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Site study for a water well, Fort Wingate Army Ordnance Depot, McKinley County, New Mexico

By

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Prepared by the U.S. Geological Survey in cooperation with Fort Wingate Army Ordnance Depot

Open-file report

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Introduction

The Fort Wingate Army Depot (fig. 1) is now supplied with water

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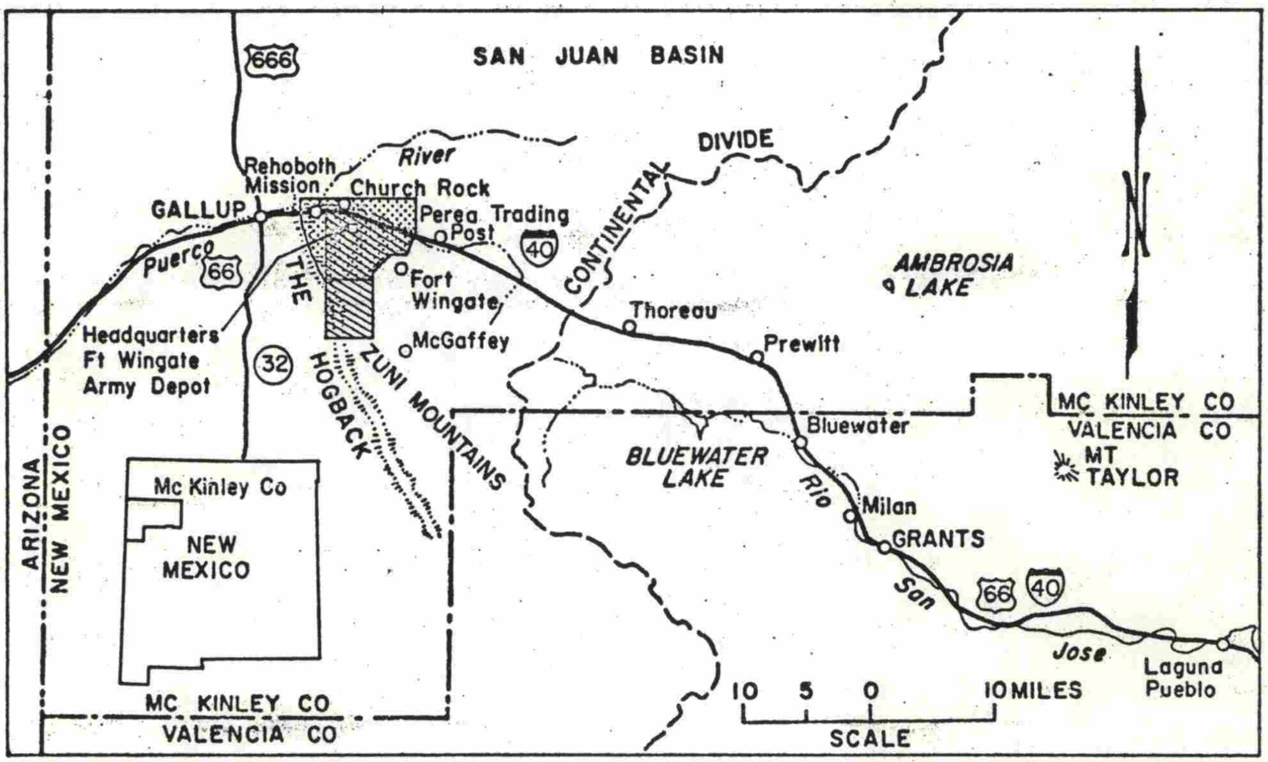
from only one source, well No. 68 which is 1,125 feet deep. The well casing is deteriorating and the well may fail. The Depot considers this an emergency situation that requires a new well to be drilled as soon as possible. In addition, the Army Materiel Command has suggested to the Depot that the total ground-water resources of the Depot area be evaluated as an aid to long-range planning.

The Depot requested the U.S. Geological Survey to suggest study plans to accomplish an evaluation of the ground-water resources. The study plans include an areal study of possible aquifers available to the Depot, drilling an exploratory test well, conversion of the test well to a production well, and a study of the feasibility of recharging the aquifers by diversion of runoff in the outcrop areas of the aquifer rocks.



EXPLANATION

Area of investigation

Fort Wingate Army Depot

Figure 1.--Map showing location of Fort Wingate Army Depot, and area of well-site investigation

This report marks the conclusion of the first step in a complete water resources evaluation for the Depot; it is the result of a reconnaissance study aimed toward establishment of a dependable water supply in as short a time as possible.

