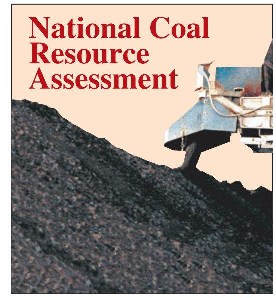
Chapter M

# Assessment of the Distribution and Resources of Coal in the Fairfield Group of the Williams Fork Formation, Danforth Hills Coal Field, Northwest Colorado

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Chapter M *of*

**Geologic Assessment of Coal in the Colorado Plateau: Arizona, Colorado, New Mexico, and Utah**

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* This report, although in the USGS Professional Paper series, is available only on CD-ROM and is not available separately

U.S. Department of the Interior
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# Metric Conversion Factors

[Data in this volume are reported in customary inch-pound units because the metric system is not currently in use by the coal industry of the United States. Readers wishing to convert measurements to the International System of units (SI) may use the following factors]

| U.S. customary unit | SI conversion |
|---|---|
| Acre | = 4,046.87 square meters |
| Acre-foot | = 1,233.49 cubic meters |
| British thermal unit (Btu) | = 1,055.056 joules |
| Btu/lb | = 2,326 joules per kilogram |
| Foot (ft) | = 0.3048 meters |
| Inch (in.) | = 0.0254 meters |
| Mile (mi) | = 1.609 kilometers |
| Pound (lb) | = 0.4536 kilograms |
| Short ton (ton) | = 0.9072 metric tons |
| Square miles ($mi^2$) | = 2.59 square kilometers |
| Short ton/acre-foot | = 0.7355 kilograms per cubic meter |

# Assessment of the Distribution and Resources of Coal in the Fairfield Coal Group of the Williams Fork Formation, Danforth Hills Coal Field, Northwest Colorado

*By* M.E. Brownfield, L.N.R. Roberts, E.A. Johnson, *and* T.J. Mercier


## Abstract

The assessment of coal resources in the Fairfield coal group, Danforth Hills coal field, Moffat and Rio Blanco Counties, Colorado, is part of the U.S. Geological Survey's (USGS) "National Coal Resource Assessment" (NCRA) Project, a 5-year program to identify and characterize coal deposits that could potentially provide fuel for the Nation's coal-derived energy needs during the first quarter of the 21st century. For this project, the Nation is divided into nine regions, one of which encompassed the Rocky Mountains and Colorado Plateau. One of the priority subareas for resource assessment in the Rocky Mountains and Colorado Plateau region is the Danforth Hills coal field that is located along the northeastern margin of the Piceance Basin.

Coal zones targeted for assessment in the Danforth Hills coal field are in the Fairfield coal group and occur in the lower part of the Williams Fork Formation of the Upper Cretaceous Mesaverde Group. The coal beds in these zones are laterally discontinuous, are considered to be low sulfur (averaging 0.47 percent), and have an apparent rank of high-volatile C bituminous when compared to many other coal-bearing regions in the United States. The coal quantities estimated for the Fairfield coal group are only in the identified and hypothetical resource categories and represent the total net coal in beds greater than 1.2 ft thick.

The Fairfield coal group contains an estimated coal resource of 21 billion short tons in seven coal zones of which more than 60 percent of the total coal is contained within the 1,000-ft maximum overburden category. More than 90 percent of the total is federally owned. The coal resources estimated for Danforth Hills coal field do not include the area inside the Colowyo Federal and State coal leases and the Preference Right Lease Application (pending Federal coal lease) nor do they reflect economic, land-use, environmental, technological, and geologic constraints that may ultimately affect the availability and recoverability of the coal. The amount of recoverable coal is not addressed in this study. Important factors affecting recoverability are (1) a significant amount of the coal is found at depths greater than 1,000 ft and (2) many of the coal beds are in close proximity stratigraphically, which may restrict underground mining of some beds. Coal can be bypassed due to longwall mining methods related to reduced thickness from partings and splits. Currently, coal is being mined at the Colowyo mine by dragline, and truck and shovel methods, and is transported by rail line to the Denver Rio Grande Railroad lines at Craig, Colo.


## Introduction

### Purpose and Scope

The assessment of the distribution and resources of the coal in the Danforth Hills coal field of northwest Colorado is part of the U.S. Geological Survey's National Coal Resource Assessment (NCRA) Project, which was initiated in 1994. The primary goal of the NCRA project is to characterize the resource potential and quality of coal resources for areas in the United States that will be utilized for the next few decades. The Danforth Hills coal field (figs. 1 and 2), in Moffat and Rio Blanco Counties, is one of the priority areas within the Rocky Mountains and Colorado Plateau region. To restrict the resource assessment in the context of a 10- to 20-year development period, only coals in the Fairfield coal group (Hancock and Eby, 1930) of the Williams Fork Formation of the Upper Cretaceous Mesaverde Group were assessed for this study (fig. A on pl. 1 and fig. 3). The Fairfield coal group contains many of the thickest and potentially economic coal beds in the Danforth Hills coal field. Study areas were determined by analyzing current mining activity, coal ownership, and by discussions with the U.S. Bureau of Land Management (BLM). This study area was selected because it contains active mining, large amounts of federally administered lands, and has potential for future

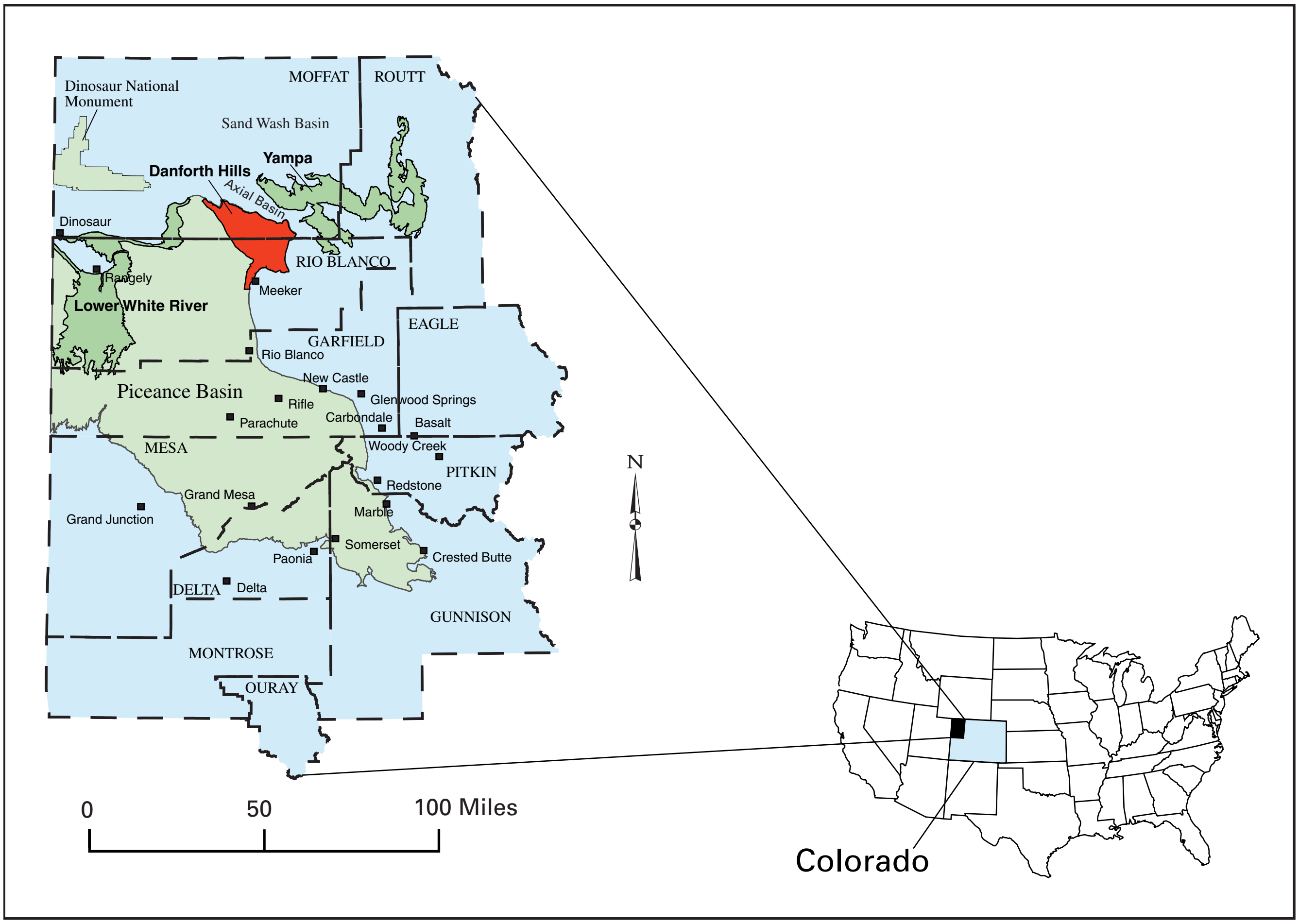


**Figure 1.** Map showing the locations of the Danforth Hills, Lower White River, and Yampa coal fields in Moffat, Rio Blanco, and Routt Counties, Colorado.

development. Mineral rights to more that 90 percent of coal within the study area are owned by the U.S. Government. One mine (Kennecott's Colowyo mine) is presently operating in the study area and produces coal from the Fairfield coal group.

The assessment of the Fairfield coal group in the Danforth Hills coal field is based largely on data derived from geologic mapping, outcrop measurements, and drilling conducted in the study area by the U.S. Geological Survey (USGS) since the early 1900's. The coal-resource data has been stored digitally and manipulated in a Geographic Information System to calculate coal resources within a variety of spatial parameters that were deemed useful for land-use planning and potential mining. The major coal deposits in the Danforth Hills coal field are present in the Upper Cretaceous Iles and Williams Fork Formations of the Mesaverde Group (figs. 3 and 4). Coal resources reported in this study are for total net coal and assessed coal zones in the Fairfield coal group of the Williams Fork Formation and represent only a part of the total in-place coal for the Danforth Hills coal field. The Colowyo Coal Company's Federal and State coal leases and their pending Preference Right Lease Application (PRLA) were excluded in this study (fig. B on pl. 1).

## Location

The Danforth Hills coal field (fig. 1 and fig. A on pl. 1) is situated in northwest Colorado, in Moffat and Rio Blanco Counties, and is within the Rocky Mountain Coal Province of Tully (1996). The coal field lies north of the White River along the northeastern margin of the Piceance Basin (fig. 1), south and west of the Axial Basin, and east of the Lower White River coal field along the northern extension of the Grand Hogback (fig. 2). The area is characterized by north- and east-trending ridges separated by steep canyons on the north, and to the south and west by steeply dipping, long and narrow hogbacks. Elevations in the coal field range from 6,200 to 8,700 ft. Northward drainage is to the Yampa River and southward drainage is to the White River. The Flat Tops highlands of the White River Plateau (fig. 2) to the southeast ranges in elevation from 8,500 to 12,000 ft.

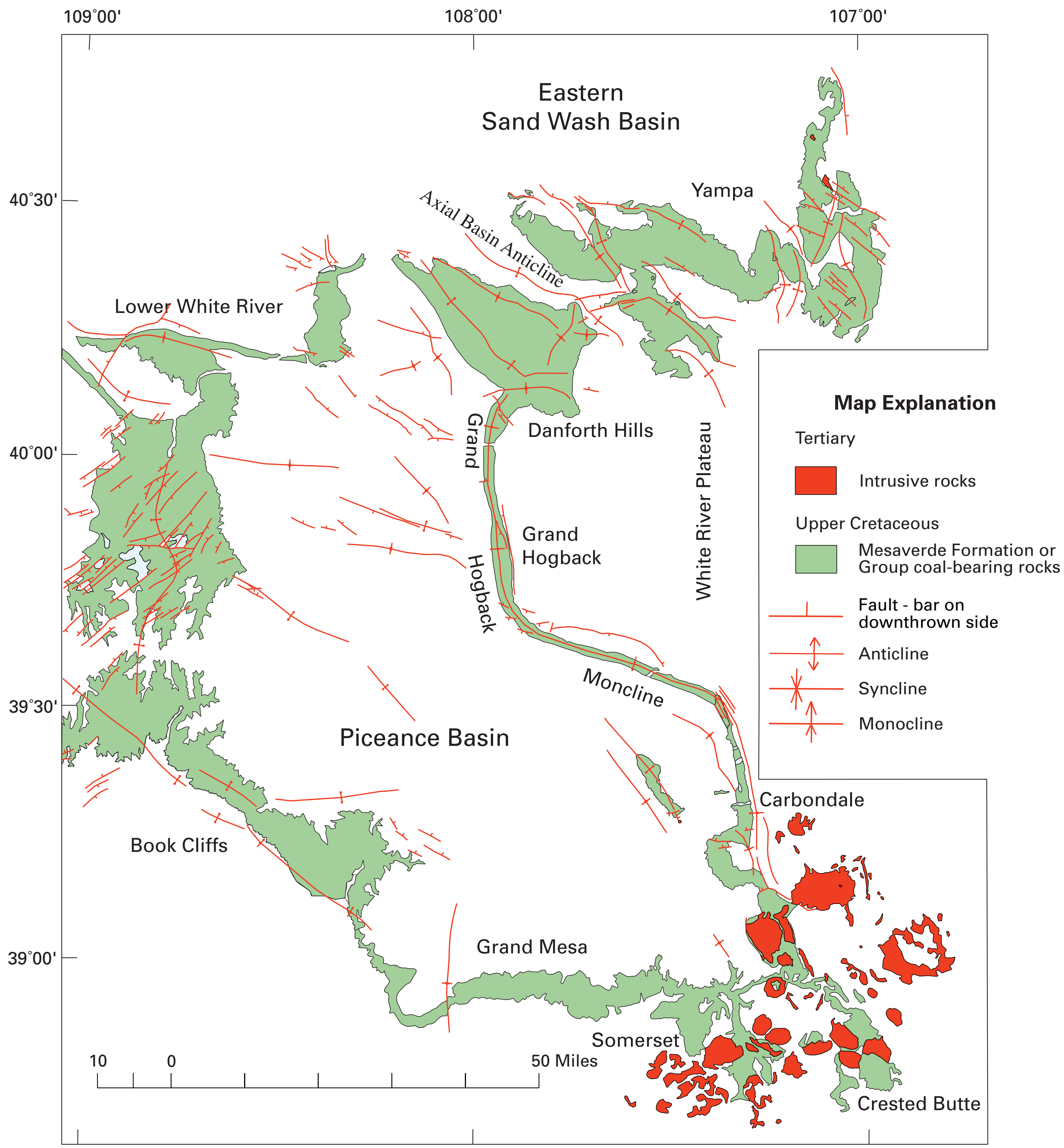


**Figure 2.** Generalized geologic map of northwest Colorado showing outcrops of the coal-bearing Mesaverde Formation and Group and major coal fields within the eastern Sand Wash and Piceance Basins.

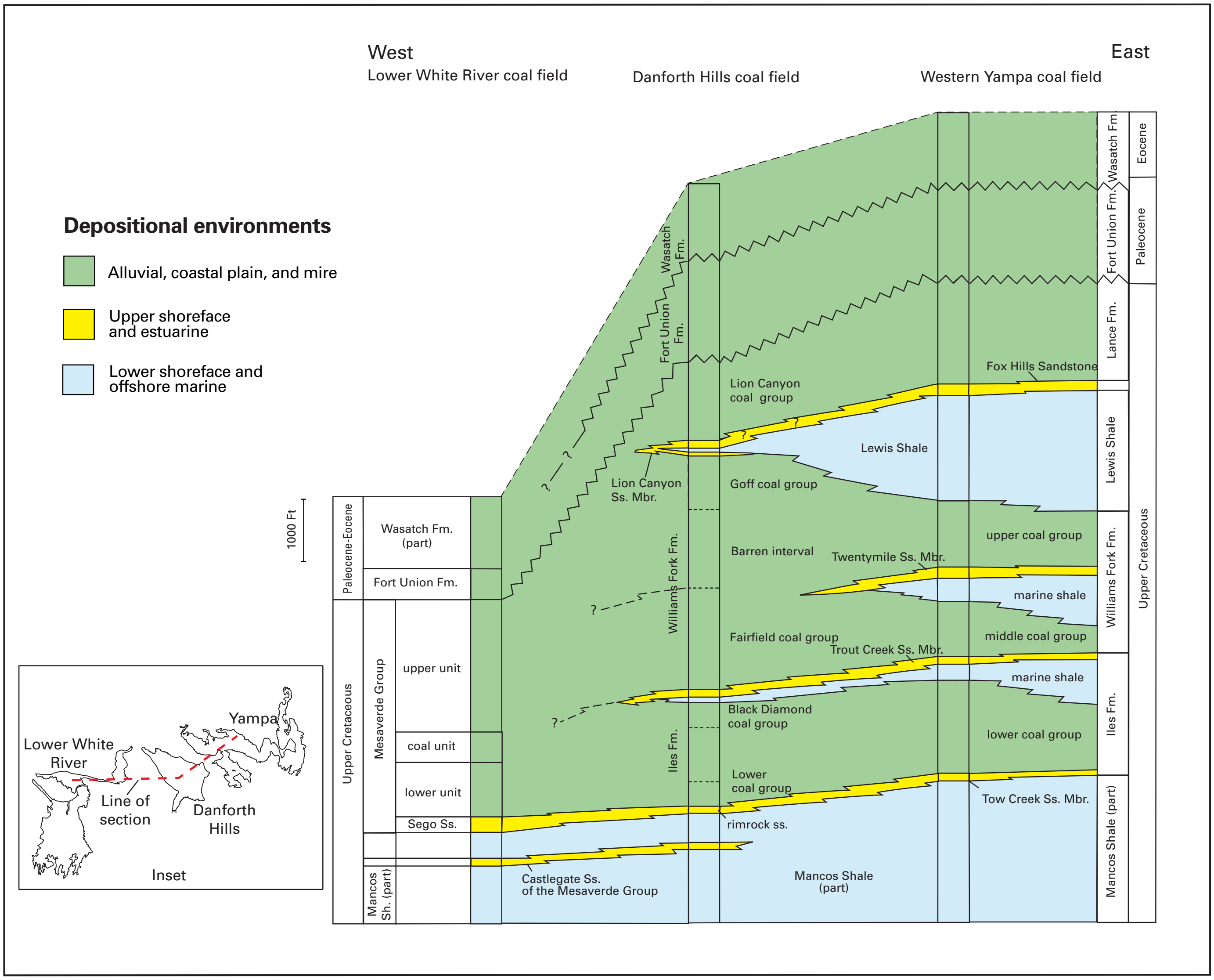


**Figure 3.** Generalized regional cross section showing stratigraphic correlations and facies relationships for part of the Upper Cretaceous and Tertiary rocks in the Danforth Hills, Lower White River, and Yampa coal fields, northwest Colorado. Modified from Brownfield and Johnson (1984).

## Previous Geologic Studies and Mining Activity

Since the early 1900's the USGS has conducted investigations to study the geology and to assess the coal, oil and gas, and oil-shale resources in Colorado. Gale (1907, 1909, 1910) was the first to investigate the coal resources in the Danforth Hills coal field. Hancock (1925) and Hancock and Eby (1930) conducted the first detailed geologic investigations in the Danforth Hills from 1911 to 1913. Detailed geologic mapping of the Danforth Hills was completed by Nutt (1981), Reheis (1981, 1983a, 1983b), and Izett and others (1983, 1985). Additional mapping in the Danforth Hills was conducted by Dyni (1966), Collins (1976), and Pipiringos and Rosenlund (1977).

Early mining activity in the Danforth Hills was limited because the closest railroad lines were more than 50 miles away. However, during the late 1800's and early 1900's, several mines in the Danforth Hills coal field produced coal for local utilization. In addition to local heating uses, some of the coal provided fuel for the Meeker electric plant, nearby lumber mills, and blacksmith shops (Hancock, 1925). Gale (1910) reported quality analyses of coal from several of the mines.

Coal is currently mined in the Danforth Hills coal field by surface methods at the Colowyo mine, operated by Kennecott Corporation. The coal is mined from nine beds in the upper two coal zones of the Fairfield coal group of the Williams Fork Formation by dragline, and by truck and shovel methods, then shipped by a private rail to the Denver Rio Grande rail lines at

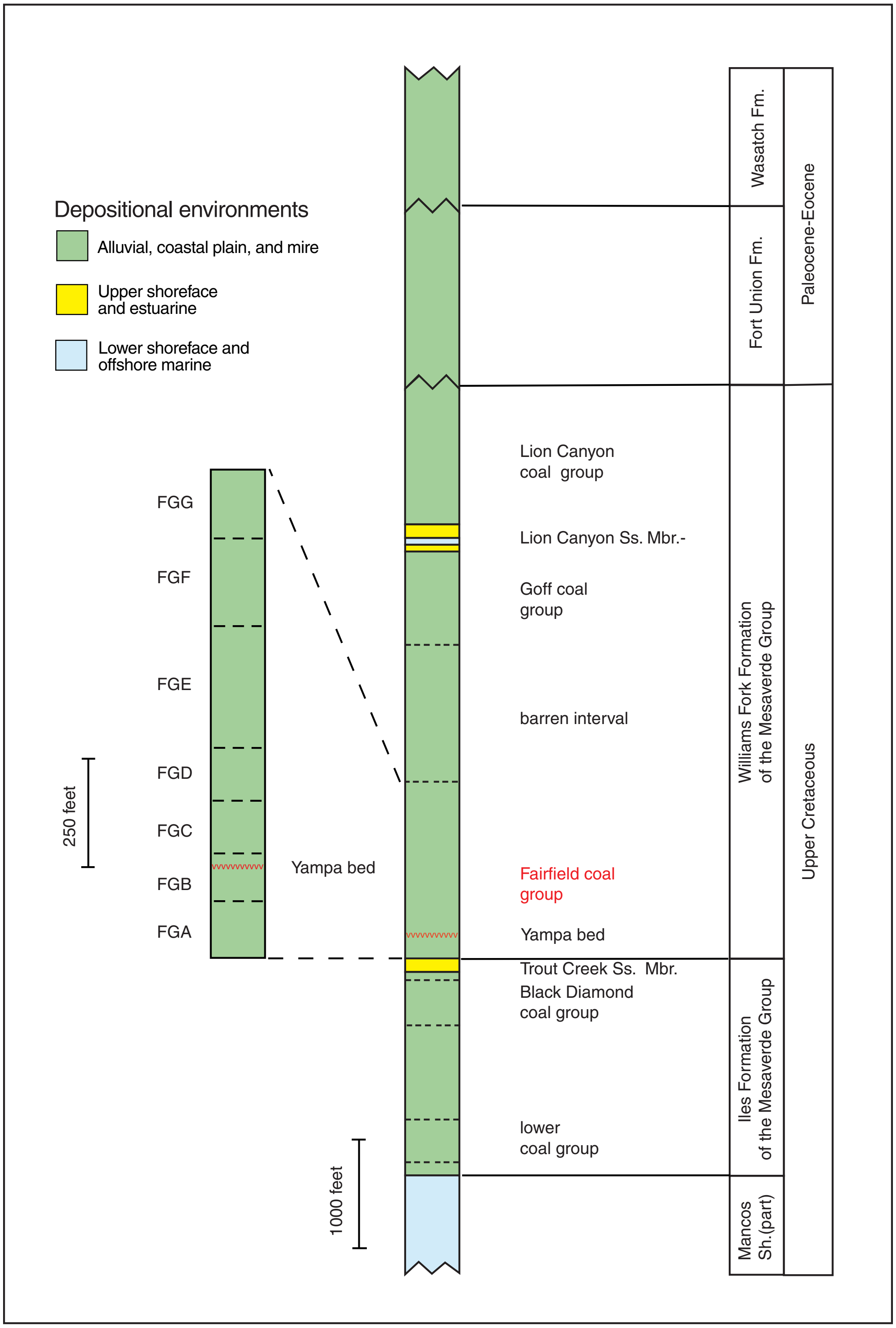


**Figure 4.** Generalized stratigraphic column showing depositional environments for a portion the Upper Cretaceous and Tertiary rocks in the Danforth Hills coal field, Colorado. Shown are the major divisions of the Fairfield coal group and the Yampa bed of the Williams Fork Formation. Yampa bed not drawn to scale.

Craig, Colo. Coal production averaged 4.5 million short tons per year from 1989 to 1996 (Resource Data International, Inc., 1998). In 1997, the Colowyo mine produced 4.3 million short tons of coal, accounting for 18 percent of the 24 million short tons of coal produced in northwest Colorado (Resource Data International, Inc., 1998). Future coal production in the Colowyo mine will probably be limited to the upper part of the Fairfield coal group and potential new mines are expected to be located in the Fairfield coal group as well. Because of limited access to the Danforth Hills area by rail, new mining activity will likely be restricted to localities adjacent to the Colowyo mine.

## Methods

In order to assess the coal resources of the Danforth Hills coal field, we created digital files for storing data on various geologic and other features such as outcrop lines, elevation data, coal thickness, faults, fold axes, and extent of Federal coal leases and mined-out areas within the study area. Drill-hole data have been stored and analyzed in a relational stratigraphic database and graphics software package (Stratifact, GRG Corporation, Denver, Colo., 1997). Digital files of the publicly available drill holes are provided in Appendix 1 of this chapter, which is on disc 2 of this CD-ROM. Mean coal-zone thicknesses and elevation data, derived from the Stratifact drill-hole database, were integrated with digital elevation data to derive the Fairfield coal-zone outcrop lines (Roberts and others, chap. C, this CD-ROM). These outcrop lines were then used to define assessment areas for the study. The drill-hole data were analyzed by USGS computer program (G.D. Stricker, written commun., 1998) to determine net-coal-bed thickness, after Wood and others (1983). The digital files were stored, analyzed, and manipulated in a Geographic Information System (GIS) using ARC/INFO (Environmental Systems Research Institute, Inc.) software. Gridding, and subsequent generation of contour and isopach maps, was done with EarthVision (Dynamic Graphics, Inc.) software, and the contours were converted to ARC/INFO coverages using custom programs ISMARC and Convert-ISM.AML (Roberts and others, 1998). This software integrated the various coverages, allowing us to calculate coal resources and characterize coal distribution within a variety of geologic and geographic parameters. The various digital coverages used in this report are available in the ArcView project in Appendix 2, and they are explained by Biewick and Mercier (chap. D, this CD-ROM). The methodology for reporting the estimated coal resources is from Wood and others (1983) and is described in more detail in the methodology chapter of this report (Roberts and others, chap. C, this CD-ROM).

## Geologic Maps

Digital geologic maps of the study area were generated using ARC/INFO coverages that included stratigraphic unit boundaries and elevations, faults, fold axes, and coal thicknesses. Data from the 1:500,000-scale geologic map of Colorado (Tweto, 1979; Green, 1992) were used to generate digital regional maps of northwest Colorado (fig. 2). The study-area portion of Colorado geologic map was compiled from 1:250,000-scale geologic maps (Tweto 1975, 1976; Rowley and others, 1979) and published at a scale of 1:500,000. The geologic map for the Danforth Hills coal field was compiled at a scale of 1:62,500 and modified from 1:62,500-scale maps by Hancock (1925), Hancock and Eby (1930), Barnum and others (1974), and Izett and others (1985), and from 1:24,000-scale maps by Nutt (1981), and Reheis (1981, 1983a, 1983b). The 1:62,500-scale map was then reduced to the map shown on plate 1 (see fig. A on pl. 1).

