UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division

EVALUATION OF POTENTIAL SOURCES OF WATER IN CRATER LAKE NATIONAL PARK, OREGON

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By E. R. Hampton

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Prepared in cooperation with
the National Park Service
Department of the Interior

ADMINISTRATIVE REPORT
For U. S. Government use only

Portland, Oregon
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SUMMARY

Crater Lake National Park, in volcanic terrain at the crest of the southern Cascade Range, is well watered by a 67-inch average annual precipitation, measured at park headquarters. Existing park facilities utilize springs that provide quantities of water adequate for present-day as well as foreseeable future needs.

Ground water occurs under both perched and water-table conditions in the park. Perched ground-water bodies drain to the numerous springs that issue at various altitudes. Test drilling in the northern part failed to locate perched-water bodies capable of supplying quantities of water adequate for proposed facilities, and established that the regional water table is at an altitude below 4,960 feet.

Many springs and streams at altitudes below 6,500 feet in the western, southern, and southeastern parts discharge quantities of water adequate for a variety of park facilities. Future park-facility development should take into account where water supplies are available. The western, southern, and southeastern parts of the park are more favorable than the northern part in this respect.

In the northern part of the park, where there are no springs or streams, artificial catchment aprons and storage facilities could be constructed to provide water to points of use. A 100- by 100-foot catchment apron and suitably sized storage tank could provide as much as 1,850 gallons per day for 120 days.

INTRODUCTION

Some of the most spectacular scenic vistas in North America are in Crater Lake National Park. The popularity and increased use of the park have at times placed overwhelming demands on existing camping facilities, and have prompted the consideration of several additional sites for camping and other uses. Park records show that the park had 310,659 visitors in 1950, 343,839 in 1955, 397,700 in 1960, 480,500 in 1965, and 552,531 in 1966.

In 1962 the National Park Service requested the Geological Survey to supervise drilling of test wells at two planned recreation sites. The test holes were completed in subsequent years and both proved to be dry. To minimize future expenditures in seeking water supplies for new recreation sites, the Park Service requested the Geological Survey to evaluate the potential sources of water for the entire park.

Purpose and Scope

The purpose of this report is to summarize the general water-supply conditions in the park to provide guidance for the Park Service in planning future camping and recreation sites. The general relationships of geology and the occurrence of springs, streams, and ground water are described. The relationship of sources of water to possible use areas and the possibility of constructing artificial catchment basins are discussed.

Physical and Geologic Setting

Crater Lake National Park occupies about 250 square miles of mountainous terrain astride the crest of the Cascade Range. Altitudes range from 3,977 feet near Red Blanket Creek at the south park boundary to 8,926 feet atop Mount Scott east of the crater rim and the highest point in the park. The principal feature of the park is Crater Lake (fig. 1), which occupies about 20 square miles. The rim of the crater ranges from 6,650 to more than 8,000 feet in altitude, and the lake level is about 6,170 feet. The area north of the lake is characterized by broad moderate slopes and flat areas, broken by five lava and cinder cones and several steep rocky ridges. Steep-sided Mount Scott and rolling lava terrain with several steep-walled broad canyons lie east of the lake. The area south of the lake contains steep-walled broad valleys, sharp-crested intervalley ridges, and volcanic cones. The area southwest of the lake is characterized by gently inclined slopes broken by sharp bluffs and ridges. West of the lake is a uniform, steep concave slope dissected by many small drainageways, some occupied by permanent streams.

The geology of the region was studied by Diller and Patton (1902) and more extensively by Williams (1942). The entire park (excepting small areas of glacial deposits) is directly underlain by volcanic rocks. The principal rock types are andesitic lava flows, basaltic lava flows, and pumiceous volcanic flow breccias and tuffs, largely of andesitic composition. The andesitic lava flows are the most common rocks in the park and are interstratified with the other rocks. The consolidated volcanic rocks are overlain throughout most of the area by pumice that was ejected from Mount Mazama just prior to the collapse of the upper part of that mountain. The subsequently modified collapse crater, or caldera, is occupied by Crater Lake.