The stratigraphic section in the Fort Wingate area

The sequence of rocks shown below is a composite of the following: Above the top of the Glorieta Sandstone, the section measured by Jackson and Johnson (which appears in Callahan and Cushman, 1955) has been repeated in condensed form and with some modification of nomenclature (i.e., use of currently accepted member names). The section below the top of the Glorieta has been measured near McGaffey by Read and Wanek (1961), and was measured there again for this report; the thickness of the lower part of the composite section has been adjusted to fit preliminary data obtained through a seismic investigation (oral communication, R. T. Zbur, November 1967).

The seismic study was conducted on October 20 and 21, 1967, by Mr. Richard T. Zbur of the U.S. Air Force Weapons Laboratory. The complete results of the study are not yet available.

Stratigraphic section, Permian and Triassic Systems, Fort Wingate area

	Feet
Triassic System:	
Wingate Sandstone (undescribed, not present along line of geologic cross section)	355
Unconformity:	
Chinle Formation:	
Owl Rock Member:	
6. Mudstone, variegated grayish-red and light-greenish-gray, banded; composed of silt and clay; poorly cemented..	8
5. Limestone, pale-reddish-purple; silty; contains some medium-crystalline calcite	10
4. Limestone, mottled very light gray and pale-reddish-purple; medium crystalline with rare rounded quartz grains	6
3. Limestone, light-brownish-gray; finely crystalline	6
2. Mudstone, same as unit 26 of Petrified Forest Member	9
1. Limestone, mottled pale-reddish-purple and light-gray; aphanitic	2
Total Owl Rock Member	41

Petrified Forest Member (upper part):	Feet
30. Mudstone, same as unit 26	440
29. Limestone, sandy, same as unit 27	2
28. Mudstone, same as unit 26	38
27. Limestone, sandy, pale-red-purple; silty and finely crystalline	2
26. Mudstone, mottled dark-reddish-brown and light-greenish-gray; very thick gnarly bedded	11
25. Sandstone, grayish-red-purple, very fine grained, poorly sorted; composed of subangular stained quartz with rare mica, rare black accessory minerals, and rare argillaceous material; firmly cemented, weakly calcareous	10
24. Covered interval	45
23. Sandstone, light-olive-gray, fine to very fine grained, fair-sorted; composed of subrounded to subangular frosted quartz with abundant black accessory minerals, common argillaceous material and rare red accessory minerals; firmly cemented, weakly calcareous. Beds contain siltstone and claystone granules at base. Unit becomes more calcareous toward the top	20

Petrified Forest Member (upper part) continued: Feet

22. Siltstone conglomerate:

Matrix, light-greenish-gray, medium-to fine-grained, poorly sorted; composed of subangular frosted quartz with common black and red accessory minerals and argillaceous material; firmly cemented, calcareous;

Gravel, angular to subangular siltstone and claystone pebbles (1/8 to 1/2 in. across), reddish-brown to dark-reddish-brown 2

21. Claystone 1

20. Claystone, same as unit 18 54

19. Mudstone, grayish-red; composed of amber and white quartz with common mica and rare green accessory minerals; poorly cemented 1

18. Claystone, mottled grayish-red-purple and light-greenish-gray; very thin, irregularly bedded 54

17. Mudstone, mottled grayish-red-purple and light-greenish-gray; composed of silt and clay 18

Petrified Forest Member (upper part) continued:	Feet
16. Conglomerate:	
Matrix, sandstone, light-greenish-gray, fine-grained, poorly sorted; composed of subangular amber, white, and clear quartz with rare black accessory minerals and abundant argillaceous material; poorly cemented, weakly calcareous.	
Pebbles, siltstone, limestone and quartz pebbles (1/8 to 1 in. across), angular to subangular; siltstone and limestone pebbles predominate	5
15. Claystone, mottled moderate-reddish-brown and light-greenish-gray. Contains common subangular quartz granule inclusions	19
14. Claystone, variegated grayish-red-purple and greenish-gray	30
13. Sandstone, calcareous, variegated pale-reddish-purple and light-greenish-gray, very fine grained, poorly sorted; composed of subangular to angular white and amber quartz grains with common black detrital and argillaceous material; firmly cemented, highly calcareous	24
12. Claystone, grayish-red-purple	6