## Geographical Boundaries

Geographic boundary coverages were imported from existing public-domain databases. Surface and mineral ownership were obtained from 1:24,000-scale digital compilations completed by the Craig District Office, BLM. County and State lines were obtained from 1:100,000-scale Topologically Integrated Geographic Encoding and Referencing (TIGER) files produced by the U.S. Bureau of the Census in 1990. Surface topography was obtained from 1:24,000 Digital Elevation Model (DEM) files for the 7.5-minute quadrangles within the study area (fig. 5). Coal-lease boundaries were obtained from the U.S. Bureau of Land Management and compiled digitally by the USGS.

## Geophysical Logs

More than 640 borehole geophysical logs, supplied in part by the BLM, were used in this study. Table 1 lists information on 110 of the publicly available exploratory drill holes. Fifty-six of these holes were drilled from 1976 to 1979 by the U.S. Geological Survey. Another 52 holes were obtained from expired coal leases, and two are oil and gas exploration holes. Figure B on plate 1 shows drill-hole locations with index numbers that are cross-referenced with the hole number in table 1. Data on the other drill holes in the Danforth Hills coal field are proprietary and were obtained over a 25-year drilling period by several different operators and organizations, commonly at different scales. Coal and other lithologic units are readily identified on the geophysical logs because good natural gamma and density traces are recorded on them. The log quality allowed unit boundaries generally to be picked to the nearest ½ ft. A few of the older, lower quality logs allowed interpretations to the nearest foot, but a few of the most recent, well-calibrated logs allowed unit picks to the nearest one-tenth of a foot.

As in most coal studies, the degree of certainty in establishing coal-bed correlations varies with distance between control points (the higher the drilling density, the better the corre-

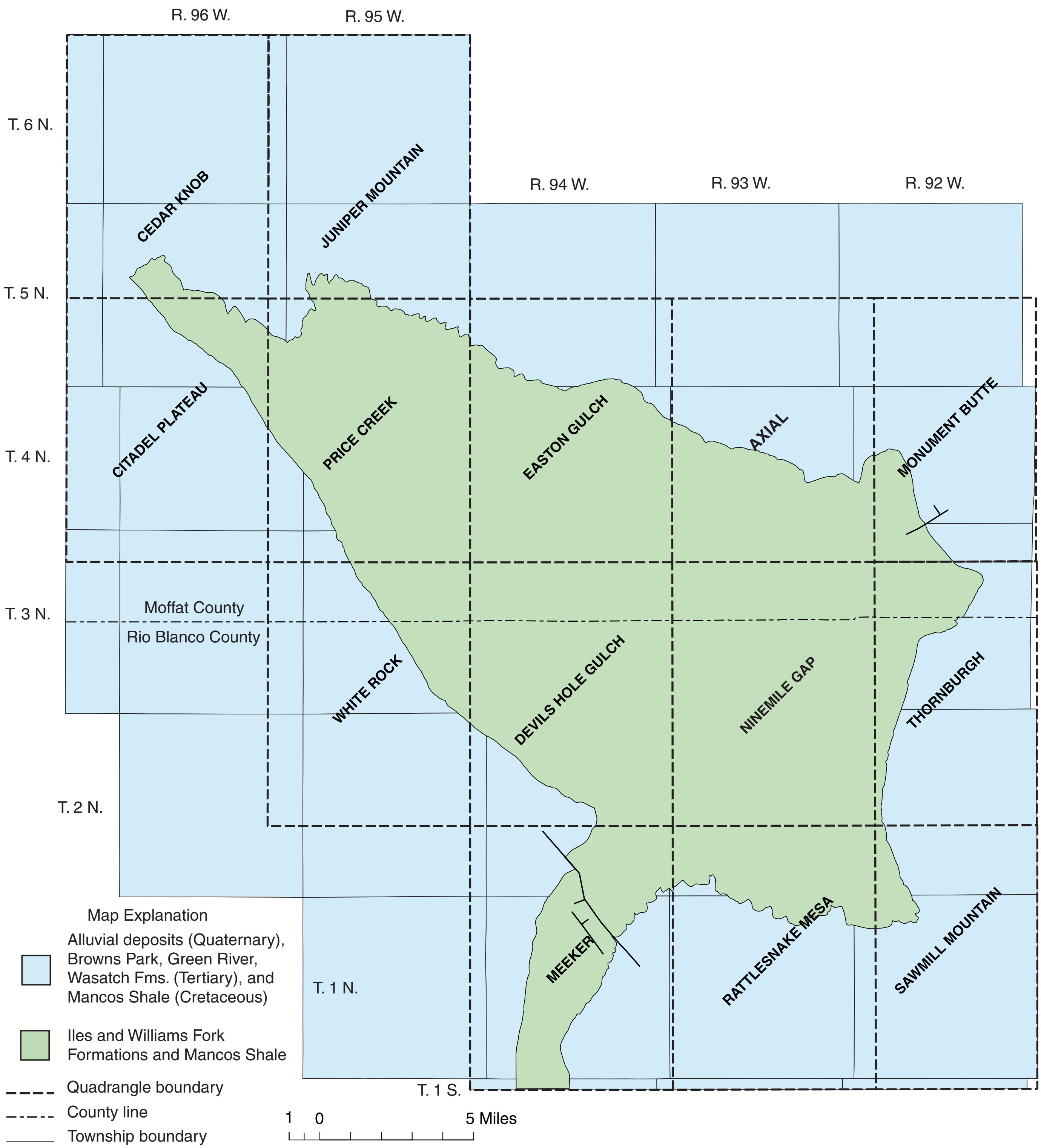


**Figure 5.** Index map showing location of the Danforth Hills coal field with respect to the 7.5′ topographic quadrangles. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation.

**Table 1.** Locations of coal exploration drill holes in the Danforth Hills coal field, northwest Colorado, for which data are publicly avaliable.

[Index number shown on figure B, plate 1. Also shown for the holes are elevations, depth drilled, and quadrangle. Surface elevation and depth drilled are in feet; to convert feet to meters, multiply by 0.3048]

| Index no. | Drill hole no. | Latitude | Longitude | Sec | Township | Range | 7.5′ quadrangle | Elevation (feet) | Depth drilled (feet) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | D-53EG | 40.3229 | 107.96235 | 17 | T. 4 N. | R. 94 W. | EASTON GULCH | 7560 | 706 |
| 2 | D-51EG | 40.31652 | 107.93306 | 15 | T. 4 N. | R. 94 W. | EASTON GULCH | 7080 | 1510 |
| 3 | D-38EG | 40.31292 | 107.97329 | 18 | T. 4 N. | R. 94 W. | EASTON GULCH | 7895 | 1080 |
| 4 | D-44EG | 40.29633 | 107.90723 | 23 | T. 4 N. | R. 94 W. | EASTON GULCH | 6990 | 1320 |
| 5 | D-49EG | 40.29474 | 107.95667 | 29 | T. 4 N. | R. 94 W. | EASTON GULCH | 7260 | 1425 |
| 6 | D-47A | 40.28484 | 107.82436 | 28 | T. 4 N. | R. 93 W. | AXIAL | 6980 | 715 |
| 7 | D-39EG | 40.27864 | 107.93852 | 33 | T. 4 N. | R. 94 W. | EASTON GULCH | 6895 | 800 |
| 8 | D-41EG | 40.27829 | 107.91592 | 34 | T. 4 N. | R. 94 W. | EASTON GULCH | 6980 | 820 |
| 9 | D-42EG | 40.27805 | 107.96646 | 32 | T. 4 N. | R. 94 W. | EASTON GULCH | 7400 | 700 |
| 10 | D-40EG | 40.27699 | 107.92591 | 34 | T. 4 N. | R. 94 W. | EASTON GULCH | 7290 | 1453 |
| 11 | D-47A1 | 40.27566 | 107.83014 | 33 | T. 4 N. | R. 93 W. | AXIAL | 7045 | 975 |
| 12 | D-56A | 40.27499 | 107.80896 | 34 | T. 4 N. | R. 93 W. | AXIAL | 7200 | 1430 |
| 13 | D-45EG | 40.26531 | 107.94592 | 4 | T. 3 N. | R. 94 W. | EASTON GULCH | 7050 | 840 |
| 14 | D-50EG | 40.26158 | 107.92715 | 3 | T. 3 N. | R. 94 W. | EASTON GULCH | 7200 | 620 |
| 15 | D-26A | 40.25948 | 107.84076 | 5 | T. 3 N. | R. 93 W. | AXIAL | 7327.5 | 500 |
| 16 | #1 GOSSARD | 40.25602 | 107.82337 | 4 | T. 3 N. | R. 93 W. | AXIAL | 7357 | 8785 |
| 17 | D-11A | 40.25235 | 107.84564 | 5 | T. 3 N. | R. 93 W. | AXIAL | 7560.8 | 1140 |
| 18 | D-03A | 40.25068 | 107.87005 | 7 | T. 3 N. | R. 93 W. | AXIAL | 7620 | 900 |
| 19 | D-31NG | 40.2492 | 107.8599 | 7 | T. 3 N. | R. 93 W. | NINEMILE GAP | 6917 | 200 |
| 20 | D-52D | 40.24872 | 107.95106 | 9 | T. 3 N. | R. 94 W. | DEVILS HOLE GULCH | 7200 | 600 |
| 21 | D-06NG | 40.24576 | 107.79421 | 11 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7240 | 1583 |
| 22 | D-43DH | 40.24483 | 107.97887 | 7 | T. 3 N. | R. 94 W. | DEVILS HOLE GULCH | 7400 | 560 |
| 23 | D-27NG | 40.24468 | 107.85122 | 8 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7774.1 | 500 |
| 24 | D-01NG | 40.23941 | 107.76081 | 7 | T. 3 N. | R. 92 W. | NINEMILE GAP | 7250 | 1102 |
| 25 | D-29NG | 40.23922 | 107.86176 | 7 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7257.8 | 381 |
| 26 | D-34NG | 40.23887 | 107.7917 | 11 | T. 3 N. | R. 93 W. | NINEMILE GAP | 6700 | 200 |
| 27 | D-12NG | 40.2385 | 107.85236 | 8 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7913.6 | 1240 |
| 28 | D-54D | 40.23737 | 107.94241 | 9 | T. 3 N. | R. 94 W. | DEVILS HOLE GULCH | 8120 | 940 |
| 29 | D-07NG | 40.23682 | 107.81922 | 15 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7747 | 1675 |
| 30 | D-35NG | 40.23418 | 107.86255 | 18 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7514.7 | 380 |
| 31 | D-02NG | 40.23327 | 107.8553 | 17 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8018.7 | 800 |
| 32 | D-20NG | 40.23306 | 107.84364 | 17 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7991.1 | 520 |
| 33 | D-18NG | 40.23047 | 107.81049 | 15 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7480 | 540 |
| 34 | D-04NG | 40.23037 | 107.75639 | 18 | T. 3 N. | R. 92 W. | NINEMILE GAP | 7000 | 1171 |
| 35 | D-28NG | 40.2273 | 107.86126 | 18 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7780 | 280 |
| 36 | D-19NG | 40.22453 | 107.84029 | 17 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8095 | 520 |
| 37 | D-24NG | 40.22449 | 107.86777 | 18 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8336.2 | 220 |
| 38 | D-17NG | 40.22323 | 107.82707 | 16 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7827 | 500 |
| 39 | D-32NG | 40.22187 | 107.81128 | 22 | T. 3 N. | R. 93 W. | NINEMILE GAP | 6885 | 220 |
| 40 | D-25NG | 40.22185 | 107.85228 | 20 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8241.8 | 540 |
| 41 | D-37DH | 40.22151 | 107.99056 | 19 | T. 3 N. | R. 94 W. | DEVILS HOLE GULCH | 8080 | 715 |
| 42 | D-33NG | 40.22119 | 107.867 | 19 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8243 | 600 |
| 43 | D-05NG | 40.2195 | 107.76436 | 24 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7345 | 1235 |
| 44 | D-23NG | 40.21922 | 107.86302 | 19 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8441.8 | 500 |
| 45 | D-10NG | 40.21869 | 107.84266 | 20 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8114.3 | 1480 |
| 46 | D-22NG | 40.21622 | 107.8525 | 20 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8228 | 500 |
| 47 | D-48NG | 40.21429 | 107.86422 | 19 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8411 | 1200 |
| 48 | D-16NG | 40.21276 | 107.83113 | 21 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7443.6 | 518 |
| 49 | D-21NG | 40.21075 | 107.84955 | 20 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7983.4 | 560 |
| 50 | D-58NG | 40.20518 | 107.87 | 30 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8155.3 | 660 |
| 51 | D-62NG | 40.20318 | 107.84271 | 29 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7105.1 | 320 |
| 52 | D-61NG | 40.20152 | 107.8511 | 29 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7225.5 | 275 |
| 53 | D-60NG | 40.19709 | 107.87215 | 30 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8006.5 | 400 |
| 54 | D-13NG | 40.19594 | 107.8343 | 28 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7855 | 500 |
| 55 | D-14NG | 40.19436 | 107.84436 | 29 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7815 | 500 |
| 56 | 75-M-184 | 40.18805 | 107.83736 | 33 | T. 3 N. | R. 93 W. | NINEMILE GAP | 7948.2 | 1100 |

**Table 1.** Locations of coal exploration drill holes in the Danforth Hills coal field, northwest Colorado, for which data are publicly avaliable—*Continued*.

| Index no. | Drill hole no. | Latitude | Longitude | Sec | Township | Range | 7.5′ quadrangle | Elevation (feet) | Depth drilled (feet) |
|---|---|---|---|---|---|---|---|---|---|
| 57 | K15-CD-79 | 40.18023 | 107.85085 | 32 | T. 3 N. | R. 93 W. | NINEMILE GAP | 8125 | 1085 |
| 58 | D-08NG | 40.15764 | 107.75801 | 7 | T. 2 N. | R. 92 W. | NINEMILE GAP | 8490 | 1231 |
| 59 | 75-M-172 | 40.15664 | 107.82444 | 9 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7701.1 | 700 |
| 60 | 74-M-169 | 40.15588 | 107.82207 | 9 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7401.3 | 700 |
| 61 | 75-M-171 | 40.15143 | 107.82865 | 9 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7510.6 | 100 |
| 62 | 75-M-174 | 40.14857 | 107.82647 | 16 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7622.4 | 1000 |
| 63 | 77-M-211 | 40.14239 | 107.82757 | 16 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7172.7 | 2578 |
| 64 | 74-M-163 | 40.14037 | 107.8212 | 16 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7165.5 | 860 |
| 65 | 76-M-199 | 40.13683 | 107.82968 | 16 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7051.7 | 2700 |
| 66 | HFC-5 | 40.13563 | 107.81944 | 21 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7150 | 679 |
| 67 | 70-M-002 | 40.13408 | 107.80002 | 23 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7407.6 | 1000 |
| 68 | 74-M-164C | 40.13316 | 107.79113 | 23 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7434 | 270 |
| 69 | HFC-4A | 40.13013 | 107.83968 | 20 | T. 2 N. | R. 93 W. | NINEMILE GAP | 6978 | 110 |
| 70 | 79-23 | 40.1297 | 107.82768 | 21 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7249.4 | 251 |
| 71 | 79-17 | 40.12924 | 107.83619 | 21 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7170.9 | 2635 |
| 72 | 75-M-175 | 40.12905 | 107.76387 | 24 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7154.3 | 634 |
| 73 | 77-M-207 | 40.12881 | 107.79258 | 23 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7629.5 | 2756 |
| 74 | 76-M-204 | 40.12812 | 107.77314 | 24 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7445.7 | 2020 |
| 75 | 74-M-152 | 40.12646 | 107.78214 | 24 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7567.8 | 1001 |
| 76 | 74-M-153 | 40.12506 | 107.79494 | 23 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7863.7 | 1000 |
| 77 | 74-M-160 | 40.12425 | 107.77066 | 24 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7717.9 | 1050 |
| 78 | 76-M-198 | 40.12315 | 107.78997 | 23 | T. 2 N. | R. 93 W. | NINEMILE GAP | 7619 | 1995 |
| 79 | 74-M-151 | 40.11946 | 107.82884 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7414 | 1100 |
| 80 | HRP-1 | 40.11881 | 107.84462 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 6925.2 | 701 |
| 81 | 76-M-195 | 40.11747 | 107.77728 | 25 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7876.8 | 1485 |
| 82 | 80-08C | 40.11738 | 107.83514 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7532.7 | 1475 |
| 83 | 79-13 | 40.11725 | 107.82793 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7499 | 1564 |
| 84 | 77-NNG-04 | 40.117 | 107.84733 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 6940 | 1600 |
| 85 | 77-M-210A | 40.11663 | 107.76616 | 25 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7542.1 | 1250 |
| 86 | 80-04 | 40.11642 | 107.81915 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7681.9 | 1700 |
| 87 | 77-NNG-07C | 40.11604 | 107.84023 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7541 | 1800 |
| 88 | HRJ-1 | 40.11598 | 107.84509 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 6915.5 | 204 |
| 89 | 77-NNG-01C | 40.11549 | 107.8538 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7664 | 1820 |
| 90 | 74-M-161 | 40.11467 | 107.80488 | 27 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7686.3 | 780 |
| 91 | 77-NNG-05C | 40.11452 | 107.84787 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 6940 | 1120 |
| 92 | HRG-1 | 40.1141 | 107.84524 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 6910.8 | 182 |
| 93 | D-09RM | 40.11371 | 107.76102 | 30 | T. 2 N. | R. 92 W. | NINEMILE GAP | 7025 | 761 |
| 94 | 79-08 | 40.11341 | 107.83526 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7707.8 | 868 |
| 95 | 76-M-203 | 40.11309 | 107.83714 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7709.1 | 1460 |
| 96 | 74-M-159 | 40.11283 | 107.79058 | 26 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 8104.9 | 906 |
| 97 | 80-06C | 40.11281 | 107.82345 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7990 | 1148 |
| 98 | 77-NNG-10 | 40.11216 | 107.84886 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 6960 | 1220 |
| 99 | 77-NNG-02C | 40.11173 | 107.85671 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7883.2 | 1340 |
| 100 | 80-03 | 40.11109 | 107.83517 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7851.6 | 1000 |
| 101 | 76-M-194A | 40.1109 | 107.77672 | 25 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 8170.9 | 778 |
| 102 | 77-NNG-09 | 40.11029 | 107.83968 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7720 | 800 |
| 103 | 80-12 | 40.10967 | 107.83163 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 8024.3 | 660 |
| 104 | 77-NNG-03 | 40.10925 | 107.85716 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7880 | 1220 |
| 105 | 77-NNG-06A | 40.10873 | 107.84856 | 29 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 6920 | 990 |
| 106 | 80-11 | 40.10692 | 107.82769 | 28 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 8143 | 580 |
| 107 | 76-M-196 | 40.10681 | 107.79196 | 26 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 8330.7 | 1465 |
| 108 | 68-M-016 | 40.10678 | 107.80705 | 27 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 7559.5 | 655 |
| 109 | 77-M-208B | 40.10428 | 107.77509 | 36 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 8102.8 | 1560 |
| 110 | 74-M-154 | 40.09947 | 107.79502 | 35 | T. 2 N. | R. 93 W. | RATTLESNAKE MESA | 8559 | 512 |

lation), local stratigraphy, presence or absence of stratigraphic markers, and log quality. Although correlations of individual coal beds should generally be regarded as indications of stratigraphic position within coal zones, the lithologic and stratigraphic log interpretations resulting from the present study are considered to reflect an accurate representation of the stratigraphic framework of coal beds that exist within the Danforth Hills area.

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# Geologic Setting

## Stratigraphy of the Cretaceous and Tertiary Strata of the Danforth Hills Coal Field

All of the coal stratigraphic units exposed within the Danforth Hills coal field are of Upper Cretaceous and Tertiary age (fig. 3), with all the coal-bearing rocks considered in this study confined to the Upper Cretaceous Mesaverde Group. The lowest unit is the thick marine Mancos Shale of Early to Late Cretaceous age, which is overlain by the mostly nonmarine, coal-bearing Iles and Williams Fork Formations of the Mesaverde Group. A generalized columnar section for the Danforth Hills coal field is shown in figure 4. The Mesaverde Group generally consists of a thinly to thickly interbedded succession of shale, siltstone, and sandstone deposited largely in a terrestrial environment, although regional relations indicate that this sedimentation was directly influenced by sea-level changes. Carbonaceous rocks are common, and thick beds of coal occur throughout the Williams Fork Formation. Rocks of marine or marginal-marine origin do occur within the Mesaverde Group, most notably the Trout Creek Sandstone Member at the top of the Iles Formation (figs. 3 and 4). This persistent marginal-marine sandstone is one of the best stratigraphic markers in the area. It is directly overlain by the Fairfield coal group (Hancock and Eby, 1930), which contains the most extensive coal resources in the area.

The Iles Formation averages about 1,500 ft thick in the Danforth Hills coal field. Thick ledge-forming sandstones are the most notable feature of the Iles when observed in outcrop. Thin coals occur throughout the formation and locally reach significant thickness and continuity in the Black Diamond coal group (Hancock and Eby, 1930) and in the lower coal group (see Coal Geology of the Danforth Hills Coal Field section, this report). The Trout Creek Sandstone Member at the top of the Iles Formation averages about 75 ft in thickness in the central part of the Danforth Hills. The Trout Creek is a persistent, upward-coarsening, ledge-forming, light-colored sandstone that can be mapped over the entire study area. The Iles Formation correlates well to other areas of northwest Colorado, although the Trout Creek Member thins out and disappears to the west (fig. 3). Thus, the Trout Creek cannot be used to separate of the Iles and the overlying Williams Fork (fig. 3) in the Lower White River coal field (Brownfield and others, chap. N, this CD-ROM).

The Williams Fork Formation is present at the surface over most of the study area, and it contains a large majority of the coal resources in the area. Hancock and Eby (1930) subdivided the Williams Fork into five stratigraphic units: in ascending order, these are the Fairfield coal group, barren interval, Goff coal group, Lion Canyon Sandstone, and Lion Canyon coal group. Hancock and Eby (1930) estimated the Williams Fork to be 4,500 to 5,000 ft thick and to contain all of the significant coal beds; thickness of 3,000 to 3,500 ft were considered to be a more reliable range for the present study. These large thicknesses relative to other areas of northwest Colorado are the result of structural and erosional relationships and to facies changes. The lower part of the barren interval correlates with the upper coal group of the Yampa coal field (fig. 3). The uppermost part of the Goff coal group of the Williams Fork Formation in the Danforth Hills coal field is equivalent to the Lewis Shale–Fox Hills Sandstone succession (fig. 3) in the Yampa coal field to the north (Hancock and Eby, 1925). Marine units equivalent to the Lewis Shale are represented by a thin shale tongue that occurs below the Lion Canyon Sandstone, which is present along the western margin of the Danforth Hills; this shale, however, has been eroded from most of the study area. The shoreward facies of this marine unit is represented by the Lion Canyon Sandstone Member (fig. 3), which is equivalent to the Fox Hills Sandstone in the western part of the Yampa coal field. The 1,000 ft of coal-bearing Williams Fork Formation overlying the Lion Canyon Sandstone in the western part of the Danforth Hills area represents an extension of the Lance Formation westward from the Yampa coal field (Sears, 1925). Thin lenticular coals present in the Lance-equivalent rocks are included in the Lion Canyon coal group (fig. 4) of Hancock and Eby (1930). No definite correlative unit to the Twentymile Sandstone Member (fig. 3), an important marker unit in the Williams Fork to the northeast in the Yampa coal field, is present in the Danforth Hills coal field.

The depositional setting of the Williams Fork Formation in the Danforth Hills was especially favorable for the formation of coal. The rocks were deposited along the western margin of the late Campanian to Maastrichtian Western Interior Seaway (Roberts and Kirschbaum, 1995), where, regionally, there was a stacking of several thousand feet of coal-bearing strata along the coastal plain. During deposition of this strata, the area that is now northwest Colorado was at a latitude of about 42 degrees north (Roberts and Kirschbaum, 1995) and had a humid, subtropical climate. This coupled with a high water table, characteristic of lower-coastal-plain depositional setting, was conducive to the development of a complex network of peat swamps. The resulting coal-bearing rocks typically show a cyclic pattern of coal deposition, which is now reflected in the coal zones defined during the present study. Sedimentary processes associated with near-shore deposition and fluvial deposition in the Danforth Hills area have influenced the geometry and distribution of these deposits.

Tertiary rocks in the Danforth Hills coal field are restricted to the western margin of the study area along the Grand Hogback monocline (fig. 2). Overlying the Upper Cretaceous rocks is a section of fluvial and lacustrine rocks assigned to the Paleocene Fort Union Formation and Paleocene to Eocene Wasatch Formation (fig. 3). Thin lenticular coals have been mapped in the Fort Union (Pipiringos and Rosenlund, 1977; Izett and others, 1985) but were not included in this study.

### Structure

The Danforth Hills area lies along the northeastern flank of the Piceance Basin. The Grand Hogback monocline, a major structure, forms the eastern margin of the basin (fig. A on pl. 1 and fig. 2). The study area lies northwest of the broad White River Plateau and directly south of the Axial Basin (figs. 1 and 2), which can be considered an eastward extension of the Uinta Mountain uplift.

The study area is deformed by several major folds, as shown on a structure map drawn on the top of the Trout Creek Sandstone Member of the Iles Formation (fig. A on pl. 1). The Sulphur Creek syncline trends generally east-west across the southern part of the area (fig. A on pl. 1). The Danforth Hills anticline trends generally southeastward along the southwest margin of the study area where it is subparallel to the Grand Hogback monocline where dips commonly reach 45° (fig. A on pl. 1 and fig. 2). The anticline then turns eastward, paralleling the Sulphur Creek syncline. Structural relief of 2,000 to 3,000 ft is common between the axes of these two folds (fig. A on pl. 1). Strata on the flanks of the Sulphur Creek syncline dip 10°–30°.

Structural deformation is less intense in the northern and northeastern part of the study area (fig. A on pl. 1), and dips are generally less than 10° and commonly less than 5°. The Elkhorn syncline plunges north-northeast across the eastern margin from a structural “saddle” on the trend of the Danforth Hills anticline. Subparallel to the northern margin is the Collom syncline (Hancock, 1925). The northernmost margin of the study area coincides with the south flank of the Axial Basin anticline (Hancock, 1925).

Large-displacement faults are not common in the Danforth Hills area except for two faults cutting the northern extension of the Grand Hogback (fig A on pl. 1). The northern fault has produced a distinct offset in the Trout Creek Sandstone and has an estimated vertical displacement of 510 ft (Hancock and Eby, 1930), whereas the southern fault has a vertical displacement of 285 ft. However, local faulting related to folding along the Danforth Hills anticline is common, and fracturing and minor displacements have accompanied the removal of thick coals by burning.

Older, published elevation and outcrop data for the Danforth Hills coal field and adjacent areas is of uncertain quality because of the small-scale and now-obsolete methods used for preparing topographic bases (Gale, 1910). Perhaps the best sources for structural information for much of the study area are the Meeker quadrangle geologic map (1:62,500 scale) by Hancock and Eby (1930) and the Axial quadrangle geologic map (1:62,500 scale) by Hancock (1925) who constructed structure contours on the top the Trout Creek Sandstone Member of the Iles Formation. Geologic mapping and exploration drilling by Nutt (1981), Reheis (1976, 1978a, 1978b, 1981, 1983a, 1983b), and Izett and others (1985) provided additional structural information for some parts of the study area. Information derived from an analysis of drill-hole data during the present study was used to further update and construct the final structure contour map shown in figure A, plate 1.

