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# GROUND WATER AND RELATED GEOLOGY OF JOSHUA TREE NATIONAL MONUMENT, CALIFORNIA

By

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Prepared in cooperation with the
National Park Service

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CONTENTS

PART I - TEXT

Ground water--Continued

Extensively alluviated valleys and nearby mountains--Continued

## PART II - TABLES OF HYDROLOGIC DATA

ILLUSTRATIONS



For preliminary release illustrations are at end of report. The page given is the page on which the first principal reference to that illustration is made.

# GROUND WATER AND RELATED GEOLOGY OF JOSHUA TREE NATIONAL MONUMENT, CALIFORNIA

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## PART I - TEXT

## ABSTRACT

Joshua Tree National Monument is in a mountainous part of the desert region of southern California. The geographic center of the monument is about 130 miles east of Los Angeles, Calif.; the area investigated, covering almost 1,000 square miles in area, is included between 115°20' and 116°28' west longitude, and 33°44' and 34°07' north latitude.

For the area studied all data on known and potential sources of ground water are assembled and described. Reconnaissance geologic maps outline main types of consolidated basement rocks and the water-bearing or potentially water-bearing unconsolidated rocks. Basement complex of pre-Tertiary age differentiated into metamorphic and igneous rocks and residuum crop out and underlie all the mountainous parts of the monument. The metamorphic rocks of the basement complex, probably Precambrian in age, are intruded by large bodies of igneous rock of undetermined age. Residuum is developed over large areas underlain by the igneous rock. Locally, small quantities of water are contained in near-surface joints and fractures of the igneous rocks and in the residuum.

The important water-bearing deposits of the area are the old alluvial deposits of Tertiary(?) and Quaternary age; the older alluvium of Quaternary age; the lacustrine deposits of Quaternary age; and the younger alluvium of Quaternary age. Of these, the old alluvial deposits and the older alluvium contain the principal aquifer units in the area, although the lacustrine deposits may yield some water to wells. The younger alluvium is thin in most parts of the area and contains saturated beds in a few places only.

Fault barriers compartment and locally bound the large alluvial aquifers, and impede ground-water movement in some places. Faults and some igneous dikes in the consolidated rocks localize the occurrence of ground water, as indicated primarily by springs. Also, buried bedrock ridges locally impound ground water or impede its migration.

Ground water occurs in three kinds of areas within the monument: (1) high, residuum-floored valleys, such as Lost Horse Valley, (2) moderately alluviated valleys, such as Quail Wash, and (3) extensively alluviated valleys, such as Pinto Basin. Mountainous areas near all the valleys have a few minor occurrences of ground water in jointed igneous rock.

In general, the quality of ground water within the area is good. High-fluoride concentrations at many places, however, render it unsatisfactory for continuous drinking-water supply for children.

# INTRODUCTION

The area of the geologic and hydrologic investigation described in this report covers 930 square miles of desert and mountain valleys south of the town of Twentynine Palms in the Colorado Desert region about 130 miles east of Los Angeles, Calif. (fig. 1), and includes

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Figure 1. Map of part of southern California showing area described in this report.

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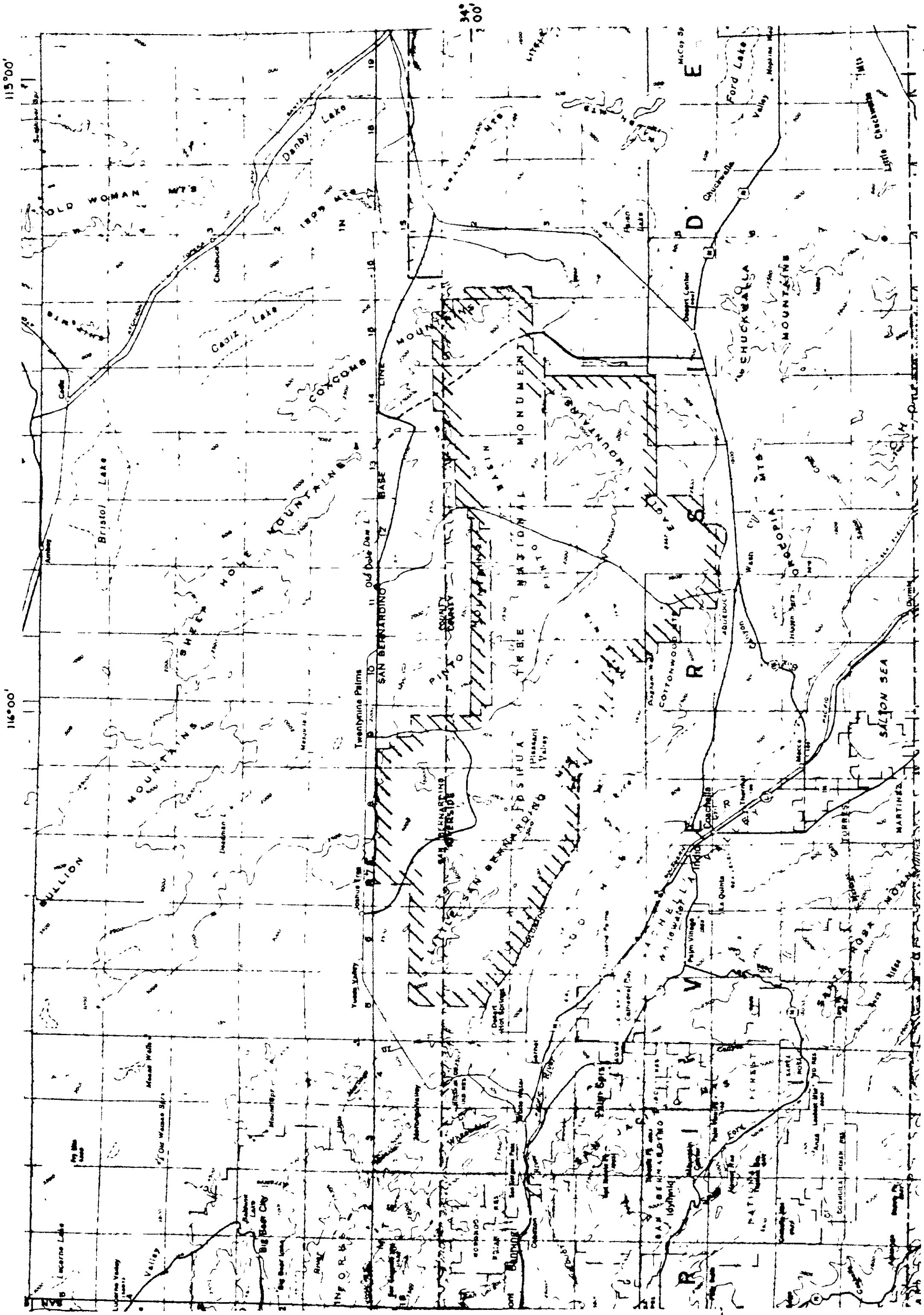
all of the Joshua Tree National Monument. The total area is shown on all of one and parts of ten other 15-minute quadrangles (see inset index maps on figs. 2 and 3).

The monument is accessible by automobile and the main routes lead south from the Twentynine Palms highway and north from U.S. Highway 60-70. Automobile travel within the monument is limited principally to the main roads. Numerous secondary (usually dead-end) roads branch from the main roads, and these are posted at the branching point to indicate advisability of automobile travel. Small-scale maps that show routes of travel and current road conditions are available on request at the monument headquarters at the Oasis of Mara in Twentynine Palms, which is about 4 miles north of the monument proper.




Base map from U.S Geological Survey topographic map of State of California, south half, scale 1:633,600

Boundary of report area

0 5 10 20 Miles
Scale

FIGURE 1.—Map of part of southern California showing area described in this report

Although the monument is dedicated primarily to preservation of archeological antiquities, native desert animal life and vegetation (especially the Joshua tree), geology is one of the principal attractions for visitors. Also the geology of the area is critical with respect to the occurrence of ground water which virtually is the only source of water within the monument.

## Purpose and Scope of the Investigation

The investigation was made by the U.S. Geological Survey at the request of and in cooperation with the U.S. National Park Service. The purpose was to describe known sources of ground water that might be developed to supply water for visitors in the monument campgrounds, park-ranger stations, and wildlife; and to evaluate areas within the monument with reference to their potential for development of new sources of ground water.

The scope of the investigation included:

1. Assembly and tabulation of all existing hydrologic data for the area of the monument (tables 1-5).

2. Preparation of a reconnaissance geologic map of the monument showing the areas of water-yielding deposits (figs. 2 and 3).

3. Preparation of a report summarizing and evaluating items 1 and 2 above (this report).

Fieldwork for the study was begun in November 1961 and completed in January 1962. The investigation was carried out under the direct supervision of G. M. Hogenson, geologist in charge of the Long Beach office of the Ground Water Branch, U.S. Geological Survey, and under the general supervision of Fred Kunkel, district geologist in charge of ground-water investigations in California.

## Methods of Investigation

Pertinent hydrologic and geologic information were obtained from published reports on parts of the region, from data in the files at the monument headquarters, and by field studies.

Most of the fieldwork consisted of inspection of known sources of water for purposes of (1) measuring water level in wells or estimating discharge of springs, (2) plotting location of wells and springs as accurately as available maps permitted, and (3) appraising geologic conditions related to the occurrence and movement of ground water. Reconnaissance geologic mapping, on topographic maps and aerial photographs, was done concurrently with the collection of the hydrologic data.

Tables 1-5 show all the known hydrologic data. The geologic maps show reconnaissance geology, and the text evaluates areas within the monument with reference to their potential for development of new sources of ground water. The scope of the work and the funds available did not permit detailed geologic mapping in the field. A few of the more inaccessible parts of the monument were not visited, but were evaluated from aerial photographs. Also two small areas outside the monument boundary (central Pinto Mountains and eastern Eagle Mountains) were mapped exclusively by photogeologic methods. In most of the areas that were mapped solely by photogeologic methods, the units of the basement complex are not differentiated.

The mapping as shown on figures 2 and 3 is of sufficient accuracy and detail to permit the Park Service to proceed with overall plans for water-resources developments. However, additional detailed geologic mapping would be required for other specific needs.

The authors gratefully acknowledge the aid given by the superintendent, Mr. W. R. Supernaugh of the Park Service at Joshua Tree National Monument, who made available to the Geological Survey geologic and hydrologic data from files at the monument headquarters. Ground-water data and incidental assistance also were given by miners and businessmen who live or formerly lived in and around the monument.

## Previous Investigations

The earliest investigations in the area were regional reconnaissances of desert watering places and included parts of the area that now is Joshua Tree National Monument. Reports on the studies mention such sources of water as Cottonwood Spring and springs in Lost Palms Canyon (Mendenhall, 1909, p. 78; Brown, 1923, p. 184, 266), Quail Spring (Mendenhall, 1909, p. 75), and Stubby Spring (Mendenhall, 1909, p. 77). Also among these earlier reports is one by Thompson (1921, p. 247) in which Quail Spring, Lost Horse well, and Keys Ranch are mentioned as sources of water for the desert traveler. Ground-water data usually were given only briefly and qualitatively in road logs in the earlier reports. Waring (1915, p. 387) gave the temperature of the water and estimated discharge at Cottonwood Spring.

Harder (1912) investigated the iron-ore deposits in the Eagle Mountains, and described and gave approximate locations of some of the sources of water supply in the region. Among the sources included were Cottonwood Spring and Eagle Tank.

A brief discussion by Scharf (1935) of the major geologic units in the area is included in an archeological study of Pinto Basin (Campbell and Campbell, 1935). No geologic map or ground-water data are included.

Unpublished data prepared by J. V. Lewis (written communication, 1941 and 1942) shows the extent of alluvial deposits and locations of wells and springs and discusses the water resources of the monument.

Rogers (1954) investigated an area of about 250 square miles in the northern part of the monument. This study was mainly petrographic, but a geologic map and brief text summarizes the investigation.

A brief hydrologic and geologic reconnaissance of Pinto Basin was made by Kunkel (1960).

## Numbering System for Wells and Springs

The system used for numbering wells and springs in the area of this report is that used by the Geological Survey in California since 1940. It has been adopted by the California Department of Water Resources and by the California Water Pollution Control Board for use throughout the State.

Wells and springs are assigned numbers according to their location in the rectangular system for the subdivision of public land. For example, in the number 2S/8E-21G3, assigned to one of the Lost Horse wells, the part of the number preceding the slash indicates the township (T. 2 S.); the number following the slash, the range (R. 8 E.); the number following the hyphen, the section (sec. 21); and the letter following the section number, the 40-acre subdivision of the section as shown in the diagram below:

| | | | |
|---|---|---|---|
| D | C | B | A |
| E | F | G | H |
| M | L | K | J |
| N | P | Q | R |

Within the 40-acre subdivision, the wells are numbered serially as indicated by the final digit. Thus, well 2S/8E-21G3 is the third well to be listed in the $SW\frac{1}{4}NE\frac{1}{4}$ sec. 21. All location numbers in this report are referenced to the San Bernardino base and meridian lines.

For well numbers where a Z has been substituted for the letter designating the 40-acre subdivision, the Z indicates that the well is plotted from unverified location descriptions. The indicated sites of such wells were visited but no evidence of a well could be found.

Springs are numbered according to the same system as wells, except that the letter S has been substituted for the final digit in the number.

For the number where X has been substituted for the letter designating the 40-acre subdivision, the X indicates that planimetric control in that area is poor and the well or spring location could not be definitely established.

The northern part of the west one-third and the central part of the east two-thirds of the monument are largely unsurveyed. Therefore, a projected section-line net is used in these areas (fig. 2).

## Climate

The climate of most of the monument typically is hot and arid. Average daily temperatures range between approximately 50°F and 104°F during spring and summer and between 35°F and 85°F during fall and winter (U.S. National Park Service, 1960).

