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MEMORANDUM

ON

GROUND WATER CONDITIONS

IN THE

VICINITY OF THE CITY AIRPORT SOUTHWEST OF CARLSBAD NEW MEXICO

By

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GEOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF THE INTERIOR

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MEMORANDUM ON GROUND WATER CONDITIONS IN THE VICINITY OF THE CITY AIRPORT SOUTHWEST OF CARLSBAD, NEW MEXICO

By W. E. Hale and C. V. Theis

Geological Survey, United States Department of the Interior

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INTRODUCTION

The War Department is considering the establishment of an air base at the city airport about 4½ miles southwest of Carlsbad, in sections 35 and 36, T. 22 S., R. 26 E. One million gallons of potable water a day will be required for use at the airport. The accompanying map shows the location of wells in the vicinity.

There are four possible sources of water for the air base. These are:

(1) The Carlsbad limestone, which produces an adequate supply of hard but potable water, such as that of the Carlsbad city supply. The water would have to be piped a few miles to the air base.

(2) Limestone beds in the Rustler formation, which yield water of good quality, but the supply of which might be inadequate and which would have to be piped some distance.

(3) The valley fill near the Southern Canal, which would produce an adequate supply of highly mineralized and impotable water, which would also have to be piped a few miles.

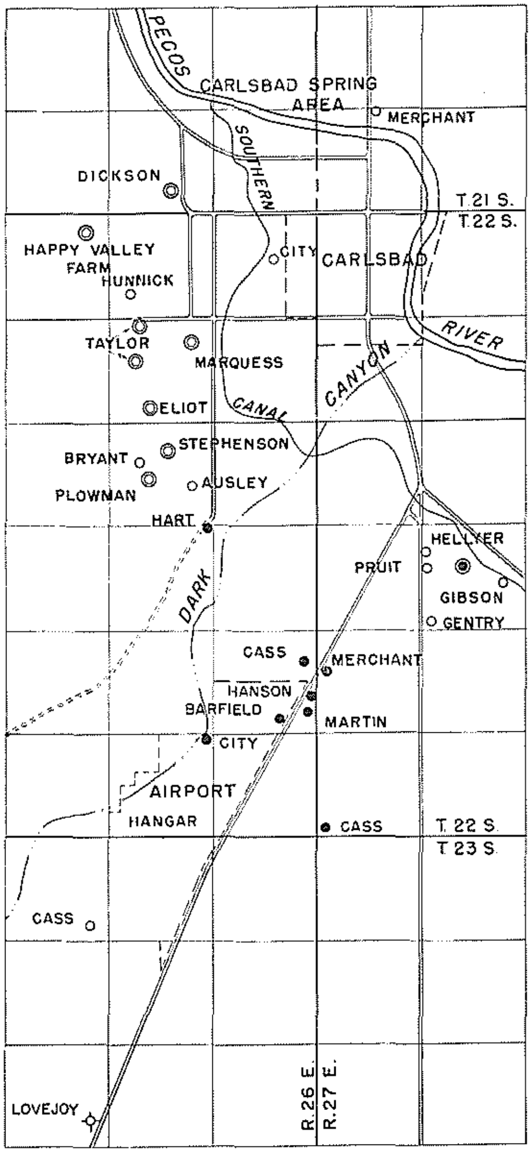
(3a) Conglomerate beds in the valley fill near the air base, which would produce water of the best quality available in the vicinity but from which the supply of water might not be continuously adequate.

GROUND WATER IN THE CARLSBAD LIMESTONE

OCCURRENCE

The Carlsbad limestone covers the foothills of the Guadalupe Mountains west and southwest of the airport. East of the foothills the limestone dips beneath the surface. The limestone is 300 to 600 feet thick in the foothills but grades abruptly into different rocks to the west and east of the foothills.

Numerous wells have been drilled into the Carlsbad limestone along the flank and just east of the foothills, obtaining water in channels in the limestone. The developed area extends from about 2½ miles north of the airport to about 7 miles north of it. These wells range in depth from 60 to 345 feet but usually encounter water at about the same elevation. The water usually rises about 15 feet in the hole when encountered and, except near the main irrigation canals just west of town, it is the first water found. Although water is encountered everywhere in this developed area, the aquifer is more open in some places than others. The thickness of the aquifer is not known but water has been found at three



MAP OF WELLS IN VICINITY OF AIRPORT, CARLSBAD, N.M.

