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Strippable Coal Reserves of Wyoming

Location, Tonnage, and Characteristics of Coal and Overburden

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STRIPPABLE COAL RESERVES OF WYOMING

Location, Tonnage, and Characteristics of Coal and Overburden

by

Joseph Blake Smith,[1] Maynard F. Ayler,[1] Clinton C. Knox,[1]
and Benjamin C. Pollard[1]

ABSTRACT

Coal resource data from published sources and company files were used by the Bureau of Mines to determine the location and extent of strippable coal reserves in Wyoming. Total strippable reserves of 23 billion tons were estimated in seven major coal areas. Seven large strip mining operations were active in 1969, and their production totaled 4½ million tons of coal. Cutoffs used to define strippable reserves were (1) minimum coalbed thicknesses of 5 feet; (2) overburden-to-coal ratios of less than 10 cubic yards of overburden per ton of coal; and (3) total overburden thicknesses of less than 120 feet, except where reserves occur in multiple beds or a single thick bed.

Tertiary rocks along margins of the Powder River basin contain most of the strippable coal reserves in Wyoming. The Wyodak beds, ranging in combined thickness from 30 to 130 feet, crop out on the east flank of the basin and contain an estimated 19 billion tons of strippable subbituminous C-rank coals under less than 200 feet of overburden. Partings between these beds total less than 60 feet. The 100- to 200-foot-thick Healy bed on the western flank of the basin and the 35-foot-thick School and 20-foot-thick Badger beds on the south also contain large strippable reserves. Elsewhere in Wyoming, strippable reserves. Elsewhere in Wyoming, strippable deposits are subbituminous coal of Late Cretaceous and Tertiary ages, mostly in the Hanna and Great Divide basins in the south-central portion of the State and in the Kemmerer-Hamms Fork region in the southwestern corner.

INTRODUCTION

Wyoming has the largest coal resources of any State--546 billion tons within 6,000 feet of the surface (2).[2] Interest in large strippable coal reserves has been stimulated recently by accelerating electric power demands, significant additions to thermal power generating capacity, and prospects for development of synthetic fuels from coal.

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[1]Mining engineer.

[2]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

Projected shortages of natural gas reserves and research progress on commercial processes for converting coal to liquid and gaseous hydrocarbon fuels have enlisted further competitive interest by petroleum and coal companies in the search for large blocks of low-cost coal.

A commercial-scale conversion plant producing liquid products would be expected to use a minimum of 10 million tons of subbituminous C-rank coal per year, and one producing gaseous products would use a minimum of 6.5 million tons of such coal annually. When economic and technologic factors justify their construction, such plants likely would be fueled by some of the largest and most technologically advanced strip coal mines in the world. Moreover, each such plant is expected to require strippable reserves of at least 200 million tons.

This report summarizes and interprets information available to the Bureau of Mines on strippable coal in Wyoming. Firms and individuals engaged in exploration and acquisition of coal lands in Wyoming were consulted to obtain supplemental information. Coal outcrop and reserve data in reports of the U.S. Geological Survey were used freely. Cursory examinations were made of the coalfields and strip coal mines, and factors that would affect strip mining, particularly coal and overburden characteristics, were noted.

Where drill hole data for defining stripping limits or adequate topographic maps were not available, strippable deposits were defined by using the stratigraphic interval between the coalbed of interest and an overlying coalbed, together with maps showing surface traces of coalbed outcrops to locate stripping limits.

Most of the strippable reserves of Wyoming are in strata of Tertiary age on margins of the Powder River basin. This area also contains more than 78 percent (95 billion tons) of Wyoming's 121.5-billion-ton reserve of mapped and measured coal that lies within 3,000 feet of the surface (2-3).

Strippable coal deposits and coalfields having strip mining potential are shown on figure 1 and are listed in table 1.

ACKNOWLEDGMENTS

Recognition is due the personnel of the U.S. Geological Survey for their invaluable work in the coalfields of Wyoming, including not only the several authors of publications cited in the references at the end of this report, but also George H. Horn and John Paul Storrs of Denver, Colo., and Elmer M. Schell and George D. Mowat of Billings, Mont., who provided unpublished data that were not classified as company confidential.

Companies and individuals contributed information from their exploration programs, most of which were begun after 1965. Detailed data from drilling programs were provided by Garth Duell of Pacific Power & Light Co.; Glen E. Sorensen, Roy C. Coulson, and Donald H. Townsend of the Kemmerer Coal Co.; Harold E. Ross and Sydney J. Gerrans of Wyodak Resources Development Corp.; Carmal (Pat) Patton, Union Pacific Railroad Co.; Robert L. Duncan and

Jean C. Finley of the Kerr-McGee Corp.; and Sheldon P. Wimpfen, formerly with Reynolds Mining Corp. Useful drill logs and other data were provided by James E. Keenan, Mobil Oil Corp.; Robert A. Noel, Sun Oil Co.; Robert L. Sprinkel, Texaco Inc.; and by independent consultants Thomas C. Woodward and E. L. Lockhart. George A. Nugent, Cliff Artis, and John F. Ratche, Jr., of the Big Horn Coal Co. contributed a general description of that company's deposits.

Harold D. Levene of Cameron Engineers and the Connie Mull Mining and Oil Lease Service provided coal ownership information. Bureau of Mines employees contributing to this report include Doss H. White, Jr., mining engineer, and David Alison, student assistant.

TABLE 1. - Strippable coal deposits and coalfields in Wyoming

Location number[1]		Figure number[2]	Strippable reserves, million tons	Maximum overburden, feet
	DEPOSITS			
1	Wyodak.....	2-3	19,000	[3]260
2	Felix.....	4	480	120
3	Smith-Local.....	5	236	120
4	Canyon.....	6	185	120
5	School-Badger.....	7	137	140
6	Dry Cheyenne.....	8	179	120
7	Healy.....	9	1,000	200
8	Kleenburn.....	10	32	100
9	Red Desert.....	11	733	120
10	Cherokee.....	12	200	120
11	Jim Bridger.....	-	200	120
12	Adaville.....	13-14	1,000	1,400
	COALFIELDS			
13	Powder River.....	-	-	-
14	Buffalo.....	-	-	-
15	Barber.....	-	-	-
16	Pumpkin Butte.....	-	-	-
17	Sussex.....	-	-	-
18	Lost Spring.....	-	-	-
19	Hanna basin.....	-	-	-
20	Big Horn basin.....	-	-	-
21	Wind River basin.....	-	-	-

[1]Numbers in this column refer to locations on figure 1.
[2]Numbers in this column refer to detailed maps.
[3]Overburden is as much as 200 feet in thickness over the Wyodak zone, and partings are as much as 60 feet thick between coalbeds.

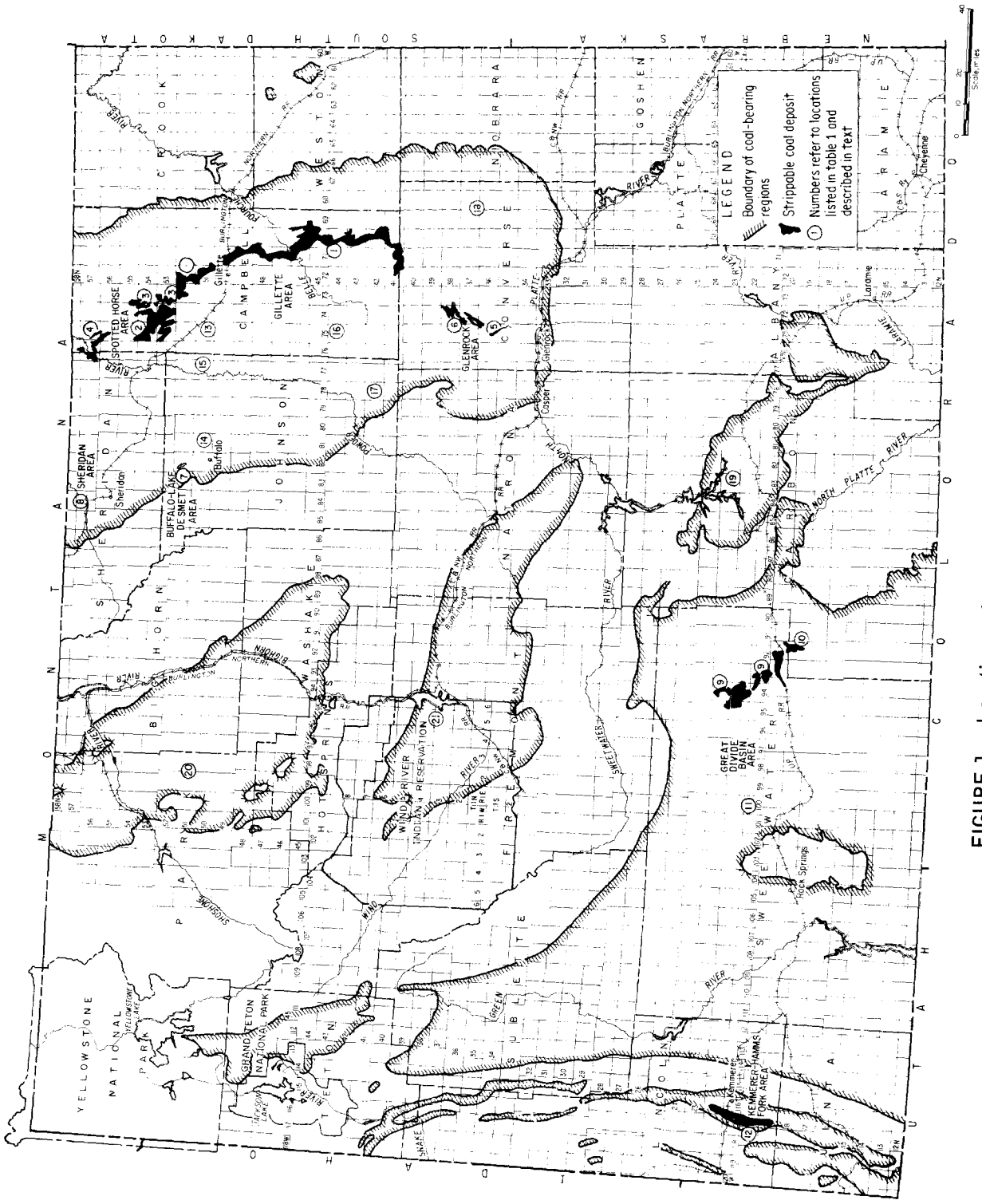

FIGURE 1. – Locations of strippable coal in Wyoming.

PREVIOUS INVESTIGATIONS

No published report on Wyoming coal has delineated the deposits that would be recoverable by open pit mining methods, but many reports contain in aggregate enough information so that such deposits can be identified. Averitt (1) estimated Wyoming's strippable coal reserves within 150 feet of the surface to be 10 billion tons. Specific deposits were not described, but strip mining areas defined by Mapel (15) and Hose (10) were cited. The several U.S. Geological Survey reports and other sources of information that were used in this investigation are referred to in the descriptions of the strippable deposits and are given in the list of references.

GENERAL INFORMATION

Wyoming, one of the Rocky Mountain States, embraces high mountains, elevated and sparsely vegetated plateaus, and mature, undulating grasslands. Open, grass-covered, rolling plains are typical of the coal basins of Wyoming. Trees are limited to scattered stands along stream and river valleys. In southwestern Wyoming the coal areas occupy high deserts where even native range grasses are sparse.

Wyoming lies astride the Continental Divide, about two-thirds of the State being on the east slope and one-third on the west. Topographically, Wyoming consists of high mountain ranges separated by broad, relatively flat-floored basins. The mean altitude of the State is about 6,700 feet.

The climate in Wyoming is semi-arid; warm dry summers alternate with cold rigorous winters. Inclement weather is most common in January, the coldest month. Annual precipitation ranges from a low of 5 inches in the Red Desert of the Great Divide basin to a high of 45 inches in some mountain ranges. In coal areas, rainfall varies from less than 6 to 12 inches in the southwestern part of the State to 6 to 18 inches in the Powder River basin, where the highest annual precipitation occurs along the east side of the Big Horn Mountains. Late spring rains provide most of the moisture (22).

Although Wyoming is considered one of the Mountain States, the strippable coal deposits underlie the relatively smooth, flat, undulating plains of the basin areas. Mining operations continue throughout the year. In fact, by following cold-weather procedures, oil well drilling, construction, and open pit mining all are conducted during the winter months. Snow usually is stripped from roads by the prevailing westerly winds and seldom reaches a depth that seriously impedes mining operations.

The north and south portions of the Powder River basin are served by the Burlington Northern railroad, and the south portion is crossed by the Chicago and Northwestern railroad. The Green River, Great Divide, Washakie, and Laramie basins are served by the Union Pacific railroad. Interstate Highway 90 crosses the northern Powder River basin, and Interstate Highway 25 crosses the southern part. In southern Wyoming, Interstate Highway 80 (U.S. Highway 30) generally follows the tracks of the Union Pacific railroad. Mountain chains limit interbasin travel to a few low passes, but within each basin access is

provided by a network of paved State and Federal roads, improved county roads, and all-weather farm and ranch roads. The topography of most basins is such that large areas can be traversed by off-road vehicles.

Many of the towns near strippable coal deposits are small, but most have basic facilities for education and family living. The relatively few principal towns in Wyoming are located on transcontinental highway and railroad routes. A low population density limits local markets and requires export of the State's products. Economic growth is therefore limited. Only Cheyenne, the State capital and principal city, can be classed as a primary wholesale-retail center[3] and only Casper as a secondary wholesale-retail center.[4]

GENERAL GEOLOGY (3, 15)

The coal measures of Wyoming are in Cretaceous- and Tertiary-age strata occupying, in general, broad synclinal basins between the several ranges comprising the Rocky Mountain chain. The coalbeds are relatively flat in most central parts of the basins except where warped by localized structural features, such as the Rock Springs uplift. Strippable reserves are limited to the near outcrop areas of coalbeds on inclined edges of the basins. Most Wyoming coalbeds are structurally disturbed and, at some basin edges, have relatively steep dips. On some flanks of mountain ranges, coalbeds appear to be corrugated by small downfolds parallel to the axis of the basin. The least disturbed beds are in the Powder River basin. The Hanna and Carbon basins and the Kemmerer-Hamms Fork region exhibit the most complex folding.

Most Wyoming coal outcrops have burned; thus, the immediate overburden is fused and baked, and only extensive, erosion-resistant, clinker zones remain. Such hardened zones are readily apparent as the protective cap rocks on many ridges, buttes, and other topographic features. The weathered clinker outcrops are generally light to dark red in color and contrast with the normally somber colors of unaltered coalbed-enveloping strata.

STRIP COAL MINING AND PRODUCTION

Total reported production of coal in Wyoming from 1894 through 1969 is 415 million tons (3, 30). Early production was mostly from underground mines and was largely used for railroad locomotive fuel (20). Since 1940, production has been 147 million tons, of which about 53 million tons came from strip mines. Annual production for these years is shown in table 2. Electric utilities, now the largest coal consumer, used 79 percent of Wyoming coal production in 1968.

In 1969, the 16 coal mines operated in Wyoming employed 448 men and produced 4,605,995 tons of coal (12). Seven of these were major strip mines that produced 4,490,430 tons of coal at an average productivity of 53 tons per man-shift (table 3). Average overburden ratio was 1-1/3 cubic yards per ton of coal, and average overburden thickness was about 60 feet. Coalbeds mined by stripping averaged 39 feet in thickness. The average price of coal in 1969 was $3.43 per ton. Data on coal characteristics at several strip mines are given in tables 3 and 4 (8, 13).

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[3]A primary wholesale-retail center has more than 100 wholesale establishments, and all of the following wholesale functions: automotive supplies, bulk oil, chemicals and paint, drugs, dry goods, apparel, electrical goods, groceries and food, tobacco and beer, lumber and construction materials, hardware, industrial and farm machinery, paper, plumbing, heating, air-conditioning equipment, and professional service equipment.

[4]A secondary wholesale-retail center has more than 50 wholesale establishments and at least 10 of the wholesale functions listed in footnote 3.

TABLE 2. - Underground and strip mine coal production, Wyoming[1]

(Thousand short tons)

Year	Strip	Total production, strip and underground	Year	Strip	Total production, strip and underground
1940.....	178	5,808	1955.....	1,539	2,927
1941.....	180	6,646	1956.....	1,528	2,553
1942.....	186	8,133	1957.....	1,468	2,117
1943.....	319	9,155	1958.....	1,265	1,629
1944.....	572	9,540	1959.....	1,646	1,977
1945.....	855	9,847	1960.....	1,713	2,024
1946.....	993	7,635	1961.....	2,224	2,529
1947.....	1,269	8,051	1962.....	2,340	2,569
1948.....	1,059	6,412	1963.....	3,007	3,124
1949.....	1,077	6,001	1964.....	2,976	3,101
1950.....	1,459	6,348	1965.....	3,136	3,260
1951.....	1,836	6,230	1966.....	3,547	3,670
1952.....	1,962	6,088	1967.....	3,471	3,588
1953.....	1,705	5,245	1968.....	3,713	3,829
1954.....	1,437	2,831	1969.....	(2)	[3]4,260

[1]Bureau of Mines. Minerals Yearbook, 1940-69. V. 1. Chapter on Coal-Bituminous and Lignite.
[2]Not published.
[3]Preliminary estimate.

TABLE 3. - Relative productivity of major Wyoming strip coal mines, 1968-69[1]

Mine	Year	Coal production, short tons	8-hour man-shifts worked	Average tons per man-shift	Coalbed thickness, feet	Overburden thickness, feet
			Campbell County			
Wyodak.....	1968	540,084	8,004	67	71	30
	1969	588,106	8,278	-	-	-
			Carbon County			
Hanna[2].....	1968	45,648	1,688	27	31	50
Rosebud.....	1968	431,252	8,422	51	24	40
	1969	615,235	12,576	49	-	-
			Converse County			
D. Johnson.....	1968	1,387,630	8,740	158	34	55
	1969	1,504,243	9,016	167	-	-
			Lincoln County			
Elkol.....	1968	245,932	6,876	36	20-90	150
	1969	243,475	12,015	20	-	-
Sorensen.....	1968	706,292	24,863	28	10-42	80
	1969	1,215,996	33,881	36	-	-
			Sheridan County			
Big Horn No. 1.....	1968	194,750	8,480	23	45	40
	1969	323,275	8,610	38	-	-
Total all counties...	1968	3,551,588	67,073	-	-	-
	1969	4,490,430	84,376	-	-	-
Average all counties.	1968	-	-	52.95	-	-
	1969	-	-	53.22	-	-

[1]State Inspector of Mines of Wyoming. Annual Report, year ending Dec. 31, 1968, pp. 14 and 15, and year ending Dec. 31, 1969, pp. 12 and 13.
[2]Closed Sept. 30, 1968.