Most of the precipitation, including infrequent snow, generally occurs in winter. The average annual precipitation at the monument headquarters is 4.19 inches. On the main part of the monument precipitation has been measured at 13 stations since 1949 and 15 stations since 1954. The annual precipitation at these stations during the period 1949-61 are given in table 1 (Part II of this report). These data show that recorded averages of annual precipitation throughout the monument range from 2.37 inches at the South Boundary station to 5.08 inches at the Cap Rock Wye station. In general the average annual rainfall increases from about 2 to 3 inches in the south part of the monument to about 4 to 5 inches, or perhaps slightly more, in the higher altitudes of the northwestern part.

Because the altitude (about 1,000 ft) at the extreme eastern end of the monument is lower than at any of the stations shown on table 1, average annual precipitation may be less than the approximate 2- to 3-inch average for stations in the southern part. Therefore, the general variation from east to west probably ranges from an average annual of about 1.5 inches in the east to about 5 inches, or slightly more, in the mountainous western part of the monument.

The averages of annual precipitation in themselves do not tell the complete story. Of more critical importance is the extreme variation in precipitation from month to month and from year to year. For example, the average annual precipitation at Old Dale Junction of 2.72 inches is based on a precipitation record that ranges from 0.21 inch (1950) to 5.15 inches (1959), a record that indicates a variation of annual precipitation of nearly 25 times.

The extreme variability of precipitation and therefore runoff indicates that large amounts of storage would be required to smooth out the effect of these variations if surface reservoirs were used to store water supplies. Also owing to the low humidity and high summer temperatures evaporation losses from surface-water reservoirs would be large. Consequently the feasibility of surface storage of water is not considered in this study, but an attempt is made to identify natural subsurface areas that might contain moderate to large quantities of ground water in storage. Such ground-water reservoirs are not subject to large evaporation losses and they usually store sufficient water to span prolonged drought periods when recharge from precipitation is deficient.

# GEOLOGY

The area of Joshua Tree National Monument is complex as to its stratigraphy, structure, and geologic history. However this investigation has been limited in scope to a discussion of the geologic units with particular reference to their water-bearing character and only to those elements of structure that relate to the source, occurrence, and movement of ground water. Because the geologic history is not directly pertinent to the occurrence of ground water it is not discussed except by reference to studies by previous workers.

On the basis of age and water-bearing character the geologic formations of the area are subdivided into nine units, listed from oldest to youngest, as follows: (1) Basement complex, (2) old alluvial deposits, (3) olivine basalt, (4) Pinto Formation of Scharf, (5) older alluvium, (6) lacustrine deposits, (7) younger alluvium, (8) playa deposits, and (9) windblown sand.

All of the geologic units listed above yield or are capable of yielding ground water. However, in general, the older consolidated units yield only small amounts of water locally, whereas the younger unconsolidated deposits yield moderate to large quantities of ground water where they are saturated and sufficiently permeable.

## Basement Complex

The basement complex of pre-Tertiary age underlies the younger rocks and crops out in all the mountainous parts of the area as shown on figures 2 and 3.

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Figure 2. Map of the eastern part of Joshua Tree National Monument and vicinity, California, showing reconnaissance geology and location of wells and springs.

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Figure 3. Map of the western part of Joshua Tree National Monument and vicinity, California, showing reconnaissance geology and location of wells and springs.

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The rocks of the basement complex consist of three general units: (1) metamorphic rocks, (2) igneous intrusive rocks, (3) residuum (residual materials developed upon 2 above). Also in many places the basement complex is cut by dikes. For some parts of the area the basement complex is undifferentiated. In other places the basement complex is divided into the three units listed above.

The metamorphic rocks are the oldest rocks of the basement complex. They probably are Precambrian in age (Miller, 1938, p. 418) and are closely associated with igneous rocks that intrude them. They crop out in much of the Pinto, Little San Bernardino, Hexie, and Eagle Mountains, and locally in areas adjacent to these mountains and include schist, gneiss, and quartzite. The Pinto Gneiss of Miller (1938, p. 424) is a part of the basement complex and the term should not be confused with the Pinto Formation of Scharf (1935, p. 12-15). (See explanation, fig. 2.) The estimated thickness of the metamorphic rocks range from a few feet to several hundreds of feet.

Because the metamorphic rocks of the area are dense and resistant to weathering, they virtually are impervious to the percolation of water. They are not known to be water bearing in the area studied.

The igneous intrusive rocks of the basement complex, in close association with the metamorphic rocks which they intrude crop out in all the mountainous parts of the area. They consist mainly of quartz monzonite, although some rocks in the southern and eastern parts of the area appear to be granite. The unit also includes the Gold Park Gabbro-Diorite of Miller (1938, p. 419), the Cactus Granite of Vaughan (1922, p. 365) and the Palms and White Tank Quartz Monzonite units of Miller as redescribed by Rogers (1954). The igneous rocks are emplaced by intrusion from the earth's interior and therefore extend to great depth.

The monzonitic and granitic rocks are jointed strongly, but at depth the joints are closed tightly and the entire rock is dense and nonporous. Near the surface some joints have been enlarged slightly by weathering and are partly backfilled with weathering debris. These near-surface joints locally contain small quantities of water. The amount of water that can be obtained from them depends largely on the nature of the weathering debris which in most places is clayey, generally of low permeability and, therefore, poorly water yielding.

The residuum of the basement complex occurs only on igneous terrane. It crops out over large areas of low relief in the central part of the western part of the area (fig. 3) and in two smaller areas in the south-central part of the eastern part of the area (fig. 2). The residuum consists of a weathering layer formed in place by the alternation of a large percentage of the mineral grains, principally the feldspars, of the igneous rocks, to clayey and silty sand. The residuum appears to be identical to the parent rock, but is considerably less dense and commonly slightly porous and permeable. Locally thin discontinuous layers of alluvial materials that overlie residuum have not been differentiated from the residuum. Because these layers of alluvium are thin and are not water bearing they are not considered significant. The maximum thickness of the residuum could not be determined in the areas of outcrop. Studies in similar terranes indicate that the thickness of the residuum generally is less than 100 feet. Some evidence, however, suggests greater thicknesses; the materials as identified on the available drillers' logs suggest that residuum may have been encountered in wells 2S/9E-3Q1, 3S/15E-4J1, and 4S/11E-27Q1 between 95 to 160 feet, 340 to 575 feet, and 215 to 403 feet, respectively.

Residuum locally contains water in its interstices, although permeabilities are low. Nevertheless wells of small yield, such as 2S/8E-6N1, can be developed where residuum is thickest and where several feet of its basal part is saturated. However, well 2S/9E-3Q1 which probably penetrated 65 feet of residuum yielded virtually no water. On the other hand well 4S/11E-27Q1 which may have penetrated 188 feet of residuum and well 3S/15E-4J1 which may have penetrated 235 feet of residuum yield moderate to large quantities of water from the residuum and overlying materials and its is not possible to determine from the data available how much water, if any, is yielded by the residuum.

## Old Alluvial Deposits

The old alluvial deposits are the oldest fluvial sediments exposed in the area. These deposits probably are late Tertiary and early Quaternary in age and therefore overlie the basement complex and, where present, underlie all other units.

The old alluvial deposits crop out only in the western part of Pinto Basin (fig. 2) and are not well exposed. The most extensive exposure in the monument is in the northern part of sec. 15, T. 11 S., R. 3 E., along the south side of an east-west fault.

The old alluvial deposits consist of faulted, deformed, and moderately consolidated fanglomerate, silt, and sand in alternating layers. The fanglomerate contains rocks up to boulder size. Silt and sand layers appear to be fairly well sorted and have only small amounts of clay intermixed. The total thickness of the unit could not be determined. However, where exposed the thickness of the unit appears to be at least 200 feet. In sec. 15, T. 3 S., R. 11 E., the deposits dip slightly more than 20 degrees southward, although at other exposures the dips are less steep.

Wells are not known to penetrate the old alluvial deposits. However, the fanglomerate and sand layers in the outcrop appear to be moderately permeable, and probably are saturated at depth near where they are exposed in the central-northern parts of Pinto Basin. They may also be part of the water-bearing zone elsewhere in Pinto Basin.

## Olivine Basalt

The olivine basalt of Tertiary age overlies the basement complex in the western part of the area and is interbedded with the old alluvial deposits in the eastern part of the area. It crops out over small areas in the Pinto and Eagle Mountains in the eastern part of the monument (fig. 2).

Where exposed, the olivine basalt is dense but vesicular and ranges from approximately 10 to 200 feet in thickness. In the eastern part of the monument (northwest and southeast of Mission well) where it apparently is interbedded with the old alluvial deposits it evidently was extruded through fissures along major fault zones. Only small erosional remnants of the old alluvial deposits remain on top of the basalt to show the interbedded relationship. In the western part of the monument (in sec. 33, T. 2 S., R. 8 E., sec. 6, T. 2 S., R. 7 E., and on Malpai Hill) where it rests on rocks of the basement complex it apparently was extruded through local pipelike vents.

No wells are known to be drilled into the olivine basalt. If saturated, the olivine basalt probably would yield water from cracks or fractures. However because the basalt is known only to cap hills or crop out at high altitudes it probably is not saturated and therefore is not considered as a source of ground water.

## Pinto Formation of Scharf

The Pinto Formation of Scharf (1935, p. 11-20) has been dated by Scharf (1935, p. 19) from fossil evidence as Pleistocene. Because of its age the Pinto Formation presumably overlies the old alluvial deposits and olivine basalt and from evidence in the field it appears to underlie or form the basal part of the older alluvium.

The formation crops out only in the southeast corner of Pinto Basin and consists of fanglomerate, lacustrine deposits, and interbedded basalt. The maximum thickness of the unit is unknown. About 150 feet of the sedimentary deposits and 150 feet of the basalt crop out in the exposures. However, these beds are displaced by faulting and are moderately deformed by folding and a reliable estimate of thickness is not possible.

It cannot be determined from existing data whether the Pinto Formation has been penetrated by wells. However based on general field relationships it appears that wells 3S/15E-4J1, 3S/15E-4K1, and 3S/15E-4K2, drilled to 575, 547, and 675 feet, respectively, may have penetrated the Pinto Formation from 185 to 340, from 226 to 547, and from 244 to 675 feet. If the Pinto Formation is penetrated by these wells it yields moderate to large quantities of water.

## Older Alluvium

The older alluvium is of Pleistocene age and overlies the Pinto Formation of Scharf and older units. It probably is interbedded with the lacustrine deposits and underlies deposits of Recent age. The older alluvium is exposed at the valley margins throughout the area and consists of consolidated and moderately indurated fan and stream-channel deposits of gravel, sand, silt, and clay. The exposures are moderately dissected and often display a dark-brown "varnished" desert pavement on the surfaces between the drainage channels. Locally, the unit is displaced by faulting. The deposits probably are thickest near the central part of the valleys, where they may be on the order of 300 feet thick or at well 3S/15E-4K2 (table 3) older alluvium may be 189 feet thick between depths of 55 to 244 feet.

The unit is moderately permeable and will yield moderate to large quantities of water wherever saturated.

## Lacustrine Deposits

The lacustrine deposits have not been dated, but probably are of Pleistocene age and are the equivalent of the older alluvium. The unit is exposed only in a small area at the east end of Pleasant Valley where it consists of poorly sorted deposits of sand, silt, clay, and calcareous tufa. Isolated small exposures also may occur elsewhere and the unit also may be present beneath younger deposits in Pleasant Valley. The coarser parts of the deposit probably are permeable and if saturated, would yield water to wells.

## Younger Alluvium

The younger alluvium is of Recent age and overlies all deposits of Pleistocene age and older. The unit underlies much of the floors of valley areas and consists of poorly sorted lenticular deposits of gravel, sand, silt, and clay. The deposits for the most part are water laid, but locally thin discontinuous windblown sand overlie and are not differentiated from the younger alluvium.

Although the younger alluvium is distributed widely, it is very thin in most areas; perhaps only a few tens of feet thick. The only logs of wells known to start in younger alluvium are wells 3S/15E-4K1 and 3S/15E-4K2. The logs (table 3) suggest that the younger alluvium could be 132 feet thick at well 4K1 or 54 feet thick at well 4K2. Based on work in other desert areas the thickness of 54 feet probably is the more accurate estimate of maximum thickness.

The younger alluvium is moderately permeable and although it probably is above the zone of saturation throughout most of the area, it is important to the ground water of the monument in that it receives and transmits recharge to the underlying deposits.

## Playa Deposits

Playa deposits of Recent age locally overlie older deposits in three areas (sec. 12, T. 2 S., R. 8 E.; secs. 8, 9, 16, and 17, T. 3 S., R. 9 E.; and sec. 3, T. 3 S., R. 10 E.). They consist of unconsolidated sand, silt, and clay that have been deposited locally. These deposits are very thin and of very low permeability. They contain no saturated beds and, therefore, have no apparent importance as sources of ground water.

## Windblown Sand

Windblown sand of Recent age overlies older deposits in sec. 33, T. 1 S., R. 14 E. Only in that area is windblown sand considered to be sufficiently thick and extensive to constitute a mappable unit. In that small locality the sand dunes are as much as 80 feet in height, and the total thickness of sand may be as much as 100 feet. Thin windblown deposits occurring locally elsewhere in Pinto Basin are not differentiated from the materials they overlie. The windblown sand is moderately permeable, although the unit is apparently not saturated and is not considered as a source of ground water. However, part of the precipitation which infiltrates these deposits ultimately recharges the underlying materials.

## GROUND WATER

The source of ground water in Joshua Tree National Monument is precipitation within the tributary area, of which only a small part percolates to the ground water. As described in the section on geology, ground water probably occurs to some extent in most of the geologic units. However the principal ground-water reservoir in Joshua Tree National Monument is in Pinto Basin where large quantities of ground water are contained in storage; mainly in the older alluvium but perhaps also in the older alluvial deposits and the Pinto Formation of Scharf (1938).