LEGEND

IRRIGATION WELLS	DOMESTIC WELLS	FORMATION PENETRATED
◎	○	CARLSBAD LIMESTONE
◉	●	VALLEY FILL
	⌖	RUSTLER FORMATION

different depths in some of the deeper wells. The depth to water in the various wells is 30 to 150 feet.

The piezometric surface of the water in the aquifer slopes about 3 feet to the mile in a general northeasterly direction toward the Pecos River. The water level fluctuates yearly about 3 feet. The water levels are lowest at the end of the irrigation season in October.

The recharge area for the water moving through the Carlsbad limestone is probably the foothills of the Guadalupe Mountains where the Carlsbad limestone crops out. The water discharges into the Pecos River between Carlsbad Spring in the northwest part of Carlsbad and Tansill Dam east of town.

EXISTING WELLS AND QUANTITY AVAILABLE

Seven large irrigation wells and the municipal wells of Carlsbad derive water from the Carlsbad limestone. The following table lists the irrigation wells, their owners, pumping rate, drawdown where known, static depth to water, and distance from the airport hangar.

Table 1

IRRIGATION WELLS DRAWING WATER FROM CARLSBAD LIMESTONE

Location		Owner	Pumping rate g.p.m.	Drawdown (feet)	Approx. static depth to water in feet below land surface	Approx. distance from airport hangar, in miles
T. 22 S., R. 26 E.						
SW¼NE¼	sec. 3	Happy Valley Farms	2,000	....	143	5 2/3
NE¼NE¼	sec. 11	T. Marquess	1,000	....	35[1]	4 1/2
NE¼NW¼	sec. 11	S. A. Taylor	725	....	....	4 3/4
SE¼NW¼	sec. 11	S. A. Taylor	1,630	....	60	4 1/3
NW¼NE¼	sec. 14	H. E. Stephenson	1,000[1]	20	60	3 1/2
	sec. 14	P. Plowman	1,000[1]	4[1]	87	3 1/4
T. 21 S., R. 26 E.						
SW¼SE¼	sec. 35	Dickson	850[1]	....	73[1]	6

The city wells are in sec. 1, T. 22 S., R. 26 E., about 5 miles north of the airport hangar. These wells are from 150 to 237 feet deep and the depth to water is about 26 feet. Altogether these wells pump about 2,000 gallons a minute. A test made on one of the wells in October 1939 showed the well to have a specific capacity of 275 gallons per foot of drawdown, a very high value. This indicates that in this particular locality the aquifer has large openings which yield the water readily.

However, there are places where the aquifer is relatively tight, as for instance in sec. 14, T. 22 S., R. 26 E. A well in this section was drill-

1 Reported by owner.

ed 152 feet deep and encountered water from 107 to 110 feet, from 117 to 124 feet and from 138 to 144 feet. The static depth to water is about 92 feet. A pumping test was made on this well on Feb. 27, 1942. The well was pumped for 4½ hours at the rate of about 160 gallons a minute. The drawdown was 25 feet.

The present average withdrawal of water from the Carlsbad limestone throughout the year by irrigation wells, domestic wells, and the city wells amounts to about 4 second-feet, but during the irrigation season the withdrawal of water at times may be as high as 26 second-feet. Practically all the irrigable land is under cultivation in the area, so that no large additional withdrawal of water by irrigation wells is likely to occur. Additional wells to supply the city of Carlsbad will probably be needed in the near future.

From a study of the Carlsbad Spring area made in 1940, it was estimated that out of a total normal discharge of 60 second-feet from the springs, 12 second-feet was coming from the Carlsbad limestone, the remainder being derived from leakage from Lake Avalon and the irrigation canals.

QUALITY

The water found in the Carlsbad limestone in the developed area is hard but not very highly mineralized. The analyses of water samples collected from various wells deriving water from the Carlsbad limestone is given in the table of analyses appended.

During the irrigation season when the withdrawal of water from the aquifer is higher, the city wells show a slight increase in mineralized matter. This may be due to a slight influx of highly mineralized water leaking from Lake Avalon. As more water is withdrawn from the aquifer, more leakage water from Lake Avalon may enter and increase the mineralization of the city water supply and other nearby wells.

POLLUTION

The community of West Carlsbad has no sewer system and there are numerous outhouses and cesspools. The fill material overlying the Carlsbad limestone is only a few feet thick in some places and has a maximum thickness of 60 feet near the Southern Canal to the east. No shallow water occurs in this locality above the limestone except near the Southern Canal from which considerable leakage occurs. As the water in the limestone is encountered under pressure the limestone itself must be practically impermeable, but there may be cracks down through which waste water could percolate. Further, it is possible for the water from cesspools to move laterally to the walls of the wells, which generally are poorly cased, and down the walls of the well into the ground water.

