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TECHNICAL REPORT 18

New Mexico State Engineer
Santa Fe, N. Mex.

AVAILABILITY OF GROUND WATER AT PROPOSED WELL SITES IN GILA NATIONAL FOREST, SIERRA AND CATRON COUNTIES, NEW MEXICO

By

F. D. Trauger

Prepared in cooperation with
the United States Geological Survey
and
the United States Forest Service

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U. S. Geological Survey

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AVAILABILITY OF GROUND WATER AT PROPOSED WELL SITES IN GILA NATIONAL FOREST, SIERRA AND CATRON COUNTIES, NEW MEXICO

By

F. D. Trauger

ABSTRACT

One proposed well site in Catron County and four sites in Sierra County were examined. The proposed sites are in high mountainous country. The geology is complex; faulted and folded marine sedimentary rocks of Paleozoic age and volcanic rocks of Tertiary age occur in the vicinity of Lake Valley in Sierra County; volcanic, lacustrine, and fluviatile rocks, mostly of Tertiary age, occur in Catron County.

Ground water in quantities sufficient to supply stock wells and camp facilities can be developed where needed. In general, wells should be drilled more than 500 feet deep, and water levels in the wells probably will be deep. Water in some of the areas may be under artesian pressure.

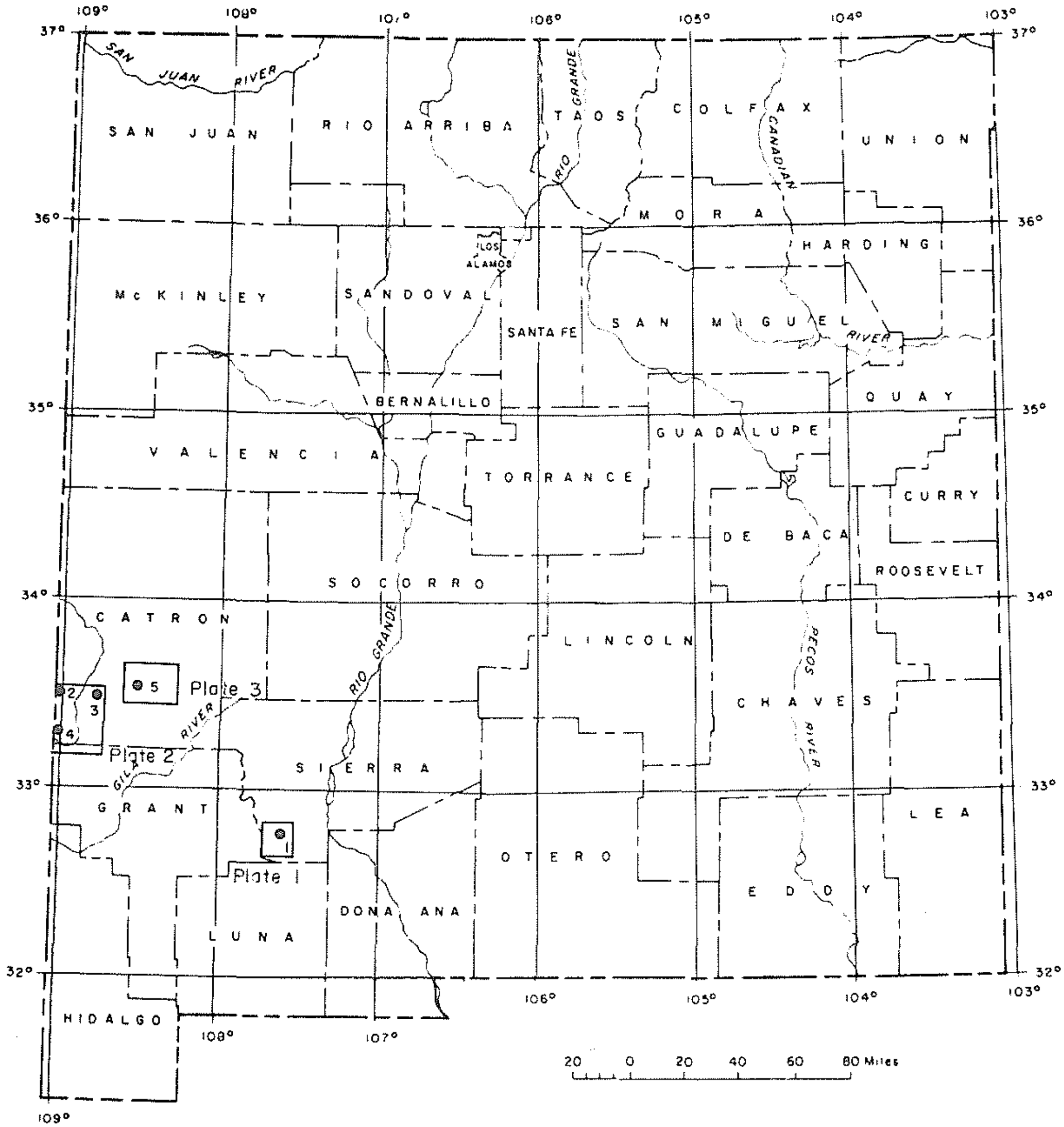
The chemical quality of the ground water in all areas is such that the water probably is suitable for livestock and human use.

INTRODUCTION

As part of its program to develop supplies of potable water on range lands and at recreational facilities in the Gila National Forest, the U. S. Forest Service requested that the U. S. Geological Survey make a study of proposed sites for wells (fig. 1).

The purpose of the investigation was 1) to determine if the required quantities of potable ground water could be developed at or near the proposed sites, 2) to determine the approximate depth to which wells would need to be drilled, and 3) to ascertain the type of rock to be penetrated at each site.

Four sites were designated in the original request for the investigation; these were on the Mackey allotment in Sierra County, the Alma and Pleasanton allotments in Catron County, and near the Negrito Airstrip in Catron County. A fifth site, on the Cedar Brakes allotment in Catron County, was included in the investigation at the suggestion of the District Ranger. The proposed sites are listed in table 1 and pinpointed on plates 1, 2, and 3. Alternate sites are listed for two of the proposed well locations.



Proposed well site

1. Mackey allotment
2. Alma allotment
3. Cedar Brakes allotment
4. Pleasanton allotment
5. Negrito airstrip

Plate 3

Box and plate number refer to detailed illustrations elsewhere in this volume.

Figure 1. -- Map of New Mexico showing the location of proposed well sites.

Table 1. -- Location of proposed well sites and alternate sites.

County and allotment or area	Number on fig. 1	Proposed and alternate locations by township, range, and section*	Proposed location by USGS number	Amount of water needed (gpm)
Sierra:		(See pl. 1.)		
Mackey	1	1. NE¼NE¼NW¼ sec. 27, T. 17 S., R. 8 W.	17.8.27.122	3
		2. SE¼NW¼NE¼ sec. 27	27.214	
		3. NE¼SE¼NE¼ sec. 27	27.242	
Catron:		(See pl. 2.)		
Alma	2	1. NE¼SW¼NW¼ sec. 9, T. 10 S., R. 21 W.	10.21.9.131	3
		2. SW¼SE¼NE¼ sec. 5	5.243	
		3. SE¼NW¼SE¼ sec. 5	5.414	
		4. NE¼SW¼SW¼ sec. 10	10.332	
Catron: Cedar Brakes	3	SE¼SW¼NE¼ sec. 24, T. 10 S., R. 20 W.	10.20.24.234	3
Catron: Pleasanton	4	NW¼SW¼NW¼ sec. 11, T. 12 S., R. 21 W.	12.21.11.131	3
Catron:		(See pl. 3.)		
Negrito Airstrip	5	NW¼SW¼NW¼ sec. 18, T. 9 S., R. 16 W.	9.16.18.131	2½

* Where more than one site number is listed the first is for the location proposed by the Forest Service; others are for alternate sites considered.

A reconnaissance was made of the geology and the existing wells in the general vicinity of each site. Some of the data on the area in the vicinity of the Negrito Airstrip (sec. 13, T. 9 S., R. 17 W.) and Collins Park (sec. 2, T. 8 S., R. 16 W.) were supplied by the State Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology.

In addition to the geologic maps and reports referred to in the text, the following topographic quadrangle maps published by the Geological Survey were used in this investigation: Hillsboro, scale 1:62,500; Morenci, scale 1:125,000; Mogollon, scale 1:125,000; Reserve, scale 1:125,000; Pelona, scale 1:125,000; and Alum Mountain, scale 1:125,000.

