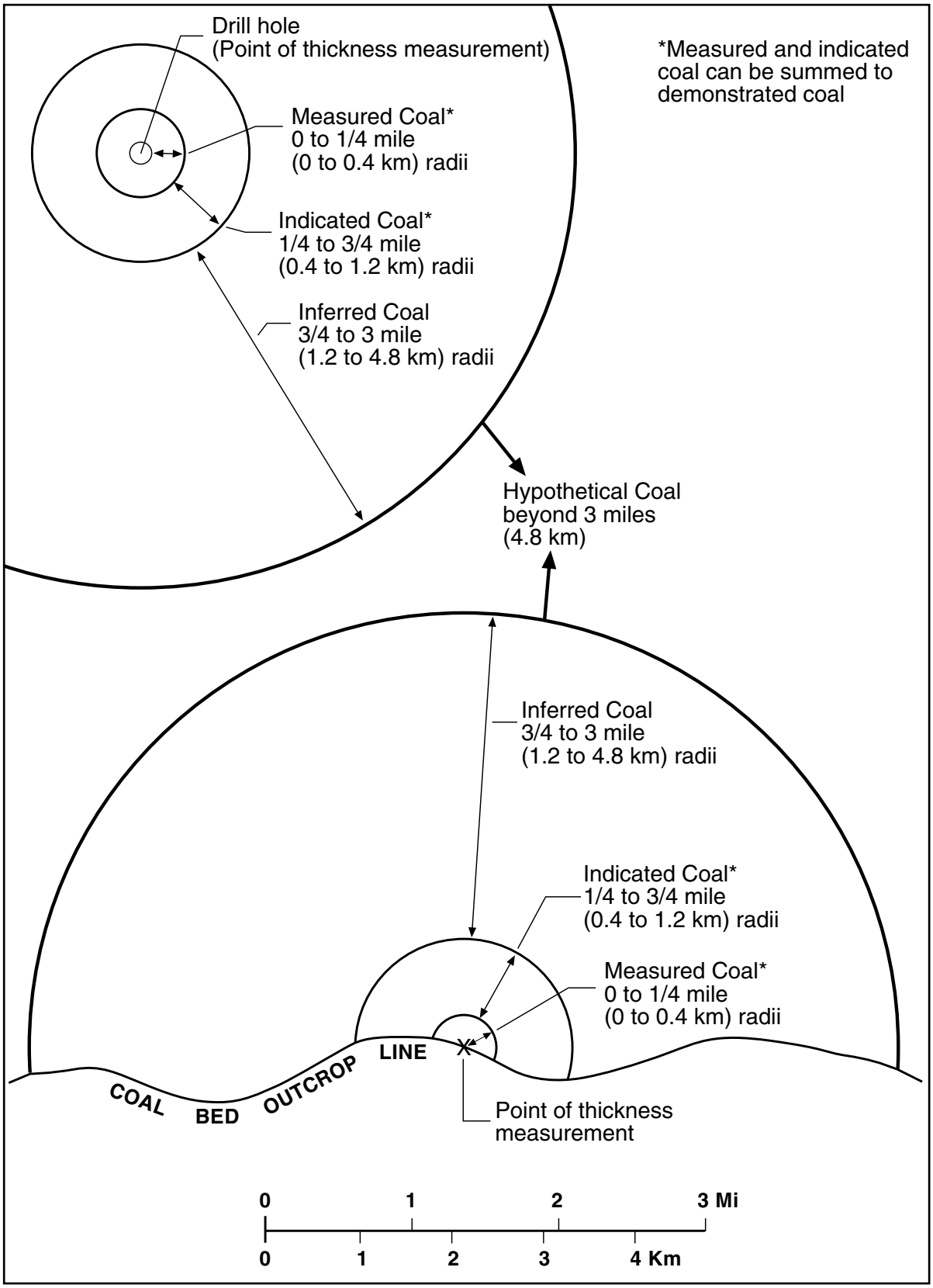

Figure 3. Diagram showing reliability categories base solely on distance from points of measurement (from Wood and others, 1983).

Table 2. Coal thickness categories.

Bituminous Coal Thickness (in.)	Subbituminous Coal Thickness (ft)
2842	5–10
42–84	10–20
84–168	20–40
168+	40+

10.1 ft, 20.1 ft, 50.1 ft, and 100 ft. These values reflect net coal thickness for particular coal groups and not the thickness of individual coal seams. The net coal thickness calculated for each coal group represents the total of all benches and beds in the coal group above the designated minimum thickness thresholds.

The USGS standard (Wood and others, 1983) was used as a guide in determining the thickness of coal beds to include in resource calculations. Benches less than 2.3 ft thick were omitted for all bituminous coals. For subbituminous coals, a minimum bed thickness of 5 ft was used. Beds and parts of beds made up of alternating layers of thin coal and partings were omitted if the bed was thinner than either adjacent parting, or if beds in proximity to each other did not total 2.3 ft. Volumetric calculations sorted by thickness categories indicate that the major volume of coal is the 5.4 billion tons in Moffat County from net coal intervals greater than 50 ft thick. This is the result of several USGS deep drillholes that log a significant amount of coal in T.6 N., R.93 W.; T.6 N., T.92 W.; and T.5 N., R. 92 W.

Depth of Coal

Coal reserve estimates were itemized by USGS standard categories of coal depth (Wood and others, 1983). These are shown in Table 3.

Surface minable resources were determined for coal less than 200 ft deep, and from accessible reserves assigned a recoverable factor of 90 percent. Underground minable coal was that volume of coal greater than 200 ft but less than 2000 ft deep. This volume was assigned a recoverable factor of 64 percent of the ARB.

The depth to each coal group was derived from the coal group structure map and digital topographic data. Structure maps were based on the elevation of the top coal in each coal group, calculated for all available data points. The accuracy of coal group depths between data points vary, depending on data density and local structural complexity. Surficial drainages that incise the Williams Fork Formation outcrop play a considerable role in the depth to coal model for this particular project.

Table 3. Coal depth categories (modified from Wood and others, 1983).