In addition to Pinto Basin, ground-water reservoirs of small-to-moderate size occur in several other areas and in several geologic units throughout the monument. Accordingly for the discussion of ground water the monument has been subdivided into three broad groups of valleys which in turn are subdivided further into a total of 18 smaller areas. Because each of the 18 areas comprises a distinct hydrologic unit, the source, occurrence, and movement of ground water is discussed separately for each area.

## Extensively Alluviated Valleys and Nearby Mountains

The area described as extensively alluviated valleys and nearby mountains includes all of the eastern part (fig. 2) of the monument plus Pleasant Valley and vicinity. Most of the valleys are a known or potential source of ground water where thick unconsolidated materials occur in the central parts of the valleys. In the mountains, small amounts of ground water occur locally in joints in consolidated rock and alluvial deposits in a few canyons and small mountain valleys.

## Eastern Part of Pinto Basin

The major ground-water reservoir in the monument is in that part of Pinto Basin (fig. 2) eastward from the vicinity of the Mission well (2S/12E-35F1) where alluvial and lacustrine deposits underlie an area of about 50 square miles, are saturated, and contain an extensive water body. Depths below land surface to the top of the zone of saturation as indicated by water-level measurements range from about 100 feet at well 3S/15E-4K1 (table 4) to about 450 feet at well 2S/12E-35G1 (table 2). The depth to the base of the zone of saturation is not known. However, the driller's log for well 3S/15E-4K2 (table 3) near the east end of the basin shows that the base was not reached at 675 feet below land surface, and therefore, the thickness of the water-bearing zone near the east end is estimated to be more than 550 feet, which is the minimum thickness of the material beneath the water table. Wells in the west end of eastern Pinto Basin penetrate about 100 feet into but do no reach the base of the saturated zone.

Recharge to ground water in the eastern part of Pinto Basin occurs along the south edge and part of the north edge of the basin, where coarse-grained permeable fan deposits are exposed. In these areas much of the precipitation on the heads of the fans and some of the runoff from nearby mountains percolates downward to the water table.

There are not sufficient data to make an estimate of the annual quantity of recharge to the ground water in the eastern part of Pinto Basin. However, average annual recharge is insignificantly small in comparison to the large quantity of water in storage. Kunkel (1960) estimated that there is 230,000 acre-feet of ground water stored in the upper 100 feet of the zone of saturation in the east two-thirds of eastern Pinto Basin. An additional 100,000 acre-feet is estimated herein to be stored in the western one-third of the eastern part of Pinto Basin in the same depth zone.

The movement of ground water in the area is from west to east through the basin. The gradient in the central part of the basin is only about 1 to 2 feet per mile, which suggests moderate to high permeabilities for the aquifer. The increased gradient at the lower end of the basin could reflect the reduction of cross sectional area of the water-bearing deposits or the effect by a probable barrier near the east end of Pinto Basin, as discussed by Kunkel ( 1963, P. 545).

There is no natural surface discharge in the eastern part of Pinto Basin except, during infrequent periods of heavy precipitation, when runoff from surrounding mountains and the western part of Pinto Basin may reach the central part of eastern Pinto Basin occasionally some runoff reaches Chuckwalla Valley. However, ground water moves southward into Chuckwalla Valley, from the east end of Pinto Basin, through the alluvial sediments in the gap between the Eagle and Coxcomb Mountains.

The only other discharge is from wells 2S/12E-35F1, 3S/15E-4K1, and 3S/15E-4K2. Pumpage records (fig. 4) of Kaiser Steel Corp. show

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Figure 4. Hydrographs of wells and pumpage in the eastern part of of Pinto Basin.

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3S/15E-4K1 and 4K2 increased from 130 acre-feet in 1952 to about 2,000 acre-feet of water in 1962. This water is piped to the Eagle Mountain mine several miles south of the wells and out of the watershed of Pinto Basin.

Mission well (2S/12E-35F1) is pumped periodically for short periods at about 50 gpm to furnish domestic water for persons living just off the monument north of the well. Mr. W. Rose, one of the users, reported that 1,000 to 1,200 gallons is pumped from Mission well about once every 2 weeks and hauled to the several users.

A total of 8 wells were found in the easter part of Pinto Basin, including the 3 wells that are used. The other 5 have no pumping equipment.

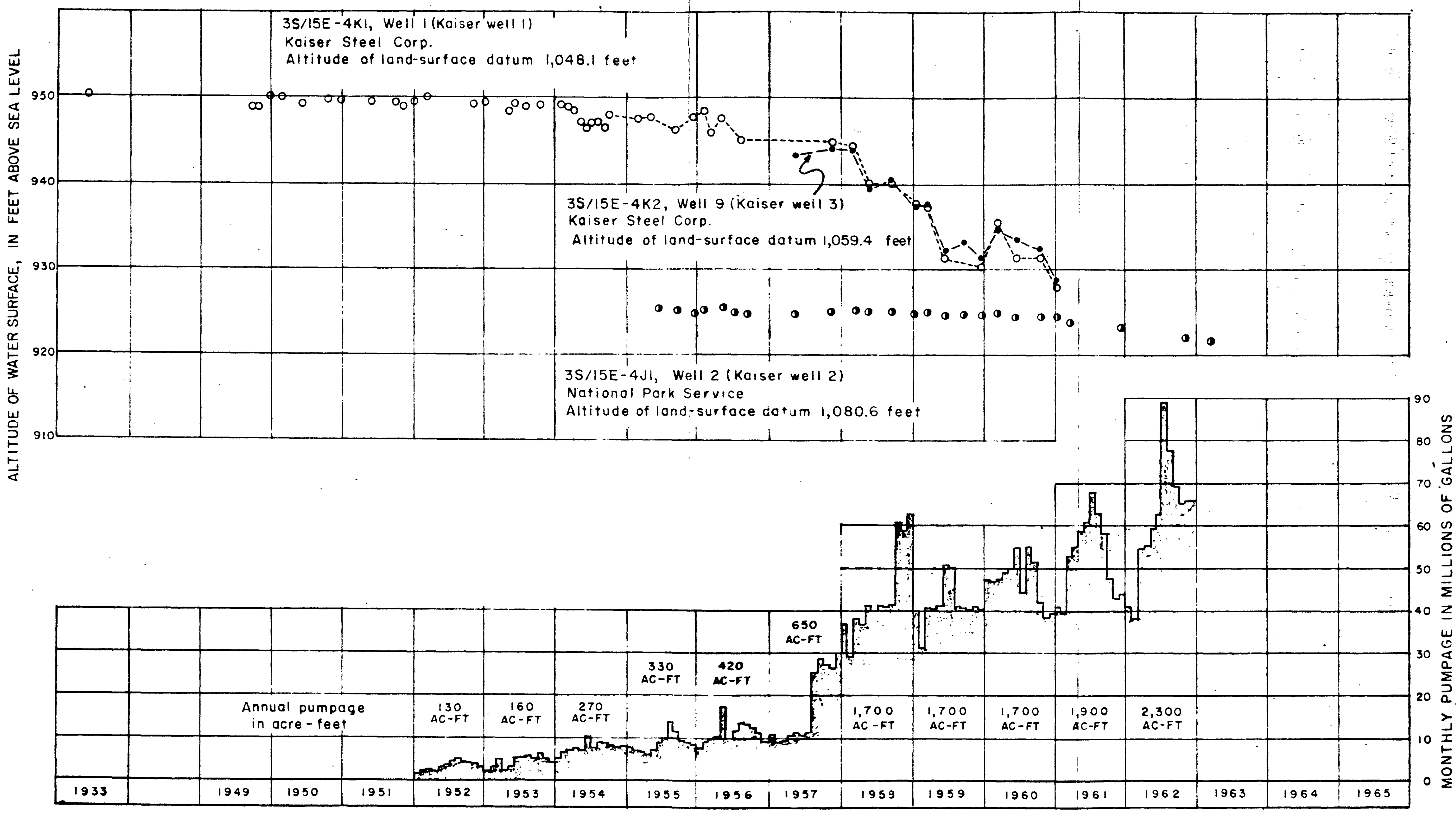


FIGURE 4.-HYDROGRAPHS OF WELLS AND PUMPAGE IN THE EASTERN PART OF PINTO BASIN

At the east end of Pinto Basin water levels west of the fault in the vicinity of wells 3S/15E-4K1 and 4K2 declined about 16 feet between 1956 and 1959 as a result of pumping from these wells. Because of virtually continuous pumping no static water levels were obtainable from wells 3S/15E-4K1 and 4K2 since 1959. However, in well 3S/15E-4J1 on the east side of the fault, measurements (table 4) and the hydrograph (fig. 4) show a water-level decline of nearly 4 feet from 1955 to 1962; the decline has been caused by pumping from wells 3S/15E-4K1 and 4K2.

Water-level measurements in Mission well in 1956 and 1961 (table 2) show a rise in water level of almost 25 feet during the interval between the two measurements. The reason for the rise is unknown but it probably occurred because of decreased pumping of the well in 1961 as compared to 1956.

Chemical analyses (table 5) of water from wells 3S/15E-4K1, 4K2, 4J1, and 2S/12E-35F1 show that the water in the eastern part of Pinto Basin generally is of sodium sulfate type. The principal difference in water from the eastern and western ends of eastern Pinto Basin is in the fluoride content, which is 6.0 ppm (parts per million) in water from Mission well and ranges from 2.0 to 2.7 at the east end of the Basin. The recommended upper limit for fluoride content of drinking water in areas where the annual average of maximum daily air temperatures is between 79.3° and 90.5°F is 0.8 ppm (U.S. Public Health Service, 1962, p. 2154). Annual average of maximum daily air temperature at the Monument Headquarters is about 83°F (U.S. National Park Service, 1960).

Because of excessively high fluoride concentration, water from Mission well probably would cause tooth mottling in most children who drink it regularly. Such concentration is reportedly not harmful to adults (California Water Pollution Control Board, p. 256-257, and p. 82-83 in Addendum). Concentrations of other dissolved chemical constituents are not high enough to limit the general use of the ground water from Mission well and vicinity.

## Western Part of Pinto Basin

The area includes Pinto Basin west and south of Mission well. The southern extent of the western part of Pinto Basin arbitrarily is set at the approximate latitude of Old Dale Junction. In this area the geologic evidence indicates favorable conditions for the occurrence of ground water in the old alluvial deposits and older alluvium and possibly in the younger alluvium and residuum, although no successful wells have been drilled in the area.

South of the east-west fault zone that trends across the north-central parts of T. 3 S., Rs. 11 and 12 E. the geologic conditions are favorable and ground water probably occurs in permeable beds of the old alluvial deposits, although there are no wells to substantiate this occurrence. The depth to the top of the water-bearing zone is estimated roughly at 600 feet, based on the probability that the fault is a partial barrier to northward ground-water migration and that it impounds the water at an altitude at least as high as and probably higher than that at Mission well (2S/12E-35F1). The water level altitude at Mission well is 986 feet (fig. 2).

Ground water probably also occurs locally in the younger and the older alluvium and residuum elsewhere in the western part of Pinto Basin. Two such localities are in part of sec. 8 and in secs. 4, 5, 9, and 10, T. 4 S., R. 12 E. In secs. 4, 5, 9, and 10 the bedrock mass, indicated by knobs projecting above the surrounding alluvium, should impede northeastward ground-water movement at depth. The southeast-trending concealed fault and a dike exposed in the quartz monzonite in sec. 8 may cause a small amount of ground water to be impounded in younger alluvium on the southeast side.

The aquifers in the western part of Pinto Basin are recharged from infiltration of precipitation and runoff from the adjoining consolidated-rock areas. In general, ground water in the area moves northeastward and enters the eastern part of Pinto Basin as subsurface inflow. No surface discharge occurs in western Pinto Basin except immediately following infrequent cloudbursts.

The only known attempts to develop water in the western part of Pinto Basin were unsuccessful. Wells 3S/11E-7Z1 and 11Z1, now destroyed, were hand dug to reported depths of 60 to 100 feet. Both evidently were north of the fault barrier which displaces the old alluvial deposits. Neither of these dug wells was deep enough to have reached the zone of saturation, even if they had been located in nearby areas south of the fault where geologic conditions are more favorable to the occurrence of ground water.

There are no data on the quality of ground water in the western part of Pinto Basin. However the ground water probably is similar in chemical quality to water in the eastern part.

## Mountains Surrounding Pinto Basin

The Pinto, Coxcomb, and most of the Eagle Mountains are composed of impermeable rocks of the basement complex locally overlain by thin alluvial deposits. These mountain ranges around the Pinto Basin contain no known and virtually no potential supplies of ground water.

Eagle Tank, a natural rock basin in sec. 23, T. 3 S., R. 13 E., was visited because reports of an almost perennial supply of water there suggested that it might be fed by ground water (Harder, 1912, p. 15, and W. R. Supernaugh, National Park Service, oral communication). A brief examination indicated no evidence of ground-water supply to the tank. The tank efficiently preserves runoff collected there because it does not leak and is well protected from wind and sunlight.

The Hexie Mountains also are barren of known or potential water sources, except in the small valley in which the Ruby Lee well (4S/11E-10E1) is located. This well derives a small supply from joints in igneous rock. Farther east in the small valley, ground water may also occur in older alluvium.

Two former sources of water from jointed igneous rock are located about 1.5 and 2 miles north of the Ruby Lee well. Pinkham well and spring (4S/11E-3D1 and 3DS) which were reported as a supply by Brown (1923, p. 277) are now dry. Barrel Spring, 3S/11E-34JS, apparently is a wet-weather seep from joints and other fractures in bedrock at the mouth of a canyon. It was dry when visited in December 1961.

Recharge in the Hexie Mountains is from local precipitation and runoff in water sheds of limited size. Ground-water movement within this area generally is basinward, and there is no natural surface discharge. Presumably, a few buckets of water are bailed occasionally from the Ruby Lee well when the owner is staying there.

