Voegeli, P.T.

Water for the Proposed West Side
Campground Site Rocky Mountain National
Park, Colorado. 1963

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
FEDERAL CENTER, DENVER 25, COLORADO

October 31, 1963

PRESS STATEMENT FOR:

SUBJECT: WATER FOR PROPOSED WEST SIDE CAMPGROUND SITE, ROCKY MOUNTAIN NATIONAL PARK, COLORADO

RELEASE DATE: November 5, 1963

FOR ADDITIONAL INFORMATION CALL: Leonard A. Wood, District Geologist, Ground Water Branch, 233-3611, Ext. 8546

Ample quantities of ground water are available for the water supply at the proposed West Side Campground Site, Rocky Mountain National Park, Colorado.

A study of the ground-water resources in and near the campground site was completed recently by the U.S. Geological Survey. Results of the study described in an open-file report prepared for the U.S. National Park Service indicate that the aquifer in the terrace deposits underlying the site is capable of providing ample quantities of good quality water for the operation of the campground.

The report, "Ground Water for the Proposed West Side Campground Site, Rocky Mountain National Park, Colorado," by Paul T. Voegeli, Sr., may be examined in the following offices of the Survey: Room 1242-N, General Services Administration Building, Washington, D.C.; Room 2425, Building 25, Denver Federal Center; and Public Inquiries Office, New Custom House, Denver, Colo. The report may also be examined at the office of Robert Haraden, Park Engineer, Rocky Mountain National Park, Estes Park, Colo.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

WATER FOR THE PROPOSED WEST SIDE CAMPGROUND SITE, ROCKY MOUNTAIN NATIONAL PARK, COLORADO

By
Paul T. Voegeli, Sr., 1923
Geologist

Prepared for U.S. National Park Service
Administrative Report
Open File - October 1963

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WATER FOR THE PROPOSED WEST SIDE CAMPGROUND SITE, ROCKY MOUNTAIN NATIONAL PARK, COLORADO

By
Paul T. Voegeli, Sr.
Geologist

INTRODUCTION

At the request of the U.S. National Park Service, the U.S. Geological Survey investigated the possibility of obtaining a water supply at the proposed West Side Campground Site in the western part of Rocky Mountain Park (fig. 1).

The first field investigation of the site, made July 24, 1962, revealed two possibilities for obtaining a water supply: a well or wells tapping terrace deposits or diverting part of the flow of the North Fork of the Colorado River. Each possibility was investigated considering the location of the source with respect to the proposed point or points of use, adequacy of quantity and chemical quality of water, reliability as a perennial source, and problems of development involving topography and earth materials. Because a ground-water source was preferred by Park Service officials and the ground-water possibilities seemed to be promising, the remaining study effort was devoted entirely to the appraisal of the ground-water potential. Work in and near the proposed campground site consisted of field observation and mapping of surface geologic and hydrologic features, selection of a drilling site for a test well, supervision of the drilling of the test well, and testing the yield of the well.

The assistance of Robert Haraden and Dave Spivey, National Park Service, is gratefully acknowledged. Thanks are given to Earl Reaksecker, driller, for his excellent cooperation during the drilling of the test well.

CLIMATOLOGIC SETTING

In 1961, precipitation near the campground site was 26 inches, most of which fell from April through September. Precipitation for the year was about 6 inches above average. During the same year, the monthly mean temperature was above 38°F only from May through October. The monthly mean temperatures in 1961 were near normal.

GEOLOGIC SETTING

Rocks exposed in and near the West Side Campground Site are (1) Precambrian schist and gneiss, and (2) Quaternary sediments including glacial deposits in the form of moraines, terrace deposits, and alluvium (fig. 2). The unconsolidated sediments overlying the Precambrian rock are of Pleistocene or Recent ages or both. Moraines were formed by glacial action during the Pleistocene. The remnants of the moraines north and southeast of the site are composed of rock material ranging in size from clay to boulders. The material is poorly sorted, but locally may contain zones of moderately well sorted sand and gravel. Stream action during the Pleistocene resulted in the deposition of terrace deposits. Unlike the moraine sediments, the sand and gravel of the terrace deposits exhibit fair to good sorting. The Recent deposits of generally well sorted alluvial material on the flood plain of the North Fork of the Colorado River were derived chiefly from moraines and terraces.

