PREPARED IN COOPERATION WITH
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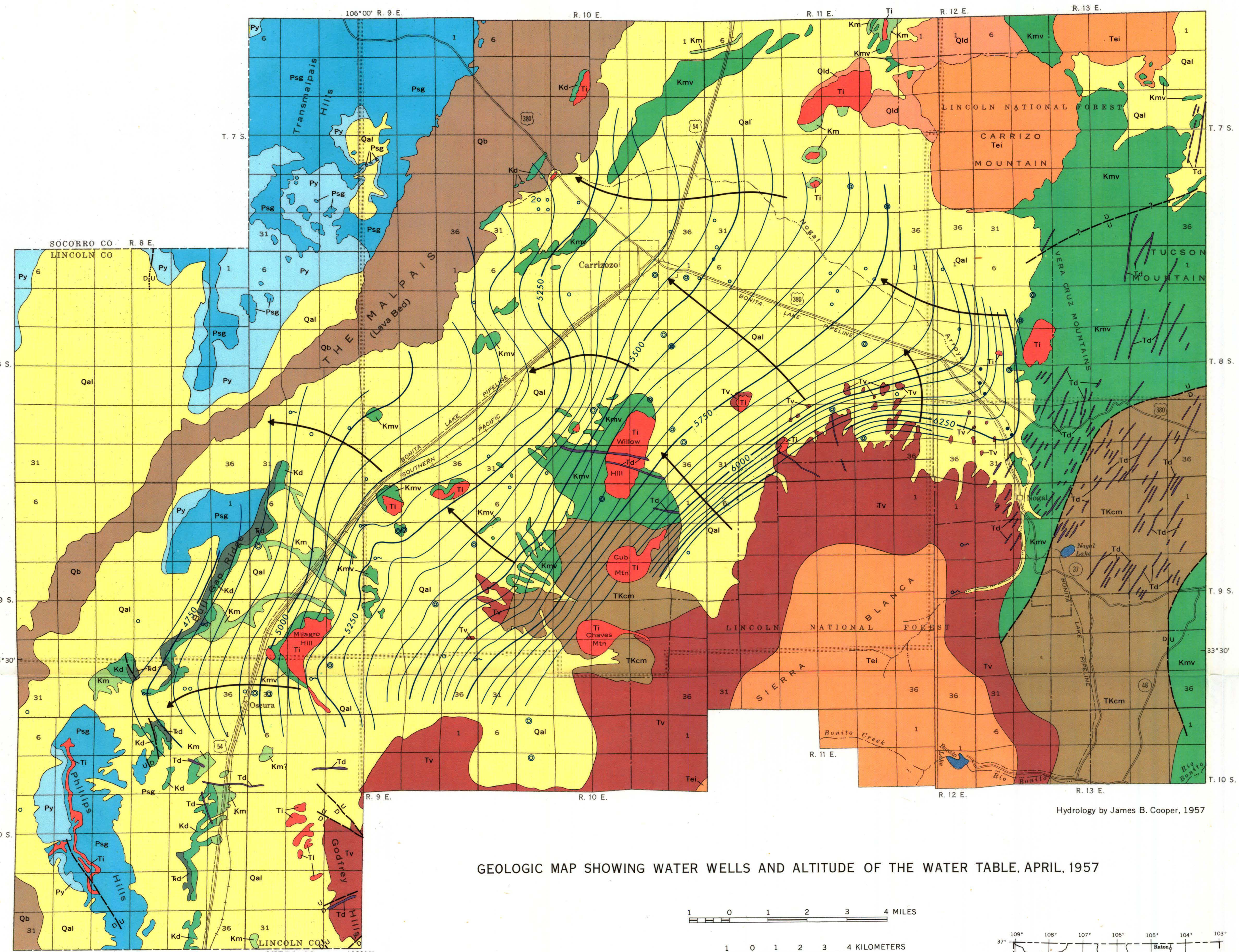


Hydrology by James B. Cooper, 1957

Base from U.S. Geological Survey topographic quadrangles

GEOLOGIC MAP SHOWING WATER WELLS AND ALTITUDE OF THE WATER TABLE, APRIL, 1957

EXPLANATION

SEDIMENTARY ROCKS

Qal — Alluvium
Clay, silt, sand, gravel, boulders. May include some gravel of Tertiary age. The principal aquifer; yields 10 to 400 gpm of water to wells

Qld — Landslide detritus
Mostly from Cretaceous rocks. Yields little or no water to wells

QUATERNARY

TKcm — Cub Mountain Formation of Bodine (1956)
Sandstone, quartzite, conglomerate. Not an aquifer; lies mostly above the water table

CRETACEOUS AND TERTIARY(?)

