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Availability of ground water in the vicinity of Cloudcroft, Otero County, New Mexico

By
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AVAILABILITY OF GROUND WATER IN THE VICINITY OF CLOUDCROFT, OTERO COUNTY, NEW MEXICO

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ABSTRACT

The village of Cloudcroft is on the crest of the Sacramento Mountains in Otero County, New Mexico, about 15 miles east of Alamogordo. The area is characterized by comparatively gentle slopes in the upland areas and by adjacent deep canyons. The area is covered with dense forest growth as a result of the relatively high annual precipitation, about 25 inches.

Rocks which are of significance with respect to ground water in the area are, in descending order, the limestone of the San Andres limestone which is at the surface at Cloudcroft and the shale, silt, gypsum, and limestone of the Yeso formation. The San Andres limestone caps the crest of the Sacramento Mountains and absorbs precipitation which in turn recharges the ground-water reservoir. Limestones in the underlying Yeso formation are the principal aquifers in the Cloudcroft area. Ground water in the Yeso formation comes partly from the overlying limestone of the San Andres and partly from direct recharge where the Yeso is exposed in the bottoms of canyons. Not all of the water in the San Andres is transmitted to the Yeso formation; some discharges through springs near the contact of the Yeso and San Andres.

The ground water in the Cloudcroft area is not highly mineralized owing both to the proximity of the intake area and to the relatively high permeability of porous zones in the limestones.

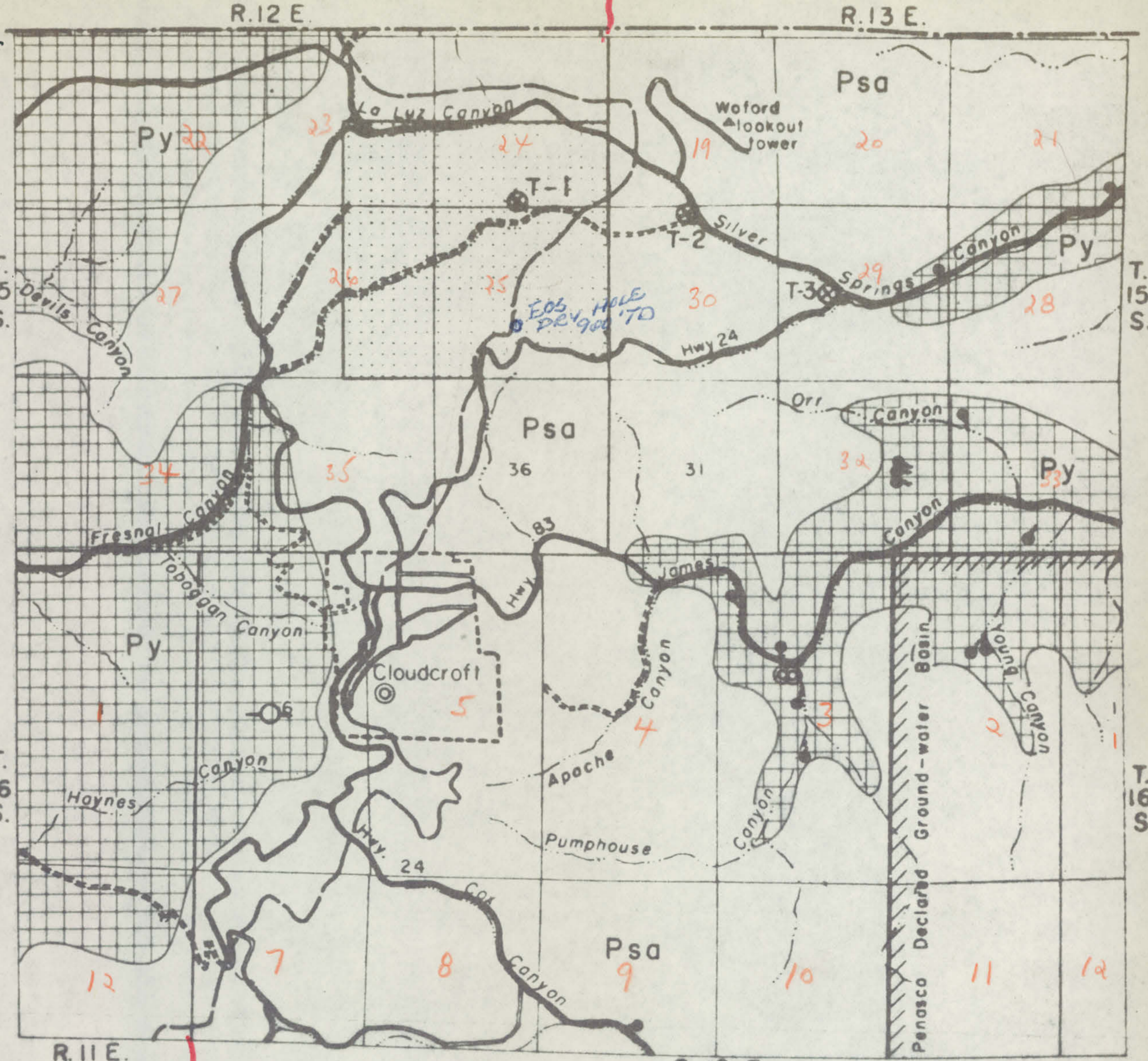
Estimated minimum water requirements for the proposed Air Force installation to be built 1 1/2 miles north of Cloudcroft are about 10,000 gpd (gallons per day) or about 20 gpm (gallons per minute) for 8 hours a day. Study of the area indicates that the requirements probably can be met by drilling into limestones in the Yeso formation, beneath the installation site. However, it is possible that the required amount cannot be obtained from beneath the installation site, and it is also possible that the water requirements for the installation may be increased in the future. For these reasons, three sites are suggested for exploratory drilling. The sites shown on figure 1 are numbered in the order of increasing distance from the proposed installation, and also increasing probability of success in obtaining large yields. Test hole 1 should be drilled to a depth of about 550 feet, test hole 2 to a depth of about 500 feet, and test hole 3 to a depth of about 200 feet. The depths given should be great enough to permit the testing of both the lower limestone beds of the San Andres and the upper 200 feet of the Yeso formation. Exploratory drilling should be so planned as to permit the determination of the nature of the rocks, the testing of ground-water production from the limestones of the Yeso, and the determination of chemical quality of water from the various types of rocks.