Petrified Forest Member (upper part) continued:	Feet
11. Covered	8
10. Sandstone, pale-red-purple, fine to very fine grained, poorly sorted; composed of subangular amber, clear and smoky quartz with abundant black accessory minerals, rare green accessory minerals and common argillaceous material; well-cemented, noncalcareous	6
9. Mudstone, grayish-red-purple; composed of silt and clay with common mica accessories, highly argillaceous; firmly cememted	18
Sonsela Sandstone Bed of Petrified Forest Member:	
8. Sandstone, grayish-orange-pink, fine-grained, well-sorted; composed of rounded to subrounded clear and frosted quartz and rare green accessory minerals and argillaceous material	29
7. Limestone, pale-olive, medium-crystalline ...	18
6. Sandstone, argillaceous, pinkish-gray, very fine to coarse-grained, poorly sorted; composed of subangular to angular clear and frosted quartz grains with abundant argillaceous material; poorly cemented	11
Petrified Forest Member, lower part:	
5. Claystone, dusky red-purple and light-gray ..	98

Petrified Forest Member (lower part) continued:	Feet
4. Mudstone, mottled grayish-green and pale-reddish-purple; composed of silt and clay. Contains pale-greenish-gray siltstone	31
3. Claystone, mottled grayish-yellow-green and dark-reddish- brown	89
2. Siltstone, argillaceous, yellowish-gray, poorly sorted; composed of subangular quartz with rare red accessory minerals, common black accessory minerals, and common to abundant argillaceous material	3
1. Covered	70
Total Petrified Forest Member	1,163
Lower red member:	
9. Sandstone, grayish-orange-pink (weathers light brown) very fine grained, fair-sorted; composed of subrounded clear quartz with common black accessory minerals; firmly cemented, siliceous	33
8. Conglomerate: Matrix, grayish-red-purple, medium to very fine grained, poorly sorted; composed of subangular clear and frosted quartz with common black accessory minerals. Gravel, pale-olive-gray to reddish-brown; limestone and siltstone pebbles (¼ to 1 in), subangular and pitted	7

Lower red member continued:	Feet
7. Claystone, dark-reddish-brown	35
6. Claystone, reddish-brown-purple	41
5. Covered	83
Total lower red member	199
Shinarump (?) Member (may be part of lower red member):	
4. Conglomerate:	
Matrix, very pale orange, very coarse to very fine grained, poorly sorted; composed of subangular clear, frosted, and stained quartz with rare red accessory mineral and feldspar detritals; firmly cemented.	
Gravel, quartz, jasper, chalcedony and feldspar pebbles, subangular (½ to 2½ in. across)	13
3. Mudstone, mottled grayish-purple and light-brown; composed of claystone and siltstone; firmly cemented	12
Total Shinarump Member	25
Moenkopi (?) Formation (may be part of lower red member):	
2. Sandstone, yellowish-gray (weathers reddish-brown) very fine grained, poorly sorted; composed of subrounded to subangular clear quartz grains and rare red accessory minerals, common black accessory minerals and abundant argillaceous material; firmly cemented	27

Moenkopi(?) Formation (may be part of lower red member)

continued:

	Feet
1. Claystone, dark-reddish-brown; very flat, thin bedded; weathers hackly; forms an irregular slope. Base is irregular	5
Total Moenkopi(?) Formation	32

Permian System:

San Andres Limestone:

2. Limestone, grayish-orange-pink (weathering gray), finely crystalline. Manganese detritals are common	86
1. Dolomitic limestone, silty, light-brown, aphanitic; composed of dolomite and silt	11
Total San Andres Limestone	97

Glorieta Sandstone:

1. Sandstone, white, tan, or buff, fine to very fine grained, generally well sorted; almost entirely composed of rounded or subrounded clear quartz grains, but with some accessory mica and magnetite(?) and occasional small limonite nodules; well cemented	250-300

Yeso Formation:

San Ysidro Member:

8. Sandstone, buff or brown, medium to fine grained, quartzose; interbedded with thin-bedded orange or brown siltstone	90

Yeso Formation:

San Ysidro Member - continued:

	Feet
7. Limestone, gray, dense, dolomitic	8
6. Sandstone and siltstone similar to unit 8 ..	40
5. Limestone, similar to unit 7	7
4. Sandstone, similar to Unit 8	20
3. Sandstone, brown or reddish-brown, fine to very fine grained; interbedded with very thin-bedded orange siltstone	45
2. Limestone, similar to Unit 7	10
Total San Ysidro Member	220

Meseta Blanca Member:

1. Sandstone, orange or orange-brown, fine-grained to silty	80

Abo Formation:

2. Sandstone, brown or red-brown, medium grained to silty, poorly sorted; contains some mica; alternates with thick-bedded, brown to orange siltstone	300
1. Arkose, brown, coarse; composed of pink feldspar fragments in a dark brown sand matrix	0-25?
Total Abo Formation (base covered)	325?