Upper Cretaceous

Kmv — Mesaverde Group
Coal-bearing sandstone and shale. Yields 5 to 25 gpm of water to wells

Km — Mancos Shale
Dark fissile shale. Yields little or no water to wells

Kd — Dakota Sandstone
Buff sandstone. May yield water to wells

CRETACEOUS

Upper Triassic

Ŧd — Dockum Group
Red beds, siltstone, sandstone, and conglomerate. Yields little or no water to wells

TRIASSIC

Psg — San Andres Limestone and Glorieta Sandstone
Limestone, gypsum, and sandstone. May yield water to wells in western part of area

Py — Yeso Formation
Gypsum, siltstone, limestone, and sandstone. May yield water to wells in western part of area

PERMIAN

IGNEOUS ROCKS

Qb — Basalt flow
Black to brown vesicular basalt. Yields no water to wells

QUATERNARY

Tv, Extrusive rocks
Ti, Intrusive rocks
Tei, Extrusive and intrusive rocks
Yield little or no water to wells

Td — Dike

TERTIARY

Contact
Dashed where approximately located

Fault, approximately located
Dotted where concealed; queried where doubtful.
U, *upthrown side*; D, *downthrown side*

5500 — Water-table contours
Dashed where data meager. Contour interval 50 feet; datum is mean sea level

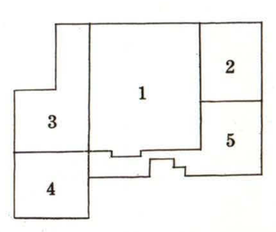
Well in alluvium
Numeral represents number of wells at indicated location

Well in Cretaceous rocks

Well in alluvium and Cretaceous rocks

Spring

Direction of ground water movements

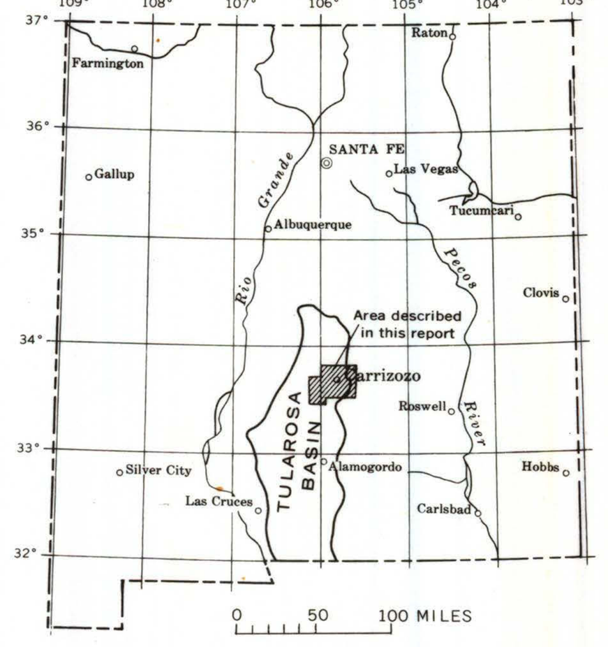


Boundaries shown by pattern on geologic map

SOURCES OF GEOLOGIC DATA

1. Weber, R. H., New Mexico Inst. Mining and Technology, State Bur. Mines and Min. Resources Div.(*).
2. Allen, J. E., and Jones, S. M., 1951.
3. Weir, J. E., Jr., 1957 (*).
4. Schmaltz, R. F., New Mexico Inst. Mining and Technology, State Bur. Mines and Min. Resources Div.(*)
5. Dane, C. H., and Bachman, G. O., 1957.

(*) Indicates unpublished map.



INDEX MAP OF NEW MEXICO

Table 1.—*Records of selected wells*

Township and range: S before number indicates spring.
Owner or name: The owner of, or name used for, well or spring at time of visit.
Altitude: Altitudes of land surface at wells and springs have been extrapolated from topographic maps.
Stratigraphic unit: Determined from field observation or from geologic map.
Depth: Depth below land-surface datum of well and water level: Reported depths are given to the nearest foot; measured depths are given to the nearest 0.1 foot. P, pumping level.
Diameter: The diameter of the casing, if cased, or the mean diameter of the well, if uncased.
Use of water: D, Domestic; I, irrigation; In, industrial; N, none; PS, public supply; S, stock.
Remarks: CA., chemical analysis given in table 2; gpm, reported yield in gallons per minute; IA, reported acres irrigated.