INTRODUCTION

The area described in this report is in the Sacramento Mountains in north-central Otero County, New Mexico. The area,which covers about 38 square miles, is shown in figure 1 and centers about the village of Cloudcroft. The village, a resort center, is on the crest of the Sacramento Mountains at the junction of State Highways 83 and 24, about 15 miles east of Alamogordo.

The ground-water investigation described in this report was made as a part of a continuing program of the U.S. Geological Survey with funds provided by the Corps of Engineers, Albuquerque District, U. S. Army. The program provides in part for initial studies leading to the development of ground-water supplies at defense installations in the Albuquerque District of the Corps of Engineers.

The investigation of the Cloudcroft area was made to determine the feasibility of developing ground-water supplies at a proposed Air Force installation in parts of secs. 23, 24, 25, and 26, T. 15 S., R. 12 E., about 1 1/2 miles north of Cloudcroft. According to an initial estimate of the Corps of Engineers, the water requirement for the installation would ultimately amount to a maximum of about 300 gpm. Approximately 5 days were spent in the field in March 1956, during which the existing water supplies of the area were inventoried, and rocks exposed in the area were studied briefly. Subsequent to the field work the initial requirement for water was revised downward to about 10,000 gpd, or about 20 gpm for 8 hours a day.



Base from Cloudcroft, Alamogordo and Mescalero quadrangles, U.S. Geological Survey Topographic Division and New Mexico State Highway Department map of Otero Co.

