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WATER RESOURCES OF THE CAPULIN TOPOGRAPHIC BASIN, COLFAX AND UNION COUNTIES, NEW MEXICO

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Abstract—Large quantities of ground water are present in the Capulin ground-water basin. It is estimated that the Capulin aquifer contains from 740,000 to 900,000 acre-ft of water in transient storage. Probably 222,000 to 270,000 acre-ft can be recovered through pumping at an annual rate of 7,000 acre-ft per year over a period of 32 to 39 years. Appreciable declines in water levels in the basin will result from pumping at this rate.

The highest yields are in the vicinity of the village of Capulin. A major portion of the aquifer, from about five mi west of Capulin east to the Union County line, is relatively untested. Most of the portion of the aquifer overlain by volcanic rocks is also untested.

No aquifer-test data are available which could be used for computing the transmissivity and coefficient of storage, two values that are essential in long-range planning of aquifer development.

The ground water is chemically suitable for most municipal or industrial needs. Total dissolved solids generally do not exceed the recommended standards of the Public Health Service; silica content commonly is less than 35 mg/l.

The average annual discharge of Una de Gato Creek at the gaging station one mi below Throttle Dam was 3.48 ft^3/s for the period of record, May 1975 through September 1983.

INTRODUCTION

A study was made in June and July 1975, of the water resources of the Capulin topographic closed basin lying south of Johnson Mesa and southwest of Capulin National Monument. The study was initiated at the request of the management of Plains Electric Generation and Transmission Cooperative Inc., as one of several appraisals of potential sites for the location of a new generating plant. This paper is a slightly-modified version of the report submitted to Plains Electric Generation and Transmission Cooperative Inc. The authors thank the management of Plains Electric for permission to publish this report, thus making available to the public information on the hydrology of the region that may be of help in the future development of water resources.

The study included an investigation of the occurrence of ground water in the Capulin basin and an appraisal of potential supplies of surface water from the Una de Gato Creek upland drainage basin northwest of the Capulin basin.

A reconnaissance of the area was made to determine the geologic conditions, to evaluate the accuracy and usefulness of existing data and to determine the boundaries of the Capulin topographic ground-water basin (which does not coincide with the Capulin basin). About 160 wells were visited to determine water levels, well characteristics and water quality. Well logs and other historical data pertinent to the study were obtained from files, publications and property owners.

The Capulin basin is located in eastern Colfax County and western Union County (Fig. 1). The village of Capulin is on the eastern edge of the area. The drainage within the basin is interior, whereas the surrounding country is drained by tributaries of the Canadian and Cimarron River systems. The Canadian drainage on the west is included within the Canadian River underground water basin as declared by the New Mexico State Engineer; ground water within that basin is administered by the State Engineer.

Griggs's (1948) report on the geology and ground-water resources of eastern Colfax County included much of the area covered by this paper. However, the report contained little information of value on the hydrology of the area included in this paper, being concerned mainly with the region to the west. Cooper and Davis's (1967) report on ground water in Union County contained somewhat more information, but again stopped at the county line and included only a small part of the area studied for this paper. Of particular value was information provided by Cooper and Davis (1967) on wells in the vicinity of Capulin. Dinwiddie and Cooper (1966) summarized the water-bearing characteristics of the various geologic formations in the vicinity of Capulin but gave no details on water levels or yields. Herrick (1951), in a short memorandum report, discussed the possibilities of irrigation in the Capulin area.

An area of about 500 mi^2 was included in the original study for Plains Electric to assure that the boundaries of the ground-water basin could be defined as accurately as possible without test drilling. About 360 mi^2 are included in the maps accompanying this paper.

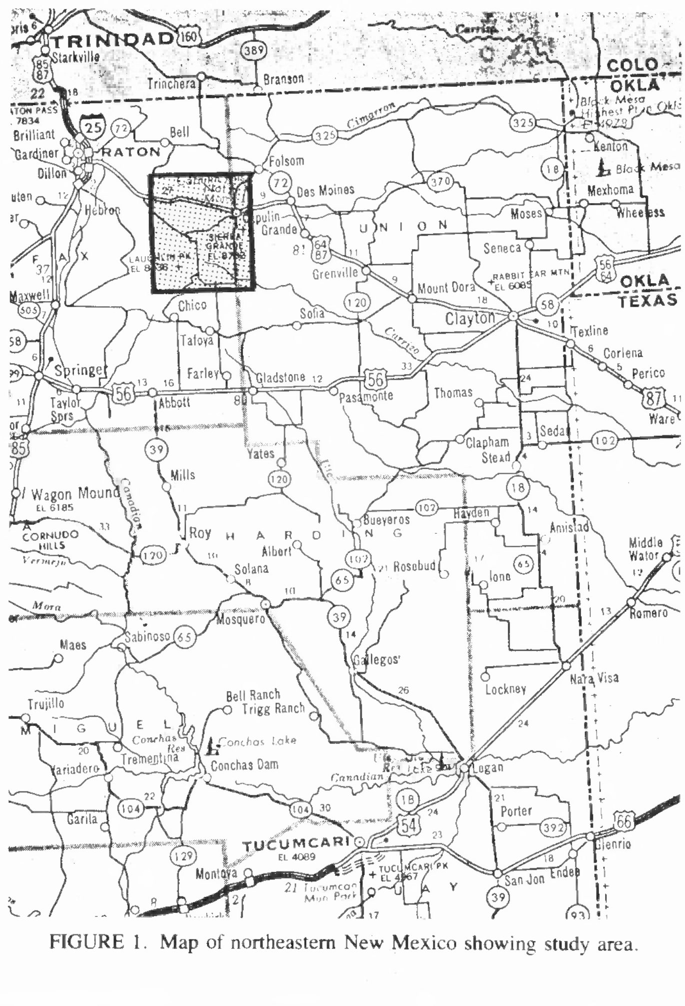

FIGURE 1. Map of northeastern New Mexico showing study area.

