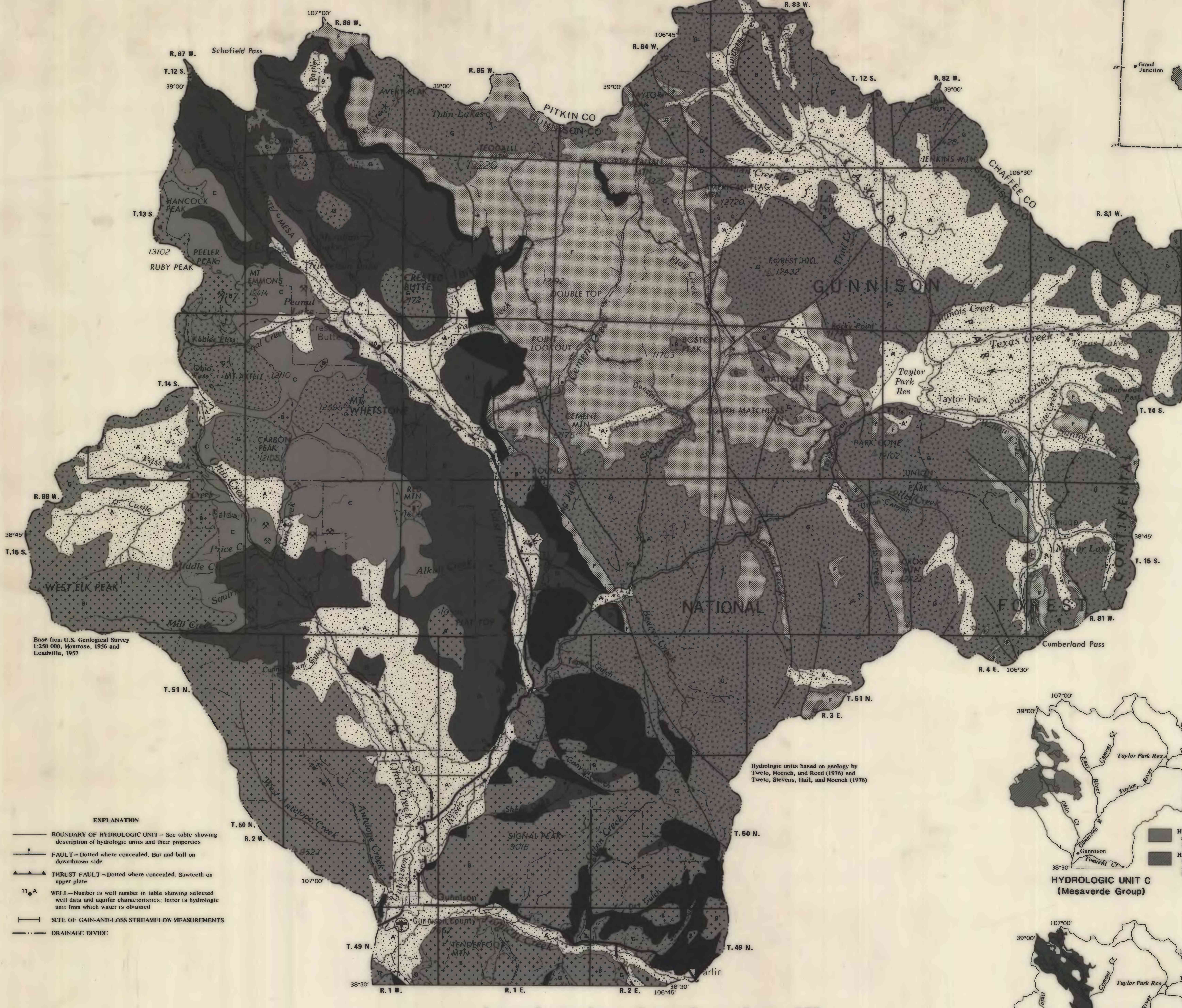
Prepared in cooperation with the
COLORADO DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER RESOURCES
OFFICE OF THE STATE ENGINEER



Base from U.S. Geological Survey 1:250 000, Montrose, 1956 and Leadville, 1957

Hydrologic units based on geology by Tweto, Moench, and Reed (1976) and Tweto, Stevens, Hail, and Moench (1976)

HYDROGEOLOGIC MAP

INTRODUCTION

In recent years parts of the Gunnison-Crested Butte area (index map) have undergone rapid population growth due to an increase in winter sports activities. This rapid growth has been most prominent in the Ohio Creek, the Gunnison River, and the East River valleys, and has resulted in a demand for additional domestic, recreational, and municipal water supplies. Information on the occurrence, availability, and quality of ground water was needed for a more efficient allocation of this resource by the State of Colorado. An investigation to provide the information was begun in 1976 by the U.S. Geological Survey in cooperation with the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer.