## Smoke Tree Wash and Vicinity

Ground water occurs in older alluvium and probably in residuum in parts of secs. 26, 27, 33, and 34, T. 4 S., R. 11 E. (upper part of the wash) and sec. 19, T. 4 S., R. 12 E. (lower part of the wash).

Depth to the top of the zone of saturation near well 4S/11E-27Q1 is 170 feet below the land surface. According to the driller's log of the well (table 3), bedrock was not reached at 403 feet although 199 feet of material penetrated in the lower part of the well probably was residuum, and, therefore, consolidated bedrock probably lies close to the bottom of the well. Based on the driller's log, in places, the thickness of the zone of saturation in Smoke Tree Wash is at least 233 feet.

The aquifers of Smoke Tree Wash are recharged chiefly from local precipitation and runoff occurring infrequently in the dry washes. A small amount of recharge along the edges of the water shed probably also reaches the aquifer. Ground-water moves through the area in the zones of saturation probably northeastward. It probably migrates slowly through or over the fault zones bounding the aquifers on the north and eventually may reach aquifers in the Pinto Basin. Ground water does not discharge at the surface in the area.

Cottonwood well, 4S/11E-27Q1, was finished in December 1958. The tested yield of the well is 45 gpm with 85 feet of drawdown at the end of 20 hours of pumping from a static water level of 170.6 feet. Water from the well may be used to augment the supply at Cottonwood Spring campground to the south. Continuing measurements of water level in Cottonwood well (table 4) show minor fluctuations that probably reflect only changes in atmospheric pressure.

The quality of water from Cottonwood well is very good (table 2), except that the fluoride concentration is 2.7 ppm. This concentration is higher by about 2 ppm than the recommended upper control limit for drinking water (U.S. Public Health Service, 1962, p. 2154).

## Cottonwood Spring Area

The Cottonwood spring area includes the watershed of Cottonwood Canyon which is underlain by basement complex, residuum, older alluvium, and younger alluvium. Recharge to ground water in the area is from infiltration of precipitation within the watershed area. In general the ground water percolates southward through joints and residuum until it reaches the alluviated part of Cottonwood Canyon where it continues southward as underflow in the alluvial deposits of the canyon.

Presumably ground water in the alluvium is discharged as underflow to the south and out of the area. However the main discharge in the area is at Cotton, Cottonwood, and Wood Springs (4S/11E-14CS, 14LS, and 14PS) where it appears that water percolating through joints in the igneous rock is brought to the surface by dikes, which act as barriers or dams.

The yield of Cottonwood Spring, the largest of the group, was estimated by Waring (1915, p. 387) at 5 gpm. As with other springs on the monument, discharge of these springs varies with quantity of rainfall. Records from files at the monument show the fluctuations and a considerable decrease in flow through the years. The decrease in discharge presumably has been caused by drought conditions and a decrease in recharge.

| Discharge of Cottonwood Spring | | | |
|---|---|---|---|
| Date | Discharge (gpm) | Date | Discharge (gpm) |
| Sept.16, 1944 | 1.2 | Sept. 6, 1951 | 0.75 |
| Aug. 28, 1948 | 1.8 | Sept.11, 1952 | 1.0 |
| Aug. 28, 1949 | 0.8 | Dec. 1957 | Small trickle |
| Sept.15, 1950 | 3.0 | | |

In addition to flow of the spring, phreatophytes (plants which require a perennial and secure water supply, such as palms and cottonwood), near Cottonwood Spring discharge by transpiration a considerable quantity of water, perhaps equal to or greater than the spring flow during warm weather.

Cotton Spring is used infrequently for domestic water supply, Wood Spring is used by the Park Service to water wildlife in the area, Cottonwood Spring, one of the oldest and best known sources of water in the region, is now used to supply water for a campground, although the discharge was formerly piped 15 miles northeast to the Black Eagle mine (Mendenhall, 1909, p. 78).

The chemical quality of water in the area is indicated by several analyses of water from Cottonwood Spring (table 2). In general, the water contains 500 ppm or less of dissolved solids and is a calcium sodium bicarbonate water. The fluoride concentration usually is high (2.8 to 3.4 ppm); however, a sample taken in 1959 had only 0.86 ppm. Water from the area is good for general use, except the fluoride is higher than recommended for drinking (U.S. Public Health Service, 1962, p. 2154).

## Lost Palms Canyon Area

The mountainous area around Conejo Spring (5S/12E-9AS), as well as the area of Lost Palms and Munsen Canyons is included in the Lost Palms Canyon area. In this area ground water occurs in joints and cracks in the igneous intrusive rocks. Recharge to the area occurs by infiltration of precipitation on the mountain slopes and runoff in the canyons, which infiltrates directly into the joints and cracks of the rock. This water migrates generally southward beneath the canyon floors through the joints and cracks. The migrating water appears as seeps in many places in the canyon floors where joints are closed for short distances. When the water reaches the fault-zone barriers, it comes to the surface and issues as springs.

Canejo Spring (5S/12E-9AS) apparently is a wet-weather seep that was dry in December 1961. However, in the area of Lost Palms and Munsen Canyon the occurrence of ground water appears to be controlled by two faults (fig. 2), above which five springs (5S/12E-20NS, 28ES, 29DS, 29FS, and 29JS) issue. The largest and steadiest flow (approximately 0.75 gpm) has been reported from spring 5S/12E-28ES in Munsen Canyon. In addition to the observed flow palms grow in many places in Lost Palms and Munsen Canyons, and discharge a considerable amount of ground water by evapotranspiration.

Water discharged from three of the springs in Lost Palms Canyon (5S/12E-29DS, 29FS, and 29JS) and spring 5S/12E-28ES is piped about 4 or 5 miles southward for use outside the monument. The total quantity of water piped from the springs usually is no more than 2 gpm.

The chemical quality of the water from the Lost Palms Canyon area (table 2) is similar to the quality of water from Cottonwood Springs. The fluoride content (4.0 ppm) is higher than the recommended control limits in drinking water (U.S. Public Health Service, 1962, p. 2154); otherwise, the water is acceptable for general use.

## Pleasant Valley Area

Watersheds tributary to Pleasant Valley (fig. 3) are included in the Pleasant Valley area, except for the drainage area north of the west end of the valley, where the boundary is an arbitrary line extending west from Squaw Tank. The area north of this line is included as part of the Queen Valley area.

The few data from wells in the area indicate that ground water in the Pleasant Valley area probably occurs in older lacustrine deposits at the east end of the valley and perhaps toward the west in the vicinity of exposures of playa deposits. The occurrence of water in the valley probably is controlled by faults which cross the former lake basin at the east end and south side. These faults are thought to impede partially the eastward movement of ground water, thus impounding water in coarse-grained parts of the deposit. In addition to water in the older lacustrine deposits a few wells, that now are dry but formerly supplied water, suggest that joints in the igneous rocks of the basement complex probably yielded water to wells during periods of above average rainfall. However, it also is possible that the wells originally were deeper and may be filled with debris.

Recharge to the ground water in the Pleasant Valley area occurs mainly from infiltration of precipitation and runoff near the edges of the valley where stringers of alluvium are recharged from local precipitation and runoff. Movement of ground water is valleyward from the canyons and generally is eastward in Pleasant Valley. Some ground water probably leaks through or spills over the fault barrier at the east end of the valley and migrates slowly as underflow through Fried Liver Canyon, ultimately reaching Pinto Basin. There is no discharge to the surface in the Pleasant Valley area.

Wells 3S/9E-16Z1 and 19Z1 are destroyed. Well 16Z1 reportedly was drilled in an unsuccessful attempt to develop water in the area, and did not reach bedrock. Well 19Z1 reportedly encountered water at about 50 to 60 feet, but never was used. Other wells in the Pleasant Valley area were developed and formerly were used primarily to supply mining operations. Well 3S/9E-14G1 is near the site of an old ore mill. Water from the Pinyon well (3S/8E-12K1), a group of five closely spaced wells (all dry in December 1961), was piped to El Dorado mine, 8 miles east in a canyon tributary to Pinto Basin. The westernmost end of that pipeline reportedly was at Hansen well, which was farther up the canyon from Pinyon well. The site of Hansen well cannot be found, and it is not shown on figure 3 or in the tables.

There are no data on the quality of water in the Pleasant Valley area. The chemical quality of water that may occur in the tributary canyons during wet years probably would be good, judging from the excellent chemical quality of water that occurs in rocks of similar character elsewhere in the monument.

## Moderately Alluviated Valleys in the Higher Mountains

Several small valleys with thin to moderately thick alluvium and, locally, residuum occur in the west part of the monument. These valleys contain, or potentially contain, small quantities of ground water. The principal part of the Quail Wash drainage is the largest and most important of these areas.

## Quail Wash Area

The Quail Wash area as described in this report includes all of the valley underlain by alluvium and residuum northwest of and downstream from Lost Horse Valley. It is bounded on the east by the Wonderland of Rocks, and on the south, north, and west by parts of the Little San Bernardino Mountains. Quail Wash leaves the monument at the north edge of sec. 20, T. 1 S., R. 7 E., which is the northwestern limit of the area. The bedrock exposure surrounding Hidden Valley in sec. 8, T. 2 S., R. 8 E. is at the southeast end of the area.

Recharge to the ground water in the area is principally runoff from the surrounding high mountains through several large canyons. These include Smith Water Canyon, which drains part of Lower Covington Flat. Lost Horse Valley and the northernmost part of Queen Valley are also tributary to the area.

Measurements of the water level in wells in the Quail Wash area indicate that the lower part of the alluvium and, in some places, the residuum is saturated. Water-level altitudes suggest a ground-water gradient northwestward from well 2S/8E-7K1 to well 1S/7E-27R1. This gradient probably continued down the wash to the monument boundary. The presence of the gradient shows that ground water moves out of the monument beneath Quail Wash.

In November 1961 the only water pumped from wells in the area was from well 2S/8E-6N1 at the Lost Horse Ranger Station. This well and the wells owned by W. W. Whitlow (2S/8E-5E1) and William Keys (1S/8E-32C1), both drilled in areas underlain by bedrock, represent most of the development in the Quail Wash area. A few other wells were observed, two of which contained water (2S/7E-27R1 and 2S/8E-7K1), and the rest of which were found to be dry or destroyed. Quail Spring (1S/7E-33LS) was dry when visited.

Measurements show a water-level decline of about 15 feet from May 1958 to November 1961, which indicates that recharge was insufficient to replenish the natural northwestward migration or drainage of ground water from the area during that period.

A chemical analysis of water from well 2S/8E-6N1 indicates that the water in the area is of very good quality.

The small drainage area underlain by alluvium in secs. 9 and 16, T. 1 S., R. 7 E., and tributary to Quail Wash, appears to contain no saturated material and is not considered to be a potential source of ground water.

## Juniper Flats and Vicinity

Juniper Flats is a small valley slightly larger than 1 square mile in area in the Little San Bernardino Mountains, west of Lost Horse Valley. It is underlain by thin alluvium. The surrounding area has several major faults, which probably have a definite effect on the occurrence of ground water in the vicinity.

Recharge to the potential aquifer in Juniper Flats probably is from local precipitation, but may come in part from runoff and percolation originating in the high bedrock areas to the north, northeast and south of the flats. The recharge area is small and the thin permeable materials in the valley probably contain only a small amount of water.

## Lower Covington Flat

Lower Covington Flat is a rather narrow northwest-trending valley about 7 miles long in the northwest part of the monument. It is floored with alluvium and follows a major fault zone.

Recharge to the ground water of the flat occurs locally from precipitation and runoff from the high bedrock areas on both sides of the valley. During winter months ground water may move as underflow from the southeast end of Lower Covington Flat through Smith Water Canyon, which drains northeastward into Quail Wash. During periods of heavy precipitation the canyon undoubtedly has streamflow. A shallow dug well (2S/7E-6R1) was observed in the channel of Smith Water Canyon, but was dry in December 1961.

Ground-water underflow also appears to move northwestward in the flat from the low drainage divide about $\frac{1}{4}$ mile north of the county line. This underflow moves out of the monument and into Yucca Valley to the north.

Two wells (1S/6E-23L1 and 23Q1), in Nolina Cove just north of Lower Covington Flat, penetrated igneous bedrock and reportedly were unsuccessful attempts to develop ground water on this private property within the monument.

Well 2S/7E-6R1 and Covington Spring are the only known attempts to develop water in the valley proper. The well penetrates 2 feet of alluvium, then enters bedrock. It reportedly contained water in 1944. The locality known and shown on maps as Covington Spring reportedly was an 80-foot adit dug into the valley wall by cattlemen at about the turn of the century. Park Service records indicate that in September 1945 there was a dam in the adit over which the water was flowing at a rate of about 1 gpm. In November 1961, no evidence of the adit or spring flow could be found.

## Indian Cove Area

Indian Cove is a reentrant in the northernmost part of the monument that covers about 6 square miles and is underlain by residuum and thin alluvium. Runoff from Rattlesnake Canyon, which drains the northern part of the Wonderland of Rocks, enters the cove at the southern end and reportedly is large after heavy storms.

The floor of the channel in Indian Cove is permeable and relatively large amounts of the runoff from Rattlesnake Canyon percolates into it. However, the alluvium and residuum in Indian Cove probably is fairly thin, and the ground-water storage capacity is small. A small water supply might be developed by a well or infiltration pit dug into the zone of underflow that probably occurs beneath the wash that passes through the area.

## Twentynine Palms Reentrant

The Twentynine Palms reentrant includes the drainage system west of the Pinto Mountains in T. 1 S., R. 9 E. This drainage system heads near Pinto Wye and drains northward over an evenly sloping area sometimes referred to as the Twentynine Palms fan. Also included in the area is the alluviated part of sec. 5, T. 1 S., R. 9 E.