Township, range, section, and ¼ section locations	Owner or name	Year completed	Altitude (ft)	Stratigraphic unit	Depth of well (ft)	Diameter of well (in.)	Depth to water (ft)	Date of measurement	Use of water	Remarks
7S 10E 28 SENWSE	New Mexico Copper Corp.	1956	5,250	Alluvium	60	4	24.32	4- 2-57	In	100 gpm.
29 NWSE	J. F. Harkey	1951	5,210	do.	60	12	38.93	4-26-57	I	400 gpm; 20 IA.
29 NESE	do.	1957	5,205	do.	60	8	42.00	4-26-57	N	-
29 SWSE	do.	1957	5,205	do.	60	8	13.88	4-26-57	N	150 gpm.
29 SESE	do.	1954	5,205	do.	40	8	17.14	4-26-57	N	Do.
36 NWNWSW	State of New Mexico	1956	5,425	do.	61.9	8	22.87	4- 2-57	D	CA
7S 11E 26 SWSE	Benino Gallegos	1957	5,830	Cretaceous rocks	203	6	83.99	4-18-57	S	-
27 NESWNE	P. Pino	-	5,730	do (?)	98.2	6	80.84	4-18-57	S	-
31 SENWNW	Unknown	-	5,500	Alluvium	42.7	48	40.08	4-19-57	S	Dug well.
8S 9E 12 NESENE	do.	-	5,120	do.	19.5	48	16.77	4- 3-57	S	-
28 NWNESE	Branum Well	-	5,025	do.	61.0	-	Dry	4-23-57	N	-
S 29 SWNWNW	Lower Willow Spring	-	4,875	Cretaceous rocks and alluvium	-	-	-	-	S	CA; 5 gpm; improved spring.
34 SWSWSW	B. Nickels	-	5,110	Alluvium	62.3	6	P34.43	4-24-57	S	CA; "Cattle Guard Well".
8S 10E 1 SENESW	Town of Carrizozo	1954	5,540	Cretaceous(?) rocks	219.0	8	49.22	4-19-57	N	Test well; cased to 200 feet.
1 SWNESE	Mr. Petty	-	5,555	Alluvium(?)	114.5	6	61.27	4-19-57	N	-
13 SWSWNW	Bryce Duggar	1957	5,650	Cretaceous rocks	180	-	98.16	4- 3-57	PS	CA; 850 gpm.
23 NWSWSE	C. J. Harrold	-	5,700	do.	300	5	P69.09	4- 3-57	S	CA; reported dry in summer.
25 NWNWSW	Town of Carrizozo	1957	5,825	do.	350	6	113.53	4-25-57	N	Test well; 25 gpm.
25 SESESW	do.	1957	5,875	do.	216	10	118.40	4-25-57	N	Do.
31 NWSENW	Claude Branum	-	5,260	Alluvium	64.5	6	P62.70	4-24-57	S	CA.
32 SWNESE	C. J. Harrold	-	5,460	Alluvium(?)	115	7	P41.12	4-26-57	S	CA.
8S 11E 2 NWNESW	P. Pino	-	5,785	Alluvium	67.4	36	65.22	4-18-57	D,S	Dug well.
2 SWSWSE	Benino Gallegos	1900	5,805	do.	60	48	54.39	4-18-57	D,S	Do.
3 NESW	do.	-	5,730	do.	125	6	P43.74	4-18-57	S	CA.
6 SENWNW	Mrs. Pat Dunning	-	5,525	do.	55.7	8	P10.86	4-19-57	S	-
6 NWSWSE	J. B. Sidwell	1956	5,590	do.	106	8	46.60	4- 5-57	N	Casing slotted 71 to 106 feet; 200 gpm.
10 SESENW	Unknown	-	5,800	do.	-	6	P127.30	4-18-57	S	CA.
10 NWNWNE	do.	-	5,750	do.	55.0	36	Dry	4-18-57	N	Dug well.
14 NENWSW	Bryce Duggar	-	5,950	Cretaceous rocks	259.5	8	P227.15	4- 4-57	S	CA.
24 NWSWSW	Fulton Duggar	-	6,165	Alluvium(?)	110	6	P85.05	4- 4-57	S	CA.
26 SESWSW	Bryce Duggar	-	6,490	Cretaceous rocks	-	6	P86.08	4- 4-57	S	CA.
27 NENENW	do.	-	6,180	Cretaceous(?) rocks	126.4	8	82.97	4- 4-57	N	-
8S 12E 1 NWSW	F. W. Leach	-	6,020	Alluvium(?)	81.3	6	P76.42	4-17-57	S	CA.
13 NWNWNE	do.	-	6,010	do.	100	6	P62.73	4-17-57	S	CA.
8S 13E 8 SENENW	do.	-	-	Cretaceous rocks	150	6	P101.75	4-17-57	S	-
8 SWSW	Walter Snell	-	6,430	do.	164.0	6	117.93	4-17-57	S	-
19 NWNWNW	F. W. Leach	1956	6,090	Alluvium and Cretaceous rocks	100	14	24.52	4-17-57	N	Test well.
19 SWSWNW	do.	1956	6,100	do.	100	6	17.34	4-17-57	N	Do.
19 NENE	do.	1953	6,300	Cretaceous rocks	125	6	P69.10	4-17-57	S	CA.
19 SESW	F. W. Leach	1957	6,170	Alluvium and Cretaceous rocks	200	12	21.14	4-17-57	N	Test well; casing slotted 0 to 200 feet; 400 gpm.
30 NWNESE	Fulton Duggar	1951	6,260	do.	300	10	23.36	4- 5-57	I	CA; 170 gpm.
30 NESESE	do.	1954	6,275	do.	218	8	28.74	4- 5-57	I	CA; cased to 20 feet; 300 gpm.
S9S 8E 23 SWNESE	Bull Gap Spring	-	4,825	Triassic rocks	-	-	-	-	N	CA; 1 to 2 gpm; unimproved spring.
S 34 SWSENW	Phillips Spring	-	4,750	Alluvium and Cretaceous rocks	-	-	-	-	S	CA; 3 gpm; improved spring.
S9S 9E 9 NENENE	Root Spring	-	5,200	Cretaceous rocks	-	-	-	-	S	CA; 5 gpm; improved spring.
10 SENENE	Brack Cornett	-	5,280	do.	123.0	5	P76.26	4-26-57	S	-
S 10 SWSESW	Jake's Spring	-	5,290	do.	-	-	-	-	D,S	CA; 30 gpm; improved spring.
11 SWNWNW	Brack Cornett	-	5,280	do.	60	5	P16.98	4-26-57	S	CA.
12 NENESE	C. J. Harrold	-	5,485	do.	229	6	P162.00±	4-24-57	S	CA.
23 NENENE	do.	-	5,495	do.	126.0	6	P109.28	4-24-57	S	CA.
S 25 NENESE	I Bar X Spring	-	5,720	Alluvium	-	-	-	-	S	CA; 4 to 5 gpm; improved spring.
S 32 NWNWNE	Milagro Spring	-	5,265	Cretaceous rocks	-	-	-	-	N	CA; 15 to 20 gpm; unimproved spring.
9S 10E 3 NWSENW	C. J. Harrold	-	5,675	do.	39.4	7	22.87	4-26-57	S	CA.
6 NENWNE	do.	-	5,350	Alluvium	70	6	P36.90	4-24-57	S	CA.
8 NWSE	do.	-	5,600	Alluvium(?)	131.0	6	41.70	4-26-57	S	-
12 NESESW	do.	-	6,390	Alluvium	83.0	7	P72.63	4-25-57	S	CA.
S9S 12E 12 NWSE	Nugget Spring	-	6,800	Cretaceous(?) rocks	-	-	-	-	N	CA; 1 gpm; unimproved spring.
S 13 SESW	Tunnel Spring	-	7,200	do.	-	-	-	-	N	CA; 2 gpm; unimproved spring.