The purpose of the investigation was to identify and describe the hydrologic units and to evaluate the availability and chemical quality of groundwater in the 1,100-mi² study area. A review of published geologic maps and reports was made, and available data from approximately 100 existing wells were obtained. Hydraulic characteristics of alluvial aquifers were estimated using data from drillers' logs of wells completed in these aquifers. Hydraulic characteristics of bedrock aquifers were estimated using the results of single-well aquifer tests made in seven wells completed in these aquifers. Eighty-five water samples from wells and springs were analyzed to determine the quality of ground water. Gain-and-loss streamflow measurements were made along a selected reach of the Taylor River. The data were collected during the fall of 1976 and the spring and fall of 1977. Geologic information used in preparation of this report is from published reports by Tweto, Moench, and Reed (1976); Tweto, Stevens, Hail, and Moench (1976); Gaskill and Godwin (1966); Staatz and Trites (1955); and Prather (1964); and unpublished theses by Prather (1961) and Murphy (1951).

AVAILABILITY OF GROUND WATER

Ground water occurs in seven hydrologic units in the study area. (See hydrogeologic map and table describing the hydrologic units.) The seven hydrologic units overlap the geologic framework in the study area and are separated on the basis of similar hydrologic properties. Formations within a given unit have a common geology and a related hydraulic system.

The hydrologic units consist of: Unit A, sand and gravel deposits of Quaternary age along the East, the Taylor, and the Gunnison Rivers, and their principal tributaries; Unit B, basalts and tuffs of Tertiary age and semiconsolidated sandstones and conglomerates of the Wasatch and Ohio Creek Formations of Tertiary age; Unit C, sandstones of the Mesaverde Group of Late Cretaceous age; Unit D, fractured and weathered beds of the Mancos Shale of Late Cretaceous age; Unit E, sandstones of the Dakota Sandstone, Morrison Formation, and Entrada Sandstone of Late Cretaceous to Late Jurassic age; Unit F, sedimentary rocks of Permian to Cambrian age, and Unit G, granitic and gneissic rocks of Precambrian age.

Hydrologic Unit A

The aquifers of hydrologic unit A consist primarily of alluvium or river-channel deposits. These deposits of cobbles, gravel, sand, silt, and clay range in thickness from less than 10 ft to about 140 ft, and are generally less than 30 ft in the tributary valleys. The alluvium is thin or absent where streams cross the hard resistant sandstones of the Dakota, Morrison, and Entrada Formations. The alluvium is thicker and wider where the streams cross less resistant rock units, such as the Mancos Shale. Wells completed in the alluvium range in depth from 17 to 139 ft. The deepest measured depth to water was 32 ft below land surface.

Reported yields of wells completed in the alluvium range from 2 to 100 gal/min. The largest well yields in the area can be obtained from the alluvium along the Gunnison River and Ohio Creek near Gunnison. Wells that fully penetrate the alluvium along these streams may yield more than 100 gal/min. Data for wells completed in the alluvium and hydraulic characteristics of the aquifer are shown on the hydrogeologic map and in the table of selected well data and aquifer characteristics.

Significant colluvial deposits, consisting of glacial, landslide, and slope talus are found in the higher upland areas and valleys, particularly in the vicinity of Taylor Park and Tincup. These deposits, ranging from 20 to 100 ft thick, are relatively permeable and retain water only seasonally. During the spring or early summer, springs may flow from the base of the colluvial material at the contact with underlying less permeable material. Spring discharges are generally less than 5 gal/min, vary seasonally, and depend primarily on the areal extent, the hydrologic characteristics, and the topographic relief of the colluvial deposits.