The present geologic setting of the campground site resulted chiefly from erosional and depositional activities of the ancestral equivalent of the North Fork of the Colorado River. The entire site probably was covered by moraine material at the conclusion of glacial activity. With the retreat and melting of glacial ice to the north, large quantities of water eroded the moraines and deposited alluvial material. The outcrop of Precambrian rock to the north sheltered the site from the erosive forces of the water, and the glacial sediments were only partly eroded. Later terrace deposits covered these partly eroded moraine sediments. The thickness of the glacial material underlying the area is unknown. Presently, the North Fork of the Colorado River is slowly eroding the terrace deposits and developing its alluvial plain.

HYDROLOGIC SETTING

Ground-water resources at the campground site are closely related to the streamflow of the North Fork of the Colorado River. During the 1961 water year (October 1960 to September 1961), a total flow of 45,730 acre-feet was recorded at the Geological Survey gaging station ("Colorado River below Baker Gulch") 2-3/4 miles north of the campground site. Discharge was greatest in October 1960 and from April through September 1961; discharge was lowest during the remainder of the water year. This distribution of discharge is normal, as shown by the other 7 years of record for the station and by the records for the long-term (42 years) Geological Survey gaging station 5 miles south of the campground site. Table 1 shows the concurrent monthly discharge for the two gaging stations.

Table 1.--Monthly discharge (acre-feet) of the North Fork of the Colorado River near the project area

Gaging station--Colorado River below Baker Gulch (drainage area 53 square miles)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1954	693	551	420	367	319	359	2,290	6,190	4,150	1,680	680	1,360	19,060
1955	1,700	736	519	445	314	313	2,260	6,640	8,540	3,140	1,530	916	27,050
1956	785	677	531	329	279	340	1,890	15,260	11,510	2,120	1,210	701	35,630
1957	569	442	280	240	232	347	848	7,180	27,510	19,190	2,720	1,740	61,300
1958	1,660	893	575	517	403	407	780	19,380	15,940	2,240	1,350	944	45,090
1959	667	541	321	288	258	301	857	7,860	12,600	3,020	1,800	1,520	30,030
1960	2,310	1,600	778	528	476	620	3,370	8,810	14,400	3,510	1,270	1,520	39,190
1961	1,180	789	615	492	389	462	922	9,810	21,360	3,460	1,760	4,490	45,730

Gaging station--Colorado River near Grand Lake (drainage area 103 square miles)

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1954	1,150	1,000	928	762	748	817	4,160	9,160	1,660	263	1,300	1,890	23,840
1955	2,590	1,510	1,010	1,030	793	797	3,630	9,370	8,000	786	2,460	1,340	33,320
1956	1,370	1,240	1,110	893	902	946	3,710	21,670	15,370	413	2,100	1,160	50,880
1957	1,180	865	736	805	730	831	1,570	12,840	37,810	25,390	5,800	2,930	91,490
1958	2,880	1,870	1,590	1,210	1,030	1,080	1,840	26,280	19,080	495	1,690	1,150	60,200
1959	1,010	1,010	889	863	774	803	1,920	11,490	17,840	1,760	3,040	2,190	43,590
1960	3,820	2,730	1,430	998	900	1,920	8,400	15,150	21,080	1,870	1,630	1,810	61,740
1961	1,650	1,270	869	845	789	797	1,410	12,940	24,010	2,390	2,860	7,160	56,990

The valley of the North Fork of the Colorado River is between high ridges of Precambrian gneiss, schist, and granite (fig. 3). The Precambrian rock assimilates a relatively small amount of precipitation or runoff. Water rejected by the Precambrian rock travels to the valley floor, where it flows in streambeds of permeable sediments. Water from the streams percolates into the valley fill mainly during the higher flows from May through October. During the remainder of the year, when the streams are low, base flows are maintained by water percolating from the valley fill. During the period of base flow (December through March), the quantity of water passing the gaging station "Colorado River near Grand Lake" is much greater than that passing the station "Colorado River below Baker Gulch." Table 2 shows the increase of streamflow, in acre-feet, between the upper and lower stations.

Table 2.--Flow increase (acre-feet) of the North Fork of the Colorado River between the gaging stations "Colorado River below Baker Gulch" and "Colorado River near Grand Lake."