Table 2.—*Chemical analyses of water from selected wells and springs*

(Analyses by U.S. Geological Survey. Chemical constituents are in parts per million.)
Township and Range: S before number indicates spring.

Township, range, section, and ¼ section locations	Date collected	Temperature (°F)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium plus Potassium (as Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Sodium adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH
a 7S 10E 29 NESE	4-26-57	62	-	-	-	-	170	1,040	363	-	-	-	140	1,180	-	-	2,920	7.5
36 NWNWSW	4- 2-57	58	-	-	-	-	148	723	241	-	-	-	121	854	-	-	2,130	7.5
b 7S 11E 31 SWSESW	4-19-57	60	-	-	-	-	178	651	163	-	-	-	146	684	-	-	1,850	7.5
S8S 9E 29 SWNWNW	5-18-55	62	-	-	-	-	150	1,140	470	-	-	2,560	120	1,300	-	-	3,340	7.4
c 29 SENWSE	5-18-55	68	-	-	-	-	178	1,190	440	-	-	2,610	150	1,290	-	-	3,350	7.3
34 SWSWSW	9-20-55	66	-	-	-	308	179	1,380	525	0.3	5.7	-	150	1,510	29	3.3	3,860	7.2
d 8S 10E 2 NWSE	-	-	-	153	38	39	184	255	77	-	-	790	-	-	-	-	-	-
e 9 NENENW	4-25-57	58	-	-	-	-	172	391	119	-	-	-	141	424	-	-	1,320	7.3
13 SWSWNW	11-28-55	-	25	212	56	81	147	609	126	.1	4.4	-	121	639	19	1.3	1,630	7.2
f 14 NENENE	12- 7-56	-	28	228	45	97	142	620	136	.1	3.2	1,230	116	638	21	-	1,670	7.3
23 NWSWSE	4- 3-57	61	-	-	-	-	189	516	101	-	-	-	155	555	-	-	1,520	7.6
g 27 NWNWNW	4- 2-57	67	-	-	-	-	343	1,060	82	-	-	-	281	999	-	-	2,430	7.2
31 NWSENW	4-24-57	63	-	-	-	-	192	1,300	458	-	-	-	160	1,160	-	-	3,650	7.2
32 SWNESE	4-26-57	71	-	-	-	-	274	632	148	-	-	-	225	540	-	-	1,920	7.3
8S 11E 3 NESW	4-18-57	61	-	-	-	-	183	579	110	-	-	-	150	630	-	-	1,600	7.5
10 SESENW	4-18-57	64	-	-	-	-	116	594	286	-	-	-	195	870	-	-	2,020	7.5
14 NENWSW	4- 4-57	56	-	-	-	-	134	800	160	-	-	-	110	790	-	-	1,990	7.6
24 NWSWSW	4- 4-57	53	-	-	-	-	176	840	178	-	-	-	144	976	-	-	2,130	7.3
26 SESWSW	4- 4-57	58	-	-	-	-	221	1,440	172	-	-	-	180	1,440	-	-	2,970	7.2
8S 12E 1 NWSW	4-17-57	60	-	-	-	-	219	463	216	-	-	-	180	640	-	-	1,750	7.0
13 NWNWNE	4-17-57	60	-	-	-	-	232	785	129	-	-	-	190	880	-	-	1,970	7.5
8S 13E 19 NENE	4-17-57	61	-	-	-	-	187	889	219	-	-	-	150	1,110	-	-	2,330	7.3
30 NWNESE	4- 5-57	58	-	-	-	-	260	736	99	-	-	-	213	732	-	-	1,870	7.5
30 NESESE	4- 5-57	57	30	189	82	89	248	649	86	.7	.5	1,210	202	606	19	1.4	1,730	7.4
h 9S 8E 22 NWNWSW	5-31-55	72	-	-	-	-	175	2,160	960	-	-	4,960	140	2,480	-	-	5,870	7.7
S9S 8E 23 SWNESE	11- 3-55	-	20	578	301	684	249	2,680	830	.5	1.0	5,530	200	2,480	36	5.7	6,290	7.6
i 31 SWSESW	5-31-55	65	-	-	-	-	97	1,440	262	-	-	2,670	80	1,400	-	-	3,150	7.6