Hydrologic Units B, C, D

Consolidated and semiconsolidated aquifers in the study area include the Tertiary basalts and tuffs and the sandstones of the Wasatch and Ohio Creek Formations (hydrologic unit B), the Mesaverde Group (hydrologic unit C), and the Mancos Shale (hydrologic unit D). Well yields from these aquifers are variable and are generally less than those from the unconsolidated alluvial aquifers (hydrologic unit A).

Yields greater than 20 gal/min are obtained from the basalts and tuffs where ground water is stored in the fractured and collapsed areas and perched on the underlying confining beds. Yields less than 20 gal/min are obtained from the indurated sandstones and shales of the Wasatch, Ohio Creek, Mesaverde, and Mancos units. Because of the fine-grained, partly cemented sandstones and the relatively small hydraulic conductivity of the shales, well yields in these aquifers are controlled primarily by formation fracturing.

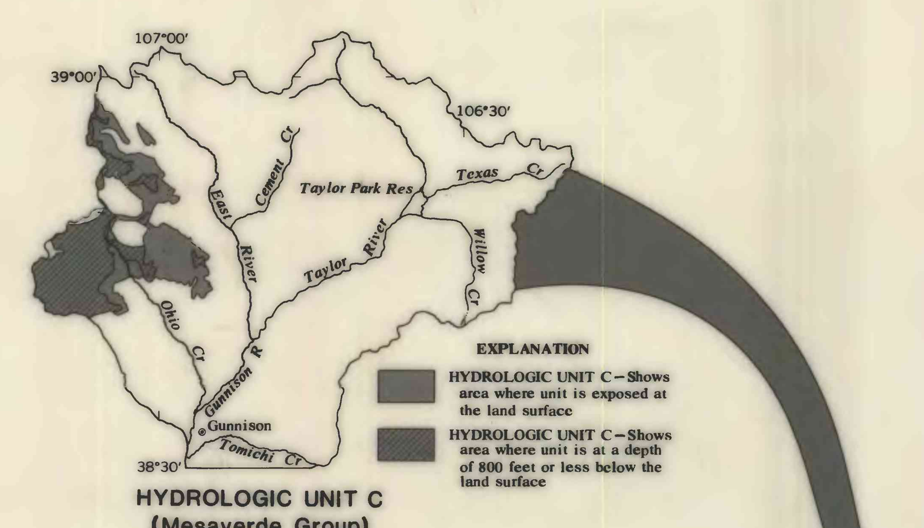
Hydrologic Unit E

Sandstones of the Dakota, Morrison, and Entrada Formations comprise the principal aquifers of hydrologic unit E. Well yields are generally less than 20 gal/min, but in some areas may be as much as 60 gal/min. The largest well yields are obtained in the western part of the study area where the sandstones are overlain and confined by shales of the Mancos and Morrison Formations, and in the area between Gunnison and Almont along the Gunnison River where the sandstones are overlain by impermeable volcanic material. Smallest well yields are obtained where the sandstones are exposed at or near the surface. In these areas, the aquifer is unconfined and well depths are shallow. In the northern part of the study area from Almont to Gothic along the East River, these sandstones are partly cemented by silica and may not constitute an aquifer.