## Coal Geology of the Danforth Hills Coal Field

### Stratigraphy

The coal-bearing intervals in the Iles and Williams Fork Formations of the Mesaverde Group in the Danforth Hills were stratigraphically subdivided into six coal units (see figs. 3 and 4) by Hancock and Eby (1930). The Iles was subdivided into two units, the lower and the Black Diamond coal groups. The Williams Fork was subdivided into three coal units and one barren interval. In ascending order, these units are Fairfield coal group, the barren interval, the Goff coal group, and the Lion Canyon coal group.

Along the northern and eastern margins of the study area, thin coal beds occur in the lower coal group between 100 to 250 ft above the base of the Iles Formation. The lower coal group consists of a few thin coal beds and thick beds of carbonaceous shale associated with thick, cliff-forming sandstones north of Meeker, Colo. (fig. A on pl. 1). These coals were used for local consumption in the late 1800's and are presently of little economic value. The principal coal beds of the Iles Formation occur in the upper part, within an interval from 150 to 350 ft below the top the Trout Creek Sandstone. This coal-bearing interval was named for the Black Diamond coal mine (Hancock and Eby, 1930) north of Meeker (fig. A on pl. 1). The Black Diamond coal group commonly contains four to six coal beds that were extensively developed in the late 1800's and early 1900's owing to their proximity to the town. This coal interval thins eastward and also has little current economic value. The Iles Formation is predominately terrestrial in origin and consists of thick beds of sandstone interbedded with mudstone, carbonaceous shale, and coals deposited in a coastal-plain environment.

The Williams Fork Formation contains the thickest and economically the most important coal beds in the Danforth Hills coal field. Data from drill holes and geologic maps indicates that the formation is about 3,000 to 3,500 ft thick. Thickness of the Fairfield coal group at the base of the Williams Fork averages 1,300 ft (Hancock and Eby, 1930), but the complete interval was rarely penetrated in the drill holes studied. This coal group was named for the Fairfield mine near the town of Meeker (fig. A on pl. 1 ). The Fairfield coal group is equivalent to the Cameo-Wheeler coal zone in the southern part of the Piceance Basin and to the Wheeler-Fairfield coal zone along the southern part of the Grand Hogback (Hettinger and others, chap. O, this CD-ROM). It is correlated to the middle coal group of the William Fork Formation (fig. 2) in the Yampa coal field (Johnson and others, chap. P, this CD-ROM). The Fairfield coal group is predominately terrestrial in origin and consists of thin to thick beds of sandstone interbedded with mudstone, carbonaceous shale, and coal deposited in a coastal-plain environment.

A regionally persistent tonstein (altered ash-fall tuff) named the Yampa bed by Brownfield and Johnson (1986) occurs in the lower part of the Fairfield coal group of the Williams Fork Formation (pl. 1, fig. C and fig. 4). Where exposed on the surface or observed in drill core, this unit is a white to grayish white structureless claystone. In the subsurface, it serves as an important regional marker bed that is easily identified on geophysical logs. The Yampa bed ranges in thickness from less than 1 ft to more than 3 ft. In the central and western parts of the coal field, the unit lies between 100 and 300 ft above the top of the Trout Creek Sandstone, respectively. However, in the northern part of the coal field the stratigraphic separation is less than 100 ft. The age of the Yampa bed, 72.5±5.1 Ma, was determined using K-Ar dating methods on andesine. The tonstein was used to as a datum for the correlation of coal beds in the Fairfield coal group throughout the Danforth Hill coal field (pl. 1, fig. C).

The Goff coal group named after the Goff ranch (Hancock and Eby, 1930) averages 700 ft thick and consists of sandstone, mudstone, carbonaceous shale, and coal. The unit is separated from the Fairfield coal group below by approximately 1,000 ft of strata that are virtually barren of coal called the barren interval by Hancock and Eby (1930). Drill holes and outcrops in the Sulphur Creek syncline area contain coals assigned to the Goff coal group. The Lion Canyon coal group of Hancock and Eby (1930) averages 1,000 ft thick and directly overlies the Lion Canyon Sandstone (figs. 3 and 4) in the southwestern and western part of the Danforth Hills coal field. The Lion Canyon coal group consists of sandstone, mudstones, carbonaceous shale, and thin lenticular coal beds. The barren interval and the Goff and Lion Canyon coal groups were not assessed in this study.

## Coal Distribution in the Fairfield Coal Group

The Fairfield coal group was the only unit for which resources were assessed in this study. The coal group directly overlies the Trout Creek Sandstone and has average an maximum thicknesses of 1,130 ft and 1,770 ft, respectively, based on available drill-hole data. For this study, the Fairfield coal group was subdivided into seven coal zones in order to focus on the most important coal resources and resources were calculated for each coal zone. We were generally able to reliably identify and trace the individual zones across the area (fig. C on pl. 1).

The Fairfield coal group includes the FGA, FGB, FGC, FGD, FGE, FGF, and FGG coal zones (fig. C on pl. 1 and fig. 4). The average thickness and average stratigraphic distance above the Trout Creek are shown for each zone in table 2. The range in the number of coal beds with net-coal thickness greater than 1.2 ft (Wood and others, 1983) is also shown. The Fairfield coal group contains at least 26 coal beds that have maximum thicknesses greater than 5 ft; 20 of these coal beds have a thicknesses greater than 12 ft. The deeper drill holes, which penetrated most of the Fairfield coal group, consistently contain total net-coal thicknesses greater than 100 ft. Total net-coal thickness greater than 200 ft occurs in a few of the deep drill holes that penetrated coals of the Fairfield, Goff, and Lion Canyon coal groups. The thickest net-coal deposits in the study area occur where there is a merging of several coal beds. The most significant deposits of this type occur in the FGB and FGE zones, which locally have net-coal coal thicknesses of 40 to 80 ft in intervals that have only minor partings. These intervals are known only from drill holes and have not been observed in outcrop.

The FGA coal zone of the Fairfield coal group (FGA coal zone, fig. C, pl. 1) directly overlies the Trout Creek Sandstone Member of the Iles Formation; it ranges in thickness from 17 to 280 ft and contains as many as five coal beds. The FGA coal-thickness map (fig. 6) displays the thickest total net coal (>30 ft) in townships T. 2 N., R. 93 W.; T. 4 N., Rs. 92 and 93 W. The FGB zone ranges in thickness from 6 to 230 ft, with at least five coal beds having a net-coal thickness of 20–30 ft over much of the area and 60 ft or more in T. 2 N., Rs. 92 and 93 W. (fig. 7). Zone FGC, 12 to 195 ft thick, contains as many as five coal beds. The coal-thickness map (fig. 8) shows net-coal thickness to range from 10 to 30 ft with the thickest (>

40 ft) occurring in the central part of the Danforth Hills (Tps. 2 and 3 N., R. 93 W.). The FGD zone ranges in thickness from 3.5 to 248 ft and contains as many as four coal beds. Figure 9 shows a uniform distribution of total net-coal thickness ranging from 10 to 20 ft thick for this zone over most of the study area, and a maximum greater than 30 ft locally in the southeastern part. The FGE zone, 7.5 to 500 ft thick, contains at least nine coal beds with thicknesses generally ranging from 10 to 50 ft, but exceeding 60 ft in several areas (fig. 10). In the FGF zone, which ranges in thickness from 3 to 310 ft, there are as many as seven coal beds with total net coal ranging in thickness from 10 to more than 40 ft (fig. 11). This zone contains pods of coal greater than 30 ft thick in several townships (Tps. 2, 3, and 4 N., Rs. 93 and 94 W.). The FGG zone ranges in thickness from 2.5 to 410 ft and contains at least six coal beds. The coal-thickness map (fig. 12) generally displays a uniform distribution of total net coal ranging in thickness from 5 to more than 20 ft. The variability in total net-coal thicknesses in the Fairfield coal group coal zones within the study area is due in part to the lenticularity and the varying number of beds within each coal zone.

Overburden-thickness maps (figs. 13–19) were constructed for each of the Fairfield coal zones based on depths where the elevation to the base of each zone was combined with the digital elevation data for the study area. Overburden is thickest along the southwest margin of the study area where the generally northwest-striking rocks of the Fairfield coal group dip from 30° to 50° to the southwest. Other areas of thick overburden are related to the Collom, Elkhorn, and Sulphur Creek synclines. The overburden thickness along the axis of the Sulphur Creek syncline is greater than 2,000 ft for the FGA through FGF zones, whereas the thinnest overburden areas are generally related to the crest of the Danforth Hills anticline and (or) near outcrops of the Trout Creek Sandstone. Only the FGE, FGF, and FGG zones in the north half of the study area have extensive areas where the overburden thickness is less than 500 ft (figs. 17–19). This is the area where the Colowyo strip mine is located.

Net-coal-thickness category (Wood and others, 1983, p. 34) maps (figs. 20–26) generally show net-coal-thickness trends that are in agreement with the coal isopach maps. The FGB, FGC, FGE, and FGF coal zones (figs. 21, 22, 24, 25, respectively) display the largest areas where total net-coal thickness exceeds 14 ft.

## Coal Quality

Gale (1910) reported that coal analyses for several mines in the southern part of the Danforth Hills coal field showed values for the heat of combustion to be 11,210 to 12,000 Btu/lb, total sulfur content ranges to vary from 0.33 to 1.42 percent, and ash yields to range from 5.2 to 5.52 percent on an as-received basis. Analytical data reported by Hancock (1925) for several mines in the northern part of the Danforth Hills shows heat of combustion to range from 10,140 to 11,830 Btu/lb, total sulfur content to range from 0.3 to 1.12 percent, and ash yields to range from 4.6 to 7.4 percent on an as-received basis. Coal quality data from Hancock and Eby (1930) for coals in several mines in the Meeker 15′ quadrangle, in the southwestern part of the Danforth Hills, suggest that the heat of combustion ranges from 10,790 to 11,490 Btu/lb, total sulfur content ranges from 0.28 to 1.36 percent, and ash yields range from 2.2 to 9.6 percent on an as-received basis. The above analyses yield an apparent rank of high-volatile C bituminous using the Parr formula (American Society for Testing and Materials, 1997, D388-95). The Colowyo mine shipped about 4.6 million short tons of coal in 1994 with a with a mean heat of combustion of 10,550 Btu/lb, total sulfur content of 0.039 percent, moisture content of 16.54 percent, and an ash-yield content of 5.32 percent (S.K. Allen, Colowyo Coal Company, written commun., 1996).

In the present study, the 47 coal samples from the Danforth Hills coal field (table 3) were determined to be high-volatile C bituminous in apparent rank (Parr formula, American Society for Testing and Materials, 1997, D388-95)

*Text continues on page 35*

**Table 2.** Fairfield coal zones of the Williams Fork Formation showing, thickness range, average thickness, number of coal beds, general net-coal thickness range, maximum net-coal thickness, and average stratigraphic distance above the Trout Creek Sandstone Member of the Iles Formation, Mesaverde Group, Danforth Hills coal field.

| Fairfield coal zone | Thickness range (feet) | Average zone thickness (feet) | Average stratigraphic distance above Trout Creek Sandstone Member (feet) | Number of coal beds in zone | General net-coal thickness range (feet) | Maximum net-coal thickness (feet) |
|---|---|---|---|---|---|---|
| FGG | 2.5-410 | 160 | 970 | 1 to 6 | 5-20 | >30 |
| FGF | 3-310 | 210 | 760 | 1 to 7 | 10-40 | >40 |
| FGE | 7.5-500 | 280 | 480 | 1 to 9 | 10-50 | >60 |
| FGD | 3.5-248 | 120 | 360 | 1 to 4 | 10-20 | >30 |
| FGC | 12-195 | 115 | 240 | 1 to 5 | 10-30 | >40 |
| FGB | 6-230 | 110 | 130 | 1 to 5 | 20-30 | >60 |
| FGA | 17-280 | 130 | 0 | 1 to 5 | 10-20 | >30 |

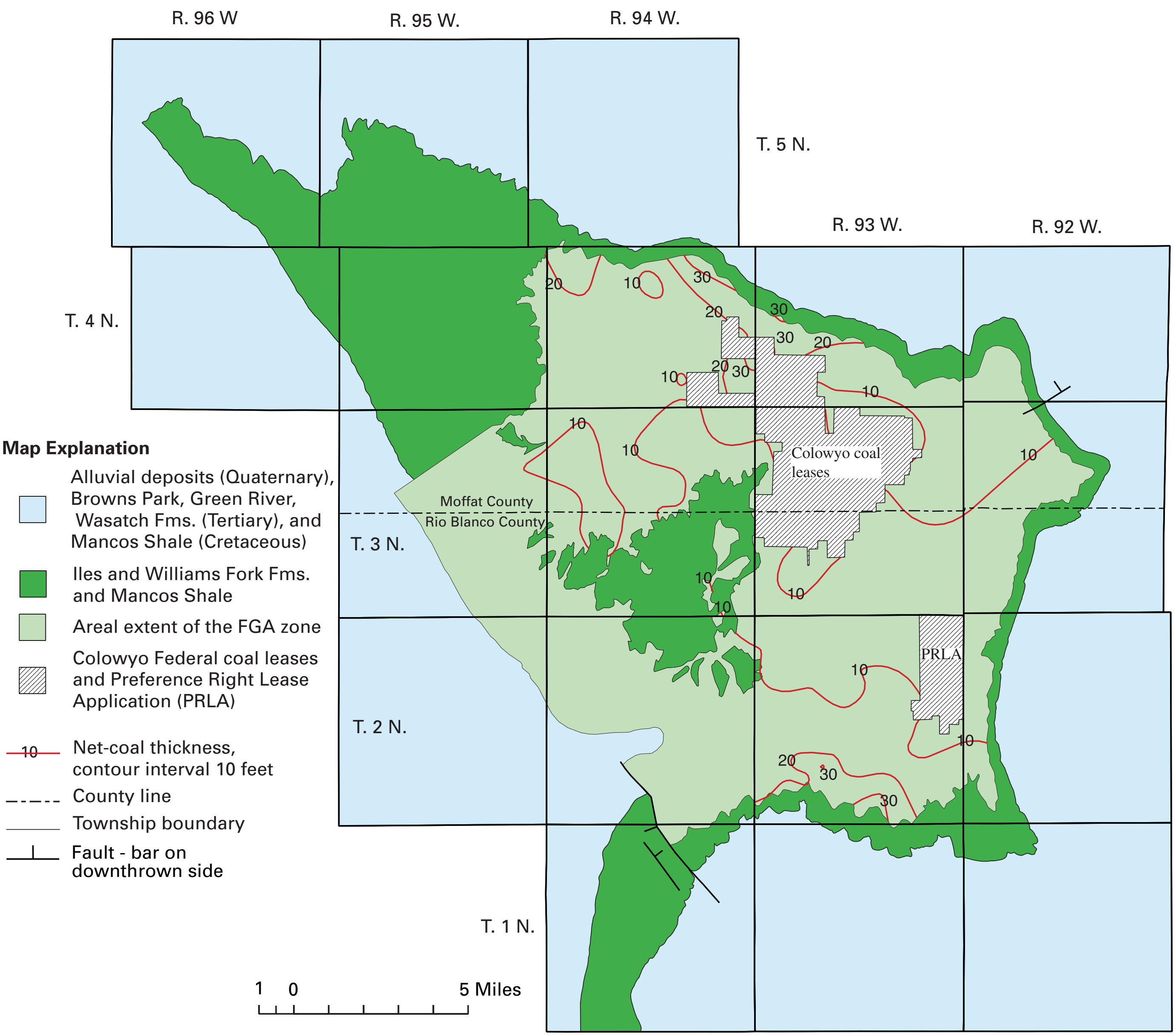



**Figure 6.** Map showing total net-coal thickness for the FGA coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGA zone shown in light green. Data not shown for the Colowyo Federal and State coal leases or PRLA.

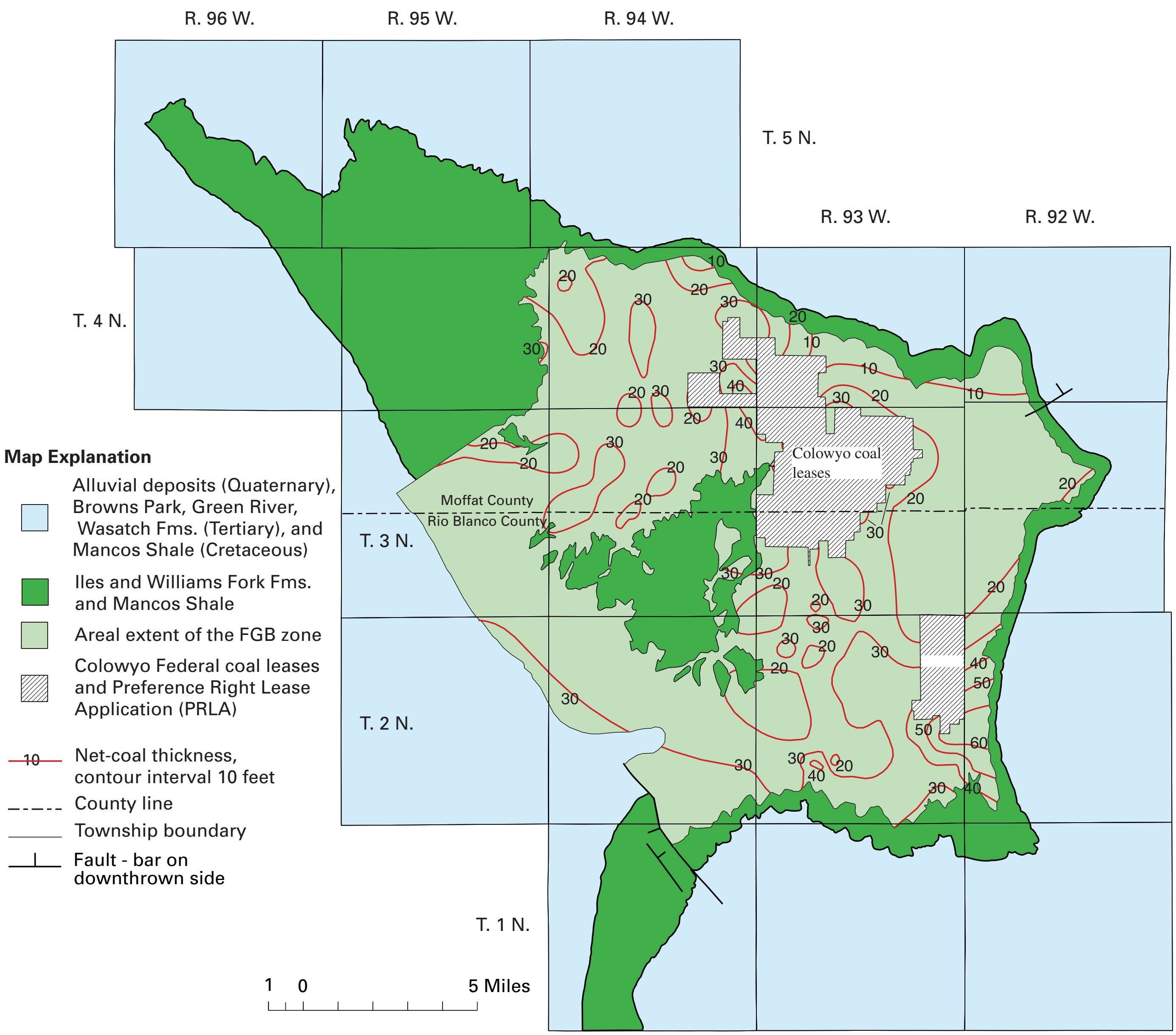



**Figure 7.** Map showing total net-coal thickness for the FGB coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGB zone shown in light green. Data not shown for the Colowyo Federal and State coal leases or PRLA.

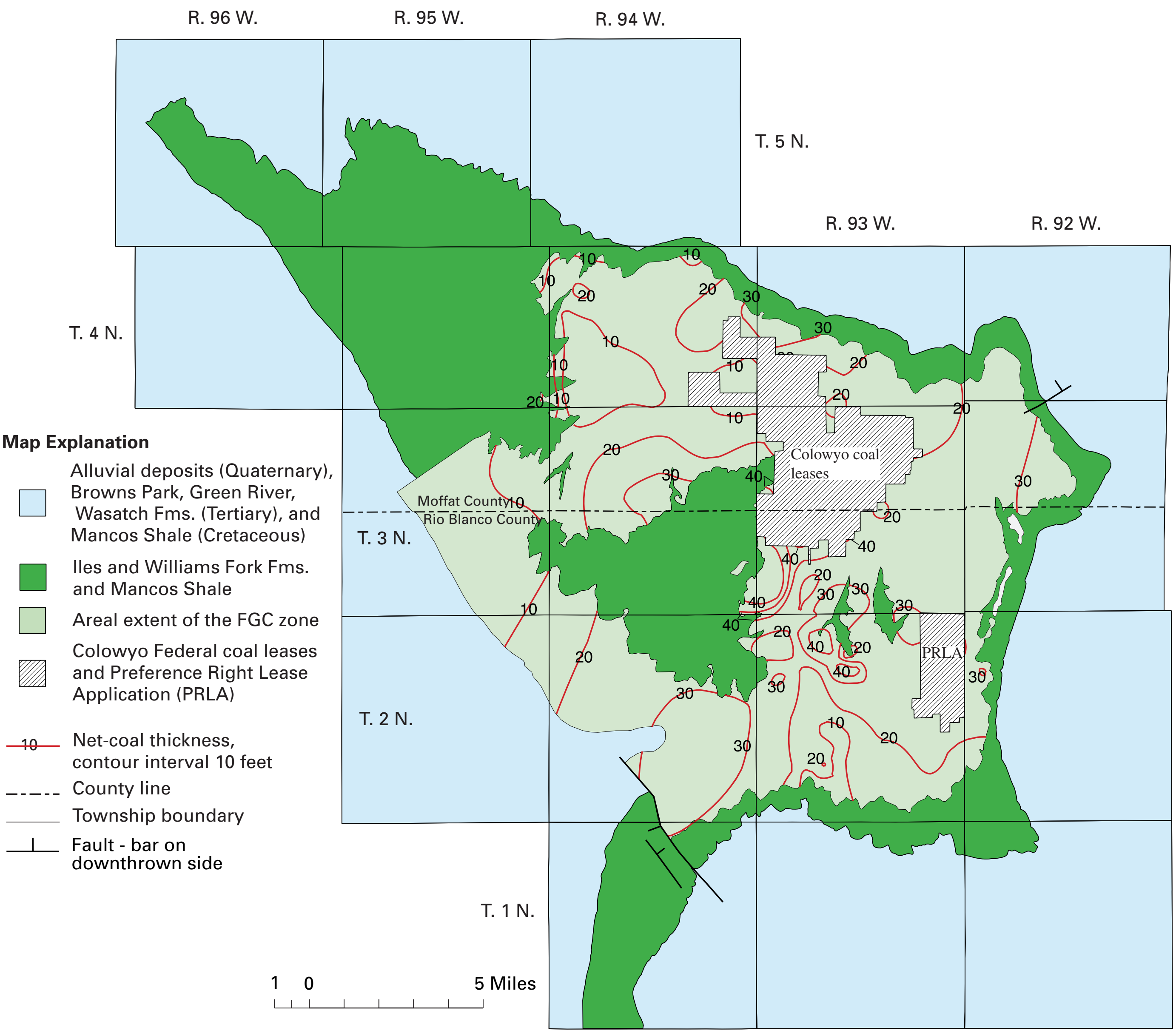



**Figure 8.** Map showing total net-coal thickness for the FGC coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGC zone shown in light green. Data not shown for the Colowyo Federal and State coal leases or PRLA.

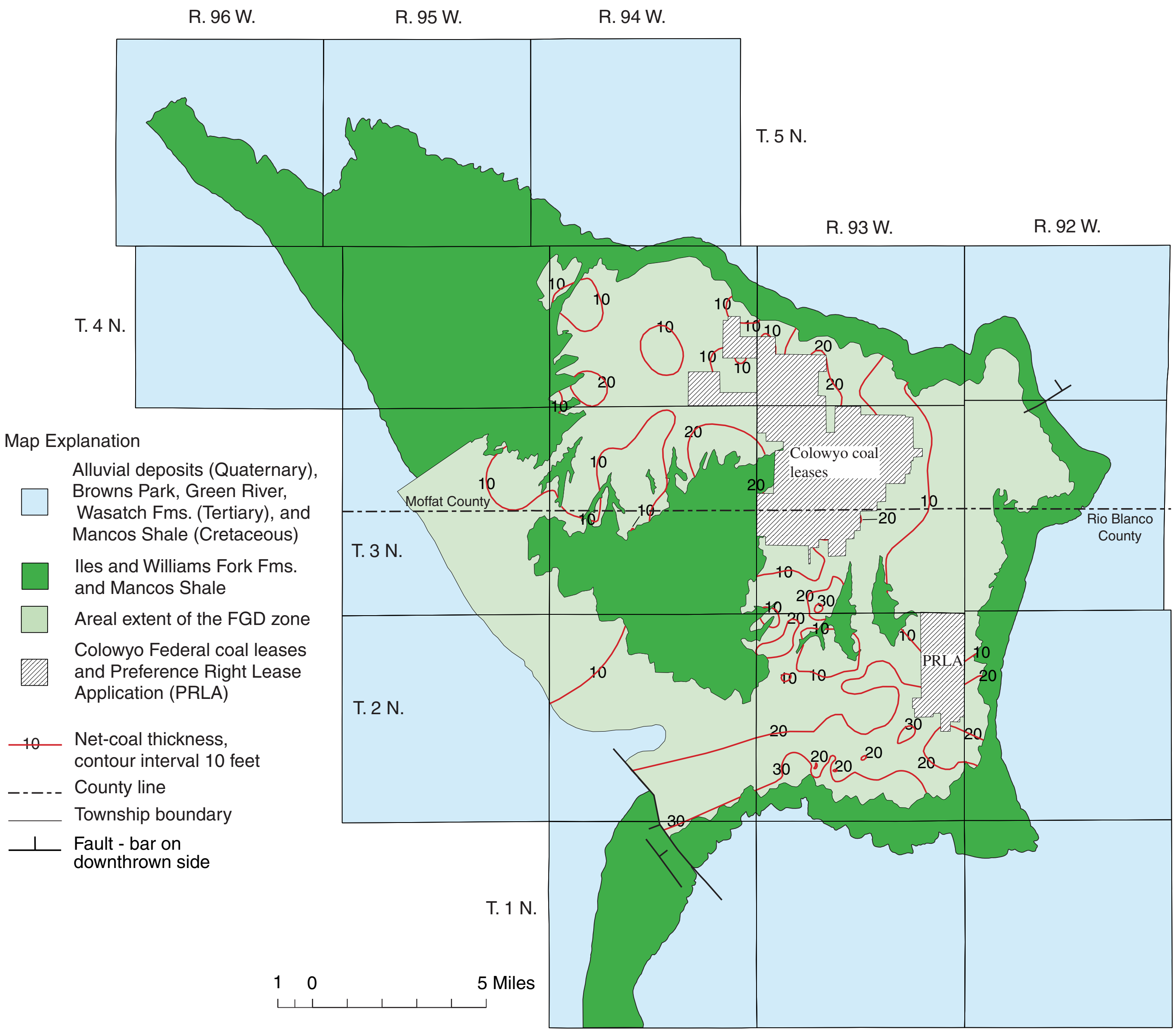



**Figure 9.** Map showing total net-coal thickness for the FGD coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGD zone shown in light green. Data not shown for the Colowyo Federal and State coal leases or PRLA.