S 34 SWSENW	5-31-55	68	-	-	-	-	204	810	272	-	-	1,760	167	803	-	-	2,420	7.9
j 35 NWSENW	6- 1-55	73	-	-	-	-	143	784	385	-	-	1,920	120	1,040	-	-	2,600	7.9
k 35 NESENW	6- 1-55	67	-	-	-	-	148	773	320	-	-	1,830	122	958	-	-	2,440	7.6
l 36 SESENE	6- 1-55	70	-	-	-	-	475	274	148	-	-	1,030	108	0	-	-	1,670	8.1
m 9S 9E 7 NENWSW	4-23-57	62	-	-	-	-	210	1,340	384	-	-	-	170	1,360	-	-	3,430	7.0
S 9 NENENE	8-23-55	63	-	-	-	170	177	842	285	.2	7.0	1,840	145	915	26	2.3	2,420	7.7
S 10 SWSESW	8-23-55	63	-	-	-	135	105	744	166	.5	9.8	1,480	86	724	27	2.1	1,920	7.6
11 SWNWNW	4-26-57	73	-	-	-	-	149	711	200	-	-	-	122	758	-	-	2,030	7.5
12 NENESE	4-24-57	63	-	-	-	-	186	2,210	182	-	-	-	150	1,390	-	-	4,230	7.8
23 NENENE	4-24-57	66	-	-	-	-	161	683	194	-	-	-	132	728	-	-	1,990	7.3
n 25 SWSWNE	10-19-55	-	29	181	62	119	220	538	150	.1	15	1,250	180	526	27	1.9	1,710	7.4
S 25 NENESE	10-19-55	63	31	171	62	110	225	501	144	.1	15	1,190	185	497	26	1.8	1,650	7.4
o 29 SENESE	9-20-55	65	30	134	58	98	184	434	127	.3	4.3	1,010	151	422	27	1.8	1,440	7.4
p 31 SWSWNW	-	-	-	2	6	412	392	215	115	-	-	1,098	-	-	-	-	-	-
q 31 SWSWNE	8-23-55	77	-	-	-	436	243	1,420	530	.3	2.5	-	200	1,280	39	-	4,070	7.4
S 32 NWNWNE	8-18-55	-	-	-	-	-	198	564	288	-	-	1,430	162	658	-	-	2,050	7.5
9S 10E 3 NWSENW	9-13-56	-	25	175	83	131	332	550	151	.9	4.0	1,390	272	506	27	2.0	1,880	7.5
6 NENWNE	4-24-57	64	-	-	-	-	195	1,300	346	-	-	-	160	1,160	-	-	3,330	7.9
12 NESESW	9-13-56	-	20	130	60	40	294	304	68	.6	4.9	833	241	330	13	.7	1,170	7.6
S9S 12E 12 NWSE	4-16-57	-	-	-	-	-	227	1,110	122	-	-	-	190	1,230	-	-	2,340	7.6
S 13 SESW	4-16-57	-	-	-	-	-	191	730	61	-	-	-	156	784	-	-	1,600	7.1
r 10 S 8E 18 NWSWNW	6- 2-55	-	-	-	-	-	379	2,340	840	-	-	5,260	310	2,670	-	-	6,030	7.6
s 10 S 9E 5 SWNENW	9-20-55	65	-	-	-	165	158	716	288	.3	20	1,650	130	810	28	2.3	2,230	7.4
t 8 NWNENW	9-20-55	69	-	-	-	514	155	1,030	278	1.0	4.0	-	127	353	70	10	2,940	7.2

OWNER AND NAME	STRATIGRAPHIC UNIT
a J. F. Harkey	Alluvium
b Mrs. Pat Dunning	do.
c George McDonald	do.
d Southern Pacific Co.	Cretaceous and pre-Cretaceous rocks
e J. West	Alluvium
f Town of Carrizozo	Cretaceous rocks
g C. J. Harrold	Alluvium or Permian rocks
h P. Withers	do.
i Do.	Alluvium
j Rube McDonald	do.
k Do.	do.
l L. S. Drake	Alluvium
m B. Nickels	Cretaceous rocks
n C. J. Harrold	Alluvium
o B. Nickels	Cretaceous rocks
p Southern Pacific Co.	Do.
q B. Nickels	Do.
r A. Helm	Alluvium
s B. Nickels	Cretaceous(?) rocks
t C. J. Harrold	Do.

d,p Analyses from Meinzer and Hare (1915).