The Capulin basin is characterized by relatively flat to gently sloping alluvial plains, shallow closed basins and scattered playas. Rising above these plains are numerous volcanic features including steep-sided cinder cones, mesas and low-lying lava flows of Quaternary age. These deposits overlie a thick sequence of shale and fine-grained sandstone of Cretaceous age which forms a relatively impermeable barrier to the downward movement of ground water.

ROCK CHARACTERISTICS

The rocks that underlie the volcanic rocks and alluvium are sandstone, shale and limestone of Late Cretaceous age. They include black to gray shale of the Niobrara Formation, including the Fort Hays Limestone Member and the Carlile Shale. These units can have a combined thickness of as much as 1,200 ft. They are mostly dense and relatively impermeable and cannot be considered as a source of water for anything but low-yield stock wells. In general, water from these rocks is of poor quality, commonly unsuited for human or most industrial use.

The volcanic rocks are of varied composition; they are mostly of Pleistocene age, but some of the cinder cones, particularly Capulin Mountain, are of Holocene age. A few of the large mountains surrounding the basin, including peaks such as Palo Blanco and Laughlin Peak, are probably of late Tertiary-early Quaternary age. Basaltic flows, mostly less than 100 ft thick, are highly jointed and broken. Surfaces of the flows are rough and blocky and only thinly, if at all, covered with alluvium. Pressure domes and ridges are prominent on the surfaces crossed by U.S. Highway 67-84 west of Capulin. Around the margins of the basin the slopes up to the various cones and vents are underlain by coarse cinders and scoria which, like the flows, are only thinly covered by soil. Bedded scoria and cinders are reported in logs for wells in the Capulin basin. These deposits formed in the lake that resulted from the damming of the ancestral Pine Viente Creek by flows issuing from Capulin Mountain (Baldwin and Muehlberger, 1959, p. 128). The highly jointed, rough-surfaced basalt flows and the areas underlain by the scoria are of great hydrologic importance because where they are above the water table they serve as recharge conduits to transmit large quantities of precipitation downward to the water table. Where they lie below the water table they are aquifers having large storage capacity and high transmissivity. The porosity of the bedded cinders and scoria may be as great as 50%.

The alluvium that underlies most of the valley plain is relatively fine-grained in its upper portions, but at depth it consists of fine-to-medium sand and fine gravel which is moderately-to-well sorted. It, like the scoria and cinders, is highly porous and transmissive and will yield large quantities of water to wells. The alluvium and the volcanic rock together constitute the principal aquifer of the Capulin ground-water basin.

The playa beds are largely underlain by clayey gumbo that tends to support water, thus essentially preventing infiltration; lenses and beds of clay overlie some of the deeper beds of scoria, sand and gravel. Such clay layers are believed to act as confining beds and are responsible for the local artesian conditions reported in some wells near Capulin, at the lower (east) end of the basin.

THICKNESS AND EXTENT OF AQUIFER

The Capulin aquifer in the Capulin ground-water basin is believed to underlie an area of at least 105 mi^2 in parts of Colfax and Union Counties. The exact extent of the aquifer is difficult to determine without detailed mapping and test drilling, which was not scheduled as part of this study. Locally, in the vicinity of Capulin, the alluvium rests directly on lava, cinders and scoria, and these same deposits overlie the alluvium on the north flank of the basin.

In general, the thickness of the aquifer is poorly defined. Available data indicate that the maximum thickness probably is about 180 ft or perhaps a little more, thinning to less than 20 ft under much of the alluvial plain (Fig. 2). Detailed information is available only for the T-O Ranch property in the northwest part of the basin. A total of 24 test holes were drilled in T29N and T30N, R26E and R27E during 1972. With the exception of one hole that was lost at 38 ft due to drilling problems, the holes ranged in depth from 80 to 514 ft. Not all of the test holes were developed as wells, and only those that could be located and were open to measurement in 1975 are included in Table 1.

Most of the tests were drilled through the alluvium and cinders and about 20 ft into the underlying shale. Elsewhere in the basin, numerous wells have been constructed for stock or domestic purposes; however, because of the high productivity of the aquifer, few if any of these completely penetrated the aquifer.

None of the wells near Capulin have fully penetrated the aquifer. Records for a few wells indicate that the aquifer in that area may be more than 100 ft thick. A well drilled by the Park Service at Capulin National Monument reportedly penetrated 680 ft of saturated volcanic and alluvial material without reaching the underlying shale. However, this well is located in an unusual geological situation.

The maximum thicknesses of the aquifer are believed to occur along an east-west axis in the north half of T29N, R26E and R27E. North of this axis the aquifer is overlain by a thick sequence of volcanic rocks and is virtually untested. The aquifer feathers out to the south against the arc of volcanic cones, buttes and mesas that define the southern margin of the basin.

RECHARGE, MOVEMENT AND DISCHARGE OF GROUND WATER

The average annual precipitation at Capulin is approximately 15 inches. However, precipitation commonly increases with an increase in altitude of the land surface. Consequently, the annual precipitation may be appreciably higher on the north edge of the basin where Johnson Mesa rises as much as 1,200 ft above the adjacent plains. Rainfall on the mesa is reported to average about 20 inches annually.

The Capulin ground-water basin (Fig. 3) is somewhat smaller than the topographic basin because the ground-water divide does not coincide with the topographic divide on the east and southeast margins. Precipitation that falls on the topographic basin outside the boundaries of the ground-water basin may contribute to recharge of the ground-water basin but only if surface runoff moves westerly across the ground-water divide. If precipitation infiltrates to the water table east of the divide it is lost to the basin. For purposes of this report, no recharge is considered to be derived from those areas outside the boundaries of the ground-water basin.