Areas WITH Surface Minable Coal Depth (ft)	Areas WITHOUT Surface Minable Coal Depth (ft)
20–200	200–500
200–500	
500-1000	500–1000
1000–2000	1000–2000

A maximum depth of 2000 ft was selected for three primary reasons: 1) This depth is a reasonable cutoff for the depth limit of minable coal; 2) Data is generally unavailable at depths approaching 2000 ft or greater; 3) Demonstrated reserves in this depth category would therefore be minimal. The DRB in the 1000 to 2000 ft category is 1.93 billion tons of coal. Much of this coal also corresponds with the 5.4 billion ton reserve noted in the net coal calculations where the net coal isopach is greater than 50 ft. The accessible reserve of this coal is much less, and may actually be difficult to remove economically.

Depletion Adjustments

Depletion adjustments were based exclusively on mapping mined-out areas of historical coal production. Production data was not used in the depletion adjustments, but is provided for comparison purposes only.

The CGS, with assistance from the USGS, established a digital database of the extent of mined-out areas for the Yampa Coal Field. Information on the extent of mines was obtained from individual mine maps or previously-compiled 1:24,000 scale maps available at the CGS, from maps within mine permits at the Colorado Division of Minerals and Geology, or from mine operators. Boundaries of active mines were updated through December 1, 1999, in part based on

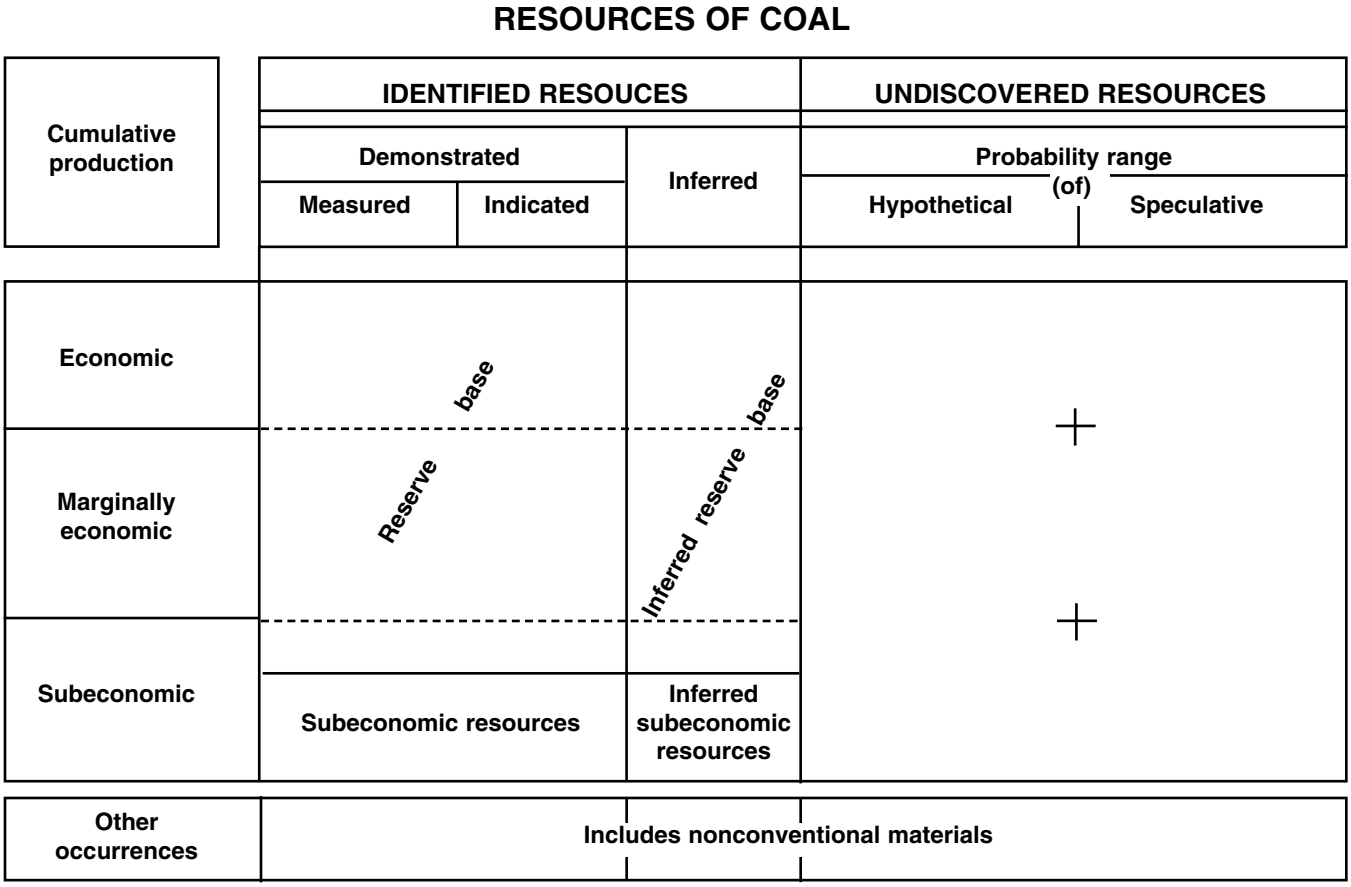

Figure 4. Format and classification of coal resources by reserve and inferred reserve bases and subeconomic and inferred subeconomic resource categories (from Wood and others, 1983).

mine plans as of the end of 1998. This includes production at all of the active mines to that date.

Depleted reserves consist of coal tonnages that were originally present in mined-out areas. These reserves were extracted by mining or left as pillars within underground mining. Coalbeds spoiled during mining of adjacent beds are also considered depleted for the entire coal group. Coal resources for an area where one group was mined and the other group left intact is still calculated as remaining resources. Coal left around abandoned mines was not excluded from resources. Colorado law requires that a barrier pillar at least 500 ft wide be left around active mines, however, once a mine becomes inactive, mining may be permitted up to the abandoned workings.

Coal Quality Characterizations

Estimated reserves were allocated to coal quality categories of sulfur, rank, heat content and ash as specified in the EIA procedural guidelines and shown in Table 4. The areas of varying coal quality were established by mapping each coal zone using the available coal quality data.

Coal quality data is not well distributed in the Yampa Coal Field. Previous drilling investigations concentrated on stratigraphic resource quantification and not coal quality. Most of the quality data collected for this study represents conditions at active mines. Large distances between mines (nearly 20 miles) results in coal quality data gaps that must be modeled with less reliable outcrop data. While all of the study area was covered for coal quality mapping, much of the area without data should be designated as “unable to classify”. Hence, the statistical variance on coal quality for the Yampa Coal Field is mostly distributed around bituminous, low-ash, low-sulfur coal.