INTRODUCTION

This report presents information about the hydrology of the northern part of the Tularosa Basin, near Carrizozo, N. Mex. The area covers about 500 square miles lying mostly within the basin, but including the edge of the bordering mountains on the east. The invesigation was conducted in cooperation with the U.S. Army, Corps of Engineers, to determine the availability and quality of water that might be utilized by military installations in and near the basin.

Tularosa Basin is an elongated valley more than 200 miles long and 24 to 60 miles wide that extends southward from the Carrizozo area into the State of Chihuahua, Mexico.

The area described in this report is bounded on the east by Sierra Blanca, Vera Cruz, Tuscon, and Carrizo Mountains and on the west by a long, narrow flow of Recent basalt, The Malpais. South of Carrizozo, and west of Sierra Blanca, a ridge composed of Willow Hill, Cub, and Chaves Mountains has a west-facing front more than 1,000 feet higher than the general level of the valley floor to the west. Between this ridge and The Malpais are numerous smaller ridges and escarpments. The land surface slopes to the west and south; at Nogal the altitude is 6,476 feet, at Carrizozo 5,429 feet, and at Oscura, 5,016 feet.

Permanent bodies of surface water and perennial streams are absent west of the mountains in the Carrizozo area. Several springs discharge small amounts of water that percolate back into the ground within a few hundred feet.

Sierra Blanca drains largely to the east into the Rio Bonito drainage basin. Rio Bonito is perennial from its headwaters in the mountains to Bonito Lake in sec. 12, T. 10 S., R. 12 E. Below the lake it is intermittent. Nogal Lake in sec. 9, T. 9 S., R. 13 E. is in a natural basin and provides storage for a relatively small amount of runoff from the mountains.

On the western flanks of Sierra Blanca, Vera Cruz, Tuscon, and Carrizo Mountains, storm runoff is discharged into the Tularosa Basin through small westward trending arroyos on the Mountain slopes and through larger arroyos that occupy the gaps between the mountains. Much of the runoff carried by these arroyos percolates into the ground before it reaches The Malpais, where the main arroyos terminate.

The climate is semiarid. At Carrizozo the annual precipitation is about 13 inches, most of which is heavy precipitation from a few storms during the summer. The mean annual temperature is about 56°F, and in both summer and winter the days are generally warm and the nights are cool. On the plains the vegetation is sparse and desertlike, but in the higher mountains heavier precipitation sustains forests.

GEOLOGY

Northern Tularosa Basin near Carrizozo is underlain by eastward-dipping sedimentary rocks of Permian, Triassic, Cretaceous, and Tertiary(?) ages (map). These strata have been intruded in many places by igneous rocks of various kinds and are overlain in part by Tertiary and Quaternary volcanic rocks. Except for scattered outcrops of these older rocks, alluvium of Quaternary age is the surface formation in the main part of the valley and in the reentrants of the mountains east of the valley.

The Yeso Formation, the San Andres Limestone, and the Glorieta Sandstone of Permian age crop out in the western part of the Carrizozo area and are the oldest rocks exposed. Rocks of the Dockum Group, of Triassic age, crop out near Oscura and rocks of Cretaceous age crop out near Nogal, Carrizozo, and Oscura.

Exposed rocks of Cretaceous age, from oldest to youngest, are the Dakota Sandstone, the Mancos Shale and the Mesaverde Group (Late Cretaceous). These rocks consist of alternating beds of shale, sandstone, and limestone, and show extensive intertonguing, owing to repeated regression and transgression of the Late Cretaceous sea. The thickness of the Mancos Shale between Bull Gap Ridge and Milagro Hill, is about 1,200 feet (oral communication, J. E. Weir, Jr., 1957). Elsewhere in the area the total thickness of Cretaceous rocks may exceed 2,000 feet.

The Dakota Sandstone crops out discontinuously along the west side of the valley paralleling U.S. Highway 54. The sandstone generally is buff colored, but in places is heavily iron stained and cemented, and contains thin layers of shale. The grain size ranges from fine to very coarse.

The Mancos Shale crops out in low areas near the middle of the valley east of the outcrop of the Dakota. The Mancos is chiefly a dark fissile shale containing, in places, numerous limy concretions, iron-cemented nodules, and thin beds of sandstone and limestone. It also contains much vein, sheet, and crystal gypsum.

The Mesaverde Group crops out irregularly in areas ranging from a few acres to several square miles in several places within the valley and on the larger ridges and hills south of Carrizozo. The largest outcrop is in the vicinity of Nogal and Tuscon Mountain. The Mesaverde is composed of buff sandstone interbedded with varicolored shale, thin beds of limestone, and coal. Coal has been mined at several places, notably at Milagro Hill and in the gap between Willow Hill and Cub Mountain.

The type locality of the Cub Mountain Formation of Bodine (1956) of Tertiary(?) age is Cub Mountain, about 7 miles south of Carrizozo. Extensive outcrops of these rocks also are present southeast of Nogal.

Volcanic rocks of Tertiary age are exposed along the flank of Sierra Blanca, where they are cut by dikes in many places. Dikes and sills also occur in the Cretaceous rocks, and the crests of several hills are composed of sills that protect the Cretaceous escarpments from erosion.