Ground water occurs locally in the reentrant, mainly toward the north end outside the monument boundary. A well in the older alluvium of the northeastern part of sec. 5, T. 1 S., R. 9 E. (1S/9E-5A1) is used to supply domestic water to several houses in the vicinity. The configuration of the bedrock exposures in parts of secs. 21, 22, and 28, T. 1 S., R. 9 E., suggest that small ground-water supplies may be obtained from wells in the older alluvium and possibly the younger alluvium at that locality also. Exploratory wells 2S/9E-3Q1 and 2S/9E-11D1 (table 3) indicate that virtually no ground water occurs in the upper part of the drainage system.

Recharge to the area occurs locally by infiltration of precipitation and runoff from adjacent mountains. Movement of ground water is generally northward toward Twentynine Palms. The quality of the ground water in the reentrant is very good, as indicated by an analysis of water from well 1S/9E-5A1 (table 4).

## High Residuum-Floored Valleys and Adjacent Mountains

These valleys are in the high mountains of the west part of the monument. Most of the valleys are floored with residuum composed of deeply weathered quartz monzonite of the basement complex. Locally, alluvium covers the residuum. Small amounts of ground water occur locally in the residuum, alluvium, or in joints in the igneous rock.

## Upper Covington Flat

Upper Covington Flat is an area of about 3 square miles, high in the Little San Bernardino Mountains (fig. 3). It is underlain by older alluvium, residuum, and a thin stringer of younger alluvium along the wash that drains the area.

There are no data available on ground-water occurrence in the flat, and no attempts to develop water are known. However, the large area of older alluvium and residuum and the relatively large rainfall in this part of the monument (about 5 inches annually) suggest that a small ground-water supply may be available during part of the year.

Drainage of Upper Covington Flat is northeastward from sec. 12, T. 2 S., R. 6 E., toward Lower Covington Flat. There is no perennial flow in the canyon between these areas, and, consequently, the only natural discharge from the flat is by evaporation and a minor amount of transpiration from sparse vegetation.

## Stubby Spring Area

Stubby Spring flows perennially from the side of a steep canyon in the southern part of sec. 27, T. 2 S., R. 7 E. (fig. 3). The spring is supplied by infiltration and percolation of precipitation through a small area of residuum which underlies the area north of the spring. The water percolates downgradient along the base of the residuum until it gets to the canyon, where it emerges along the contact of residuum and local patches of alluvium with underlying consolidated rocks.

The watershed which supplies the spring is limited in size and is drained by deeply entrenched canyons so that runoff quickly flows out of the area and only a very small amount of the precipitation infiltrates the residuum.

Discharge from the area is very small and largely is confined to Stubby Spring. A few nearby ephemeral springs, such as Burns Spring (2S/7E-27RS), have been reported but these flow for only a short time after wet periods.

Use of Stubby Spring as a source of water began prior to 1909 (Mendenhall, 1909, p. 77). National Park Service records show that the flow has varied from 10 gph (gallons per hour) in 1949 to a "small trickle" in 1957. In November 1961, the total flow from the pipes at the spring was estimated at 2 or 3 gph, and there also was a small amount of seepage from the saturated alluvium around the spring.

The chemical quality of the water from Stubby Spring is not known, however, when the spring was visited in November 1961, an unexplained antiseptic odor was noted which may have resulted from the decay of some plant in the spring area.

## Lost Horse Valley Area

Lost Horse Valley is an area of about 14 square miles which is bordered on the east by Lost Horse and Ryan Mountains, on the north by the Wonderland of Rocks, and on the south and west by the Little San Bernardino Mountains. It is underlain by residuum, older alluvium, bedrock, and some stringers of younger alluvium in the washes. Strongly jointed igneous rock occur at the edge of the valley.

The occurrences of ground water in Lost Horse Valley are scattered and apparently local in extent. Water occurs in joints and cracks in igneous rock, as in sec. 21, T. 2 S., R. 8 E., and in residuum and alluvium, as in sec. 3, T. 2 S., R. 8 E. The local extent of water-bearing materials in the valley is demonstrated by well 2S/8E-18Q1, which is 458 feet deep and dry. No log is available for the well, but it is located in a part of the valley where the residuum would be expected to be relatively thick and saturated.

A small amount of recharge comes from precipitation and local runoff, a part of which percolates into the alluvial units, residuum, and fractures in the bedrock. Movement of ground water in Lost Horse Valley generally is toward the northwest, but locally the direction may vary widely.

There is no natural discharge to the surface in the valley, and a small pumping discharge from a total of only four wells. Of the four wells that yield water, three are near the site of Lost Horse well (2S/8E-21G1, 21G2, and 21G3) and one (2S/8E-3C1) is near the northeast corner of the valley. Park Service records show that well 2S/8E-21G2 has a yield of less than 1 gpm. In addition, a destroyed well (1S/8E-34P1) is reported to have yielded a small amount of water for an ore mill. The Lost Horse well (2S/8E-21G1) supplied water to the Lost Horse mine, when it was active, via a pipeline.

An analysis of water from well 2S/8E-21G2 indicates that the water is of good chemical quality. No data are available on the chemical quality of water from well 2S/8E-3C1, which is used for domestic purposes.

## Queen Valley Area

The Queen Valley area covers about 40 square miles and is almost entirely within T. 2 S., Rs. 8 E. and 9 E. It is bounded by Lost Horse and Ryan Mountains on the west, Queen Mountain on the north, the Pinto Mountains on the east, and the Hexie Mountains on the south. An arbitrary line west from Squaw Tank, at the western end of the Hexie Mountains, separates Queen Valley from the northwest end of Pleasant Valley. The area is underlain by residuum, older alluvium, and low-lying exposures of igneous rock, largely quartz monzonite. The residuum and alluvium are believed to be very thin throughout most of the area and, except perhaps locally, they are unsaturated.

There are no proven sources of ground water in the Queen Valley area. Four destroyed wells (1S/8E-35R1 and 35R2, 2S/8E-12L1, and 2S/9E-17Z1) may have yielded water initially, but Park Service records show they have been dry for many years. Well 1S/8E-35R1 is 215 feet deep and drilled mostly into bedrock.

Some ground water may occur in a small area of the SW$\frac{1}{4}$ sec. 26, T. 2 S., R. 9 E., a short distance north of Hidden and Stirrup Tanks. Partly buried bedrock, indicated by numerous quartz monzonite knobs protruding above the residuum, may impound underflow in the basal part of the residuum which is estimated to be as much as 100 to 150 feet in thickness here.

Some of the precipitation that falls on the Queen Valley area infiltrates the residuum and alluvium and migrates laterally through residuum, alluvium, and, locally, jointed bedrock. The directions of lateral ground-water movement are, in general, the same as the ground-surface slope--principally eastward toward Pinto Basin, southward toward Pleasant Valley, and westward toward Lost Horse Valley. It is not known whether a significantly large quantity of underflow leaves the Queen Valley area, and there is no natural discharge as springs or seeps in the area.

## Fortynine Palms Canyon and Vicinity

Fortynine Palms Canyon and vicinity includes the mountainous district from Fortynine Palms Canyon southeastward to the locality of Pine Spring. This rugged area is known locally as Fortynine Palms Mountain.

Ground water occurs and is recharged locally by direct infiltration of precipitation into joints in igneous rock exposed in the area. The most important of these occurrences is at Fortynine Palms Oasis in Fortynine Palms Canyon, which in November 1961, contained the only perennial flowing spring in the area. Discharge from the spring has fluctuated somewhat in response to quantity of rainfall as shown by the following records from the files at the monument:

| Date | Discharge (gpm) | Date | Discharge (gpm) |
|---|---|---|---|
| Sept.21, 1944 | 0.03 | Sept.21, 1950 | 1.7 |
| Sept.13, 1945 | .2 | Sept.10, 1951 | .3 |
| Aug. 27, 1948 | .6 | Sept.27, 1952 | .8 |
| Aug. 25, 1949 | .4 | | |

In addition to the spring, natural discharge occurs as transpiration from the native palms growing in the canyon, which may be greater than the flow of the spring during dry years.

Park Service records show that Lone Palm Spring (1S/9E-18FS) discharged 0.5 gpm in 1945, but was dry in 1958. The spring was not visited during the investigation. The records also show that Pine Spring (1S/9E-32GS) had a small seepage between the years 1945 (about 0.5 gpm) and 1952 (less than 0.1 gpm), but has been dry since 1957.

There are no data available on the chemical quality of the water in Fortynine Palms Canyon. The quality of ground water in the area probably is very good, however, as is the quality of water from rocks of similar character elsewhere in the monument.

## Mountainous Area in the Southwestern Part of the Monument

The strip 3 to 6 miles wide in the Little San Bernardino Mountains along the west and southwest boundaries of the monument extends from the drainage system of Pushawalla Canyon to the northwest corner of the monument and is shown on figure 3 as a large area of undifferentiated basement complex. The area is the most remote and inaccessible part of the monument.

Ground water occurs in jointed bedrock near the northwest corner of the monument, as indicated by several seeps and springs in Long Canyon, in sec. 24, T. 1 S., R. 5 E., and a former seep at Black Rock Spring (1S/6E-30GS). Points of discharge in the vicinity of Long Canyon are controlled primarily by igneous dikes that act as dams. An old county well (3S/8E-31C1) which now is backfilled derived its supply from alluvium in Pushawalla Canyon, where the occurrence of water apparently is controlled by a geologically Recent fault of local extent.

Recharge to sources of ground water in the Long Canyon area occurs locally by infiltration into joints. Runoff in Pushawalla Canyon recharges the local water-bearing alluvial sediments there. The ground water of the mountainous area migrates mainly southward toward Coachella Valley, except in the vicinity of Black Rock Spring, where the movement is generally northward into the Yucca Valley area.

The discharge from springs in the vicinity of Long Canyon is very small. Some water transpires from cottonwoods and mesquite that grow in several spring areas, as well as in the vicinity of dry Black Rock Spring. Seepages from the four springs near the west boundary of the monument are collected in small reservoirs dug to provide water for wildlife.

The quality of the ground water issuing from seeps in the mountainous area probably is similar to the excellent quality of water from similar igneous rocks elsewhere in the monument. Reportedly, the quality of water formerly obtained from the county well was poor.

## Summary

Moderate to large quantities of ground water are available in alluvial deposits of Pinto Basin. Small quantities occur locally in residuum, thin alluvium, and joints in bedrock in the west and south parts of Joshua Tree Nationsl Monument. Faults are of considerable importance to the occurrence and movement of ground water in the monument by impounding water behind them.

Recharge to smaller aquifers occurs locally and recharge to the larger aquifers is greatest in the marginal parts of large valleys. Places of natural discharge from smaller aquifers are often controlled by faults and igneous dikes. The larger aquifers do not discharge at the surface within the monument, but ground water percolates through them southeastward out of the area and into nearby Chuckwalla Valley. Water-level data from eastern Pinto Basin indicate an unusually flat gradient slightly more than 1 foot per mile toward the east. A generally northward slope of the ground-water surface is indicated in a smaller aquifer in the Quail Wash area.

The largest withdrawal of ground water is by pumping at the east end of Pinto Basin for use at Kaiser Steel Corporation's Eagle Mountain mine. Water usage elsewhere is small and usually is for domestic purposes.

The chemical quality of ground water in the area investigated is generally good, except for local areas of high fluoride concentration. The high fluoride content probably is not hazardous to the general use of the water by adults and temporary visitors, however, such water should not be used as the continuous drinking water supply for children.

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GROUND WATER AND RELATED GEOLOGY OF

JOSHUA TREE NATIONAL MONUMENT, CALIFORNIA

By J. E. Weir, Jr., and J. S. Bader

PART II - TABLES OF HYDROLOGIC DATA

CONTENTS

Table 1.--Precipitation records for 1949 to 1961 at 15 stations on Joshua Tree National Monument, Calif.[1]

(Precipitation in inches)

| Station number | Approximate location[2] (Township, range, and section) | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | Station average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | South Boundary (6/11-2) | 0.69 | 1.08 | 3.67 | 4.14 | 0.29 | 1.39 | -- | -- | 2.58 | 3.39 | 4.54 | 3.12 | 1.22 | 2.37 |
| N4 | South end Cottonwood Canyon (5/11-35) | -- | -- | -- | -- | -- | 2.52 | 2.53 | -- | 3.06 | 4.09 | 5.55 | 3.34 | 1.85 | 3.28 |
| 2 | Cottonwood Junction (5/11-10) | .86 | .54 | 5.92 | 6.92 | .87 | 4.60 | 2.76 | -- | 3.73 | 5.87 | 5.06 | 4.65 | 1.78 | 3.63 |
| 3 | Old Dale Junction (4/12-18) | .65 | .21 | 3.32 | 4.22 | .51 | 3.25 | 2.20 | -- | 4.07 | 4.96 | 5.15 | 2.32 | 1.83 | 2.72 |
| 4 | Barrel Spring (3/11-35) | .69 | .31 | 3.76 | 5.37 | .46 | 2.76 | 1.7 | -- | 3.15 | 4.23 | 6.75 | 1.65 | 1.26 | 2.67 |
| 5 | Fried Liver Wash (3/10-13) | .69 | .65 | 3.53 | 3.73 | .60 | 1.16 | 4.52 | -- | 2.27 | 4.55 | 6.26 | 2.21 | 1.99 | 2.68 |
| 6 | Head of Wilson Canyon (2/9-36) | 1.13 | 2.61 | 4.31 | 6.51 | .57 | 1.75 | .96 | Records lost | 4.32 | 5.92 | 6.59 | 4.28 | 2.52 | 3.46 |
| 7 | White Tanks Wye (2/9-23) | 1.32 | 3.26 | 3.91 | 6.55 | .92 | 2.57 | 2.06 | | 3.89 | 8.97 | 5.81 | 4.01 | .93 | 3.68 |
| 8 | Pinto Wye (2/9-3) | 1.48 | 2.90 | 4.43 | 6.35 | 1.97 | 3.47 | -- | | 4.18 | 7.21 | 4.88 | 3.44 | 3.10 | 3.95 |
| 9 | John's Camp Road (2/9-9) | 2.83 | 3.05 | 4.04 | 7.46 | 2.64 | 4.17 | 3.18 | | 4.02 | 9.78 | 5.56 | 3.70 | 2.37 | 4.40 |
| 10 | Sheep Pass borrow pit (2/8-14) | 2.34 | 2.33 | 5.81 | 9.34 | 1.68 | 4.50 | 3.27 | -- | 4.44 | 9.01 | 7.91 | 4.10 | 1.98 | 4.73 |
| 11 | Cap Rock Wye (2/8-17) | 2.22 | 2.63 | 4.63 | 9.84 | 1.42 | 5.12 | -- | -- | 4.85 | 10.08 | 7.14 | 3.20 | 3.75 | 5.08 |
| 12 | Randolph Road (2/8-7) | 2.08 | 2.63 | 5.80 | 9.56 | 1.39 | 4.24 | 1.89 | -- | 4.89 | 8.36 | 6.01 | 3.61 | 4.55 | 4.58 |
| 13 | Bill Keys Junction (1/8-31) | 2.42 | 2.31 | 5.29 | 8.91 | 1.41 | 3.37 | 1.99 | -- | 4.22 | 7.05 | 6.55 | 3.30 | 3.09 | 4.16 |
| -- | Queen Valley master (2/8-12) | -- | -- | -- | [illegible] | [illegible].13 | 5.45 | 4.69 | 4.47 | 4.08 | 7.24 | 7.35 | 3.93 | 1.65 | [illegible] |

1. Gage records maintained by U.S. National Park Service in cooperation with California Institute of Technology, Pasadena, Calif.