Another problem stems from how to assign quality parameters collected from individual coal beds. In this study, such data is used to characterize an entire coal group, not just the bed. The coal quality for one bed does not necessarily reflect all

Table 4. Coal Quality Categories (MBtu = million British thermal units)

Coal Quality Parameter	Equivalency (Btu/lb)	Categories
Heat Value	8,500–10,000	15–19.99 MBtu/ton
	10,000–11,500	20–22.99 MBtu/ton
	11,500–13,000	23–25.99 MBtu/ton
	>13,000	>26.00 MBtu/ton
Sulfur		<0.40
(Lbs/MBtu)		0.41–0.6
		0.61–0.83
		0.84–1.24
		1.25–1.67
		1.68–2.5
		>2.5
Ash (%)		0–5.00
		5.01–10.00
		10.01–15.00
		>15.00

of the coal in that group. Several large assumptions were used to assess which values truly reflect the quality for each data point. Resources tabulated by specific ranges of heat value, sulfur, and ash are listed in the Appendix.

The coal quality data is not listed in the report because parts of it are considered confidential data. The public part of the coal quality data contains: sample point identifying numbers, sample dates, mine or corehole names, bed and coal group designation, coal rank, ash, and sulfur data, location data, and source information. This data was collected mainly from public information sources such as the National Coal Resource Data System (NCRDS) databases. These five databases were developed from the USGS (USALYT), USBM and EIA (BMALYT), CGS coal core data (PETALYT), the USGS trace element database (CHEMALYT), and historic coal quality data in Colorado. All of the data was reported on an 'as-received' basis for this study. The sulfur data in these databases is reported as percent sulfur by weight. These values were converted to pounds of sulfur per MBtu before incorporation into the mapping routines. Quality data at the outcrop was used only in areas where drill hole data was sparse.

Coal Accessibility Adjustments

The accessible reserve base (ARB) is defined as the portion of the DRB that can be mined at present, using local or regional mining practices and technologies, and under physical or geological conditions, and societal constraints (Table 5). Factors restricting accessibility are divided into two broad categories for this report: land use restrictions and technological restrictions. A relatively large number of factors were evaluated as possible restrictions. The specific factors considered and how they were applied is summarized on the table below.

Exclusions and restrictions to coal mining from *Colorado Revised Statutes*, 34-33-101 *et. seq.*, are listed below. These exclusions and restrictions were considered, and applied where they are relevant. Exclusions are factors which cannot be mitigated and will prevent coal mining. Restrictions are factors that may be mitigated, and are therefore considered to permit mining.

Data Sources for Land-Use Restrictions

Streams—Digital coverages were obtained from several government agency sources for GIS data. Lakes and reservoirs, towns, railroads and cemeterie —these features were marked on topographic maps for digitizing by CGS. 1:50,000 scale maps were used for the Yampa Coal Field contouring. Only relatively major lakes and reservoirs, those having surface areas greater than 20 acres, were selected for restrictions.

Highways—digital coverages were obtained from the Colorado Department of Transportation.

Power lines — Guidance was obtained from Public Service Co. and Western Area Power Administration (WAPA), then power lines were highlighted on 1:100,000 scale BLM maps for review by WAPA. The coverage was then modified based on WAPA input.

Pipelines—Individuals working for major natural gas pipeline companies were contacted and regional maps of major pipelines were obtained. A set of digital coverages of pipelines in Routt and Moffat Counties was used, with only the major natural gas pipelines for Public Service Co. and Northern Natural Gas selected for restrictions.

Alluvial Valley Floors—The portions of alluvial valley floors in the vicinity of the Yampa Coal

Table 5. Factors potentially affecting coal accessibility.

Potential Restriction	Size of Buffer Zone (ft)	Comments
Land Use Restrictions		
Streams, lakes, reservoirs	500	This buffer size is conservative. The actual size is based on the angle of draw and regulatory approval. Only major rivers and lakes over 20 acres in size were considered as restricted. Regulatory approval for underground mining beneath tributary drainages may alter calculations.
Residences, towns, public buildings	300	Mapped towns only. Rural individual residences were not considered a restriction.
Historic sites and non-federal Parks	X	No restrictions to mining in these coal fields.
Highways and railroads	200	Actual buffer will be 100 ft outside right-of-way. ROW sizes are not applicable to a regional study; therefore an alternate buffer size was applied. Only State and Federal highways were included.
Power lines and pipelines	500	This buffer size is conservative. The actual size will be based on the angle of draw and regulatory approval. Only major utilities were included.
Federal lands and endangered species habitat	X	No National Parks, Monuments, or U.S. Forest Service property in the study area.
Oil and Gas Wells	200	Mitigation is possible. Most areas of dense oil and gas activity are located north of the study area. Coalbed methane potential not fully realized at this time.
Alluvial valley floors (AVF)	200	Surface mines only. Underground coal may be minable under an AVF. The AVF's used are associated with the mainstem rivers such as the Yampa River.
Cemeteries	100	A small cemetery northwest of Craig was not included because it likely would be moved. Cemeteries within municipal boundaries were not mapped separately.
Technological Restrictions		
Coalbed depth	N/A	Maximum depth—2000 ft (DRB, ARB)
Coalbed thickness	N/A	Minimum bed thickness—7 ft (ARB).
Geologic conditions that impact underground mining		Faulting and dip of beds may impact mining. These restrictions were considered in a regional way for this reserve base update. It is estimated that faults or steeply-dipping strata may affect 10 percent of the study area.
Geologic conditions that impact surface mining		Also, the Twentymile Sandstone outcrop restricts accessibility to coal available for surface mining in the middle coal group.
Proximity to another coalbed or mine	40	Note that the buffer is "vertical." Implies that non-coal partings are no thicker than the thinner of two coals greater than 2.3 ft thick.

Table 6. Colorado State Mining Regulations (Division of Minerals and Geology) for restrictions and exclusions to mining.