Alluvium of Quaternary age, and possibly in part of Tertiary age in the area is composed of rock waste from the mountains and consists mostly of clay, silt, sand, gravel, and boulders. These materials form a heterogeneous deposit that differs considerably over short lateral distances. Sand and gravel strata at one locality cannot be expected to be present elsewhere at the same horizon. Boulders and coarse gravel are common near the mountains; fine-grained deposits predominate at lower elevations. Most of the clayey deposits are gypseous and commonly grade into nearly pure gypsum. The alluvium is thickest near the middle of the basin. Reportedly it is about 180 feet thick about a mile south of Carrizozo; the average thickness, between 50 to 100 feet, occurs eastward and southwestward of Carrizozo.

One of the most striking geological features of the area is a basalt flow of Recent age, The Malpais, which occupies an old stream course of an arroyo west of Carrizozo. The lava was erupted from a crater a few miles north of Carrizozo and flowed southwestward for about 45 miles. The maximum width of the flow is 5½ miles, and the average thickness is about 100 feet; near the crater it is several hundred feet thick.

GROUND WATER

Most wells in northern Tularosa Basin tap water-bearing beds in either unconsolidated deposits of Quaternary age or rocks of Cretaceous age.

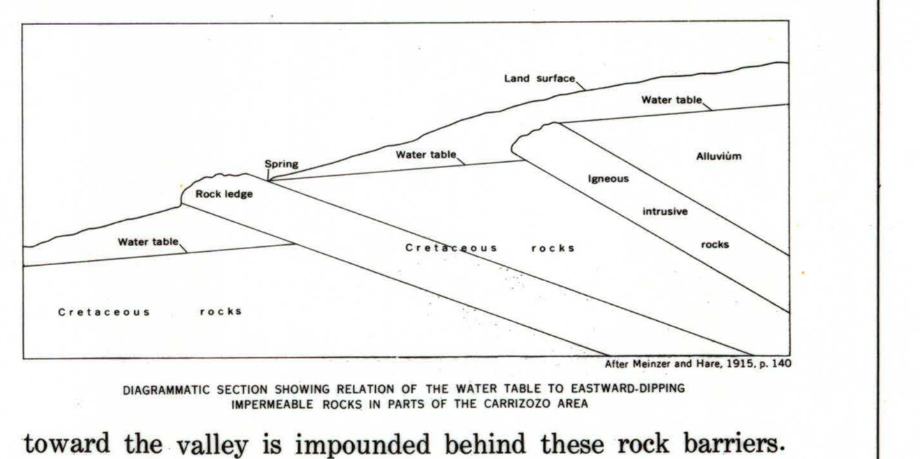
An occasional spring seeps from rocks of Triassic age, and a few wells yield small quantities of water from rocks of Permian age near the western edge of the area. Elsewhere these older rocks are too deeply buried to be utilized as aquifers. Although only sparse data are available on their water-bearing qualities, because of their depth of burial and their gypseous composition they probably contain impotable water. The Cub Mountain Formation of Bodine (1956), where present, lies mostly above the water table, and no wells in the area are known to tap it.

The principal aquifer is alluvium of Quaternary age. At places, near Carrizozo, several tens of feet of the alluvium is saturated and yields in excess of 100 gpm (gallons per minute) are obtained from wells. Sandstone in the underlying Cretaceous rocks forms an aquifer in places and is tapped by wells where the alluvium is thin or relatively impermeable.

Ground water in the alluvium is under water-table conditions. In rocks of Cretaceous age the water is under different degrees of artesian pressure, although in much of the area the pressure is negligible, and the shallower Cretaceous aquifers, at least, probably are in hydraulic connection with the alluvium. The deeper Cretaceous aquifers that were tapped at Carrizozo and Oscura in wells drilled by the El Paso and Northeastern Railroad Co. in the early 1900's, and since destroyed, probably contained water under considerable artesian pressure. Meinzer and Hare (1915, p. 147, 150) report static water levels of 193 feet for a well 1,125 feet deep at Carrizozo and 100 feet for a well 965 feet deep at Oscura.

The altitude and configuration of the water table are shown on the map. In general, the water table slopes from the mountains toward the valley. Near the mountains the depth to water is about 100 feet. Away from the mountains the depth to water is shallower as the altitude of the land surface decreases. East of Carrizozo ground water moves westward and northwestward and in general follows the direction of Nogal Arroyo past Carrizozo towards The Malpais. Southwest of Carrizozo water moves generally northwestward toward The Malpais.

The water table is not a plane surface but has irregularities comparable with and related to those of the land surface, although much more subdued. The irregularities are caused chiefly by local differences in geology and topography. In the valley southwest of Carrizozo and in the reentrant between Sierra Blanca and Vera Cruz Mountain impermeable rock ledges in the eastward-dipping strata of Cretaceous age, and intrusive rocks of Tertiary age, commonly form barriers that retard the movement of the ground water and create springs (see section). Ground water moving from the mountains



DIAGRAMMATIC SECTION SHOWING RELATION OF THE WATER TABLE TO EASTWARD-DIPPING IMPERMEABLE ROCKS IN PARTS OF THE CARRIZOZO AREA

toward the valley is impounded behind these rock barriers. The reservoir of water created in this manner is commonly small but does cause high ground-water levels of low gradient behind the barriers. Several wells in the reentrant, along Nogal Arroyo, tap such reservoirs of water contained in alluvium overlying the Cretaceous rocks. The wells are drilled 100 to 200 feet into the Cretaceous rocks and are so constructed that water is yielded to the well from both Cretaceous sandstone and the aquifer in the alluvium. Some of these wells are reported to have an initial yield of as much as 500 to 600 gpm for several hours, after a period of shutdown. Sustained yield of the well, however, after depletion of the water stored in the alluvium, is less than half that of the initial yield.