TABLE 4. - Coal analyses, Wyoming strip coal mines

Form of analysis[1]	Composition, percent					Heating value, Btu per lb
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
WYODAK MINE[2]						
A	29.9	-	-	-	-	7,850
B	-	43.6	46.0	10.4	-	-
C	-	-	-	-	0.9	12,830
HANNA NO. 2 MINE[3]						
A	15.0	-	-	-	-	10,370
B	-	40.6	51.8	7.6	1.1	12,210
C	-	-	-	-	-	-
ROSEBUD MINE[3]						
A	11.2	-	-	-	-	11,360
B	-	43.3	52.2	4.5	-	12,800
C	-	-	-	-	-	-
DAVE JOHNSON MINE[4]						
A	28.8	31.0	29.2	11.1	-	7,450
B	-	-	-	-	-	-
C	-	51.5	48.5	-	0.8	12,390
ELKOL MINE[5]						
A	20.4	-	-	3.1	0.7	9,960
B	-	43.1	53.8	-	-	12,700
C	-	-	-	-	-	-
SORENSEN MINE[3]						
A	28.6	-	-	5.3	0.3	8,020
B	-	43.9	50.8	-	-	11,230
C	-	-	-	-	-	-
BIG HORN NO. 1 MINE[5]						
A	22.3	-	-	5.6	0.5	9,630
B	-	42.8	51.6	-	-	12,390
C	-	-	-	-	-	-

[1]A, as received; B, moisture free; C, moisture and ash free.

[2]Aresco, S. J., J. B. Janus, and F. E. Walker. Analyses of Tipple and Delivered Samples of Coal Collected During the Fiscal Year 1964. BuMines Rept. of Inv. 6622, 1965, p. 30.

[3]Aresco, S. J., J. B. Janus, and F. E. Walker. Analyses of Tipple and Delivered Samples of Coal Collected During the Fiscal Year 1965. BuMines Rept. of Inv. 6792, 1966, p. 30.

[4]Landers, W. S., V. F. Parry, Manuel Gomez, E. O. Wagner, J. B. Goodman, and C. R. Nelson. Carbonizing Properties of Wyoming Coals. BuMines Rept. of Inv. 5731, 1961, p. 23.

[5]Aresco, S. J., and J. B. Janus. Analyses of Tipple and Delivered Samples of Coal Collected During Fiscal Year 1967. BuMines Rept. of Inv. 7104, 1968, p. 23.

LEASING

Coal leasing has been primarily on public lands having large deposits and potentially favorable strip ratios. Petroleum companies have dominated the

list of successful bidders, and most of the action has been in the Powder River basin, particularly in Campbell County. Intensive leasing started in northeastern Wyoming in 1965, but Ayrshire Collieries Corp., recently acquired by American Metal Climax, Inc., initiated its exploration in central Campbell County in the early 1960's. Ayrshire's prospecting was directed at the Wyodak beds on private land along Cabello Creek, 13 miles south of Gillette, Wyo. Soon thereafter, the Kerr-McGee Corp. acquired coal interests adjacent to the Wyodak mine, 6 miles east of Gillette. Lease bids and sales reached a new high on August 18, 1967, when Humble Oil and Refining Co. bid an average of $130.75 per acre for 10,239 acres in two blocks near Gillette. The total bid was $1.34 million for roughly 1 billion tons of coal. Farmers Union Central Exchange was the second highest bidder for one of the two blocks, and Sun Oil Co. was the second highest for the other.

In 1961, Federal coal leases adjacent to the open pit Wyodak mine could have been acquired at the minimum rate of $1 per acre. Even as late as July 1, 1965, Kerr-McGee Corp. acquired Federal coal leases for per acre bids of $1.08, $3.08, and $15 on three tracts of land near the Wyodak mine. By October 1, 1965, in order to preserve its position in the coalfield, Wyodak Resources Development Corp. bid $25.55 per acre for a 2,200-acre tract just north of the Wyodak mine.

In late 1966, Sentry Royalty Co. acquired 5,541 acres in the southern part of Campbell County at $30.05 per acre. In June 1967, Atlantic Richfield Co. bid $53.13 for 5,800 acres, and Farmers Union Central Exchange bid $50.77 per acre for 599 acres. Two months later, Farmers Union bid $300,000 on a 5,457-acre tract north of Gillette but lost to Humble Oil's bid of $905,176 or $165.86 per acre.

The next Federal lease sale in Campbell County took place almost 3 years later in June 1970. At this sale Kerr-McGee Corp. bid $52 per acre for 4,352 acres on and just west of the Wyodak outcrop in southern Campbell County.

The competitive interest in Wyoming coal became apparent on December 1, 1970, when the Ark Land Company bid a bonus of $257.50 per acre for 7,595 acres in the Hanna basin, Carbon County, an alltime record bid, but a record that lasted only 9 days. On December 10, Cordero Mining Company (subsidiary of Sun Oil Company) acquired a lease on 6,560 acres 16 miles southeast of Gillette, Campbell County, for a bid of $505.00 per acre. Strippable coal reserves in the tract are 70 feet thick and under less than 200 feet of overburden. On the same date, the Mobil Oil Corporation acquired a lease on an adjacent tract containing 4,000 acres with a bid of $441.00 per acre. During 1971, no coal leases have been offered for sale but applications have been made for leases and prospecting permits on thousands of acres in coalfields throughout the State.

Private lands in northeastern Wyoming also are being sought by lease brokers and companies. Fee coal rights for land east of the present Wyodak outcrop and underlain by clinker and coal remnants from the Wyodak beds are bringing $2 per acre. On the outcrop of the Felix bed, 5 to 20 miles west of the Wyodak outcrop, fee coal rights bring $10 plus. Several options for

rights on and just west of the Wyodak outcrop have been taken at about $150 per acre. Realization by the landowner of this amount depends on coal production.

LAND RECLAMATION

The Open Cut Land Reclamation Act, passed by the 40th Legislature of Wyoming, became effective on August 7, 1969, when rules and regulations were adopted. All operators of strip mines are required to obtain a permit costing $50 in order to continue or engage in new operations. The law further requires a surety bond in an amount equal to the anticipated land reclamation costs, or in lieu thereof, operators may supply a property bond. Section 13 of the act provides penalties for failure to comply with the permit provisions. Moreover, the act applies to mining operations on all private, State, and Federal lands, except those operations under the control of any government agency having reclamation regulations equal to or greater than those required by this law. An annual report and map must be filed on all mining operations conducted during the previous year. Peaks and ridges of spoil piles must be reduced to rolling topography, and minimum widths for ridge tops are stated.

Notable examples of voluntary land reclamation have been accomplished by the Kemmerer Coal Co. at the Sorensen and Elkol strip mines near Kemmerer, Wyo., and by the Rosebud Coal Sales Co. at the Rosebud strip mine near Hanna, Wyo. Both companies used pumped water sprays to establish grass cover on spoil areas in an otherwise arid climate. A showplace for land reclamation after mining operations, even by national standards, is the Tongue River Valley near the former townsite of Kleenburn, 8 miles north of Sheridan, Wyo. There, where headframes, tipples, dilapidated houses, and dumps of abandoned underground coal mining operations once cluttered the landscape, the Big Horn Coal Co. has leveled the land, buried the refuse of a past mining era, and covered the flat valley bottom with alfalfa fields. Hundreds of trees, including several species, have been planted on recent spoil dumps and are irrigated by pumped water; a lake in an abandoned strip pit is open to public sport fishing.

STRIP MINING CRITERIA

Technologic and cost feasibility of strip coal mining relates closely to the breaking characteristics of the strata, ratios of overburden to coalbed thickness, coal characteristics, and optimum production rates. Advancements in earthmoving technology and equipment performance increasingly favor strip mining over traditional, relatively high-cost underground coal production.

Criteria for defining the cutoff limits of strippable deposits discussed herein are (1) a minimum coalbed thickness of 5 feet; (2) an overburden-to-coal ratio of less than 10 cubic yards of overburden per ton of coal; and (3) a total overburden thickness of less than 120 feet, except where strata-breaking characteristics appear ideal and coal thickness is more than 20 feet in single or multiple beds.

The total strippable reserves were estimated without regard either to any recoverability factor or to detailed analyses of coal samples. Significantly

large areas of coal reportedly mined up to 1969 in Wyoming were deleted from the strippable reserve estimates.

In discussions that follow, 12 notable coal deposits having large reserves for strip mining are described by seven general areas. Also, the potential for strip mining is presented for coalfields or portions of coalfields where strippable deposits could not be delineated.

STRIPPABLE COAL AREAS AND DEPOSITS

Gillette Area (6, 14-15, 25)

The Gillette area extends from north-central Campbell County, north of the town of Gillette, southward into the Antelope coalfield of north-central Converse County. There, coal in the massive Wyodak beds crops out for almost 100 miles along the gently dipping eastern limb of the Powder River basin.

Gillette, the county seat of Campbell County and principal town in this region, has a population of about 10,000. It is on Interstate Highway 90 and is a division point on the Burlington Northern railroad. Dryland farming and sheep and cattle raising are the principal economic mainstays of the region. During recent years, however, oil production has become an additional important source of income.

Much of the land in the Gillette area is erosion resistant owing to a protective capping of clinker formed by the burning of thick coalbeds. Rocks in the area dip gently westward except where folded locally into flat, shallow synclines and anticlines, few of which differ more than 100 feet in elevation from trough to crest. Coal measures of the Gillette area are in about 2,000 feet of strata that include the Lance, Fort Union, and Wasatch Formations. The Wasatch Formation contains most of the coalbeds, but the Wyodak beds near the top of the Fort Union Formation have far the greatest strippable coal reserves. Early workers (5-6, 25) correlated the two coalbeds at the Wyodak mine with the Roland and underlying Smith beds in the Sheridan coalfield (26). Horn (oral communication, 1969) states that several geologists exploring for coal reserves in the Powder River basin now question correlation with the Roland, but they have not yet established exact relationships of coalbeds cropping out on the eastern and western margins of the basin. Because no acceptable correlation has been published and because major partings split the coalbeds at the Wyodak mine into several seams elsewhere in the Gillette area, the term Wyodak zone is used in this report in lieu of the established Roland and Smith names. Final correlations and names are left to workers preparing detailed regional studies.

The Wyodak zone has the greatest potential for strippable coal reserves in the Western United States. Topographic data related to coal under shallow cover and along outcrops are sparse in many areas; however, companies supplied drill hole data establishing overburden limits. The easternmost evidence of a coal outcrop is clinker-capped buttes where little strip coal is indicated to remain. Farther west the coal is better protected from burning by thicker covering strata and is believed to be intact.

Other than a concentration of data pertinent to the Wyodak mine, 6 miles east of Gillette, few analyses are available on coal in the Gillette area (table 4). Most coal reserves in Campbell County are subbituminous in rank. Total reserves within 3,000 feet of the surface are more than 62 billion tons, the national high for a single county. In fact, Campbell County contains about half the coal reserves in Wyoming. A single township surrounding the townsite of Gillette, T 50 N, R 72 W, contains 2.87 billion tons of coal, and most of this reserve is in the Wyodak zone within 500 feet of the surface (3).

Location 1: Wyodak Deposit

The Wyodak zone is near the top of the Fort Union Formation and in some places marks the contact between that formation and the overlying Wasatch Formation. For many miles the coalbeds are burned along their outcrops and are identified by thick, prominent clinker. The easternmost edge is the capping of a continuous north-south line of buttes that grades westerly into prominent clinker-capped ridges. West of the ridges the topography changes to comparatively flat farmland and rangeland.

Outcrop lines for the Wyodak zone shown on figures 2 and 3 are the westward limit of burned coal. Combined, the Wyodak coalbeds have a maximum thickness of 130 feet and average about 70 feet. Dip of the beds ranges from 4° to 8° to the west. Overburden thickens westerly from 20 to 50 feet along the outcrop to an arbitrary stripping limit of 200 feet 1 to 4 miles west of the outcrop. Thicknesses of coal and overburden in W½, T 50 N, R 70 W, near the Wyodak mine, are shown in detail on figure 2.

At the Wyodak mine, 6 miles east of Gillette, the Wyodak beds are separated by an 8-inch parting, and the lower bed is about 38 feet thick. Logs of water wells at Gillette (14) indicate that, in this area, the lower bed is 22 to 35 feet thick and is separated from the overlying Wyodak bed by 85 to 100 feet of shale and sandstone. Along the outcrop north of Wyodak, the Wyodak beds split into at least five distinct seams ranging from 5 to 31 feet in thickness and are separated by 4 to 33 feet of clay and shale (fig. 3). South of Wyodak for 55 miles to Antelope Creek in north-central Converse County, coal in the Wyodak zone occurs in one or more seams. Near the center, T 49 N, R 70 W, four beds 10 to 40 feet in thickness are split by 10 to 70 feet of clay and shale. Farther south, from Tisdale Creek to the Belle Fourche River, the Wyodak beds are 60 to 80 feet of coal separated by several thin partings having a total thickness of as much as 8 feet.

Between the Belle Fourche River and Antelope Creek, the Wyodak beds occur either as a single bed up to 100 feet in thickness or as several beds with partings as much as 100 feet in thickness. Throughout southern Campbell County the aggregate thickness of coal in the Wyodak zone is near 100 feet, but not all the beds are under less than 200 feet of overburden and less than 60 feet of partings. Coal in beds under greater cover or separated from the top Wyodak bed by more than 60 feet of partings are not included in the reserve estimate.

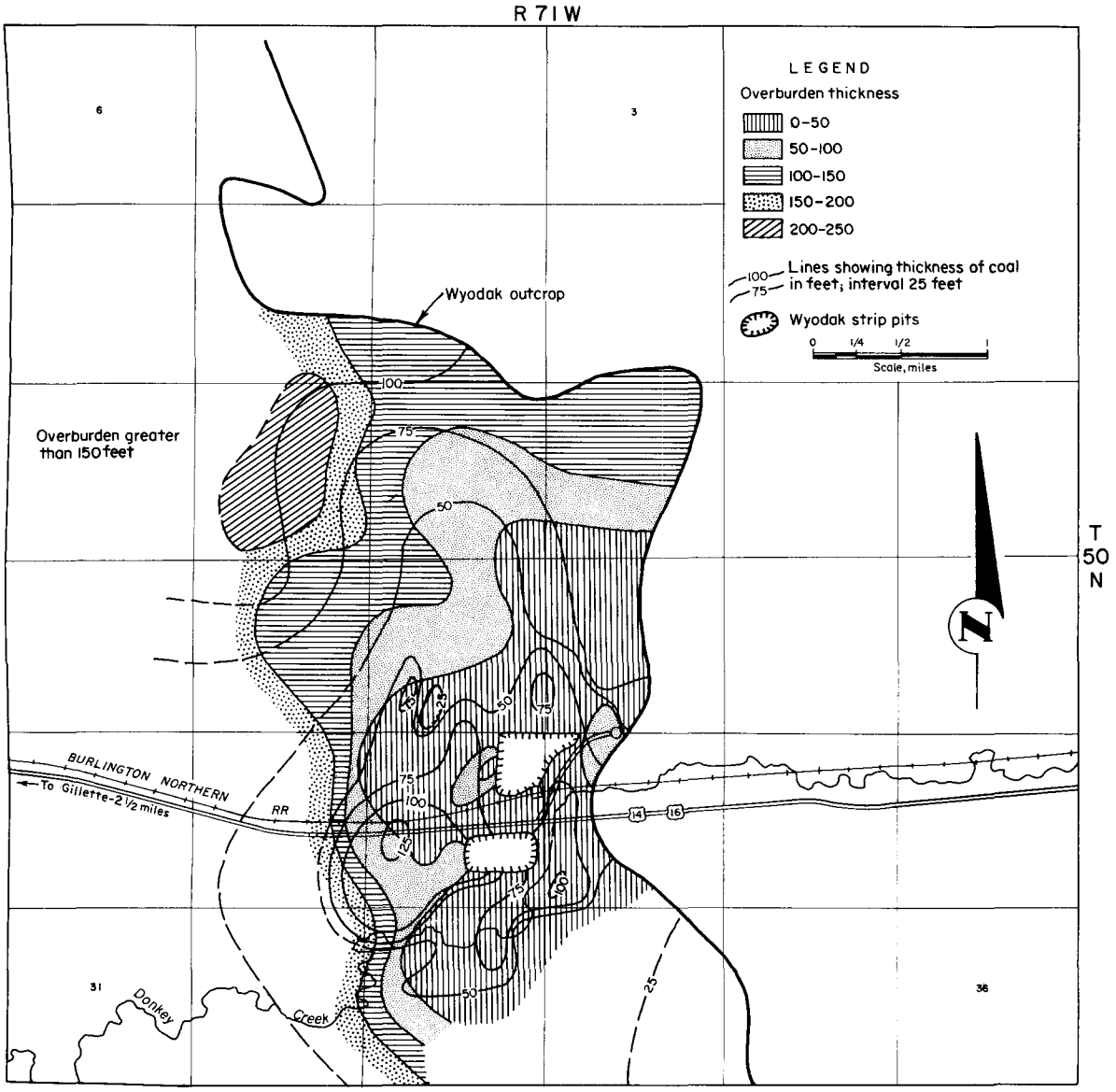
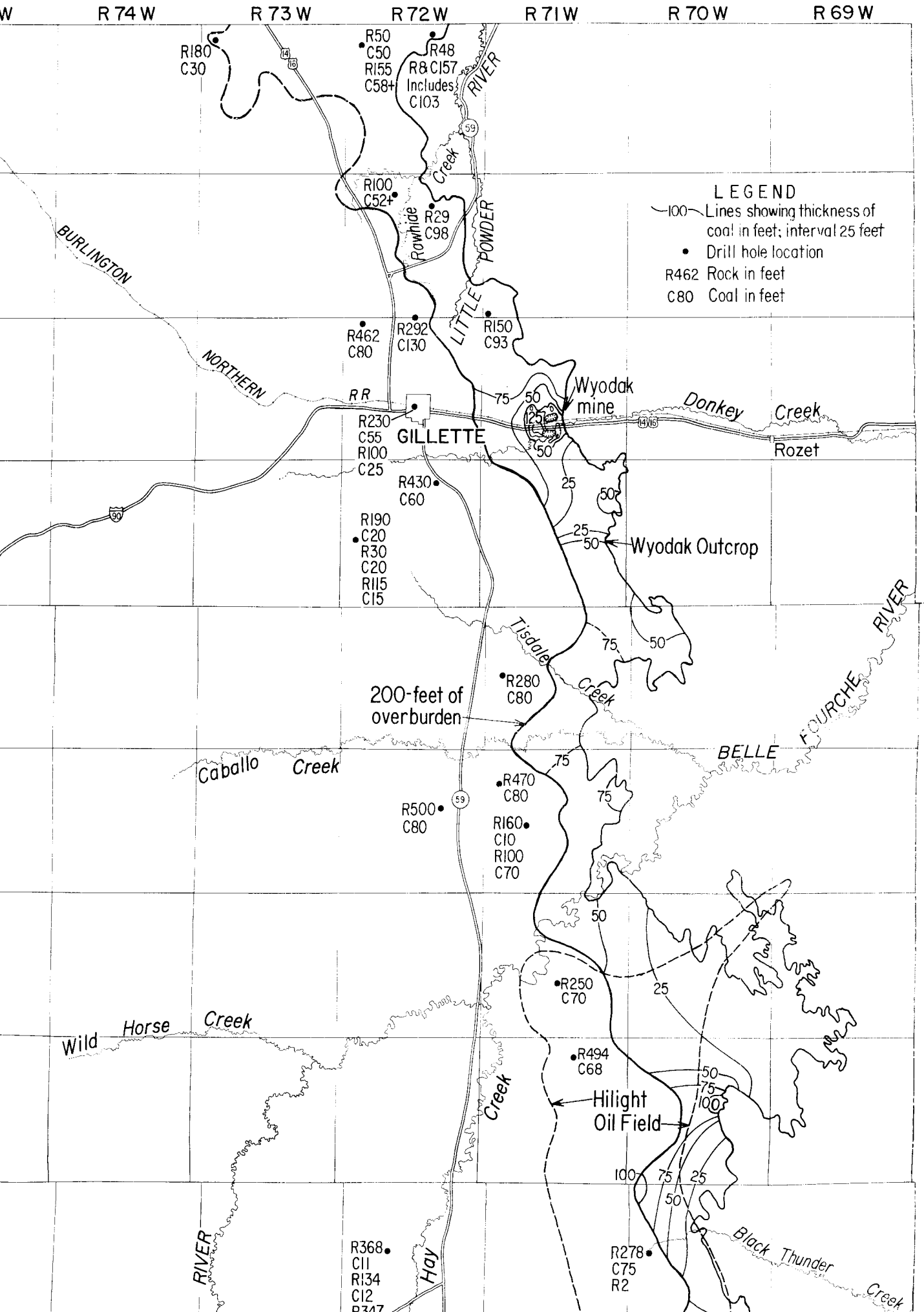