Geology adapted from Carle H. Dane and George O. Bachman, 1958

EXPLANATION

Psa — San Andres limestone of Permian age

Py — Yeso formation of Permian age

Well, equipped with turbine pump

Well, equipped with cylinder pump

Spring

Proposed test hole site

Area of Air Force installation

Divide between Tularosa Basin and Pecos River basin

Intermittent stream

Perennial stream

Figure 1.--Location of wells and springs in the vicinity of Cloudcroft.

Basic data for some of the existing water supplies in the area are given in tables 1, 2, and 3. The locations of wells and springs in the area are shown on figure 1. Wells and springs are listed in the tables according to their location numbers which are based on the public-land-survey system. Figure 2 shows the method of well numbering which indicates the location of the well or spring to the nearest 10-acre tract. The location numbers of springs contain the prefix "s".

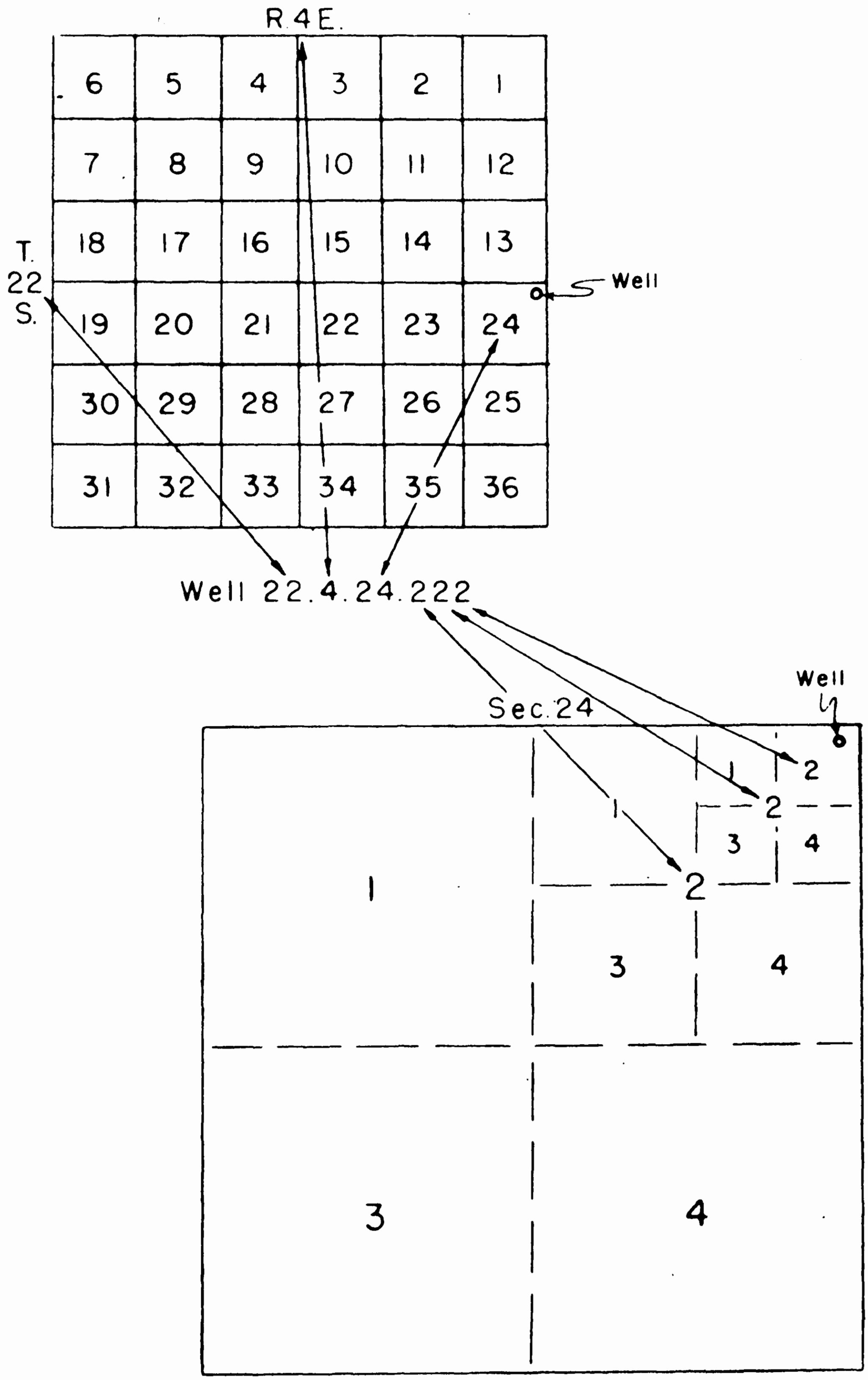


Figure 2--Plot illustrating method of numbering wells in New Mexico

TOPOGRAPHY AND CLIMATE

The Sacramento Mountain mass is a crustal block which has been uplifted and tilted to the east. The block has a relatively steep west slope and a relatively gentle east slope. The highest peaks in the mountain range have altitudes greater than 9,000 feet. The crest of the mountains forms the divide between the Tularosa Basin to the west, an area of interior drainage, and the Pecos River basin to the east. Erosion has carved deep, steep-walled canyons in the west slope and shallower canyons in the east slope. Eastward from Cloudcroft the canyons are shallower and broader, owing to the nature of the rock in the area. Most of the area is covered with dense forest, principally of coniferous trees.

The mountains in the vicinity of Cloudcroft receive an average of 25 to 30 inches of precipitation annually. As in many areas in New Mexico, the amount of precipitation received is largely a function of altitude. Cloudcroft, at an altitude of 8,575 feet, receives an annual average of 25.2 inches, whereas Mayhill Ranger Station, 19 miles east of Cloudcroft and at an altitude of 6,538 feet, receives an average of 20.2 inches annually, and Mountain Park, 6 miles west of Cloudcroft and at an altitude of 6,728 feet, receives an average of 18.3 inches annually. Most of the precipitation in the mountain area occurs from June through October, but considerable precipitation in the form of snow occurs in December and January. At Cloudcroft, the annual average temperature is about 45° F.; the warmest month is July, and the coldest month is January.