Personnel of the U. S. Forest Service were helpful in guiding the author in the field and assisting with the well inventory. The help of District Rangers Roy Gandy and Walt Lockhart, Assistant Rangers Ed Johnson and Fred James, and Messrs. M. L. Nordgren, Sam Burns, and Ken Hollimon was much appreciated.

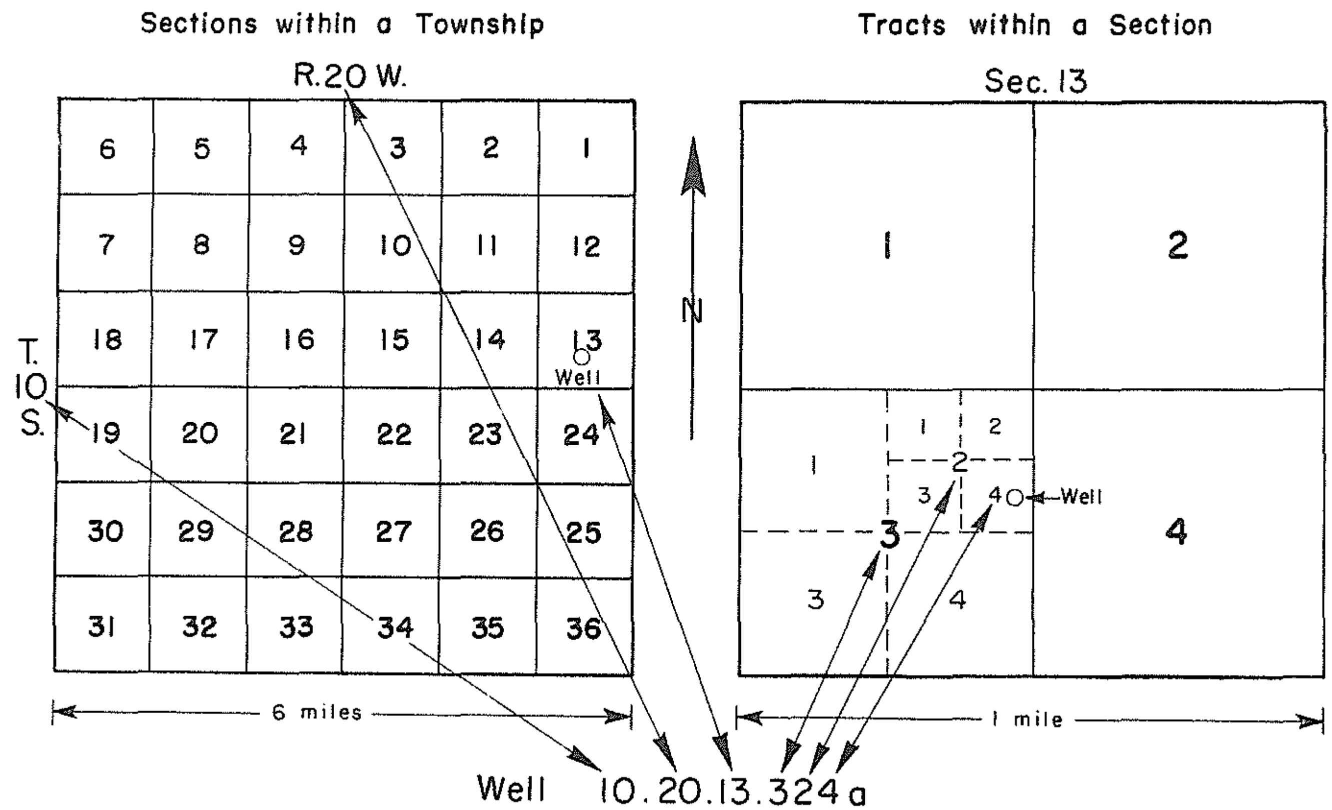


FIGURE 2. -- System of numbering wells in New Mexico.

The wells investigated for this report are listed in table 2, and their locations are shown on plates 1, 2, and 3. The wells are numbered with reference to township, range, section, and parts of sections in the Federal system of subdivision of the public lands (fig. 2). The first two parts of the well number, separated by decimal points, indicate the township south and range west of the New Mexico base line and meridian respectively; the third part of the well number is the section number. For convenience, the quarter sections are numbered 1, 2, 3, and 4, as indicated in figure 2. The first digit of the last part of the well number gives the quarter section, the second digit gives the quarter of that quarter, and the third digit designates the 10 -acre tract. Letters a, b, c, etc., are added to the last part of the well number to designate the second, third, fourth, and succeeding wells listed in the same 10-acre tract. Thus well 10.20.13.324a is in the SE$\frac{1}{4}$NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 13, T. 10 S., R. 20 W., and is the second well listed in that tract.

GENERAL GEOLOGY AND HYDROLOGY

The proposed well sites (table 1) are in high mountainous country. The geology is complex; faulted and folded marine sedimentary rocks and volcanic rocks crop out in the vicinity of Lake Valley in Sierra County; volcanic, lacustrine, and fluviatile deposits crop out in most of Catron County.

An undated geologic map of the Hillsboro Peak quadrangle, compiled by F. J. Kuellmer at scale 1:125,000, includes the Mackey allotment in Sierra County. A geologic report by H. L. Jicha (1954) of the Lake Valley quadrangle describes the geology of the area immediately south of the Mackey allotment. No geologic reports describe the geology of the four sites in Catron County; however, a geologic report by H. G. Ferguson (1927) describes the geology of the Mogollon mining district, and some of the rock formations discussed in that report occur in the vicinity of the proposed sites.

Physical character and internal structure to a large degree determine the water-bearing characteristics of a particular rock. In general, permeable unconsolidated rocks are productive aquifers and dense rocks such as limestone, marble, basalt, and porphyry are unproductive. Shale and clay have a relatively high porosity and frequently contain much water but will not yield it easily because of the great strength of the capillary bond between the water and the minute particles making up the rock. However, shale may contain interbedded stringers of sandstone that will yield small supplies of water. Fractures and joints occur in many dense rocks and may contain enough water to supply domestic and stock wells. Solution cavities in limestone, marble, and dolomite, and flow breccias and tubes in lava flows may yield large quantities of water. Intrusive igneous rocks, because of their great density and general lack of open joints and fractures, rarely contain enough water to permit development of even a small supply of water.

The regional structure of rocks also affects the occurrence of ground water. Where dipping permeable beds are overlain by relatively impermeable beds, the water may be under artesian pressure. The fracture zones along faults may serve as storage reservoirs or even as conduits for water; however, the fault planes themselves may act as barriers, or dams, where the direction of movement of the water is not parallel, or nearly parallel, to the trend of the fault.

Regional topography also exerts a great influence on the occurrence of ground water. In general the main water table is near the ground surface in lowland areas and adjacent to major streams. It may also be near the surface in broad upland areas of low relief. However, where uplands are deeply dissected the main water table is usually far below the surface -- commonly below the altitude of the floors of canyons draining the area.

Ground water moving downward toward the main water table may be stopped by local, relatively impermeable strata of rock; such water is said to be perched. Any number of perched bodies of water may occur above the main water table. If a body is large, it may furnish an adequate and permanent supply of water to domestic and stock wells. Commonly, perched bodies of water are small, and in a relatively short time they will be drained if pumping exceeds the recharge. Evidence of perched bodies of water is found in the occurrence of springs issuing from the sides of hills above the regional water table.

Table 2. -- Records of selected wells in Catron and Sierra Counties, N. Mex.
(Explanation at end of table.)