Unconformity:

Precambrian:

1. Granite, pink, medium grained; intruded by numerous thin veins of white quartz.

Consideration of aquifers for a dependable water supply

Aquifers in bedrock units stratigraphically above those that crop out at the Headquarters area (that is, rocks above the upper part of the Petrified Forest Member of the Chinle Formation) were eliminated from consideration as a possible source of water for two reasons. First, they crop out at some distance from the Headquarters area generally outside the Depot boundary, and second, they are relatively thin and have very small areas exposed for recharge. Several wells near Indian Village, apparently finished in the Wingate Sandstone of Triassic age, yield water of good quality from shallow depth. However, the small storage capacity and small recharge area of these rocks, and their distance from the Depot seem to preclude the possibility of developing a dependable water supply from them for the Depot. The Entrada Sandstone of Jurassic age, and overlying rocks north of Church Rock and in the Hogback area, doubtless lie above the water table for some distance north of Church Rock School and dip very steeply (exposing only very narrow recharge areas) in the Hogback area along the western side of the Depot. They are not considered to be a potential source of water in either area.

The alluvium at and near the Depot area is thin and discontinuous and water from the few wells finished in it is of marginal chemical quality.

Aquifers of the Petrified Forest Member (upper part) to the top of the Permian System, yield small quantities of inferior water where tapped by wells near the Depot. The Perea Trading Post well yields about 4 gpm (gallons per minute) from the upper part of the Petrified Forest Member; the water has a specific conductance of about 2,400 micromhos. A well at Rehoboth Mission yields 4-6 gpm of even more highly mineralized water from a similar stratigraphic horizon. Yields from these beds could probably be increased by certain types of well construction but there is no indication that water of better quality could be obtained from them.

Rocks beneath the Glorieta Sandstone (the presently developed aquifer) have not been tested near the Depot, but examination of them on the outcrop (near McGaffey) permits some generalization. These rocks are assigned, in descending order, to the San Ysidro Member and the Meseta Blanca Member of the Yeso Formation, the Abo Formation (all of Permian age), and to the Precambrian. The San Ysidro and Meseta Blanca Members appear to be permeable enough to yield some water, and it is possible that the Precambrian granite will yield water if it is strongly fractured. Testing of the rocks below the Glorieta is definitely warranted.

The San Andres Limestone-Glorieta Sandstone aquifer remains for consideration. The altitude of the top of the Glorieta Sandstone is shown on figure 2. Though pressure decline has been pronounced in

Figure 2 (caption on next page) belongs near here.

wells finished in the San Andres-Glorieta aquifers within the area investigated (fig. 2), water quality is still good, yields are still adequate, and storage volume and recharge area are favorable. The fact that pressure has declined from its pristine condition is not a cause for alarm; it is rather an indication that water resources management should begin. The aquifer is not depleted.

The Glorieta Sandstone should be from 250 to 300 feet thick, and the San Andres Limestone, which may or may not be present above it, can be as thick as 100 feet. Both are good aquifer rocks. Well No. 68 apparently penetrated only about 45 feet of the Glorieta (the San Andres is not present at this location), yet its specific capacity in 1956 was about 1.5 gpm per foot of drawdown. Well No. 326, after deepening, penetrated only about 60 feet of San Andres and Glorieta combined. It is said to have flowed 55 gpm shortly after completion, even though the upper aquifers were probably not completely sealed off or the Glorieta Sandstone fully penetrated or developed.

Figure 2.--Altitude of the top of Glorieta Sandstone in vicinity of Headquarters area, Fort Wingate Army Ordnance Depot, McKinley County, New Mexico.

No well on or near the Depot has completely penetrated the Glorieta Sandstone or has been constructed to take full advantage of the part that is penetrated. Every well in the area that produces from the Glorieta, except well No. 68, is equipped with a pump. Decline in yields of older wells can generally be attributed to corrosion and deterioration of the casing, together with somewhat greater pumping lifts as artesian pressure has declined. A well drilled at the location designated in this report should, if properly constructed, yield about 250 gpm, and though a pump may be required to obtain that yield, artesian head will greatly decrease the pumping lift.