Both the surficial pumice and the pumiceous volcanic flow breccias are permeable and readily absorb much of the precipitation that falls on the area. Consequently, large areas of the park lack a well-defined surface-drainage system.

Climate

The climate of Crater Lake National Park is cool and humid. The average annual precipitation recorded by the U.S. Weather Bureau at park headquarters, based on the 1931-62 period, is 67.4 inches. (See table 1.) Average monthly precipitation and temperatures for the 37-year period 1924-61 are shown on table 2.

Presently Utilized Water Sources

Four springs supplied water used at park facilities in 1966. Park headquarters and Crater Lake Lodge use water from Munson Spring, about six-tenths of a mile north of the headquarters at altitude 7,100 feet. Water from the spring is collected in a 24,000-gallon reservoir, pumped at 50 gpm (gallons per minute) to a 180,000-gallon reservoir to supply the lodge, and allowed to flow by gravity to another 180,000-gallon reservoir to supply park headquarters. According to Jeff Adams, maintenance supervisor at the park, the flow of Munson Spring ranges from a minimum of 23 gpm to a maximum of 185 gpm. Low flow occurs in May and the first week of June. Flow is reported to increase from the 23-gpm minimum to about 160 gpm in June. The increase in flow probably is due to the thawing of frozen ground in the area of recharge, thus allowing snowmelt water to percolate to the ground-water body that feeds the spring.

Mazama and Annie Spring campgrounds are supplied by Annie Spring, north of the junction of State Highways 62 and 209 at altitude 6,100 feet. Annie Spring was measured on September 20, 1908, when the discharge was 1,220 gpm, and on August 8, 1913, when the discharge was 2,160 gpm. Present facilities provide for pumping 60 gpm to a 25,000-gallon reservoir above the spring, and for gravity distribution to points of use in the two campgrounds.

Lost Creek campground is supplied by gravity from Lost Creek Spring, in SW¼ sec. 18, T. 31 S., R. 7½ E. Flow of Lost Creek Spring was estimated by Jeff Adams of the Park Service to be about 800 gpm.

Kerr Notch viewpoint is supplied drinking water from a small spring that yields about 5 gpm. The locations of Munson, Annie, and Lost Creek Springs are shown in figure 1.

POTENTIAL SOURCES OF WATER

Because of the abundant rainfall and the permeability of the rocks of the area, Crater Lake National Park is generally well watered. Many springs and streams issue from perched-water bodies at numerous places

Table 1.--Precipitation, in inches, at Crater Lake weather station for years ending June 30, 1931-62[a]

Year	Precipitation	Year	Precipitation	Year	Precipitation
1931	33.34	1942	68.24	1953	71.21
1932	75.21	1943	87.01	1954	68.82
1933	75.65	1944	53.65	1955	50.92
1934	54.24	1945	59.77	1956	87.68
1935	71.33	1946	66.64	1957	65.26
1936	55.30	1947	74.58	1958	81.14
1937	58.92	1948	78.55	1959	58.66
1938	74.41	1949	66.93	1960	64.68
1939	45.16	1950	77.07	1961	64.70
1940	59.96	1951	93.08	1962	58.12
1941	71.51	1952	84.60	Average	67.4

a/ Records for August 1930 observed at south rim of Crater Lake, altitude 7,086 feet; records for July, September, and October 1930 estimated for this report. After November 1930, precipitation station at altitude 6,475 feet. Records for most months from November 1942 to June 1946 were estimated by U.S. Weather Bureau using correlation techniques.

Table 2.--Average monthly precipitation and temperature at Crater Lake for the 37-year period 1924-61

Month	Temperature (°F)	Precipitation (inches)
Jan.	26.0	10.85
Feb.	26.4	8.68
Mar.	28.5	8.22
Apr.	34.3	4.34
May	40.4	3.31
June	47.5	2.54
July	56.3	0.63
Aug.	56.0	0.56
Sept.	49.8	2.05
Oct.	41.6	6.42
Nov.	33.1	7.95
Dec.	27.6	11.69
Year	39.0	67.24

and at various altitudes in the western, southern, and eastern parts of the park. Crater Lake, at about altitude 6,170 feet, is a vast reservoir of potable water that could and probably will be used to supply water to some park facilities in the future. A large part of the area is probably underlain at depth by rocks of at least moderate permaability that would yield useful quantities of water to deep wells.