Runoff in the area generally drains toward the center of the basin; however, the amount of infiltration and recharge depends upon the type of rocks on which the precipitation falls. Because the volcanic rocks are highly receptive to infiltration of precipitation, recharge to the ground-water body may be as much as 20% of the annual precipitation upon their surfaces.

Although the sand and gravel which make up the alluvial plains also are highly porous, the soil zone and natural grass cover generally reduce recharge, and much of the rainfall is lost by evaporation and transpiration. Consequently, the average rate of recharge is estimated to be no more than 5% of the precipitation on the alluvial plains. Recharge through the relatively impermeable shales is considered to be negligible.

Figure 3 shows the distribution of the various recharge units in the basin. The volcanic rocks underlie about 60 mi^2 of the basin. The alluvium underlies approximately 45 mi^2 of the basin. The shale crops out only in the vicinity of Mesa Largo and Kiowa Mesa. These outcrops have a total areal extent of 9 mi^2. The relationship of these units is shown in cross section (Fig. 4). On the basis of the above estimates of the outcrop area and percent of infiltration, recharge through the volcanic rocks would amount to about 9,600 acre-ft annually, and through the alluvium 1,800 acre-ft annually, for a total annual recharge of the ground-water body of about 11,400 acre-ft.

There is a general similarity between the shape of the water table and the land surface in the study area (Fig. 5); this is characteristic of a water-table aquifer rather than an artesian aquifer. Inasmuch as water migrates downslope at right angles to the contours, this map illustrates the direction of ground-water movement. Most of the ground water on the southeast flank of Johnson Mesa moves southeasterly toward the

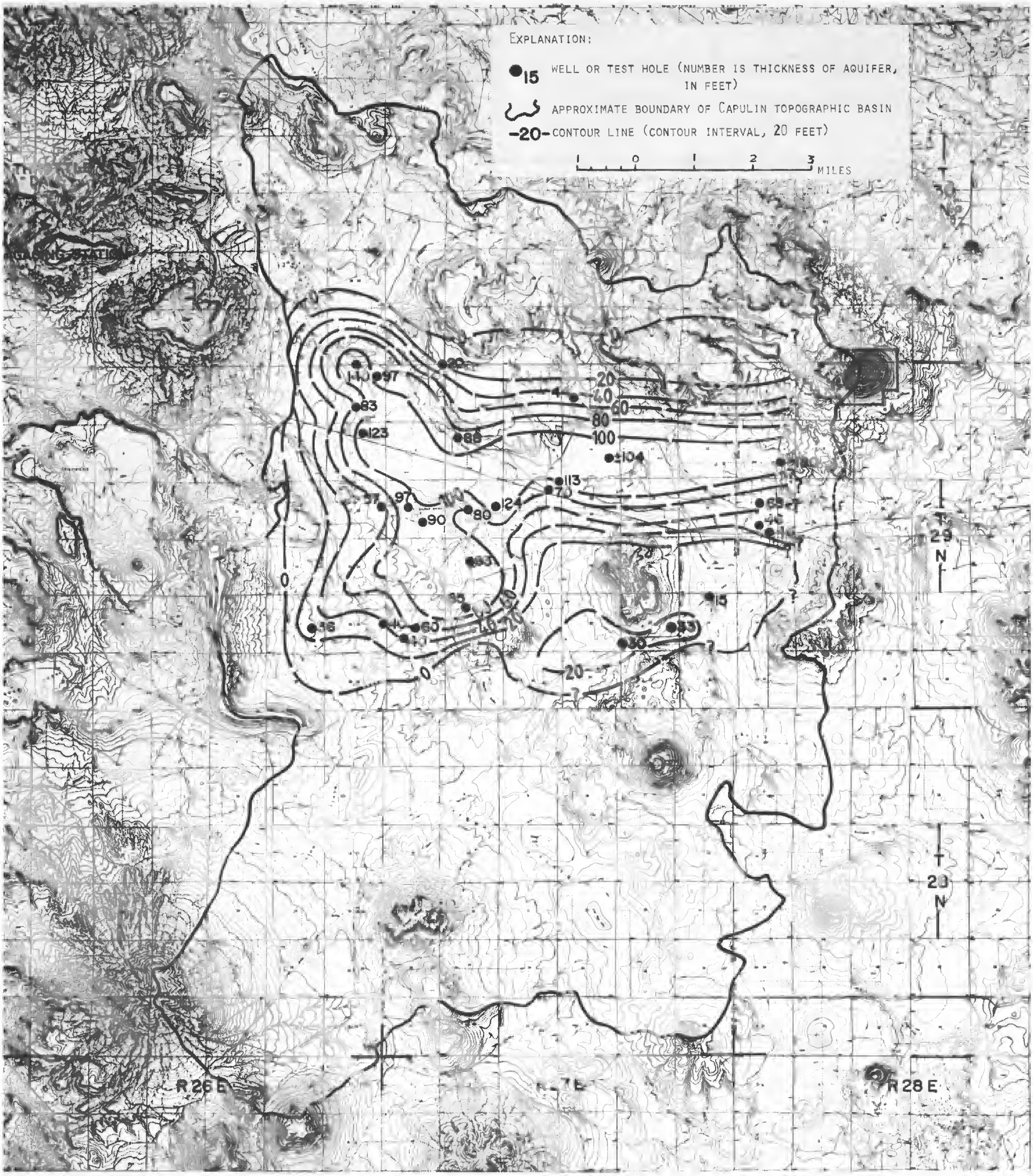

FIGURE 2. Isopach map showing approximate thickness of part of Capulin aquifer.