Restriction Exclusion/ (R/E)	Rule No.	Explanation of Restriction or Exclusion	Comments
E	2.07.6(2)(d)(iii)(A)	Lands within national park system, national wildlife refuges, national system of trails, national wilderness preservation system, wild and scenic rivers, and national recreation areas	
E	2.07.6(2)(d)(iii)(B)	Within 300 ft of public building (school, church, hospital, courthouse, government building...) community or institutional building or any public park	
E	2.07.6(2)(d)(iii)(C)	Within 100 ft of a cemetery	
E	2.07.6(2)(d)(i)	Lands designated unsuitable for mining	None have been designated in Colorado
E	2.07.6(2)(n)	Operations which affect the continued existence of threatened and endangered species	
R	2.06.4	Mining on steep slopes (has to meet specific performance standards)	
R	2.07.6(2)(d)(iii)(D)	Lands within national forest	
R	2.07.6(2)(e)(i)	Will not adversely affect publicly owned park or place eligible to be included in the National Register of Historic Places	
R	2.07.6(2)(d)(iv)	Within 100 ft of public road ROW	
R	2.07.6(2)(d)(v)	Within 300 ft of an occupied dwelling (unless owner waives)	
R	4.19(1)	500 ft, measured horizontally, from active or abandoned underground mines	
R	4.20.4	Beneath or adjacent to any perennial stream, or impoundment or other body of water >20 acre-feet	
R	2.07.6(2)(K)	Mining in alluvial valley floors and prime farm land	AVFs are identified during permitting process; prime farmland is identified by NRCS.
R	2.05.6(6)(b)(iii) 4.20	Operations where subsidence is projected to cause material damage	Essentially must avoid or leave support pillars to protect aquifers, agricultural land and occupied residential dwellings and noncommercial buildings.
R	4.08.4(7)	Blasting within 1000 ft of schools, churches, hospitals and nursing facilities and within 500 ft of wells, pipelines and storage tanks for oil, gas or water	
R	4.05.18	Surface disturbance within 100 ft of perennial streams with biological communities in them	

Field were digitized by the CGS. The sources were Office of Surface Mining draft maps (USDOI, 1983 and 1985), and from Bass and Miller (USGS).

Recovery Rates

The EIA recently provided confidential data on reported recovery rates for individual mines in Colorado. The coal mines in the Yampa field reported recovery rates that vary from 95 to 88 percent for surface mining, and 50 to 66 percent for underground mining. This data is undisclosed herein and an average of the factors was established. In addition, mine operators provided information on surface and underground mining recovery rates to the CGS. Based on recovery information from 1980 to 1995, the recovery rates applied to accessible reserves in calculating recoverable reserves are as follows:

- Underground mining .....64 percent
- Surface mining .....90 percent

A weight percentage average based on current production was used to calculate these values. The recovery rate for underground mining accounts for the predominant use of longwall mining techniques in current mines in the area. Furthermore, the recovery rate assumes that all coal in beds greater than the minimum minable thickness are minable; that is, the rate assumes that no coal will be left in place due to the coal being thicker than is feasible to extract. These recovery rates were applied throughout the study area, regardless of accessibility.

PROCEDURES

Coal tonnages were derived for specified categories by first producing computer-generated isopach, structure, and coal quality maps for the two coal groups. A stratigraphic database of drill hole data and coal quality was used to compile maps for both the upper and middle coal groups. Mapping individual coals beds thicker than 2.3 ft thick for the middle coal (generally considered bituminous) and 2.5 ft thick for the upper coal (both subbituminous and bituminous), and later 5.0 ft for subbituminous only, were selected. All coal in beds greater than the minimum minable thickness of 7 ft are assumed minable even though some of the surface mine operators take seams 4 and 5 ft thick. As stated previously, recovery factors were applied based on this assumption. The 7 ft minimum thickness criteria was applied to the ARB and the ERR.

Computer-generated maps were checked for stratigraphic consistency and modified as necessary. The database was verified for content and reorganized to delineate data for mapping purposes. The data was then used to create regional structure contour maps, and depth-to-coal maps for both coal groups. They mark the depth to coal beds tops greater than the minimum thickness and separation criteria. Hand-contoured maps were then generated and digitized at the critical intervals of 2.3 ft, 3.5 ft, 7 ft, 14 ft, etc., for net coal thickness isopachs. Depth-to-coal intervals of 200 ft, 500 ft, 1000 ft, and 2000 ft were also hand-contoured and digitized for each coal group. Hand contoured isopachs and structure intervals were necessary due to the varying topographic terrain and sinuous nature of the Williams Fork Formation outcrop. Incision of alluvial valleys was often difficult to model because of the variability of coal outcrop details. Efforts to eliminate edge affects of coal outcrops along the Williams Fork and Yampa Rivers were done with extreme care.

Coal quality maps were hand-contoured for ranges of Btu, sulfur and ash. Computer-generated maps for the coal quality data were used as a guide to accurately hand-contour the quality variability. Outcrop lines for the Williams Fork Formation coal seams, depositional features for coal pinchouts, structural controls, and the 2000 ft deep line to coal were all digitized for inclusion to the project. Oil and gas wells were also included in the study to delineate the extent of the 2000 ft deep line on the northern part of the study area, but were not used for reliability information. Faults and Tertiary intrusives were also designated as no-coal exclusions. The final hand-contoured maps represent the limits of the coal zone, thickness, depth, and coal quality that were digitized for final data calculations. Several iterations and generations for each map were done to include all parameters.

Coal resource categories were established for the maps. Reliability circles for drill holes were created. The DRB was considered for areas of coal within 0.75 mile of a data point used in the particular coal group. Mined-out areas were subtracted, along with geologic boundary conditions (outcrops, no-coal zones), to create the areas for demonstrated coal resources for each group. The ARB was then considered within the demonstrated zone that was not restricted. All coal not technologically restricted and not land-use restricted is identified for each group as an accessible resource. It should be noted that the 2.5 billion tons estimate of the ARB for surface minable coal may be elevated due to technological restriction of the Twentymile Sandstone above the middle coal group. The model to incorporate this value is beyond the scope of this project. Only the thickness in excess of the minimum minable thickness of 7 ft was applied in the calculations. The ERR was then applied to the ARB for both underground minable coal (64 percent) and surface minable coal (90 percent).

