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GEOLOGICAL SURVEY
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# WATER-SUPPLY SITES FOR WIND CAVE NATIONAL PARK, CUSTER COUNTY, SOUTH DAKOTA

by

Donald G. Adolphson

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Prepared in cooperation with the
National Park Service
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## ABSTRACT

The reconnaissance of Wind Cave National Park identifies the Pahasapa Limestone as the best aquifer in the area. Yields of 40 gallons per minute or 2.5 liters per second for periods of 8 to 10 hours could be expected from the present National Park Service well. This yield is about twice the average daily amount now being used in the Park. Water from the well had 275 milligrams per liter dissolved solids concentration. Springs, surface water, and alluvial aquifers in the valleys are not considered to be potential sources of additional water for the park.

## INTRODUCTION

This investigation of the water-supply sites in Wind Cave National Park was made on behalf of the National Park Service, Department of the Interior, as part of their program to develop park facilities. The park (fig. 1) is in the Black Hills section of the Great Plains physiographic province of Fenneman (1931). It is located 12 miles or

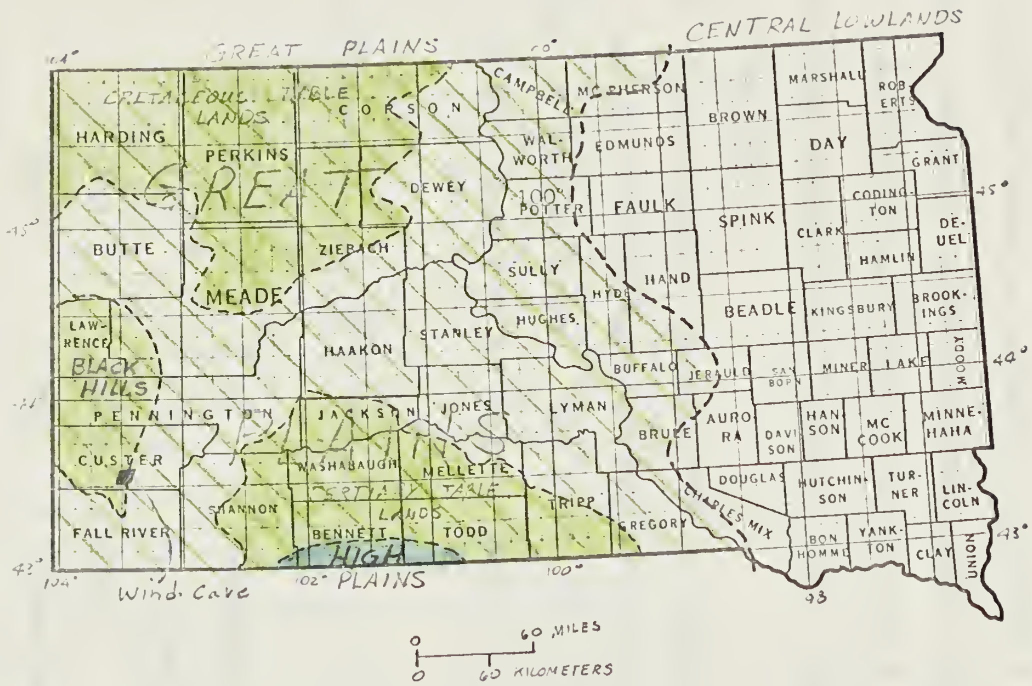


Figure I. -- Map showing physiographic divisions of South Dakota (after Fenneman, 1931), and location of Wind Cave National Park.

19.3 km northwest of Hot Springs in the southern part of Custer County, South Dakota and has an area of about 43 square miles (111 $km^2$).

The number of visitors at the park during 1972 was nearly 1.0 million and it is estimated that by 1980 the number will increase to between 1.25 and 1.5 million. The projected increase in water consumption from 4.3 million gallons (16.3 million liters) in 1972 to 6.9 million gallons (26.1 million liters) by 1980 parallels the increasing number of visitors.