Water samples were collected from various wells in this locality in October and November 1939, and sent to the State Public Health Laboratory at Albuquerque, New Mexico, for bacterial analysis. None of the analyzed samples showed *B. coli*, the indicator of human sewage. Later, in March 1940, a harmless dye, uranin (fluorescein), was introduced into as many cesspools and privies in this locality as possible. This dye is red when concentrated but in weak solutions has a greenish color, which can be easily seen in concentrations of 1 part per million parts of water. A quarter of a pound of dye mixed with 2½ gallons of water was put in nearly every privy and cesspool. Householders were urged to report any coloring that they observed in the drinking water. No reports of any coloring of the water were received by the State Health Department or by the Geological Survey.

On the basis of this evidence, it was concluded that contamination of the water supply in West Carlsbad was not taking place at that time; however, the danger of pollution always exists under present conditions.

The greatest danger of contamination is, of course, in wells down gradient from the possible source. Inasmuch as the piezometric surface of the water in the Carlsbad limestone in the vicinity of Carlsbad slopes to the northeast, the danger of pollution is at a minimum in wells to the south of West Carlsbad or in the direction of the airport. If water from the Carlsbad limestone is used for the airport, it will presumably be advantageous, at least to install a chlorinator on the line, but detailed studies of water levels and drawdowns in the vicinity of the source of the water will probably show whether or not the possibility of pollution exists in these wells.

WATER IN THE LIMESTONE OF THE RUSTLER FORMATION

OCCURRENCE, QUANTITY, AND QUALITY

The limestone of the Rustler formation crops out in a line of low hills east of the foothills of the Guadalupe Mountains and southwest from the airport. Eastward, the limestone is buried under the valley fill. Just east from the low hills the limestone may be 400 feet thick, but a few miles farther east it grades mostly into gypsum.

Dark Canyon has cut a channel across the outcrop area of the Rustler formation and water moving through the fill of Dark Canyon probably recharges the limestone of the Rustler. The water in the limestone probably discharges into conglomerates in the fill to the east wherever the fill is deep enough to intersect the piezometric surface of the water in the aquifer.

One water well in sec. 15, T. 23 S., R. 26 E., about 3½ miles south of the airport hangar, was drilled 315 feet deep and encountered water in a limestone, probably the Rustler, at a depth of 310 feet. The water rose in the hole about 35 feet. No pumping test has been made on this well. No other wells are known to be deriving water from the Rustler formation.

Because the Rustler formation changes character rapidly in this neighborhood and because the conglomerate beds in the alluvium are not greatly different from those in the Rustler, it is not possible to distinguish certainly the water-bearing formation in some of the wells. It is possible that the Cass well in sec. 3, T. 23 S., R. 26 E., and the present airport well may also be deriving water from the Rustler, although this does not seem probable.

The water in the few wells known to be drawing from the Rustler formation is of good quality. An analysis is given in the table of analyses appended.

WATER IN THE VALLEY FILL

OCCURRENCE

The valley fill extends southward from Carlsbad to Black River and eastward from the foothills of the Guadalupe Mountains to the Pecos River. The fill is as much as 200 feet thick in places just south of Carlsbad and for 3 or 4 miles up Dark Canyon. West of Dark Canyon, and in numerous places east of it, the fill is only a thin veneer. The valley fill is composed largely of clay with beds of sand, gravel, and conglomerate.

Wells drilled in the valley fill have encountered water in the sand, gravel, and conglomerate beds wherever these beds lie at or below the water table or piezometric surface.

The piezometric surface of the water in the fill near the present airport slopes gently to the east. Immediately west of the Southern Canal, the water table slopes west for a short distance. East of the Canal the water table slopes east and northeast to the Pecos River.

The water-bearing beds in the valley fill are probably recharged by flood waters in Dark Canyon. The water that enters in this way is of good quality. It moves slowly east or northeast to the vicinity of the Southern Canal. Here highly mineralized water seeping from the canal and from irrigated lands joins it. Part of the ground water appears to be deflected south on the west side of the Canal, but most of the ground water, now highly mineralized, probably moves northeastward to discharge into the Pecos River. The vicinity of the Southern Canal therefore forms a boundary dividing the ground water in the valley fill into two distinct classes so far as water supply is concerned. From somewhat west of the Canal eastward to the Pecos River, the water is impotable and could not be used at the air base except as a supplementary supply. In the vicinity of the air base the water is of the best quality available in the vicinity of Carlsbad. (See analyses in appended table.)