TABLE 1. Records of wells in the Capulin area, Colfax and Union Counties, New Mexico. *Location:* four segments divided by periods; the first segment denotes the township north of the New Mexico base line; the second denotes the range east of the New Mexico principal meridian; the third denotes the section number; the fourth segment denotes the location within the section as follows: the number "1" denotes the NW¼ of the section; "2," the NE¼; "3," the SW¼, "4," the SE¼, and so on for successively smaller quadrants. *Altitude:* elevation above sea level of land surface at well, extrapolated from topographic map. *Depth:* measured depth of well, in feet below land surface, when given in tenth of foot; all others reported. *Water level:* measured to nearest hundredths of foot, below land surface; all measurements made between 1 and 8 July 1975. *Yield:* reported pumping rate, in gallons per minute.

Location	Owner	Altitude	Depth (feet)	Water level (feet)	Water-bearing unit	Yield (gpm)	Remarks
27.27. 1.221		6921	158.5	153.07			Sp. cond. 495
2.123		6825	18.3	16.89			
2.123			27.5	21.53		2	Sp. cond. 570
3.322		6951	138.1	103.46		1	Sp. cond. 650
5.132	Trujillo	7019	20.7	19.45			
5.242	Salyer	7018	109.7	86.31			
10.344	E.E. Salyer	6950	198.0	190.87			Sp. cond. 695
12.142		6741	47.7	24.46		3	Sp. cond. 510
27.28. 6.444	Cowan Ranch	6840	177.0	167.20			
28.25.11.244	Grant Long	6750	12.5	2.09			Sp. cond. 1200
12.232		6818	170.0	24.72			
28.26. 2.312		7176	+200	120.24			Abandoned well
4.322	T-O Ranch	6965	62.0	68.86		2	Sp. cond. 1400
5.344	T-O Ranch	6911	78.5	40.83			
12.343	Reese	6950	133.0	60.12			Rept. sulphur
13.334		7014	+67	33.12			
14.212	Reese	6990	135.0	91.40			
16.322	T-O Ranch	7110	38.4	31.71			Abandoned well
20.232	Hennigan	7290	118.5	99.10			Sp. cond. 340
25.430	Hennigan	7119	186	165.15			Sp. cond. 580
26.113	Hennigan	7210	195.5	160.97		4	Sp. cond. 280
29.231	Hennigan	7845	550	282.05			
28.27. 6.222		6862	42.7	19.99			Sp. cond. 440
10.444		6914	111.0	97.77		3	
12.211		6974	185.5	178.18			
13.123		6886	77.0	74.68			Sp. cond. 875
15.434		6836	75.0	58.05		4	Sp. cond. 2800
22.112		6835	123.0	34.78			Abandoned well
23.433		6840	24.0	14.63			Abandoned well
25.421		6874	446.2	379.26		2	Sp. cond. 1100
26.143	Moore	6845	23.0	21.00		4	Sp. cond. 790
27.444	Nacol	6837	21.0	12.60		4	
28.112		6946	31.0	27.00			Abandoned well
30.133		7085	102.0	94.72			
31.131	Old Williams Pl	7097	142.2	87.1			Abandoned well
32.442	Trujillo	6961	43.0	31.84			Sp. cond. 645
35.211		6880	68	63.55			Abandoned well
35.331		6846	25.4	23.66			
28.28. 3.133		6785		31.5		10	
3.444		6814		106.0			Sp. cond. 580
4.323		6820		39.0			Abandoned well
7.212		6814	40	20.60	Dakota Ss.		
7.412		6832	100	39.60	Dakota Ss.		
8.311		6790		87.65			Sp. cond. 900
9.444	O.D. Click	6769	85	20			
16.212	O.D. Click	6773	71.0	54.60	Alluvium		Meas. 9/28/55
17.344		6890	170	144.76			
18.433		6880		304.70			
20.311		6894		172.6		2	
21.444	O.D. Click	6807	395	20			
22.444	O.D. Click	6754	499				
28.330		6801	176.5	167.79	Dakota		Sp. cond. 520
33.330		6796	266.0	257.90			Abandoned well
34.332		6770	208.2	189.20			Sp. cond. 450
35.140	A.N. Click	6717	211.5	164.74	Dakota (?)		"Soda" taste
29.24.25.441		6430		flow	Dakota	30	Sp. cond. 5000
29.25.36.233		7161	351.1	155.57		2	
29.26. 1.223	T-O Ranch	6990		33			
1.413		6925	80.0	75.64			
3.234		6955	129.0	111.85			
11.121	T-O Ranch	6995		99			
12.213	T-O Ranch	6941		58			