Year	Dec.	Jan.	Feb.	Mar.
1954	508	395	429	458
1955	491	585	479	484
1956	579	564	623	606
1957	456	565	498	484
1958	1,015	693	627	673
1959	568	575	516	502
1960	652	470	424	1,300
1961	254	353	400	335
Average for 8 years	569	525	499	605

The recording gage at the upper station measures the discharge from a drainage area of 53 square miles, the gage at the lower station an area of 103 square miles. Herein only the drainage area between the upper and lower gaging stations is considered. Runoff of tributaries in the drainage area between the two stations is at its lowest during the period of base flow. During the time of base flow, air temperatures are generally below 32°F, and water movement on the land surface is restricted because of icing ~~conditions~~. Therefore, the gain in streamflow between the two stations is derived chiefly from ground-water storage. The ability of the ground-water reservoir to maintain an appreciable base flow of the river indicates that the aquifer underlying the campground site is a reliable source of water supply.

The chemical quality of the ground water in the vicinity of the campground site meets the standards established by the U.S. Public Health Service for public supplies. The following is a laboratory analysis of water collected from the test well after pumping for 4 hours:

Chemical analysis of water from the West Side Campground test well, NE¼SE¼SE¼sec. 24, T. 4 N., R. 76 W., Grand County, Colo.

(Dissolved constituents, in parts per million)

Sample collected 11-13-62 Temperature 41°F

Silica (SiO_2)	17	Nitrate (NO_3)	.6
Iron (Fe), total	.18	Dissolved solids residue on evaporation at 180°C	63
Calcium (Ca)	10	Hardness as $CaCO_3$	29
Magnesium (Mg)	1.0	Noncarbonate	0
Sodium (Na) } Potassium (K) }	9.2	Alkalinity as $CaCO_3$	34
Bicarbonate (HCO_3)	42	Specific conductance (micromhos at 25°C)	85.6
Carbonate (CO_3)	0	pH	7.1
Sulfate (SO_4)	10		
Chloride (Cl)	2.0		
Fluoride (F)	.3		

The sanitary condition of ground water in the area was not determined.

PROSPECTS FOR OBTAINING A WATER SUPPLY AT THE WEST SIDE CAMPGROUND SITE

The National Park Service desires to develop a water supply capable of providing a sufficient quantity of water of good chemical quality for 150 to 175 campsites. A ground-water supply was favored because: (1) it is more easily developed; (2) wells are more easily maintained; (3) generally fewer structures (intakes, treatment facilities, and pipelines) are involved; and (4) better sanitation control is provided.

A site was selected for a test well, where it was estimated that the depth to water below the land surface would be between 25 and 34 feet and the depth to bedrock at least 50 feet. The test well was drilled at the location shown on figure 2, using cable-tool equipment. Test drilling began November 7, 1962, and was completed November 12, 1962. Drilling was delayed slightly because casing had to be driven as the test well was drilled. Information concerning the drilling time, sediments penetrated, and the construction of the test well is shown on figure 4.

The terrace deposits and glacial(?) material penetrated during the drilling consisted chiefly of sand and gravel and a small amount of silt and (or) clay. A cobble or boulder was encountered at 9 feet. The general character of the sediments drilled and their grain sizes are described in table 4, p. 17.

When the depth was 65 feet, the test well was developed by bailing at about 25 gpm (gallons per minute). As a result of bailing, sand entered the well through the perforations and open end of the casing, backfilling the well 8 feet. Upon completion at 91 feet, small cobbles were dropped into the well and compacted with the drill bit. The 3 feet of compacted cobble "seal" was used to prevent sand from entering the open end of the casing. The well was again bailed for 1 hour, and no sand accumulated above the cobbles.

After development, the well was pumped for 4 hours with a submersible pump at an average rate of 8.3 gpm. Water-levels measured before, during, and after pumping were used to estimate the water-bearing properties of the aquifer. (See fig. 5.) The results of the pumping and recovery tests are summarized in table 3.

Table 3.--Results of pumping test West Side Campground test well

(NE¼SE¼SE¼sec. 24, T. 4 N., R. 76 W.)