For those readers interested in using the metric system, metric equivalents of English units of measurements are given in parentheses. The English units used in this report may be converted to metric units by the following factors:

| From | | Multiply by | To obtain | |
|---|---|---|---|---|
| Unit: | Abbreviation: | | Unit: | Abbreviation: |
| Inch | (in) | 2.54 | Centimeter | (cm) |
| Inch | (in) | .0254 | Millimeter | (mm) |
| Foot | (ft) | .3048 | Meter | (m) |
| Mile | (mi) | 1.609 | Kilometer | (km) |
| Gallon | (gal) | 3.78543 | Liter | (l) |
| Cubic feet per second | ($ft^3/s$) | .02832 | Cubic meters per second | ($m^3/s$) |
| Degree Fahrenheit | (°F) | (°F-32)x5/9 | Celsius | (°C) |

## Purpose and Scope of Investigation

The study was made to evaluate the adequacy of park water supplies to meet employee and visitor needs. Both present and future water problems and needs were considered.

A field reconnaissance of the geology of the park, a well inventory and water-level survey, a survey of surface-water availability, and an aquifer test on an existing park well were made during 1971. During 1972 a reconnaissance of the area was made to select possible future well locations and water sources.

## Previous Investigations

The geology and underground waters of the area were first described by N. H. Darton (1909). Darton states that water from the Minnelusa Sandstone and Pahasapa Limestone probably is available in the area, but these formations had not yet been explored for water. The generalized geology and areas of artesian water of the central Black Hills are described by Darton and Paige (1925). During June 1959, J. P. Gries (written commun., 1959) completed a survey of the ground-water potential of the park. Gries' report contains a short geologic history of the area, a brief description of the water potential of the underlying formations and an inventory of major stream valleys. A record of deep wells in the area and location, history, and performance of many of the springs within the park are also included. Records

of artesian wells and springs of Custer County are contained in a U.S. Geological Survey report by Davis, Dyer and Powell (1961).

## Well-Numbering System

Each well, spring, or test hole referred to in this report has been assigned a number based on its location according to the Federal land-survey system used in South Dakota. The number consists of the township, range, and section numbers separated by hyphens; three capital letters after the section number indicate respectively the quarter section (160 acres), quarter-quarter section (40 acres), and quarter-quarter-quarter section (10 acres), in which the well, spring, or test hole is located. The number of letters indicates the accuracy of each location--if it can be located within a 10-acre tract, three letters are shown in the number. For example, 06-06-06DDA (National Park Well) is in the NE¼SE¼SE¼, section 6, T. 6 S., R. 6 E. (fig. 2). If two or more points are situated within the same tract, consecutive numbers, beginning with 1, are added as suffixes to designate the order in which the points were located.

## GENERAL FEATURES AND GEOLOGIC SETTING

The major part of the eastern part of the park is in the Red Valley physiographic subdivision (fig. 3) which is a broad open valley bounded on the east by the Dakota