Location	Owner	Alti- tude	Depth (feet)	Water Level (feet)	Water-bearing unit	Yield (gpm)	Remarks
29.26.13.324		6939	105.0	64.70			Abandoned well
17.131		7070	242.0	157.13			
19.131		6822	112.0	35.11			
21.423		7330	98.3	41.05			Abandoned well
26.421		7007		23			
26.443		6980	194.6	179.20			Sp. cond. 1080
26.444		6978	102.3	dry			
29.213		6993	56.2	21.55			
30.244	Cladio Aragon	6930	19.7	16.32			
31.421		7039	249.0	18.95	Dakota(?)		Sp. cond. 2200
32.211		7060	248	111.24			Sp. cond. 1325
29.27. 3.312	Mondragon	6926	117.8	73.40			Sp. cond. 560
8.141		6892		37			
9.244	King Ranch	6862	54.8	31.87			
10.423	King Ranch	6824	120.5	16.37			Sp. cond. 375
13.241	J. Morrow	6808	12.0	17			
16.223	King Ranch	6826	80.0	9.39			
17.144		6842		17			
17.243		6830		22			
17.422		6828	17.2	17.48			
18.144	T-O Ranch	6885	155.0	53.81	Alluvium	2000	T-O #1, irr. well
18.414		6882		43			
19.421		6848	24.6	23.97			Sp. cond. 670
20.144		6882		23			
21.312		6820	58.0	22.20			Sp. cond. 2850
25.211		6833	62.2	47.10			Sp. cond. 640
26.331		6805	254.3	64.71			Abandoned well
26.421	King Ranch	6863	106.5	73.13			Sp. cond. 540
27.113		6853		49.29			Sp. cond. 535
30.322		6887	88.4	77.42			Sp. cond. 1900
32.231		6841	42.0	21.96			Abandoned well
32.232		6823	33.4	15.80			Sp. cond. 975
34.232		6896	186.2	123.42			Sp. cond. 630
29.28. 7.414	J. Morrow	6895	130	107			
5.234	U.S. Govt.	7275	680	355	Volcanic rocks		
11.144	Bennett Ranch	6760		32			
11.414	Bennett Ranch	6723	150	85			
15.240		6730	42	30	basalt		Meas. 11/11/53
17.341	Sneed	6825		40.20			Unused irr. well
17.413	Sneed	6838		48			
17.431	Wright Sneed	6837		44.74			
18.323	City of Raton			20.02			Unused obs. well
18.341		6820		29.05			Unused irr. well
18.431	City of Raton	6815		20.73			Unused irr. well
18.422		6818		172.70			
21.124		6818		63+			
22.124		6858		143.00			
28.211		6850		73.10			Sp. cond. 390
30.211		6880		139.56			
30.222		6934		137.70			Sp. cond. 700
32.333		6858		71.40			
33.211		6835		67.20			
34.131		6820		59.15		10	
30.25.12.344	Popejoy	6840	400	25	shale	7	
30.26. 5.144		7240					
6.331		7010		1.50			Develop spring
15.124		7230	98.4	82.00		3	
15.323		7237	186.7	41.55			Abandoned well
23.443		7105	90.0	35		6	Sp. cond. 360
25.444		7100	111	96.95			Sp. cond. 475
27.214		7176	90	65.67			
30.27.12.341		6973	80.5	62.46		2	Sp. cond. 360
13.322		7077	54.5	29.56		3	
20.243		7298	+108			2	Sp. cond. 425
26.231		7384	191.0	187.40		5	
30.28. 5.113	Jack Williams	6540	27.0	14.00	gravel		Irrigation well
11.312		6435		55.55			
14.111		6455		63.25			
14.211		6420	80	21.55			
14.411		.6520	170	125.90			
22.223		6577	60	dry			
27.314		6745		54.60			Meas. 2/25/57
31.231		7098		145	Dakota Ss.		

FIGURE 3. Map of Capulin ground-water basin showing distribution of principal geologic units.

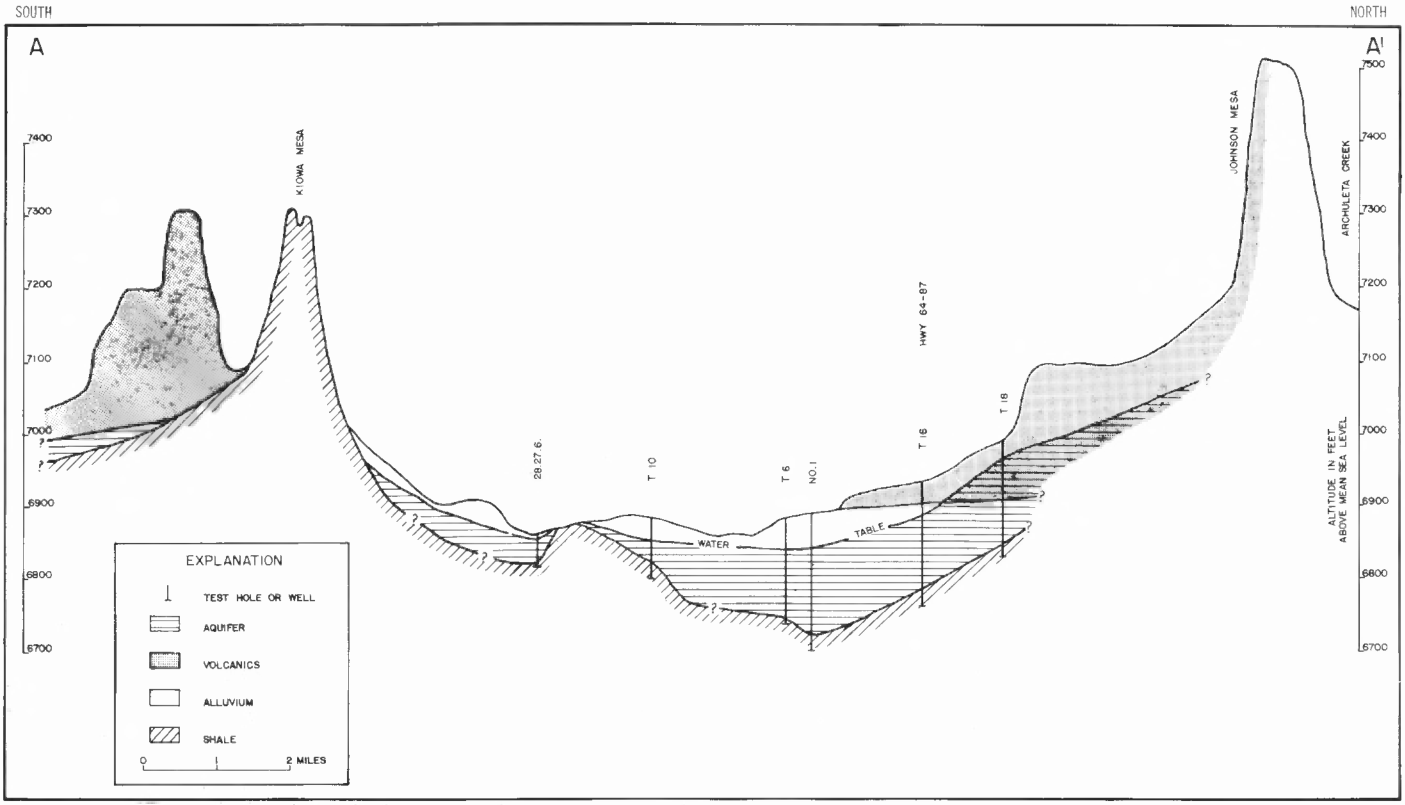

FIGURE 4. Cross section of the Capulin ground-water basin showing the relationship of the aquifer to major rock units (line of cross section shown on Fig. 3).