2. The precipitation station names are local U.S. National Park Service designations and the approximate station location is shown on figures 2 and 3 by symbol only.

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.

USGS number: The number given is the location number assigned to the well by the Geological Survey according to the method described in the text section on the system of locating and numbering wells and springs.

Source of data: GS, Geological Survey; PS, Park Service; R resident, former owner, or other user.

Date of observation: The date given is the date on which the well or spring was visited, or the date on which the data were obtained.

Owner or user: The name given is that of owner or user; names of wells and springs shown on topographic maps or recognized by the National Park Service are given also.

Year completed: The year given is the one in which the well was completed as determined from drillers' logs or reports of the Park Service and other reliable sources of information.

Depth of well: Depths given in whole feet are reported or from drillers' logs; those given in feet and tenths were measured by the Geological Survey.

Type of well: C cable tool, D dug.

Pump type and power: The type of pump or method of lift is indicated as follows: B bucket, J jet, L lift, N none, T turbine. The type of power is indicated as follows: G gasoline engine, H hand operated, N none, W windmill. A number in this column indicates the rated horsepower of an electric motor.

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

Yield: The yield given was reported, or determined by test pumping of wells. D spring, dry or not flowing at time of observation or reported data collection; E springs or seeps known to flow ephemerally. F springs flowing a minor amount at date of observation.

Use: Dm domestic, Ds destroyed or dry, I industrial, U unused, W wildlife.

Measuring point: Bhc bottom of hole in casing, Bpb bottom of pump base, Hpb hole in pump base, Ls land surface, Tap top of access pipe, Tc top of casing, Tcc top of casing cover. The height of the measuring point in feet and tenths or hundredths above land-surface datum is also given.

Altitude: Altitude given is that of land-surface datum at the well; those in whole feet are interpolated from topographic maps having 40-, 50-, and 80-foot contour intervals, and those in feet and tenths were determined by spirit leveling.

Water level: The water level in wells is given in feet below land-surface datum. Na no access into casing.

Other data: L log (table 3), W water-level measurements (table 4), C chemical analysis (table 5).

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.) | Pump type and power | Yield (gpm) | Use | Measuring point | (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | T. 1 S., R. 5 E. | | | | | | | | | | | |
| 1/5-22NS | PS | 12-14-61 | "Barrel" Spring | - | - | - - | N N | F | W | - | - | 3,520 | - | - |
| 27NS | PS | 12-14-61 | - | - | - | - - | N N | F | W | - | - | 3,240 | - | - |
| | | | T. 1 S., R. 6 E. | | | | | | | | | | | |
| 1/6-23L1 | GS | 5-21-58 | Bailey well 1 | - | 6.0 | D 40 | N N | - | Ds | - | - | 4,560 | dry | - |
| 23Q1 | GS | 5-15-58 | Bailey well 2 | - | - | - - | N N | - | Ds | - | - | 4,490 | dry | - |
| 30GS | GS | 12-14-61 | Black Rock Spring | - | - | - - | N N | E | W | - | - | 4,360 | - | - |
| | | | T. 1 S., R. 7 E. | | | | | | | | | | | |
| 1/7-13BS | PS | 11-15-61 | Dove Spring | - | - | - - | N N | E | W | - | - | 4,180 | - | - |
| 27R1 | GS | 11-21-61 | Willetts well | - | - | C 5 | N N | - | U | Tc | 2.35 | 3,770 | 97.72 | - |
| | | 5- 2-58 | | | 183.5 | | | | | | | | 82.61 | - |
| 33LS | GS | 11-17-61 | Quail Spring | - | - | - - | N N | E | W | - | - | 3,800 | - | - |

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.) | Pump type and power | Yield (gpm) | Use | Measuring point | Measuring point (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | T. 1 S., R. 7 E.--Continued | | | | | | | | | | | |
| 1/7-34E1 | GS | 5- 2-58 | Cooper well | - | 100 | - - | N N | - | Ds | - | - | 3,745 | dry | - |
| 34F1 | GS | 11-21-61 | Imbrie well | - | 101.5 | C 8 | N N | - | Ds | - | - | 3,745 | dry | - |
| | | 5- 2-58 | | | 112 | | N N | | U | Tc | 1.15 | | 99.96 | |
| 35P1 | GS | 11-21-61 | Jumbo well | - | 4.5 | D 72 | N N | - | Ds | - | - | 3,940 | dry | - |
| | | | T. 1 S., R. 8 E. | | | | | | | | | | | |
| 1/8-12DS | PS | 5- 2-58 | Fortynine Palms Oasis | - | - | - - | N N | F | W | - | - | 2,800 | - | - |
| 17CS | GS | 11-20-61 | Sneakeye Spring | - | - | - - | N N | D | - | - | - | 3,500 | - | - |
| 19Z1 | GS | 11-15-61 | Lone Willow well | - | - | D - | N N | - | Ds | - | - | 4,200 | - | - |
| 21LS | PS | 5- 2-58 | Willow Hole | - | - | - - | N N | E | W | - | - | 4,000 | - | - |
| 31J1 | GS | 5- 1-58 | Whitlow well 1 | - | 200 | C 5 | N N | - | Ds | - | - | 4,065 | dry | - |
| 31J2 | GS | 5- 1-58 | Whitlow well 2 | - | 40 | D 60 | N N | - | Ds | - | - | 4,065 | dry | - |

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.) | Pump type and power | Yield (gpm) | Use | Measuring point |  (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | T. 1 S., R. 8 E.--Continued | | | | | | | | | | | |
| 1/8-32C1 | GS | 11-22-61 | W. F. Keys | 1887 | - | D 72 | L W | - | Dm | Tc | 0 | 4,140 | 27.54 | - |
| | | 5- 1-58 | | | | | | | | | | | 16.95 | |
| 32C2 | GS | 11-22-61 | W. F. Keys | 1923 | 23 | D 36 | N N | - | Ds | Tcc | 0 | 4,110 | dry | - |
| | | 5- 1-58 | | | | | | | U | | | | 17.82 | |
| 32C3 | GS | 11-22-61 | W. F. Keys | 1943 | 25 | D 72 | N N | - | Ds | Ls | 0 | 4,110 | dry | - |
| | | 5- 1-58 | | | | | | | U | | | | 23.81 | |
| 34P1 | GS | 11-22-61 | W. F. Keys | - | 33 | D 72 | B H | - | Ds | Tcc | 3.0 | 4,320 | dry | - |
| | | 5- 1-58 | | | | | | | U | | | | 22.90 | |
| 35R1 | GS | 11-22-61 | Monstad well 1 | - | 215.0 | C 12 | N N | - | Ds | Tc | 1.0 | 4,475 | dry | |
| 35R2 | GS | 11-22-61 | Monstad well 2 | - | - | C 9 | N N | - | Ds | Tc | .5 | 4,465 | dry | - |

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.) | Pump type and power | Yield (gpm) | Use | Measuring point (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | T. 1 S., R. 9 E. | | | | | | | | | | |
| 1/9- 5A1 | GS | 4-30-58 | Goodale | - | 60 | D | J 1 | - | Dm | - - | 2,063.4 | Na | C |
| 18FS | PS | 11-15-61 | Lone Palm Spring | - | - | - - | N N | E | W | - - | 4,000 | - | - |
| 32GS | GS | 11-28-61 | Pine Spring | - | - | - - | N N | E | W | - - | 4,200 | - | - |
| | | | T. 2 S., R. 5 E. | | | | | | | | | | |
| 2/5- 3DS | PS | 12-14-61 | - | - | - | - - | N N | F | W | - - | 2,920 | - | - |
| 10KS | PS | 12-14-61 | - | - | - | - - | N N | F | W | - - | 2,320 | - | - |
| | | | T. 2 S., R. 7 E. | | | | | | | | | | |
| 2/7- 5CS | PS | 11-15-61 | Deer Spring | - | - | - - | N N | D | - | - - | 3,950 | - | - |
| 6R1 | GS | 11-17-61 | Lower Covington well | - | 24.5 | D 48 | N N | - | Ds | Ls 0 | 4,410 | dry | - |
| 7BS | GS | 11-17-61 | Covington Spring | - | - | - - | N N | D | Ds | - - | 4,500 | - | - |
| 27RS | GS | 11-29-61 | Burns Spring | - | - | - - | N N | D | - | - - | 5,100 | - | - |
| 27QS | GS | 11-29-61 | Stubby Spring | - | - | - - | N N | F | W | - - | 5,000 | - | - |

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.) | Pump type and power | Yield (gpm) | Use | Measuring point | (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | T. 2 S., R. 8 E. | | | | | | | | | | | |
| 2/8- 3C1 | GS | 11-22-61 | Queen well | 1928 | 108 | D 8 | L W | - | Dm | Tc | 1.5 | 4,300 | 94.30 | - |
| 5E1 | GS | 11-22-61 | W. W. Whitlow | 1948 | 80 | C 8 | L ½ | - | Dm | - | - | 4,200 | Na | - |
| | | 5- 1-58 | | | | | | | | Tc | 0 | | 34.75 | |
| 6N1 | GS | 11-21-61 | Stokes No. 1 | - | - | C 6 | L W | 1 | Dm | Tc | 2.0 | 4,130 | a115+ | C |
| 7K1 | GS | 11-21-61 | Stokes No. 2 | - | 290 | C 8 | N N | - | U | Tc | 1.5 | 4,100 | 208.68 | - |
| 8M1 | GS | 11-21-61 | Coulliard well | - | 0 | - - | N N | - | Ds | - | - | - | - | - |
| | | 5- 1-58 | - | - | 7.7 | D 36 | L H | - | U | Ls | 0 | 4,160 | 6.0 | - |
| 12L1 | GS | 11-21-61 | - | - | 2.0 | D 60 | N N | - | Ds | - | - | 4,390 | dry | - |
| 18A1 | GS | 11-29-61 | - | - | 458.0 | C 6 | N N | - | Ds | Tc | 1.0 | 4,160 | dry | - |
| 18D1 | GS | 11-21-61 | S. T. Randolph | - | 5.0 | D 42 | N H | - | Ds | - | - | 4,235 | dry | - |
| 18L1 | GS | 11-29-61 | - | - | 4.0 | C 12 | N N | - | Ds | - | - | 4,240 | dry | - |

See footnotes at end of table.

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.) | Pump type and power | Yield (gpm) | Use | Measuring point | (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **T. 2 S., R. 8 E.--Continued** | | | | | | | | | | | |
| 2/8-21G1 | GS | 11-29-61 | Lost Horse No. 1 | - | 70.0 | D 72 | L W | - | Dm | Tc | 0.5 | 4,400 | 40.23 | - |
| | | 5- 6-58 | | | | | | | | | | | 38.71 | - |
| 21G2 | GS | 11-29-61 | Lost Horse No. 2 | - | 39.6 | D 48 | N N | 1 | U | Ls | 0 | 4,480 | 32.54 | C |
| 21G3 | GS | 5- 6-58 | Lost Horse No. 3 | - | 18.5 | D 60 | N N | - | U | Ls | 0 | 4,380 | 9.01 | - |
| | | | **T. 2 S., R. 9 E.** | | | | | | | | | | | |
| 2/9- 3Q1 | GS | 5- 1-58 | Pinto "Y" well 1 | 1950 | b9 | C - | N N | - | Ds | - | - | 3,675 | - | L |
| 11D1 | GS | 5- 1-58 | Pinto "Y" well 2 | 1950 | c0 | C - | N N | - | Ds | - | - | 3,675 | - | L |
| 17Z1 | GS | 5- 6-58 | Steele well | - | 18 | D 72 | N N | - | Ds | - | - | 4,400 | dry | - |
| | | | **T. 2 S., R. 12 E.** | | | | | | | | | | | |
| 2/12-35F1 | GS | 12-12-61 | Mission well | - | - | - - | T G | 50 | Dm | Bpb | 2.7 | 1,408.6 | 423.09 | C |
| | | 2- 8-56 | | | | | | | | | | | 447.90 | |
| 35F2 | GS | 11-17-61 | Lane well | 1920 | | C 12 | N N | - | Ds | - | - | 1,410 | dry | - |

See footnotes at end of table.