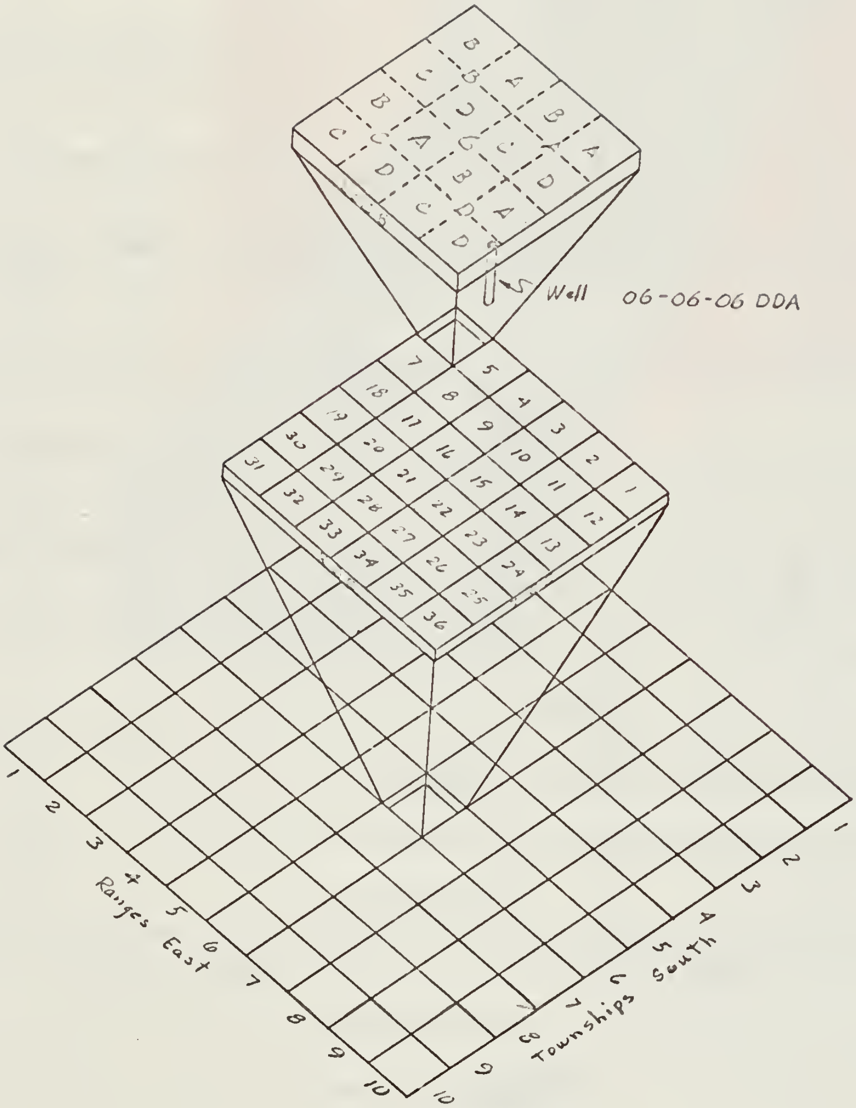


Figure 2.—Location-reference method of numbering wells, springs, and test holes.