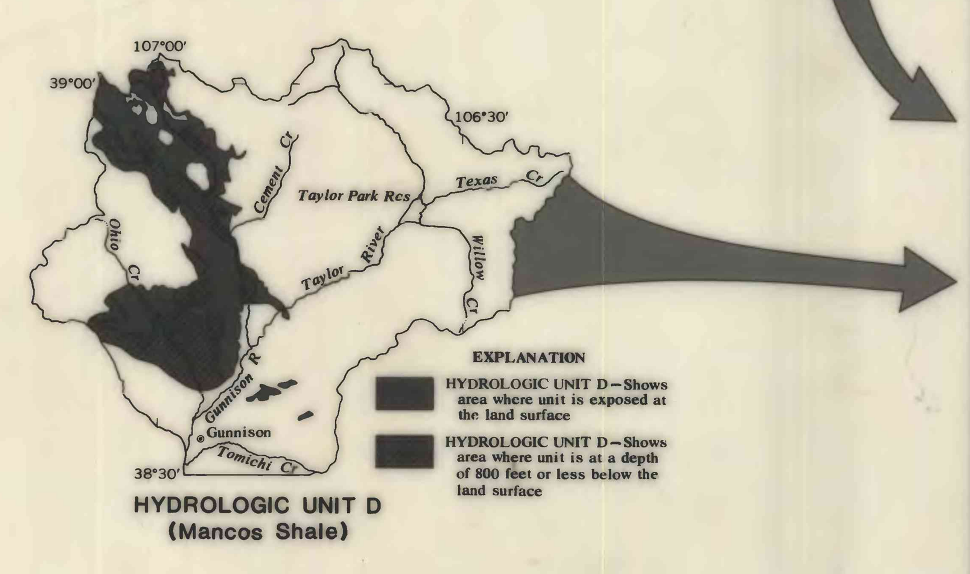
Artesian wells developed in the sandstones of the Dakota, Morrison, and Entrada Formations exist in parts of the study area. In the Gunnison River valley, about 3 mi north of Gunnison, a flowing well completed in the Entrada Sandstone has a discharge of approximately 35 gal/min and a shut-in pressure head of 157 ft above land surface. Yields of other flowing wells range from 2 to 40 gal/min, depending on the permeability, head above land surface, and well construction. The yields of flowing wells decrease rapidly as pressure in the aquifer decreases. Estimated transmissivity and hydraulic-conductivity values from analysis of single-well aquifer tests are presented in the table of selected well data and aquifer characteristics.

Hydrologic Units F and G

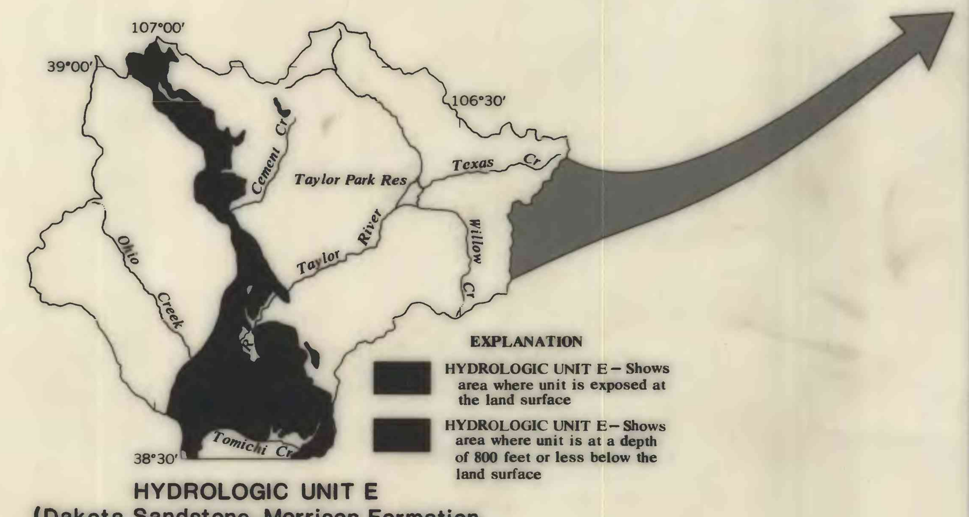
The water-yielding capabilities of these bedrock aquifers vary widely and are largely dependent on fracture permeability and the extent of cementing in the fractures. Reported well yields range from about 1 to 15 gal/min. The cementing process is very prominent in the sandstones and limestones of unit F where iron and calcium carbonates are the predominant cementing agents. Unit G consists primarily of granitic and metamorphic rocks. Porosity is due to fracturing and the cementing process plays an insignificant role. Springs issuing from these aquifers have potential for development of a water supply. A spring issuing from the Leadville Limestone near South Matchless Mountain had an estimated discharge of 300 gal/min. In general, the yields of these springs are dependent on the same factors as springs in the colluvium. However, springs issuing from the sedimentary rocks are more likely to be perennial and have larger yields than springs issuing from the colluvium.