GEOLOGY

The Sacramento Mountains are composed almost entirely of sedimentary rocks, ranging from Cambrian to Permian in age. Structurally, the mountains consist of a huge east-dipping fault block, uplifted on the west side along a normal fault zone. Erosion subsequent to the beginning of uplift stripped away much of the higher parts of the escarpment until the present crest of the range is 10 to 20 miles east of the edge of the mountains. Cloudcroft is located at the edge of the present crest on the San Andres limestone of Permian age.

The rocks which are of significance with respect to the occurrence of ground water in the vicinity of Cloudcroft are the San Andres limestone and the underlying Yeso formation both of Permian age.

Yeso Formation

In the Cloudcroft area the Yeso consists of 1,200 to 1,800 feet of limestone, gypsum, shale, siltstone, and minor amounts of sandstone. The limestones in the Yeso formation appear to be the principal aquifers in the vicinity of Cloudcroft. Most springs in the area appear to issue from rocks belonging to the Yeso. In Fresnal Canyon, west of Cloudcroft, springs issue from rocks of the Yeso at several horizons. In most of the canyons east of the crest of the mountains, springs issue from rocks near the contact between the Yeso and the overlying San Andres limestone. It is inferred that the springs result from the downward percolation of ground water through limestones to the first impermeable shale or siltstone in the Yeso formation and movement is thence parallel to the top of the impermeable bed to a point of discharge.

San Andres Limestone

The crest of the Sacramento Mountains, particularly in the higher peaks, is capped with the San Andres limestone. The thickness ranges from an observed maximum of over 700 feet in the central part of the crest to an average of about 350 feet in the vicinity of Cloudcroft. The San Andres consists principally of olive-gray or light- to dark-gray and brown limestones, which have sharp bedding planes. The limestone contains one or more beds of sandstone near the base, which range in thickness from 1 to not over 10 feet.

The San Andres is cavernous and generally serves as a recharge medium to the underlying Yeso formation.