Location number	Owner or name	Driller	Year completed	Depth of well, bls (feet)	Diameter of well (inches)	Altitude above msl (feet)	Water level: Depth bls (feet)	Water level: Date	Principal water-bearing bed: Character of material	Principal water-bearing bed: Stratigraphic unit	Method of lift; power	Use of water	Remarks
CATRON COUNTY:													
8.15.34.113	O Bar O Ranch	-	-	925	-	7,684	625	1958	-	-	-	D,S	Reported to be good; not visited.
8.16. 2.441*	U.S. Forest Service	-	-	625	6	7,490	605	7-31-59	-	Tv	P-g	D,S	Collins Park well; pumping about 3 gpm at time of visit; T 72° F.; reported to be good.
9.16.10.323	do.	-	1958	925	8	8,125	Dry	7-31-59	-	-	N	N	Reportedly found no water; hole open to at least 896 feet at time of visit; drilled in volcanic rocks.
18.223	do.	-	1955	105.0	6	7,880	Dry	7-30-59	-	-	N	N	Gwynn Canyon well site; drilled to about 110 feet in attempt to obtain water at shallow depth.
34.134	J. Y. Otondo	-	1955	735	7	7,910	700	7-29-59	Hard rock	Tv	Ts-e	S	T Bar well; pumps to 60,000-gallon tank; driller reported basalt drilled from 0 to 270 feet, ash and agglomerate from 270 to 700 feet, hard rock from 700 to 735 feet.
9.17.24.334	Earl Gilson	-	-	525	6	7,870	505	7-30-59	-	-	P-e	D,S	Gilson Ranch headquarters well; reported to be good.
26.443	J. Y. Otondo	-	1955	727	6	8,030	635	7-30-59	Black rock	Tv	P-e	D,S	N Bar Ranch headquarters well; cased to 727 feet; reported to have good yield; water cascading into well from about 400-foot level at time of visit; well cuttings on ground indicate well was drilled in basalt, tuff, and andesite.
9.21.34.242	Ephraim Spurgeon	-	(1936)	440	10-8	5,630	275	7-29-59	Gravel(?)	Ts	P-g,w	S	Indian Hills well; reportedly will break suction if pumped at rate of over 2 gpm; not visited.
10.20.13.324	M. F. Veeck	Lee Childress	-	62.2	8	5,490	27.5	7-28-59	Gravel	Qal(?)	J-e	(D,S)	Located in bed of Deep Creek; will pump out in 15 minutes in dry weather, will yield for longer in wet weather; not used regularly.
13.324a	do.	-	-	38.6	48	5,493	30.5	7-28-59	do.	Qal	P-w	(S)	Dug on bank of Deep Creek; not adequate in dry weather; not in use; about 20 feet south of well 13.324.
13.341	do.	Bob Hooker Lee Childress	- 1955	400 700	8	5,475	450	7-28-59	Gravel and sandstone	Ts	P-e	D,S	Deep Creek Ranch headquarters well; reportedly first drilled to 400 feet without finding water; later deepened and found water at about 600 feet; water level did not rise to 450 feet until after the heavy rains of 1958; will break suction if pumped at rate over 5 gpm.
13.413	do.	-	-	90.8	6	5,520	58.7	7-28-59	Gravel(?)	Ts(?)	N	(D)	Located under shop room; inadequate to supply house and grounds; not in use.

Table 2. -- Records of selected wells in Catron and Sierra Counties, N. Mex. (continued)

26.233	U.S. Forest Service	Bob Hooker	-	386	6	5,550	331	1942	Sand and gravel	Ts	P-g	S	Cedar Brakes upper well; cased to 20 feet; reported to be good; first drilled by CCC to 180 feet but was weak; deepened and struck more water at about 320 feet; not visited.
10.21. 2.342	Ephraim Spurgeon	Lee Childress	1956	515	6	5,370	Dry	1956	-	-	-	-	Weedy Flat test hole; reportedly found no water; drilled in sedimentary deposits of Tertiary age, drilling stopped when hole penetrated hard black rock; not visited.
12.334	M. L. Nordgren	Day	1952	330	6	5,220	230	7-29-59	Sand and gravel	Ts	P-g	S	Burns Place well; cased to 330 feet; drilled to 310 feet in 1951 but yield was small; deepened to 330 feet and obtained more water; reportedly will yield continuously at a pumping rate of 5 gpm but will break suction if pumped at a greater rate. A dug well about 100 yards down the creek bed reportedly had a reliable supply of water but was destroyed by a flash flood.
21.122	U.S. Forest Service	-	(1935)	500	(6)	5,710	Dry	1935	-	-	-	-	Alma allotment test hole; drilled for Forest Service; reportedly did not find water; well cuttings on ground indicate hole was drilled partly in basalt; a large juniper post at this site is believed to be set in the hole.
11.20. 5.222	Jerry Faust	-	-	300	-	5,025	195	7-24-59	Basalt(?)	Tv	P-g	S	Buzzard well; reported to have good yield; some water at 100 feet, most water found at depth of about 195 to 200 feet; not visited.
5.311	do.	-	-	325	6	5,275	260	-	Basalt	Tv	P-g	S	Keller well; cased to 20 feet; reported to have good yield; basalt cropping out at site dips toward the east.
11.21. 1.112	do.	-	-	40	-	5,225	25	7-24-59	-	-	P-g	D,S	Located in creek bottom; reported to have good yield; not visited.
22.334	U.S. Forest Service	N. H. Wade	-	370.8	8	5,890	323.4	7-24-59	Basalt	Tv	P-g	S	Roberts Park well; reported to be good; drilled mostly in basalt similar to that at the surface.
23.211	do.	-	-	228.5	8	5,875	Dry	7-24-59	do.	Tv	-	-	Pleasanton allotment test hole; drilled for Forest Service to depth of about 230 feet but found no water; well cuttings on the ground indicate hole was drilled mostly in basalt.
29.442*	do.	N. H. Wade	-	618.5	8	6,150	511.7	7-24-59	Cinders(?)	Tv(?)	P-g	D,S	Smoothing Iron well; pumps about 3 to 5 gpm; reportedly will not break suction when pumped continuously; drilled in conglomerate and sandstone according to driller; conflicting report states water was found in red cinders.

Table 2. -- Records of selected wells in Catron and Sierra Counties, N. Mex. (continued)

Location number	Owner or name	Driller	Year completed	Depth of well, bls (feet)	Diameter of well (inches)	Altitude above msl (feet)	Water level: Depth bls (feet)	Water level: Date	Principal water-bearing bed: Character of material	Principal water-bearing bed: Stratigraphic unit	Method of lift; power	Use of water	Remarks
SIERRA COUNTY:													
17. 7.18.123	Mack Nunn	Ed Boone	1954	99.0	6	5,455	12.2	7-22-59	-	-	P-w	S	Yield on test reportedly 30 gpm; water struck at 80 feet; water found at 100 feet rose to within 20 feet of the surface.
19.124	Bill Nunn	Ed Boone Tobe Tipton	-	110 237	6	5,565	80.6	7-21-59	Limestone	Pp	P-w	S	Drilled to 110 feet; water supply gave out after 1 year; deepened to 237 feet, now yields about 6 gpm.
23.121	Mack Nunn	-	(1928)	108	-	5,275	58	7-21-59	-	-	N	N	Water struck at 108 feet rose to within about 58 feet of the surface; not visited; not shown on map.
27.421*	do.	-	-	17.0	36	5,240	15.5	7-21-59	Gravel and sand	Qal	P,J-w, e	D,S	Dug near bed of creek; reportedly will yield about 3.5 gpm; has never gone dry; not shown on map.
27.423	do.	-	-	-	-	5,210	-	7-21-59	Sandstone	-	P-w	S	Dug; reportedly will yield 30 gpm; water found under a hard sandstone; not visited; not shown on map.
35.331	Ester Wilson	-	-	47.0	6	5,075	19.2	7-21-59	Gravel and sand	Qal	C-e	D,S	Stopped drilling when hard rock was struck; reportedly was test-bailed at a rate of 35 gpm; not shown on map.
17.7½.13.212	Bill Nunn	Tobe Tipton	1956	33.1	8	5,490	18.5	7-21-59	Gravel	Qal	T-e	S	Cased to 11 feet; creek just west of well has had perennial flow for past 2 years, so well not used; about 20 gpm at time of visit.
17. 8.10.432*	do.	Ed Boone	1948	61	6	5,710	20	7-22-59	Blue limestone	Pp	J-e	D,S	Cased to 61 feet; first water struck at 43 feet, rose and poured into bottom of adjacent dug well that is 20 feet deep; will yield about 12 gpm.
12.344	Big Springs Cattle Co.	-	-	226.0	8	5,555	9.5	7-21-59	do.	Pp	P-w	S	Some water was found at 69 feet; drilled through very hard blue limestone and struck water that rose to within about 10 feet of the surface.
16.132	Bill Nunn	-	-	45	6	5,940	11	7-22-59	-	-	P-w	S	Trump well, cased to 11 feet; first water struck at 30 feet rose to within about 11 feet of surface; will yield about 7 gpm.
28.143*	do.	-	Old	27.3	36	6,160	7.6	7-22-59	Sand and gravel	Qal	P-w	S	Pierce well, dug on bank of creek; about 20 feet west of drilled well; declines in dry weather; pumping of drilled well reportedly did not affect water level in dug well.