The alluvium near Carrizozo is recharged chiefly by runoff from the mountains. The area of runoff includes about 50 square miles, or 32,000 acres, which, with an average annual precipitation estimated to be 15 inches, would discharge 40,000 acre-feet of water (Hendrickson, 1949, p. 4), if it all ran off. Evaporation and transpiration during the hot summer months probably is great and the recharge to the alluvium may be only a small part of the total precipitation. Recharge to the Cretaceous rocks within the basin is principally by precipitation on The Malpais where the basalt overlies sandstone. Annual precipitation on that part of the lava west of Carrizozo is about 20,000 acre-feet. Because of almost no runoff from the lava and the absence of vegetation, most of the precipitation is available for recharge.

Ground water in the area is discharged naturally through springs, and, where the water table is near the surface, by evaporation and transpiration. The major discharge, however, is pumpage from more than 100 wells.

The locations of selected wells and springs used in the preparation of the water-table map are shown on the map; pertinent records are given in table 1. Wells range in depth from less than 50 to about 300 feet. At Carrizozo and Oscura, wells have been drilled to depths of 1,125 and 965 feet, respectively. The deeper wells tap rocks of Cretaceous age, although several also tap the overlying alluvium. Stock and domestic wells are pumped only a few gallons per minute. Those used for irrigation and public supply are pumped from 60 to 500 gpm.

The principal use of water is for public supply, domestic, and stock purposes. Water from about a dozen wells is used for irrigation. Use of water by industry is negligible. A well in the NW¼SW¼SW¼ sec. 13, T. 8 S., R. 10 E. has been used to supplement surface water in the Bonito Lake pipeline. Water is transported through this pipeline from Bonito Lake reservoir, on the east slope of Sierra Blanca, to the city of Alamogordo and Holloman Air Force Base in Tularosa Basin, more than 60 miles south of Carrizozo. The lake water, which is potable, is mixed with ground water high in total solids in storage reservoirs near Alamogordo. The resultant water is of a quality acceptable for most uses.

QUALITY OF WATER

The most objectionable mineral constituents in water sampled in the Carrizozo area are sulfate and chloride. The U.S. Public Health Service (1962) recomends that a drinking water supply should not contain more than 250 ppm (parts per million) sulfate, 250 ppm chloride, or 500 ppm dissolved solids, where other more suitable supplies are or can be made available.

In many sections of the United States, and especially in Tularosa Basin, the quality of water available does not meet these standards in one or more repects. Nevertheless, residents of such areas have used the water, often for many years, for drinking and other domestic use without adverse effect. Most of the more common constituents in drinking water appear to be objectionable only when they are present in such high concentrations as to be distasteful.

In this report, potable water is defined as water in which neither the sulfate nor the chloride ions are present in excess of 250 ppm. Inferior water is defined as water that contains between 250 and 500 ppm of either sulfate or chloride ions and less than 750 ppm of the two together. Impotable water is defined as water containing more than 500 ppm of either sulfate or chloride or more than 750 ppm of chloride and sulfate together.

The upper limits of mineral constituents in water used for livestock is many times greater than in water used for human consumption. Hem (1959, p. 241) reports that range cattle in the western United States often use water containing from 5,000 to 10,000 ppm dissolved solids.

Analyses of water from selected wells and springs are given in table 2. These analyses indicate that water from both the alluvium and from rocks of Cretaceous age is mostly of inferior quality and that much of it is impotable. Only a few wells sampled yielded water which approached potability.

SUMMARY

The best aquifer near Carrizozo is alluvium of Quaternary age, which is partly saturated and will yield fairly large quantities of water to wells over an area of about 50 square miles near and east of Carrizozo. Sandstone beds in the underlying rocks of Cretaceous age form a more widespread aquifer, which yields far smaller quantities of water to wells. Generally the water from both the alluvium and sandstone aquifers is of inferior quality, although it is suitable for stock and in some places for human consumption.

Wells 100 to 200 feet deep in the thicker sections of alluvium can yield as much as 400 gpm. Wells as deep as 1,000 feet in Cretaceous rocks can yield 50 to 100 gpm. On the basis of presently available information, as much as 20,000 acre-feet (6½ billion gallons) per year of inferior and impotable water could be obtained from wells in the Carrizozo area. At certain localities the sulfate content of the water is much less than it is at others, and a considerable quantity of water containing about 600 ppm sulfate probably could be obtained from the alluvium near Carrizozo.

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GROUND-WATER RESOURCES OF THE NORTHERN TULAROSA BASIN NEAR CARIZOZO, LINCOLN COUNTY, NEW MEXICO

By
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1965

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