FIGURE 2. – Wyodak deposit (T 50 N, R 71 W), Gillette area.


R74W
R73W
R72W
R71W
R70W
R69W
R180 C30
R50 C50 R155 C58+
R48 R8 C157 Includes C103
RIVER
Creek
R100 C52+
R29 C98
Rawhide
POWDER
LITTLE
BURLINGTON
NORTHERN
RR
R462 C80
R292 C130
R150 C93
Wyodak mine
Donkey Creek
Rozet
R230 C55 R100 C25
GILLETTE
R430 C60
R190 C20 R30 C20 R115 C15
Wyodak Outcrop
Tisdale Creek
R280 C80
200-feet of overburden
BELLE FOURCHE RIVER
Caballo Creek
R470 C80
R500 C80
R160 C10 R100 C70
R250 C70
Wild Horse Creek
R494 C68
Hilight Oil Field
Hay Creek
RIVER
R368 C11 R134 C12
R278 C75 R2
Black Thunder Creek
LEGEND
100 Lines showing thickness of coal in feet; interval 25 feet
Drill hole location
R462 Rock in feet
C80 Coal in feet

A strippable area where the Wyodak zone is covered by less than 200 feet of overburden is shown on figure 3. Large reserves under less than 100 feet of cover occur where major drainage basins cross the Wyodak outcrops. Drainages having important strippable sites are Rawhide, Donkey, Tisdale, Cabello, Belle Fourche, Thunder, Porcupine, and Antelope. Total strippable coal reserves in the Wyodak deposit are 19 billion tons.

Spotted Horse Area (5, 19, 25)

The Spotted Horse area of Sheridan and Campbell Counties in northeastern Wyoming covers about 725 square miles. It is bounded by the Sheridan coalfield on the west, the Powder River coalfield on the south, the northern extension of the Gillette area on the east, and the Montana-Wyoming State line on the north. The area is named after Spotted Horse, a hamlet of 10 residents about 37 miles northwest of Gillette on U.S. Highways 14 and 16.

Topography is characterized by flat-topped buttes, long narrow flat divides, and even-crested ridges that rise steeply 100 to 600 feet above valley bottoms. Altitudes range from 3,395 feet above sea level along the Powder River to about 4,600 feet along the divide between the Powder and Little Powder Rivers.

The Powder River flood plain, averaging about one-half mile in width, follows a sinuous, northeasterly trending course across the north-central part of the coalfield. The valley has steep slopes that generally rise 100 to 600 feet above the valley floor, although north of Big Remington Creek and Gray Cabin Draw the slopes are interrupted by a series of benches that have formed on resistant clinker.

Well-defined erosion surfaces, supported by resistant but deeply dissected strata, occur at two levels. The upper surface, which ranges in altitude from about 4,450 to 4,660 feet, caps high buttes and divides in the area south and west of U.S. Highways 14 and 16 and forms a badland topography.

The lower erosion surface is found at altitudes of 4,000 to 4,260 feet and is preserved on high stream divides and flat-topped buttes in the area north and east of U.S. Highways 14 and 16. In the north-central part of the Spotted Horse area, this surface has been destroyed by erosion except on some of the high stream divides.

The Burlington Northern railroad between Billings, Mont., and Alliance, Nebr., passes a few miles south of the area.

Stock raising and dry farming are the principal industries. Grain is the chief crop on the flatlands of the divide, and hay, used for winter feeding of livestock, is the main crop in the valleys. Oil production has become increasingly important.

In the northern part of the field, in Tps 56-58 N, Rs 74-76 W, the Wasatch Formation overlies the Tongue River Member of the Fort Union Formation and caps the divides. The Wasatch and Fort Union Formations show no marked

variations in lithology; both consist of sandstone, shale, and coal. The drab color of the Wasatch and the scarcity of timber on its outcrops do contrast, however, with the lighter colors and small stands of timber that characterize the outcrops of the Tongue River Member.

Major coalbeds in the Spotted Horse coalfield are listed in table 5.

TABLE 5. - Generalized section listing major coalbeds in the Spotted Horse area[1] (19)

Formation and bed	Interval thickness, feet
Wasatch Formation:	
Ulm No. 1 bed	75
Ulm No. 2 bed	65
Scott bed	190-280
Felix bed*	0-425
Arvada bed* (to Roland)	65
Fort Union Formation, Tongue River Member:	
Roland bed*	180
Smith bed	160
Anderson bed	75
Dietz No. 1 bed	85
Canyon bed	290
Wall bed	-
Lower part of Tongue River Member	-

[1]Intervals were measured from base of a bed to base of the bed above; beds marked by asterisk (*) occur only in northern part of the area.

Formations in the Spotted Horse area are flat lying or dip very slightly. The coal is of subbituminous C-rank, comparable to that in the adjacent Sheridan and Powder River fields.

Some faulting has taken place in the coalfield, and displacement ranges from about 20 to 300 feet. Strata on the upthrown side of many faults are relatively flat; those on the downthrown side dip steeply toward the fault but flatten a short distance from it. This type of faulting is said to be near the central parts of T 58 N, R 76 W, in the south-central part of T 56 N, R 76 W, and south of U.S. Highways 14 and 16. Strata along both sides of other faults are said to have relatively steep dips.

Coalbeds occur in carbonaceous zones, either carbonaceous shale or carbonaceous sandstone. A coalbed near the middle of a zone in one locality may be in the upper or lower part elsewhere. Thus, shale partings in a coalbed may thicken and split the coal into several stringers that eventually may pinch out.

Of the many coalbeds present in the area--10 regional in character and about 14 of local significance--strippable reserves are estimated herein only

for the Felix and Smith beds, a local bed 30 feet below the Smith, and the Canyon bed because it is believed these are the only beds for which available data are adequate to permit an estimate of stripping limits. These beds, however, are not the only potential strip areas in the Spotted Horse area.

Because topographic data are not available, it has been necessary to fix the upper stripping limit in the area by using the mapped outcrop of a second coalbed 80 to 120 feet above the possibly productive bed. In cases where the nearest overlying coal is more than 120 feet above the bed of interest, an attempt has been made to infer where the highwall limit should be by interpolating between the two outcrops.

Location 2: Felix Deposit (19)

The Felix bed (fig. 4), a part of the Wasatch Formation, is stratigraphically the highest of the beds considered. Throughout much of the area the bed is overlain by thick cover and thus is protected from burning. At many places the coal contains partings, some of which are consistent. Where the partings are less than 6 inches thick, it was assumed in estimating reserves that the full coal section would be mined. Where the partings are thicker, only the highest coal segment is included.

On this basis, and assuming the reserve tonnage factor to be 1,740 tons per acre-foot, the estimated recoverable reserve is 480 million tons. Average coal thickness is 12.5 feet.

Location 3: Smith-Local Deposit (19)

The Smith bed (fig. 5) is one of the most persistent coalbeds in the area. It crops out high on even-crested ridges on the eastern edge of the area and at lower elevations in steep valley walls of the central and western parts. Smith coal is often sandwiched between thick beds of massive, cliff-forming, yellowish-gray sandstone.

The Smith coalbed has a favorable stripping ratio in the southeastern part of the Spotted Horse area. In the southern part of the deposit, a local bed, 30 feet below the Smith bed, also is thick enough to mine, and for approximately 1 mile along the southerly striking outcrop, both the local and the Smith beds are strippable. Farther south, however, the Smith bed thins, but the underlying local bed has a minable thickness. Using a 5-foot isopach contour as the cutoff limit for the beds, the total estimated stripping reserve for this area is 236 million tons.

Location 4: Canyon Deposit (19)

Best exposures of the Canyon coalbed are found in northwestern Campbell County and northeastern Sheridan County (fig. 6). Much of the outcrop has burned and thick clinker in many places caps buttes and forms benches on the slopes.

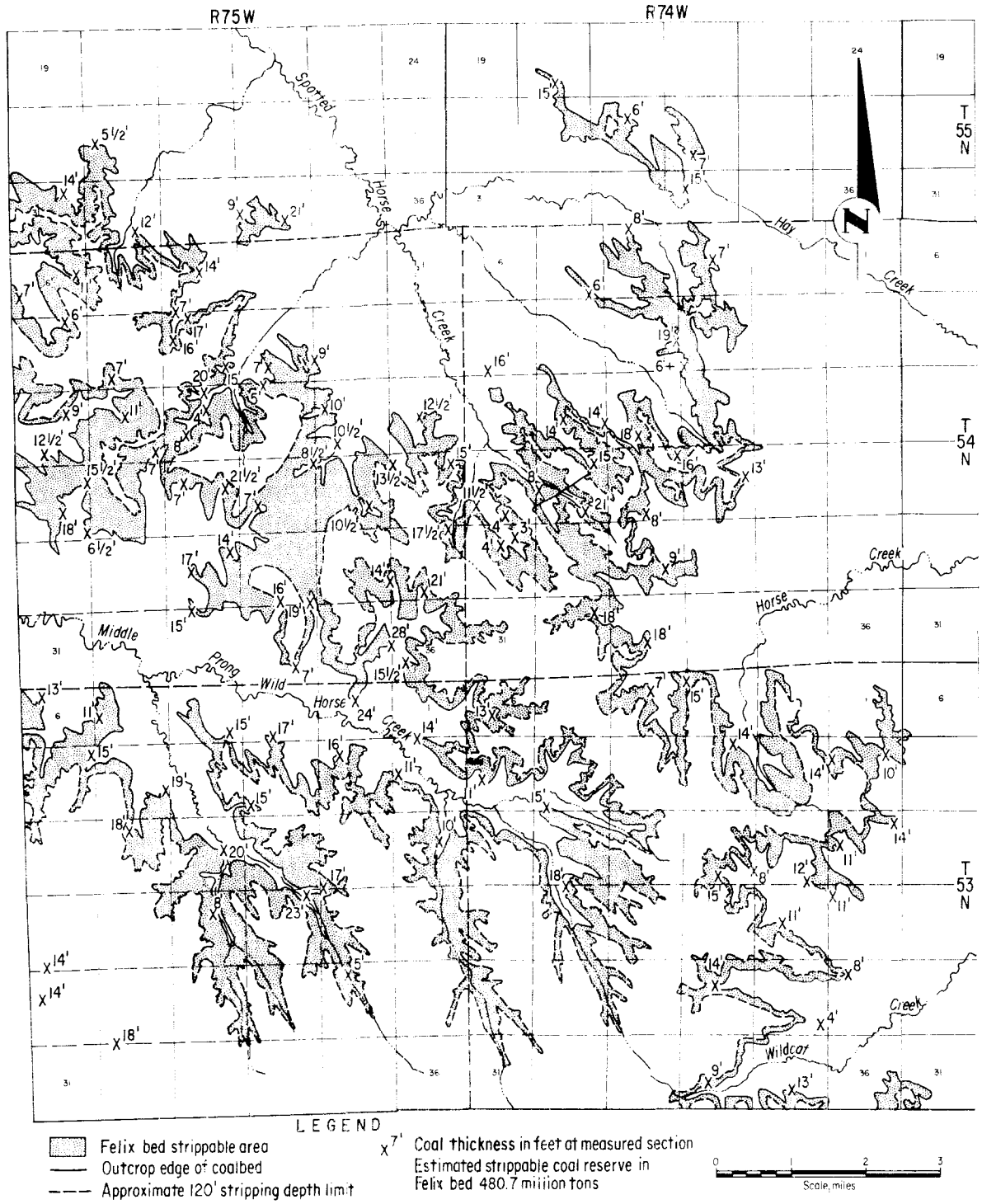


FIGURE 4. – Felix deposit, Spotted Horse area. (Based on plate 2, U.S. Geol. Survey Bull. 1050)

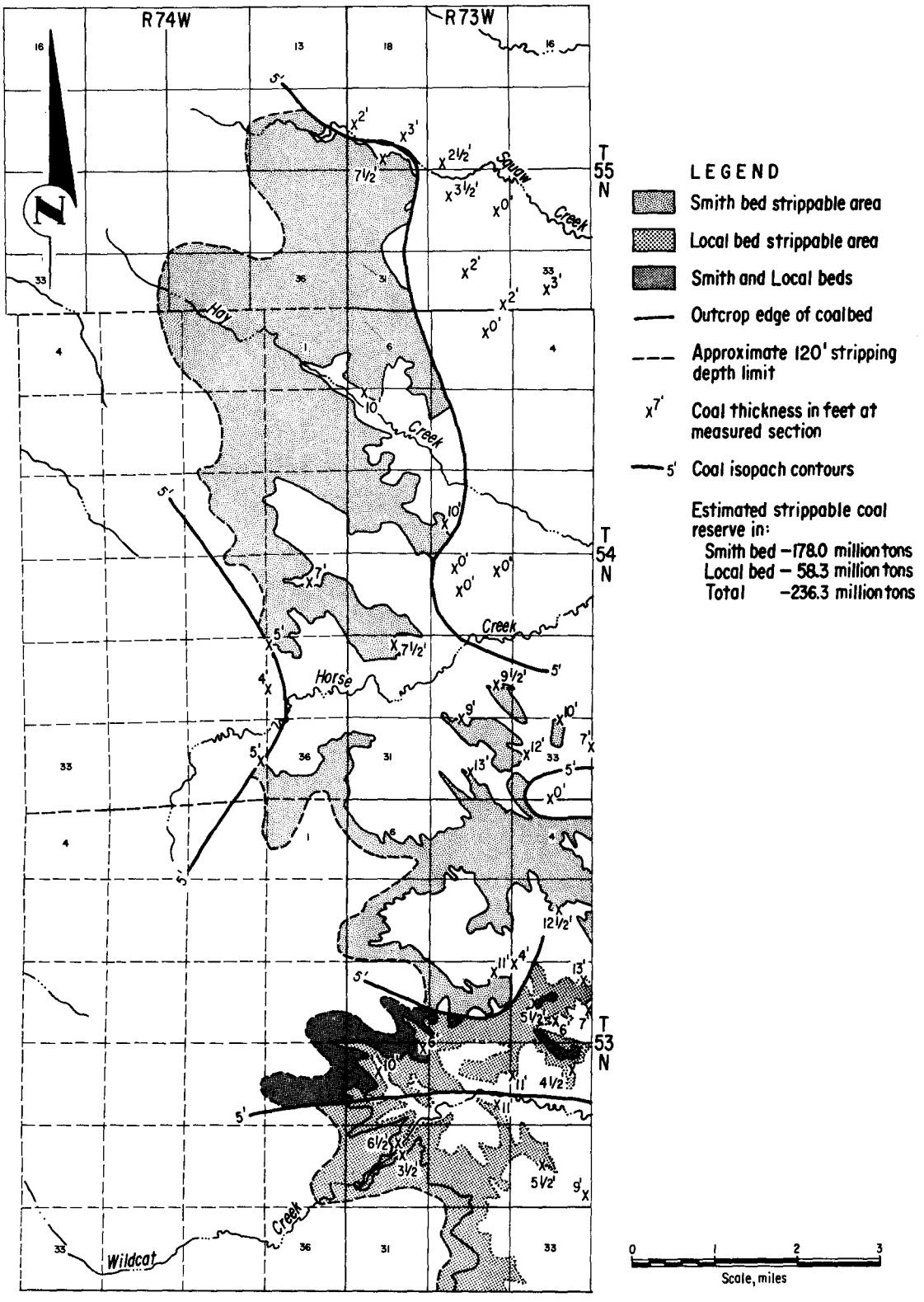


FIGURE 5. – Smith-Local deposit, Spotted Horse area. (Based on plate 2, U.S. Geol. Survey Bull. 1050)