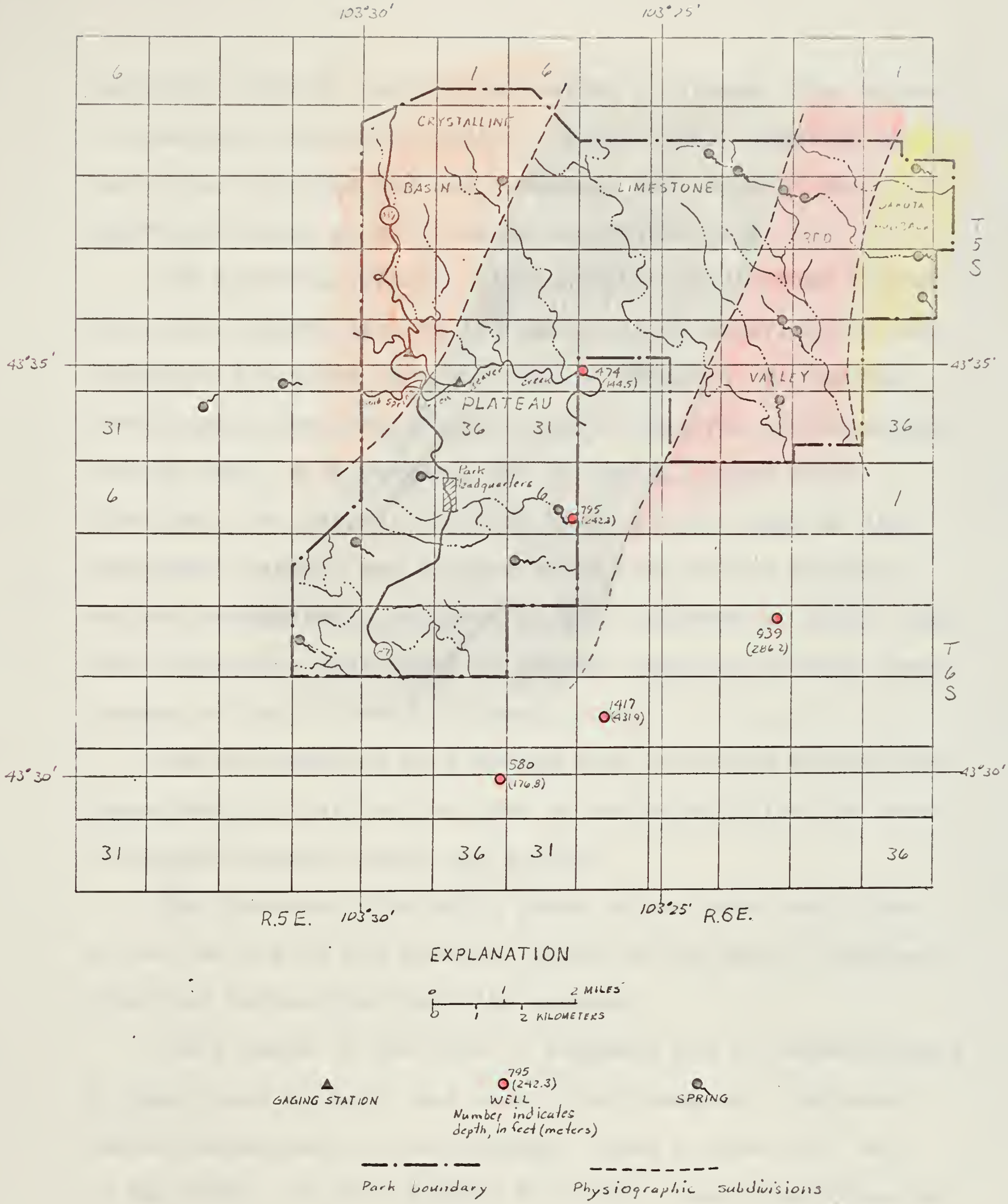


Figure 3.-- Map showing physiographic subdivisions of Wind Cave National Park (after Rothrock, 1943) and locations of water wells, springs, and stream gaging stations (after Gries, 1969) in the area.

Sandstone hogbacks and on the west by a plateau-like region of limestone (Rothrock, 1943). The surficial deposits in the valley comprise the red sandstone and shale of the Spearfish Formation of Triassic and Permian age.

The Limestone Plateau physiographic subdivision constitutes the central part of the park. It is underlain by the Minnelusa Sandstone and the Pahasapa Limestone of Permian, Pennsylvanian and Mississippian age. The area is characterized by deep, dark canyons, and by crystal-lined caves. Wind Cave, the largest and best known of the caves in the Limestone Plateau, was discovered in 1881 by Tom Bingham and was designated a national park by Congress in 1903. Wind Cave belongs to that class of caverns known as blowing caves because of the air moving through them.

The northwestern part of the Park is in the Crystalline Basin which is part of the core of the Black Hills, an area of rugged mountain peaks and gulches.

The Ponderosa pine which grows on the peaks and sides of the valleys is the dominant plant in the park. Deciduous trees and shrubs grow near the streams.

The climate of the area is subhumid and is characterized by long, cold winters, and short, cool summers. The mean annual temperature at Hot Springs, about 6 miles (9.7 km) to the south, is 48.5 degrees F (9.2°C). Most precipitation occurs as rain during the late spring and summer. The average annual precipitation at Hot Springs is 16.04 inches (407 mm).

## SPRINGS AND SEEPS

Many springs and seeps occur in the draws and ravines (see fig. 3). For many years the water for the park has been supplied by an infiltration gallery system from the Upper Spring area (T. 5 S., R. 5 E., Sec. 32). The flow of the spring fluctuates between 8 gpm (0.5 l/s) and 40 gpm (2.5 l/s) because of seasonal effects. During 1972 the spring supplied 1.6 million gallons (6.1 million liters) of water to the park. Some of the other springs are developed with concrete dish tanks for use by animals within the park; however, most of the springs have low yields that are unstable and fluctuate in response to variations in the amount and distribution of precipitation. A few springs flow year-round and the quantity of water produced by them is sufficient for development for picnic areas and campgrounds.