Coal tonnages were compiled into spreadsheets for final analysis. These tables are located in the Appendix section of the report. The tables are organized first by DRB/ARB/ERR criteria, and then by coal quality parameters. An average acreage and thickness of coal are calculated for each digital polygon, and then summed to produce a volumetric total in acre-ft. The density factor is then applied: 1800 tons/acre-ft for bituminous coal and 1770 tons/acres-ft for subbitumi-

nous coal (based on USGS Circular 891). This final factor yields a volumetric number of tons of coal per polygon area. The calculations are iterated for all combinations of criteria to produce the summary tables for both Routt and Moffat counties. Coal tonnages are displayed to the nearest 0.1 million tons in the summary tables.

SUMMARY

Resources in the DRB, ARB, and ERR were calculated for the two coal groups in the Williams Fork Formation for the Yampa Coal Field. Values are reported and sorted by county, coal quality, and type of mining. Summary totals are provided for both coal groups in Table 7, and by specific categories in Tables 8 through 19 (see Appendix). In these tables, resources are presented for four parameters: Btu/sulfur, ash, net coal thickness, and depth. These parameters were calculated for the DRB, ARB, and ERR.

In some cases, calculated values for ERR vary slightly for different parameters. This slight variance results from assigning recovery factors that have two significant figures. Actual recoverable reserves are probably less when factoring in the loss of that volume of coal too deep below the water table to mine (possibly the 1000 to 2000 ft category), and the loss of approximately 1 billion tons of middle coal that would be inaccessible to surface mining due to overburden that includes the massive Twentymile Sandstone.

Summary totals for both coal groups in the Yampa Coal Field are:

- DRB: 9.88 billion short tons
- ARB: 6.86 billion short tons, or 69 percent of the DRB
- ERR: 4.67 billion short tons, or 68 percent of the accessible reserve base and 47 percent of the demonstrated reserve.

Approximately 82 percent of the DRB or 8,075.66 million tons in the Yampa Coal Field underlies Moffat County and the remaining 1,806.59 million tons, or 18 percent is in Routt County. These percentages reflect the distribution of drill hole data used for this study. Most of the drill holes are located in Moffat County. Percentages for the ARB by county are listed in the appendix.

Table 7. DRB, ARB, ERR by coal group. All figures are in millions of short tons.

Coal Group	DRB	Percent of DRB	ARB	Percent of ARB	ERR	Percent of ERR
Upper coal	2,516.796	25.5	2,091.537	30.5	1,476.164	31.6
Middle coal	7,365.444	74.5	4,772.828	69.5	3,190.430	68.4
Total both coal groups	9,882.240	100	6,864.365	100	4,666.595	100

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APPENDIX A
Tables 8–19

Table 8. DRB assigned to Btu and sulfur categories, Yampa Coal Field, Colorado. Coal tonnages in millions of short tons.

County	Heat Value (Million Btu/ton)	Sulfur Category (Lbs Sulfur/ Million Btu)	Middle Coal Tonnage	Upper Coal Tonnage	Both Coal Groups Tonnage	Bitum-inous Tonnage	Sub-bitum-inous Tonnage
Moffat	<15	All sulfur categories	0.000	0.000	0.000		0.000
Moffat	15.00–19.99	<0.40	0.000	130.674	130.674		130.674
Moffat	15.00–19.99	0.40–0.60	0.000	343.127	343.127		343.127
Moffat	15.00–19.99	0.61–0.83	0.000	341.158	341.158		341.158
Moffat	15.00–19.99	0.84–1.24	0.000	546.339	546.339		546.339
Moffat	15.00–19.99	1.25–1.67	0.000	162.566	162.566		162.566
Moffat	15.00–19.99	1.68–2.5	0.000	0.000	0.000		0.000
Moffat	15.00–19.99	>2.5	0.000	0.000	0.000		0.000
Moffat	20.00–22.99	<0.40	1,533.322	355.008	1,888.330	1,888.330	
Moffat	20.00–22.99	0.40–0.60	1,005.599	104.539	1,110.138	1,110.138	
Moffat	20.00–22.99	0.61–0.83	910.503	0.000	910.503	910.503	
Moffat	20.00–22.99	0.84–1.24	2,642.820	0.000	2,642.820	2,642.820	
Moffat	20.00–22.99	1.25–1.67	0.000	0.000	0.000	0.000	
Moffat	20.00–22.99	1.68–2.5	0.000	0.000	0.000	0.000	
Moffat	20.00–22.99	>2.5	0.000	0.000	0.000	0.000	
Moffat	>23.00	All sulfur categories	0.000	0.000	0.000	0.000	
Routt	<15	All sulfur categories	0.000	0.000	0.000		0.000
Routt	15.00–19.99	<0.40	0.000	0.000	0.000		0.000
Routt	15.00–19.99	0.40–0.60	2.986	0.000	2.986		2.986
Routt	15.00–19.99	0.61–0.83	4.219	0.000	4.219		4.219
Routt	15.00–19.99	0.84–1.24	0.616	0.000	0.616		0.616
Routt	15.00–19.99	1.68–2.5	0.166	1.985	2.151		2.151
Routt	15.00–19.99	>2.5	0.002	0.000	0.002		0.002
Routt	20.00–22.99	<0.40	11.475	515.203	526.678	526.678	
Routt	20.00–22.99	0.40–0.60	603.833	0.000	603.833	603.833	
Routt	20.00–22.99	0.61–0.83	422.790	0.000	422.790	422.790	
Routt	20.00–22.99	0.84–1.24	216.582	0.344	216.926	216.926	
Routt	20.00–22.99	1.25–1.67	0.000	0.713	0.713	0.713	
Routt	20.00–22.99	1.68–2.5	1.197	8.536	9.733	9.733	
Routt	20.00–22.99	>2.5	0.390	0.000	0.390	0.390	
Routt	23.00–25.99	<0.40	0.000	0.611	0.611	0.611	
Routt	23.00–25.99	0.40–0.60	7.427	3.473	10.901	10.901	
Routt	23.00–25.99	0.61–0.83	1.517	1.042	2.559	2.559	
Routt	23.00–25.99	0.84–1.24	0.000	1.075	1.075	1.075	
Routt	23.00–25.99	1.25–1.67	0.000	0.001	0.001	0.001	
Routt	23.00–25.99	1.68–2.5	0.000	0.401	0.401	0.401	
Routt	23.00–25.99	>2.5	0.000	0.000	0.000	0.000	
Routt	>26.00	All sulfur categories	0.000	0.000	0.000	0.000	
Total			**7,365.444**	**2,516.796**	**9,882.240**	**8,348.402**	**1,533.838**

Table 9. DRB assigned to ash categories, Yampa Coal Field, Colorado, as of 12/1/99 (in Million short tons).