Capulin ground-water basin. Water around Mesa Largo migrates outward from a ground-water high centered under the mesa.

A bedrock structural high extends roughly from southeast of Capulin southwest under Horseshoe Crater and Kiowa Mesa to Pine Buttes. This structural feature acts as a divide which diverts ground water toward the northwest into the Capulin ground-water basin or to the southeast into the Canadian River drainage. The 6,800-ft contour and a ground-water trough between Capulin Mountain and the village of Capulin delineate approximately the extent of the aquifer within the basin through which most of the ground water is believed to discharge from the basin. Net discharge from the basin should equal annual recharge, or about 11,400 acre-ft annually. The few irrigation wells in use probably discharge no more than 300 to 400 acre-ft per year.

GROUND-WATER DEVELOPMENT AND AVAILABILITY

As early as 1951, several wells had been used for irrigation in the vicinity of Capulin; one of these was capable of producing as much as 2,000 gpm (gallons per minute). Most of the irrigation wells were dug wells; consequently, they did not adequately test the capability of the aquifer. One of the drilled wells was purchased and tested by the city of Raton. Information about this test is available in Minton's (1966) report to the city of Raton. The well has never been used since the test. Reportedly, it produced at least 1,000 gpm with only a few ft of drawdown. Pumping was said to have continued for several months with no noticeable decrease in the yield. However, as the pumped water was returned to the basin the question was raised as to whether the water may have been recirculating.

Following the test-drilling program on the T-O Ranch in 1972, a 16-inch production well was constructed (sec. 18, T29N, R27E) having a total depth of 155 ft. After construction the static water level was reported to be 53 ft below land surface. On 6 June 1975, the static level was found to be 53.81 ft below land surface. An aquifer test conducted by the drilling contractor did not yield sufficient data to permit transmissivity values to be computed with an accuracy that would allow long-range planning and well-field design. However, the specific capacity of the well was computed to be about 36 gpm per foot of drawdown. This is a measure of effectiveness of the well. Assuming that the water level in this well could be drawn down 75 ft, the well would yield 2,600 gpm.

Computations made using the isopach map (Fig. 2) of the known extent of the Capulin aquifer indicate the aquifer has a minimum gross volume of about 1,850,000 acre-ft. Data do not provide information concerning the extent and thickness of the aquifer in several large areas outside the boundaries of the T-O Ranch. It is possible the gross volume could be as much as 2,250,000 acre-ft. If the aquifer has a porosity of about 40%, then it may contain from 740,000 to 900,000 acre-ft of water in transient storage. Assuming that a properly designed well field can recover 30% of the water in storage, then 222,000 to 270,000 acre-ft of water can be recovered. If withdrawals were made at the rate of 7,000 acre-ft per year, the supply would last for 32 to 39 years.

Many factors not ascertainable with the data available could alter the above estimates. Some, such as the effectiveness of recharge, could work to increase the potential yield. Others, such as the recoverability factor and the decrease in yield with progressive lowering of the water table, would decrease the potential yield. Additional data obtained by pumping tests and test drilling could help to answer these questions.

Usually recharge is discounted in long-range planning of ground-water development because areas of recharge commonly are far from the areas of pumping, and the annual amount of recharge is insignificant in proportion to the amounts withdrawn. In the Capulin basin the amount of recharge not only is large, it occurs virtually over the points of withdrawal. It is a geohydrologic situation where the generally discounted concept of "safe yield" based on annual recharge might be invoked. In that case, approximately 11,000 acre-ft of water theoretically could be withdrawn annually without depleting the "reservoir." However, that would not be a realistic approach for several reasons, the chief of which is the fact that natural discharge will continue after pumping begins.

At present the hydrologic system in the basin is in balance, except for the relatively small amount of water presently being withdrawn by