## GROUND WATER

The only aquifer within the park that will yield adequate ground water is the Pahasapa Limestone. The National Park Service well and many water wells near the east and south boundaries of the park are completed in this aquifer. (See table 1).

Aquifers in the stream-valley alluvium are not considered a source of water supply for the park because the deposits are too thin to permit sustained pumping.

(

| Well number |
|---|
| 05-06-29CCB |
| 06-05-25ADDD |
| 06-06-06DDA |
| 06-06-15AAC |
| 06-06-20CAA |

1. "Some wat
   microscop
   School of
2. "At total
3. "Hit wate
   Detailed
   Engineeri
4. "Some wat
   1972. De
   Geologica
5. "Water fr
   surface."
   Rapid Cit

Table 1.--Artesian-well data.

(From the files of the Department of Geological Engineering, South Dakota School of Mines and Technology, Rapid City, South Dakota, and of the U.S. Geological Survey)

| Well number | Owner | Date drilled | Driller | Depth | | Aquifer | Land-surface elevation | | Casing | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Depth | | Diameter | | |
| | | | | feet | meters | | feet | meters | feet | meters | inches | millimeters | |
| 05-06-29CCB | Sanson Ranch | 1952 | R. Lawrence | 474 | 144 | Pahasapa Limestone | 3,960 | 1,207 | -- | -- | -- | -- | (1) |
| 06-05-25ADDD | Olaf Aaberg | 1951 | R. Lawrence | 580 | 117 | Minnelusa Sandstone | 3,935 | 1,199 | -- | -- | -- | -- | (2) |
| 06-06-06DDA | National Park Service | 1956 | Sioux Drilling Company | 795 | 242 | Pahasapa Limestone | 3,809 | 1,161 | 0-21<br>21-243<br>243-605 | 0-6.4<br>6.4-74.1<br>74.1-184 | 16<br>12.75<br>10 | 406<br>324<br>254 | (3) |
| 06-06-15AAC | Streeter Ranch | 1949 | Polensky and Sons | 939 | 286 | Pahasapa Limestone | 3,508 | 1,069 | 0-670<br>670-939 | 0-204<br>204-286 | 7<br>5.5 | 178<br>140 | (4) |
| 06-06-20CAA | E. W. Martin | 1922 | -- | 1,417 | 432 | Minnelusa Sandstone and Pahasapa Limestone | 3,725 | 1,135 | -- | -- | -- | -- | (5) |

1. "Some water at 55 feet (16.8 m), and again at 197 feet (60.0 m). No record of pumping water level." Detailed log, based on microscopic examination of drill cuttings by J. P. Gries, is on file in the Department of Geological Engineering, South Dakota School of Mines and Technology, Rapid City, South Dakota.
2. "At total depth, water stood about 400 feet (122 m) below surface. Crevice, lost water at 385-394 (117-120 m)."
3. "Hit water at 478 feet (146 m); rose to within 150 feet (45.7 m) of surface. Static water level 195 feet (59.4 m) (1956)." Detailed log, based on microscopic examination of drill cuttings by J. P. Gries, is on file in the Department of Geological Engineering, South Dakota School of Mines and Technology, Rapid City, South Dakota.
4. "Some water, but no flow in Minnelusa. Flow from top of Pahasapa." Water level 69.30 feet (21.1 m) above land surface May 25, 1972. Detailed log, based on microscopic examination of drill cuttings by J. P. Gries, is on file in the Department of Geological Engineering, South Dakota School of Mines and Technology, Rapid City, South Dakota.
5. "Water from Minnelusa rose to within 120 feet (36.6 m) of surface. Water from Pahasapa rose to within 20 feet (6.1 m) of surface." Driller's log on file in the Department of Geological Engineering, South Dakota School of Mines and Technology, Rapid City, South Dakota.