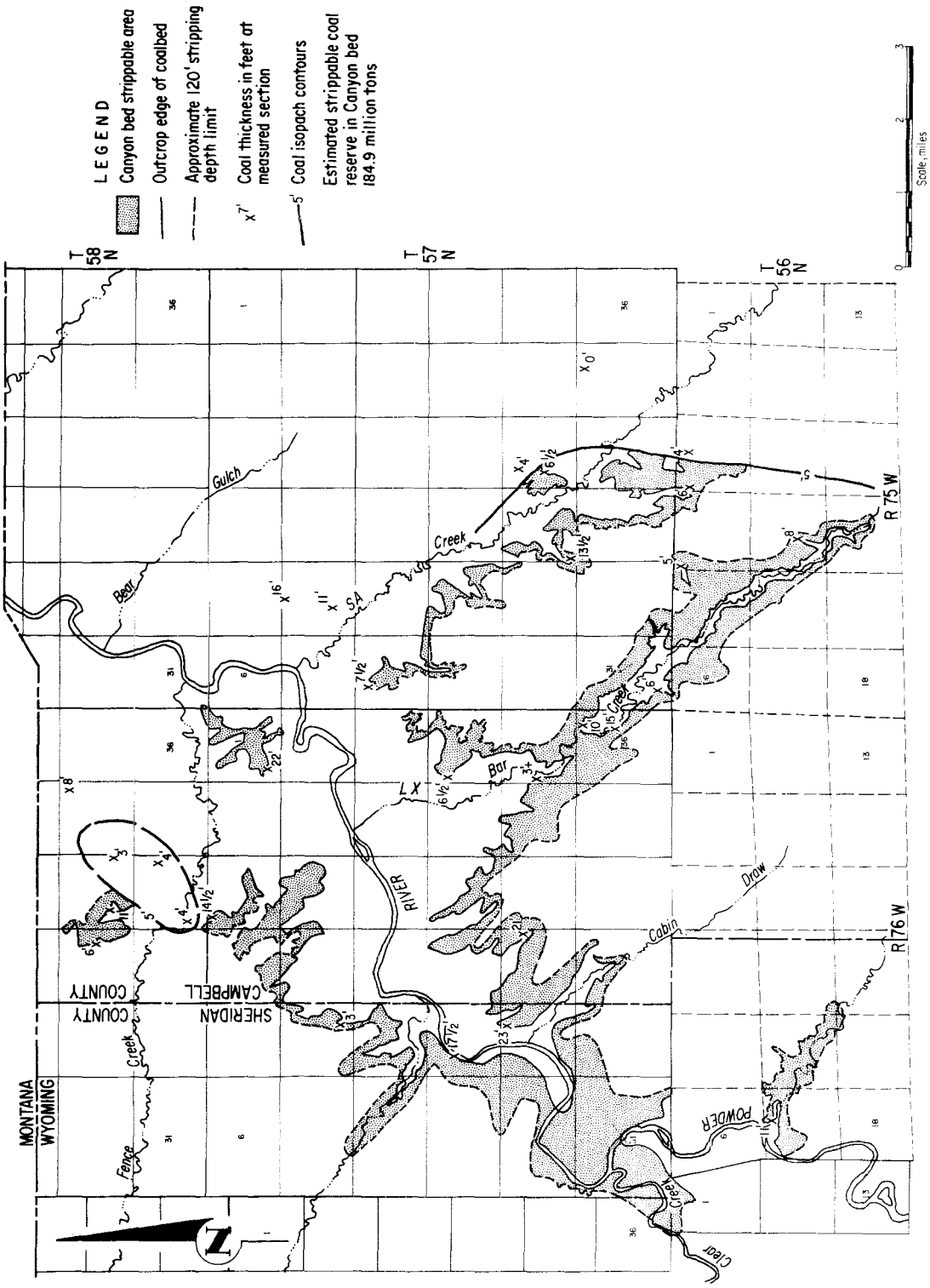


FIGURE 6.– Canyon deposit, Spotted Horse area. (Based on plate 1, U.S. Geol. Survey Bull. 1050)

The Canyon bed is overlain by the Dietz No. 1 bed in part of the potential strip area, and the interval between them is about 90 feet. The Anderson bed, about 75 feet above the Dietz No. 1, also is present in some of the area. The highwall limit for the Canyon bed, as indicated on figure 6, has been estimated on this basis to approximate 90 feet.

On the east and in part on the north, the strip area has been limited by the 5-foot isopach contours. Thickness of the Canyon bed is estimated by arithmetical average to be 11 feet. Hence, the Canyon bed contains about 185 million tons of strippable coal.

Glenrock Area (23)

The Glenrock area lies in central Converse County in the east-central part of Wyoming. Principal cities and towns in this vicinity are Casper, population about 40,000; Douglas, county seat of Converse County, population about 3,000; and Glenrock, about 8 miles south of the deposit, population about 1,600. U.S. Interstate Highway 25, the Chicago and Northwestern and the Burlington Northern railroads serve each of these communities.

Location 5: School-Badger Deposit

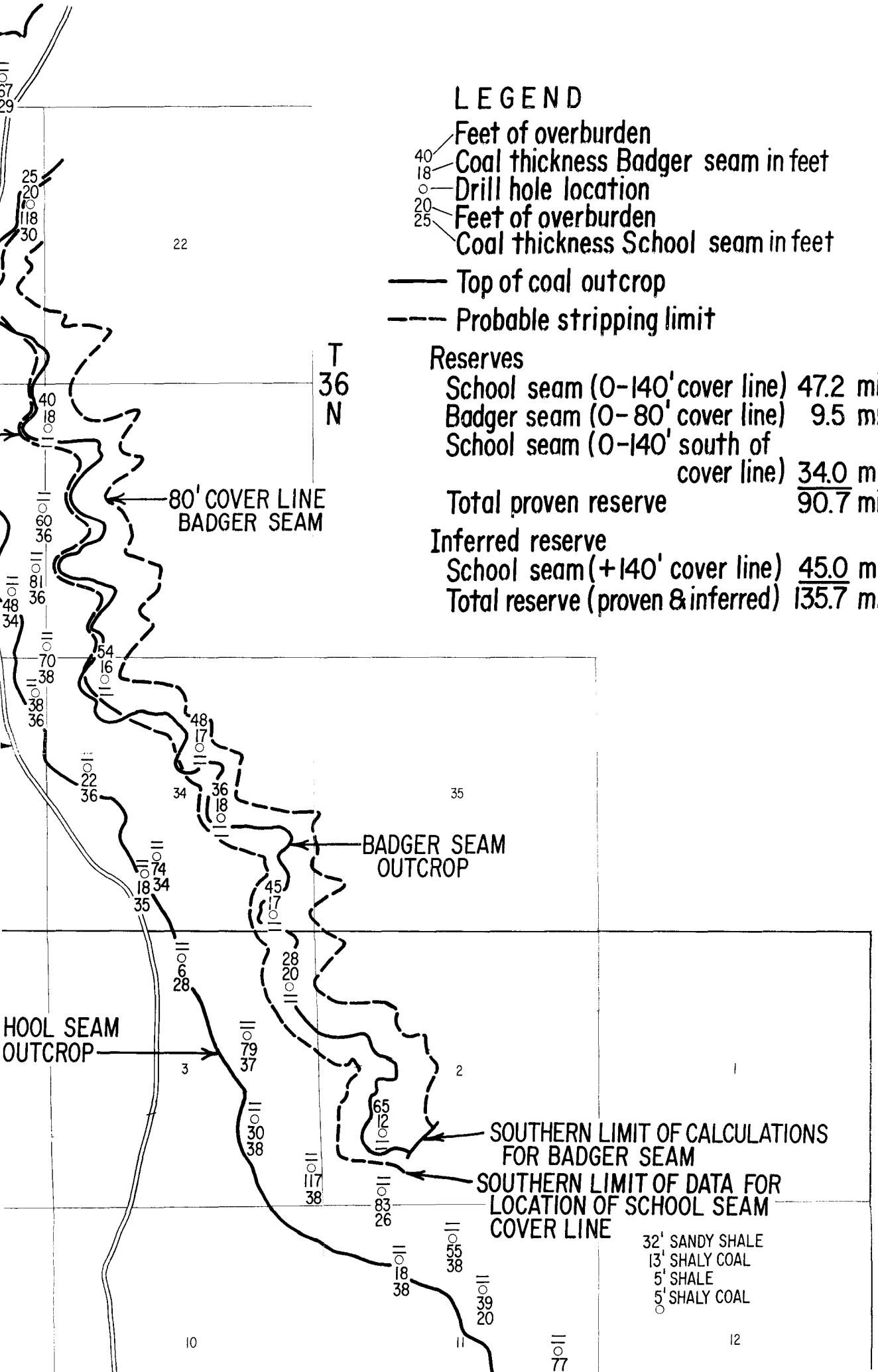
Coalbeds in the School-Badger deposit are in the Fort Union Formation. Further exploration drilling may prove strippable reserves both north and south of the presently known deposit (fig. 7). It is postulated that the north-south range of hills west of this area is the southern continuation of the Pine Ridge and that it probably represents the upturned edge of the youngest formation at the western edge of the Powder River basin. If this inference is correct, any coal that may have existed in the western one-third of T 36 N, R 75 W, has been removed by erosion.

Company data (fig. 7) show an estimated 135.7 million tons of coal in the School and Badger seams. The overburden-to-coal ratio--computed on the basis of a 140-foot highwall limit for the School seam and an 80-foot highwall limit for the Badger seam--is about 2.98 cubic yards of overburden per ton of coal. It is inferred that an additional 45 million tons of strippable coal is available beyond the 140-foot cover line where the two seams could be mined by multiple-bed stripping.

An analysis from the Badger coalbed, typical of the deposit, follows:

Form of analysis	Composition, percent[1]					Heating value, Btu per lb
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
As received.....	25.7	34.5	32.6	7.2	-	8,250
Moisture and ash free..	-	-	48.5	-	0.6	12,300

[1]Landers, W. S., J. B. Goodman, and D. J. Donaven. Low-Temperature Carbonization Assays of Coals and Relation of Yields to Analyses. BuMines Rept. of Inv. 5904, 1961, p. 17.


LEGEND
Feet of overburden
Coal thickness Badger seam in feet
Drill hole location
Feet of overburden
Coal thickness School seam in feet
Top of coal outcrop
Probable stripping limit
Reserves
School seam (0-140' cover line) 47.2 million tons
Badger seam (0-80' cover line) 9.5 million tons
School seam (0-140' south of cover line) 34.0 million tons
Total proven reserve 90.7 million tons
Inferred reserve
School seam (+140' cover line) 45.0 million tons
Total reserve (proven & inferred) 135.7 million tons
T 36 N
80' COVER LINE BADGER SEAM
BADGER SEAM OUTCROP
HOOL SEAM OUTCROP
SOUTHERN LIMIT OF CALCULATIONS FOR BADGER SEAM
SOUTHERN LIMIT OF DATA FOR LOCATION OF SCHOOL SEAM COVER LINE
32' SANDY SHALE
13' SHALY COAL
5' SHALE
5' SHALY COAL
22
34
35
3
2
1
10
11
12

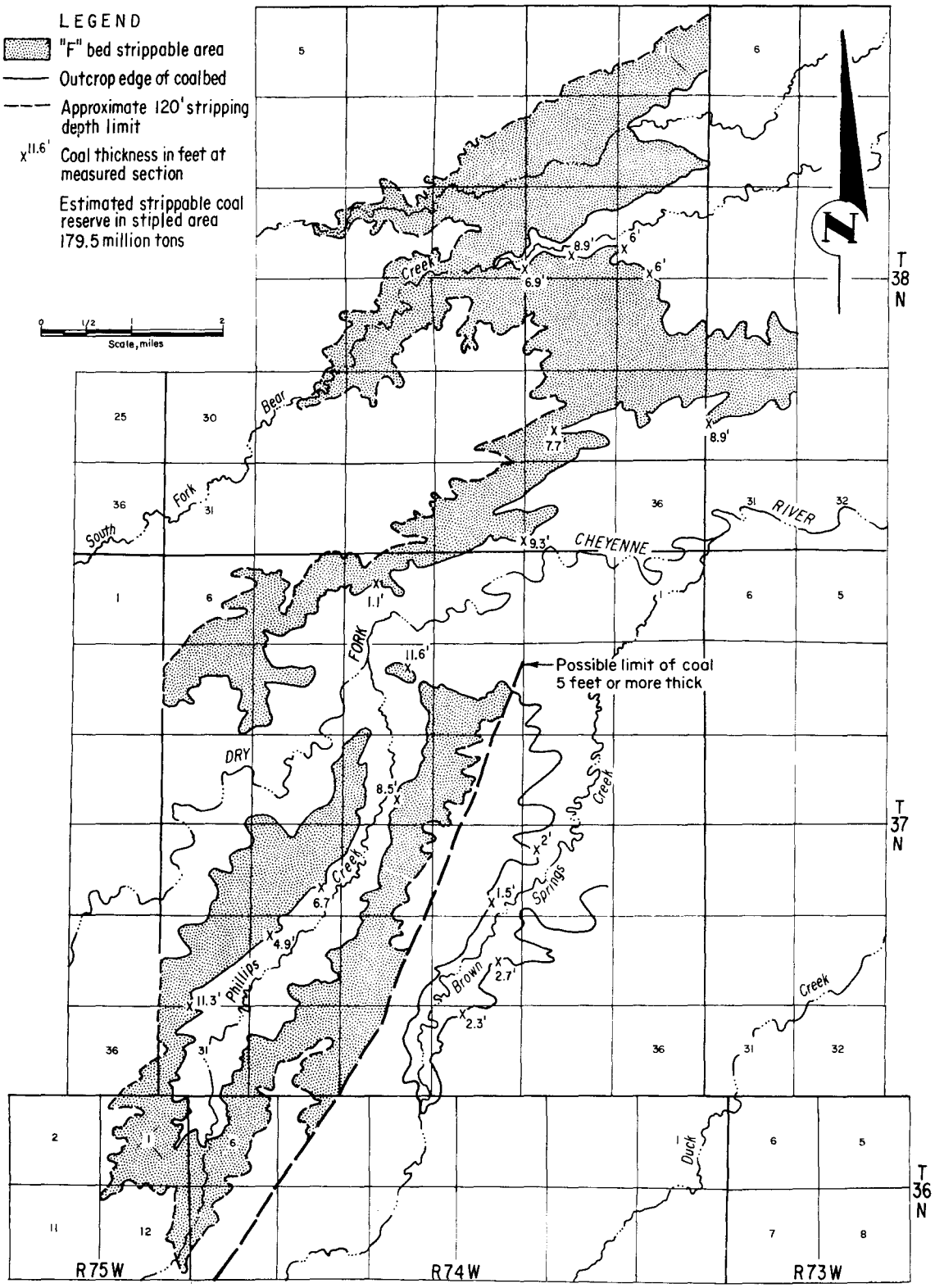


FIGURE 8. – Dry Cheyenne deposit, Glenrock area. (Based on plate 4, U.S. Geol. Survey Bull. 806A)

Location 6: Dry Cheyenne Deposit (33)

The Dry Cheyenne deposit lies in Tps 36-38 N, Rs 73-75 W, Converse County, Wyo. (fig. 8). County roads to the deposit are unimproved. Surface elevations range from about 5,000 feet along the Dry Fork of the Cheyenne River to about 5,800 feet on the Cheyenne River divide.

Exposed rocks in the field include the upper part of the Tongue River Member of the Fort Union Formation and the overlying Wasatch Formation. Of the three coalbeds exposed in the field, the lowest is bed H, which ranges in thickness from 1 foot or less to 4 feet 4 inches. Bed G lies 220 feet above bed H and averages about 2 feet in thickness. Bed F is about 160 feet above bed G and has a maximum thickness of 11.6 feet. Sections measured on the outcrop average 7.5 feet in thickness; the maximum figure included in this average is 11.6 feet and the minimum is 1.1 feet.

By transcribing available data onto a topographic map and assuming a 120-foot pit depth, it has been estimated that there is a recoverable reserve of 179 million tons of coal in the F bed.

Buffalo-Lake De Smet Area (15-17)

The Buffalo-Lake De Smet area lies in Johnson County in north-central Wyoming. Buffalo, which has a population of about 3,000, is the county seat and is about 7 miles south of Lake De Smet. Interstate Highway 90 connects Buffalo with Sheridan, Wyo., about 25 miles to the north. The nearest railroad shipping points are on the Burlington Northern railroad at Clearmont, about 23 miles to the northeast on U.S. Highway 16, and at Sheridan.

The topography is characterized by smoothly rounded hills and broad flat-topped benches and terraces. At many places in the area, coalbeds have burned along their outcrops or under shallow cover.

Lake De Smet is roughly oval in outline, about 3½ miles long and 1½ miles wide, and trends northwestward in its long dimension. It has been suggested that the lake basin was formed by the slumping of clinkered sediments into the space vacated by the burning of thick coalbeds.

The climate of the area is temperate and semiarid, similar to that in many other parts of the northern Great Plains. The maximum temperature recorded at Buffalo is 104° F and the minimum -38° F. The mean annual precipitation is about 16 inches.