Table 2. -- Records of selected wells in Catron and Sierra Counties, N. Mex. (continued)

28.143a	do.	Kite	1948	37.5	6	6,160	7.5	7-22-59	do.	Qal	N	(S)	Pierce well, drilled; reportedly will pump dry; 20 feet from drilled well.
18. 7. 8.441	Grant McGregor	-	Old	18	36	5,330	12.8	7-22-59	do.	Qal	P-w	(S)	Declined in dry weather and would not supply both house and stock.
17.221	do.	Lee Childress	1953	316.5	6	5,360	126.9	7-22-59	Red clayey rock	Ts(?)	P-w	D,S	Most water from stratum between 290 and 300 feet beneath a blue porphyry; water rose about 115 feet; bailing at 19 gpm reportedly did not lower water level.
18. 8. 4.314	Bill Nunn	-	1929	77.8	6	5,861	23.0	7-22-59	-	-	P-w	S	Uncle Lewis well; will pump steadily at rate of 4 to 5 gpm but will break suction at greater rate of pumping.
10.343	H. L. Parks	-	-	279.7	8	5,725	27.3	7-22-59	-	Tv(?)	P-e	S	Reportedly encountered only seep water above 206 feet, then would yield 6 gpm; main water at depth of 250 feet, rose in casing; yield 18 gpm.
13.341	Bill Nunn	-	1926	90	6	5,500	50(?)	7-22-59	-	-	J-e	D,S	Berrenda well; not visited.
14.311	Fred Latham	-	-	190.5	8	5,600	26.3	7-22-59	-	Tv(?)	J-e	D,S	Cased to 11 feet; seep water at 23 to 24 feet; main water at about 190 feet rose to within 12 feet of surface; pumping at time of visit at rate of 10 gpm; on for about 8 hours.
14.332	Ted Latham	-	-	204	18	5,500	-	7-22-59	-	-	T-e	Irr	Reportedly would yield 400 gpm after pumping steadily for 12 hours; not visited.
15.141	H. L. Parks	-	-	20.5	36	5,675	19.5	7-22-59	Sand	Qal	P-e	D,S	Dug well, pumped down just before visit; reported water level will stand about 10 feet higher in well.

EXPLANATION

Location number: See figure 2 for explanation; an asterisk (*) before the location number indicates partial chemical analysis available.
Owner or name: The owner or name used for well or spring at time of visit.
Year completed: Parentheses indicate approximate year; wells designated "old" were constructed generally before 1925.
Depth of well and water levels: Figures expressed to the nearest tenth of a foot were measured by the Geological Survey; those in whole feet were reported by owner, tenant, driller, or other source; bls: below land surface.
Diameter: The diameter of the casing, if cased; mean diameter of the hole, if uncased.
Altitude: Altitude of land surfaces at the wells interpolated from topographic maps; msl: mean sea level.
Principal water-bearing bed: Character of material for the most part is that reported by the owner, tenant, or driller; the stratigraphic unit has been determined by observation of outcrops, from well cuttings, or by interpretation from geologic maps, and indicates only the principal water-bearing unit although water may be derived from two or more units -- Pp, limestone of Pennsylvanian age; Qal, alluvium of Quaternary age; Ts, clay, sand, gravel, and conglomerate of Tertiary age; Tv, volcanic rocks of Tertiary age.
Method of lift and power source: C, centrifugal pump; J, jet pump; N, none; P, plunger or cylinder pump; T, turbine pump; Ts, submersible turbine pump; e, electric motor; g, gasoline engine; w, windmill.
Use of water: D, domestic; Irr, irrigation; N, none; S, stock; parentheses indicate intended or former use.
Remarks: All wells are drilled unless otherwise indicated; gpm, gallons per minute; T, temperature in degrees Fahrenheit.

Sierra County Sites

Marine sedimentary rocks of Paleozoic and Mesozoic age, and overlying volcanic rocks and associated sedimentary rocks of Tertiary age, constitute the main mass of the Mimbres Mountains in which the sites are located.

The following table shows the relative position, general character, and approximate thickness of the post-Cambrian rock units underlying the Lake Valley area which is south of the Mackey allotment (modified from Jicha, p. 4-5, and from Kuellmer).

System	Stratigraphic unit	Description and water-bearing characteristics	Thickness (feet)
Quaternary	Alluvium	Soil, sand, clay, and gravel. Yields small to large quantities of water.	0-100
Tertiary	Volcanic rocks	Andesite and latite flows, flow breccia, tuff, fanglomerate, and intrusive quartz monzonite porphyry. Flows and beds of tuff may yield small quantities of water; the intrusive rocks generally yield no water.	5,000±
Mississippian	Lake Valley limestone	Light gray to black limestone containing shale members; cherty at top and base; very fossiliferous. Generally yields small quantities of water.	200-265
Devonian	Percha shale	Black fissile shale grading to green shale; includes limestone lenses near top. Generally does not yield water.	150-175
Silurian	Fusselman limestone	Massive, gray dolomitic limestone, pink at top. May yield small quantities of water.	200-300
Ordovician	Montoya limestone	Gray limestone containing thick cherty members; dark-colored sandstone at base. May yield small quantities of water.	205±
Ordovician	El Paso limestone	Light gray limestone, mostly slabby, some massive algal beds. May yield small quantities of water.	500-850

The Mimbres Mountains, according to Jicha (p. 4), are formed by a faulted anticline. The Paleozoic rocks, mostly limestone and some sandstone and shale, were folded, faulted, uplifted, and intruded by volcanic rocks in Late Cretaceous or early Tertiary time. They were buried under a succession of flow rocks and volcanic debris during Tertiary time (Jicha, p. 36). Faulting, probably in late Tertiary time, elevated blocks in the anticlinal structure, further deformed the rocks, and determined to a large extent the courses of the major streams (pl. 1).

A major north-trending fault determines the course of Pierce Canyon; this fault is paralleled roughly by another fault 2½ to 3½ miles to the east. A nearly east-trending cross fault and a northeast-trending cross fault intersect in the south-central part of T. 17 S., R. 8 W., between the two north-trending faults to form a triangular fault block that contains two of the sites examined. The third site is just east of the northeast-trending cross fault.

Mackey Allotment

One well site in the NW¼ sec. 27, T. 17 S., R. 8 W., and two alternate sites in the northeast quarter of the same section were examined. All three sites are in P A Canyon, which is cut in the eastward-dipping limb of the faulted anticlinal structure that forms the Mimbres Mountains (pl. 1).

The rocks exposed in the bottom of P A Canyon in its course through the NW¼ sec. 26 and the NE¼ sec. 27, T. 17 S., R. 8 W., are limestones of the Lake Valley limestone of Early Mississippian age and the Percha shale of Late Devonian age. The beds dip generally eastward from 15° to 25°. As this dip is greater than the eastward slope of the canyon floor, successively older (lower) beds crop out upcanyon; strata older than the Percha shale, however, are not exposed in the canyon.

Kuellmer mapped a small body of intrusive quartz monzonite porphyry on the north side of P A Mountain, in the west-central part of sec. 27, T. 17 S., R. 8 W., along the northwest or downthrown side, of the northeast-trending cross fault. The outcrop is about 1 mile long and 1/3 mile wide; it does not crop out in the floor of P A Canyon, and its subsurface extent is not known.

An inventory of ranch and stock wells (table 2) was made in the general vicinity of the proposed well sites. The inventory showed that water generally is obtained at shallow depths in the alluvial fill in the valleys of the larger streams and at various depths in the underlying limestone and volcanic formations.

The water level in the limestone formations commonly was found to be under artesian pressure. The wells tapping these formations do not flow, but the water reportedly rises in the casings above the points at which it is first struck.

Measurements of the depth to water in wells indicate that the water table slopes almost uniformly eastward but less steeply than does the land surface. Therefore, the depth to water decreases from the head of P A Canyon eastward and, in general, the probability of getting an adequate supply of water at reasonable depth decreases upstream.

Possibly some water can be developed at shallow depth at the higher elevations. A supply of water, reported to be under artesian head, was obtained at a depth of about 30 feet in rock in well 17.8.16.132, which is in the bottom of a canyon. The alluvial fill in upland valleys and canyons may contain small amounts of water perched on the underlying consolidated rocks. Perched water also may occur in the Lake Valley limestone where it overlies the Percha.

The springs in the canyons at 17.8.14.444, 17.8.25.144, and 18.8.1.142 discharge along the trace of faults. The north-trending faults in the eastern part of the area (pl. 1) apparently act as dams to retard the movement of water down the hydraulic gradient. The water table is at land surface on the upgradient side of the fault and ground water discharges as springs or seeps in the alluvium in the floors of the canyons. The spring at 17.8.14.444 reportedly flows 20 to 30 gpm (gallons per minute), and the discharge has fluctuated little through the years. The water is used for stock, irrigation, and domestic purposes.