## Quality of Ground Water

Ground water dissolves a part of the soluble mineral constituents of rock particles as it moves toward and through an aquifer. The amount of mineral matter dissolved depends principally on the amount of soluble materials in the aquifer, temperature, and partial pressures of the dissolved gases.

The U.S. Public Health Service (1962) has established standards for drinking water used on common carriers in interstate traffic; and these standards have been adopted by the American Water Works Association as criteria of quality for public supplies. The Public Health Service established two types of limits:

(a) Limits which, if exceeded, shall be grounds for rejection of the supply. Substances in this category may have adverse effects on health when present in concentrations above the limit.

(b) Limits which should not be exceeded whenever more suitable supplies are, or can be made, available at reasonable cost. Substances in this category, when present in concentrations above the limit, are either objectionable to an appreciable number of people or exceed the levels required by good water quality control practices.

The standards for the mineral constituents are indicated in the following table along with the mineral constituents of the Pahasapa water from the Park Service well.

| Chemical constituents | Recommended limits | Pahasapa water (1957)[a/] well 06-06-06DDA |
|---|---|---|
| | (mg/l) | (mg/l) |
| Iron (Fe) | 0.3 | 0.9 |
| Manganese (Mn) | .05 | .0 |
| Magnesium (Mg) | -- | 17 |
| Sulfate ($SO_4$) | 250 | 10 |
| Chloride (Cl) | 250 | 7 |
| Fluoride (F) | b/ 1.3 | .8 |
| Nitrate ($NO_3$) | 45 | .4 |
| Dissolved solids | 500 | 275 |

a/ South Dakota State Department of Health.

b/ "When fluoride is naturally present in drinking water, the concentration should not average more than the appropriate upper limit in Table I. Presence of fluoride in average concentrations greater than two times the optimum values in Table I shall constitute grounds for rejection of the supply."

The upper limit concentration shown in Table I is 1.3 mg/l as fluoride.

Water from the Pahasapa Limestone in the area is of good quality--dissolved-solids concentration is 275 mg/l in the Park Service well. The analysis shows that the recommended limits are exceeded only by iron. However, the hardness as $CaCO_3$ is 178 mg/l and the water may not be

desirable for laundering. Water having a hardness of about 100 mg/l as $CaCO_3$ generally is considered to be moderately hard; water having a hardness of 200 mg/l or more is considered to be very hard and should be softened to be satisfactory for most uses.

## Aquifer Test

An aquifer test using the National Park Service well (06-06-06DDA) was made to determine the specific capacity of the well. The well supplied 2.7 million gallons (10.2 million liters) of water to the park in 1972. During October 5-7, 1971, it was pumped at a rate of 40 gpm (2.5 l/s) for 24 hours. The water level in the well was lowered 120 feet (36.6 m) during this period (table 2). When pumping ceased the water level rose rapidly, and recovered to the original static level in 263 minutes (fig. 4).

A determination for the values of transmissivity and storage coefficient could not be obtained because no observation wells were available for measurement. However, a general performance rate for the well (specific capacity) and the drawdown and recovery of the water in the well (table 2) were determined at various times during pumping.

| Well depth (feet) | Static water level (feet below land surface) | Drawdown after 24 hours (feet below static level) | Specific capacity (gpm/ft) |
| --- | --- | --- | --- |
| 795<br>(242 m) | 195<br>(59.4 m) | 120<br>(36.6 m) | 0.33<br>(0.07 lps/m) |