The commercially important coal deposit occurs in the Wasatch Formation in the Buffalo-Lake De Smet area (fig. 9). The coalbeds are flat lying and their outcrops closely follow the contours of the land surface. Stratigraphic intervals between the coalbeds and ranges in thickness of the beds are given in table 6 (16).

TABLE 6. - Generalized section of principal coalbeds in the Buffalo-Lake De Smet area[1]

Bed and bed thickness:	Interval thickness, feet[2]
Monument Peak (10 to 20 feet)	150-175
Walters (20 to 35 feet)	165
Healy (5 to 25 feet thick at outcrop; bed tentatively correlated with Healy reported to be as much as 220 feet thick in drill holes)	25
Schuman (1 to 9 feet)	35
Timar (1 to 4 feet)	35
Cameron beds (1 to 5 feet; commonly two or more beds present in stratigraphic interval of 10 to 35 feet)	60
Dry Creek (1 to 8 feet)	35
Murray (1 to 7 feet)	90-110
Ucross (1 to 15 feet)	-

[1] (16, p. 82).

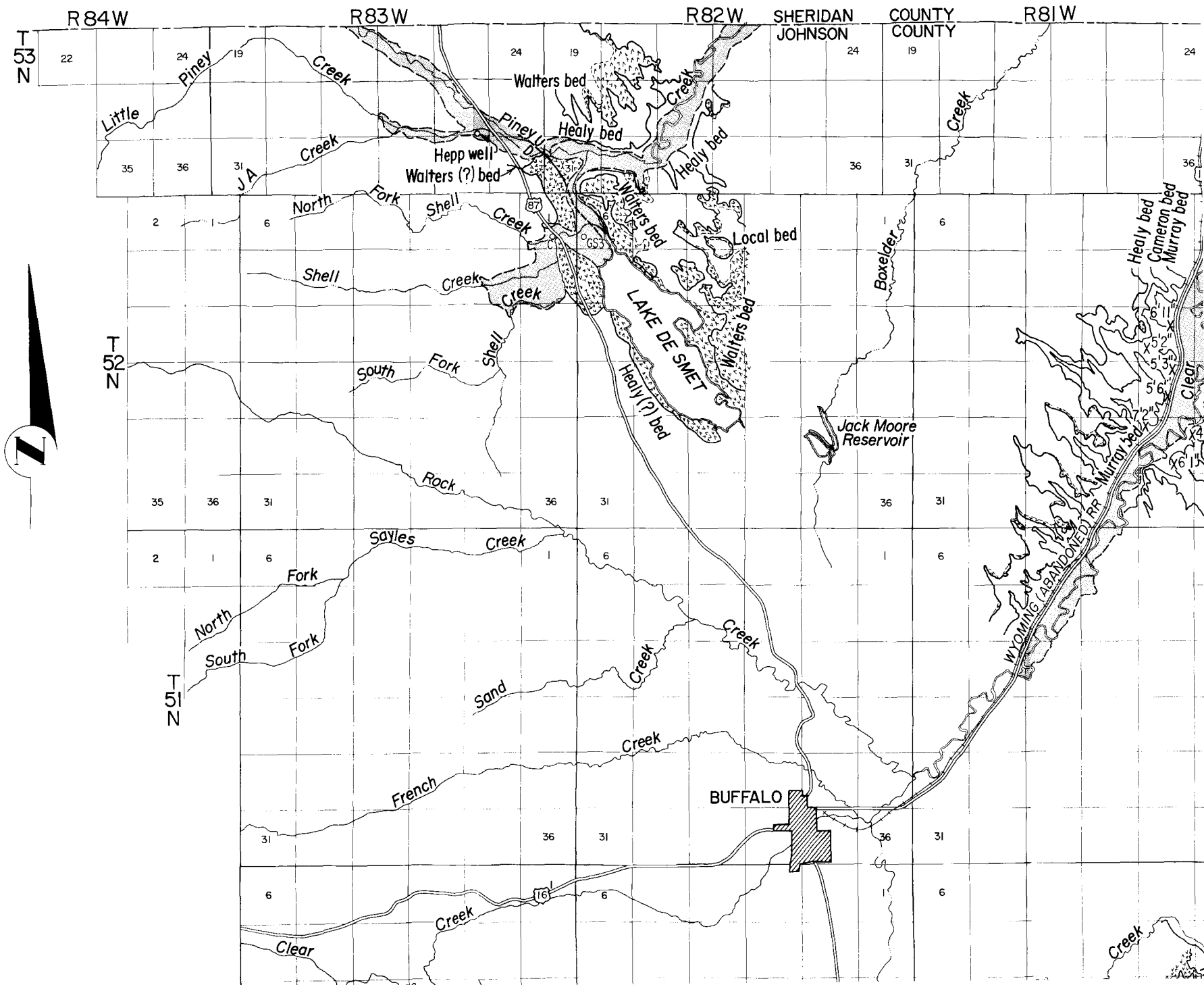
[2] Intervals given are from the base of the lower bed to the base of the next higher bed.

Location 7: Healy Deposit

Mapel and others state (17):

> "A concealed coalbed that averages more than 100 feet in thickness and locally may be as much as 200 feet thick underlies an area of at least 2½ square miles west of a normal fault at the north end of Lake De Smet, Johnson County, Wyo. The coal was found in holes drilled from 1944-51 by the U.S. Bureau of Reclamation, the U.S. Geological Survey, and private individuals. Reserves of coal in this bed and in a thinner bed beneath an area of about 3 square miles east of the fault are estimated to be 528.56 million tons, of which 35.40 million tons are measured and the rest indicated and inferred. The coal cannot be classified precisely as to rank, but available analytic data indicate that it probably is low with the range of subbituminous C. The top of the coal is less than 100 feet below the surface in much of the area tested by drilling and thus the coal is minable by stripping methods."

Figure 9 shows the boundary of the Healy deposit. The deposit contains at least 1 billion tons of strippable coal. Overburden consisting of sand, gravel, clinker, soft sandstone, and shale ranges from 40 to 200 feet in thickness. Variation in coalbed thickness is partly due to burning of varying amounts of coal from the upper part of the bed. Thicknesses for which drill logs are available are shown on figure 9.


R84W
R83W
R82W
R81W
SHERIDAN COUNTY
JOHNSON COUNTY
T 53 N
T 52 N
T 51 N
Little Piney Creek
Piney Creek
Shell Creek
North Fork Shell Creek
South Fork Shell Creek
Rock Creek
Sayles Creek
North Fork Sayles Creek
South Fork Sand Creek
French Creek
Clear Creek
Boxelder Creek
Walters bed
Healy bed
Hepp well
Walters (?) bed
Local bed
Cameron bed
Murray bed
LAKE DE SMET
Healy (?) bed
Jack Moore Reservoir
WYOMING (ABANDONED) RR
BUFFALO
JA
GSS
87
16

The weighted average analyses of coal found in 5 drill holes follows (16, p. 91):

Form of analysis	Composition, percent					Heating value, Btu per lb
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
As received.....	27.0	30.1	34.0	8.1	0.7	7,940
Moisture and ash free..	-	46.4	53.6	-	-	12,510

Sheridan Area (26)

The Sheridan area lies within T 54-58 N, R 79-85 W, and the city of Sheridan, Wyo., is in the west-central part. Within the Sheridan area, the various coalbeds can be segregated into three separate units, in descending order, the Ulm, Intermediate, and Tongue River groups.

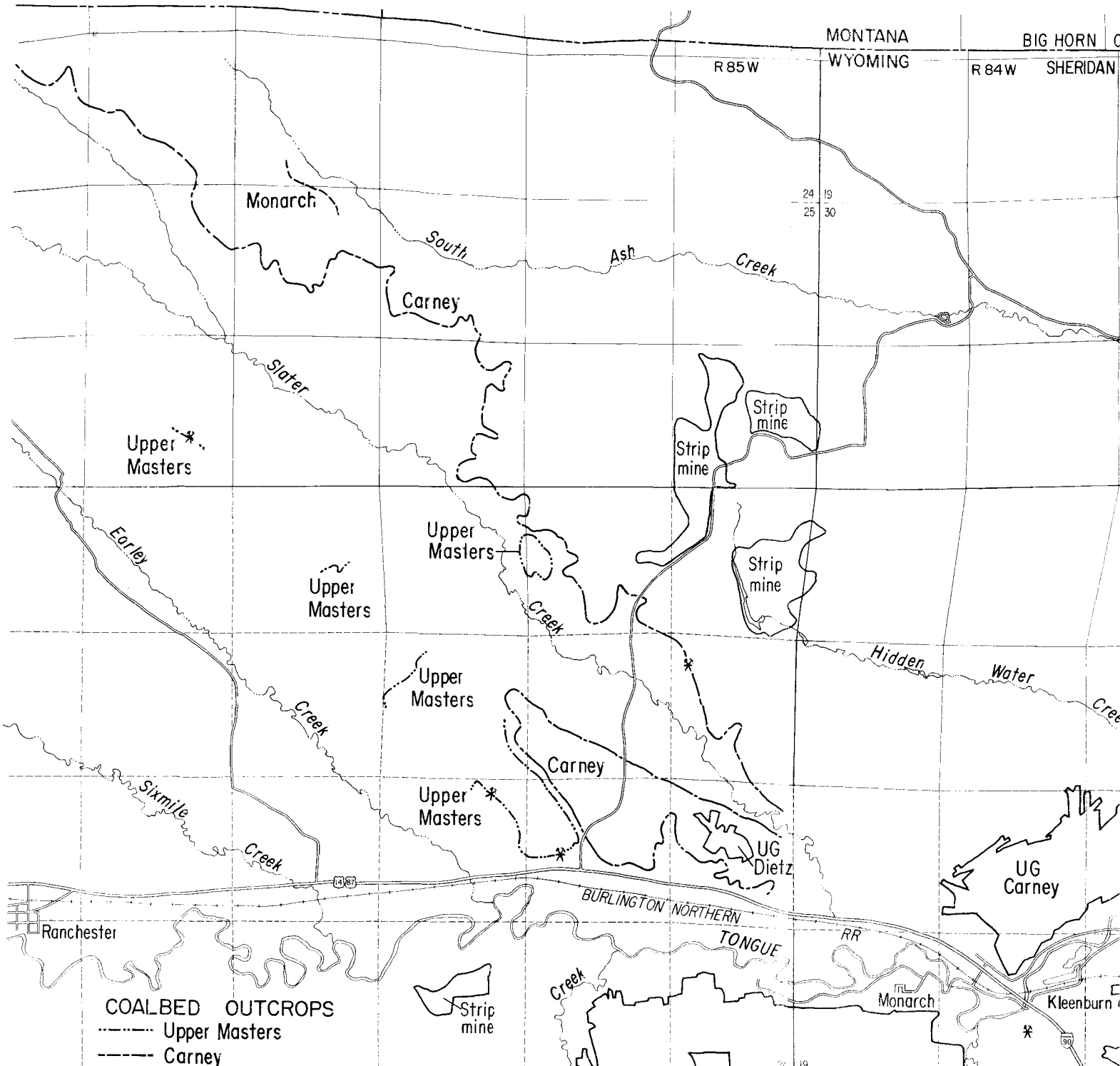
The Ulm group is divided into the Upper and Lower Ulm beds, respectively, about 12 and 16 feet thick. These beds are found in a relatively small part of the south-central part of the district. Burning has been extensive, and the remaining blocks of coal are relatively localized. Partings normally divide the beds into several benches, and there is little or no likelihood that strippable reserves of consequence will be found in this sequence.

Beds within the Intermediate group would underlie a larger portion of the Sheridan area, but they, too, seem to be somewhat local in character. The beds are usually separated into several benches by shale or bony coal partings. Even so, several of the beds are reported to have 5 feet of good coal, and one measured section is indicated to be 33.5 feet thick. It is possible that strippable reserves can be found here, but the Intermediate group is not a prime prospecting sequence for strippable coal.

Nine beds in the Tongue River group have been important in past mining and are likely prospects for development of future open pit mines. These beds, in descending order, have been named Roland, Smith, Dietz 1, 2, and 3, Monarch, Carney, and Masters upper and lower. The beds vary from 5 feet to 32 feet in thickness, consist of clean coal, and are all known to persist over reasonably extensive areas.

Location 8: Kleenburn Deposit

The Tongue River sequence is exposed in Tps 57-58 N, Rs 84-85 W, around the former townsite of Kleenburn, Wyo. Part of this area, particularly T 57 N, Rs 84-85 W, has been mined extensively by underground methods in the past. Figure 10 shows the location of coalbed outcrops and the outlines of strip and underground coal mines. The Kleenburn deposit is not shown because publishable data are too incomplete to permit delineation of possible strip areas. Stripping sites are along the near surface portion of the Dietz and other coalbeds and around the margins of strip mined areas. Artis (oral communication, 1969) states that proven strippable reserves within 2½ miles of Acme are 32 million tons.


MONTANA
WYOMING
BIG HORN
R 85 W
R 84 W
SHERIDAN
24 19
25 30
Monarch
South Ash Creek
Carney
Slater
Upper Masters
Strip mine
Strip mine
Upper Masters
Earley
Upper Masters
Strip mine
Creek
Hidden Water Cree
Upper Masters
Creek
Carney
Sixmile Creek
Upper Masters
UG Dietz
UG Carney
BURLINGTON NORTHERN RR
Ranchester
TONGUE
Creek
Strip mine
Monarch
Kleenburn
COAL BED OUTCROPS
Upper Masters
Carney

Typical analyses for coal being mined from the Dietz coalbeds near Kleenburn follow:

Form of analysis	Number of analyses	Composition, percent[1]					Heating value, Btu per lb
		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
As received.....	23	21.7	-	-	-	-	9,850
Moisture free...	-	-	44.9	49.4	5.7	0.6	12,580
As received.....	11	22.2	-	-	-	-	9,580
Moisture free...	-	-	43.0	51.8	5.2	.5	12,330

[1]Aresco, S. J., and J. B. Janus. Analyses of Tipple and Delivered Samples of Coal Collected During Fiscal Year 1968. BuMines Rept. of Inv. 7219, 1969, p. 25.

Great Divide Basin Area

The Great Divide basin, in south-central Wyoming, is a closed area of interior drainage lying astride the crest of the Continental Divide. East of this basin the land is drained by the North Platte River, a tributary of the Missouri River, and to the west by the Green River, a tributary of the Colorado River.

Coal-bearing rocks of the Wasatch Formation constitute a sequence about 700 feet thick, which was cyclically deposited in swamps and marginal lakes formed in Green River time.

Location 9: Red Desert Deposit

The Red Desert deposit of the Great Divide basin includes about 70 of the 300 square miles in Tps 20-23 N, Rs 92-95 W. Its southern end is crossed by U.S. Interstate 80 (Highway 30) and by the main line of the Union Pacific railroad. The nearest city of any consequence is Rawlins, population 9,000, about 40 miles to the east.

Coal of this region contains uranium, and it was for this reason that geologic work was done in this area (18, 21).

The coalbeds are lenticular and grade into shale to the east and west. Strata are inclined at angles of 1° and 2° so that the outcropping coalbeds, which are as much as 40 feet thick, are potentially strippable over large areas.

In many places the coalbeds have burned, and prominent beds of red clinkers or sintered roof rocks resulted. Auger holes and core holes indicate that the burning rarely extends more than 10 feet laterally into the bed. Apparently the fires were smothered by caving or collapsing roof rocks, which at most places consist of poorly consolidated siltstone and sandstone. The clinker is resistant to weathering and forms small ridges that flank many of the best coal outcrops. In a few places, the upper split of a coalbed above a thick parting has burned and left the lower split relatively unaltered.

Numerous analyses of the coals have been made by the U.S. Bureau of Mines. In summation, Masursky states (18, p. 47) that "the average, 'as received,' heating value is about 7,900 Btu, average ash content is 16 percent, average sulfur content is 2.5 percent, and average moisture content is 21 percent. These values vary widely since some of the samples are from impure coalbeds and others are from weathered beds. Calculations using the Parr formula (American Society for Testing Materials, 1938) show that the coal is subbituminous B in rank." Analyses for several of the strippable coalbeds are given in table 7.

TABLE 7. - Typical analyses for strippable coalbeds in the Red Desert deposit (18)

Form of analysis[1]	Composition, percent[2]					Heating value, Btu per lb
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
BATTLE NO. 3						
A	21.9	29.9	37.0	11.2	1.9	8,650
B	-	38.3	47.3	14.4	2.5	11,080
C	-	44.7	55.3	-	2.9	12,930
MONUMENT NO. 1						
A	18.8	31.6	35.7	13.9	2.0	8,750
B	-	38.9	44.0	27.2	2.4	10,770
C	-	46.9	53.1	-	2.9	12,990
SOURDOUGH NO. 2						
A	23.2	33.6	33.0	10.2	2.9	8,680
B	-	43.7	43.1	13.2	3.8	11,310
C	-	50.4	49.6	-	4.4	13,040
HADSELL NO. 2						
A	23.0	31.0	32.2	13.8	2.7	8,250
B	-	40.2	41.9	17.9	3.5	10,720
C	-	48.9	51.1	-	4.3	13,050
CRESTON NO. 2						
A	20.7	32.2	34.4	12.7	1.8	8,710
B	-	40.6	43.4	16.0	2.3	10,980
C	-	48.4	51.6	-	2.7	13,070
LATHAM NO. 3						
A	22.6	30.9	31.2	15.3	5.4	7,980
B	-	39.9	40.3	19.8	6.9	10,310
C	-	49.8	50.2	-	8.6	12,850

[1]A, as received; B, moisture free; C, moisture and ash free.
[2]Analyses supplied by Central Experiment Station, U.S. Bureau of Mines, Pittsburgh, Pa.

Analyses of coal from cores, made by the U.S. Geological Survey at its Washington laboratory, show that the coal yields from 7.8 to 25.2 gallons of oil per ton by the Fisher assay method.

Coal seams 5 feet or more in thickness seem potentially strippable. Accordingly, for this study, the 5-foot isopach line from the previous isopach maps of Pipiringos (21) and Masursky (18) has been used as a stripping limit.