Time (minutes)	Depth to water below land surface (feet)	Drawdown (feet)	Discharge (gpm)	Specific capacity 1/ (gpm per ft of drawdown)	Coefficient of transmissibility 2/ (gpd per ft)	Field coefficient of permeability 3/ (gpd per sq ft)
0	32.35	0.00	0.0	. .	. .	. .
5	33.89	1.54	8.3	5.4	. .	. .
10	34.00	1.65	8.3	5.0	. .	. .
20	34.10	1.75	8.3	4.7	. .	. .
30	34.22	1.87	8.3	4.4	. .	. .
40	34.28	1.93	8.3	4.3	. .	. .
50	34.35	2.00	8.1	4.1	. .	. .
60	34.41	2.06	8.3	4.0	. .	. .
70	34.46	2.11	8.3	3.9	. .	. .
80	34.49	2.14	8.3	3.9	. .	. .
90	34.51	2.16	8.3	3.8	. .	. .
110	34.57	2.22	8.3	3.7	. .	. .
130	34.62	2.27	8.3	3.7	. .	. .
150	34.66	2.31	8.5	3.7	. .	. .
180	34.67	2.32	8.3	3.6	. .	. .
210	34.70	2.35	8.3	3.5	. .	. .
240	34.72	2.37	8.3	3.5	. .	. .
		Recovery				
2	33.17	1.55	.0	. .	. .	. .
4	33.13	1.59	.0	. .	. .	. .
6	33.07	1.65	.0	. .	. .	. .
9	33.02	1.70	.0	. .	. .	. .
15	32.89	1.83	.0	. .	. .	. .
20	32.82	1.90	.0	. .	. .	. .
30	32.70	2.02	.0	. .	. .	. .
45	32.56	2.16	.0	. .	. .	. .
915	31.97	2.75	.0	. .		
					3,700	60

1/ Rate of discharge per unit of drawdown.

2/ Product of the field coefficient of permeability and the thickness of the aquifer, or the amount of water that will flow in a specified time under unit hydraulic gradient through a cross section of unit width extending the full thickness of the aquifer.

3/ The quantity of water at the existing temperature of the water that will flow in a given time under a unit hydraulic gradient through a cross section of unit area.

Extrapolation of the test data suggests that the test well is capable of yielding at least 50 gpm and perhaps as much as 100 gpm. If it is assumed that a drawdown of 20 feet should be the maximum allowable, the yield based on a specific capacity of 3.5 (fig. 6) would be 70 gpm (3.5 x 20). Long-term pumping, i.e., days or weeks, may reduce the specific capacity to 3 and the yield to 60 gpm (3 x 20). Arbitrarily, reducing a yield of 60 gpm by 25 percent to account for the effect caused by a reduction in saturated thickness near the well, the estimated yield would be about 45 gpm with a pumping lift of about 50 feet.

CONCLUSIONS

The aquifer in the terrace deposits is capable of providing sufficient quantities of water of good chemical quality for the operation of the campground facilities. Results of an aquifer test indicate that the test well is capable of yielding at least 50 gpm and perhaps as much as 100 gpm.

The base flow of the North Fork of the Colorado River is maintained chiefly by ground-water discharge from the valley fill. The average base flow between the gaging station "Colorado River below Baker Gulch" and the station "Colorado River near Grand Lake," for December through March, is about 550 acre-feet per month or 9.2 cubic feet per second.

Table 4.--Description of cuttings from the West Side Campground test well

Explanation: Size of the particles making up the sample is based on the grain-size determinations established by the National Research Council.[1] All the sediments described below consist of angular to rounded particles. The types of minerals and rocks drilled indicate that the material was derived principally from Precambrian rocks. The percentage after each size grade is the percentage by weight of the particular size grade.

	Percent	Thickness (feet)	Depth (feet)
Terrace deposits:			
Medium gravel	29		
Fine gravel	26		
Very fine gravel. . . .	14		
Very coarse sand. . . .	13		
Coarse sand	12		
Medium sand	4		
Fine sand	1		
Very fine sand.	<1		
Silt or clay or both. .	<1	3	3
Medium gravel	3		
Fine gravel	20		
Very fine gravel. . . .	26		
Very coarse sand. . . .	20		
Coarse sand	16		
Medium sand	8		
Fine sand	2		
Silt or clay or both. .	3	4	7

1/ National Research Council, 1947, Report of the subcommittee on sediment terminology: Am. Geophys. Union Trans., v. 28, no. 28, p. 936-938.