Ground Water

General conditions.--Ground water in the park occurs under perched and water-table conditions. The numerous springs that issue from the rocks drain ground-water bodies perched above the regional water table. At many places, the spring-fed streams seep back into the permeable ground a short distance downslope from the springs, and the water percolates to the next lower perched-water body or to the regional water table.

In areas where few or no perched-water bodies occur, the altitude of the regional water table can usually be approximated by observing the altitude of the water surface in nearby permanent streams. In an area such as Crater Lake National Park, which has many perched-water bodies, such a technique is invalid. The park is drained by the Umpqua, Rogue, and Klamath River systems, and the regional water table at depth may slope in any direction or may be compartmented by subsurface geologic structures. It is possible that the water table beneath the park is at about the altitude of Klamath Marsh (4,520 ft) about 10 miles east of the east crater rim, but this is speculative. In any event, it is apparent that wells situated at higher altitudes (such as around the crater rim, alt over 6,700 ft) will have to be drilled to depth exceeding 1,000 feet to obtain water, unless a perched-water body is penetrated.

Test wells.--In 1962, the Park Service requested the Geological Survey to supervise test drilling at two proposed campsites--one above Cleetwood Cove and the other near the north entrance of the park. Before drilling began, B. L. Foxworthy, Oregon district geologist of the Ground Water Branch, Water Resources Division, pointed out in a series of letters to the Park Service that there was a possibility of finding a perched ground-water body at either place, but that the regional water table was probably at great depth--perhaps near the altitude of Klamath Marsh.

The Cleetwood Cove test well was about three-tenths of a mile northwest of the point where the Cleetwood Cove Trail leaves the rim road, at about altitude 6,650 feet. The well was drilled 429 feet, to an altitude of about 6,220 feet--45 feet higher than the level of Crater Lake. Although the driller reported the well to be dry at 429 feet, a little water was entering the well on October 20, 1965, when a temporary water level of 424.1 feet was measured. Water entered the well at a rate estimated as less than 1 gpm and drained slowly out through the sloughed-in drilling cuttings that filled the bottom 5 feet or more of the hole. No perched-water bodies capable of supplying water to the proposed camp facility were found in drilling this test hole.

The North Entrance test well was about 1,000 feet west-northwest of the guard station and about 1,000 feet south of the park boundary, at about altitude 6,000 feet. A perched-water body was found during the drilling of this well. At a depth of 296 feet the water level stood at 275 feet, and the driller estimated that about half a gallon per minute was entering the hole. At a depth of 313 feet (well filled to 296 feet by sloughed-in drill cuttings and caving) the water level stood at 295.8 feet below land surface. At a depth of 340 feet the water stood at 297 feet. The well was bailed out to 340 feet in 3½ hours and recovered 2 feet of water in 45 minutes. In a hole 8 inches in diameter, the volume of water in 2 feet is about 5.3 gallons, so the rate of accumulation was, at best, about .08 gallon per minute.

The well was drilled to a depth of 1,037 feet, or bottom-hole altitude of about 4,960 feet. At this depth the bottom of the hole, which was dry, was 220 feet below the level of Diamond Lake, 5 miles north, and 1,220 feet below the level of Crater Lake, 6 miles south. As in the Cleetwood Cove well, no perched-water bodies capable of yielding 5 gpm were found, so the test well was capped. The approximate locations of the test wells are shown on figure 1. Logs of the materials penetrated in the test wells are presented in table 3.