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Well and spring data: Depth (ft.) | Well and spring data: Type, diameter (in.) | Well and spring data: Pump type and power | Well and spring data: Yield (gpm) | Well and spring data: Use | Measuring point | Measuring point (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | T. 2 S., R. 12 E.--Continued | | | | | | | | | | | |
| 2/12-35G1 | GS | 11-17-61 | Sunrise well | - | 355.0 | 16 | N N | - | Ds | Tc | 0.5 | 1,410 | dry | - |
| | | 2- 8-56 | | | 554.0 | | | | U | | | | 448.65 | |
| 36F1 | GS | 11-17-61 | Dale Holmes | 1947 | 444 | - - | N N | - | U | Tc | 2.2 | d1,350 | 400.51 | - |
| | | | T. 3 S., R. 8 E. | | | | | | | | | | | |
| 3/8-24K1 | GS | 11-15-61 | Pinyon well e/ | - | 10 | D 36 | N N | - | Ds | - | - | 4,000 | - | - |
| 31C1 | GS | 11-22-61 | County well | - | 1.0 | D 48 | L N | - | Ds | - | - | 2,400 | - | - |
| | | | T. 3 S., R. 9 E. | | | | | | | | | | | |
| 3/9-14G1 | GS | 11-21-61 | Hexie well | 1914 | 150.0 | D 40 | L N | - | Ds | Tc | .8 | 3,150 | dry | - |
| 16Z1 | R | 1-18-62 | - | 1912 | - | D | N N | - | Ds | - | - | 3,200 | - | - |
| 19Z1 | R | 1-18-62 | - | 1914 | 60 | D - | N N | - | Ds | - | - | 3,900 | - | - |

See footnotes at end of table.

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.): Type | Diameter (in.) | Pump type and power: Type | Power | Yield (gpm) | Use | Measuring point | Measuring point (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | T. 3 S., R. 11 E. | | | | | | | | | | | | | |
| 3/11- 7Z1 | R | 1-18-62 | - | 1915 | 100 | D | - | N | N | - | Ds | - | - | 1,760 | - | - |
| 11Z1 | R | 1-18-62 | - | 1913 | 70 | D | - | N | N | - | Ds | - | - | 1,625 | - | - |
| 34JS | PS | 11-14-61 | Barrel Spring | - | - | - | - | N | N | D | - | - | - | 2,300 | - | - |
| | | | T. 3 S., R. 14 E. | | | | | | | | | | | | | |
| 3/14- 6X1 | GS | 11-30-61 | Black Eagle well | - | 282 | C | 12 | N | N | - | U | Tc | 0 | 1,220 | 274.05 | - |
| | | | T. 3 S., R. 15 E. | | | | | | | | | | | | | |
| 3/15- 4J1 | GS | 11-16-61 | Kaiser No. 2 (NPS) | 1954 | f575 | C | 16 | N | N | - | U | Bhc | 0 | 1,080.6 | 154.94 | C,L,W |
| 4K1 | GS | 1- 9-61 | Kaiser No. 1 (old) | 1933 | g547 | C | 16 | T | 75 | - | I | Hpb | 2.8 | 1,048.1 | h120.11 | C,L,W |
| 4K2 | GS | 1- 9-61 | Kaiser No. 3 (new) | 1957 | 675 | - | 20 | T | 75 | - | I | Tap | 1.13 | 1,059.4 | h130.59 | C[1/],L,W |
| | | | T. 4 S., R. 11 E. | | | | | | | | | | | | | |
| 4/11- 3D1 | GS | 11-15-61 | Pinkham well | 1915 | 25 | D | - | N | N | - | Ds | - | - | 2,700 | dry | |
| 3DS | GS | 11-15-61 | Pinkham Spring | - | - | - | - | N | N | D | - | - | - | 2,800 | - | - |

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.) | Pump type and power | Yield (gpm) | Use | Measuring point | Measuring point (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **T. 4 S., R. 11 E.--Continued** | | | | | | | | | | | |
| 4/11-10E1 | GS<br>PS | 11-15-61<br>1956 | Ruby Lee well | - | 12.5 | D 48 | B H | - | Dm | Tc | 0 | 2,925 | 12.4<br>11.5 | - |
| 27Q1 | PS<br>GS | 1944<br>10-26-61 | Cottonwood well | 1958 | 403 | C 12 | N N | 45 | U | Tap | 1.0 | 2,975 | 10<br>170.48 | C, L, W |
| | | | **T. 5 S., R. 11 E.** | | | | | | | | | | | |
| 5/11-14CS | GS | 12- 1-61 | Cotton Spring | - | 10.0 | D 180 | N N | F | Dm | - | - | 3,050 | - | - |
| 14LS | GS | 10- 9-61 | Cottonwood Spring | - | - | - - | N N | F | Dm | - | - | 2,950 | - | C |
| 14PS | GS | 11-14-61 | Wood Spring | - | - | - - | N N | F | W | - | - | 2,890 | - | - |
| | | | **T. 5 S., R. 12 E.** | | | | | | | | | | | |
| 5/12- 9AS | GS | 11-15-61 | Conejo Spring | - | - | - - | N N | D | - | - | - | 3,850 | - | - |
| 20NS | GS | 11-15-61 | Lost Palms Springs | - | - | - - | N N | F | Dm | - | - | 3,300 | - | - |
| 28ES | GS | 11-28-61 | - | - | - | - - | N N | F | Dm | - | - | 2,850 | - | C[3] |
| 29DS | GS | 11-28-61 | - | - | - | - - | N N | F | Dm | - | - | 3,115 | - | - |

See footnotes at end of table.

Table 2.--Data on water wells and springs in Joshua Tree National Monument, Calif.--Continued

| USGS number | Source of data | Date of observation | Owner or user or local name | Well and spring data: Year completed | Depth (ft.) | Type, diameter (in.) | Pump type and power | Yield (gpm) | Use | Measuring point (feet) | Altitude of lsd (feet) | Water level: Depth below lsd (feet) | Other data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | T. 5 S., R. 12 E.--Continued | | | | | | | | | | |
| 5/12-29FS | GS | 11-28-61 | - | - | - | - - | N N | F | Dm | - - | 3,040 | - | - |
| 29JS | GS | 11-28-61 | Victory Palms Oasis | - | - | - - | N N | F | Dm | - - | 2,700 | - | C |

a. Tape smeared.

b. Drilled to 209 ft., backfilled and leveled.

c. Drilled to 51 ft., backfilled and leveled.

d. Determined by triangulation from bench mark near Mission Well.

e. Reportedly five wells at this site.

f. Depth of 575 ft from records of driller. Geological Survey on February 13, 1956, measured depth at 445 ft.

g. Depth of 547 ft from records of Metropolitan Water District. Geological Survey on July 18, 1956 measured depth at 482 ft.

h. Well pumped recently.

i. Composite samples of wells 4K1 and 4K2.

j. Composite sample of springs 28ES, 29FS, and 29JS.

Table 3.--Drillers' logs of wells

Lithologic units are by the driller; geologic groupings are by the Geological Survey and are generalized approximations based on field relationships.

2S/9E-3Q1. National Park Service. Drilled by C. H. Suffdy in 1950. Altitude about 3,675 ft. Log from files of Park Service.

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Older alluvium | | |
| Sand, coarse; gravel fill | 20 | 20 |
| Sand; gravel; clay content | 75 | 95 |
| Basement complex (residuum) | | |
| Granite, with some quartz content | 55 | 150 |
| Quartz, with some decomposed granite | 10 | 160 |
| Basement complex (igneous intrusive rocks) | | |
| Granite, gray | 30 | 190 |
| Granite and quartz, faulted | 2 | 192 |
| Granite, gray, very tight, no water | 17 | 209 |

2S/9E-11D1. National Park Service. Drilled by C. H. Suffdy in 1950. Altitude about 3,675 ft. Log from files of Park Service

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Older alluvium | | |
| Fill and coarse gravel | 20 | 20 |
| Sand; gravel; clay content | 20 | 40 |
| Basement complex (undifferentiated) | | |
| Schist, green | 5 | 45 |
| Granite, light-gray, very hard; no water | 6 | 51 |

3S/15E-4J1, Kaiser well 2. National Park Service. Well drilled for Kaiser Steel Corp. by the Freelove Drilling Co., Phoenix, Arizona in 1954. Cased with 532 feet of 16-inch stovepipe casing and 53 feet of 14-inch liner. Perforated from 250 to 520 feet, 8 holes to the round 1-inch apart. Altitude 1,080.6 feet. Log and test-pumping data from files of Kaiser Steel Corp.

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Older alluvium | | |
| Boulders and sand | 18 | 18 |
| Sand and gravel | 36 | 54 |
| Conglomerate | 46 | 100 |
| Sand | 30 | 130 |
| Sandy clay | 20 | 150 |
| Sand and gravel | 35 | 185 |
| Pinto Formation of Scharf | | |
| Sand with streaks of clay | 155 | 340 |
| Basement complex? (residuum) | | |
| "Decomposed granite" | 140 | 480 |
| Sand, gravelly clay with hard ribs of granite | 95 | 575 |

SUMMARY OF TEST PUMPING

| Date | Time | Pumping rate (gpm) | Depth to water[1/] (feet) | Specific capacity (gpm/ft dd)[2/] |
|---|---|---|---|---|
| Dec. 4, 1954 | 6:50 p.m. | 0 | 150 | -- |
| | 11:50 | 870 | 170 | 43 |
| 5 | 8:50 a.m. | 1,075 | 174 | 46 |
| | 1:50 p.m. | 1,480 | 183 | 45 |

Table 3.--Drillers' logs of wells--Continued

3S/15E-4K1, Kaiser Steel Corp., Kaiser well 1. Drilled for the Metropolitan Water District by R. E. McSwain and J. F. Barkwill in 1933. Cased with 16-inch, 8-gage, stovepipe casing. Perforated from 390 to 532 ft; 6 holes to the round, 3/8-inch by $1\frac{1}{4}$-inch, 8 inches apart. Altitude 1,048.1 feet. Log and test-pumping data from records of the Metropolitan Water District, except as indicated.

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Younger alluvium | | |
| Sand and gravel | 132 | 132 |
| Older alluvium | | |
| Cemented rock | 8 | 140 |
| Fine sand and silt | 44 | 184 |
| Gravel | 42 | 226 |
| Pinto Formation of Scharf | | |
| Cemented rock | 8 | 234 |
| Sand and gravel | 40 | 274 |
| Clay and gravel | 18 | 292 |
| Brown clay | 54 | 346 |
| "Shot" clay | 16 | 362 |
| Clay and gravel | 30 | 392 |
| Gravel | 34 | 426 |
| Hard clay | 4 | 430 |
| Gravel | 114 | 544 |
| Clay | 3 | 547 |

3S/15E-4K1--Continued

SUMMARY OF TEST PUMPING

| Date | Time | Pumping rate (gpm) | Depth to water (feet) | Specific capacity (gpm/ft dd)[2/] |
|---|---|---|---|---|
| May 26, 1933 | -- | 0 | 97 | -- |
| | -- | 410 | 114 | 24 |
| Feb. 11, 1956 | 12:30 p.m. | a330 | b118.64 | 18 |
| 13 | 6:55 a.m. | 0 | 100.28 | |

Table 3.--Drillers' logs of wells--Continued

3S/15E-4K2, Kaiser Steel Corp., Kaiser well 3. Cable-tool well drilled by Ray Roberts Drilling Co. in April-May 1957. 20-inch casing, perforated with Mills perforator from 449 to 658 ft. Altitude 1,059.4 ft. Log by James Cahill, driller.

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Younger alluvium | | |
| Coarse sand and pea gravel | 47 | 47 |
| Gravel | 8 | 55 |
| Older alluvium | | |
| Clay, brown | 60 | 115 |
| Sand, fine | 28 | 143 |
| Sand and some gravel | 48 | 191 |
| Sand, fine | 53 | 244 |
| Pinto Formation of Scharf | | |
| "Pack" sand | 6 | 250 |
| "Caliche" | 22 | 272 |
| "Sand clay" | 78 | 350 |
| "Caliche" | 41 | 391 |
| Clay, hard brown | 58 | 449 |
| Clay, gravelly | 72 | 521 |
| Sand and gravel | 6 | 527 |
| Clay | 4 | 531 |
| Sand and pea gravel | 15 | 546 |

Table 3.--Drillers' logs of wells--Continued

3S/15E-4K2--Continued

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Pinto Formation of Scherf--Continued | | |
| Clay, gravelly | 45 | 591 |
| Sand and gravel | 19 | 610 |
| Clay, sandy | 6 | 616 |
| Sand, gravel and layers of clay | 42 | 658 |
| Clay | 15 | 673 |
| Sand, cemented | 2 | 675 |

SUMMARY OF TEST PUMPING
(Date collected by U.S. Geological Survey)

| Date | Time | Pumping rate (gpm) | Depth to water[1] (feet) | Drawdown (feet) | Specific capacity[2] |
|---|---|---|---|---|---|
| June 20, 1957 | 6:00 a.m. | -- | 126 | -- | -- |
| | 6:05 | 1,209 | 156 | 30 | 40 |
| | 6:20 | 1,209 | 176 | 50 | 24 |
| | 7:00 | 1,209 | 179 | 53 | 23 |
| | 8:00 | 1,209 | 182 | 56 | 22 |
| | 9:00 | 1,209 | 184 | 58 | 21 |
| | 10:00 | 1,209 | 184 | 58 | 21 |
| | 11:00 | 1,209 | 184 | 58 | 21 |
| | 12:00 | 1,200 | 184 | 58 | 21 |
| | 1:00 p.m. | 1,200 | 190 | 64 | 19 |
| | 2:00 | 1,200 | 190 | 64 | 19 |

Table 3.--Drillers' log of wells--Continued

4S/11E-27Q1, National Park Service, Cottonwood Pass well. Cable-tool well drilled by C. H. Suffdy in 1958. 12-3/4-inch casing from zero to 232 ft, perforated with Mills perforator from 212 to 228 ft; 10-3/4-inch casing preperforated from 208.75 to 402.75 ft. Altitude about 2,975 ft. Log and test-pumping data by driller, except as indicated.

| | Thickness (feet) | Depth (feet) |
|---|---|---|
| Younger alluvium | | |
| Sand, gravel | 60 | 60 |
| Older alluvium | | |
| Boulders, clay content | 55 | 115 |
| Sand, clay content | 20 | 135 |
| Clay, boulders | 43 | 178 |
| Clay, pure | 5 | 183 |
| Boulders, clay, very rough, water showed | 32 | 215 |
| Basement complex? (residuum) | | |
| Boulders, clay | 16 | 231 |
| Gravel, boulders, clay | 54 | 285 |
| Soft, probably more water | 20 | 305 |
| Clay, some gravel | 98 | 403 |

Table 3.--Drillers' log of wells--Continued

4S/11E-27Q1--Continued

SUMMARY OF TEST PUMPING

| Date | Time | Pumping rate (gpm) | Depth to water (feet) | Drawdown (feet) | Specific capacity[2] |
|---|---|---|---|---|---|
| Nov. 21, 1958 | 8:00 a.m. | -- | 170.6 | -- | -- |
| | 2:30 p.m. | 40 | -- | -- | -- |
| Dec. 1 | -- | -- | 170.6 | -- | -- |
| | -- | 45 | 256 | 85 | 0.5 |

a. Rate determined from metered discharge.

b. Well being pumped at least 6 hours.