Table 4.--Description of cuttings from the West Side Campground test well--Continued

	Percent	Thickness (feet)	Depth (feet)
Terrace deposits--Continued			
Medium gravel	1		
Fine gravel	9		
Very fine gravel	29		
Very coarse sand	29		
Coarse sand	22		
Medium sand	6		
Fine sand	2		
Very fine sand	1		
Silt or clay or both	1	8	15
Fine gravel	7		
Very fine gravel	27		
Very coarse sand	27		
Coarse sand	23		
Medium sand	9		
Fine sand	3		
Very fine sand	2		
Silt or clay or both	2	1	16
Fine gravel	12		
Very fine gravel	29		
Very coarse sand	23		
Coarse sand	20		
Medium sand	8		
Fine sand	3		
Very fine sand	2		
Silt or clay or both	3	2	18
Fine gravel	7		
Very fine gravel	28		
Very coarse sand	27		
Coarse sand	24		
Medium sand	8		
Fine sand	3		

Table 4.--Description of cuttings from the West Side Campground test well--Continued

	Percent	Thickness (feet)	Depth (feet)
Terrace deposits--Continued			
Very fine sand.	1		
Silt or clay or both. .	2	2	20
Fine gravel	8		
Very fine gravel. . . .	27		
Very coarse sand. . . .	28		
Coarse sand	23		
Medium sand	8		
Fine sand	3		
Very fine sand.	1		
Silt or clay or both. .	2	2	22
Fine gravel	9		
Very fine gravel. . . .	31		
Very coarse sand. . . .	30		
Coarse sand	23		
Medium sand	4		
Fine sand	1		
Very fine sand.	1		
Silt or clay or both. .	1	4	26
Fine gravel	12		
Very fine gravel. . . .	27		
Very coarse sand. . . .	27		
Coarse sand	23		
Medium sand	6		
Fine sand	2		
Very fine sand.	1		
Silt or clay or both. .	2	4	30

Table 4.--Description of cuttings from the West Side Campground test well--Continued

	Percent	Thickness (feet)	Depth (feet)
Terrace deposits--Continued			
Fine gravel	13		
Very fine gravel.	28		
Very coarse sand.	29		
Coarse sand	25		
Medium sand	3		
Fine sand	1		
Very fine sand.	<1		
Silt or clay or both. . .	1	4	34
Fine gravel	8		
Very fine gravel.	26		
Very coarse sand.	31		
Coarse sand	25		
Medium sand	5		
Fine sand	2		
Very fine sand.	1		
Silt or clay or both. . .	2	9	43
Fine gravel	12		
Very fine gravel.	23		
Very coarse sand.	29		
Coarse sand	29		
Medium sand	5		
Fine sand	1		
Very fine sand.	<1		
Silt or clay or both. . .	1	6	49
Fine gravel	1		
Very fine gravel.	9		
Very coarse sand.	17		
Coarse sand	33		
Medium sand	25		
Fine sand	9		
Very fine sand.	3		
Silt or clay or both . . .	3	10	59

Table 4.--Description of cuttings from the West Side Campground test well--Continued

	Percent	Thickness (feet)	Depth (feet)
Terrace deposits--Continued			
Very fine gravel	8		
Very coarse sand	49		
Coarse sand	29		
Medium sand	9		
Fine sand	3		
Very fine sand	1		
Silt or clay or both	1	5	64
Very coarse sand	6		
Coarse sand	35		
Medium sand	37		
Fine sand	12		
Very fine sand	4		
Silt or clay or both	6	1	65
Very coarse sand	1		
Coarse sand	13		
Medium sand	45		
Fine sand	29		
Very fine sand	9		
Silt or clay or both	3	9	74
Very coarse sand	6		
Coarse sand	27		
Medium sand	45		
Fine sand	16		
Very fine sand	4		
Silt or clay or both	2	6	80

Table 4.--Description of cuttings from the West Side Campground test well--Continued

	Percent	Thickness (feet)	Depth (feet)
Terrace deposits--Continued			
Very fine gravel	5		
Very coarse sand	24		
Coarse sand	33		
Medium sand	19		
Fine sand	10		
Very fine sand	5		
Silt or clay or both . .	4	3	83
Very fine gravel	8		
Very coarse sand	22		
Coarse sand	24		
Medium sand	21		
Fine sand.	12		
Very fine sand	7		
Silt or clay or both . .	6	1	84
Glacial(?) deposits:			
Medium gravel	1		
Fine gravel	2		
Very fine gravel	10		
Very coarse sand	15		
Coarse sand	15		
Medium sand	14		
Fine sand	11		
Very fine sand	10		
Silt or clay or both . .	22	7	91

POCKET CONTAINS
6 ITEMS.