County	Category (% Ash)	Middle Coal Group	Upper Coal Group	Total Both Coal Groups
Moffat	<=5.0	4,228.598	0.000	4,228.598
Moffat	5.01–10.00	1,863.646	1,983.411	3,847.057
Routt	<=5.0	268.921	5.347	274.268
Routt	5.01–10.00	999.510	519.085	1,518.595
Routt	10.01–15.00	3.891	8.178	12.069
Routt	>15	0.878	0.775	1.653
Total both counties	**7,365.444**	**2,516.796**	**9,882.240**	

Table 10. DRB net coal thickness intervals, Yampa Coal Field, Colorado, as of 12/1/99. Total coal thickness for coal beds with a minimum of 2.3 ft thick for bituminous coal and minimum of 2.5 ft thick for sub-bituminous coal.

County	Net Coal Interval (thickness in feet)	Middle Coal (million tons)	Upper Coal (million tons)	Total (million tons)
Moffat	2.3–5.0	3.689	6.927	10.616
Moffat	5.1–10.0	9.813	28.594	38.407
Moffat	10.1–20.0	36.089	108.144	144.233
Moffat	20.1–50.0	608.966	1,648.303	2,257.269
Moffat	50.1–100.0	2,705.386	191.442	2,896.828
Moffat	>100	2,728.301	0.000	2,728.301
Routt	2.3–5.0	4.434	30.161	34.595
Routt	5.1–10.0	19.321	28.551	47.873
Routt	10.1–20.0	309.624	133.951	443.575
Routt	20.1–50.0	685.048	340.722	1,025.770
Routt	50.1–100.0	254.773	0.000	254.773
Total both counties		**7,365.444**	**2,516.796**	**9,882.240**

Table 11. DRB assigned to depth categories, Yampa Coal Field, Colorado. Coal <200 ft of the surface is highlighted in yellow. Tonnages in millions of short tons.

County	Depth Category (in feet)	Middle Coal Group	Upper Coal Group	Total	Surface Minable	Underground	Totals
Moffat	<200	1,020.628	956.546	1,977.174	1,977.174		1,977.174
Moffat	200–500	1,029.838	647.615	1,677.453		1,677.453	1,677.453
Moffat	500–1000	2,355.931	379.250	2,735.181		2,735.181	2,735.181
Moffat	1000–2000	1,685.847	0.000	1,685.847		1,685.847	1,685.847
Total Moffat County							**8,075.655**
Routt	<=200	203.411	379.086	582.497	582.497		582.497
Routt	200–500	491.860	112.892	604.752		604.752	604.752
Routt	500–1000	348.959	28.238	377.198		377.198	377.198
Routt	1000–2000	228.969	13.169	242.138		242.138	242.138
Total Routt County							**1,806.585**
Total both counties		**7,365.444**	**2,516.796**	**9,882.240**	**2,559.671**	**7,322.569**	

Table 12. DRB assigned to townships within the Yampa Coal Field, Colorado, as of 12/1/99. Comparison with 1959 USGS resource calculations for same area. Tonnages listed in millions of short tons.

Township and Range	Middle Coal	Upper Coal	Total	USGS—Landis, 1959	Difference	Comments
4N,85W	0.796	0.000	0.796	148.96	–148.164	
4N,86W	88.136	0.130	88.267	460.80	–372.533	
4N,87W	63.650	0.557	64.206	57.68	6.526	
5N,85W	8.745	0.000	8.745	187.78	–179.035	
5N,86W	126.947	16.465	143.411	725.60	–582.189	Twentymile coal mined out area, lack of drillhole data 1999.
5N,87W	26.699	5.926	32.625	46.90	–14.275	
5N,88W	62.509	66.551	129.059	224.02	–94.961	
5N,89W	590.136	340.485	930.620	906.54	24.080	
5N,90W	692.346	137.882	830.228	492.80	337.428	
5N,91W	291.758	8.104	299.862	336.46	–36.598	
5N,92W	1,127.932	97.675	1,225.606	77.08	1,148.526	
5N,93W	0.332	0.000	0.332	10.66	–10.328	
5N,94W	0.000	0.000	0.000	6.03	–6.030	
6N,86W	20.811	0.000	20.811	63.39	–42.579	
6N,87W	10.424	0.000	10.424	773.29	–762.866	Area lacking drillhole data 1999
6N,88W	198.604	31.203	229.806	114.05	115.756	
6N,89W	75.743	72.070	147.813	—	147.813	not listed by Landis
6N,90W	410.039	243.233	653.273	76.70	576.573	
6N,91W	328.285	194.542	522.827	101.53	421.297	
6N,92W	1,553.082	767.204	2,320.286	68.92	2,251.366	Substantial increase in coal due to newer drillhole data
6N,93W	1,685.495	534.770	2,220.265	212.25	2,008.015	Substantial increase in coal due to newer drillhole data
6N,94W	2.976	0.000	2.976	5.44	–2.464	
Total 22 townships	**7,365.444**	**2,516.796**	**9,882.240**	**5,096.88 “**	**4,785.360**	

Table 13. Accessible reserve base (ARB) assigned to Btu and sulfur categories, Yampa Coal Field, Colorado.