HYDROLOGY

Occurrence of Ground Water

Most of the water entering the ground-water reservoir beneath the crest of the Sacramento Mountains, in the Cloudcroft area, apparently moves eastward in the general direction of the regional dip of the beds. This statement is based on the fact that few if any springs issue near the top of the Yeso formation in the west face near the crest of the range. The Lost Lodge well (16.12.6.322) drilled west of and very close to the crest obtains water from beds which are exposed about 250 feet above the floor of nearby Toboggan Canyon. On the east side of the crest, numerous springs appear along the sides of nearly all of the canyons. Most of the ground water in the area is contained in the Yeso formation because the San Andres limestone generally is above the water table.

If a saturated zone exists in the San Andres limestone near Cloudcroft, the water occurs under water-table, or unconfined, conditions. Although water-table conditions generally may occur also in the saturated part of the Yeso formation, artesian conditions are known to occur locally. In well 3 of the village of Cloudcroft (16.12.3.142b), the principal water-bearing zone was reported to be a limestone encountered at a depth of 145 feet. Ground water in this zone was confined beneath an overlying bed of yellow clay, and rose to a level of about 60 feet below land surface when encountered.

Recharge and Discharge of Ground Water

The only possible source of recharge in the vicinity of Cloudcroft is from local precipitation. The soil mantle consists of porous forest soil and accumulations of leaf mold and is absorbent to the extent that direct runoff occurs only after very heavy rains. Water which moves downward past the soil zone enters limestone in the San Andres limestone and is transmitted downward to the siltstones, shales, and limestones in the Yeso formation. A considerable part of the recharge apparently enters the limestones beneath the canyon floors, where the floors are above the water table. Ground water in the Yeso formation is discharged by springs or moves downdip through the formation. Perennial streamflow is sustained by ground-water discharge from the Yeso formation where the streambeds have been cut below the water table, for instance, in Silver Springs Canyon.

Availability of Ground Water

The availability of ground water in an area must be judged by the permeability of rocks in the area, by the distribution of the permeable rocks, and by the amount of water stored in the area. If the amount of ground-water storage is small, the amount of recharge becomes important to obtaining a perennial supply of ground water. In the immediate area of the proposed Air Force installation north of Cloudcroft, none of these factors are known. Only data from two wells in the general area, used by the village of Cloudcroft, indicate the permeability of the limestones in the Yeso formation. Both of these wells have specific capacities of 3 gpm or less per foot of drawdown, indicating a moderate permeability. There are undoubtedly zones in the Yeso formation of much higher and lower permeability. No recorded data are available with regard to the permeability of the San Andres limestone. However, it is inferred that there are very permeable porous zones in the limestones. Although there are no springs which are known to dry up completely, many of the springs at the base of the limestone are reported to respond rather quickly to increased recharge during the summer months when most of the annual rainfall occurs.

The amount of water available to wells in the area probably increases with distance east of the water-table divide, because the volume of saturated rocks increases downdip. The most likely areas for development of wells are the floors of the canyons, particularly at the junctions of canyons. The canyons at the higher elevations are areas where recharge from surface flow may be greatest. Moreover, in much of the area, beds are slumped toward the canyons, and recharge from the uplands moves toward the canyons. It is for these reasons that test-hole locations T-2 and T-3 have been chosen as shown in figure 1.

CHEMICAL QUALITY OF GROUND WATER

Ground water from the limestones in the Cloudcroft area is of good chemical quality. Chemical analyses of water from three wells and three representative springs in the area are given in table 3. The ground waters from all sources cited are calcium bicarbonate waters and are very similar in chemical quality. The most highly mineralized water sampled contained only 434 ppm (parts per million) of total solids. All constituents with the exception of calcium carbonate and bicarbonate amounted to less than 100 ppm each. The maximum nitrate content was 6.2 ppm in the village of Cloudcroft spring, 16.12.3.144. From the similarity of the analyses, it can be inferred that water encountered in wells or test holes for the Air Force installation north of Cloudcroft will be of similar quality.