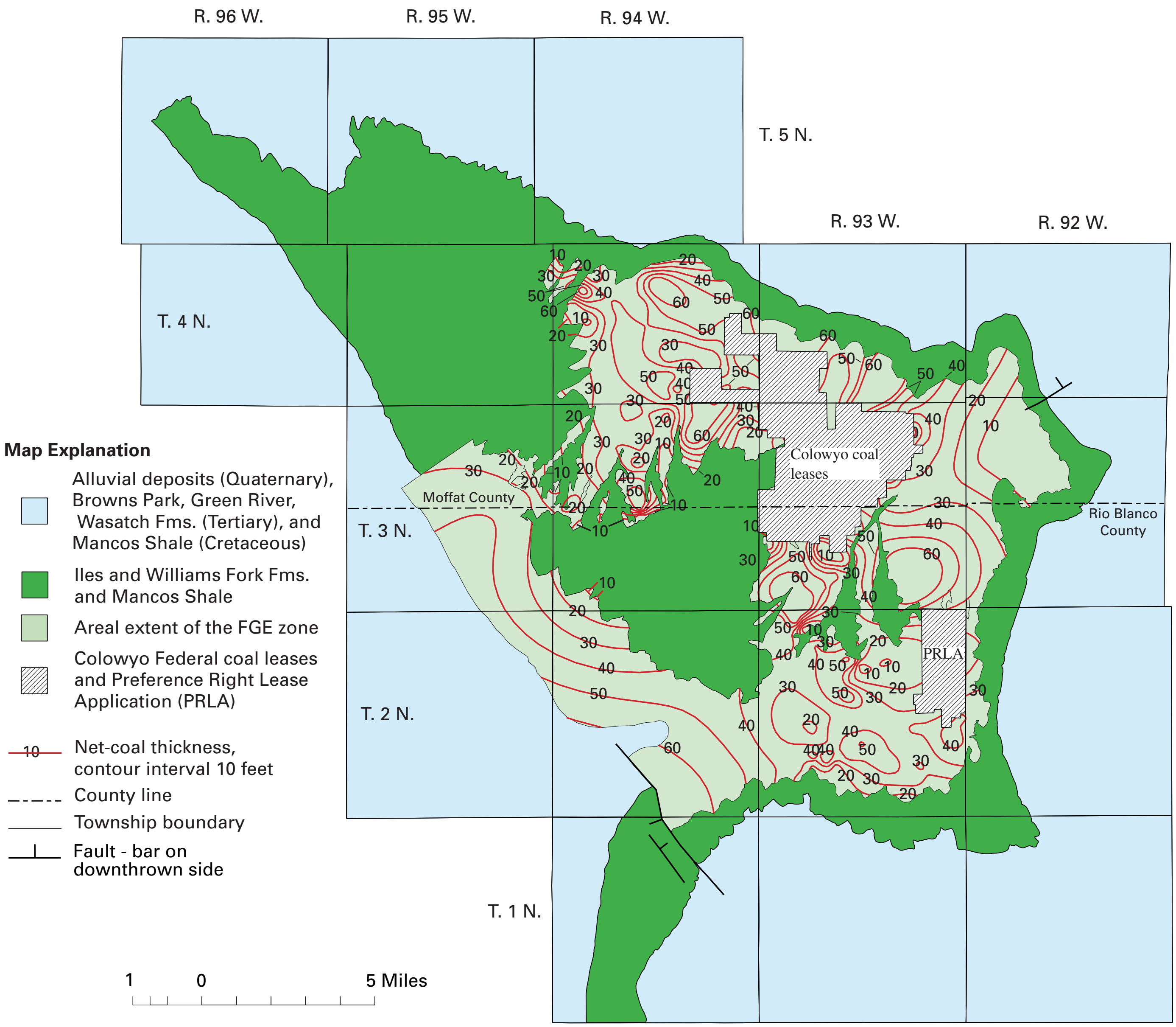



**Figure 10.** Map showing total net-coal thickness for the FGE coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGE zone shown in light green. Data not shown for the Colowyo Federal and State coal leases or PRLA.

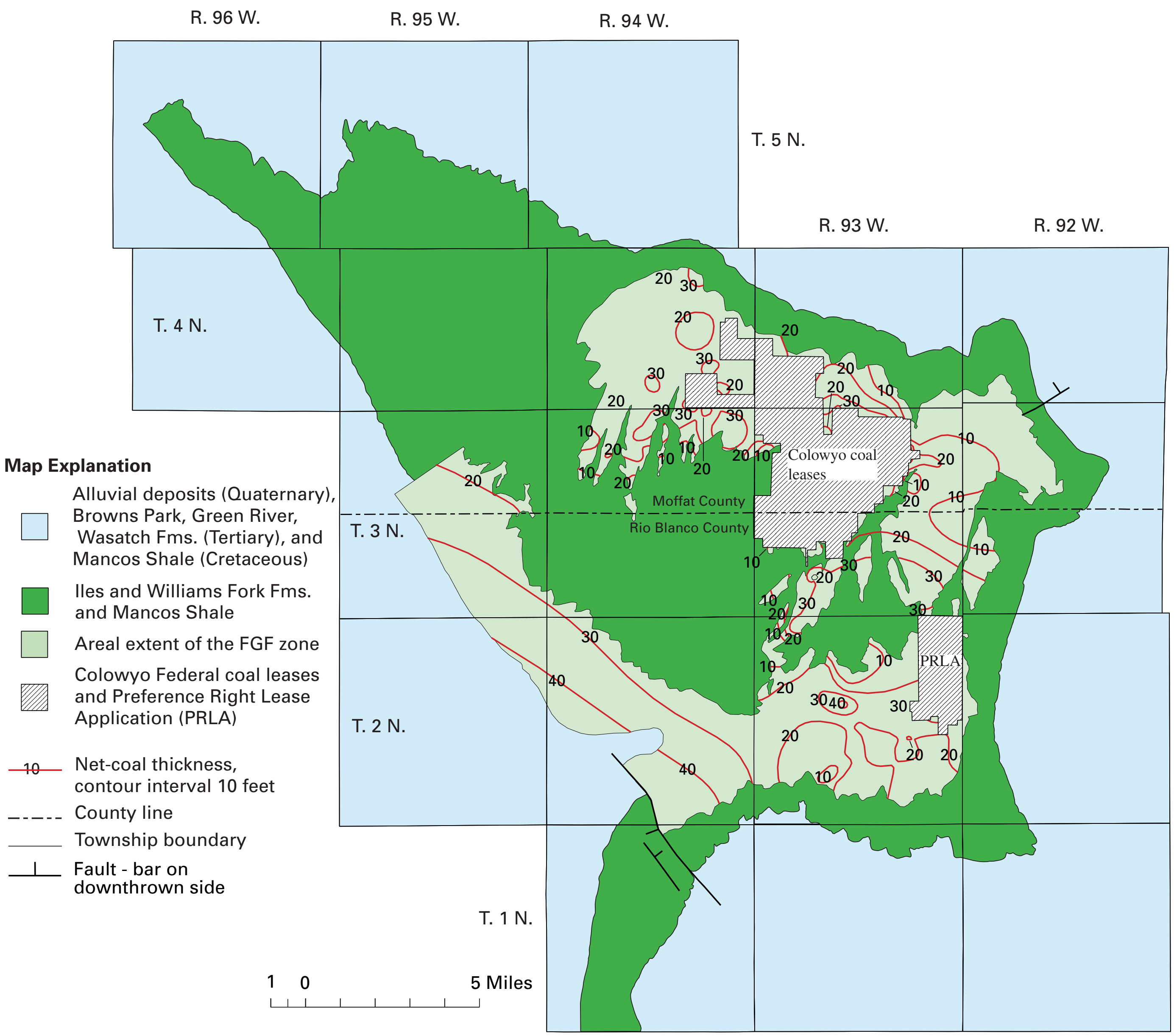



**Figure 11.** Map showing total net-coal thickness for the FGF coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGF zone shown in light green. Data not shown for the Colowyo Federal and State coal leases or PRLA.

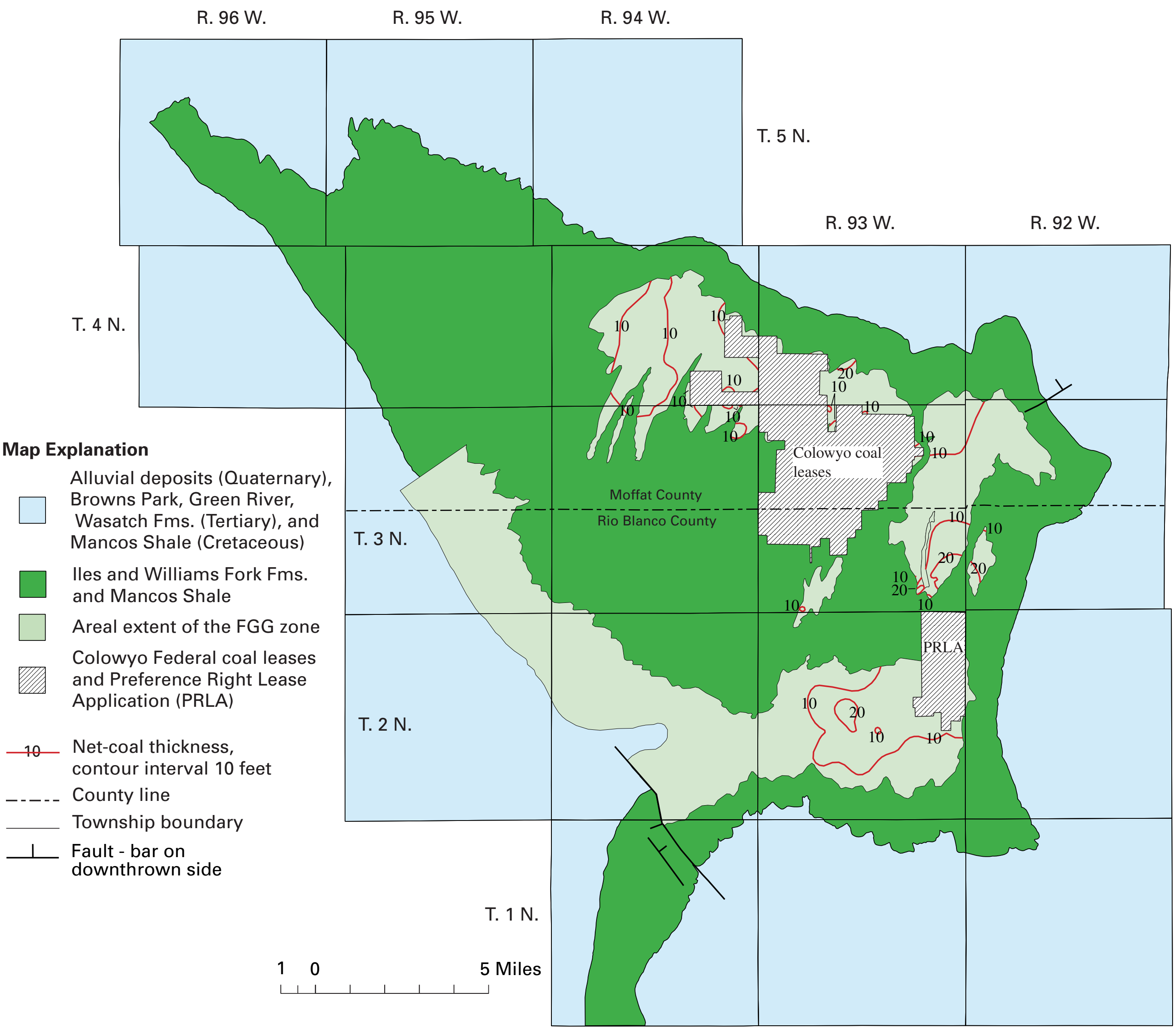



**Figure 12.** Map showing total net-coal thickness for the FGG coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGG zone shown in light green. Data not shown for the Colowyo Federal and State coal leases or PRLA.

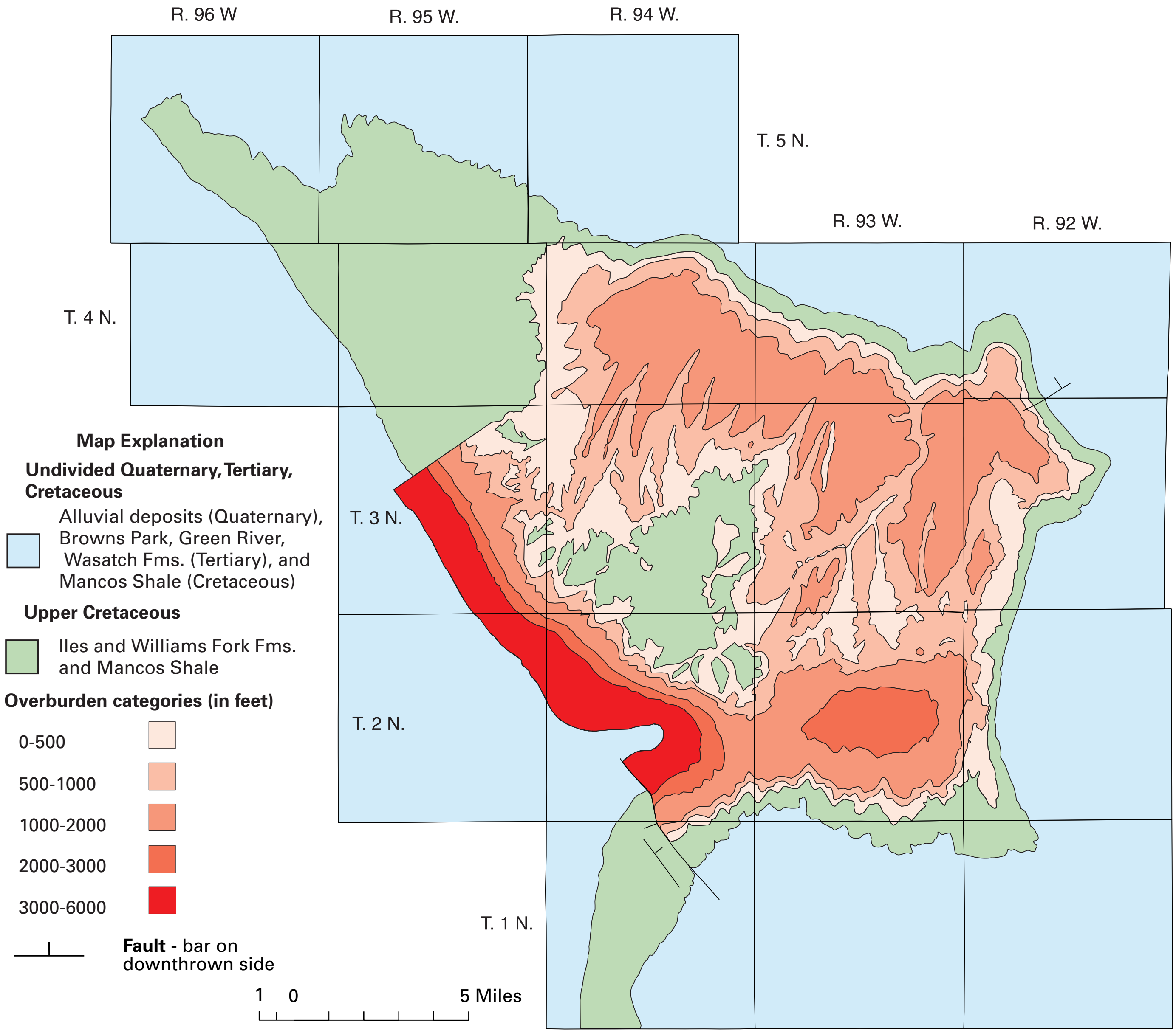



**Figure 13.** Map showing overburden thickness for the FGA coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGA zone is drawn on the top of the Trout Creek Sandstone.

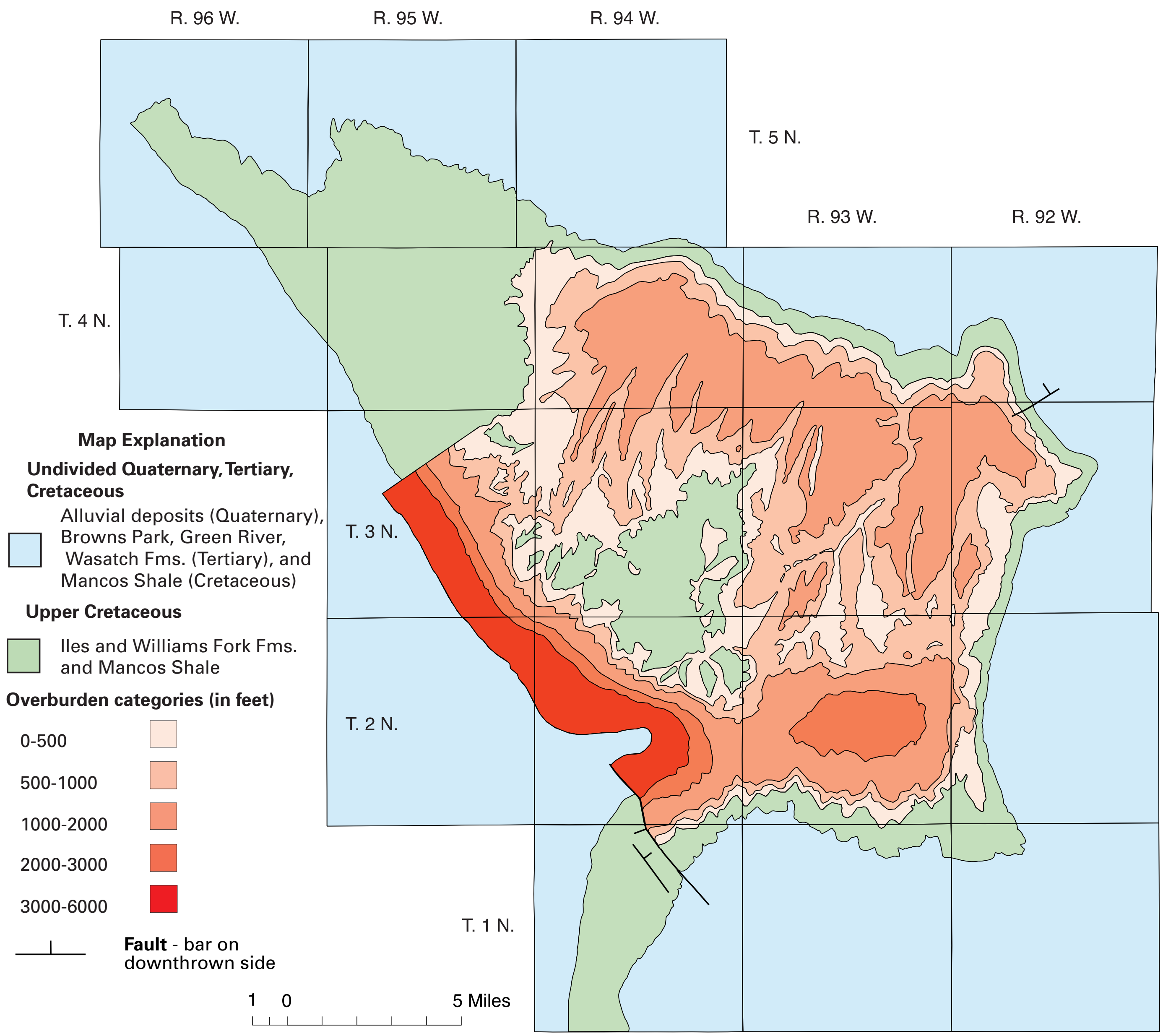



**Figure 14.** Map showing overburden thickness for the FGB coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGB zone is drawn on the top of the Trout Creek Sandstone.

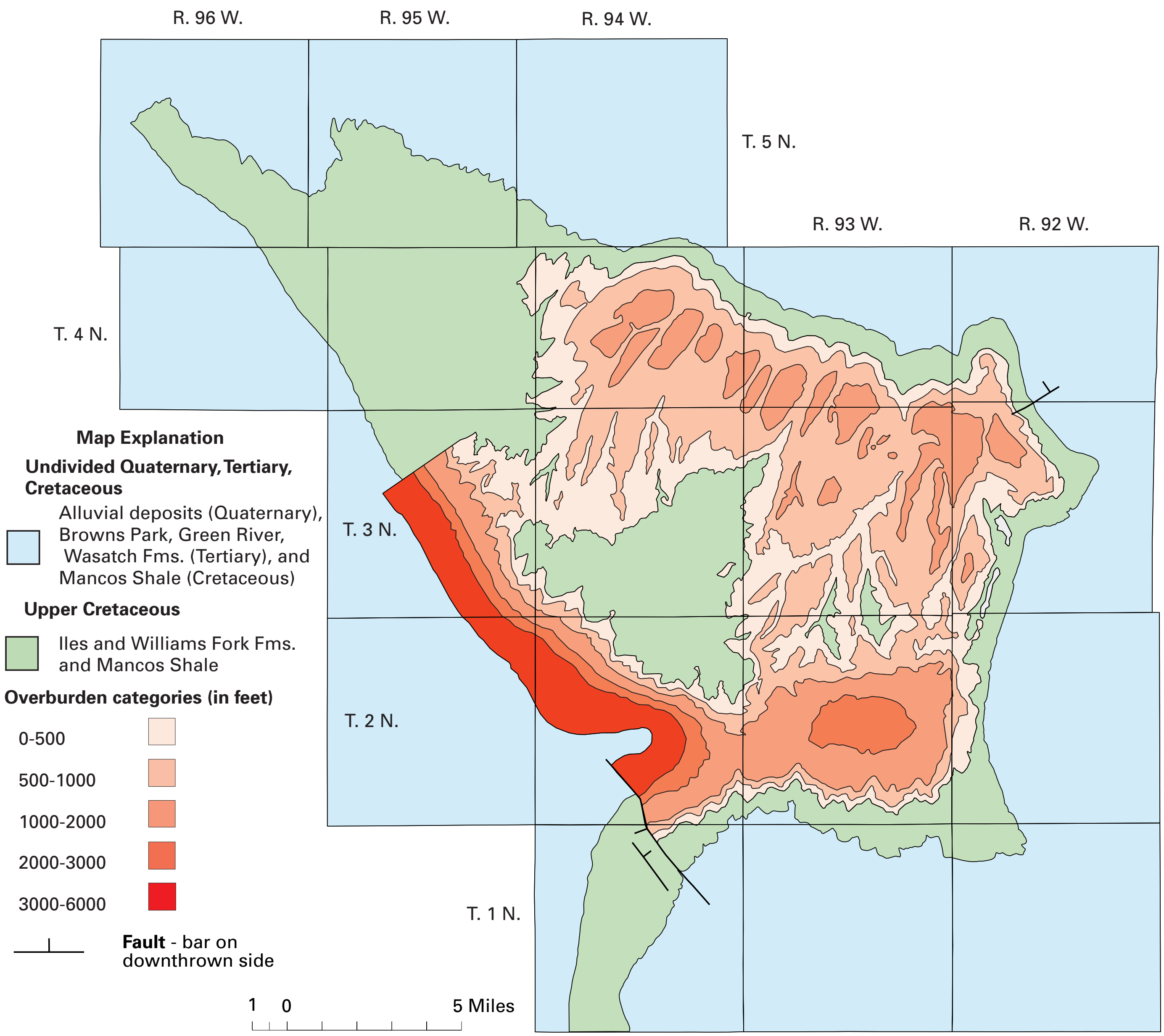



**Figure 15.** Map showing overburden thickness for the FGC coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGC drawn on base of zone.

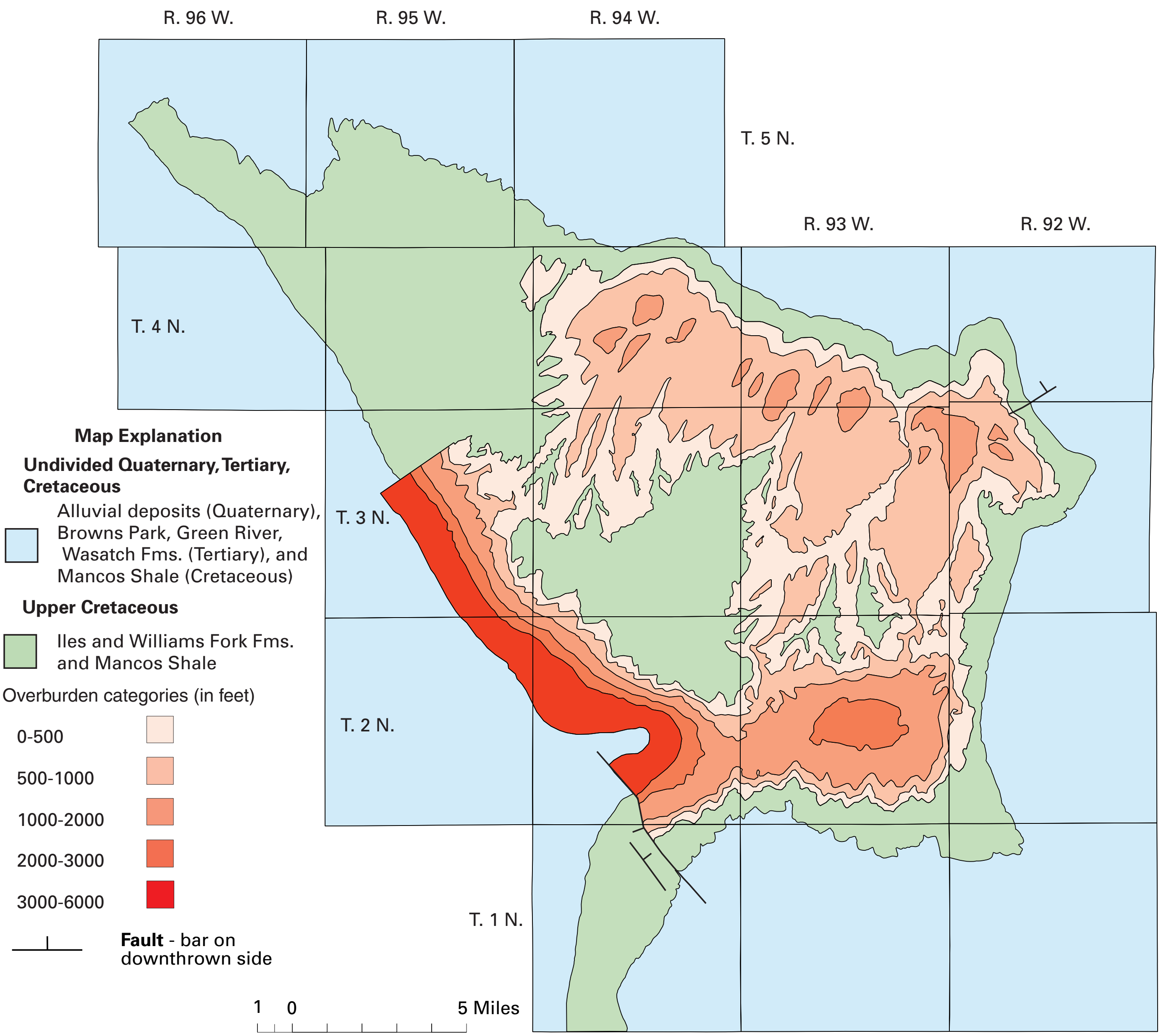



**Figure 16.** Map showing overburden thickness for the FGD coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGD drawn on base of zone.