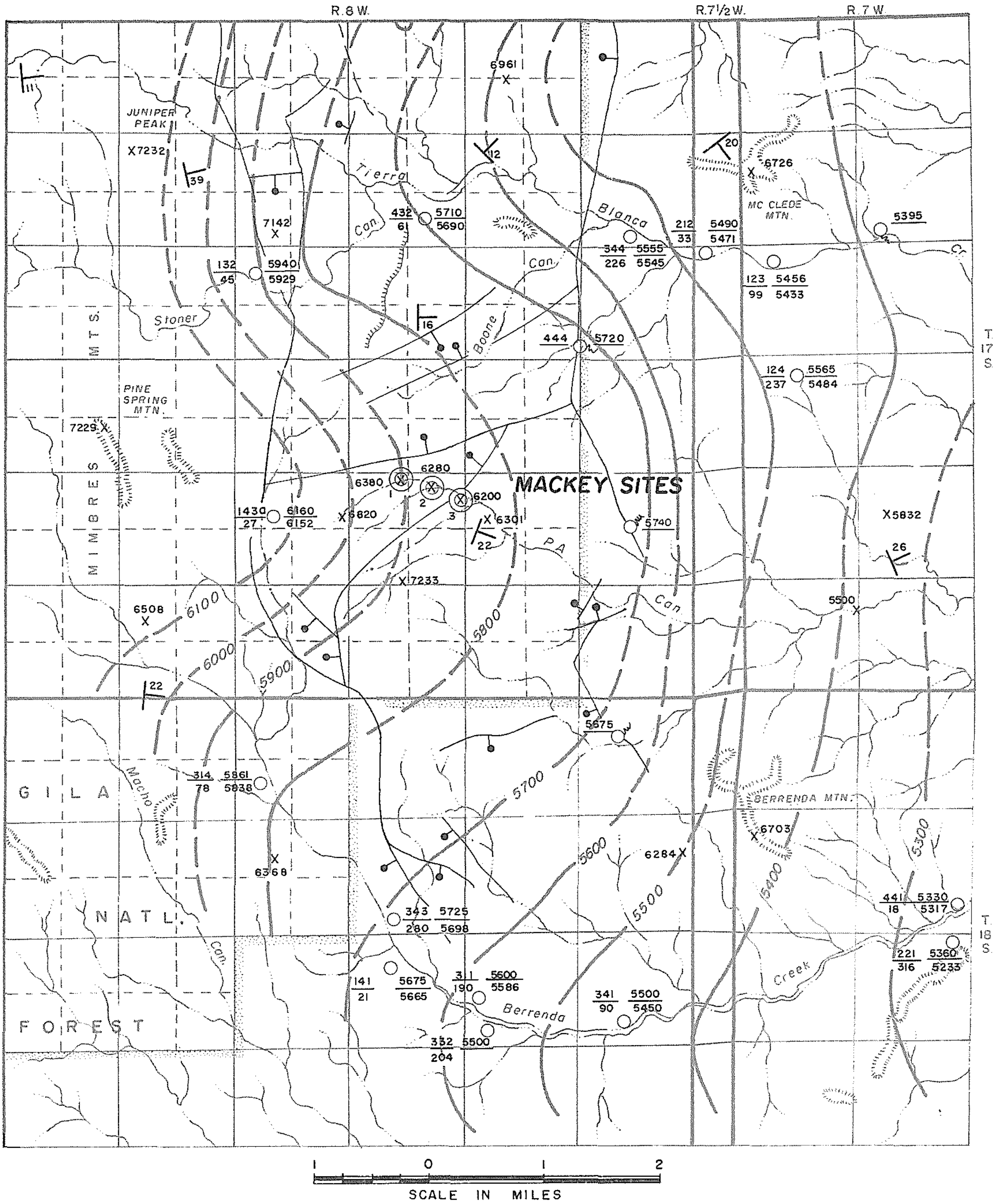
Near site 1 (17.8.27.122) a dark-gray fissile shale, believed to be a part of the Percha, crops out in the canyon bottom; the shale dips eastward about 20°. Drilling at site 1 would start at or near the top of the Percha, which is 150 to 175 feet thick, and which, in general, is not water bearing. The Fusselman limestone, underlying the Percha, is about 200 to 300 feet thick and is in turn underlain by the Montoya limestone. The water-table contours (pl. 1) indicate that the water level is about 480 feet below the land surface. To obtain water at site 1, it may be necessary to drill through 165 to 200 feet of Percha shale, 220 to 325 feet of Fusselman limestone, and 100 or more feet of the Montoya limestone.

At site 2 (17.8.27.214), the Lake Valley limestone crops out in the floor of P A Canyon. A short distance downstream, limestone beds of the formation dip eastward about 15°.

Intrusive quartz monzonite porphyry, mapped by Kuellmer, crops out on the slope south of the site but not on the canyon floor. If the intrusive rock underlies P A Canyon at a relatively shallow depth, the chances of obtaining an adequate supply of water at site 2 are poor. However, the intrusion probably is a small stock having steep or nearly vertical sides and, therefore, may not extend under the bed of the canyon.

Site 2 is estimated to be about one-third of the way up from the base of the Lake Valley limestone and, if the intrusive porphyry does not underlie the site, a well drilled there would penetrate about 100 feet of limestone before entering the Percha shale.

The water-table contours at site 2 indicate that the water level is about 410 feet below the land surface. Thus, wells yielding adequate supplies of water probably would have to be drilled through about 100 feet of Lake Valley limestone, 160 to 185 feet of Percha shale, and 150



Base from the Black Range Ranger District Map. U. S. Forest Service.

Hydrology by F. D. Trauger, 1959; geology after F. J. Kuellmer. Altitude of land surface from topographic maps.

EXPLANATION

Well number within section | Altitude of land surface, in feet

341/90 ○ 5500/5400

Depth of well, in feet | Altitude of water table, in feet

Well

Spring number within section | Altitude of land surface, in feet

444 ○ 5720

Spring

Those not visited omitted from table 1

5000

Water-table contour

Contour interval 100 feet. Dashed where approximate. Datum is mean sea level.

Fault

Showing downthrown side. Dashed where approximate.

Site number 2

Site of proposed well

X 7545

Altitude of land surface, in feet

12

Strike and dip of bed or flow structure.

PLATE 1

Map of the Tierra Blanca-Berrenda Creek area in the Mimbres Mountains, Sierra County, N. Mex.

or more feet of the Fusselman limestone. Perched water might occur at the base of the Lake Valley limestone or in the limestone above the base.

Site 3 is a short distance east of, and on the upthrown side of, a northeast-trending normal fault. The Lake Valley crops out at the site and dips eastward about 22°. Because of its position in a canyon and on the upthrown side of the fault, the site is near the base of the Lake Valley limestone.

The water level at site 3 is about 350 feet below the land surface. A well yielding an adequate supply of water probably would have to penetrate from 50 to 100 feet of Lake Valley, 165 to 200 feet of Percha shale, and about 200 or more feet of the Fusselman limestone. As at sites 1 and 2, perched water or confined water may occur at depths less than 350 feet.

Site 2 might entail the greatest risk of failure to discover an adequate water supply because it is closest to the outcrop of the intrusive quartz monzonite porphyry. If the drill should enter the porphyry before reaching water, the chance of drilling through the intrusive mass and obtaining water below the porphyry would be poor.

The fact that no springs or seeps were found in the bed of P A Canyon where the northeast-trending fault crosses suggests that the fault does not act as a ground-water dam. Therefore, moving site 3 to the west side of the fault in the hope of discovering water at shallower depth would not be advantageous.

Catron County Sites

Rocks of Tertiary and Quaternary age are exposed in the parts of Catron County included in this investigation (pls. 2 and 3). The uplands are underlain by a thick sequence of volcanic rocks and minor amounts of associated sediments of continental origin. The intermediate slopes between the inner valley of the San Francisco River (pl. 2) and the upland are largely underlain by thick deposits of fluviatile origin that are older than the gravels of the inner valley and younger than the deposits in the uplands. The inner valley of the San Francisco River is filled with fluviatile deposits composed largely of beds of poorly sorted gravel and coarse to medium silty sand.

Ferguson (p. 6) determined that the composite thickness of rocks of Tertiary age in the Mogollon mining district 7 miles northeast of Glenwood is about 8,000 feet, of which about 80 percent is lava, tuff, and volcanic agglomerate, and the remaining 20 percent is rock of fluviatile origin. The thick deposits of partly cemented gravel underlying the intermediate slopes west of Mogollon were described by Ferguson (p. 23) and correlated with the Gila conglomerate of Tertiary and Quaternary age. The Gila conglomerate near Mogollon is in fault contact with the volcanic rocks.