Where such data were not available from the earlier maps, the limits were estimated by comparing their maps, core log, and measured section data. From such data figure 11 was prepared.

The average stratigraphic interval between coalbeds was used as an approximate gage of stripping limits. An interval of 120 feet was considered to be a maximum, unless two or more beds in the same section, less than 120 feet apart, were more than 5 feet thick. In this case, the depth limit was set at approximately 120 feet to the uppermost bed.

Much difficulty was experienced in trying to resolve data concerning the Sourdough No. 2, Sourdough-Monument, Monument 2, Tierney 5, and Tierney 6 nomenclature. All of these names apply to coalbeds within a limited stratigraphic section. In parts of the area, partings between beds may disappear and thus cause some confusion in nomenclature. In other parts of the area, it would seem that two or more names have been assigned to the same bed. Because the stratigraphic section is limited and all of the named beds seem to exceed the arbitrary 5-foot minimum thickness, at least in limited areas, and because present data do not permit separating these beds into individual units, the problem has been resolved herein by including all data concerning beds of the names cited as one bed only--the Sourdough-Monument-Tierney group. Future investigators should so plan their exploration as to identify properly individual coalbeds before planning a stripping operation. Estimated strippable reserves of 733.1 million tons are listed for the Red Desert deposit by coalbed group in table 8.

TABLE 8. - Indicated strippable coal reserves in the Red Desert deposit[1]

Township	Range	Strippable area, sq mi	Average thickness, feet	Millions of tons in coalbeds				
				Battle 2-3	Sourdough, Monument, Tierney	Hadsell 2	Creston 2-3	Latham 3-4
20 N	92 W	2.62	5.7	-	-	-	-	17.2
		1.40	18.0	-	-	-	29.0	-
20 N	93 W	8.15	5.7	-	-	-	-	53.5
		3.38	18.0	-	-	-	71.1	-
		.48	6.0	-	3.3	-	-	-
20 N	94 W	1.23	18.0	-	-	-	25.5	-
21 N	93 W	4.49	7.7	-	-	39.8	-	-
		5.53	8.5	-	54.1	-	-	-
21 N	94 W	2.51	7.0	-	20.2	-	-	-
22 N	94 W	22.85	9.1	-	239.5	-	-	-
		1.69	8.6	16.7	-	-	-	-
22 N	95 W	5.80	5.0	-	33.4	-	-	-
23 N	94 W	8.83	7.4	-	-	-	-	-
		2.90	6.4	21.4	-	-	-	-
23 N	95 W	5.75	5.0	-	33.1	-	-	-
Total.....				38.1	458.9	39.8	125.6	70.7

[1]Total strippable reserve is 733.1 million tons.

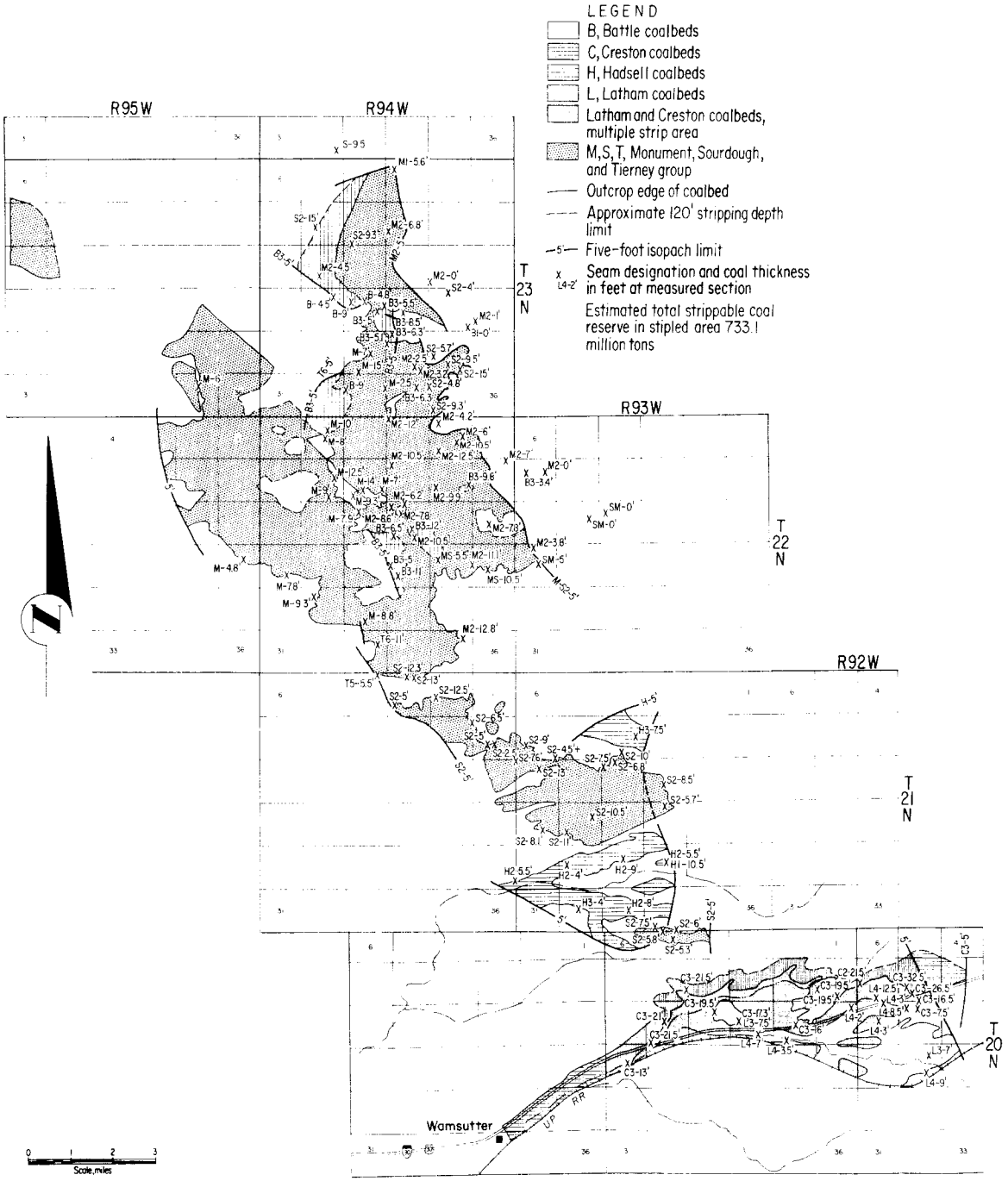


FIGURE 11. – Red Desert deposit, Great Divide basin area. (Based on plate 1, U.S. Geol. Survey Bull. 1099A and plate 1, U.S. Geol. Survey Bull. 1099B)

Location 10: Cherokee Deposit

The Cherokee deposit (fig. 12) lies in the eastern part of the Great Divide basin in Tps 19-20 N, Rs 91-92 W. It is in Sweetwater and Carbon Counties, south-central Wyoming, just south of the main line of the Union Pacific railroad and Interstate Highway 80.

The topography is relatively flat, being characterized by low flat-topped hills, abrupt escarpments at the edges of the flat-topped hills, and low ridges. Elevations range from about 6,800 feet to 7,200 feet.

The climate is essentially semiarid, rainfall for the area averaging about 7.5 inches per year. The average temperature is 68° F in July and 15° F in January. The maximum low temperature recorded is -20° F. Appreciable snow and high winds are received in the area at times.

Coalbeds of this deposit are in the Wasatch Formation of Tertiary age, and they contain high-volatile subbituminous A coals. Overburden consists of loosely consolidated shales and sandstones interspersed with occasional, but minor, layers of harder sandstone. Overlying strata appear to be generally uniform and free from faults but exhibit modest local undulations. Both rocks and coal dip to the west and northwest about 2 to 10 percent, and the coalbeds crop out at places.

The A, or top, seam is disregarded in this report. It is quite erratic but may have local value while stripping the lower seams. The B seam crops out along the center of the deposit, ranges from 10 to 18 feet in thickness, and usually has a 1- to 2-foot parting that must be removed selectively. The C seam, 0 to 70 feet below the B seam, crops out along the eastern edge of the deposit and ranges from 20 to 32 feet in thickness. It, too, has a 1- to 1½-foot band within the seam that must be removed and wasted.

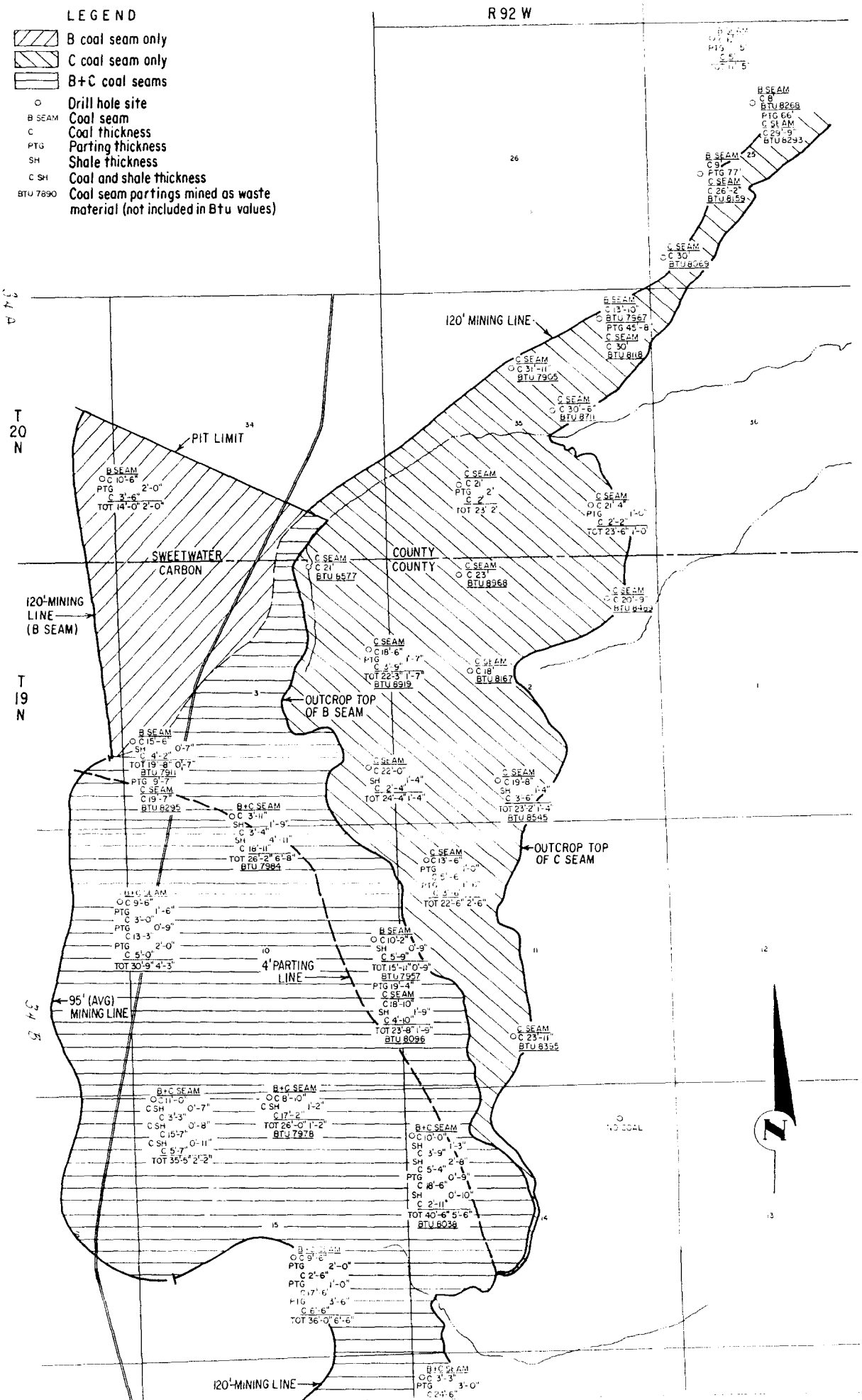
In certain well-defined areas, however, the B and C seams come together and even crop out jointly. In these locations the coal seam is 30 to 40 feet thick and contains a 0- to 4-foot band to be removed and wasted.

These coal seams, including thin splits, have analyses that range about as follows: moisture, 15 to 25 percent; volatile matter, 28 to 36 percent; fixed carbon, 27 to 40 percent; ash, 10 to 25 percent; sulfur, 0.5 to 5.0 percent; Btu per pound, 5,009 to 9,000.

Measured strippable reserves in the deposit are 200.9 million tons, having a stripping ratio of about 2.65 yards of overburden per ton of coal.

Location 11: Jim Bridger Deposit (9)

On the western edge of the Great Divide basin, in the southwestern portion of T 21 N, R 100 W, and north-central portion of T 20 N, R 100 W, two coalbeds crop out for 15 miles at the base of the Fort Union Formation. Averaging 15 feet in thickness, these two beds at some places coalesce into a single bed 30 feet thick.


LEGEND
B coal seam only
C coal seam only
B+C coal seams
Drill hole site
B SEAM Coal seam
C Coal thickness
PTG Parting thickness
SH Shale thickness
C SH Coal and shale thickness
BTU 7890 Coal seam partings mined as waste material (not included in Btu values)
R 92 W
T 20 N
T 19 N
PIT LIMIT
SWEETWATER COUNTY
CARBON COUNTY
120' MINING LINE
120'-MINING LINE (B SEAM)
OUTCROP TOP OF B SEAM
OUTCROP TOP OF C SEAM
4' PARTING LINE
95' (AVG) MINING LINE
NO COAL
N

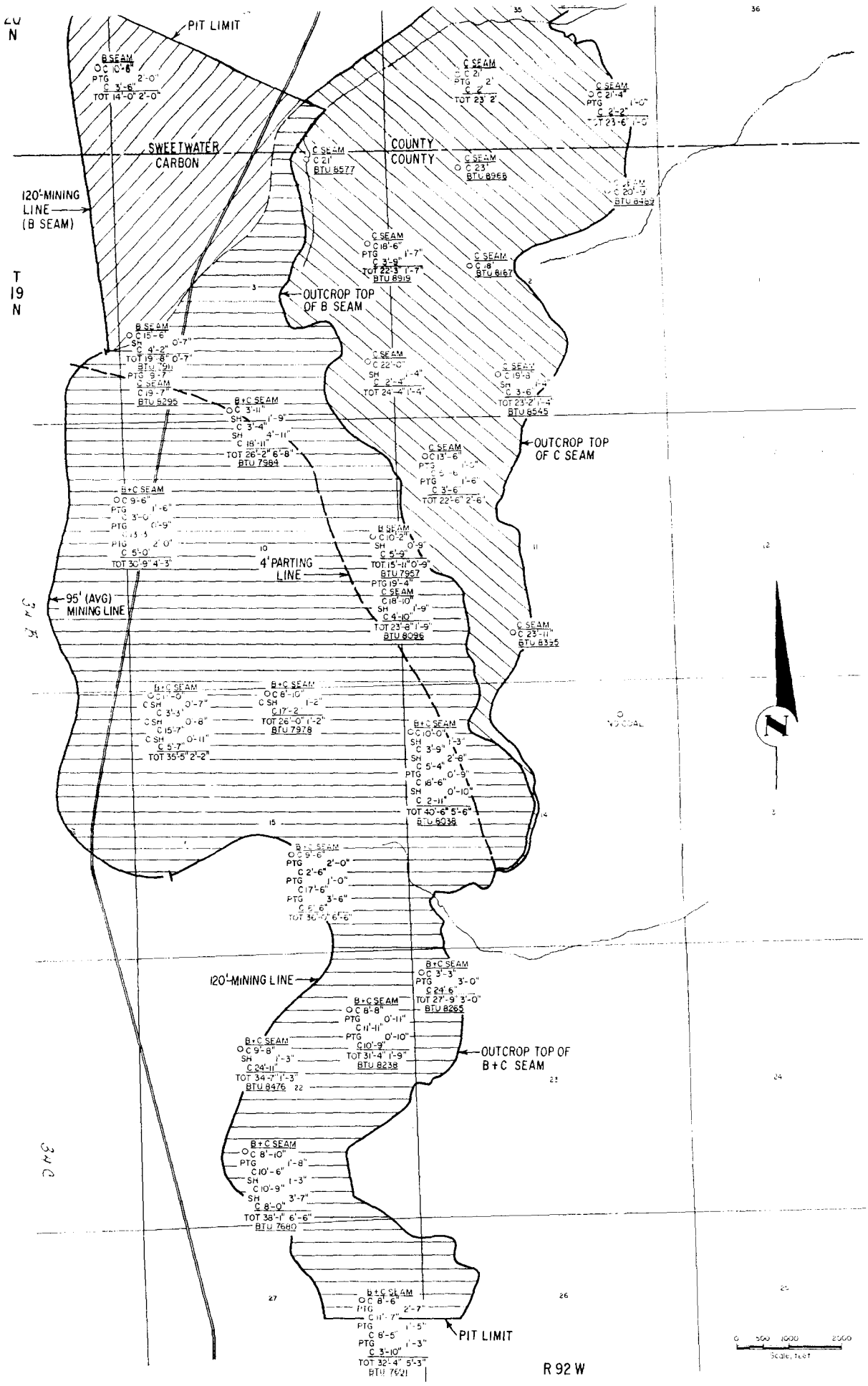


FIGURE 12. -- Cherokee deposit, Great Divide basin area. (Based on company data)

Not enough data are available to include a detailed map of the deposit, but known strippable reserves are 137 million tons under less than 120 feet of overburden. Total reserves under less than 200 feet of overburden are 250 million tons. The site is 25 miles northeast of Rock Springs, Sweetwater County.

Kemmerer-Hamms Fork Area (24)

The Kemmerer coalfield of the Hamms Fork region extends for many miles north and south of Kemmerer, Wyo. Kemmerer, the county seat of Lincoln County, has a population of about 2,000. It is in the southwestern part of the county, on U.S. Highways 30N and 189 and on the Union Pacific railroad.

The topography is characterized by a series of north-south trending hogbacks at elevations that range from about 7,000 to 8,000 feet.