GROUND-WATER SUPPLIES

Required and Existing Supplies

The proposed Air Force installation is to be built in parts of secs. 23, 24, 25, and 26, T. 15 S., R. 12 E. Current planning includes bachelor quarters for about 30 persons, and other facilities, requiring a total of about 10,000 gpd of water. A well producing 21 gpm for 8 hours or 14 gpm for 12 hours would supply the estimated daily requirement. If the daily requirements are revised upward, the yield of the supply well would have to be proportionately higher.

There are no existing wells in the area of the proposed installation. The nearest existing supplies are springs in Silver Springs Canyon and the public-supply well at Cloudcroft $1\frac{1}{2}$ miles to the south. Most of the springs yield only a few gallons per minute. A large, expensive collection system would be necessary to exploit spring flow in Silver Springs Canyon 1 to 2 miles east of the proposed installation. The public supply at Cloudcroft probably would be inadequate to supply both the village and the Air Force installation.

Exploratory Drilling for New Supplies

From the geologic and hydrologic observations previously described, it appears that the required water for the proposed Air Force installation can be obtained from a well in the area of the installation. It seems probable that as much as 40 gpm may be obtained at the location of test hole T-1. However, it is possible that the required amount of water cannot be obtained from beneath the installation site. It is also possible that the water requirements for the installation may be increased in the future. To confirm the ground-water conditions indicated by data from existing supplies and by the geology of the area, test holes should be drilled at the locations shown on figure 1. The locations are numbered in the order of increasing probable success in obtaining large yields.

To test the ground-water supply at each test-drilling site, the test holes should be drilled to depths of 200 feet below the first red or yellow shale bed in the Yeso formation, or to a depth where there is at least 100 feet of water in the hole after the first red or yellow shale in the Yeso formation has been penetrated, whichever depth is shallower. On the basis of geological interpretation, it is estimated that the maximum depths required will be 550 feet at test hole T-1, 500 feet at T-2, and 200 feet at T-3. With the exception of a thin section of canyon fill, nearly all of the drilling will be in consolidated rocks consisting of limestone, sandstone, shale, and siltstone. Some igneous rock may be encountered. If so, it will probably be a thin sill in the Yeso formation and probably will be less than 10 feet thick. The Yeso formation beneath the sill, if one is encountered, also should be tested.

Test holes should be drilled by the cable-tool method to permit the following: (1) ~~D~~determining the depth to water when first encountered, and any changes in depth to water while drilling, (2) drilling through cavernous limestone, where encountered, and (3) obtaining water samples where desired.

The diameter of test holes should be adequate to permit completion of a production well, if such completion is desired. It is suggested that blank surface pipe be installed to the base of the canyon fill if present, and that the test hole be of sufficient diameter to accommodate 8-inch casing in the event that casing becomes necessary to support the walls of the well in the shale section of the Yeso formation.

Provision should be made for terminating drilling if the drill cuttings contain more than 50 percent gypsum in an interval of more than 5 feet. If such quantities of gypsum are encountered, a water sample should be bailed from the hole. If analysis of the water sample indicates that the water from the bed of gypsum contains more than 1,000 ppm of dissolved solids (or has a specific conductance of more than 1,400 micromhos) provision should be made for plugging the hole with cement, back to a point not less than 5 feet above the top of the gypsiferous zone.

It is desirable that the following data be obtained from each test hole: (1) Driller's log and drilling-time log, showing the depth, thickness, color, and character of each stratum penetrated, and the time required to penetrate each stratum. Individual intervals logged should not exceed 5 feet. The driller's log should also contain a record of the depth at which water was first encountered, the depth to which the water rose when first encountered, and any subsequent changes in depth to water, while drilling.

(2) Drill-cutting samples from intervals of 5 feet or less. Samples of drill cuttings should be obtained from each stratum irrespective of thickness but at intervals not to exceed 5 feet. The samples should be taken from the bailer and should be composites of the entire sample interval, not of a single point in the interval. Samples should be washed, sacked, and labeled with the test-hole number and the zone represented by the sample.

(3) Driller's record of casing and screen placed in the test hole.

(4) Driller's record of bailing test.