The highland that slopes up to Maple Peak in Arizona, west of Glenwood (pl. 2) and about 3 miles west of the State line, also is underlain by a great thickness of volcanic and sedimentary rocks. Beds exposed in the upper part of Big Pine Canyon (T. 12 S., R. 21 W.) contain tuff, agglomerate, and medium to coarse sandstone interbedded with lava flows. The lava flows predominate and in this area the ratio of volcanic rocks to fluviatile deposits probably is about the same as it is in the Mogollon district.

Several wells (table 2) finished in the volcanic rocks yield small to moderate quantities of water with relatively small drawdown. The successful development of these wells in the volcanic rocks show that drilling should not stop when the volcanic rocks are penetrated; they are potential aquifers and should be explored.

The older gravel underlying the intermediate slopes west of the San Francisco River is correlated with the Gila conglomerate west of Mogollon described by Ferguson. Locally it is moderately to well cemented. Flows of basalt are interbedded with the Gila conglomerate farther south but none were observed in this area.

Ferguson (p. 23) measured an exposure of Gila conglomerate 700 feet thick in the canyon cut by Mineral Creek about 5 miles northeast of Alma (pl. 2). Well 10.20.13.341 was drilled in the Gila conglomerate about 2 miles to the northwest of the measured exposure and did not encounter bedrock at the finished depth of 700 feet. An additional 400 to 500 feet of gravel is exposed in the hills and cliffs surrounding the well, indicating that in this general area the Gila conglomerate is at least 1,200 feet thick.

The Gila conglomerate generally does not yield large quantities of water to wells but will yield amounts adequate for stock and domestic use. The drawdown in wells tapping the Gila commonly is as much as 50 feet for each gallon of water pumped per minute.

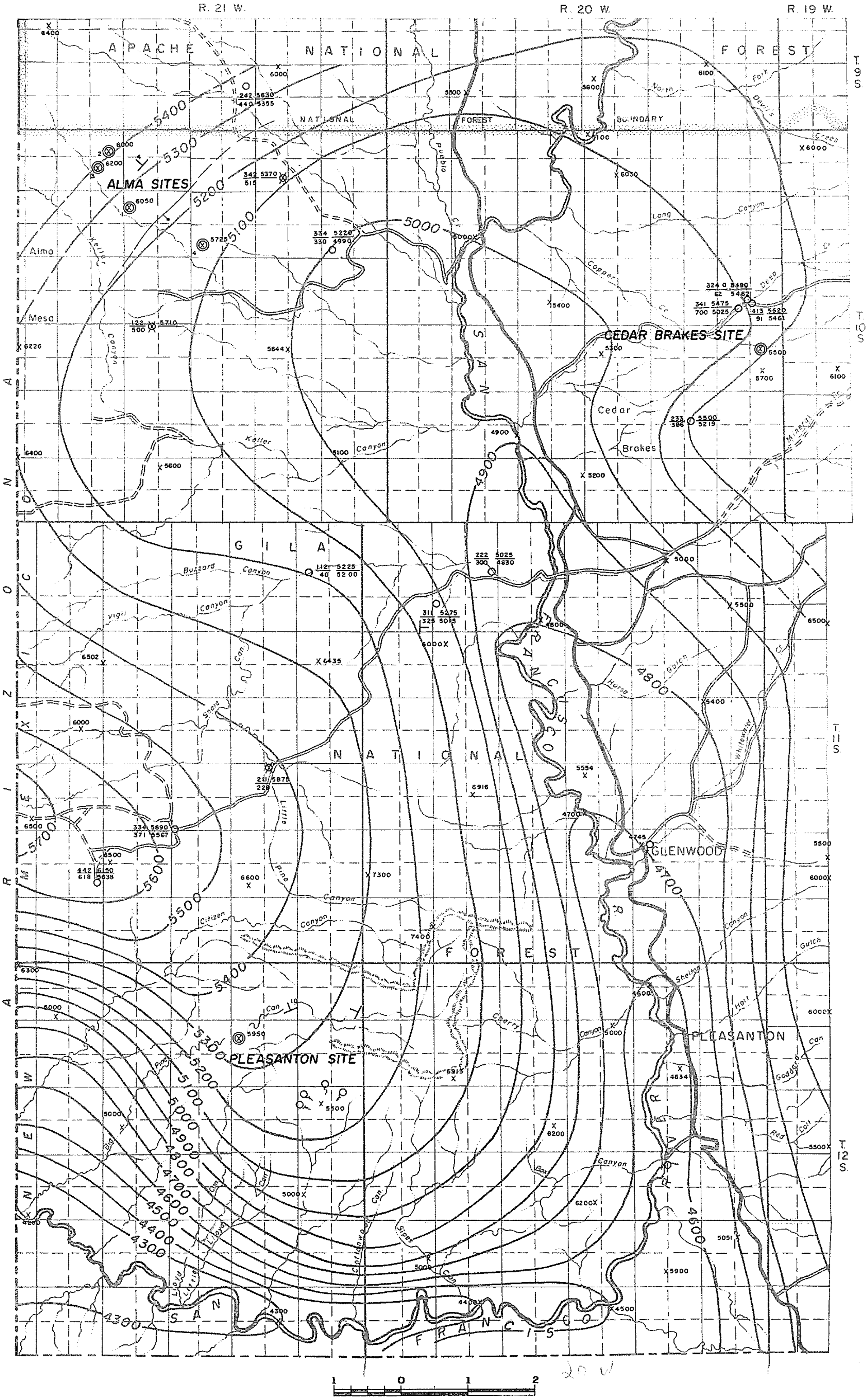
The fluviatile deposits of the inner valley of the San Francisco River yield small to large quantities of water to wells, depending on whether the wells are drilled in fine-grained or in coarse-grained deposits.

Alma Allotment

The selection of a site in sec. 9, T. 10 S., R. 21 W., was requested by the Forest Service; one site in sec. 9 and three alternate sites were examined. Sites 1, 2, and 3 are in the northwest part of T. 10 S., R. 21 W. (pl. 2), on a dissected upland plain that is part of Alma Mesa; site 4 is on somewhat lower ground east of Alma Mesa.

The upland plain is underlain by fluviatile deposits, mostly poorly sorted coarse gravel and sandy gravel containing some fine sand and silt. These deposits are representative of the Gila conglomerate and are equivalent to similar deposits on the east side of the San Francisco River. However, the thickness of these gravels is believed to be less under Alma Mesa than near Mineral Creek and at the town of Mogollon, 7 miles northeast of Glenwood.

The Forest Service attempted to develop a well at 10.21.21.122 in about 1935 but abandoned the hole as dry at a reported depth of 500



Base from Glenwood Ranger District map, U. S. Forest Service

Geology and hydrology by F. D. Trauger, 1959. Altitude of land surface from topographic maps.

EXPLANATION

Well number within section / Depth of well within section — Altitude of land surface, in feet / Altitude of water table, in feet

$\frac{311}{325}$ ○ $\frac{5275}{5015}$

Well

Well number within section / Depth of hole, in feet — Altitude of land surface, in feet

$\frac{211}{228}$ $\frac{5875}{}$

Dry well

Spring

Those not visited omitted from table 1.

5000

Water-table contour
Contour interval 100 feet. Dashed where approximate. Datum is mean sea level.

X 6050

Altitude of land surface, in feet

Site number 3

Site of proposed well

Fault
Showing downthrown side. Dashed where approximate.

10

Strike and dip of bed or flow structure.

PLATE 2

Map of the Deep Creek-Keller Canyon-Roberts Park area, Catron County, N. Mex.

feet (alt. 5,200). Drill cuttings at the site indicate the well was drilled partly in basalt that is believed to be bedrock and not a flow within the Gila conglomerate. To the north basalt is exposed at an altitude of about 6,000 feet in the canyons cut in the mesa in the SE$\frac{1}{4}$ sec. 4, T. 10 S., R. 21 W., and the thickness and attitude of the flows suggest that they are part of the volcanic bedrock of Tertiary age underlying the Gila conglomerate

A hole was drilled at 10.21.2.342 in Weedy Flat in 1956, according to Mr. M. L. Nordgren, and when hard black rock was struck at a depth of 515 feet the hole was abandoned as dry. The hard black rock or basalt probably is the same unit exposed in the canyons in section 4.

On the basis of these exposures a fault is inferred as trending northeast through secs. 3 and 9, T. 10 S., R. 21 W. Upward movement on the west side of this fault would have lifted the basaltic rock of pre-Gila age against the Gila conglomerate.