HYDROLOGIC UNIT C (Mesaverde Group)



HYDROLOGIC UNIT D (Mancos Shale)



HYDROLOGIC UNIT E (Dakota Sandstone, Morrison Formation, and Entrada Sandstone)

DESCRIPTION OF HYDROLOGIC UNITS AND THEIR PROPERTIES

Hydrologic unit	Geologic age		Geologic units	Predominant rock type	Maximum thickness (feet)	Hydrologic characteristics
A	QUATERNARY	Holocene	Unconsolidated alluvium, glacial drift, landslide deposits, and talus deposits	Material ranges in size from clay to large boulders and consists of both angular to subrounded and well-rounded rocks, depending primarily upon type of deposit, rock type, and source material	140 (estimated)	Reported well yields range from 2 to 100 gal/min, but average 20 gal/min. Important source of water in the Gunnison and Crested Butte areas. The abundant colluvial material in Taylor Park is a source of water for several springs. See table of selected well data and aquifer characteristics for additional information.
		Pleistocene				
B	TERTIARY	Miocene and Oligocene	Miocene basalts, Oligocene ashflow tuffs, Oligocene sedimentary rocks, and middle Tertiary intrusive rocks	Extrusive rocks consist primarily of dense black resistant lava flows, breccias, volcanic conglomerates, and ashflow tuffs which range from rhyolite to quartz-latite. Some gravels, water-laid tuffs, sands, and silts are present within the volcanic sequence. Intrusive rocks are present in the form of granodiorites, quartz monzonites, and granites in stocks, dikes, sills, laccoliths, and irregular bodies	Unknown	Water quantity is variable, depending on underlying bedrock and the extent of the fractured volcanic material. Reported well yields locally are greater than 20 gal/min from the basalts and tuffs. Not considered an important source of water. In the southern part of the area, the lava flows act as confining layers to sandstones of hydrologic unit E.
		Eocene and Paleocene	Wasatch and Ohio Creek Formations	Varicolored sandstones and shales with interbedded siltstones and conglomerates	2,200	
C	CRETACEOUS	Late Cretaceous	Mesaverde Group	Light-brown to gray, fine- to medium-grained ledge-forming sandstone, with interbedded gray carbonaceous shale, coal, and clinker beds. Coals are economically important in the lower beds	2,300	Data for only one well obtained; yield is 9.3 gal/min. See table of selected well data and aquifer characteristics for additional information.
D			Mancos Shale	Medium- to dark-gray fossiliferous marine shale with interbedded limestone in the lower beds. Shales are calcareous and slightly carbonaceous. The overall area occupied by the Mancos Shale is characterized by a rolling hummocky topography	5,000	Reported well yields are as much as 15 gal/min; yields of 1 to 5 gal/min are more common. Largest well yields are developed in landslides and slump blocks developed on the shale.
E			Dakota Sandstone	Light-gray to light-brown, fine- to medium-grained locally carbonaceous sandstone with some interbedded coal, light-gray to green shales, and lenticular chert-pebble conglomerates. The sandstones weather to a rust-brown color and form ridges	200	Reported well yields range from 5 to 60 gal/min. Primary source of water in the Gunnison area. Flowing wells (2 to 40 gal/min) can be found in the Ohio Creek and Gunnison River valleys and in areas where the Dakota and Entrada Sandstones are overlain by impervious shales of the Mancos Shale and Morrison Formation. See table of selected well data and aquifer characteristics for additional information.
		Early Cretaceous	Burro Canyon Formation		100	
	JURASSIC	Late Jurassic	Morrison Formation	Interbedded variegated shales, light-yellow to white sandstones, and dense gray limestones	400	
			Junction Creek Sandstone		180	
			Entrada Sandstone	Pale-orange to white, very fine- to medium-grained, crossbedded eolian sandstones	85	
F	PERMIAN		Maroon Formation	Conglomerates, sandstones, siltstones, shales, limestones, and quartzites. Rocks vary considerably in color and are generally arkosic, micaceous, hard, calcareous, and may be metamorphosed	3,500	May be aquifers near outcrop areas. Reported well yields are less than 15 gal/min. Leadville Limestone may have potential for larger yields.
	PENNSYLVANIAN		Gothic (of local usage) or Minturn Formation		1,750	
			Belden Formation		650	
	MISSISSIPPIAN		Leadville Limestone		300	
	CAMBRIAN		Peerless Formation Sawatch Quartzite		300	
G	PRECAMBRIAN		Granitic rocks and interlayered felsic and hornblendic gneisses	Granites, granodiorites, quartz monzonites, and a variety of metavolcanic rocks and gneisses are the predominant rock types	-----	Reported well yields range from 1 to 3 gal/min where rocks are fractured.