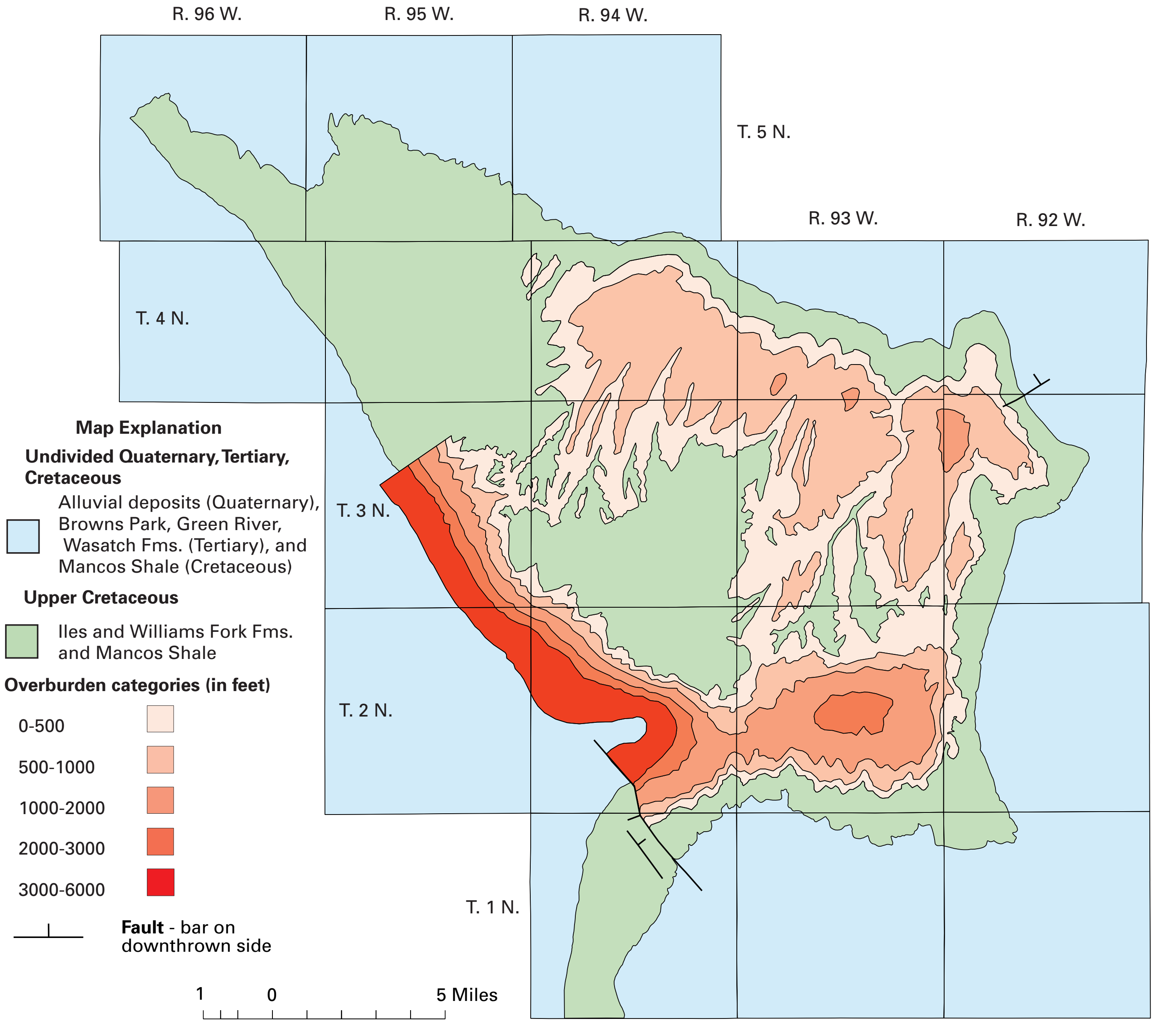



**Figure 17.** Map showing overburden thickness for the FGE coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGE drawn on base of zone. Data not shown for the Colowyo Federal and State coal leases or PRLA.

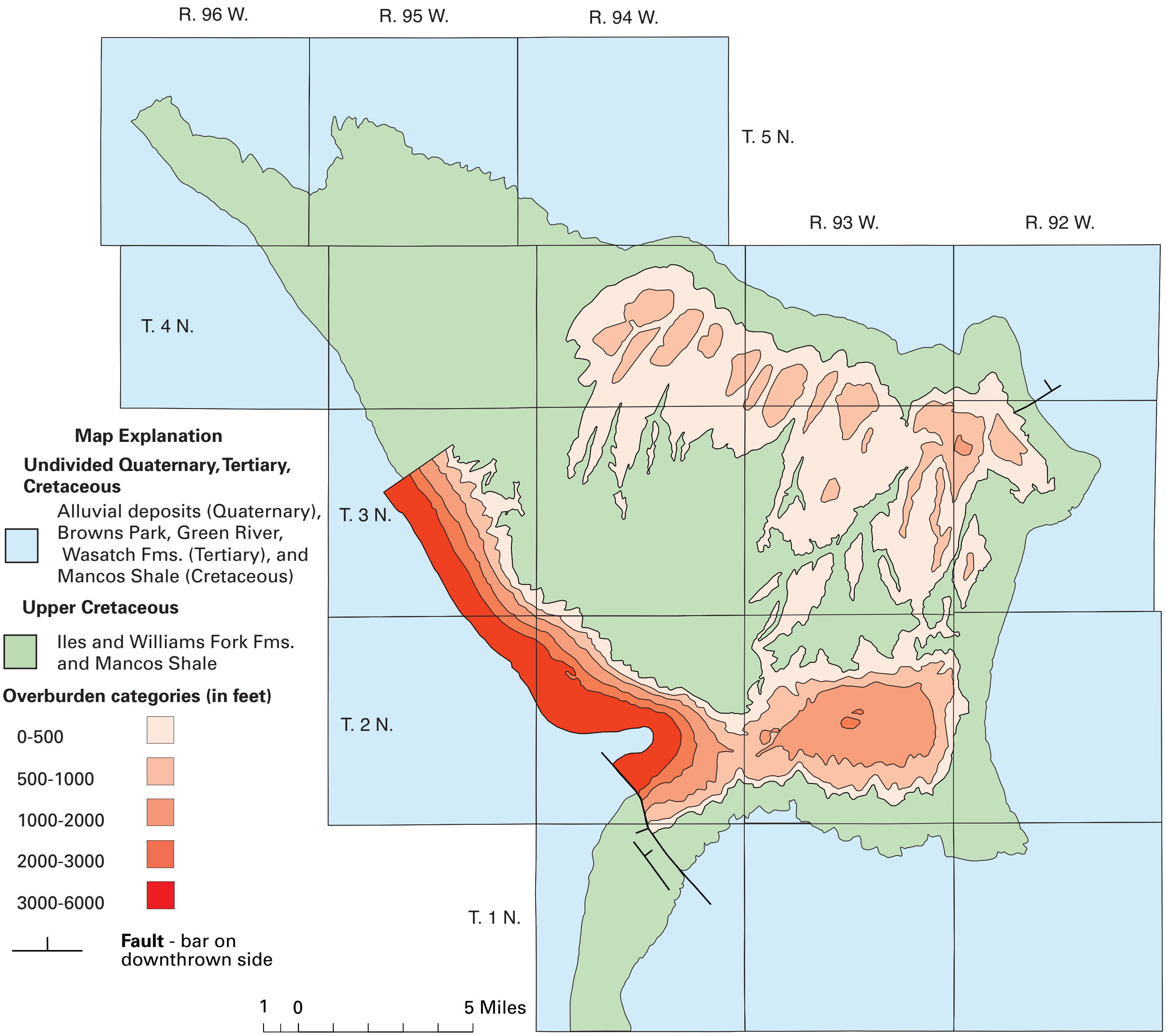



**Figure 18.** Map showing overburden thickness for the FGF coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGF drawn on base of zone.

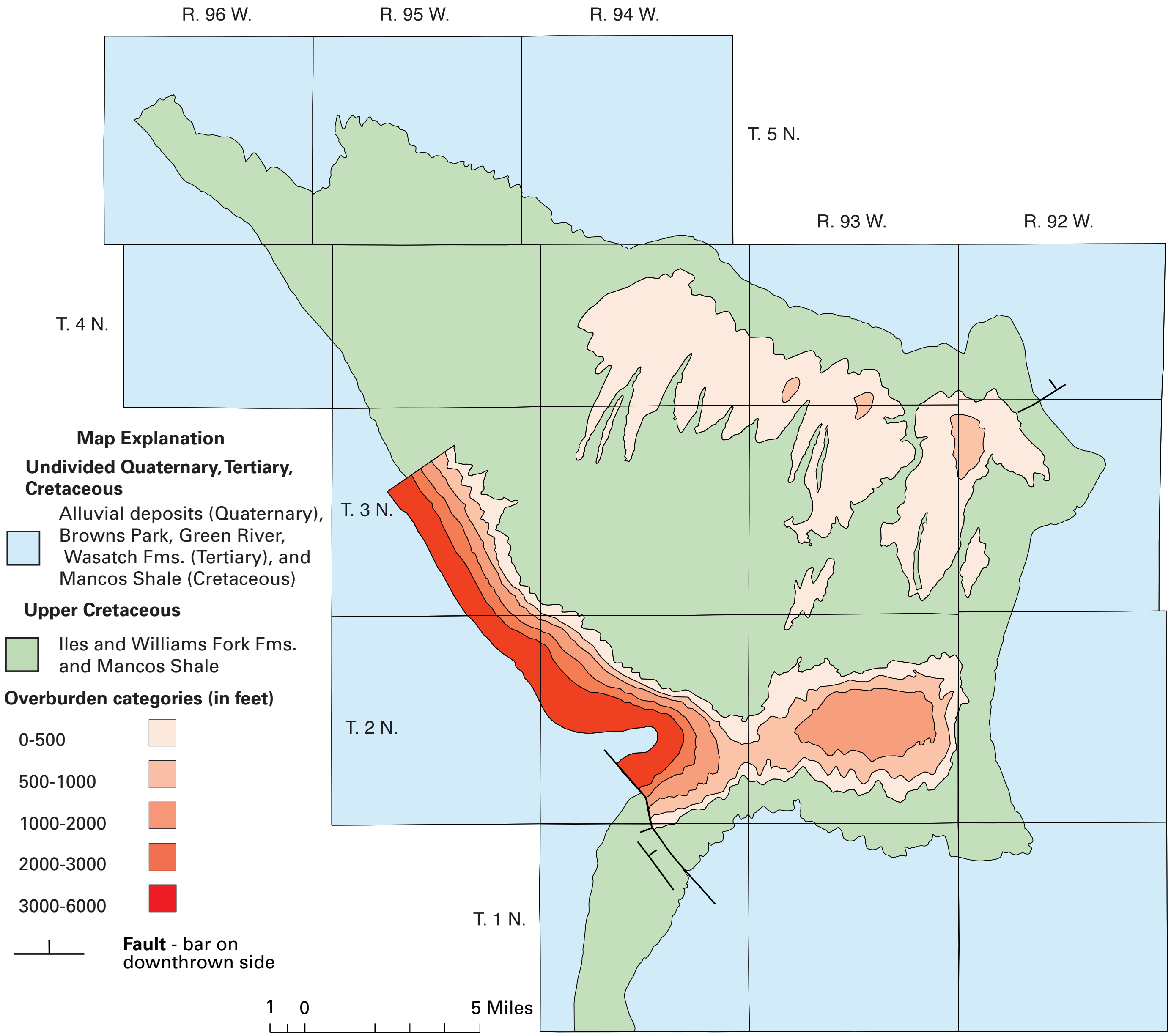



**Figure 19.** Map showing overburden thickness for the FGG coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGG drawn on base of zone.

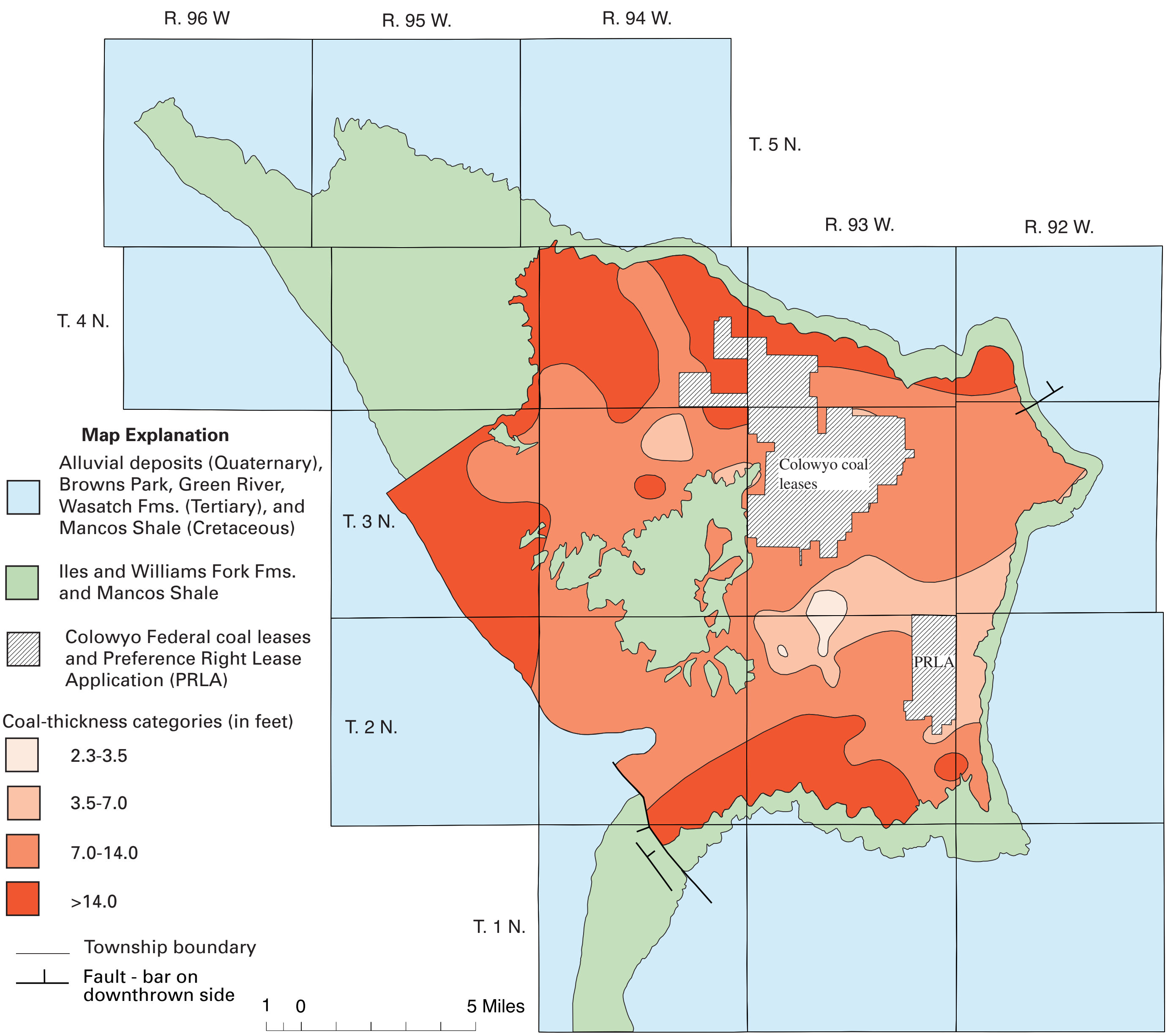



**Figure 20.** Map showing coal-thickness categories for the FGA coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGA drawn on base of zone. Data not shown for the Colowyo Federal and State coal leases or PRLA.

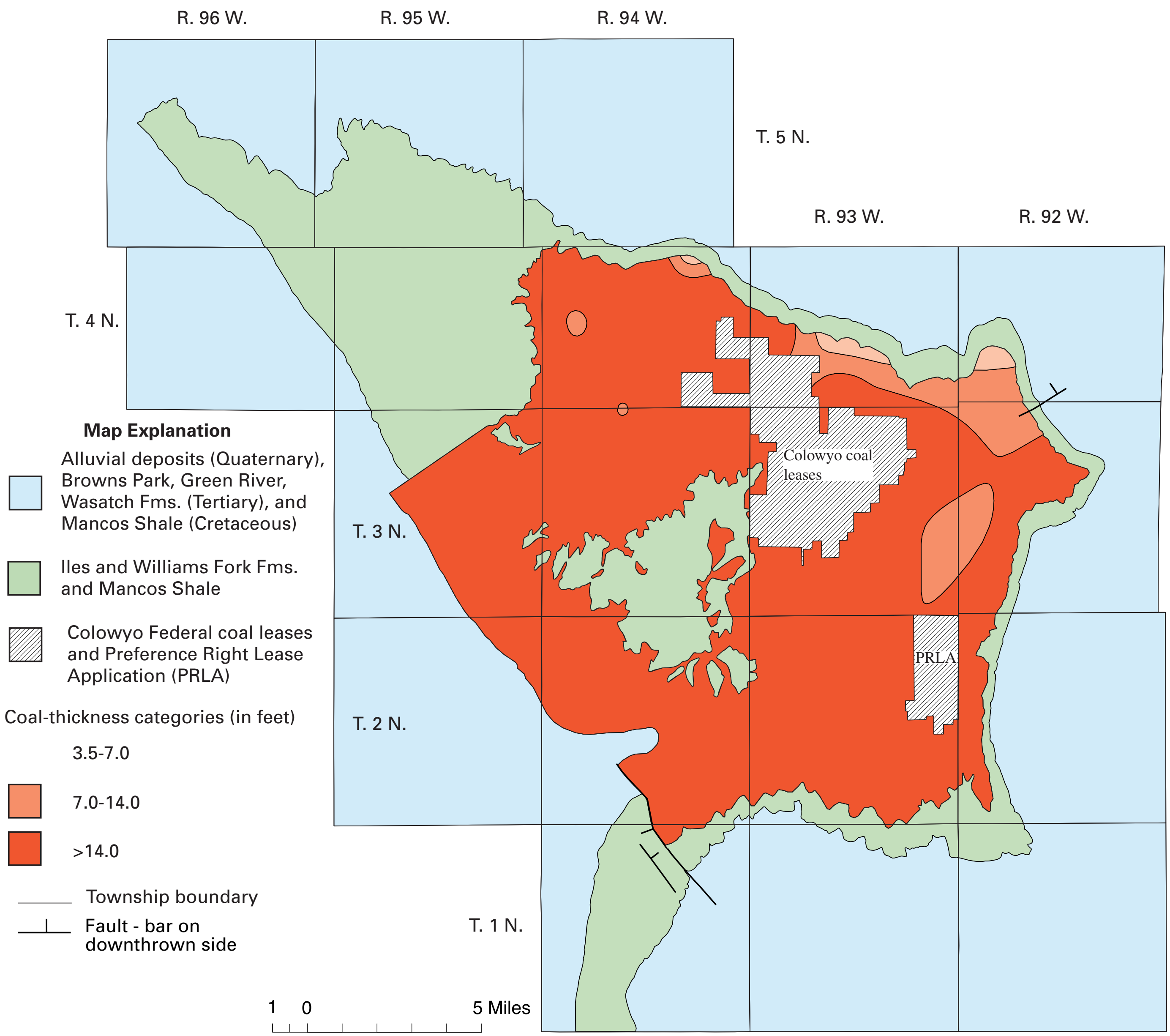



**Figure 21.** Map showing coal-thickness categories for the FGB coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGB drawn on base of zone. Data not shown for the Colowyo Federal and State coal leases or PRLA.

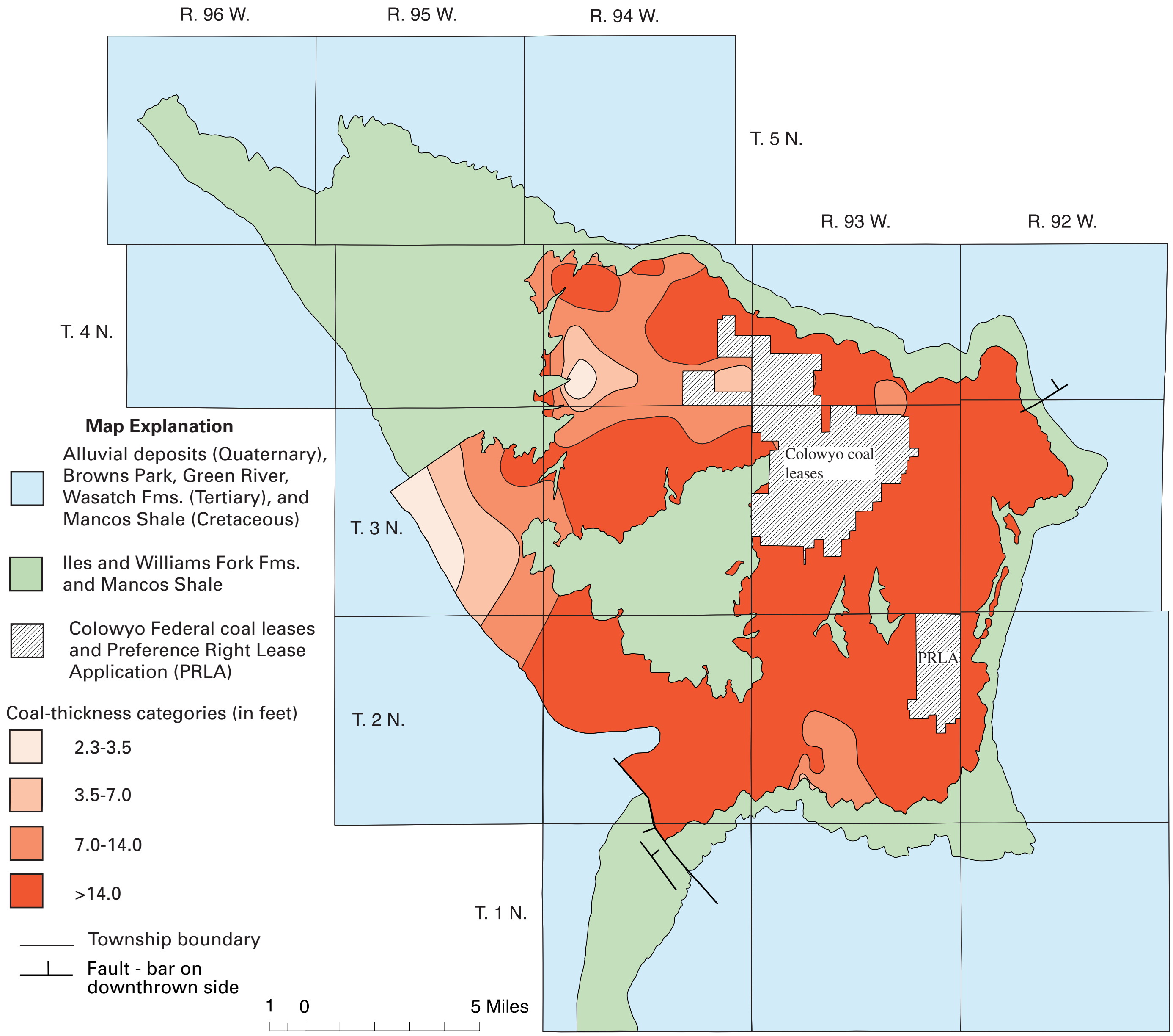



**Figure 22.** Map showing coal-thickness categories for the FGC coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGC drawn on base of zone. Data not shown for the Colowyo Federal and State coal leases or PRLA.

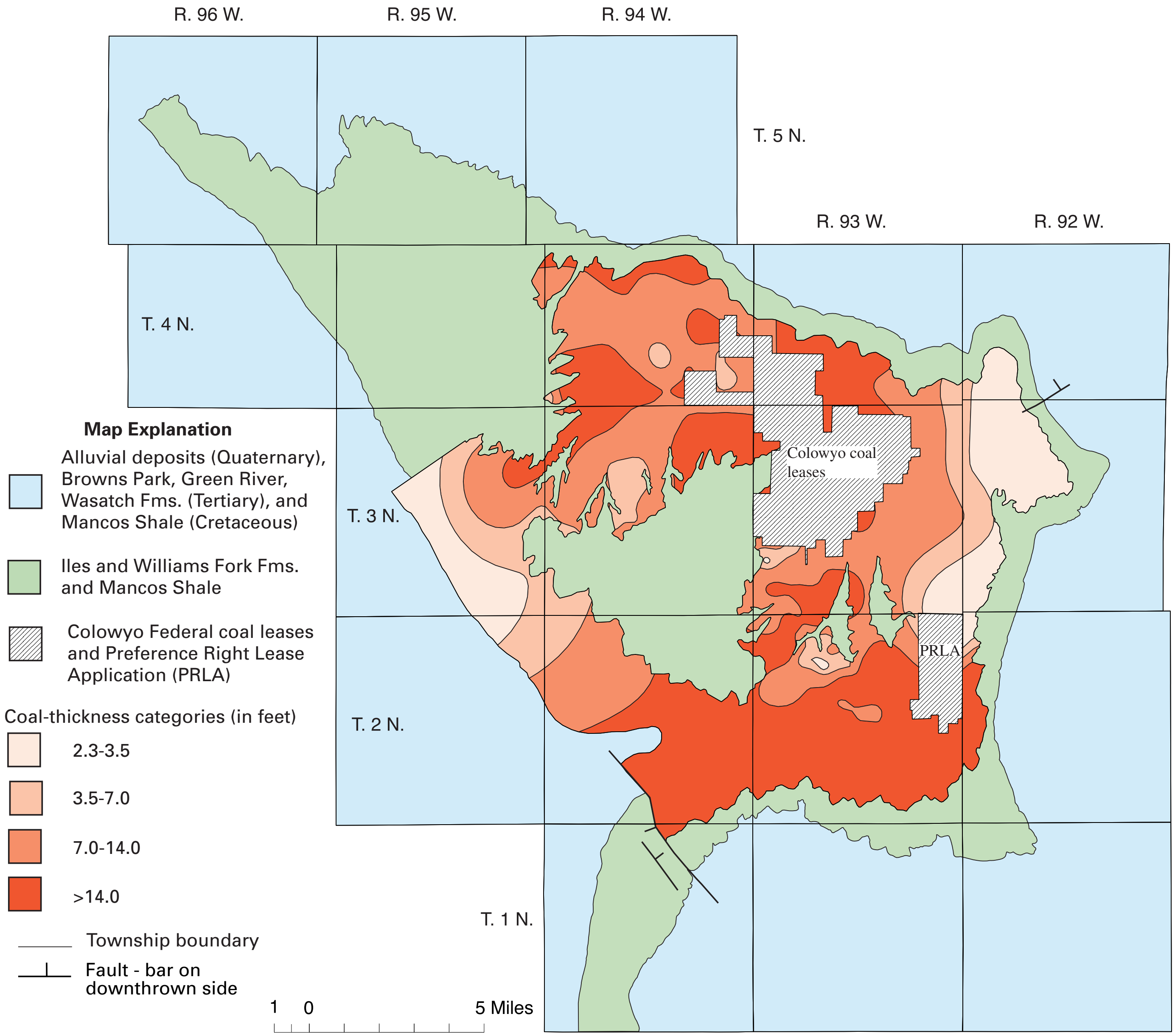



**Figure 23.** Map showing coal-thickness categories for the FGD coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGD drawn on base of zone. Data not shown for the Colowyo Federal and State coal leases or PRLA.