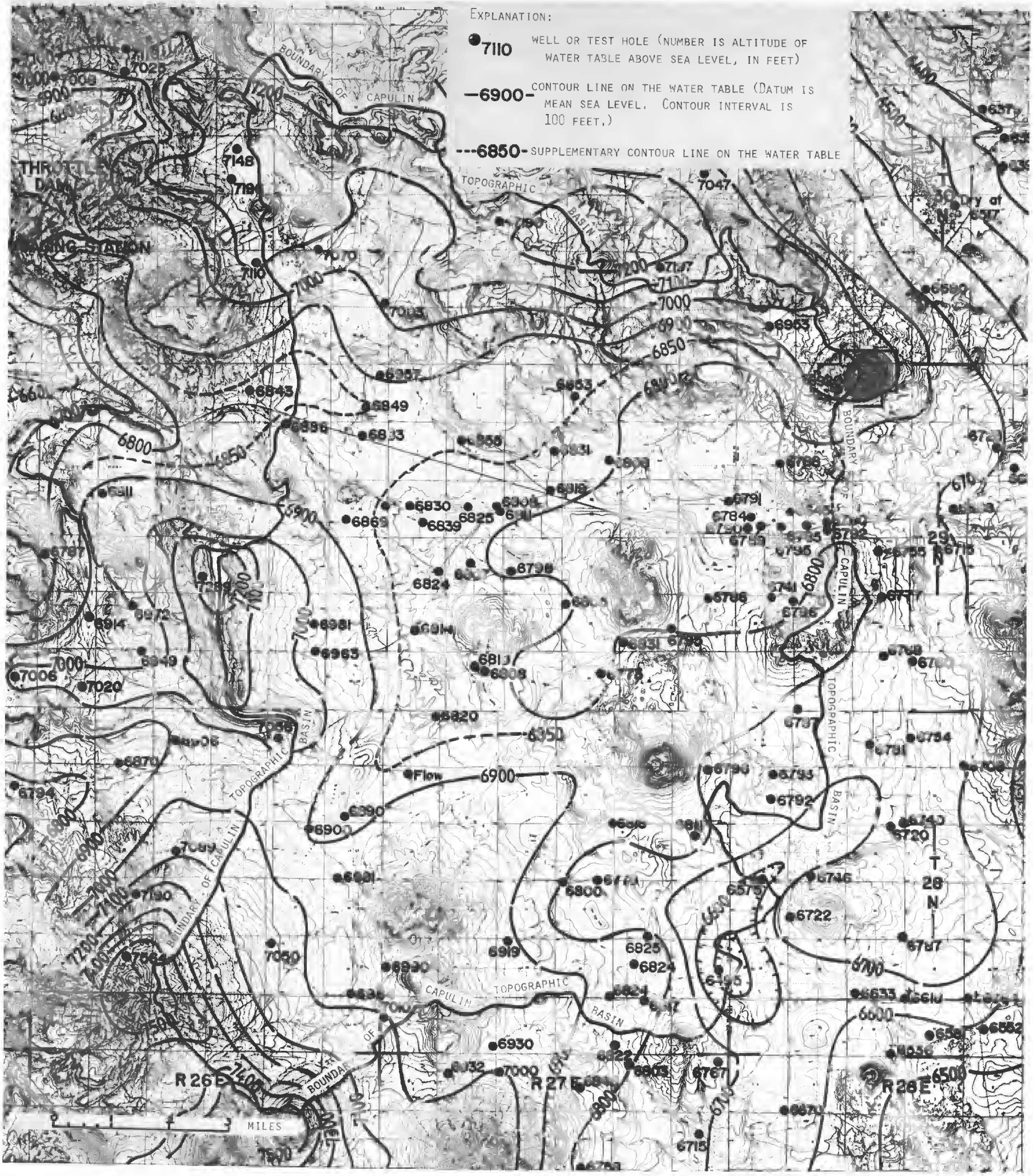

FIGURE 5. Contour map showing configuration of the water table in parts of Colfax and Union Counties, New Mexico.

TABLE 2. Chemical analyses of waters from representative wells in the Capulin basin.

Constituents	1	2	3	4	5	6
Silica (SiO_2)	-	-	33	34	15	-
Iron (FE), total	-	0.19	-	-	-	-
Manganese (Mn), total						
Calcium (CA)	65	36.8	32	46	13	11
Magnesium (Mg)	37	11.3	18	41	12	7.9
Sodium (Na)	11	17	36	74	129	616
Potassium (K)	-	4	5.1	-	-	-
Bicarbonate (HCO_3)	291	178	209	323	308	150
Carbonate (CO_3)	-	-	0	0	0	-
Sulfate (SO_4)	118	14	27	135	68	9.1
Chloride (Cl)	48	7	10	25	22	33
Fluoride (F)	0.3	0.64	0.6	0.6	2.0	-
Nitrate (NO_3)	7.6	0.7	9.7	3.7	4.1	0
Dissolved solids						
Sum	431	274	289	518	416	1,450
Residue						
Hardness as $CaCO_3$	314	139	154	284	82	60
Non-carbonate	176	-	0	0	D	0
Specific conductance						
(micromhos @ 25° C)	85.9	-	453	808	680	-
pH	-	-	8.2	7.4	7.6	-
Percent sodium	7	-	-	-	-	-

1. Produced from alluvium in SW¼ sec. 3. T. 29 N., R. 27 E., King Ranch
2. Produced from alluvium in NW¼ sec. 18, T. 29 N., R. 27 E., T O Ranch
3. Produced from alluvium in SE¼ sec. 7, T. 29 N., R. 28 E., Morrow Ranch
4. Produced from volcanics in SW¼ sec. 18, T. 29 N., R. 28 E., Pachta well
5. Produced from alluvium in SW¼ sec. 32. T. 29 N., R. 28 E., Cowan Ranch
6. Produced from shale in NE¼ sec. 14, T. 28 N., R. 26 E., old Harris well

pumping. Imposition of a 7,000 acre-ft per year demand on the system would appreciably disturb the balance. Water levels in the basin would decline, and natural discharge also would decline, although at a slowly diminishing rate until, theoretically, it is stopped as water levels declined below the outlet for the basin; however, under any circumstances, that would not be likely to occur for many years. Thus, for practical purposes, it should be assumed that some natural discharge will continue throughout the period of a major pumping operation.

QUALITY OF GROUND WATER

Chemical analyses of water from wells in the area show that the water quality generally is adequate for most industrial purposes (Table 2). Water from the alluvium commonly does not exceed 500 mg/l (milligrams per liter) dissolved solids and locally it contains less than 250 mg/l. Available data indicate that silica (SiO_2) commonly is less than 35 mg/l in water from the alluvium and volcanics. The most highly mineralized water was obtained from wells completed in the shale and sandstone that underlie the main aquifer. However, no significant amount of water would be contributed by the shales. Thus, the quality of water from the volcanic-alluvial aquifer likely would not be appreciably affected by large withdrawals.