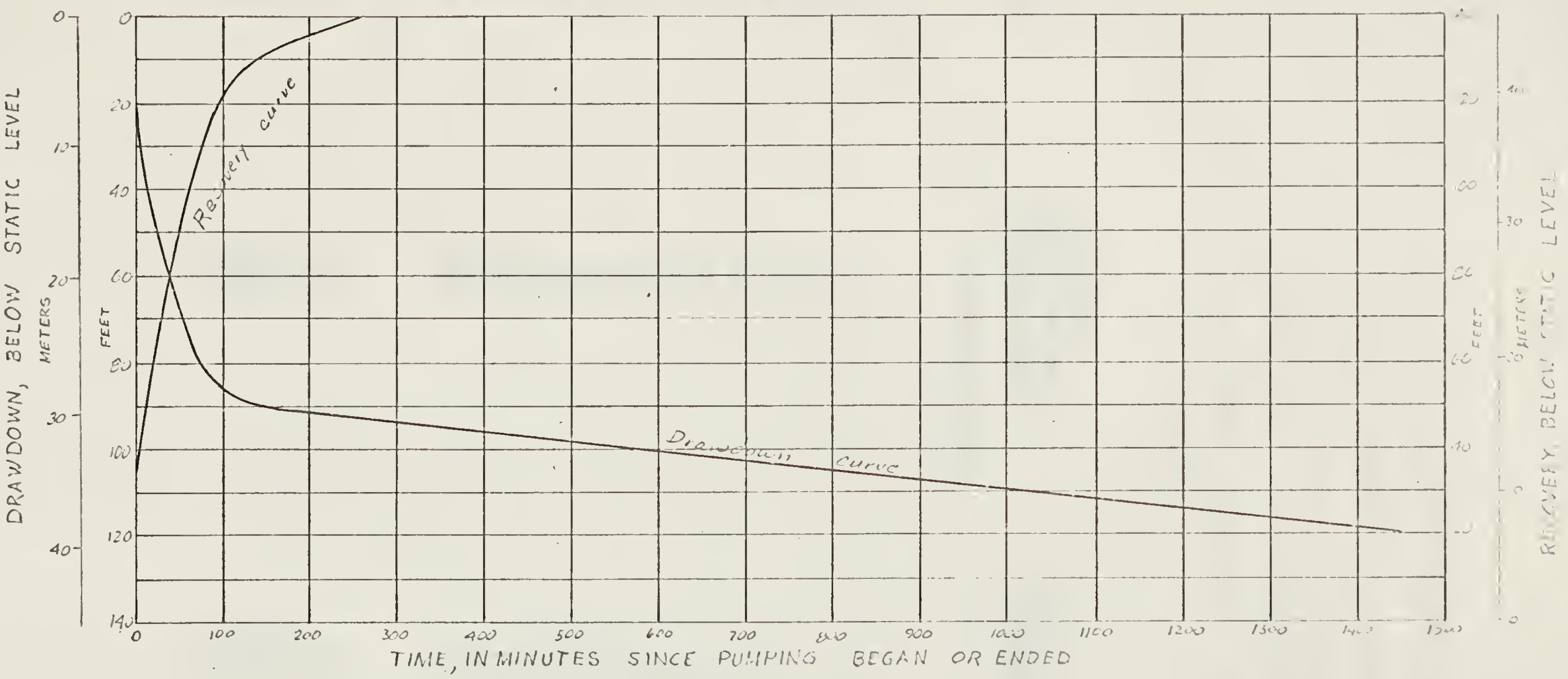


Figure 4.--Drawdown and recovery curves for National Park Service well, October 5-7, 1971.

Table 2.--Drawdown and recovery record for Wind Cave National Park well (06-06-06DDA) October 5-7, 1971.

Depth 795 feet (242 m), diameter 10 to 16 inches (254 to 406 mm). Static water level 195 feet (59.4 m). Well pumped at rate of 40 gpm (2.5 l/s) for 24 hours.

| Time | Drawdown (feet below static level) | Minutes of pumping |
|---|---|---|
| | (feet x 0.3048=meters) | |
| October 5, 1971 | | |
| 1122 | 0 | 0 |
| 1123 | 20 | 1 |
| 1128 | 52 | 6 |
| 1134 | 70 | 12 |
| 1150 | 84 | 28 |
| 1215 | 86 | 53 |
| 1245 | 88 | 83 |
| 1415 | 90 | 173 |
| 1530 | 88 | 248 |
| 1630 | 96 | 308 |
| 1730 | 98 | 369 |
| 1830 | 98 | 428 |
| 1930 | 100 | 488 |
| 2100 | 102 | 578 |
| 2330 | 106 | 728 |
| October 6, 1971 | | |
| 0315 | 112 | 953 |
| 0515 | 114 | 1073 |
| 0715 | 116 | 1193 |
| 0915 | 118 | 1313 |
| 1122 | 120 | 1440 |