SELECTED WELL DATA AND AQUIFER CHARACTERISTICS

Well number (on hydrogeologic map)	Location	Hydrologic unit-geologic unit	Well depth (feet below land surface)	Approximate aquifer thickness (feet)	Depth of contributing interval or perforated zone (feet)	Static water level (feet below land surface)[1]	Yield (gallons per minute)	Drawdown[2] (feet)	Estimated transmissivity of the contributing interval[3] (feet squared per day)	Estimated hydraulic conductivity of the contributing interval (feet per day)	Specific capacity (feet squared per day)[4]	Casing diameter (inches)	Source of data[5]
1	NA05000108AA	A-Alluvium	34	60	29-34	11	15	5	600	100	600	5	2
2	NB05000105CC	A-Alluvium	29	50	18-29	9	35	14	500	40	500	---	2
3	NB05000108AC	A-Alluvium	27	55	22-27	7	15	4	700	100	700	5	2
4	NB05000124BD	A-Alluvium	26	50	20-26	6	20	5	800	100	800	5	2
5	NB05000125CC	A-Alluvium	30	50	15-30	2	9	---	---	---	---	5½	2
6	NB05000126CC	A-Alluvium	23	55	16-23	3	10	20	100	10	100	5	2
7	NB05000135AA	A-Alluvium	71	50	32-42	30	15	4	700	70	700	5	2
8	NB05100135BC	A-Alluvium	28	18	12-18	5	12	8	---	---	300	5	2
9	SC01408534AA	A-Alluvium	55	60	48-55	38	20	5	800	100	800	5	2
10	SC01408601CC	A-Alluvium	40	60	33-40	19	20	5	800	100	800	5	2
11	SC01508415CA	A-Alluvium	47	46	33-47	10	9	4	400	30	400	4½	2
12	SC01508422CC	A-Alluvium	47	70	20-47	19	--	---	---	60	---	---	2
13	SC01508628CA	A-Alluvium	43	28	12-21	11	8	34	5	5	50	4½	2
14	SC01508608DCB	C-Mesaverde Group	200	24	---	28	([6])	113	---	---	---	6	1
15	NA05100133CCB	E-Morrison	405	100	open hole	134	4.3	144	.8	.008	5.8	6	1
16	NB05000113CDC	E-Entrada	797	85	451-797 (open hole)	-157	35	F	70	.8	43	12½" at 50' 10" at 110' 8" at 451'	1,3
17	NB05000114CAA	E-Dakota	423	150	400-410	185	7.3	215	1.6	.16	6.5	7	1
18	NB05000125ACD1	E-Dakota	125	150	105-125	7	8.6	16	90	4.5	103	6	1
19	NB05000134DD	E-Dakota	103	150	63-103	65	15	10	400	10	290	5	1
20	SC01508513CAB1	E-Entrada	1480	85	1400-1480 (open hole)	-58	40	F	65	.8	---	10" at 66' 8" at 340' 7" at 940' 5" at 1400'	1,3

[1] Negative number indicates a flowing well with shut-in pressure head given in feet above land surface.
[2] F indicates flowing well.
[3] Transmissivity and hydraulic conductivity values estimated using method in Thomasson, Olmstead, and LeRoux (1960) for hydrologic unit A and using method in Jacob and Lohman (1952) for hydrologic units C and E.
[4] Specific capacity is the yield converted to cubic feet per day divided by the drawdown, in feet.
[5] 1. U.S. Geological Survey data collection; 2. Driller's log data; 3. Petroleum Information Corporation cards.
[6] Pumping at 9.2 gal/min drew water level down below 141 ft (maximum lift capacity of pump) in 42 minutes.

CONVERSION FACTORS

For those readers who may prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply inch-pound unit	*By*	*To obtain metric unit*
inch (in.)	2.540	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
foot per day (ft/d)	0.3048	meter per day
square foot per day (ft^2/d)	0.09290	square meter per day
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
gallon per minute (gal/min)	0.06309	liter per second

RECONNAISSANCE OF GROUND-WATER RESOURCES IN THE VICINITY OF GUNNISON AND CRESTED BUTTE, WEST-CENTRAL COLORADO

By
T. F. Giles
1980