County	Heat Value (Million Btu/ton)	Sulfur Category (Lbs/Sulfur/ Million Btu	Middle Coal ARB	Upper Coal ARB	Total
Moffat	<15	all categories	0.000	0.000	0.000
Moffat	15.00–19.99	<0.40	0.000	55.758	55.758
Moffat	15.00–19.99	0.40–0.60	0.000	295.216	295.216
Moffat	15.00–19.99	0.61–0.83	0.000	365.085	365.085
Moffat	15.00–19.99	0.84–1.24	0.000	432.623	432.623
Moffat	15.00–19.99	1.25–1.67	0.000	117.008	117.008
Moffat	15.00–19.99	>1.68	0.000	0.000	0.000
Moffat	20.00–22.99	<0.40	964.254	282.808	1,247.061
Moffat	20.00–22.99	0.40–0.60	621.770	108.357	730.126
Moffat	20.00–22.99	0.61–0.83	707.333	0.000	707.333
Moffat	20.00–22.99	0.84–1.24	1,562.329	0.000	1,562.329
Moffat	20.00–22.99	>1.24	0.000	0.000	0.000
Routt	<15	all categories	0.000	0.000	0.000
Routt	15.00–19.99	<0.40	0.000	0.000	0.000
Routt	15.00–19.99	0.40–0.60	3.310	0.000	3.310
Routt	15.00–19.99	0.61–0.83	5.463	0.000	5.463
Routt	15.00–19.99	0.84–1.24	0.454	0.000	0.454
Routt	15.00–19.99	1.24–1.67	0.000	0.000	0.000
Routt	15.00–19.99	1.68–2.5	0.116	2.107	2.223
Routt	15.00–19.99	>2.5	0.002	0.000	0.002
Routt	20.00–22.99	<0.40	7.019	408.327	415.345
Routt	20.00–22.99	0.40–0.60	511.964	0.003	511.967
Routt	20.00–22.99	0.61–0.83	220.653	0.000	220.653
Routt	20.00–22.99	0.84–1.24	165.268	0.347	165.615
Routt	20.00–22.99	1.25–1.67	0.000	1.214	1.214
Routt	20.00–22.99	1.68–2.5	0.838	9.547	10.385
Routt	20.00–22.99	>2.5	0.273	0.000	0.273
Routt	23.00–25.99	<0.40	0.000	0.109	0.109
Routt	23.00–25.99	0.40–0.60	1.786	5.501	7.286
Routt	23.00–25.99	0.61–0.83	0.000	3.466	3.466
Routt	23.00–25.99	0.84–1.24	0.000	2.913	2.913
Routt	23.00–25.99	1.25–1.67	0.000	0.026	0.026
Routt	23.00–25.99	1.68–2.5	0.000	1.122	1.122
Routt	>26.00	all categories	0.000	0.000	0.000
Total			4,772.828	2,091.537	6,864.365

Table 14. ARB assigned to ash categories, Yampa Coal Field, Colorado, as of 12/1/99 (in million short tons).

County	Category (% Ash)	Middle Coal Group	Upper Coal Group	Both Coal Groups
Moffat	<=5.0	2,720.872	0.000	2,720.872
Moffat	5.01–10.00	1,134.812	1,656.854	2,791.666
Moffat	>10.00	0.000	0.000	0.000
Routt	<=5.0	179.393	8.291	187.684
Routt	5.01–10.00	733.352	413.617	1,146.969
Routt	10.01–15.00	3.575	12.204	15.779
Routt	>15	0.824	0.570	1.394
Total		**4,772.828**	**2,091.537**	**6,864.365**

Table 15. ARB assigned to net coal thickness intervals, Yampa Coal Field, Colorado. Calculation of total coal thickness for coalbeds with a minimum 7 ft thickness.

County	Net Coal Interval (thickness in feet)	Middle Coal	Upper Coal	Total
Moffat	7.0–14.0	29.946	77.738	107.684
Moffat	14.1–21.0	48.200	116.204	164.405
Moffat	21.1–28.0	70.729	165.127	235.855
Moffat	28.1–35.0	110.503	467.235	577.738
Moffat	35.1–42.0	240.024	504.715	744.739
Moffat	42.1–49.0	272.132	325.835	597.967
Moffat	49.1–56.0	187.022	0.000	187.022
Moffat	> 56	2,897.127	0.000	2,897.127
Routt	7.0–14.0	93.997	91.332	185.329
Routt	14.1–21.0	247.518	170.937	418.455
Routt	21.1–28.0	166.343	58.393	224.736
Routt	28.1–35.0	117.564	58.160	175.724
Routt	35.1–42.0	50.559	55.860	106.419
Routt	42.1–49.0	50.298	0.000	50.298
Routt	49.1–56.0	23.812	0.000	23.812
Routt	> 56	167.053	0.000	167.053
Total		**4,772.828**	**2,091.537**	**6,864.365**

Table 16. ARB and Estimated Recoverable Reserve (ERR) assigned to depth categories, Yampa Coal Field, Colorado. Coal tonnages in millions of short tons. ERR assumes 64 percent recoverable rate for underground mining and 90 percent recoverable factor for surface mining in the Yampa Coal Field.

County	Depth Category	Middle Coal ARB	Upper Coal ARB	Total All Coal ARB	Surface ARB	Surface ERR	Under-ground ARB	Under-ground ERR	Middle Coal Total ERR	Upper Coal Total ERR
Moffat	<=200	420.064	304.265	724.329	724.329	651.896			378.058	273.838
Moffat	200–500	698.778	601.654	1,300.432			1,300.432	832.276	447.218	385.059
Moffat	500–1000	1,365.368	672.514	2,037.882			2,037.882	1,304.244	873.836	430.409
Moffat	1000–2000	1,371.474	78.422	1,449.896			1,449.896	927.934	877.744	50.190
Routt	<=200	102.322	224.891	327.213	327.213	294.492			92.090	202.402
Routt	200–500	370.279	148.744	519.023			519.023	332.175	236.978	95.196
Routt	500–1000	279.684	39.478	319.162			319.162	204.263	178.998	25.266
Routt	1000–2000	164.859	21.570	186.429			186.429	119.314	105.510	13.805
Total	**4,772.828**	**2,091.537**	**6,864.365**	**1,051.542**	**946.388**	**5,812.823**	**3,720.207**	**3,190.430**	**1,476.164**	
Total ERR									**4,666.595**	

Table 17. ARB and ERR assigned to Btu and sulfur categories by mine type, Yampa Coal Field, Colorado (as of 12/1/99). Tonnages listed in millions of short tons.