Table 2.--Continued

| Time | Recovery (feet below static level) | Minutes of recovery |
|---|---|---|
| | (feet x 0.3048=meters) | |
| October 6, 1971 | | |
| 1123 | 106 | 1 |
| 1124 | 104 | 2 |
| 1125 | 102 | 3 |
| 1126 | 100 | 4 |
| 1127 | 98 | 5 |
| 1128 | 96 | 6 |
| 1129 | 94 | 7 |
| 1130 | 90 | 8 |
| 1134 | 88 | 12 |
| 1140 | 84 | 18 |
| 1145 | 80 | 23 |
| 1150 | 78 | 28 |
| 1200 | 76 | 38 |
| 1210 | 70 | 48 |
| 1220 | 60 | 58 |
| 1230 | 52 | 68 |
| 1245 | 40 | 83 |
| 1300 | 20 | 98 |
| 1445 | 5 | 203 |
| 1545 | 0 | 263 |
| October 7, 1971 | | |
| 1015 | 0 | 1370 |

Results of the test indicate that the well can supply ground water in sufficient quantity to meet current demands and to support substantial additional pumping. The well can be pumped at a rate of 40 gpm (2.5 l/s) for periods of 8 to 10 hours per day, which would provide about twice the average daily amount of water now being used in the park.

## Potential Development

Several locations in the park have a potential for development of supplementary ground-water supplies from the Pahasapa. A test hole could be drilled to a depth of at least 800 feet (244 m) about 500 feet (152 m) west of the existing water-supply facilities in sec. 6, T. 6 S., R. 6 E. and a well could be completed here if hydrologic test data indicate an adequate supply. Sites in sec. 34 of T. 5 S., R. 6 E., should be considered as a future source of water supply if a well cannot be completed at the first site. The area is about 2 miles (3.2 km) northeast of the present well site and is easily accessible for drilling; however, the installation would be costly because of the relative remoteness of the area. Also, the well would have to be 500 feet (152 m) deeper than at the first site because the Pahasapa dips to the east.

# SURFACE WATER

Beaver Creek is the major drainage in the park. Perennial flow exists from the upper reaches of the creek to a

water-loss zone in section 30, T. 5 S., R. 6 E., where water is lost to sinkholes in the carbonaceous limestone. The small stream in section 13, T. 5 S., R. 6 E. (a tributary to Lame Johnny Creek to the east), and tributaries to Beaver Creek are intermittent and flow only during snowmelt and local storm periods.

Stream gaging on Beaver Creek between September 1, 1966, and July 1967 shows an average discharge of 1.1 $ft^3/s$ (31.2 l/s) below Concrete Arch Bridge at Highway 87 and 0.66 $ft^3/s$ (18.7 l/s) between August 1967 and February 1969 below the confluence with Cold Spring Creek (Gries, 1969).

Streams in the park are not considered sources of permanent water supply because of their small and seasonal flow.

## CONCLUSIONS

1. Springs, surface water, and alluvial aquifers in the valleys are not considered to be potential sources of additional water for the park. Only small supplies could be developed from these sources without major construction costs.
2. The Pahasapa Limestone aquifer can provide water of suitable quality and quantity for public use and should be used if a supplemental water supply is needed in the future.

3. A well tapping the Pahasapa Limestone aquifer in either sec. 6, T. 6 S., R. 6 E., or in sec. 34, T. 5 S., R. 6 E., should yield adequate quantities of water for expansion of park facilities.
4. Results of an aquifer test show that the National Park Service well can be pumped at a rate of 40 gpm (2.5 l/s) for periods of 8 to 10 hours per day without excessive drawdown. Monitoring of the water level in the well, if continued, would enable the Park Service to obtain a long-term record of response to pumping that would be useful in planning future development.

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