Water in well 10.21.12.334 stands at an altitude of 4,990 feet and in well 9.21.34.242 at an altitude of 5,355 feet. The reason why holes 10.21.2.342 and 10.21.21.122 were dry cannot be explained satisfactorily with the data available. At well 10.21.21.122 the basalt simply may be at an elevation above the water table. The bottom of the dry hole at 10.21.2.342 is at an altitude of 4,855 feet and water might have been expected in the lower part of the hole. There is no reason to believe water would not be present in the basaltic rock at depth.

The fault inferred as trending northeastward through secs. 3 and 9 possibly has influenced the occurrence of ground water in a relatively narrow northeast-trending zone that includes the two dry holes. Another possibility is that only impermeable sediments were penetrated above the basalt in well 10.21.2.342. Well 10.21.12.334 was drilled to 100 feet below the static water level but according to the owner the pump will break suction if operated at a rate of more than 5 gpm. This indicates that at the particular location the materials penetrated will yield less than 1 gpm for each 20 feet penetrated below the water table. A third possibility is that the water occurring in well 10.21.12.334 is perched above the regional water table, and that the inferred fault retards water moving southeastward from Alma Mesa toward the river.

If the third possibility is true, it would follow that the three sites west of the inferred fault present better prospects for developing ground water than would sites at lower elevations immediately east of the inferred fault. The fact that a small but dependable supply of water is reported in well 9.21.34.242 is encouraging to more exploration in this area.

Site 4 (10.21.10.332) appears unfavorable because of the two dry holes nearby. However, by drilling deeper into the basaltic rocks a supply might be developed. The data available indicate that sites 1, 2, and 3 are more favorable for the development of water supplies.

The choice between these three sites can be made on the basis of economics. Site 1, in a canyon, has the advantage of requiring less drilling to reach the water table. The land surfaces at sites 1 and 2 are at altitudes of about 6,000 feet and 6,200 feet respectively, and the water table is presumed to be at an altitude of about 5,400 feet. At site 3 the altitude of the land surface is about 6,050 feet and the altitude of the water table is at about 5,275 feet.

From the records of wells drilled in the Gila conglomerate in this general region, it is inferred that about 100 feet or more of water-bearing rock should be penetrated to assure an adequate supply for a stock well. Drilling should not necessarily be stopped if basalt is penetrated at an altitude above that estimated for the water table. The volcanic rocks in this area are as apt to be as good a source of water as the Gila conglomerate.

Cedar Brakes Allotment

The proposed location for a well (10.20.24.234) on the Cedar Brakes allotment is on a low terrace bordering Copper Creek about 1 mile west of the steep front of the Mogollon Mountains (pl. 2). Copper Creek at the proposed site is entrenched in a canyon cut in the Gila conglomerate. The steep slopes rise about 200 to 300 feet above the creek bed on either side.

From the records (table 2) of well 10.20.13.341, drilled at the Deep Creek Ranch about three-fourths of a mile north of the proposed site, and well 10.20.26.233, about 1½ miles southwest of the site, it may be inferred that the Gila conglomerate underlies the proposed site to a depth of at least 400 feet, and most likely to more than 700 feet. Water occurred at shallow depths in three shallow wells at the Deep Creek Ranch headquarters (sec. 13, T. 10 S., R. 20 W.); one of the wells is in the bed of Deep Creek, one is adjacent to the bank, and one is under the bunkhouse. However, the ranch foreman, Mr. Sam Smith, stated that none of these wells provide an adequate supply of water.

The ranch water supply comes from the well at 10.20.13.341. This well reportedly was first drilled to a depth of 400 feet and no water was found. It was later deepened to 700 feet; water was found at a depth of about 600 feet and drilling was continued for 100 feet into the saturated zone. The water level reportedly remained at about 600 feet until the heavy rains of 1958, after which it rose to within about 450 feet of the surface.

The supply well is reported to discharge steadily at 5 gpm but if pumped at a greater rate the pump will break suction. It is assumed that the pump is set to within a few feet of the well bottom because such is the general practice in this area.

According to Mr. Sam Burns, foreman of the McKeen Ranch, well 10.20.-26.233 was drilled in about 1936 to a depth of 180 feet and yielded a very small supply of water. Later, when it was deepened to 400 feet, sand and gravel reportedly were penetrated from 280 to 400 feet, and water found at 320 feet rose to about 300 feet. Forest Service records show that in 1942 the well was 386 feet deep and the water level was 331 feet below land surface.

The possibilities of developing water at the proposed site are good. The altitude of the land surface at the site is about 5,500 feet, and the altitude of the general water table is at about 5,200 feet. If shallow perched water occurs, the hole should be test-bailed on the chance that the supply might be adequate for a stock well. However, experience with the supply well at the Deep Creek Ranch headquarters suggests that it may be necessary to penetrate the saturated zone as far as 250 feet to obtain an adequate supply of water.

Pleasanton Allotment

The site examined in sec. 11, T. 12 S., R. 21 W., is in Big Pine Canyon (pl. 2) on a small flat between the main canyon and the mouth of a tributary. The rocks underlying the site are mostly volcanic and belong to the thick sequence of flows, pyroclastics, and interbedded fluviatile deposits of Tertiary age. They were observed in the floor and walls of Big Pine Canyon, from near its head to the proposed site. The upper part of the sequence is mainly lava flows, some of which are thin, platy, and highly jointed, and some of which are dense and massive. Lower in the sequence more scoriaceous beds -- tuff, agglomerate, and sandstone strata -- are interbedded with flows.

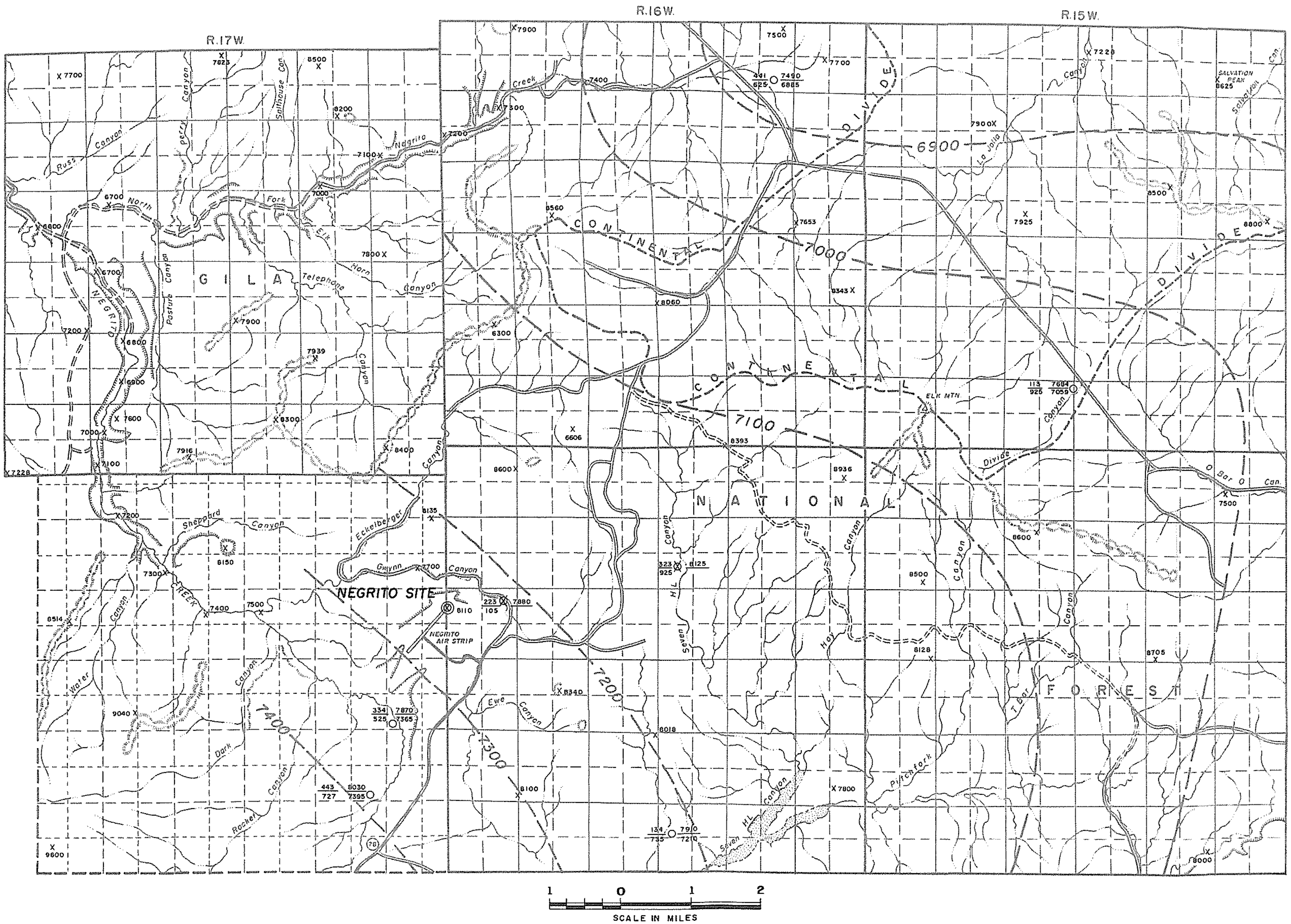
A well-bedded, light-colored medium- to coarse-grained sandstone is exposed in the bottom of the canyon about three-fourths of a mile up the canyon from the site. The strike of the beds is about N. 80° E., and the dip is less than 10° and to the north. Roughly bedded coarse agglomerate is exposed in the floor and walls about a mile farther up the canyon. The strike of these beds is about N. 30° E., and the dip is low and to the west.