WATER IN THE VALLEY FILL NEAR AND EAST OF THE SOUTHERN CANAL

EXISTING WELLS

Several domestic wells and six irrigation wells draw water from the valley fill near the Southern Canal. A list of the irrigation wells and their respective pumping rates is shown in the table below.

Location		Owner	Pumping Rate (g.p.m.)
T. 22 S., R. 27 E.			
SW¼SW¼	sec. 17	O. W. Hanson	600
NE¼NE¼	sec. 20	Neal and Taldon	600
SE¼NW¼	sec. 20	Gibson	675
SW¼SE¼	sec. 29	J. C. Tidwell	900
T. 23 S., R. 27 E.			
SW¼SW¼	sec. 4	A. C. Bindel	1,200
	sec. 9	Simms	600

QUALITY

All the wells near the Southern Canal producing large quantities of water, and with few exceptions all the domestic wells, yield calcium sulfate waters with hardness ranging from about 550 to 2,000 parts per million and with a chloride content ranging from about 300 to 600 parts per million. The water could not be used except as a supplementary supply for irrigation or in sewerage works at the air base.

WATER IN VALLEY FILL NEAR PRESENT AIRPORT

GENERAL CONDITIONS

Water enters certain limestone conglomerate beds in the valley fill along the course of Dark Canyon arroyo. This water, of good quality, moves eastward and in all probability joins with the highly mineralized water in the valley fill near the Southern Canal. There is, at present, no way available for estimating the quantity of good water entering the conglomerates at the outcrops.

EXISTING WELLS

The following are the wells that obtain water of good quality from the valley fill in the vicinity of the present airport:

Location		Owner	Depth of well (feet)	Depth to water (feet)
T. 22 S., R. 26 E.				
SE¼NE¼	sec. 25	K. Cass	150	94.8
SW¼SE¼	sec. 25	R. V. Barfield	140	103.7
SE¼SE¼	sec. 25	W. M. Martin	140	99
NE¼NE¼	sec. 35	City of Carlsbad	155	132
T. 22 S., R. 27 E.				
SW¼NW¼	sec. 30	W. H. Merchant	207	92
NE¼SW¼	sec. 30	Goat Ropers Club	190+	85±
T. 23 S., R. 26 E.				
SE¼	sec. 3	K. Cass	300	225

The logs of a few of the wells are listed below:

LOG OF MARTIN WELL

SE¼SE¼ sec. 25, T. 22 S., R. 26 E.

Drilled in June 1941. Cased with 10-in. casing. Logged from cuttings by R. H. King, Geological Survey.

Material	*Depth (feet)*
Missing	0-10
Gravel, coarse, poorly sorted, composed of subrounded to well-rounded pebbles of limestone and dolomite, white, tan, gray, and some reddish	10-20
Missing	20-30
Clay, tan, and gravel, moderately well sorted, mostly subangular pebbles of limestone and dolomite, white to dark gray	30-35
Gravel, poorly sorted, composed of pebbles of limestone and dolomite, mostly white and light gray, some tan and dark gray, trace of reddish, mostly subrounded	35?-40?
Missing	40-55
Gravel, poorly sorted, composed of limestone and dolomite pebbles, white to dark gray, some tan, subrounded to well-rounded	55-60
Same	60-65
Same	65-70
Clay, light tan, very calcareous, and gravel, as in preceding samples	70-75
Same	75-80
Missing	80-90

LOG OF MARTIN WELL—Contd.

About like that between 70 and 80 feet	90-95
Conglomerate, limestone and dolomite pebbles as in preceding samples, bound by pinkish calcareous cementing material	95-100
Same, very little bit of weak cementing material; virtually a gravel	100-105
Same, but considerable tan clayey calcareous cementing material	105-110
Same	110-115
Same	115-120
Same, ground very fine, and containing some crystalline calcite and some quartz, in crystals and angular to well-rounded grains	120-125
Same, fairly numerous quartz grains	125-130
Conglomerate, very poorly sorted, firmly cemented, consisting of pebbles of limestone and dolomite, seemingly rounded to well-rounded, white, tan, gray, pinkish, light brown and yellowish; some quartz in crystals and angular to well-rounded grains; some calcite	130-135
Clay, brown; some conglomerate, as in preceding samples	135-140
Total depth 140 feet	

LOG OF AIRPORT WELL

NE¼NE¼ sec. 35, T. 22 S., R. 26 E.