(5) Driller's record of measurements obtained while test pumping the hole.

After drilling has been completed, and well screen, if necessary, has been placed in the hole, the well should be cleaned thoroughly by bailing.

After cleaning of the well is completed, the well should be bailed as rapidly as possible for 1 hour to provide a basis for estimating the yield of the well. If the preliminary estimated yield is 25 gpm or more, a test pump should be installed.

If the bailing test indicates a rather low, but continuous, yield of 5 to 15 gpm, it might be worth while to try additional development by treating the formation with acid of the type specifically compounded for well treatment. The yield of the well may thus be substantially increased. If acid treatment is undertaken, not less than 500 gallons of 20-degree ($31\frac{1}{2}$ percent) commercial-grade muriatic acid, containing inhibitors and retardants, should be used in the treatment. The acid should be placed in the well through a pipe extending to a depth not less than 10 feet above the bottom of the well. After the acid is emplaced, the lower end of the pipe should be raised to the water level in the well, and 500 gallons of water should be poured into the well through the pipe. The pipe should then be removed from the well. The acid should remain in the well for not less than 18 hours during which time the solution in the well should be agitated several times at intervals of 1 hour by surging with a surge block or bailer. If a bailer is used, the bottom valve should be fixed in the open position. After the acid treatment, the well should be cleaned very thoroughly by bailing for not less than 4 hours, or longer if the water is not free of odor or suspended matter at the end of 4 hours. The well should then be tested again by bailing.

After the preliminary bailing test, the water level in the well should be allowed to recover for at least 8 hours. Test pumping should consist of 12 hours of continuous pumping at a rate based on the results of the preliminary bailing test. The test pump should be capable of pumping as little as 25 gpm and as much as 150 gpm from a depth of 550 feet. Measurements of the rate of recovery of water level should be made for at least 8 hours following the test.

A water sample should be bailed from the hole when the base of the San Andres limestone is encountered. A second sample should be collected if gypsum is encountered while drilling. A third water sample should be collected at the end of the pumping test.

SELECTED REFERENCES

Bachman, G. O., and others, 1954, Road log from Cloudcroft to Carlsbad, in New Mexico Geol. Soc. 5th Field Conf. Guidebook, Southeastern New Mexico: p. 32-39.

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Table 1.--Records of wells and springs in the vicinity of Cloudcroft, Otero County, N. Mex.

Altitude of land surface: Estimated from topographic map.
Water level: R, reported.
Method of lift: C, cylinder pump; E, electric; PJ, pump jack; T, turbine pump.
Use of water: D, domestic; PS, public supply; S, stock.

Location No.	Owner	Driller	Year drilled	Depth of well (feet)	Diameter of well (inches)	Estimated altitude of land surface (feet)
S15.13.29.144	-	-	-	-	-	8,380
29.244	-	-	-	-	-	8,300
S16.12.3.111	-	-	-	-	-	8,400
3.142	-	-	-	-	-	8,400
16.12.3.142a	Village of Cloudcroft	Perry Bros.	1954	195	12	8,340
3.142b	do.	Ray Taylor	1956	172	8	8,330

Table 1.--Records of wells and springs - Continued

Location No.	Water level: Below land surface (feet)	Water level: Date of measurement	Method of lift	Use of water	Remarks
S15.13.29.144	-	-	Flows	S	Spring in Silver Springs Canyon. Discharges from canyon fill. Probable source: limestone in Yeso formation. Estimated discharge on Mar. 20, 1956: 3 to 5 gpm. See chemical analysis.
29.244	-	-	Flows	S	Spring in Silver Springs Canyon. Discharges from limestone, probably in Yeso formation. Estimated discharge on Mar. 29, 1956: 1 to 2 gpm. See chemical analysis.
S16.12.3.111	-	-	Flows	S	Spring in James Canyon. Discharges from canyon fill. Probable source: limestone in Yeso formation. Old spring box now dry and spring issues as seep from below box. Estimated discharge on Mar. 28, 1956: 1 gpm.
3.142	-	-	Flows	-	Spring in James Canyon. Source: limestone in Yeso formation. Boxed, with welded steel cover.
16.12.3.142a	60R	1954	T, E	PS	Cloudcroft well 2, at junction of James and Pumphouse Canyons. Water-bearing formation: Yeso. Bottom 22 ft. of well drilled in dry "caliche". Casing: 12-inch steel to 60 feet. Drawdown in Aug. 1954 reported to be 115 ft. while pumping 160 gpm. Temperature 47°F. See chemical analysis.
3.142b	64.8	Mar. 20, 1956	T, E	PS	Cloudcroft well 3. At junction of James and Pumphouse Canyons. Water-bearing formation: Yeso. Casing: 8-inch steel to 150 ft., perforated from surface to 150 ft. Drawdown in Mar. 1956 reported to be 56 ft. while pumping 170 gpm. Water cascades down hole to water level. See log.