These and similar beds in that part of the sequence that is exposed indicate the probability that similar beds occur in the sequence underlying the proposed well site. Such beds could contain perched water at relatively shallow depths, or if they are below the regional water table they would almost surely yield a supply of water adequate for a stock well.

Mr. Ken Hollimon reports that water occurs in red cinders in the Smoothing Iron well (11.21.29.442). Land surface at the well is at an altitude of about 6,150 feet and the water level is at an altitude of about 5,640 feet. The Roberts Park well (11.21.22.334) is at an altitude of about 5,890 feet and the water level is at an altitude of about 5,570 feet. The water reportedly was found in "black rock" which is presumed to be a lava flow.

The altitude at the proposed site (12.21.11.131) is about 5,950 feet, and the water level is estimated to be at an altitude of about 5,350 feet. This estimate is based on the altitude of the water levels in the two wells mentioned, with consideration given to the altitude of the bed of the San Francisco River. The river gains water in this general area and may be considered the probable base toward which ground water moves.

Lack of data pertaining to occurrence of ground water in the area between the proposed well site and the river makes the estimate of the



EXPLANATION

Well number within section — Altitude of land surface in feet

$\frac{334}{525}$ ○ $\frac{7870}{7365}$

Depth of well in feet — Altitude of water level in feet

Well

Well number within section — Altitude of land surface in feet

$\frac{353}{925}$ ⊗ $\frac{8125}{}$

Depth of hole in feet

Dry well

◎

Proposed well site

x 7100

Altitude of land surface in feet

—7100—

Approximate water-table contour. Contour interval 100 feet. Datum is mean sea level.

Hydrology from data collected by F. D. Trauger, 1959, and data furnished by the New Mexico Bureau of Mines and Mineral Resources. Altitude of land surface from topographic maps.

Base from the Reserve Ranger District map, U. S. Forest Service

PLATE 3

Map of the Negrito Creek-Collins Park area in the Mogollon Mountains, Catron County, N. Mex.

depth to water extremely uncertain. However, it is probable that water can be obtained and that the depth to the water will be about 600 feet, but possibly as much as 800.

If water occurs at appreciably shallower depths, it must be presumed to be perched. Such a supply might prove adequate temporarily but probably would be only a small "pocket" that would be rapidly depleted under steady pumping. If perched water is suspected, a prolonged bailing test should be run, and precise measurements of the water level should be made at intervals to determine if the water level is being lowered greatly without subsequent recovery.

Negrito Airstrip

A study of a site in the SW¼ sec. 18, T. 9 S., R. 16 W., was requested. However, a site in the NW¼ was considered to be preferable because it was nearer to the airstrip (pl. 3). The site of a test hole (9.16.18.223) drilled to 110 feet depth in Gwynn Canyon in 1956(?) also was examined.

Basalt is exposed at the test hole, at the proposed site (9.16.18.131), and in ravines and canyons in the vicinity. Dissection of this part of the Mogollon upland is not deep enough to reveal much of the rock section underlying the plateau. However, it is concluded that the sequence of volcanic rocks is at least as thick here as in other parts of the region.

Reports indicate that the few stock wells drilled in the area penetrated interbedded lava flows and softer rocks of pyroclastic origin. A partial log of T-Bar well 9.16.34.134, 4.4 miles southeast of the proposed site, indicates basalt from 0 to 270 feet, ash and tuff from 270 to 700 feet, and "hard rock," probably basalt, from 700 to 735 feet. Water was struck in the hard rock under the ash and tuff.

The drill cuttings on the ground at N-Bar Ranch well 9.17.26.443, 2.8 miles south-southwest of the proposed site, indicated that the drill penetrated basalt, andesite, and tuff. Water reportedly was found in black rock near the bottom of the well. Efforts to check the reported water level (635 feet) failed because water cascading into the hole from about the 425-foot level washed the marking chalk from the measuring line.

Drill cuttings on the ground at a test hole (9.16.10.323) that was drilled 3.3 miles east of the site in 1958 to a depth of 925 feet indicate that much of the rock penetrated was of pyroclastic origin -- probably tuff similar to that penetrated in the T-Bar well about 4 miles south of the test hole. The test hole was found open and completely dry to a depth of 896 feet, the limit of the measuring tape. A comparison of land-surface altitude and water-surface altitude at wells in the area suggest that this dry test hole probably would have struck water had it been drilled from 50 to 100 feet deeper.

Water-level data indicate that there is a regional water table under the Mogollon upland and that in this area it slopes northeastward toward the Plains of San Agustin. The proposed well site adjacent to the airstrip is at about 8,110 feet and the water table is at about 7,250 feet. At the Gwynn Canyon test hole, about three-fourths of a mile to the east, the land-surface altitude is about 7,880 feet and the water-table altitude is about 7,225 feet. Water undoubtedly can be obtained at either site.

QUALITY OF WATER

Samples of water from five wells were collected for chemical analysis. Three of the samples were from wells in the vicinity of Tierra Blanca Creek and Berrenda Creek in Sierra County; one was from a well in mountains west of Glenwood, and one was from a well in the Mogollon Mountains in Catron County. The data shown in the table below indicate that the chemical quality of the water in the wells sampled ranged from excellent to good for most purposes.

Chemical analyses, in parts per million

Well number and owner or name	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$ Calcium, Magnesium	Specific conductance (micromhos at 25° C)
8.16.2.441 Collins Park well	5.8	4.8	73	227
11.21.29.442 Smoothing Iron well	4.9	14	184	456
17.7.27.421 Mack Nunn house well	41	13	237	518
17.8.10.432 Bill Nunn house well	74	7.4	326	638
17.8.28.143 Pierce Canyon well	21	7.0	207	467

The data indicate that in general the water in the vicinity of Tierra Blanca Creek and Berrenda Creek would be considered hard by most classifications and contains moderate amounts of sulfate. Water from the volcanic rocks of the Mogollon Mountains and in the vicinity of Glenwood would be classified as soft to moderately hard and contains small amounts of sulfate. The chloride content of the water is negligible in both areas. A sufficient quantity of iron precipitated from the sample from well 17.7.27.421 to indicate that the water probably would stain procelain and laundry.

Ground water from other places in the Gila National Forest, particularly in the area of the Gila Hot Springs in Grant County, contains fluoride in excess of 1.5 ppm (parts per million) and for that reason is not suitable for human use. Any supply of water developed in the volcanic rocks and intended for continuous or prolonged human consumption should be analyzed for fluoride.

CONCLUSIONS

Ground water in quantities sufficient to meet the needs indicated (table 1) probably can be developed at all the sites proposed. In general the wells should be more than 500 feet deep, and the water levels in the wells will also be deep. Water in some of the areas may be under artesian pressure, but probably the pressure will not be sufficient to cause the wells to flow or to raise water levels close to the surface.

The rocks to be drilled in the vicinity of Lake Valley will be mostly limestone, and some shale, depending on the site selected. In the Glenwood-Mogollon region the rocks to be drilled will range from unconsolidated gravel through hard conglomerate to hard basalt and andesite lava. Relatively soft beds of tuff and ash are interbedded with the basalt flows and are of about equal thickness.

Because the permeability of the rocks at all the sites is low, a well may need to penetrate the saturated zone about 50 feet for each gpm of water produced. In the event cavities or highly permeable saturated zones are encountered in either the volcanic or limestone rocks, the penetration may not have to be so great. Each well drilled should be tested with either a bailer or a pump for information on capacity and dependability of supply over a period of time.

Wells probably will require casing through materials that tend to weather upon exposure to air or dampness, particularly beds of shale, ash, and poorly cemented gravel or sand.

The chemical quality of the ground water at all sites is expected to be suitable for livestock and human use.

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