County	Heal Value (MBtu/ton)	Sulfur (Lbs S/MBtu)	Surface – MC ARG	Surface – UC ARB	ERR Surface Total Tonnage	Under-ground – MC ARB	Under-ground – UC ARB	ERR Under-ground Total Tonnage
Moffat	<15.00	all categories	0.000	0.000	0.000	0.000	0.000	0.000
Moffat	15.00–19.99	<0.40	0.000	35.495	31.945	0.000	20.263	12.968
Moffat	15.00–19.99	0.40–0.60	0.000	61.195	55.075	0.000	234.021	149.774
Moffat	15.00–19.99	0.61–0.83	0.000	3.780	3.402	0.000	361.305	231.235
Moffat	15.00–19.99	0.84–1.24	0.000	56.618	50.956	0.000	376.005	240.643
Moffat	15.00–19.99	1.25–1.67	0.000	6.410	5.769	0.000	110.597	70.782
Moffat	20.00–22.99	<0.40	210.182	140.767	315.854	754.071	142.040	573.511
Moffat	20.00–22.99	0.40–0.60	83.878	0.000	75.490	537.892	108.357	413.599
Moffat	20.00–22.99	0.61–0.83	86.651	0.000	77.986	620.682	0.000	397.236
Moffat	20.00–22.99	0.84–1.24	39.353	0.000	35.418	1,522.975	0.000	974.704
Routt	<15	all categories	0.000	0.000	0.000	0.000	0.000	0.000
Routt	15.00–19.99	<0.4	0.000	0.000	0.000	0.000	0.000	0.000
Routt	15.00–19.99	0.40–0.60	2.684	0.000	2.416	0.626	0.000	0.400
Routt	15.00–19.99	0.61–0.83	4.010	0.000	3.609	1.453	0.000	0.930
Routt	15.00–19.99	0.84–1.24	0.326	0.000	0.293	0.128	0.000	0.082
Routt	15.00–19.99	1.68–2.5	0.046	0.737	0.705	0.070	1.370	0.921
Routt	15.00–19.99	>2.5	0.000	0.000	0.000	0.002	0.000	0.001
Routt	20.00–22.99	<0.40	3.873	205.997	188.883	3.146	202.330	131.505
Routt	20.00–22.99	0.40–0.60	73.022	0.000	65.720	438.942	0.003	280.925
Routt	20.00–22.99	0.61–0.83	18.362	0.000	16.526	202.292	0.000	129.467
Routt	20.00–22.99	0.84–1.24	0.000	0.347	0.313	165.268	0.000	105.771
Routt	20.00–22.99	1.25–1.67	0.000	1.164	1.048	0.000	0.050	0.032
Routt	20.00–22.99	1.68–2.5	0.000	5.795	5.215	0.838	3.752	2.938
Routt	20.00–22.99	>2.5	0.000	0.000	0.000	0.273	0.000	0.175
Routt	23.00–25.99	<0.40	0.000	0.109	0.098	0.000	0.000	0.000
Routt	23.00–25.99	0.40–0.60	0.000	5.501	4.951	1.786	0.000	1.143
Routt	23.00–25.99	0.61–0.83	0.000	3.203	2.883	0.000	0.263	0.169
Routt	23.00–25.99	0.84–1.24	0.000	2.027	1.824	0.000	0.886	0.567
Routt	23.00–25.99	1.25–1.67	0.000	0.008	0.007	0.000	0.018	0.011
Routt	23.00–25.99	1.68–2.5	0.000	0.003	0.003	0.000	1.120	0.717
Total			**522.386**	**529.156**	**946.388**	**4,250.442**	**1,562.381**	**3,720.207**

Table 18. ARB and ERR assigned to ash categories by mine type, Yampa Coal Field. All tonnages listed in millions of short tons.

County	Category (% Ash)	Surface – MC	Surface – UC	Total Surface	ERR – Surface	Underground – MC	Under-ground – UC	Total Underground	ERR –Under-ground
Moffat	<=5.0	152.155		152.155	136.940	2,568.717		2,568.717	1,643.979
Moffat	5.01–10.00	267.909	304.265	572.173	514.956	866.903	1,352.590	2,219.493	1,420.475
Moffat	>=10.01	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Routt	<=5.0	18.272	7.976	26.249	23.624	161.121	0.315	161.436	103.319
Routt	5.01–10.00	79.745	210.380	290.125	261.113	653.607	203.237	856.844	548.380
Routt	10.01–15.00	3.480	6.408	9.888	8.899	0.095	5.796	5.890	3.770
Routt	>15	0.824	0.127	0.951	0.856		0.443	0.443	0.284
Total		**522.386**	**529.156**	**1,051.542**	**946.388**	**4,250.442**	**1,562.381**	**5,812.823**	**3,720.207**

MC = Middle Coal Group, UC = Upper Coal Group, Combined ERR=4,666.595

Table 19. ARB and ERR assigned to net coal thickness intervals by mine type, Yampa Coal Field, Colorado. Tonnages shown in millions of short tons. MC = Middle Coal Group, UC = Upper Coal Group.

County	Net coal interval (thickness in ft)	Surface-MC tonnage	Surface-UC tonnage	Underground-MC tonnage	Underground-UC tonnage	Total tonnage
Moffat	7.0–14.0	28.124	54.776	1.823	22.962	107.684
Moffat	14.1–21.0	43.512	60.300	4.689	55.904	164.405
Moffat	21.1–28.0	56.567	88.772	14.161	76.355	235.855
Moffat	28.1–35.0	46.631	87.417	63.872	379.818	577.738
Moffat	35.1–42.0	66.674	12.999	173.350	491.716	744.739
Moffat	42.1–49.0	42.737	0.000	229.395	325.835	597.967
Moffat	49.1–56.0	40.574	0.000	146.448	0.000	187.022
Moffat	> 56	95.246	0.000	2,801.882	0.000	2,897.127”
Routt	7.0–14.0	29.896	53.403	64.101	37.929	185.329
Routt	14.1–21.0	27.301	59.345	220.217	111.592	418.455
Routt	21.1–28.0	27.475	44.950	138.868	13.443	224.736
Routt	28.1–35.0	17.650	47.288	99.914	10.873	175.724
Routt	35.1–42.0	0.000	19.905	50.559	35.955	106.419
Routt	42.1–49.0	0.000	0.000	50.298	0.000	50.298
Routt	49.1–56.0	0.000	0.000	23.812	0.000	23.812
Routt	> 56	0.000	0.000	167.053	0.000	167.053
Total		**522.386**	**529.156**	**4,250.442**	**1,562.381**	**6,864.365**