Table 1.--Records of wells and springs - Continued

Location No.	Owner	Driller	Year drilled	Depth of well (feet)	Diameter of well (inches)	Estimated altitude of land surface (feet)
S16.12.3.144	Village of Cloudcroft	-	-	-	-	8,400
16.12.5.133	Cloudcroft Lodge	Perry Bros.	1954	600	10, 8	8,680
[illegible].6.322	James and Bud Holland	Haskell Harris	1955	429	8	8,725

Table 1.--Records of wells and springs - Continued

Location No.	Water level: Below land surface (feet)	Water level: Date of measurement	Method of lift	Use of water	Remarks
S16.12.3.144	-	-	Flows	PS	Spring in Pumphouse Canyon, used by village of Cloudcroft. Water gathered from at least ~~3~~ three spring boxes. Aggregate discharge reported to be 60 gpm. Temperature: 44°F. See chemical analysis.
16.12.5.133	500R	-	T,E	D	Casing: 10-inch steel to about 200 feet; 8-inch steel to less than 600 feet. Well entered Yeso formation. Reported to yield 40 gpm. See chemical analysis.
.6.322	392.1	3-27-56	C,PJ	D	Well 1 at Lost Lodge Subdivision. Slush dump shows no rock cuttings similar to those of Yeso formation; all limestone cuttings. Casing: 8-inch steel to 419 feet. Temperature 46°F. See chemical analysis.

Table 2.--Driller's log of well 3 (16.12.3.142b) Village of Cloudcroft, Otero County, N. Mex.

Material	Thickness (feet)	Depth (feet)
Alluvium:		
Canyon fill - gravel, etc.	40	40
Yeso formation:		
Gray lime	62	102
Yellow clay and gravel	43	145
Gray lime	27	172

Table 3.--Chemical analyses of water from wells and springs in the vicinity of Cloudcroft, Otero County, N. Mex.

(Analyses by U.S. Geological Survey, in parts per million except specific conductance and pH.)

Location No.	Owner	Depth (feet)	Date of collection	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na + K)
S15.13.29.144	-	Spring	3-20-56	98	16	7.1
.29.244	-	do.	3-29-56	-	-	-
16.12.3.142a	Village of Cloudcroft	195	3-20-56	98	18	6.7
S16.12.3.144	do.	Spring	3-29-56	-	-	-
16.12.5.133	Cloudcroft Lodge	600	3-28-56	119	20	13
6.322	James and Bud Holland	429	3-27-56	118	21	13

Table 3.--Chemical analyses of water from wells and springs - Continued

Location No.	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$ Noncarbonate	Hardness as $CaCO_3$ Total	Specific conductance (micromhos at 25°C)	pH
S15.13.29.144	308	56	9.5	0.2	1.2	349	58	310	590	7.7
29.244	312	77	9.5	-	-	-	34	290	590	8.0
16.12.3.142a	308	61	8.5	.2	5.7	359	66	318	603	7.6
S16.12.3.144	341	52	11	-	6.2	-	50	330	622	7.7
16.12.5.133	407	52	12	.2	2.7	429	46	379	707	7.5
6.322	401	57	14	.2	1.7	434	52	381	718	7.4