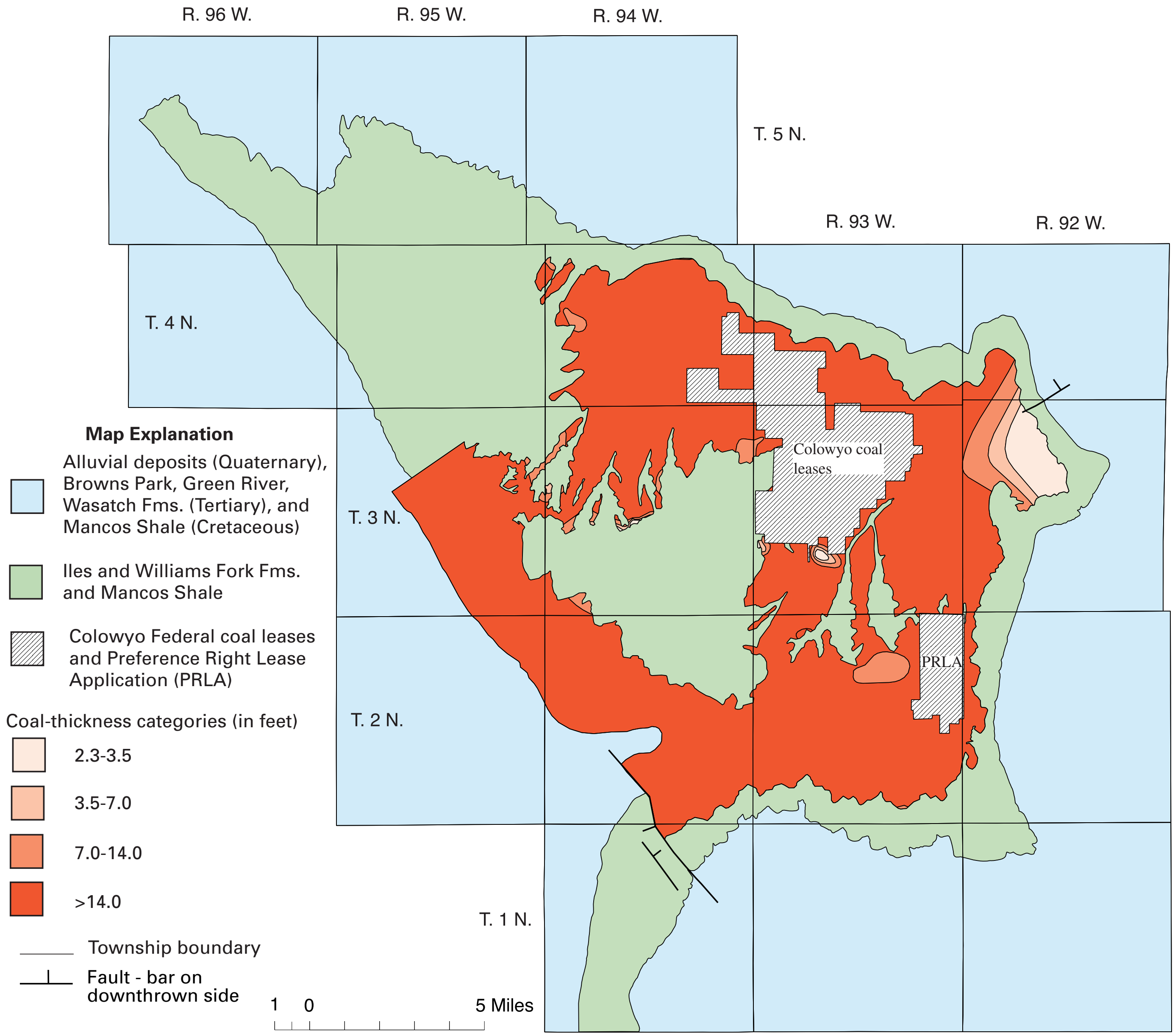



**Figure 24.** Map showing coal-thickness categories for the FGE coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGE drawn on base of zone. Data not shown for the Colowyo Federal and State coal leases or PRLA.

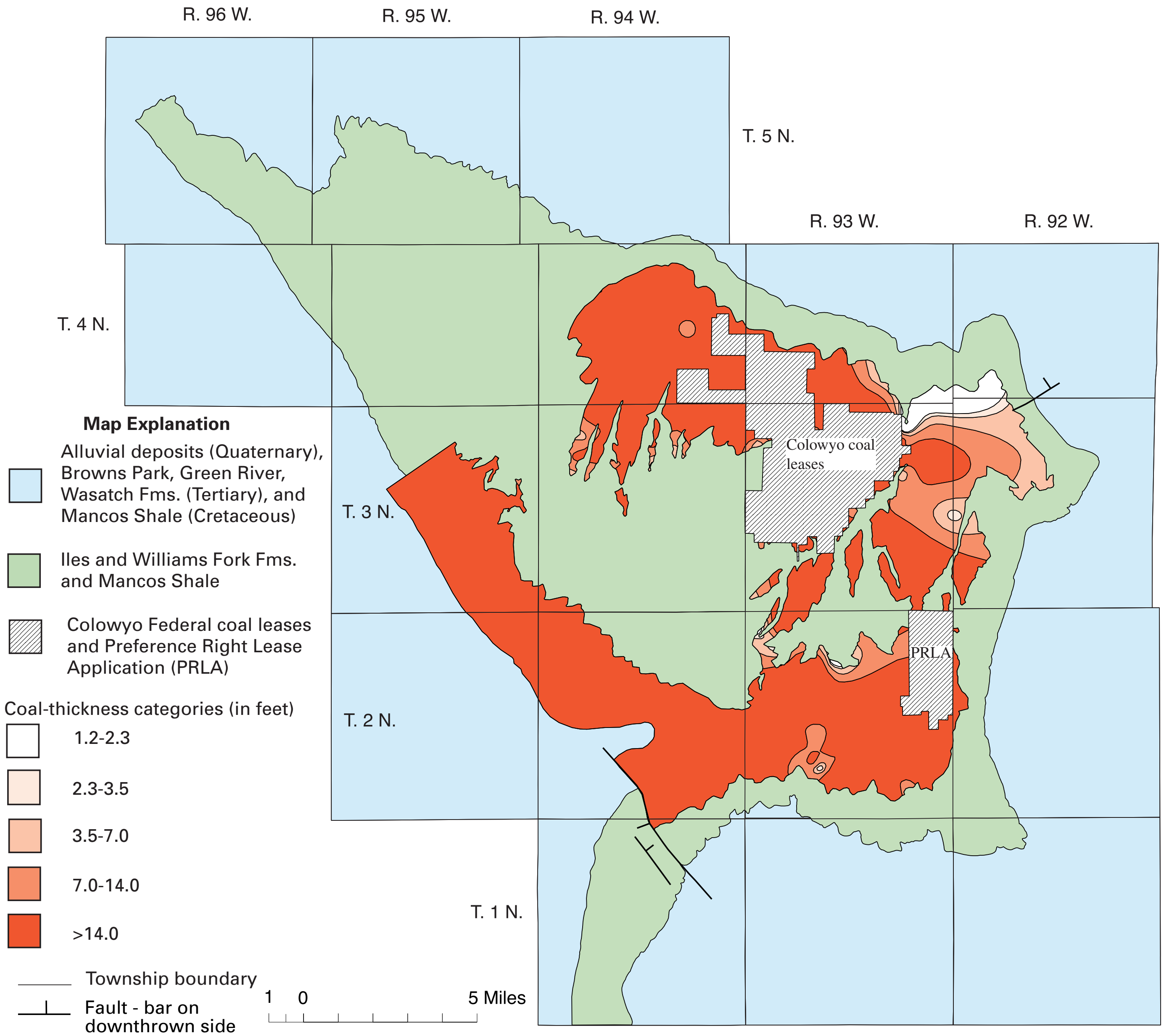



**Figure 25.** Map showing coal-thickness categories for the FGF coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGF drawn on base of zone. Data not shown for the Colowyo Federal and State coal leases or PRLA.

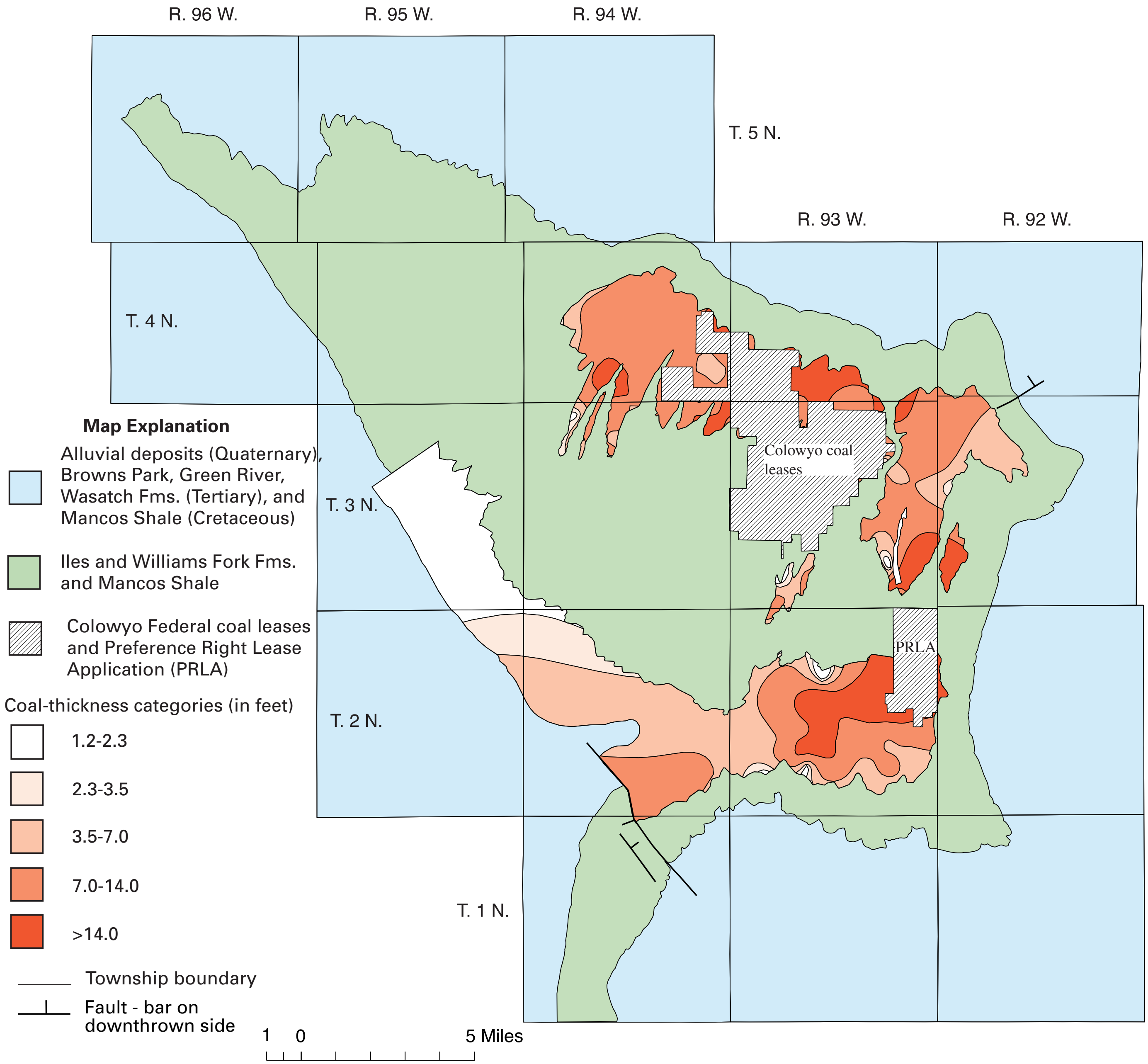



**Figure 26.** Map showing coal-thickness categories for the FGG coal zone of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, Colorado. Outline of the Danforth Hills coal field drawn on the base of the Upper Cretaceous Iles Formation. Areal extent of FGG drawn on base of zone. Data not shown for the Colowyo Federal and State coal leases or PRLA.

with a calculated mean heat of combustion (moist, mineral-matter-free basis) of 11,030 Btu/lb. Hildebrand and others (1981) reported proximate and ultimate data on 19 coal samples included in table 3. Nine samples were collected at the Colowyo mine, and the other samples were from drill cores within the Fairfield coal group elsewhere in the study area. The coal has a mean heat of combustion of 9,650 Btu/lb, a total sulfur content of 0.47 percent, and an ash yield of 11.51 percent on an as-received basis (R.H. Affolter, written commun., 1998). Ranges in values for proximate and ultimate analyses are given in table 3. Means and ranges of selected trace-element data for as many as 50 coal samples from the Danforth Hills and the Fairfield group are given in table 4. The methods for sampling and inorganic analysis of coal used to determine the elements listed in table 4 are discussed in Golightly and Simon (1989).

# Methodology

Digital files or coverages of various geologic and other features such as outcrop lines, elevation data, coal thickness, faults, fold axes, Federal coal leases, and mined-out areas were created within the study area. The coal benches and parting thicknesses were determined from geophysical logs using the natural gamma and density traces. Coal-bed thicknesses from the log traces are calculated using a USGS program (G.D. Stricker, written commun., 1998) that follows the methodology of Wood and others (1983) and excludes bituminous coal beds less than 1.2 ft thick. The total net-coal thickness values for each zone were used in the resource calculations (see Roberts and others, chap. C, this CD-ROM).

Coal resources for the Fairfield coal group are reported in the identified and hypothetical resource categories (Wood and others, 1979). Identified resources are located within a 3-mile radius of a data point and include the reliability categories of measured, indicated, and inferred. The measured resource category has the highest degree of geologic assurance and is located within a 0.25-mile radius of a data point. The indicated resource category has a more moderate degree of geologic assurance and is located within an area bounded by a 0.25- to 0.75-mile radius from a data point. The inferred resource category has a lower degree of geologic assurance and is located within an area bounded by a 0.75- to 3-mile radius from a data point. The hypothetical resource category has the lowest degree of geologic assurance in this scheme and is located within an area beyond a 3-mile radius from a data point and to a depth of 6,000 ft. Coal resources estimated in this study do not include the area inside the Colowyo Federal and State coal leases and the Preference Right Lease

**Table 3.** Number of samples, range, arithmetic mean, and standard deviation of proximate and ultimate analyses, heat of combustion, forms of sulfur, and ash-fusion temperatures of coal from the Danforth Hills coal field.

[All values are in percent except Btu/lb and ash-fusion temperatures, and are reported on the as-received basis (R.H. Affolter, written commun, 1998)]

| | Number of samples | Range | | Arithmetic mean | Standard deviation |
|---|---|---|---|---|---|
| | | Minimum | Maximum | | |
| **Proximate and ultimate analyses** | | | | | |
| Moisture | 47 | 2.9 | 23.8 | 14.82 | 3.27 |
| Volatile matter | 47 | 11.3 | 34.9 | 30.86 | 4.11 |
| Fixed carbon | 47 | 22.5 | 50.9 | 42.82 | 6.23 |
| Ash | 47 | 2.59 | 45.8 | 11.51 | 10.29 |
| Hydrogen | 47 | 2.5 | 6.16 | 5.48 | 0.65 |
| Carbon | 47 | 33.5 | 64.4 | 55.85 | 7.53 |
| Nitrogen | 47 | 0.6 | 1.62 | 1.31 | 0.24 |
| Oxygen | 47 | 6.4 | 30.6 | 25.37 | 3.72 |
| Sulfur | 47 | 0.3 | 1.1 | 0.47 | 0.20 |
| **Heat of combustion** | | | | | |
| Btu/lb | 47 | 5,780 | 11,200 | 9,650 | 1,320 |
| **Forms of sulfur** | | | | | |
| Sulfate | 41 | 0.01 | 0.04 | 0.01 | 0.01 |
| Pyritic | 47 | 0.01 | 0.41 | 0.09 | 0.10 |
| Organic | 47 | 0.12 | 0.76 | 0.37 | 0.13 |
| **Ash-fusion temperatures, °F** | | | | | |
| Initial deformation | 47 | 2,030 | 2,910 | 2,420 | 220 |
| Softening temperature | 47 | 2,090 | 2,910 | 2,520 | 220 |
| Fluid temperature | 47 | 2,140 | 2,910 | 2,590 | 210 |

**Table 4.** Number of samples, range, arithmetic mean, and standard deviation of ash content and 36 elements in coal from the Fairfield coal group of the Williams Fork Formaiton, Danforth Hills coal field, Colorado Plateau.

[All analyses are in percent or parts per million and are reported on a whole-coal basis. L, less than value shown]

| | Number of samples | Range | | Arithmetic mean | Standard deviation |
|---|---|---|---|---|---|
| | | Minimum | Maximum | | |
| **Percent** | | | | | |
| Ash | 50 | 2.4 | 45 | 13 | 11 |
| Si | 49 | 0.32 | 15 | 3.3 | 3.6 |
| Al | 49 | 0.18 | 4.2 | 1.3 | 0.96 |
| Ca | 49 | 0.16 | 2.2 | 0.49 | 0.35 |
| Mg | 50 | 0.009 | 0.36 | 0.1 | 0.068 |
| Na | 50 | 0.003 | 1.1 | 0.078 | 0.15 |
| K | 49 | 0.002 | 0.65 | 0.12 | 0.16 |
| Fe | 49 | 0.084 | 1 | 0.31 | 0.24 |
| Ti | 49 | 0.009 | 0.2 | 0.058 | 0.045 |
| **Parts per million** | | | | | |
| As | 50 | 0.35 | 11 | 1.5 | 1.9 |
| B | 50 | 21 | 83 | 48 | 15 |
| Ba | 50 | 81 | 940 | 240 | 170 |
| Be | 46 | 0.14L | 4.4 | 1.2 | 1 |
| Co | 50 | 0.33 | 8.8 | 2.3 | 1.8 |
| Cr | 48 | 0.1L | 47 | 7.5 | 8.7 |
| Cu | 50 | 1.3 | 33 | 6.4 | 5.9 |
| F | 50 | 20L | 510 | 120 | 100 |
| Ga | 50 | 0.62 | 14 | 3.2 | 2.9 |
| Hg | 50 | 0.010L | 0.39 | 0.046 | 0.071 |
| La | 44 | 4.3L | 22 | 6.8 | 5.3 |
| Li | 50 | 0.28 | 63 | 6.5 | 10 |
| Mn | 50 | 0.81 | 150 | 21 | 31 |
| Mo | 46 | 0.071L | 3.1 | 0.68 | 0.65 |
| Nb | 47 | 0.68L | 13 | 2.2 | 2.8 |
| Ni | 50 | 0.86 | 33 | 7 | 7.3 |
| Pb | 50 | 0.72L | 57 | 4.8 | 8.6 |
| Sb | 50 | 0.10L | 4.4 | 0.77 | 0.85 |
| Sc | 50 | 0.77L | 8.8 | 1.8 | 1.6 |
| Se | 44 | 0.25 | 1.9 | 0.71 | 0.31 |
| Sr | 50 | 11 | 520 | 120 | 110 |
| Th | 50 | 0.3 | 10 | 2.4 | 1.8 |
| U | 50 | 0.18L | 6.3 | 1.4 | 1.2 |
| V | 50 | 2.1 | 88 | 15 | 16 |
| Y | 50 | 1 | 22 | 5.9 | 5.1 |
| Yb | 50 | 0.1 | 2.2 | 0.53 | 0.45 |
| Zn | 50 | 1.2 | 100 | 15 | 21 |
| Zr | 50 | 2.4 | 110 | 28 | 25 |

Application (PRLA). Estimated coal resource tonnages were rounded to 2 significant figures. Therefore, totals may not equal the sum of individual categories because of independent rounding.

Estimates of coal resource tonnages for the Fairfield coal group are based on the methodology of Wood and others (1983) which uses a mean density of 1.32 g/cm$^3$ or 1,800 short tons/acre-ft for bituminous coal. Also, following this methodology (1) calculations were made for the 0–500 ft, 500–1,000 ft, 1,000–2,000 ft, 2,000–3,000 ft, and 3,000–6,000 ft overburden categories by integrating the overburden maps (figs. 13–19), net coal isopach maps (figs. 6–12), and the areal extent of each zone (figs. 6–12) and (2) isopach maps that show total net coal in the thickness categories of 1.2–2.3, 2.3–3.5, 3.5–7.0, 7.0–14.0, and greater than 14.0 ft were con-

*Text continues on page 52*

**Table 5.** Identified and hypothetical coal resources in millions of short tons for the FGA zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field reported by quadrangle, township, and ownership categories.

[Resources are not reported for areas inside the Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| | Overburden categories (feet) | | | | | Grand total |
|---|---|---|---|---|---|---|
| | 0-500 | 500-1,000 | 1,000-2,000 | 2,000-3,000 | 3,000-6,000 | |
| **By quadrangle** | | | | | | |
| AXIAL | 47 | 55 | 48 | 0 | 0 | 150 |
| DEVILS HOLE GULCH | 190 | 100 | 56 | 32 | 100 | 480 |
| EASTON GULCH | 160 | 160 | 230 | 0 | 0 | 560 |
| MEEKER | 14 | 13 | 46 | 23 | 28 | 120 |
| MONUMENT BUTTE | 9.8 | 27 | 18 | 0 | 0 | 54 |
| NINEMILE GAP | 48 | 140 | 160 | 67 | 0 | 410 |
| PRICE CREEK | 15 | 0.07 | 0 | 0 | 0 | 15 |
| RATTLESNAKE MESA | 58 | 38 | 120 | 11 | 0 | 230 |
| SAWMILL MOUNTAIN | 4.2 | 0 | 0 | 0 | 0 | 4.2 |
| THORNBURGH | 32 | 25 | 15 | 0 | 0 | 72 |
| WHITE ROCK | 16 | 35 | 58 | 33 | 120 | 260 |
| Total | 590 | 600 | 750 | 170 | 250 | 2400 |
| **By township** | | | | | | |
| T1N R93W | 0.63 | 0 | 0 | 0 | 0 | 0.63 |
| T1N R94W | 4.4 | 2.9 | 0.72 | 0 | 0 | 8.1 |
| T2N R92W | 26 | 9.5 | 0.96 | 0 | 0 | 36 |
| T2N R93W | 66 | 80 | 190 | 78 | 0 | 410 |
| T2N R94W | 51 | 30 | 88 | 51 | 110 | 330 |
| T2N R95W | 0 | 0 | 0.27 | 3.1 | 38 | 41 |
| T3N R92W | 34 | 45 | 63 | 0 | 0 | 140 |
| T3N R93W | 23 | 82 | 87 | 0 | 0 | 190 |
| T3N R94W | 140 | 100 | 35 | 0 | 0 | 280 |
| T3N R95W | 59 | 46 | 63 | 34 | 100 | 300 |
| T4N R92W | 12 | 25 | 1.1 | 0 | 0 | 37 |
| T4N R93W | 42 | 49 | 19 | 0 | 0 | 110 |
| T4N R94W | 110 | 130 | 200 | 0 | 0 | 440 |
| T4N R95W | 28 | 0 | 0 | 0 | 0 | 28 |
| T5N R94W | 0.45 | 0 | 0 | 0 | 0 | 0.45 |
| Grand total | 590 | 600 | 750 | 170 | 250 | 2400 |

| Coal ownership | Total | Surface ownership | Total |
|---|---|---|---|
| Federal | 2100 | BLM | 640 |
| Non-Federal | 300 | Private | 1700 |
| | | State | 83 |
| Total | 2400 | | 2400 |

**Table 6.** Identified and hypothetical coal resources in millions of short tons for the FGA zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field reported by county, reliability, overburden, and coal-thickness categories.

[Resources are not reported for area inside the Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| County | Reliability | 0-500 feet overburden coal-thickness categories, in feet | | | | 0-500 total | 500-1000 feet overburden coal-thickness categories, in feet | | | | 500-1,000 total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 0 | 4.1 | 110 | 190 | 300 | 0 | 8.2 | 150 | 160 | 320 |
| | Hypothetical | 0 | 0.85 | 14 | 7.3 | 22 | 0 | 0 | 24 | 17 | 41 |
| Moffat total | | 0 | 4.9 | 120 | 200 | 330 | 0 | 8.2 | 170 | 180 | 360 |
| Rio Blanco | Identified | 2.6 | 32 | 130 | 75 | 240 | 1.5 | 47 | 120 | 60 | 230 |
| | Hypothetical | 0 | 1.8 | 15 | 4.0 | 21 | 0 | .30 | 11 | 3.7 | 15 |
| Rio Blanco total | | 2.6 | 33 | 150 | 79 | 260 | 1.5 | 47 | 130 | 60 | 240 |
| Total | | 2.6 | 38 | 270 | 280 | 590 | 1.5 | 55 | 300 | 240 | 600 |

| County | Reliability | 1,000-2,000 feet overburden coal-thickness categories, in feet | | | | 1,000-2,000 total | 2,000-3,000 feet overburden coal-thickness categories, in feet | | | 2,000-3,000 total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 0 | 0.8 | 170 | 190 | 360 | 0 | 0 | 11 | 11 |
| | Hypothetical | 0 | 0 | 19 | 0 | 19 | 0 | 0 | 0 | 0 |
| Moffat total | | 0 | 0.8 | 190 | 190 | 380 | 0 | 0 | 11 | 11 |
| Rio Blanco | Identified | 0.33 | 11 | 140 | 180 | 330 | 0.22 | 67 | 62 | 130 |
| | Hypothetical | 0 | 0 | 19 | 12 | 31 | 0 | 23 | 2.1 | 25 |
| Rio Blanco total | | 0.33 | 11 | 160 | 190 | 360 | 0.22 | 90 | 64 | 160 |
| Total | | 0.33 | 12 | 350 | 390 | 740 | 0.22 | 90 | 75 | 170 |

| County | Reliability | 3,000-6,000 feet overburden coal-thickness categories, in feet | | 3,000-6,000 total | Grand total |
|---|---|---|---|---|---|
| | | 7.0-14.0 | >14.0 | | |
| Moffat | Identified | 0 | 19 | 19 | 1000 |
| | Hypothetical | 0 | 6.1 | 6.1 | 900 |
| Moffat total | | 0 | 25 | 25 | 1100 |
| Rio Blanco | Identified | 5.4 | 44 | 49 | 980 |
| | Hypothetical | 110 | 66 | 180 | 270 |
| Rio Blanco total | | 120 | 110 | 230 | 1300 |
| Total | | 120 | 135 | 250 | 2400 |

**Table 7.** Identified and hypothetical coal resources in millions of short tons for the FGB zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field.