Conclusions.--Conclusions regarding the ground-water conditions in the park, deduced previously from geologic and hydrologic evidence, are borne out by the results of the test drilling. Perched-water bodies in the northern part of the park are apparently few, and the one found by drilling did not yield enough water to supply a campground facility. Because the test well at North Entrance extended below the level of both Crater and Diamond Lakes, those lakes are judged to be perched above the regional water table and are not indicative of the altitude of the regional water table in the area. Any future test drilling should be undertaken with the expectation that the regional water table probably lies near altitude 4,250 feet or lower and that the existence at a specified site of productive perched ground-water bodies above that altitude is speculative at best.

Streams and Springs

Numerous spring-fed streams drain the western and southern areas of the park. Bear Creek is the only permanent stream draining the eastern part, and the northern part has no permanent springs or streams above the 5,500-foot level.

Table 3.--Lithologic logs of materials penetrated in test wells

North Entrance test well

Materials	Thickness (feet)	Depth (feet)
Pumice, reddish-brown, tan to pink; includes pebble-sized particles of andesitic basalt	40	40
Cinders and pumice, dark-gray and reddish-brown, grit-sized	5	45
Pumice, medium-gray, massive, contains scattered basalt fragments up to 1/2-in. diameter	35	80
Glass, volcanic, gray, massive, shattered, and pumice	7	87
Pumice, gray	8	95
Andesite, medium-gray	5	100
Glass, volcanic, gray	5	105
Andesite, glassy, some basalt and pink pumice	15	120
Pumice, light-tan, 1/8-in. to 1-in. diameter	3	123
Pumice, angular basalt fragments	2	125
Andesite, gray, glassy (probably boulders)	2	127
Cinders, basaltic, reddish-brown, gray, black	18	145
Pumice, gray	5	150
Cinders or scoria, basaltic, dark-gray; cuttings 1/8 in. to 1/2-in. diameter	5	155
Lava, hard, medium-gray	25	180
Basalt, dark-gray, and reddish scoria	5	185

Table 3.--Lithologic logs of materials penetrated in test wells--

Continued

North Entrance test well--Continued

Materials	Thickness (feet)	Depth (feet)
Basalt, medium-gray, fractured; cuttings up to 2-in. diameter	10	195
Basalt, dark-gray	5	200
Scoria, basaltic, dark-gray	5	205
Basalt, dark-gray, vesicular, grading to dense	20	225
Basalt, medium-gray, vesicular	10	235
Cinders and scoria, red to black, basaltic	25	260
Cinders and boulders of pumice, gray	5	265
Andesite, gray, hard	34	299
Cinders, black, some water	2	301
Andesite, gray, hard	28	329
Andesite, dark-gray, soft	6	335
Andesite, dark-gray, glassy, hard	45	380
Rock, dark-gray to black, glassy	5	385
Lava, black, scoriaceous	5	390
Lava, black, hard	12	402
Pumice and welded tuff, tan, consolidated, layers of cinders	298	700
Pumice, tan, consolidated, layers of welded(?) tuff	60	760
Crystal pumice tuff, light-tan to cream; contains layers of red scoria, glassy medium-gray lava	40	800

Table 3.--Lithologic logs of materials penetrated in test wells--

Continued

North Entrance test well--Continued

Materials	Thickness (feet)	Depth (feet)
Crystal tuff, layers of red-brown to black scoriaceous lava; cuttings brown, iron stained ----------	50	850
Volcanic glass, dark-gray, some layers of red-coated dark-gray scoria; iron oxide stain and coating give cuttings dark red-brown color; some magnetite ------	80	930
Lava, inflated, glassy, dark-gray to black, red iron coating; contains much magnetite ------------------	15	945
Lava, dark-gray to dark red-brown, scoriaceous at top; contains magnetite ----------------------------	37	982
Lava, medium- to dark-gray, fine-grained, hard; contains dark-red iron-stained grains and glass, magnetite --	24	1,006
Lava, light pink-gray, fine- to medium-grained, veins of cream to white secondary silica, iron oxide stain on some crystals ----------------------------	31	1,037