Suggested well location

The most favorable area for a water well to serve the Depot appears to be that shown on figure 3 as "suggested area in which to drill a test

Figure 3 (caption on next page) belongs near here.

well". The actual well site, within the area, can be determined by Depot personnel through cost analysis involving well depth, pipeline distance, and estimated pumping lift. The choice of location was made on the following grounds:

1. The Glorieta Sandstone is probably the best aquifer available in the Depot area.
2. Depth to the Glorieta increases rapidly to the north and northwest and decreases to the southeast. It is thought that the depth to the Precambrian varies in the same manner, however, some refinement may be possible when the results of the seismic investigation become available (fig. 3). Surface topography is taken into account in fig. 3.
3. The advantage of decrease in depth to the Glorieta is offset to some extent by decrease in storage volume available, and by increase in the length of pipeline required.
4. To minimize interference between wells, it is desirable to locate new wells as far as possible from existing wells, and in the direction of the strike of the formation, if feasible.
5. It is a general rule that the chemical quality of water in a formation improves in the direction of the outcrop; in the case of the Glorieta, the outcrop area is to the south. A well drilled south of the present one might thus be expected to yield somewhat better quality water.

Figure 3.--Depth to top of Precambrian granite and depth to top of Glorieta Sandstone in vicinity of Headquarters area, Fort Wingate Army Ordnance Depot, McKinley County, New Mexico.

6. Rocks below the Glorieta Sandstone may yield usable quantities of good water, and the site for the new well should be such as to take advantage of that possibility. Fortunately, underlying formations lie at more-or-less constant depths below the Glorieta, and are likely to be of fairly uniform thickness and character beneath the Depot.

7. According to information received from the Post Engineer, the well installation should be no closer than 400 feet from explosives storage points.

When a site for drilling is selected, the contour maps that accompany this report (fig. 2 and fig. 3) can be consulted to determine the depth to the Glorieta and the depth to the Precambrian (i.e., total depth of the well). The geologic section that probably will be penetrated can be determined from the composite stratigraphic section in this report as soon as the well site has been pinpointed.

Production well construction

Under geologic conditions such as those at Fort Wingate Army Depot, yield of a well is probably influenced more by the well construction than by the well location. The considerations outlined below are critical.

The strata that are found to yield water of acceptable quality must be penetrated fully and the casing must be perforated, or appropriate screen installed, throughout the intervals opposite such strata. The well casing should be perforated so that as much area as possible will be open to the aquifer. The number, arrangement, and, in particular, the size of the perforations must be chosen to correspond with the character of the aquifer material. If the formation does not cave at all or pump any sand it will probably be best to have open hole at the producing zone.

Strata that bear unacceptable water must be cased off, so that the poorer water will not enter the well. It is very likely that the entire section above the top of the Permian rocks will yield either inferior water or no water at all; therefore, casing should be blank and cemented above that point. If inferior water is encountered below the Glorieta it must be sealed off by plugging back.

Leakage around the casing can be a singularly difficult problem, and must be carefully guarded against. Water in the deeper rocks will be under artesian pressure, and will rise to the surface outside the casing if the casing is not very carefully cemented from the top of the production zone to land surface. Possibilities for foundation damage and related effects are obvious; not so obvious are the pressure relief and waste of water that will result if constant leakage around the casing and into surficial material is permitted. Thorough cementing outside the outer casing will also serve to protect it from the corrosive action of waters in strata above the production zone. At least one well (Rehoboth Mission) near the Depot produces highly mineralized water from the annulus between the outer casing and the "production string", apparently because the outer casing has been perforated by corrosion and now allows the saline water to rise within it. Needless to say, this situation is not desirable unless there is a use for the saline water and unless the production casing is of some material that will withstand the corrosive water.

The production casing should be large enough, and straight enough, to accept a pump of sufficient capacity to provide the required quantity of water from a setting of 500 or 600 feet, if necessary.

Development of the well by overpumping, surging, or some other appropriate method, is as much a part of the construction as the drilling itself.

Summary

The Glorieta Sandstone is probably the soundest choice as an aquifer to be tapped by the new well; the Glorieta must be penetrated fully, and the rocks below it, some of which also appear to be potential aquifers, should be tested by drilling to the Precambrian granite.

The most favorable area for drilling would seem to be the floor of the valley south of well No. 326, as shown on figure 3. Within that area the depth to the Precambrian ranges between 1,200 and 1,600 feet, and the depth to the top of the Glorieta ranges between 300 and 700 feet. Once the well site has been chosen, the depth to the Glorieta and the depth to the Precambrian can be determined from figure 3, and the strata that should be penetrated can be determined from the foregoing stratigraphic section.

References cited

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