SURFACE-WATER RESOURCES

Although there are numerous small springs in the Capulin basin, no perennial streams are present. The flanks of the basin are drained by the tributaries of the Canadian and Cimarron Rivers, most of which have perennial flow near the headwaters. In early July 1975, there was an estimated discharge of 40 gpm near the head of Carrizo Creek on the southeast flank of the basin. A small amount of discharge was also present at that time in Palo Blanco Creek at the south edge of the basin and in Blosser Arroyo, northwest of Laughlin Peak, a flow of about 30 to 40 gpm was noted.

Una de Gato Creek is one of the major streams in the area. The headwaters of this stream drain much of Johnson Mesa. Above Throttle Dam in sec. 24, T30N, R25E, the drainage basin was calculated to be approximately 48 mi^2. A discharge station installed by the U.S. Geological Survey one mi downstream from Throttle Dam in May 1975 was discontinued in September 1983. Discharge measurements made from May 1975 through September 1983 showed an average annual rate of discharge of 3.45 cfs (cubic ft per second) or about 2,520 acre-ft (U.S. Geological Survey, 1983, p. 25). This is considerably less than the 5,000 acre-ft per year estimated in the authors' 1975 report to Plains Electric. That estimate was made assuming 10% runoff of 20 inches of precipitation on the 48 mi^2 drainage basin. It is interesting to note that discharge records from May 1975 through September 1982 show an average discharge of 1.63 cfs (1,180 acre-ft per year) for the seven-year period. Discharge in water-year 1983 was about eight times greater, resulting in a doubling of the seven-year average in the eighth year of record. This example exemplifies the danger of relying on short-term records for long-term prediction of stream flow.

Throttle Dam, one mi above the gauging station, impounds the flow of Una de Gato Creek, thus interrupting the normal flows of the creek at the gauging station. Also, water is lost by evaporation from the lake surface which covers about 100 acres when full. Annual evaporation rates in that area are estimated to be 45 to 50 inches per year, based on pan-evaporation records of northeastern New Mexico stations. Thus, up to 400 acre-ft could be lost annually above the gauging station. Various conflicting reports, oral and written, give the capacity of the lake as 1,800 to 3,300 acre-ft.

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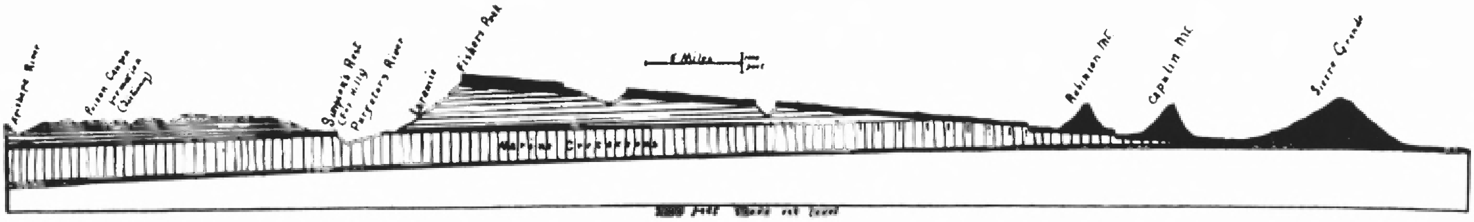

FIG. 2. *Section extending from the Apishapa River, Colorado, southeastward through Fisher's Peak to Sierre Grande, New Mexico, illustrating the Ocate bench which appears at the left, the Mesa de Maya in the center, and the Las Vegas plains at the right occupied by the volcanoes.*

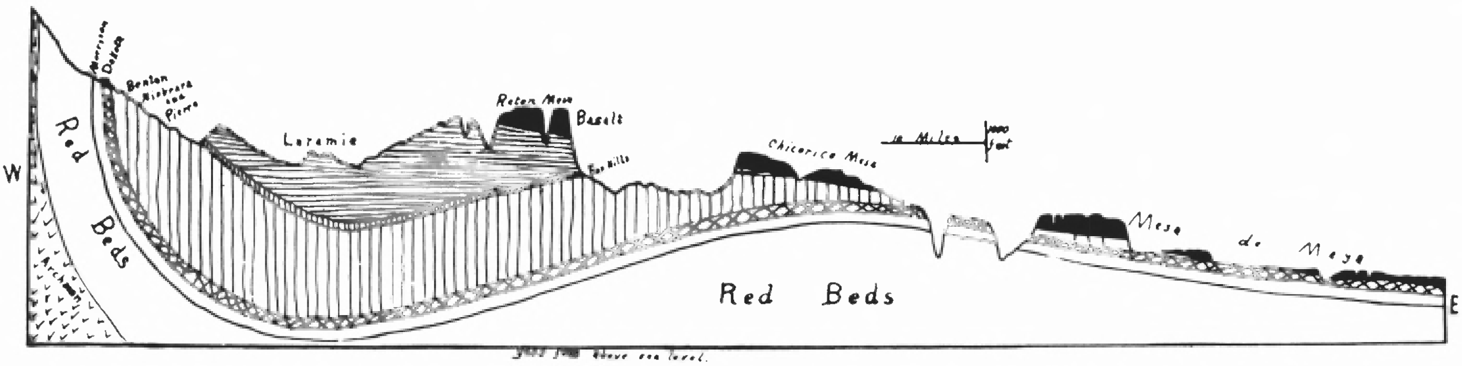

FIG. 3. *Section along the Colorado-New Mexico boundary line, from the front range of the Rocky Mountains eastward. (The relative elevations are greatly exaggerated.)*

Geological cross sections of the Raton Basin. From Lee, W. T., 1903, The canyons of northeastern New Mexico: Journal of Geography, v. 2, pp. 63–82.