Table 3.--Lithologic logs of materials penetrated in test wells--Continued

Cleetwood Cove test well

Materials	Thickness (feet)	Depth (feet)
Pumice, reddish-brown	10	10
Pumice, gray-brown to gray; contains rock particles and cinders	15	25
Cinders, gray-brown, glassy	5	30
Pumice, gray-brown, and cinders	45	75
Pumice, pink, massive (crystal tuff)	30	105
Rock, reddish-gray	5	110
Pumice, cinders, and rock particles, reddish-brown, gray, and black	60	170
Obsidian, black	20	190
Obsidian, black, and red-gray dacite cinders	15	205
Dacite, reddish-gray, some pumice	5	210
Dacite, reddish-gray	10	220
Dacite-andesite, some obsidian (medium-hard gray rock and black volcanic glass)	20	240
Andesite, dark-gray, fine-grained, hard, cavity or crevices at 255, 332-334, 364, and 384 ft	144	384
Andesite, dark-gray, fine-grained, rich in magnetite, very hard	45	429

Major streams.--The Rogue River and several tributaries head within the park. The tributaries are, from north to south: Minnehaha, National, Crater, Copeland, Bybee, Castle, and Red Blanket Creeks. Tributaries to the Klamath River that head within the park are, from south to north: Annie, Sun, and Sand Creeks. Any of these, or some of the numerous smaller spring-fed streams, would provide adequate supplies of water to a variety of park facilities. Miscellaneous measurements have been made a few miles outside the park boundary on Castle, Copeland, Crater, National, and Sand Creeks. Those measurements, from Water-Supply Paper 574 and from the files of the Geological Survey, are tabulated in table 4.

The discharge of Annie Creek was gaged continuously from 1923-26, and miscellaneous measurements were made during the fall in 1931, 1949-53, 1955-56, and 1959-66.

The monthly and yearly mean discharge, in cubic feet per second, for Annie Creek for water years 1923-27 is tabulated in table 5.

The average discharge of Annie Creek at the gaging station for the 3 water years 1924-26 was 52.5 cfs (cubic feet per second). The average of two measurements of the outflow of Annie Spring, 10 miles upstream from the gage, was 3.7 cfs. A similar relationship between outflow of the headwater spring and flow several miles downstream appears to apply to other streams that rise in the park, and should be considered when evaluating streamflow measurements such as those listed in table 4.

Relation of stream location to points of use.--With the notable exception of Munson Spring at altitude 7,100 feet, most of the major streams and their source springs are below an altitude of 6,500 feet. Consequently, most of the area served by the present Rim Drive road is at least 1,000 feet above and at least 2 miles from a spring or stream capable of supplying enough water for a campsite or other facility. In planning future campsites or other facilities within the park, the ready availability of an adequate water supply should be a principal prerequisite.

Suitability of water for use.--All spring and stream water in the park, with the possible exception of water from parts of Munson Creek and perhaps Dutton Creek, should be suitable for drinking with little or no treatment. Most springs and streams drain areas of lava and volcanic debris where bacterial contamination is unlikely; the water is probably similar in chemical character to Annie Spring, which, according to Newcomb and Hart (1958), had a hardness of 15 ppm (parts per million) and a chloride content of 2 ppm.

Table 4.--Miscellaneous stream measurements in and near Crater Lake National Park

Stream	Measuring site	Date	Discharge (cfs)
Castle Creek	SE¼ sec. 25, T. 30 S., R. 3 E.	7-16-23	30.5
Do.	do.	9-10-23	14.1
Copeland Creek	NE¼ sec. 8, T. 30 S., R. 4 E.	7-16-23	49.4
Do.	do.	9-10-23	37.1
Sand Creek	NE¼ sec. 29, T. 31 S., R. 7 E.	11-16-11	14.5
Do.	do.	4-21-14	26.5
Do.	do.	8-11-14	27.3
Do.	sec. 32, T. 31 S., R. 7 E.	8-11-14	37.4
Do.	NE¼ sec. 29, T. 31 S., R. 7 E.	11-28-15	24.0
Do.	do.	5-30-16	16.2
Do.	do.	8-20-16	8.6
Do.	do.	6-15-16	20.0
Do.	do.	10-13-16	6.7
Crater Creek	NE¼ sec. 5, T. 30 S., R. 4 E.	7-16-23	65.6
Do.	do.	9-10-23	45.8
National Creek	NE¼ sec. 32, T. 29 S., R. 4 E.	7-18-23	45.3
Do.	do.	9-10-23	35.0