1. Depth-to-water measurements are by airline from an unspecific measuring point. The measurements are comparable with each other but are not comparable with measurements made from the specified measuring point described in table 2.

2. Specific capacity is the yield of the well in gallons per minute per foot of drawdown of the water level below the static or nonpumping level for indicated duration of pumping.

Table 4.--Water levels in wells

(Water levels are in feet below land-surface datum: altitude also is with reference to land-surface datum)

3S/15E-4J1, Kaiser well 2. National Park Service. Altitude 1,080.6 ft. Records after Dec. 4, 1954, by Geological Survey.

| Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|
| Dec. 4, 1954 | f150 | Sept.19, 1956 | 155.7 | June 11, 1959 | 155.8 |
| 4 | ef183 | May 18, 1957 | 155.21 | Sept. 8 | 155.71 |
| June 2, 1955 | 154.94 | May 19 | 155.65 | Dec. 10 | 155.74 |
| Sept.22 | 155.2 | June 26 | h155.48 | Mar. 1, 1960 | 155.6 |
| Dec. 22 | 155.6 | Aug. 21 | g155.49 | June 12 | 156.0 |
| Feb. 9, 1956 | 155.2 | Sept.18 | g155.37 | | 155.90 |
| Feb. 11 | 155.1 | Nov. 30 | 155.0 | Oct. 13 | 155.93 |
| 12 | 155.0 | Mar. 2, 1958 | 155.1 | Jan. 1, 1961 | 156.14 |
| Mar. 23 | 155.0 | May 30 | 155.4 | Mar. 28 | 156.81 |
| May 27 | 154.88 | Sept.15 | 155.6 | Nov. 9 | 157.49 |
| July 27 | g155.3 | Jan. 7, 1959 | 155.7 | Nov. 16 | 157.77 |
| Aug. 18 | 155.3 | Mar. 12 | 155.6 | Nov. 1, 1962 | 158.79 |

3S/15E-4K1, Kaiser well 1. Kaiser Steel Corp. Altitude 1,048.1 ft. Records through June 2, 1955, by Kaiser Steel Corp., except as indicated; thereafter by the Geological Survey.

| | | | | | |
|---|---|---|---|---|---|
| May 26, 1933 | a97 | June 29, 1950 | c98.1 | May 2, 1951 | 98.1 |
| Sept.27, 1949 | b98.5 | Aug. 1 | c98.0 | June 1 | 98.2 |
| Oct. 27 | b98.8 | 31 | c98.3 | 20 | c98.5 |
| Nov. 28 | b98.1 | Oct. 7 | 98.0 | Aug. 3 | c98.3 |
| Dec. 28 | c97.5 | Nov. 3 | b98.1 | Sept. 4 | b98.3 |
| Jan. 31, 1950 | c97.5 | Nov. 30 | c97.2 | Oct. 1 | b98.3 |
| Feb. 28 | c97.6 | Dec. 31 | c98.2 | Nov. 2 | b98.4 |
| Mar. 31 | c97.8 | Feb. 1, 1951 | c98.2 | 30 | b98.2 |
| Apr. 2 | b97.6 | Mar. 2 | c98.0 | Jan. 2, 1952 | b98.0 |
| June 2 | c98.5 | 31 | 98.1 | Feb. 1 | b98.1 |

Table 4.--Water levels in wells--Continued

3S/15E-4K1--Continued

| Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|
| Mar. 2, 1952 | b97.8 | Mar. 1, 1954 | 98.8 | Mar. 24, 1956 | b102.05 |
| Apr. 1 | d98.8 | Apr. 5 | 99.1 | May 27 | b100.93 |
| May 1 | d98.0 | May 5 | 100.7 | 28 | b100.19 |
| June 2 | b98.3 | June 2 | 101.2 | Aug. 18 | b102.65 |
| July 1 | d99.3 | July 2 | 100.6 | May 18, 1957 | e232.3 |
| Aug. 1 | d99.2 | Aug. 2 | 100.8 | 19 | d115.5 |
| Sept. 2 | d98.7 | Sept. 2 | b101.2 | 19 | e231.9 |
| Oct. 1 | d99.7 | Oct. 2 | d99.8 | Nov. 30 | b102.8 |
| Nov. 1 | b98.7 | Mar. 2, 1955 | b100.0 | Mar. 2, 1958 | c103.18 |
| Dec. 1 | d99.2 | Apr. 4 | b100.1 | May 31 | b107.77 |
| Jan. 3, 1953 | b98.3 | May 4 | b100.0 | Sept. 15 | b108.08 |
| Feb. 1 | b98.8 | June 2 | d100.4 | Jan. 7, 1959 | b110.88 |
| Mar. 3 | d98.8 | 22 | e110.33 | Mar. 12 | b110.78 |
| Apr. 1 | d98.6 | 22 | d102.61 | June 11 | b116.85 |
| May 3 | b99.4 | Sept. 22 | d102.09 | Sept. 8 | d121.89 |
| June 1 | b98.4 | 22 | b101.57 | Dec. 10 | d117.67 |
| July 1 | b98.9 | Dec. 22 | d100.28 | Mar. 1, 1960 | 112.56 |
| Aug. 1 | c99.0 | 22 | b100.14 | June 11 | 121.14 |
| Sept. 1 | d98.9 | Feb. 11, 1957 | e117.64 | 12 | 116.57 |
| Oct. 4 | c98.5 | 11 | d101.19 | Oct. 13 | 117.14 |
| Nov. 1 | b98.4 | 11 | b100.17 | 13 | 116.67 |
| Dec. 1 | d98.8 | 13 | c99.28 | Jan. 9, 1961 | 120.11 |
| Feb. 1, 1954 | d98.4 | Mar. 23 | e118.35 | | |

3S/15E-4K2, Kaiser well 3. Kaiser Steel Corp. Altitude 1,059.4 ft.

| | | | | | |
|---|---|---|---|---|---|
| Nov. 30, 1957 | c114.22 | Mar. 12, 1959 | b121.58 | June 11, 1960 | 130.9 |
| Mar. 2, 1958 | b114.27 | June 11 | b127.42 | 12 | 125.77 |
| May 13 | b118.64 | Sept. 8 | d126.10 | Oct. 13 | 127.45 |
| Sept. 15 | b118.89 | Dec. 10 | d127.87 | Jan. 9, 1961 | 130.59 |
| Jan. 7, 1959 | b121.89 | Mar. 1, 1960 | 123.63 | | |

Table 4.--Water levels in wells--Continued

4S/11E-27Q1, Cottonwood well. National Park Service. Altitude about 2,970 ft. Measurements by Geological Survey except as indicated.

| Date | Water level | Date | Water level | Date | Water level |
|---|---|---|---|---|---|
| Nov. 21, 1958 | j170.6 | June 6, 1959 | 170.30 | Mar. 17, 1961 | 170.39 |
| Dec. 1 | j170.6 | Dec. 10 | 170.32 | Apr. 7 | 170.40 |
| Jan. 7, 1959 | 170.48 | Mar. 1, 1960 | 170.30 | Oct. 26 | 170.43 |
| Mar. 12 | 170.29 | Oct. 13 | 170.36 | | |

a. From records of the Metropolitan Water District.

b. Pump off 1 hour or more.

c. Pump off 10 hours or more.

d. Pump off less than 1 hour.

e. Pumping.

f. Measurement by Freelove Drilling Co., record from Kaiser Steel Corp.

g. Measurement from Kaiser Steel Corp.

h. Measurement from recorder chart.

j. Measurement by driller.

63-137

Table 5.--Chemical analyses of water

The calculated values of dissolved solids were computed from the sum of determined constituents by the Ground Water Branch, U.S. Geological Survey.

Values for sodium and iron preceded by the letter a indicate a combination of sodium and potassium and iron and manganese.

Analyzing laboratory: DPH California Department of Public Health, DWR California Department of Water Resources, EB Edward S. Babcock and Sons,

GS U.S. Geological Survey, U Laboratory unknown

| Well number | Date of collection | Depth of well (feet) | Temperature (°F) | Silica ($SiO_2$) | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Bicarbonate ($HCO_3$) | Carbonate ($CO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Nitrate ($NO_3$) | Boron (B) | Dissolved solids: Calculated (Sum of determined constituents) | Dissolved solids: Residue at 180°C | Hardness as $CaCO_3$ | Noncarbonate hardness as $CaCO_3$ | Percent sodium | Specific conductance (micromhos at 25°C) | pH | Laboratory and laboratory number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Results in parts per million | | | | | | | | | | | | | | | | | | | | |
| 1S/9E- 5A1 | 1937 | 60 | - | - | 0.6 | 26 | 3 | a17 | - | 98 | 0 | 13 | 14 | 1.1 | - | - | 123 | - | 78 | - | 32 | - | 7.3 | DPH |
| 2S/8E- 6N1 | 7-23-61 | - | - | - | a.03 | 23 | 4.4 | 13 | 0.8 | 78 | - | 7.4 | 7.9 | .1 | 1.2 | - | 96 | 145 | 76 | - | - | - | 7.0 | DWR |
| 2S/8E-21G2 | - | 39.6 | - | - | 1.3 | 80 | 17 | 40 | 6 | 299 | 0 | 45 | 64 | .8 | 0 | 0 | 401 | - | 271 | - | 24 | 687 | 7.9 | EB |
| 2S/12E-35F1 | 2-23-62 | - | 78 | 30 | .12 | 30 | 6.6 | 168 | 5.7 | 94 | 0 | 241 | 89 | 6.0 | 1.0 | .5 | 624 | 663 | 102 | 25 | 77 | 1,030 | 7.6 | GS 89429 |
| 3S/15E-4J1 | 12-16-54 | 575.0 | - | 20 | 0 | 14 | .7 | a199 | - | 77 | 8 | 245 | 97 | - | - | - | 622 | 571 | - | - | - | - | 8.1 | U |
| 3S/15E-4K1 | 2-11-56 | 482.2 | 84 | - | - | 10 | .7 | 208 | 3.2 | 118 | 0 | - | 102 | 2.0 | 18 | .44 | 402 | - | 28 | - | 93 | 1,010 | 8.2 | GS 10362 |
| 3S/15E-4K[b] | 11-30-57 | - | 79 | 12 | - | 11 | 2 | 200 | 3.5 | 102 | 0 | 216 | 104 | 2.5 | 22 | .38 | 623 | 585 | - | - | - | 1,020 | 7.7 | DWR 8047 |
| | 8- 2-61 | - | - | 17 | - | 10 | 1 | 191 | 3.1 | 107 | 0 | 198 | 98 | 2.1 | 27 | .27 | 600 | 565 | 28 | - | 93 | .906 | 8.0 | DWR R40 |
| 4S/11E-27Q1 | 12- 4-58 | 403 | 70 | 24 | - | 36 | 8 | 41 | 1.9 | 142 | 0 | 23 | 44 | 2.7 | 4 | .20 | 255 | 314 | 123 | - | 42 | 473 | 7.0 | DWR 708 |
| 5S/11E-14LS | 7-24-52 | - | - | - | - | 69 | 15 | a64 | - | 293 | - | 33 | 60 | - | 3.0 | .23 | 388 | 435 | - | - | 38 | 780 | 7.8 | DWR 2309 |
| | 4- 6-55 | - | - | - | a0 | 66 | 12 | 59 | 2.7 | 256 | 0 | 43 | 58 | 3.4 | 1.3 | - | 372 | 500 | 217 | - | - | - | 7.9 | DPH |
| | 2- 3-59 | - | - | 40 | - | 41 | 13 | 55 | 6 | 216 | - | 13 | 62 | .9 | 3 | 0 | 340 | 398 | 156 | - | 42 | 551 | 7.8 | DWR 742 |
| | 7-23-61 | - | - | - | a0 | 65 | 13 | 61 | 3.0 | 206 | 0 | 41 | 58 | 2.8 | .3 | - | 345 | 403 | 214 | - | - | - | 7.9 | DWR 8685 |
| 5S/12E-29JS | 5-21-61 | - | 72 | 31 | - | 78 | 13 | 52 | 1.2 | 217 | 0 | 50 | 85 | 4.0 | 5.6 | .12 | 427 | 423 | 248 | 70 | 31 | 773 | 7.9 | DWR R39 |
| 5S/12E-28,29[a] | 1- 5-61 | - | - | - | a.15 | 72 | 11 | 58 | .6 | 215 | 0 | 45 | 53 | 4.0 | 14 | - | 350 | 390 | 225 | - | - | - | 8.3 | DPH |

b. Composite sample of wells 4K1 and 4K2.

a. Composite sample of springs 5/12-28ES, 5/12-29FS, and 5/12-29JS.