Climatic conditions are essentially semiarid, and the common vegetation is sagebrush. Grass is sparse, but a few aspen are found where there is a little water. The land is agriculturally useful only for grazing.

The coalbeds lie in the prominent Lazeart syncline, and the axis of this syncline runs generally north and south. Sedimentary rocks of Upper Cretaceous age have been downfolded into the trough. The east limb of the syncline rises above the surrounding country and forms prominent parallel hogback ridges. Strata of the east limb dip 16° to 23° to the west, and the west limb of this syncline dips steeply to the east, wherever exposed (fig. 13).

Coal is found in both the Frontier and Adaville Formations. The Hilliard Shale lies between the two coal-bearing formations.

The Frontier Formation, the lowest of the coal-bearing formations, is about 2,900 feet thick and contains sandstone beds and coalbeds alternating with shales. The coalbeds, together with sandstone beds, are present in the upper 1,400 feet of the formation. Shales, largely barren of commercial coal, together with minor amounts of sandstone, make up the lower 1,500 feet. Some coal can be mined by underground methods from both the Willow Creek and Kemmerer coal zones. Tests made in 1942 by the Bureau of Mines showed that coal of the Willow Creek beds, from the Gomer mine of Kemmerer Coal Co., has coking qualities (27). The upper Kemmerer coal group represents the upper limit of the Frontier Formation. This group contains one major seam, locally called the Frontier No. 1, and three less persistent beds called the A, B, and Radio. The Frontier No. 1, which is about 50 feet below the Radio bed and above the A and B beds, contains two definite benches of coal, separated at times by a clay parting that is usually less than 6 inches thick. The top bench may be 10 to 16 feet high, whereas the bottom bench reaches a maximum thickness of 4 to 5 feet. The coal is relatively free from ash and low in moisture and has a heating value of about 12,420 Btu per pound. Strippable reserves of the area are contained in the Adaville Formation.

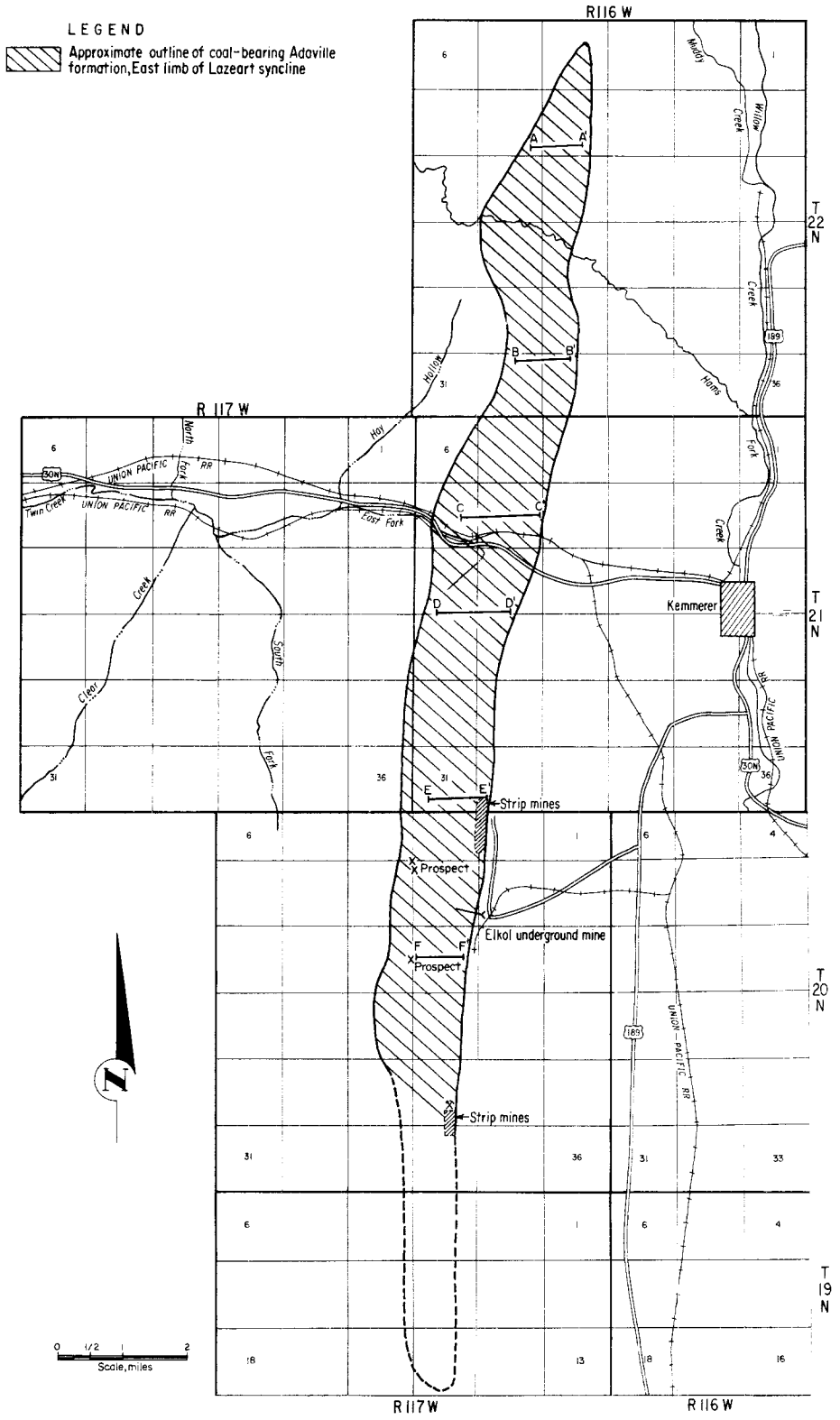


FIGURE 13. – Adaville deposit, Kemmerer-Hamms Fork area. (Based on company data)

Location 12: Adaville Deposit (11, 28)

The Adaville Formation (fig. 13), overlying the Hilliard Shale, is the most important coal-bearing formation in the Kemmerer-Hamms Fork area. It rises sharply above the valley floor and exposes many seams of coal of varying thickness.

The lower limit of the Adaville Formation is the Lazeart Sandstone, and the upper limit is the relatively flat-lying Evanston Formation of Wasatch age.

Major seams vary in thickness along their outcrops, but at least eight exposed seams have thicknesses of 8 feet or more (fig. 14). The maximum thickness for a single bed is 100 feet for the No. 1 Adaville 2 miles north of the Elkol mine. North of the mine 3 to 4 miles, this seam is split by several partings. In all seams splits are encountered that may range from 1 inch of clay to 15 feet of shale.

At least 150 million tons of coal is available along the length of the deposit and from eight seams mined individually by contour stripping at a 4-to-1 stripping ratio. By multiple-bed strip mining of all major seams, 200 feet of coal can be recovered under less than 1,400 feet of overburden (4). These reserves offering favorable stripping ratios are estimated to total more than 1 billion tons of coal.

An analysis of the No. 1 Adaville coalbed at the Elkol mine, made by the Bureau of Mines, follows:

Form of analysis	Number of analyses	Composition, percent[1]					Heating value, Btu per lb
		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
As received.....	12	20.00	-	-	-	-	10,250
Moisture free...	-	-	43.0	53.8	3.2	0.7	12,810

[1]Aresco, S. J., and J. B. Janus. Analyses of Tipple and Delivered Samples of Coal Collected During Fiscal Year 1968. BuMines Rept. of Inv. 7219, 1969, p. 25.

A typical analysis of coal from the Adaville Formation would be high in moisture, low in ash, have a Btu content of about 10,400, and contain about 0.6 percent sulfur.

POTENTIAL OF OTHER COALFIELDS

Data are too sparse and incomplete to permit reasonable estimates of strippable reserves within other coal-bearing regions of Wyoming. Because extensive, easily recoverable reserves undoubtedly exist within some of the areas; however, they should not be ignored here. It seems reasonable then to identify each coal-bearing area, briefly describe each one, and then indicate whether or not strippable coal reserves should be expected. It is hoped that this approach will assist in guiding future prospectors. Coalfield sites are listed in table 1 and shown on figure 1.

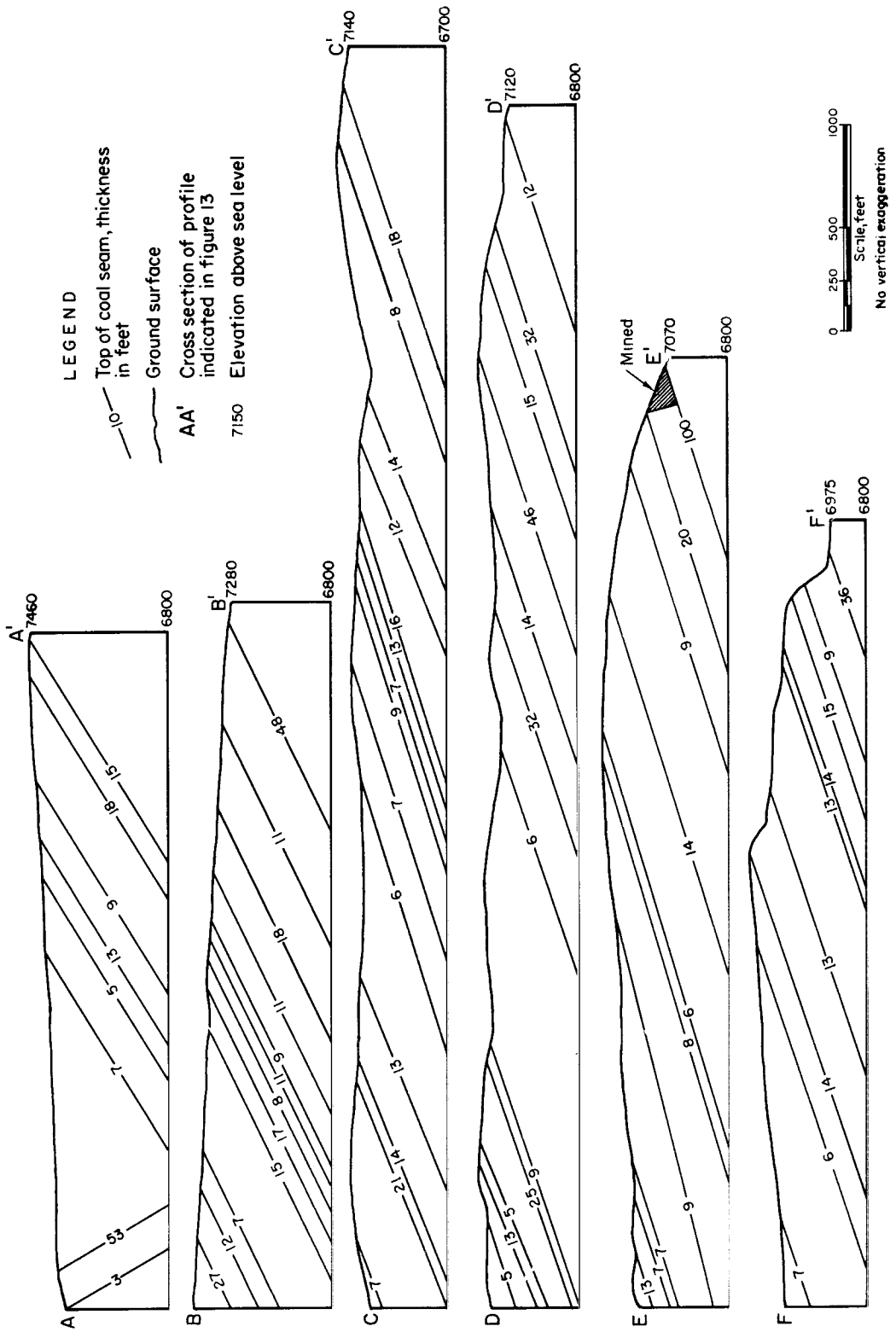


FIGURE 14. — Cross sections, Adaville deposit. (Based on company data)

Location 13: Powder River Coalfield (25)

The Powder River coalfield embraces Tps 48-52 N, Rs 70-75 W, and Tps 52-55 N, Rs 76-78 W. Resource potential of the Roland bed, as defined by Stone and Lupton (25), along the eastern side of the Powder River field has been included elsewhere in this report as strip reserve in the Wyodak deposit. West of the Wyodak outcrop are at least three other beds, Arvada, Felix, and Lower Ulm, that will be found in locations favorable to strip mining. Each bed is known to extend over a considerable area. Bed thicknesses of 10 feet or more of clean coal are common. In all cases, the coal is classed as subbituminous. Because the beds are essentially flat lying, stripping should be easily accomplished wherever bed thickness and depth of cover are favorable.

Location 14: Buffalo Coalfield (15)

As described in the literature, the Buffalo coalfield includes the area within Tps 47-53 N, Rs 79-83 W (fig. 9). The Healy deposit near Lake De Smet, reviewed elsewhere herein, is within this area (fig. 9). Exposures of good quality coal in other areas of the field suggest that additional strip areas ultimately may be defined.

The Walters bed is the highest thick seam exposed. In places it is as much as 35 feet thick, but almost everywhere it is split by multiple partings. It also is extensively burned. Such constraints suggest that this bed is not worthy of consideration.

The Healy bed, approximately 150 to 170 feet below the Walters, is represented by two members, sometimes as much as 60 feet apart. Usually both beds are of good quality, and often one or both is more than 10 feet thick. It seems likely that the beds should lie within stripping depths over reasonably extensive areas within the Buffalo coalfield.

The lowest coalbed of possible interest is the Dry Creek bed, which is about 150 feet stratigraphically below the lower Healy bed. Although this bed apparently has merit, particularly in the southeastern part of the coalfield, the Dry Creek does not seem to be as consistent as the overlying Healy beds. It does appear to merit prospecting, however, and may well provide one or more potential strip deposits.

Mapel (16, pp. 93-94) divided the coalfield into two principal parts, one embracing coal lands near the northern end of Lake De Smet and another comprising the southeastern segment of the Buffalo-Lake De Smet area. Mapel's discussion of the potential strip deposits in the southeastern part is as follows (also see fig. 9):

> "Two areas in the southeastern part of the Buffalo-Lake De Smet area offer possibilities for strip mining:
>
> (1) The Healy bed underlies part of a broad flat in secs 5, 6, 7, and 8, T 50 N, R 81 W. Gale and Wegemann (1910, p. 163) report that an inclined adit (now abandoned) in the W½ sec 5

encountered 10 feet of coal 25 feet below the surface at an elevation of about 4,620 feet. Inasmuch as the strata are nearly flat lying, the coal probably occurs beneath less than 80 feet of overburden in an area of about 1 square mile between the outcrop of the bed and the 4,700-foot contour. No detailed information other than the reported thickness of coal in the mine and in incomplete exposure of the bed in the SW¼ sec 6 (loc. 2) is available.

(2) The Ucross bed underlies much of sec 25, T 50 N, R 80 W, at an estimated depth of less than 40 feet. The land surface is a broad flat that slopes gently eastward toward Crazy Woman Creek. The coal is 10 to 12 feet thick where exposed in the stream bank of Crazy Woman Creek to the south. Locally, however, the bed is split by lenticular shale partings, and the area should be prospected by drilling to determine the amount and quality of coal.

Other areas of low relief which appear favorable for strip mining are: the valley of Clear Creek in the south-central part of T 52 N, R 81 W, underlain by the Murray bed; the valley of Dry Creek in the southwestern corner of T 50 N, R 81 W, underlain by the Dry Creek bed; and the valley of Dry Creek near the east edge of T 50 N, R 81 W, underlain by the Healy bed.

Thick coalbeds which crop out on the ridgès between tributaries to the larger streams pass under thick cover a short distance back from their outcrops at most places and these beds can probably best be mined underground from entries along the outcrops."

Location 15: Barber Coalfield (32)

The Barber coalfield is described arbitrarily as the area east of the Buffalo coalfield and west of the Powder River coalfield. It includes Tps 50 and 51 N, Rs 77-79 W, and T 49 N, R 79 W. Because this area is near the axis of the Powder River basin, only the upper Fort Union rocks are exposed; the youngest part of the section has been removed by erosion.

The highest coals in the area correspond to the lower two beds in the Ulm section of the Sheridan field. These beds, found on the highest part of the divide between Crazy Woman Creek and the Powder River, are some of the thickest exposed coals in this field, reaching as much as 12 feet. Although these coals probably could be mined as strip pits, the coal area left by erosion is so limited that economic recovery is doubtful.

Coals in the remainder of the district lie within what is described in Taff (26) as the Intermediate section. As in the Sheridan area, the beds are relatively thin, although 6- and 7-foot-thick exposures are noted. These thicker coals may be relatively local; thinner beds with frequent shale splits are more common.

Thicker coals of the Tongue River Member should underlie this area, but all would be too deep to permit strip mining. Thus, the deep coals must be considered a subsurface resource available for development at some time in the future.

It is possible that economically strippable coal reserves may be found within the Barber coalfield, but no deposits of adequate size are presently known. Other parts of the northern Powder River basin would seem to warrant exploration and evaluation before such work is attempted in the Barber coalfield.

Location 16: Pumpkin Buttes Coalfield (33)

Pumpkin Buttes coalfield has been divided into four parts, referred to as the Divide, Pumpkin Creek, Belle Fourche, and Dry Cheyenne fields. The Belle Fourche field is along the Belle Fourche River in Tps 43-46 N, Rs 72-74 W; the Pumpkin Creek field is along Pumpkin Creek in T 46 N, Rs 75-76 W; and the Divide field is in Tps 46-47 N, R 74 W, along the divide between the Powder and Belle Fourche River drainages. Strippable reserves in the Dry Cheyenne field are described separately.

Data on the Divide, Pumpkin Creek, and Belle Fourche fields are too limited to evaluate the potentially strippable coal reserves. Several measured sections in the Belle Fourche field indicate thicknesses up to 18 feet for the E bed and 7.8 feet for the D bed. Partings are apparent in both beds.

Measured sections in the Pumpkin Creek field indicate many splits in thin coalbeds. The available sections may represent only the top of bed E; if so, drilling could show this to be an interesting reserve.

Coals exposed in the Divide field are remnants left by erosion. As such, they underlie only the higher hills that have rather limited areal extent. Measured sections of as much as 8 feet indicate bed B may provide the best reserve, but this resource is quite likely to be limited in available tonnage.