Table 5.--Discharge of Annie Creek, NE¼ sec. 36, T. 32 S., R. 6 E., in cubic feet per second[a/]

/Drainage area about 40 square miles/

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
1923	-	48.9	49.8	49.7	44.6	46.9	50.3	73.2	80.6	77.5	58.0	53.2	-
1924	58.1	57.4	59.5	43.6	43.1	40.2	44.8	62.9	56.2	47.5	38.5	39.7	49.3
1925	39.6	40.7	36.9	41.5	40.8	39.8	60.3	113	133	102	67.3	55.5	64.3
1926	51.3	48.4	42.0	34.0	40.0	37.0	53.2	57.4	45.4	43.4	39.4	36.3	44.0
1927	-	-	-	-	-	-	-	-	140	116	-	-	-

a/ From U.S. Geological Survey Water-Supply Paper 1315-B.

Crater Lake

Crater Lake is the largest untapped source of potable water in the park. According to K. N. Phillips (written commun., 1967), it contains about 14 million acre-feet of water, receives about 90,000 acre-feet of precipitation and runoff annually, and loses about 25,000 acre-feet to evaporation and 65,000 acre-feet to seepage annually. The seepage loss is about 90 cfs. The water contains only about 80 ppm of total dissolved solids.

Unless facilities are built near or at lake level, the lake water would have to be lifted about 525 feet to deliver water to Rim Drive road at the three lowest points on the rim and about 925 feet to deliver water to the existing lodge. Even so, if at some future date a large volume of water is needed to serve a large facility on the northeast rim of the lake, pumping from the lake may be economically feasible.

Artificial Collection and Storage

A 65-square-mile area in the northern part of the park has no readily available surface water. At the conclusion of test drilling at North Entrance, Manuel Morris of the Park Service suggested construction of catchment aprons and storage cisterns to utilize the seasonal precipitation. Such a water supply might be obtained at any point in the park where springs or streams are not readily available.

A catchment apron could be constructed in nearly any open, gently sloping area of the park, utilizing any of several methods. The apron should be floored with impermeable material, such as asphalt or plastic sheeting. Probably the least expensive kind of catchment apron could be constructed by grading a suitably sized area to a predetermined slope, laying down an impermeable floor of plastic sheeting, and covering the sheet with about 6 inches to a foot of the native pumice that underlies the surface of much of the park. The catchment apron should be fenced to prevent damage to the impermeable plastic membrane and to prevent entry of large animals. Water collected on the apron could be conducted from a collecting box (which would also act as a sediment trap) at the lower side of the basin to a storage tank or cistern with a capacity large enough to assure an adequate supply to the using facility during summer. Because of the mountainous terrain, the entire system could be designed to provide gravity flow to points of use.

A 100- by 100-foot catchment apron would provide 10,000 square feet of area to collect infalling precipitation. Assuming that the annual average 67-inch precipitation_/ measured at park headquarters

_/ Short-term precipitation records collected near Cleetwood Cove by the Geological Survey indicate that the northern part of the park receives somewhat less precipitation than does the weather station at park headquarters.

occurs at the site and that about 50 percent of it percolates through the pumice covering the catchment-apron floor, then about 3 feet of water, or about 30,000 cubic feet of water, or about 224,000 gallons per year, would be collected by a 100- by 100-foot apron. If this water were stored, it would provide about 1,850 gallons per day for 120 days.

If the annual precipitation is as little as the 33 inches recorded in 1931 and only 18 inches of water is collected on the catchment apron, then about 112,000 gallons would be collected; and if all were stored, about 900 gallons per day for 120 days could be provided for use.

Catchment aprons and associated storage facilities would provide water for man's use at points remote from springs and streams. At some places overflow water from the storage tank associated with an apron could be conducted to stock tanks or artificial ponds to provide water for wildlife.

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