[Resources are reported in overburden categories and are grouped by county, township, and 7½-minute quadrangle. Resources in coal- and surface-ownership categories are also reported. Resources are not reported for areas inside the Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| | Overburden categories (feet) | | | | | Grand total |
|---|---|---|---|---|---|---|
| | 0-500 | 500-1,000 | 1,000-2,000 | 2,000-3,000 | 3,000-6,000 | |
| **By quadrangle** | | | | | | |
| AXIAL | 29 | 45 | 63 | 0 | 0 | 140 |
| DEVILS HOLE GULCH | 440 | 240 | 120 | 68 | 230 | 1100 |
| EASTON GULCH | 210 | 270 | 410 | 0 | 0 | 890 |
| MEEKER | 28 | 27 | 98 | 52 | 71 | 280 |
| MONUMENT BUTTE | 6.7 | 18 | 19 | 0 | 0 | 43 |
| NINEMILE GAP | 230 | 480 | 340 | 170 | 0 | 1200 |
| PRICE CREEK | 22 | 0.09 | 0 | 0 | 0 | 22 |
| RATTLESNAKE MESA | 110 | 62 | 220 | 22 | 0 | 420 |
| SAWMILL MOUNTAIN | 16 | 0 | 0 | 0 | 0 | 16 |
| THORNBURGH | 87 | 45 | 22 | 0 | 0 | 150 |
| WHITE ROCK | 26 | 60 | 92 | 53 | 190 | 420 |
| Grand total | 1200 | 1200 | 1400 | 370 | 490 | 4700 |
| **By township** | | | | | | |
| T1N R93W | 0.67 | 0 | 0 | 0 | 0 | 0.67 |
| T1N R94W | 10 | 7.0 | 1.8 | 0 | 0 | 19 |
| T2N R92W | 140 | 75 | 8.4 | 0 | 0 | 220 |
| T2N R93W | 150 | 220 | 400 | 190 | 0 | 950 |
| T2N R94W | 99 | 60 | 180 | 120 | 270 | 730 |
| T2N R95W | 0 | 0 | 0.54 | 6.1 | 70 | 80 |
| T3N R92W | 78 | 76 | 82 | 0 | 0 | 240 |
| T3N R93W | 97 | 240 | 160 | 0 | 0 | 490 |
| T3N R94W | 350 | 280 | 77 | 0 | 0 | 700 |
| T3N R95W | 100 | 81 | 100 | 53 | 150 | 480 |
| T4N R92W | 5.6 | 14 | 0.89 | 0 | 0 | 20 |
| T4N R93W | 27 | 37 | 26 | 0 | 0 | 90 |
| T4N R94W | 130 | 165 | 340 | 0 | 0 | 630 |
| T4N R95W | 39 | 0 | 0 | 0 | 0 | 39 |
| T5N R94W | 0.32 | 0 | 0 | 0 | 0 | 0.32 |
| Grand total | 1200 | 1200 | 1400 | 370 | 490 | 4700 |

| **By ownership category** | | | |
|---|---|---|---|
| Coal ownership | Total | Surface ownership | Total |
| Federal | 4100 | BLM | 1200 |
| Non-Federal | 600 | Private | 3400 |
| | | State | 120 |
| Total | 4700 | | 4700 |

**Table 8.** Identified and hypothetical coal resources in millions of short tons for the FGB zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field reported by county, reliability, overburden, and coal-thickness categories.

[Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| County | Reliability | 0-500 feet overburden coal-thickness categories, in feet | | | 0-500 total | 500-1000 feet overburden coal-thickness categories, in feet | | | 500-1,000 total |
|---|---|---|---|---|---|---|---|---|---|
| | | 3.5-7.0 | 7.0-14.0 | >14.0 | | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 3.9 | 17 | 460 | 480 | 1.4 | 32 | 520 | 550 |
| | Hypothetical | 1.8 | 4.8 | 17 | 24 | 2.6 | 14 | 8.0 | 25 |
| Moffat total | | 5.7 | 22 | 480 | 500 | 4.0 | 46 | 530 | 580 |
| Rio Blanco | Identified | 0 | 1.4 | 670 | 700 | 0 | 20 | 630 | 650 |
| | Hypothetical | 0 | 0 | 15 | 15 | 0 | 0 | 17 | 17 |
| Rio Blanco total | | 0 | 1.4 | 720 | 720 | 0 | 20 | 650 | 670 |
| Grand total | | 5.7 | 23 | 1200 | 1200 | 4.0 | 66 | 1200 | 1200 |

| County | Reliability | 1,000-2000 feet overburden coal-thickness categories (feet) | | 1,000-2,000 total | 2000-3,000 feet overburden coal-thickness categories (feet) | 2,000-3,000 total | 3,000-6,000 feet overburden coal-thickness categories (feet) | 3,000-6,000 total | Grand total |
|---|---|---|---|---|---|---|---|---|---|
| | | 7.0-14.0 | >14.0 | | >14.0 | | >14.0 | | |
| Moffat | Identified | 38 | 580 | 610 | 15 | 15 | 24 | 24 | 1700 |
| | Hypothetical | 5.6 | 0.63 | 6.3 | 0 | 0 | 7.3 | 7.3 | 62 |
| Moffat total | | 44 | 580 | 620 | 15 | 15 | 31 | 31 | 1800 |
| Rio Blanco | Identified | 33 | 680 | 710 | 310 | 310 | 150 | 150 | 2500 |
| | Hypothetical | 0 | 41 | 41 | 39 | 39 | 310 | 310 | 420 |
| Rio Blanco total | | 33 | 720 | 750 | 350 | 350 | 460 | 460 | 2900 |
| Grand total | | 77 | 1300 | 1400 | 370 | 370 | 490 | 490 | 4700 |

**Table 9.** Identified and hypothetical coal resources in millions of short tons for the FGC zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field.

[Resources are grouped in overburden categories and are grouped by county, township, and 7½-minute quadrangle. Resources in coal- and surface-ownership categories are also reported. Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| | Overburden categories (feet) | | | | | Grand total |
|---|---|---|---|---|---|---|
| | 0-500 | 500-1,000 | 1,000-2,000 | 2,000-3,000 | 3,000-6,000 | |
| **By quadrangle** | | | | | | |
| AXIAL | 66 | 64 | 48 | 0 | 0 | 180 |
| DEVILS HOLE GULCH | 360 | 110 | 87 | 61 | 175 | 790 |
| EASTON GULCH | 120 | 210 | 80 | 0 | 0 | 410 |
| MEEKER | 22 | 23 | 96 | 45 | 61 | 250 |
| MONUMENT BUTTE | 30 | 49 | 20 | 0 | 0 | 99 |
| NINEMILE GAP | 410 | 460 | 210 | 85 | 0 | 1200 |
| PRICE CREEK | 1.7 | 0 | 0 | 0 | 0 | 1.7 |
| RATTLESNAKE MESA | 31 | 32 | 110 | 5.2 | 0 | 180 |
| THORNBURGH | 91 | 75 | 18 | 0 | 0 | 180 |
| WHITE ROCK | 26 | 20 | 20 | 11 | 33 | 110 |
| Grand total | 1200 | 1100 | 690 | 210 | 270 | 3400 |
| **By township** | | | | | | |
| T1N R94W | 4.9 | 4.3 | 0.11 | 0 | 0 | 9.3 |
| T2N R92W | 58 | 15 | 0.18 | 0 | 0 | 73 |
| T2N R93W | 160 | 170 | 250 | 890 | 0 | 670 |
| T2N R94W | 77 | 69 | 170 | 100 | 220 | 640 |
| T2N R95W | 0 | 0 | 0.61 | 3.2 | 29 | 33 |
| T3N R92W | 120 | 160 | 80 | 0 | 0 | 350 |
| T3N R93W | 220 | 270 | 79 | 0 | 0 | 570 |
| T3N R94W | 290 | 130 | 0.99 | 0 | 0 | 420 |
| T3N R95W | 46 | 24 | 23 | 11 | 18 | 120 |
| T4N R92W | 28 | 24 | 0 | 0 | 0 | 52 |
| T4N R93W | 59 | 46 | 10 | 0 | 0 | 120 |
| T4N R94W | 88 | 140 | 80 | 0 | 0 | 310 |
| T4N R95W | 6.7 | 0 | 0 | 0 | 0 | 6.7 |
| Grand total | 1200 | 1100 | 690 | 210 | 270 | 3400 |

**By ownership category**

| Coal ownership | Total | Surface ownership | Total |
|---|---|---|---|
| Federal | 3100 | BLM | 900 |
| Non-Federal | 320 | Private | 2400 |
| | | State | 66 |
| Grand Total | 3400 | | 3400 |

**Table 10.** Identified and hypothetical coal resources in millions of short tons for the FGC zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field reported by county, reliability, overburden, and coal-thickness categories.

[Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| County | Reliability | 0-500 feet overburden coal-thickness categories, in feet | | | | 0-500 total | 500-1000 feet overburden coal-thickness categories, in feet | | | | 500-1,000 total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 1.6 | 5.9 | 74 | 380 | 470 | 0.64 | 11 | 120 | 330 | 460 |
| | Hypothetical | 0 | 0 | 0 | 49 | 49 | 0 | 0 | 0 | 46 | 46 |
| Moffat total | | 1.6 | 5.9 | 74 | 430 | 520 | 0.64 | 11 | 120 | 380 | 510 |
| Rio Blanco | Identified | 0 | 0.6 | 24 | 610 | 630 | 0 | 3.5 | 14 | 500 | 520 |
| | Hypothetical | 0 | 0 | 0 | 15 | 15 | 0 | 0 | 0 | 21 | 21 |
| Rio Blanco total | | 0 | 0.6 | 24 | 620 | 645 | 0 | 3.5 | 14 | 530 | 540 |
| Grand total | | 1.6 | 6.5 | 98 | 1100 | 1200 | 0.64 | 15 | 130 | 910 | 1100 |

| County | Reliability | 1,000-2,000 feet overburden coal-thickness categories, in feet | | | 1,000-2,000 total | 2,000-3,000 feet overburden coal-thickness categories, in feet | | | | 2,000-3,000 total |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 3.5-7.0 | 7.0-14.0 | >14.0 | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 9.4 | 31 | 190 | 230 | 0.36 | 2.1 | 0 | 0 | 2.5 |
| | Hypothetical | 0 | 0 | 2.6 | 2.6 | 0 | 0 | 0 | 0 | 0 |
| Moffat total | | 9.4 | 31 | 190 | 230 | 0.36 | 2.1 | 0 | 0 | 2.5 |
| Rio Blanco | Identified | 7.6 | 32 | 390 | 430 | 0 | 5.5 | 13 | 150 | 170 |
| | Hypothetical | 0 | 0 | 34 | 34 | 0 | 0 | 1.1 | 34 | 35 |
| Rio Blanco total | | 7.6 | 32 | 420 | 460 | 0 | 5.5 | 14 | 180 | 200 |
| Grand total | | 17 | 63 | 610 | 690 | 0.36 | 7.6 | 14 | 180 | 200 |

| County | Reliability | 3,000-6,000 feet overburden coal-thickness categories, in feet | | | | 3,000-6,000 total | Grand total |
|---|---|---|---|---|---|---|---|
| | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | |
| Moffat | Identified | 2.6 | 0.21 | 0 | 0 | 2.8 | 1200 |
| | Hypothetical | 0.78 | 0 | 0 | 0 | 0.78 | 99 |
| Moffat total | | 3.3 | 0.21 | 0 | 0 | 3.6 | 1300 |
| Rio Blanco | Identified | 5.4 | 5.1 | 0.37 | 78 | 89 | 1800 |
| | Hypothetical | 0.15 | 3.3 | 18 | 150 | 180 | 280 |
| Rio Blanco total | | 5.6 | 8.3 | 18 | 230 | 270 | 2100 |
| Grand total | | 8.9 | 8.5 | 18 | 230 | 270 | 3400 |

**Table 11.** Identified and hypothetical coal resources in millions of short tons for the FGD zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field.

[Resources are grouped in overburden categories and are grouped by county, township, and 7½-minute quadrangle. Resources in coal- and surface-ownership categories are also reported. Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| | Overburden categories, in feet | | | | | Grand total |
|---|---|---|---|---|---|---|
| | 0-500 | 500- 1,000 | 1,000-2,000 | 2,000-3,000 | 3,000-6,000 | |
| **By quadrangle** | | | | | | |
| AXIAL | 43 | 39 | 13 | 0 | 0 | 95 |
| DEVILS HOLE GULCH | 150 | 43 | 38 | 28 | 84 | 340 |
| EASTON GULCH | 150 | 220 | 21 | 0 | 0 | 390 |
| MEEKER | 23 | 24 | 76 | 27 | 37 | 190 |
| MONUMENT BUTTE | 3.8 | 4.4 | 0.74 | 0 | 0 | 8.9 |
| NINEMILE GAP | 190 | 170 | 110 | 68 | 0 | 540 |
| PRICE CREEK | 0.70 | 0 | 0 | 0 | 0 | 0.70 |
| RATTLESNAKE MESA | 60 | 68 | 150 | 2.2 | 0 | 280 |
| THORNBURGH | 7.3 | 5.5 | 0.64 | 0 | 0 | 13 |
| WHITE ROCK | 28 | 17 | 16 | 7.8 | 18 | 87 |
| Grand total | 650 | 590 | 430 | 130 | 140 | 1900 |
| **By township** | | | | | | |
| T1N R94W | 5.0 | 3.2 | 0.02 | 0 | 0 | 8.2 |
| T2N R92W | 34 | 7.8 | 0 | 0 | 0 | 42 |
| T2N R93W | 120 | 130 | 260 | 71 | 0 | 580 |
| T2N R94W | 42 | 48 | 110 | 54 | 120 | 370 |
| T2N R95W | 0 | 0 | 0.29 | 1.2 | 11 | 11 |
| T3N R92W | 12 | 17 | 5.9 | 0 | 0 | 35 |
| T3N R93W | 93 | 100 | 7.4 | 0 | 0 | 200 |
| T3N R94W | 150 | 74 | 0.12 | 0 | 0 | 220 |
| T3N R95W | 40 | 18 | 17 | 7.5 | 13 | 96 |
| T4N R92W | 3.8 | 1.4 | 0 | 0 | 0 | 5.2 |
| T4N R93W | 43 | 29 | 5.2 | 0 | 0 | 77 |
| T4N R94W | 100 | 160 | 21 | 0 | 0 | 280 |
| T4N R95W | 4.6 | 0 | 0 | 0 | 0 | 4.6 |
| Grand total | 650 | 590 | 430 | 130 | 140 | 1900 |

| **By ownership category** | | | |
|---|---|---|---|
| Coal ownership | Total | Surface ownership | Total |
| Federal | 1700 | BLM | 500 |
| Non-Federal | 180 | Private | 1400 |
| | | State | 29 |
| Grand Total | 1900 | | 1900 |

**Table 12.** Identified and hypothetical coal resources in millions of short tons for the FGD zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field reported by county, reliability, overburden, and coal-thickness categories.

[Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| County | Reliability | 0-500 feet overburden coal-thickness categories, in feet | | | | 0-500 total | 500-1000 feet overburden coal-thickness categories, in feet | | | | 500-1,000 total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 7.6 | 14 | 130 | 180 | 330 | 11 | 16 | 170 | 130 | 320 |
| | Hypothetical | 1.6 | 0 | 0 | 0 | 1.6 | 0 | 0 | 0 | 0 | 0 |
| Moffat total | | 9.2 | 14 | 130 | 180 | 330 | 11 | 16 | 170 | 130 | 320 |
| Rio Blanco | Identified | 6.8 | 24 | 100 | 180 | 310 | 5.0 | 21 | 62 | 170 | 260 |
| | Hypothetical | 0 | 0 | 6.0 | 0.67 | 6.6 | 0 | 0 | 8.0 | 2.2 | 10 |
| Rio Blanco total | | 6.8 | 24 | 110 | 180 | 320 | 5.0 | 21 | 70 | 180 | 270 |
| Grand total | | 16 | 38 | 240 | 360 | 650 | 16 | 37 | 240 | 310 | 590 |

| County | Reliability | 1,000-2,000 feet overburden coal-thickness categories, in feet | | | | 1,000-2,000 total | 2,000-3,000 feet overburden coal-thickness categories, in feet | | | | 2,000-3,000 total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 3.9 | 10 | 25 | 8.0 | 48 | 0.78 | 1.4 | 0 | 0 | 2.2 |
| | Hypothetical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Moffat total | | 3.9 | 10 | 25 | 8.0 | 48 | 0.78 | 1.4 | 0 | 0 | 2.2 |
| Rio Blanco | Identified | 1.8 | 8 | 3.8 | 350 | 360 | 2.5 | 3.8 | 5.8 | 110 | 120 |
| | Hypothetical | 0 | 0.39 | 11 | 3.0 | 14 | 0.10 | 2.1 | 10 | 3.5 | 16 |
| Rio Blanco total | | 1.8 | 8.9 | 15 | 350 | 380 | 2.6 | 6.0 | 15 | 110 | 130 |
| Grand total | | 5.7 | 19 | 40 | 360 | 430 | 3.4 | 7.4 | 16 | 110 | 130 |

| County | Reliability | 3,000-6,000 feet overburden coal-thickness categories, in feet | | | | 3,000-6,000 total | Grand total |
|---|---|---|---|---|---|---|---|
| | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | |
| Moffat | Identified | 2.3 | 0.21 | 0 | 0 | 2.6 | 710 |
| | Hypothetical | 0.78 | 0 | 0 | 0 | 0.78 | 2.4 |
| Moffat total | | 3.1 | 0.21 | 0 | 0 | 3.3 | 710 |
| Rio Blanco | Identified | 7.2 | 0.81 | 0 | 44 | 52 | 1100 |
| | Hypothetical | 3.7 | 9.1 | 43 | 28 | 84 | 130 |
| Rio Blanco total | | 11 | 9.9 | 43 | 72 | 140 | 1200 |
| Grand total | | 14 | 10 | 43 | 72 | 280 | 1900 |

**Table 13.** Identified and hypothetical coal resources in millions of short tons for the FGE zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field.

[Resources are grouped in overburden categories and are grouped by county, township, and 7½-minute quadrangle. Resources in coal- and surface-ownership categories are also reported. Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| | Overburden categories, in feet | | | | | Grand total |
|---|---|---|---|---|---|---|
| | 0-500 | 500-1,000 | 1,000-2,000 | 2,000-3,000 | 3,000-6,000 | |
| **By quadrangle** | | | | | | |
| AXIAL | 170 | 140 | 12 | 0 | 0 | 320 |
| DEVILS HOLE GULCH | 270 | 100 | 110 | 96 | 350 | 920 |
| EASTON GULCH | 410 | 670 | 0 | 0 | 0 | 1100 |
| MEEKER | 45 | 57 | 170 | 67 | 110 | 440 |
| MONUMENT BUTTE | 23 | 9.9 | 0.27 | 0 | 0 | 33 |
| NINEMILE GAP | 750 | 470 | 180 | 83 | 0 | 1500 |
| PRICE CREEK | 0.17 | 0 | 0 | 0 | 0 | 0.17 |
| RATTLESNAKE MESA | 56 | 97 | 180 | 0.14 | 0 | 330 |
| THORNBURGH | 30 | 8.6 | 0.10 | 0 | 0 | 39 |
| WHITE ROCK | 71 | 71 | 97 | 82 | 240 | 560 |
| Grand total | 1800 | 1600 | 750 | 330 | 700 | 5200 |
| **By township** | | | | | | |
| T1N R94W | 12.5 | 4.1 | 0 | 0 | 0 | 17 |
| T2N R92W | 64 | 6.2 | 0 | 0 | 0 | 70 |
| T2N R93W | 240 | 210 | 350 | 83 | 0 | 890 |
| T2N R94W | 90 | 130 | 270 | 160 | 420 | 1100 |
| T2N R95W | 0 | 0 | 2.7 | 11 | 97 | 110 |
| T3N R92W | 83 | 69 | 15 | 0 | 0 | 170 |
| T3N R93W | 470 | 360 | 4.6 | 0 | 0 | 830 |
| T3N R94W | 320 | 120 | 0.14 | 0 | 0 | 440 |
| T3N R95W | 88 | 77 | 100 | 78 | 180 | 520 |
| T4N R92W | 28 | 2.0 | 0 | 0 | 0 | 30 |
| T4N R93W | 170 | 86 | 0.95 | 0 | 0 | 260 |
| T4N R94W | 260 | 560 | 0 | 0 | 0 | 820 |
| T4N R95W | 7.3 | 0 | 0 | 0 | 0 | 7.3 |
| Grand total | 1800 | 1600 | 750 | 330 | 700 | 5200 |

**By ownership category**

| Coal ownership | Total | Surface ownership | Total |
|---|---|---|---|
| Federal | 4500 | BLM | 1200 |
| Non-Federal | 700 | Private | 3800 |
| | | State | 160 |
| Grand total | 5200 | | 5200 |

**Table 14.** Identified and hypothetical coal resources in millions of short tons for the FGE of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field reported by county, reliability, overburden, and coal-thickness categories.

[Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| County | Reliability | 0-500 feet overburden coal-thickness categories, in feet | | | | 0-500 total | 500-1000 feet overburden coal-thickness categories, in feet | | | | 500-1,000 total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 3.6 | 3.9 | 24 | 810 | 840 | 4.0 | 3.9 | 9.9 | 920 | 940 |
| | Hypothetical | 0 | 0 | 0.91 | 7.3 | 8.2 | 0 | 0 | 0 | 0 | 0 |
| Moffat total | | 3.6 | 3.9 | 25 | 820 | 850 | 4.0 | 3.9 | 9.9 | 920 | 940 |
| Rio Blanco | Identified | 0.37 | 1.2 | 14 | 950 | 960 | 0 | 0.09 | 7.0 | 640 | 650 |
| | Hypothetical | 0 | 0 | 0 | 20 | 20 | 0 | 0 | 0 | 29 | 29 |
| Rio Blanco total | | 0.37 | 1.2 | 14 | 970 | 980 | 0 | 0.09 | 7.0 | 670 | 680 |
| Grand total | | 4.0 | 5.1 | 39 | 1800 | 1800 | 4.0 | 4.0 | 17 | 1600 | 1600 |

| | | - | | 1,000-2,000 total | 2000—3000 feet overburden coal-thickness categories (feet) | 2,000-3,000 total | 3000-6000 feet overburden coal-thickness categories (feet) | 3,000-6,000 total | Grand total |
|---|---|---|---|---|---|---|---|---|---|
| County | Reliability | 7.0-14.0 | >14.0 | | >14.0 | | >14.0 | | |
| Moffat | Identified | 9.2 | 52 | 61 | 19 | 19 | 25 | 25 | 1900 |
| | Hypothetical | 0 | 0 | 0 | 0 | 0 | 16 | 16 | 24 |
| Moffat total | | 9.2 | 52 | 61 | 19 | 19 | 41 | 41 | 1900 |
| Rio Blanco | Identified | 1.7 | 630 | 630 | 250 | 250 | 270 | 270 | 2800 |
| | Hypothetical | 00 | 48 | 48 | 63 | 63 | 390 | 390 | 550 |
| Rio Blanco total | | 1.7 | 680 | 680 | 310 | 310 | 660 | 660 | 3300 |
| Grand total | | 11 | 730 | 740 | 330 | 330 | 700 | 700 | 5200 |

**Table 15.** Identified and hypothetical coal resources in millions of short tons for the FGF zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field.

[Resources are grouped in overburden categories and are grouped by county, township, and 7½-minute quadrangle. Resources in coal- and surface-ownership categories are also reported. Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| | Overburden categories, in feet | | | | | Grand total |
|---|---|---|---|---|---|---|
| | 0-500 | 500-1,000 | 1,000-2,000 | 2,000-3,000 | 3,000-6,000 | |
| **By quadrangle** | | | | | | |
| AXIAL | 38 | 20 | 0.61 | 0 | 0 | 60 |
| DEVILS HOLE GULCH | 107 | 60 | 83 | 72 | 250 | 570 |
| EASTON GULCH | 400 | 110 | 0 | 0 | 0 | 510 |
| MEEKER | 31 | 70 | 78 | 36 | 680 | 280 |
| MONUMENT BUTTE | 5.9 | 4.0 | 0 | 0 | 0 | 9.9 |
| NINEMILE GAP | 350 | 110 | 150 | 4.1 | 0 | 610 |
| RATTLESNAKE MESA | 39 | 82 | 42 | 0 | 0 | 160 |
| THORNBURGH | 20 | 4.3 | 0 | 0 | 0 | 24 |
| WHITE ROCK | 51 | 46 | 60 | 67 | 170 | 400 |
| Grand total | 1000 | 500 | 410 | 180 | 490 | 2600 |
| **By township** | | | | | | |
| T1N R94W | 5.8 | 0.12 | 0 | 0 | 0 | 5.9 |
| T2N R92W | 13 | 0.09 | 0 | 0 | 0 | 13 |
| T2N R93W | 120 | 150 | 190 | 4.0 | 0 | 460 |
| T2N R94W | 75 | 120 | 150 | 100 | 280 | 730 |
| T2N R95W | 0 | 0.08 | 5.1 | 14 | 84 | 100 |
| T3N R92W | 49 | 24 | 2.6 | 0 | 0 | 76 |
| T3N R93W | 240 | 34 | 0 | 0 | 0 | 270 |
| T3N R94W | 170 | 1.8 | 0 | 0 | 0 | 170 |
| T3N R95W | 59 | 51 | 63 | 60 | 120 | 360 |
| T4N R92W | 1.5 | 0 | 0 | 0 | 0 | 1.5 |
| T4N R93W | 32 | 11 | 0 | 0 | 0 | 43 |
| T4N R94W | 270 | 110 | 0 | 0 | 0 | 380 |
| Grand total | 1000 | 500 | 410 | 180 | 490 | 2600 |

| By ownership category | | | |
|---|---|---|---|
| Coal ownership | Total | Surface ownership | Total |
| Federal | 2200 | BLM | 500 |
| Non-Federal | 390 | Private | 2000 |
| | | State | 61 |
| Grand total | 2600 | | 2600 |

**Table 16.** Identified and hypothetical coal resources in millions of short tons for the FGF zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field reported by county, reliability, overburden, and coal-thickness categories.

[Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| County | Reliability | 0-500 feet overburden coal-thickness categories, in feet | | | | | 0-500 total | 500-1000 feet overburden coal-thickness categories, in feet | | | | | 500-1,000 total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1.2-2.3 | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 1.2-2.3 | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Identified | 3.6 | 0.73 | 16 | 38 | 480 | 540 | 1.1 | 0.66 | 6.42 | 21 | 160 | 190 |
| | Hypothetical | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Moffat total | | 3.6 | 0.73 | 16 | 38 | 480 | 540 | 1.1 | 0.66 | 6.4 | 21 | 160 | 190 |
| Rio Blanco | Identified | 0.1 | 0.61 | 6.7 | 39 | 400 | 450 | 0 | 0.05 | 0.89 | 12 | 270 | 280 |
| | Hypothetical | 0 | 0 | 0 | 0 | 45 | 45 | 0 | 0 | 0 | 0 | 34 | 34 |
| Rio Blanco total | | 0.1 | 0.61 | 6.7 | 39 | 450 | 500 | 0 | 0.05 | 0.89 | 12 | 300 | 310 |
| Grand total | | 3.7 | 1.3 | 23 | 77 | 930 | 1000 | 1.1 | 0.71 | 7.3 | 33 | 460 | 500 |

| County | Reliability | 1000-2000 feet overburden coal-thickness categories (feet) | | 1,000-2,000 total | 2000-3000 feet overburden coal-thickness categories, in feet | 2,000-3,000 total | 3000-6000 feet overburden coal-thickness categories (feet) | 3,000-6,000 total | Grand total |
|---|---|---|---|---|---|---|---|---|---|
| | | 7.0-14.0 | >14.0 | | >14.0 | | >14.0 | | |
| Moffat | Identified | 2.2 | 21 | 23 | 13 | 13 | 14 | 14 | 780 |
| | Hypothetical | 0. | 0 | 0 | 0.01 | 0.01 | 12 | 12 | 12 |
| Moffat total | | 2.2 | 21 | 23 | 13 | 13 | 26 | 26 | 790 |
| Rio Blanco | Identified | 6.0 | 320 | 330 | 99 | 99 | 160 | 160 | 1300 |
| | Hypothetical | 0. | 62 | 62 | 68 | 68 | 300 | 300 | 510 |
| Rio Blanco total | | 6.0 | 380 | 390 | 170 | 170 | 460 | 460 | 1800 |
| Grand total | | 8.2 | 400 | 410 | 180 | 180 | 490 | 490 | 2600 |

**Table 17.** Identified and hypothetical coal resources in millions of short tons for the FGG zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field.