Location 17: Sussex Coalfield (31)

The Sussex coalfield includes all outcrops along the western limb of the Powder River basin from T 37 N to T 47 N, R 75 W to R 82 W. Throughout much of this area, the only outcrops are along the western edge where formations are tipped up against the eastern flank of the Bighorn Mountains. The thin, spotty, and multiple-parting characteristics of many of the outcrops suggest that these outcrops represent the far western edge of the original deposition. If so, considerably thicker deposits may exist within 1 or 2 miles to the east, at least east of the presently known outcrops. If further geological mapping shows some areas where structural dip flattens rapidly to the east or where erosion has cut fairly deeply just east of the outcrop edges, it may be possible to prospect by drilling and find currently unknown strippable reserves.

Wegemann (31) divided the outcrop edge into six "coal basins" to simplify discussion. The areas between coal outcrops were arbitrarily left out of the "basin" areas. "Basin No. 1" is in the extreme southwestern part of the area and is somewhat separated from the rest. "Basin No. 2" lies at the northern end of the Sussex field as described, and "basin No. 6" at the southeastern end. The remainder of the "basins" lie in order between these limits. As the "basins" are presently known, there is a reasonable possibility of strippable reserves in "basin No. 4" and "basin No. 6."

"Basin No. 4" lies along the east flank of Pine Ridge, a structural ridge lying east of and roughly parallel to the east flank of the Bighorn Mountains. The formations dip 12° to 16° northeasterly across secs 26, 36, T 43 N, R 79 W; secs 31-33, T 43 N, R 78 W; secs 1-4, 11, and 12, T 42 N, R 78 W; and sec 7, T 42 N, R 77 W. The "lower coal" zone crops out across these sections along the side of Pine Ridge. Because the structural dip is northeasterly at about 1,500 feet per mile and because the slope off Pine Ridge is also northeasterly, but at about 400 feet per mile, it is possible that a strip zone one-tenth mile wide may exist parallel to the Ridge front. Such a zone should establish a maximum stripping depth of about 120 feet. In areas where topography is more favorable, or where formations tend to flatten, a greater strip width may be possible. Throughout the length of the zone the lower coalbed averages about 11.8 feet in thickness. The maximum thickness is in the SW¼ sec 7, T 42 N, R 77 W, where the coal, exclusive of several thin splits, is 50 feet thick. It may be possible to recover 13.6 million tons by strip mining; favorable structural dip or topography could substantially increase that figure.

Two coalbeds, designated the upper and lower, are thick enough in "basin No. 6" to provide a potentially strippable coal reserve. When the upper bed of Sussex "basin No. 6" is plotted on appropriate topographic maps, it is apparent that the bed is a westward continuation of the F bed of the Dry Cheyenne portion of the Pumpkin Buttes field. The outcrop of the upper coal, as plotted on plate XLII of Wegemann's Bulletin 471 (31), follows the topographic contour fairly well so that an estimate can be made as to which section may be strippable.

A trace of the lower coalbed on the same map does not fit the topographic contour, and this suggests either a radical change in dip between the two coalbeds, which is unlikely, or something erroneous in the plot of the outcrop.

Because it is not possible to field check this problem, it is sufficient to note that two coalbeds, known as the upper and lower, are present in this area and are thick enough that strip mining may be warranted. The area of primary interest for exploration drilling would include secs 1-15, 22-26, 35, and 36, T 37 N, R 75 W, and it is likely that a strippable reserve would be outlined within those sections. Analyses for the coalbeds are given in table 9.

TABLE 9. - Analyses of coal samples from the Sussex coalfield[1]

Form[2] of analysis	Composition, percent									Heating value, Btu per lb
	Proximate				Ultimate					
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	
UPPER BED, BASIN NO. 4										
A	18.8	35.7	37.9	7.6	-	-	-	-	0.57	9,160
B	-	44.0	46.7	9.3	-	-	-	-	.70	11,280
C	-	48.5	51.5	-	-	-	-	-	.77	12,430
LOWER BED, BASIN NO. 4										
A	23.5	35.6	35.7	5.17	6.50	51.24	0.80	35.90	0.49	9,050
B	-	46.6	46.7	6.75	5.08	66.95	.91	19.67	.64	11,820
C	-	49.9	50.1	-	5.45	71.79	.98	21.09	.69	12,680
UPPER BED, BASIN NO. 6										
A	28.1	31.6	35.7	4.62	6.55	48.32	0.69	39.37	0.45	8,350
B	-	44.0	49.6	6.42	4.77	67.18	.96	20.04	.63	11,610
C	-	47.0	53.0	-	5.10	71.79	1.03	21.41	.67	12,410

[1]Data from Pittsburgh Coal Research Laboratory, Bureau of Mines.
[2]A, as received; B, moisture free; C, moisture and ash free.

Location 18: Lost Spring Coalfield (34)

The Lost Spring coalfield is in Tps 32-38 N, Rs 67-71 W, Converse County, Wyo., an area that embraces the southeastern side of the Powder River basin. Near the outcrop edge, coalbeds dip 4° to 25° northwesterly into the basin. Within one mile or so, the dip usually flattens to 2° or less. The lower beds that crop out nearest the edge of the basin offer a relatively narrow zone where stripping might be possible. Beds farther west would be higher in the section, would not be dipping as strongly, and consequently would have a wider potential stripping zone. All exposed coal in the Lost Spring field is in the Fort Union Formation, but the beds are divisible into upper and lower groups.

The lower group occurs as somewhat lenticular masses that crop out along the southern and eastern margins of the field. The coal is inferior to the upper coal; an analysis of the best coal of the lower group, from the Rosin mine in sec 35, T 34 N, R 68 W, follows:

Form of analysis	Composition, percent[1]					Heating value, Btu per lb
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
As received.....	27.6	26.7	35.7	9.99	1.03	7,810
Moisture free.....	-	36.9	49.3	13.81	1.42	10,790
Moisture and ash free.	-	42.8	57.2	-	1.65	12,520

[1]Analyzed by Pittsburgh Coal Research Laboratory, Bureau of Mines.

Despite the lenticular character and the lower quality of the beds compared with the upper coalbeds, essentially all of the coal mining in this field has been done in the lower group, probably because of its geographic position relative to transportation and markets. There would seem to be little chance of developing an open pit mine in this coal group.

The upper coal group is composed of thicker and more persistent beds of better quality. An analysis for coal of this group, from a strip wagon mine in sec 8, T 37 N, R 68 W, follows:

Form of analysis	Composition, percent[1]					Heating value, Btu per lb
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
As received.....	27.8	29.4	38.5	4.3	0.27	8,410
Moisture free.....	-	40.7	53.4	5.2	.37	11,650
Moisture and ash free.	-	43.2	56.8	5.9	.39	12,380

[1]Analyzed by Pittsburgh Coal Research Laboratory, Bureau of Mines.

Three beds of the upper group crop out in and west of the Cow Creek Buttes in the northern part of the field. Bed E, the uppermost, ranges from 5.8 to 9.8 feet in thickness with a shale parting 2 to 8½ feet in thickness as observed on the outcrop. In the northeast sections of T 38 N, R 68 W, the bed has burned, the overlying shales have been baked, and the rocks lie essentially horizontal. Exploration westerly from the outcrop toward the more central portion of the coal basin may disclose a strippable reserve at this horizon.

Bed D, 95 feet stratigraphically below bed E, at most is 4 feet thick at the outcrop. It is of good quality in T 38 N, R 68 W, but is known to thin north and east of that area. Considering the near horizontal position of the beds, it may be possible to find thicker strippable reserves farther west.

Bed B is the lowest coalbed in T 38 N, R 68 W, and it varies in thickness from 5 to 7.6 feet. At all outcrops it is divided into two roughly equal benches by a sandy shale band about 1 inch thick. Again, prospecting to the west may prove the presence of a strippable reserve.

Beds E and B of the Lost Spring coalfield seem to correlate with beds J and K, respectively, of the Gillette coalfield (6) to the north. Outcrop thicknesses and nearly flat-lying beds suggest that exploration in the western parts of Tps 38-39 N, R 68 W, may lead to discovery of a strippable coal reserve. It would seem, however, that the Lost Spring coalfield is one of the least favorable parts of the Powder River basin as a coal prospecting area.

Location 19: Hanna Basin Coalfields (3, 7)

The Hanna basin in southeastern Wyoming is about 35 miles east of Rawlins, the county seat of Carbon County. Hanna, population about 25, lies in the approximate center of the coalfield. Tracks of the Union Pacific railroad pass through the town, and U.S. Highway 30 is about 1 mile south.

The topography is similar to that of the Great Plains, but low ridges of sandstones of the Mesaverde Formation surround the Hanna basin. Elevations range from about 6,400 to 7,900 feet.

About 6 miles north of Hanna the Medicine Bow River forms the northern boundary of the coalfield. The North Platte River is the approximate western boundary some 15 miles west of Hanna.

The Hanna basin actually is the northwestern edge of the much larger Laramie basin. The depth of the Hanna basin is such that it contains at least 35,000 feet of sediments ranging in age from Carboniferous to late Tertiary. Complex folding and faulting relationships within the basin attest to multiple periods of deformation.

Four formations within the basin are coal bearing. The oldest, the Mesaverde of Cretaceous age, is divisible into three members. The lowest, ranging from 630 to 700 feet in thickness, consists of indurated, white to gray, massive to thin-bedded and cross-bedded sandstone alternating with thinner beds of shale, all of marine origin. The middle member consists of about 760 feet of gray to brown sandstones alternating with beds of gray carbonaceous shale and thin irregular beds of coal which, in many places, contain a high percentage of earthy matter. The upper member, about 890 feet thick, is lithologically similar to the lower member, although in places it contains thin beds of carbonaceous shale and coal.

The overlying Lewis Shale separates the Mesaverde from the Medicine Bow Formation, the next oldest coal-bearing sequence. The Medicine Bow formation is considered to be of late Upper Cretaceous age. The formation, ranging from 4,000 to 6,200 feet in thickness, consists of yellow, gray, and carbonaceous beds of coal and gray and brown sandstone. The brown sandstone is in the lower 1,500 feet of the formation and is reported to contain 15 coalbeds that range from 3 to 15 feet in thickness.

The Ferris Formation, of Eocene or Paleocene age, conformably overlies the Medicine Bow Formation. The lower unit, about 300 feet thick, consists of dark shale and coarse, friable, massive, buff to yellow sandstone, containing small, scattered pebbles, and irregular thin beds of conglomerate. This is overlain by about 800 feet of conglomerate, occurring as pockets, lenses, and thin beds irregularly distributed throughout. The sandstone that constitutes the main part of this, the upper unit, about 5,400 feet thick, consists of gray, brown, and yellow sandstones interstratified with numerous beds of coal. It is reported that there is a minimum of 20 beds of coal ranging in thickness from 3 to 23 feet. The thickest bed has a minable thickness for about 7 miles along the outcrop.

The overlying Hanna Formation, of Eocene age, is separated from the Ferris Formation by an unconformity in the northern part of the basin, although the contact is apparently conformable through most of the basin. The Hanna Formation consists of approximately 7,000 feet of alternating conglomerate, sandstone, shale, and coalbeds. Its base is marked by a thick conglomeratic sandstone and locally by massive conglomerate.

Berryhill (3) reports:

"At least 30 coalbeds reach thicknesses greater than 3 feet, and the maximum thickness of clean coal is more than 30 feet. The thickest bed in the field is the Hanna No. 2, which crops out in the western part of T 22 N, R 81 W. At one exposure north of the town of Hanna, this bed contains more than 30 feet of coal without partings but north of the town its outcrop is generally burned. Southwest of the town of Hanna the No. 2 bed is about 35 feet thick, including several shale partings each about 1 foot thick; but 2 miles to the south the coal reportedly thins to 12 feet. It dips about 12° to 20° eastward. The coal is of subbituminous A-rank; an analysis, on the as-received basis, of coal from the Hanna No. 2 bed in the Hanna No. 4 mine shows 5.5 percent ash, 0.5 percent sulfur, and 11,200 Btu."

Recent structural folding has affected all formations of the Hanna basin. Dips range from a few degrees to overturned. This, combined with differential resistance to weathering and erosion of the various beds, has produced a topography characterized by multiple strike ridges and frequent dip slopes. Coal seams often are made apparent in the outcrop by the presence of thick and thin exposures of coal bloom. Frequently the burned outcrop is marked by a band of red clinker.

Because of the thick stratigraphic section containing coal, the local nature of some individual seams, and the incomplete drilling data, various authorities recognize from 89 to 130 different coalbeds. Further exploration may indicate this number should be increased, or perhaps multiple numbers have been assigned to the same bed. Possibly further exploration will prove more beds to be of minable thickness and quality than those presently known. Many of the coal seams are too thin or erratic to be of interest; others are of good quality coal as much as 30 feet thick.

Coal reserves have been calculated by the U.S. Geological Survey to total about 3,900 million short tons (measured, indicated, and inferred) beneath 3,000 feet or less cover. At best, only a very small part of the total reserve ever could be produced by surface methods; eventual use of underground methods should be anticipated.

It is not known how many of the seams have been mined in the Hanna district. In general, those of the Hanna Formation are most favorably located with regard to transportation facilities and general accessibility, and, therefore, have been most extensively mined. Comparative averages of analyses of mined coal seams in the various formations are given in table 10.

Location 20: Bighorn Basin Coalfields (29, 35)

Coal deposits crop out along much of the southwestern side of the Bighorn basin in Tps 45-56 N, Rs 94-103 W. In general the coals are less than 5 feet thick and often are split by shale or bony coal partings, a situation that does not encourage prospecting for strip mine sites.

TABLE 10. - Averages of analyses for mined coalbeds in the Hanna basin[1]

Formation	Number samples averaged	Air-drying loss, percent	Form[2] of analysis	Analyses, percent									Heating value, Btu per lb
				Proximate				Ultimate					
				Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	
Mesaverde	1	5.5	A	14.1	36.5	41.6	7.8	1.1	-	-	-	-	10,290
	1		B	9.2	38.7	43.9	8.2	1.2	-	-	-	-	10,890
	1		C	-	42.5	48.4	9.1	1.3	-	-	-	-	11,980
	1		D	-	46.8	53.2	-	1.5	-	-	-	-	13,180
Medicine Bow	2	4.8	A	12.7	33.3	50.1	3.8	.81	-	-	-	-	11,050
	2		B	8.3	35.0	52.7	3.9	.90	-	-	-	-	11,605
	2		C	-	38.1	57.5	4.4	.95	-	-	-	-	12,665
	2		D	-	39.9	60.1	-	.10	-	-	-	-	13,230
Hanna	6	3.1	A	11.1	39.4	43.2	6.3	.53	5.9	62.6	1.1	23.2	11,118
	6		B	8.2	42.2	44.7	6.5	.56	5.8	64.5	1.1	21.5	11,450
	6		C	-	43.8	48.7	7.1	.62	5.3	70.0	1.2	15.7	12,490
	6		D	-	47.7	52.3	-	.64	5.8	75.9	1.2	17.0	13,453

[1] (7).
[2] A, sample is as received; B, sample after normal air drying; C, sample after complete drying; and D, sample after moisture and ash theoretically have been removed.

In T 46 N, R 99 W, the Grass Creek area, a favorable coal sequence has been noted. The following quotation is from U.S. Geological Survey Bulletin 341 (35):

> "In the Mayfield syncline erosion has cut away the coalbeds from the shallow trough until only remnants are left. Where the beds are uneroded, however, there seems to be sufficient capping to have prevented the alteration of the coals by atmospheric agencies. The syncline is cut transversely by Grass Creek, leaving a coal-bearing portion on either side. The coal occurs in three beds near the base of the Fort Union Formation. One of the beds has a maximum thickness of 32 feet, the second of 15 feet, and the third of 6 feet. ... The coal is moderately hard, burns well, seems to stand exposure to the air, and as a domestic coal is highly satisfactory. To the unaided eye the coal is free from pyrite, but under a lens small irregular particles are visible. The area of the field is not great, but owing to the thickness of the beds it contains a large tonnage."

An analysis of coal from this site follows:

Form of analysis	Composition, percent[1]					Heating value, Btu per lb
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur[2]	
As received.....	14.8	33.2	42.4	9.6	0.5	10,330

[1] (13).
[2] Moisture and ash free basis.

It is possible that exploration, starting in the south half of T 46 N, R 99 W, could outline a reserve that would warrant strip mining.

Exploration in the north half of T 44 N, R 95 W, also may disclose a possible strippable reserve. Beds there attain thicknesses of at least 11 feet, although there are no available data to indicate how extensive beds of such thickness may be.

Formational dips seem to range from 2° to 20°; this, in itself, may be a limiting factor. When topography also is considered, it seems unlikely that accessible reserves large enough to warrant strip mining will be found.

Location 21: Wind River Basin Coalfields (36)

Coal of the Mesaverde and Fort Union Formations is found in five fields in the Wind River basin. These coalfields are as follows:

Muddy Creek field, Tps 5-6 N, R 3 E to R 3 W.

Pilot Butte field, T 3 N, R 1 W.

Hudson field, Tps 1-2 S, R 2 E.

Alkali Butte field, T 2 S, R 6 E, and T 34 N, Rs 94-95 W.

Powder River field, T 31-33 N, R 85-87 W.

All have coalbeds 6 feet or more in thickness, although only the Alkali Butte field seems to have continuity in the thicker beds. In all other cases, the measured sections indicate considerable thickening and thinning of the beds.

It is doubtful that strip mines of any consequence can be developed in any of these areas because of generally steep structural dips. The Alkali Butte field, the most favorable from the coal thickness standpoint, is located around the plunging nose of an anticline. Dip of the beds varies from 12° to 54°. Average dip is about 20°. This dip, combined with a maximum relief of 500 feet in the area, precludes the possibility of strip mining along the flank of a favorably located hill. At best the tonnage that could be developed would be quite low.

Within the other areas having thicker coalbeds, the formations dip from 10° to overturned.

Although these coals undoubtedly could be mined, many other areas in Wyoming warrant prior consideration.

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