[Resources are grouped in overburden categories and are grouped by county, township, and 7½-minute quadrangle. Resources in coal- and surface-ownership categories are also reported. Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| | Overburden categories, in feet | | | | | Grand total |
|---|---|---|---|---|---|---|
| | 0-500 | 500-1,000 | 1,000-2,000 | 2,000-3,000 | 3,000-6,000 | |
| **By quadrangle** | | | | | | |
| AXIAL | 48 | 7.5 | 0 | 0 | 0 | 56 |
| DEVILS HOLE GULCH | 12 | 5.9 | 9.9 | 8.9 | 28 | 64 |
| EASTON GULCH | 160 | 0 | 0 | 0 | 0 | 160 |
| MEEKER | 7.0 | 15 | 12 | 5.7 | 10 | 50 |
| MONUMENT BUTTE | 11 | 0.28 | 0 | 0 | 0 | 11 |
| NINEMILE GAP | 130 | 34 | 85 | 0 | 0 | 250 |
| RATTLESNAKE MESA | 17 | 34 | 11 | 0 | 0 | 62 |
| THORNBURGH | 9.3 | 0.10 | 0 | 0 | 0 | 9.4 |
| WHITE ROCK | 4.2 | 3.4 | 4.1 | 4.7 | 11 | 27 |
| Grand total | 390 | 99 | 120 | 19 | 48 | 680 |
| **By township** | | | | | | |
| T1N R94W | 0.51 | 0 | 00 | 0 | 0 | 0.51 |
| T2N R92W | 3.7 | 0 | 0 | 0 | 0 | 3.7 |
| T2N R93W | 46 | 63 | 97 | 0 | 0 | 200 |
| T2N R94W | 15 | 20 | 22 | 14 | 35 | 100 |
| T2N R95W | 0 | 0.04 | 0.48 | 1.1 | 6.3 | 7.9 |
| T3N R92W | 42 | 11 | 0 | 0 | 0 | 52 |
| T3N R93W | 94 | 2.7 | 0 | 0 | 0 | 97 |
| T3N R94W | 29 | 0.01 | 0 | 0 | 0 | 29 |
| T3N R95W | 4.6 | 3.7 | 4.2 | 4.2 | 7.3 | 24 |
| T4N R92W | 1.5 | 0 | 0 | 0 | 0 | 1.5 |
| T4N R93W | 26 | 0.25 | 0 | 0 | 0 | 26 |
| T4N R94W | 130 | 0 | 0 | 0 | 0 | 130 |
| Grand total | 390 | 99 | 120 | 19 | 48 | 680 |

| By ownership category | | | |
|---|---|---|---|
| Coal ownership | Total | Surface ownership | Total |
| Federal | 600 | BLM | 110 |
| Non-Federal | 80 | Private | 560 |
| | | State | 12 |
| Grand total | 680 | | 680 |

**Table 18.** Identified and hypothetical coal resources in millions of short tons for the FGG zone of the Fairfield coal group, Williams Fork Formation, Danforth Hills coal field reported by county, reliability, overburden, and coal-thickness categories.

[Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA) boundaries. Coal resources rounded to two significant figures]

| County | Reliability | 0-500 feet overburden coal-thickness categories, in feet | | | | | 0-500 total | 500-1000 feet overburden coal-thickness categories, in feet | | | | | 500-1,000 total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1.2-2.3 | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 1.2-2.3 | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | |
| Moffat | Hypothetical | 2.2 | 0 | 0.00 | 0 | 0 | 2.2 | 1.6 | 0 | 0 | 0 | 0 | 1.6 |
| | Identified | 0.10 | 0.96 | 29 | 180 | 44 | 250 | 0 | 0 | 0.38 | 13 | 0 | 13 |
| Moffat total | | 2.3 | 0.96 | 29 | 180 | 44 | 250 | 1.6 | 0 | 0.38 | 13 | 0 | 15 |
| Rio Blanco | Hypothetical | 3.5 | 2.4 | 0.61 | 0 | 0 | 6.5 | 2.2 | 1.8 | 0.73 | 0 | 0 | 4.7 |
| | Identified | 0.72 | 2.0 | 30 | 51 | 49 | 130 | 0.04 | 0.13 | 22 | 43 | 15 | 80 |
| Rio Blanco total | | 4.2 | 4.4 | 31 | 51 | 49 | 140 | 2.2 | 1.9 | 22 | 43 | 15 | 85 |
| Grand total | | 6.5 | 5.4 | 60 | 230 | 93 | 390 | 3.8 | 1.9 | 22 | 56 | 15 | 99 |

| County | Reliability | 1000-2000 feet overburden coal-thickness categories, in feet | | | | | 1,000-2,000 total | 2000-3000 feet overburden coal-thickness categories, in feet | | | | 2,000-3,000 total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1.2-2.3 | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | >14.0 | | 1.2-2.3 | 2.3-3.5 | 3.5-7.0 | 7.0-14.0 | |
| Moffat | Hypothetical | 1.5 | 0 | 0 | 0 | 0 | 1.5 | 1.1 | 0 | 0 | 0 | 1.1 |
| | Identified | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Moffat total | | 1.5 | 0 | 0 | 0 | 0 | 1.5 | 1.1 | 0 | 0 | 0 | 1.1 |
| Rio Blanco | Hypothetical | 2.9 | 3.0 | 2.4 | 0 | 0 | 8.4 | 3.3 | 2.6 | 4.0 | 0 | 10 |
| | Identified | 0 | 0 | 6.6 | 38 | 68 | 110 | 0 | 0 | 4.5 | 3.8 | 8.2 |
| Rio Blanco total | | 2.9 | 3.0 | 9.0 | 38 | 68 | 120 | 3.3 | 2.6 | 8.5 | 3.8 | 18.2 |
| Grand total | | 4.3 | 3.0 | 9.0 | 38 | 68 | 120 | 4.4 | 2.6 | 8.5 | 3.8 | 19 |

| County | Reliability | 3000-6000 feet overburden coal-thickness categories, in feet | | | | 3,000-6000 total | Grand total |
|---|---|---|---|---|---|---|---|
| | | 1.2-2.3 | 2.3-3.5 | 3.5-7.0 | 7.0-14 | | |
| Moffat | Hypothetical | 1.8 | 0 | 0 | 0 | 1.8 | 8.2 |
| | Identified | 0 | 0 | 0 | 0 | 0 | 260 |
| Moffat total | | 1.8 | 0.00 | 0 | 0 | 1.8 | 270 |
| Rio Blanco | Hypothetical | 6.1 | 4.4 | 22 | .63 | 33 | 63 |
| | Identified | 0 | 0 | 9.2 | 4.3 | 14 | 350 |
| Rio Blanco total | | 6.1 | 4.4 | 31 | 4.9 | 47 | 410 |
| Grand total | | 7.9 | 4.4 | 31 | 4.9 | 49 | 680 |

**Table 19.** Identified and hypothetical coal resources in millions of short tons for the Fairfield coal group of the Upper Cretaceous Williams Fork Formation, Danforth Hills coal field, Colorado.

[Resources are reported in overburden categories and are grouped by county, township, and 7½-minute quadrangle. Resources in coal- and surface-ownership categories are also reported. Resources are not reported for areas inside Colowyo Federal coal leases and Preference Right Lease Application (PRLA). Coal resources rounded to two significant figures]

| | Overburden categories, in feet | | | | | Total |
|---|---|---|---|---|---|---|
| | 0-500 | 500-1000 | 1000-2000 | 2000-3000 | 3000-6000 | |
| **By county** | | | | | | |
| Moffat | 3300 | 2900 | 1400 | 64 | 130 | 7800 |
| Rio Blanco | 3600 | 2800 | 3100 | 1300 | 2300 | 13000 |
| Total | 6900 | 5700 | 4500 | 1400 | 2400 | 21000 |
| **By township** | | | | | | |
| T1N R93W | 1.3 | 0 | 0 | 0 | 0 | 1.3 |
| T1N R94W | 43 | 22 | 2.7 | 0 | 0 | 68 |
| T2N R92W | 340 | 110 | 9.5 | 0 | 0 | 460 |
| T2N R93W | 900 | 1000 | 1700 | 520 | 0 | 4100 |
| T2N R94W | 450 | 480 | 990 | 590 | 1500 | 4100 |
| T2N R95W | 0 | .12 | 9.9 | 40 | 340 | 390 |
| T3N R92W | 420 | 400 | 250 | 0 | 0 | 1100 |
| T3N R93W | 1200 | 1100 | 340 | 0 | 0 | 2600 |
| T3N R94W | 1500 | 690 | 120 | 0 | 0 | 2300 |
| T3N R95W | 400 | 300 | 370 | 250 | 590 | 1900 |
| T4N R92W | 80 | 66 | 2.0 | 0 | 0 | 150 |
| T4N R93W | 400 | 260 | 61 | 0 | 0 | 720 |
| T4N R94W | 1100 | 1300 | 640 | 0 | 0 | 3000 |
| T4N R95W | 86 | 0 | 0 | 0 | 0 | 86 |
| T5N R94W | .77 | 0 | 0 | 0 | 0 | 77 |
| Total | 6900 | 5700 | 4500 | 1400 | 2400 | 21000 |
| **By quadrangle** | | | | | | |
| AXIAL | 450 | 370 | 180 | 0 | 0 | 1000 |
| DEVILS HOLE GULCH | 1500 | 660 | 480 | 360 | 1200 | 4200 |
| EASTON GULCH | 1600 | 1600 | 740 | 0 | 0 | 4000 |
| MEEKER | 170 | 210 | 580 | 260 | 370 | 1600 |
| MONUMENT BUTTE | 90 | 110 | 58 | 0 | 0 | 260 |
| NINEMILE GAP | 2100 | 1900 | 1200 | 480 | 0 | 5700 |
| PRICE CREEK | 45 | .16 | 0 | 0 | 0 | 45 |
| RATTLESNAKE MESA | 370 | 410 | 830 | 41 | 0 | 1700 |
| SAWMILL MOUNTAIN | 25 | 0 | 0 | 0 | 0 | 25 |
| THORNBURGH | 280 | 160 | 54 | 0 | 0 | 490 |
| WHITE ROCK | 220 | 250 | 340 | 250 | 770 | 1800 |
| Total | 6900 | 5700 | 4500 | 1400 | 2400 | 21000 |

**By ownership category**

| Coal ownership | Total | Surface ownership | Total |
|---|---|---|---|
| Federal | 19000 | BLM | 5100 |
| Non-Federal | 2500 | Private | 15000 |
| | | State | 530 |
| Total | 21000 | | 21000 |

structed for each of the seven coal zones in the Fairfield coal group (figs. 20–26).

The maximum overburden for the Fairfield coal zones was determined by integrating structure contours drawn on the top of the Upper Cretaceous Trout Creek Sandstone (base of the Fairfield coal group) of the Iles Formation (fig. A on pl. 1), basal elevations for each coal zone, and surface elevations imported from 1:24,000 Digital Elevation Models for the 14 quadrangles within the Danforth Hills (fig. 5). The areal extent of each zone was determined by integrating structure contours drawn on top of the Trout Creek Sandstone, the mean base elevation for each zone above the Trout Creek (table 3), and the Digital Elevation Models for the quadrangles to determine a zero overburden line. The zero overburden line is equivalent to a basal crop line for the coal zone (see Roberts and others, chap. C, this CD-ROM). For this study, the base of the FGA and FGB zones was drawn on the top of the Trout Creek Sandstone.

# Coal Resources

Hancock and Eby (1930) reported an estimated original coal resource on a coal-group basis of 10.6 billion short tons to an overburden depth of 3,000 ft for the Meeker quadrangle. Landis (1959) reported an estimated original coal resource on an individual-bed basis of 7.9 billion short tons to an overburden depth of 3,000 ft for the Danforth Hills coal field. Hornbaker and others (1976) reported an estimated original coal resource of 10.5 billion short tons to an overburden depth of 6,000 ft for the Danforth Hills coal field.

Based on data derived from the present study, coal resources of about 21 billion short tons (table 19) in the identified and hypothetical resource reliability categories (Wood and others, 1983) are estimated for the Fairfield coal group. This estimate includes all coal beds greater than 1.2 ft thick to an overburden depth of less than 6,000 ft. The calculated coal resources are shown for various categories (coal and overburden thickness; resource type, county, township, and quadrangle location; coal ownership) in tables 5–18; a summary is given in table 19. Sixty percent of the total coal (13 billion short tons) is within the 1,000-ft overburden category, and more than 32 percent (6.9 billion short tons) is with the 500-ft overburden category. More than 47 percent of the total coal resource is contained in the FGB (4.7 billion short tons) and FGE (5.2 billion short tons) coal zones; more than 88 percent of the coal in these two zones is federally owned and administrated by the Bureau of Land Management. The FGE, FGF, and FGG zones in the northern two-thirds of the study area have significant areas where the overburden is less than 500 ft. About 32 percent of the total coal in the FGE, FGF, FGG zones (3.2 billion short tons), in the northern part of the study area, is within the 500-ft maximum overburden category.

Although the Danforth Hills coal field contains estimated original resources of 21 billion short tons of coal in the Fairfield coal group, this figure does not reflect economic, land-use, environmental, technological, and geologic constraints that may affect coal availability and recoverability (T.J. Rohrbacher, written commun., 1998). Some of the economic constraints involve costs to build or move infrastructures such as railroads, highways, and primary electrical transmission lines. Environmental restrictions include river valleys, towns and communities, wildlife habitat, and air-quality issues. Geologic constraints include faulting, coal-bed thickness, and the dip of the strata. Any combination of these constraints and (or) restrictions can reduce the amount of coal that is available and recoverable by as much as 10 to 20 percent of the original resource (Rohrbacher and others, 1994).

Within the Danforth Hills coal field, the recoverable coal will be restricted because many of the deeper coals within the Fairfield coal group are too close together for longwall mining. Longwall mining methods causes controlled collapsing of overburden, including coal beds thus reducing the amount of recoverable coal. The thickness of the partings and splits can also limit the recovery of the coal being mined. Mining techniques can reduce the original resource; for example, longwall methods can restrict the recovery of thick beds where mining equipment is engineered for a limited range of coal-bed thickness, normally less than 14 ft. Another factor that may limit recoverability is that much of the total coal resource is deeper than 1,000 ft. Currently, coal is being mined, by dragline, and truck and shovel methods, from two zones (FGF and FGG) in the Colowyo strip mine. Future mining in the Danforth Hills coal field will most likely be restricted to the areas adjacent to the Colowyo mine and its rail line by both longwall and stripping methods. Although the factors just discussed will reduce the amount of coal that can ultimately be recovered, we did not estimate the tonnages that might be affected.

# References Cited

American Society for Testing and Materials, 1997, Standard classification of coals by rank [ASTM designation D-388-95], *in* Petroleum Products, Lubricants, and Fossil Fuels: 1997 Annual Book of ASTM standards, v. 5, sec. 5, p. 168–171.

Barnum, B.E., and Bass, N.W., 1974, The Danforth Hills Known Coal Leasing Area, Moffat and Rio Blanco Counties, Colorado: U.S. Geological Survey unpublished geologic map and report supporting outline map, legal description, and minutes published in Federal Register, scale 1:62,500.

Brownfield, M.E., and Johnson, E.A., 1984, Selected references on the geology of the Danforth Hills coal field, Moffat and Rio Blanco Counties, Colorado: U.S. Geological Survey Open-File Report 84-768, 28 p.

Brownfield, M.E., and Johnson, E.A., 1986, A regionally extensive altered air-fall ash for use in correlation of lithofacies in the Upper Cretaceous Williams Fork Formation, northeastern Piceance Creek and southern Sand Wash Basins, Colorado, *in* Stone, D.S., ed., New

Interpretations of Northwest Colorado Geology: Rocky Mountain Association of Geologists, p. 293–295.

Gale, H.S., 1907, Coal fields of the Danforth Hills and Grand Hogback in northwestern Colorado: U.S. Geological Survey Bulletin 316-E, p. 264–301.

Gale, H.S., 1909, Coal fields of northwestern Colorado and northeastern Utah: U.S. Geological Survey Bulletin 341-C, p. 283–315.

Gale, H.S., 1910, Coal fields of northwestern Colorado and northeastern Utah: U.S. Geological Survey Bulletin 415, 265 p.

Green, G.N., 1992, Digital geologic map of Colorado: U.S. Geological Survey Open-File Report OF-92-0425, scale 1:500,000.

Hancock, E.T., 1925, Geology and coal resources of the Axial and Monument Butte quadrangles, Moffat County, Colorado: U.S. Geological Survey Bulletin 757, 134 p.

Hancock, E.T., and Eby, J.B., 1930, Geology and coal resources of the Meeker quadrangle, Moffat and Rio Blanco Counties, Colorado: U.S. Geological Survey Bulletin 812-C, p. 191–242.

Hornbaker, A.L, Holt, R.D., and Murray, D.K., 1976, 1975 summary of coal resources in Colorado: Colorado Geological Survey Special Publication No. 9, 17 p.

Izett, G.A, Honey, J.G., and Brownfield, M.E., 1985, Geologic map of the Citadel Plateau quadrangle, Moffat County, Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-1532, scale 1:48,000.

Landis, E.R., 1959, Coal resources of Colorado: U.S. Geological Survey Bulletin 1072-C, p. 131–232.

Nutt, C.J., 1978, Drilling during 1977 in the Danforth Hills coal field, Axial and Ninemile Gap quadrangles, Moffat and Rio Blanco Counties, Colorado: U.S. Geological Survey Open-File Report 78-273, 17 p.

Nutt, C.J., 1981, Geologic map and coal resources of the western part of the Ninemile Gap quadrangle and the southern part of the Axial quadrangle, Moffat and Rio Blanco Counties, Colorado: U.S. Geological Survey Open-File Report 81-12, scale 1:24,000.

Pipiringos, G.N. and Rosenlund, G.C., 1977, Preliminary geologic map of the White Rock quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-837, scale 1:24,000.

Resource Data International, Inc., 1998, COALdat database: Boulder, Colorado, Resource Data International, Inc. [1320 Pearl Street, Suite 300, Boulder, CO 80302].

Reheis, M.C., 1976, Reconnaissance drilling in the Danforth Hills coal field, Moffat and Rio Blanco Counties, Colorado, August–September 1976: U.S. Geological Survey Open-File Report 76-870, 74 p.

Reheis, M.C., 1978a, Drilling during 1977 in the Danforth Hills coal field, Easton Gulch and Devils Hole Gulch quadrangles, Moffat County, Colorado: U.S. Geological Survey Open-File Report 78-272, 29 p.

Reheis, M.C., 1978b, Drilling during 1978 in the Danforth Hills coal field, Easton Gulch, Devils Hole Gulch, Axial, and Ninemile Gap quadrangles, Moffat and Rio Blanco Counties, Colorado: U.S. Geological Survey Open-File Report 78-1031, 38 p.

Reheis, M.C., 1980a, Geologic map and coal sections of the Thornburgh quadrangle, Moffat and Routt Counties, Colorado: U.S. Geological Survey Open-File Report 80-251, scale 1:24,000.

Reheis, M.C., 1980b, Geologic map and coal sections of the Sawmill Mountain quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Open-File Report 80-252, scale 1:24,000.

Reheis, M.C., 1981, Geologic map and coal resources of the Easton Gulch quadrangle, Moffat County, Colorado: U.S. Geological Survey Coal Investigations Map C-87, scale 1:24,000.

Reheis, M.C., 1983a, Geologic map and coal sections of the Sawmill Mountain quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Coal Investigations Map C-99, scale 1:24,000.

Reheis, M.C., 1983b, Geologic map and coal sections of the Thornburgh quadrangle, Moffat and Rio Blanco counties, Colorado: U.S. Geological Survey Coal Investigations Map C-100, scale 1:24,000.

Roberts, L.N., and Kirschbaum, M.A., 1995, Paleogeography of the Late Cretaceous of the western interior of middle North America—Coal distribution and sediment accumulation: U.S. Geological Survey Professional Paper 1561, 115 p.

Roberts, L.N.R., Mercier, T.J., Biewick, L.R.H., and Blake, Dorsey, 1998, A procedure for producing maps and resource tables of coals assessed during the U.S. Geological Survey's National Coal Assessment: Fifteenth Annual International Pittsburgh Coal Conference Proceedings, CD-ROM (ISBN 1-890977-15-2), 4 p.

Rowley, P.D, Tweto, Ogden, Hanson, W.R., and Carrara, P.E., 1979, Geologic map of the Vernal 1°×2° quadrangle, Colorado, Utah, and Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-1526, scale 1:250,000.

Sears, J.D., 1925, Geology and oil and gas prospects of part of Moffat County, Colorado, and southern Sweetwater County, Wyoming: U.S. Geological Survey Bulletin 751, p. 269–319.

Tully, John, 1996, Coal fields of the conterminous United States: U.S. Geological Survey Open-File Report 96-92, 1 plate, scale 1:5,000,000.

Tweto, O., 1976, Geologic map of the Craig 1°×2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Investigations Series Map I-972, scale 1:250,000.

Tweto, O., 1979, Geologic Map of Colorado: U.S. Geological Survey, scale 1:500,000.

Tweto, O., 1975, Preliminary geologic map of the east half of the Vernal 1°×2° quadrangle, Colorado: U.S. Geological Survey Open-File Report 75-788, scale 1:250,000.

Wood, G.H., Kehn, T.M., Carter, M.D., and Culbertson, W.C., 1983, Coal resource classification system of the U. S. Geological Survey: U. S. Geological Survey Circular 891, 65 p.

*Click on image below to bring up high-resolution image of plate 1*

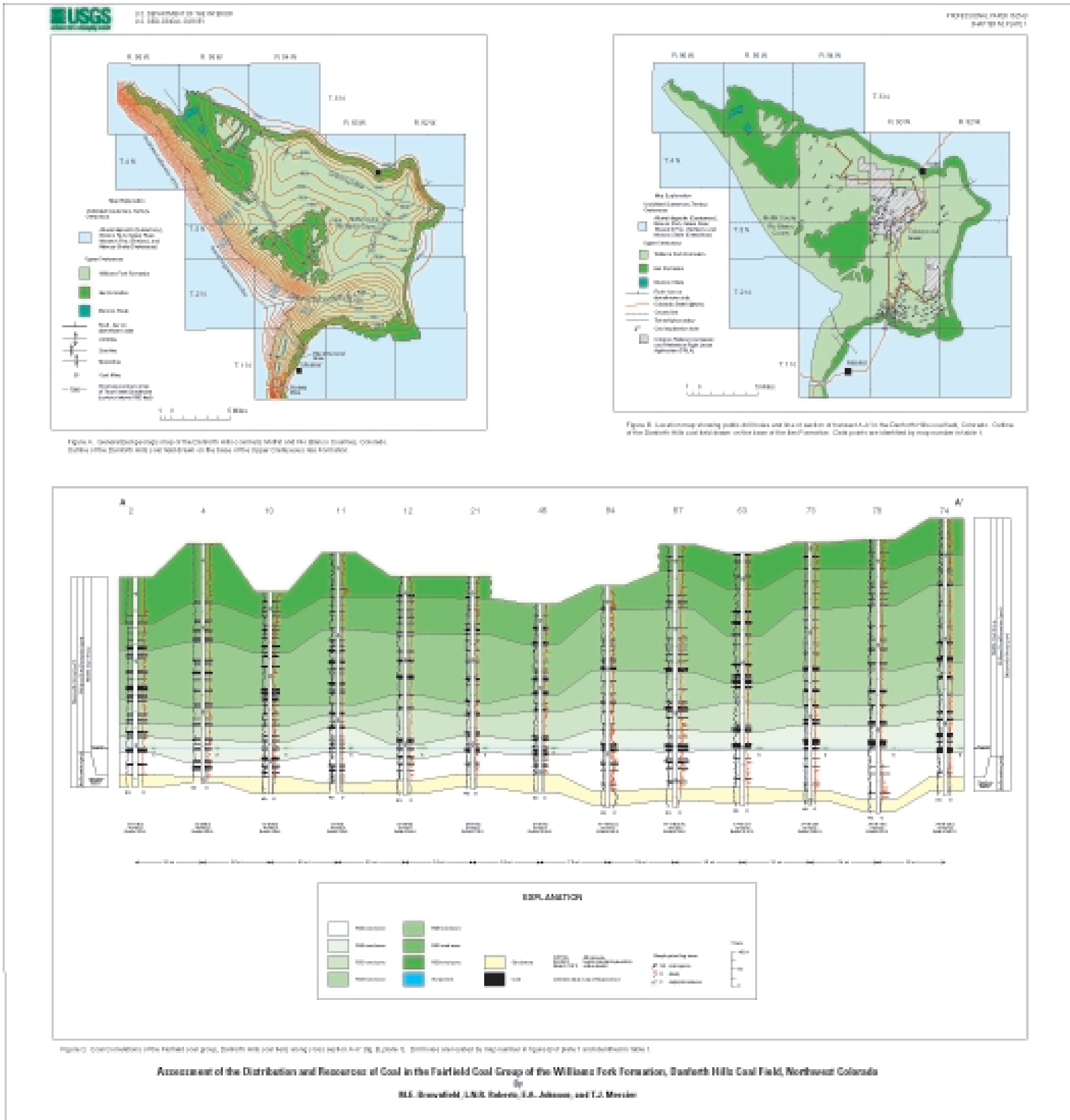



**Plate 1.** Assessment of the distribution and resources of coal in the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, northwest Colorado.

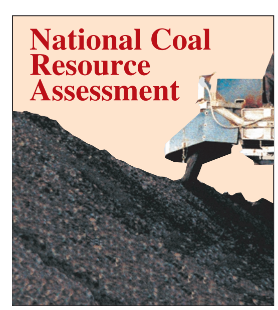
## Appendix 1—Digital Files for Coal Exploration Drill Holes in the Danforth Hills Coal Field, Northwest Colorado, for which Data are Publicly Available

Appendix 1 contains the publicly available drill-hole database (110 holes—shown in table 1) used to asses coal resources in the Fairfield coal group Williams Fork Formation in the Danforth Hills coal field, northwest Colorado. The location, lithologic, and stratigraphic data are available in ASCII format, DBF, and Excel spreadsheet files on disc 2 of this CD-ROM.

## Appendix 2—ArcView Project for the Geologic Assessment of Coal in the Fairfield Coal Group, Williams Fork Formation, Danforth Hills Coal Field, Northwest Colorado

The digital files used for the coal resource assessment of the Fairfield coal group of the Williams Fork Formation, Danforth Hills coal field, northwest Colorado, are presented as views in the ArcView project.

The ArcView project and the digital files are stored on both discs of this CD-ROM set—Appendix 2 of chapter M resides on both discs. Persons who do not have ArcView 3.1 may query the data by means of the ArcView Data Publisher on disc 1. Persons who do have ArcView 3.1 may utilize the full functionality of the software by accessing the data that reside on disc 2. An explanation of the ArcView project and data library—and how to get started using them—is given by Biewick and Mercier (chap. D, this CD-ROM). Metadata for all digital files are also accessible through the ArcView project.

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