Material	*Depth (feet)*
Soil	0-8
Limestone boulders	8-40
Clay, yellow	40-128
Limestone (conglomerate?), hit water at 144 feet	128-154

LOG OF MERCHANT WELL

SW¼NW¼ sec. 30, T. 22 S., R. 27 E.

Material	*Depth (feet)*
Soil	0-5
Gravel	5-20
Clay, yellow	20-90
Clay, red, sandy	90-148
Conglomerate, (limestone) water—cased off	148-160
Clay, red	160-170
Limestone (conglomerate?)	170-177
Sand	177-183
Limestone, broken up, (conglomerate?) (water)	183-207

LOG OF GOAT ROPERS CLUB WELL
NE¼SW¼ sec. 30, T. 22 S., R. 27 E.

Material	*Depth (feet)*
Soil	0-5
Gravel	5-55
Conglomerate, limestone, yellow	55-73
Clay, yellow	73-110
Sand, white (water)	110-120
Clay and broken-up material	120-160
Conglomerate, limestone (water)	160-190+?

A 24-hour pumping test was made on the airport well from 9:55 a. m. on March 9 to 9:56 a. m. on March 10, 1942. This well is 10 inches in diameter and 156 feet deep. It is cased with 8-inch casing to a depth of 128 feet. The water was encountered in a limestone conglomerate at a depth of 144 feet. A pump with No. 8 bowls and 144 feet of 6-inch column, equipped with air line, was installed temporarily to make the test.

During the afternoon of March 9 the discharge rate was varied at half-hour intervals and the corresponding drawdowns were noted. Over a pumping range from 300 to 600 gallons a minute, the discharge in gallons a minute was equal to 136 times the drawdown in feet to the 0.629 power ($F = 136\ D^{.629}$). At pumping rates of 300, 400, 500, and 600 gallons a minute, the corresponding respective drawdowns were 3.5, 5.25, 7.6 and 10.75 feet, and the respective pumping lifts were 135.5, 137.25, 139.6, and 142.75 feet. At the maximum pumping rate of 700 gallons a minute, the pumping lift was more than 145.5 feet, the depth to the bottom of the air line, and less than 148 feet, the depth to the bottom of the pump.

As closely as could be measured by air line, the water level after pumping stopped returned practically instantaneously to its original position. However, as the air gage could be estimated only to 3 inches of water it is possible that a small but significant residual drawdown could have existed without being apparent on the air gage. It was impossible to measure the water levels accurately by steel tape while the test pump was in place.

The following measurements by steel tape of depth to water below the top of casing are available: March 7, 1:15 p. m., 131.52 feet; March 11, 10:11 a. m., 131.70; March 15, 2:36 p. m., 131.76. There was a slow lowering of the water level during this period which continued at least to April 12, when the water level in the well was 133.07 feet below the top of the casing. This lowering was almost certainly due to slow drainage of the aquifer in the absence of recharge, which had been abnormally high during the preceding year because of the high floods in Dark Canyon. The rate of lowering over the period of the pumping test was somewhat greater than the average rate over the longer period and suggests that a semipermanent lowering of water level of the order of a tenth of a foot had occurred as a result of the pumping. However, the water level in the airport well varies also with the air pressure, unfortunately in an irregular manner. Considering all the variables and sources of error, it appears that the water level in the airport well probably, but not certainly, was lowered a small but significant amount, perhaps 0.1 foot, as a result of the pumping. The significance of the lowering is discussed in a succeeding section on permanence of the supply.

QUALITY

The water at the airport is calcium bicarbonate water and is relatively low in both sulfate and chloride. It is the water of best quality obtainable anywhere in the vicinity. However, it is high in nitrate, which generally indicates organic decomposition. Bacterial tests should be made.

To the east of the airport the water gradually becomes poorer in quality. As shown in the appended table of analyses, water in the Barfield well, about half a mile east of the airport well, has water of about the same quality but a trifle higher in sulfate and chloride. In the Martin well, about another half-mile east, the sulfate and chloride have again increased and in the Merchant well, a little farther northeast, the water is nearly as highly mineralized as the water in the Carlsbad limestone.

It is apparent, therefore, that the water of good quality found at the airport does not extend far east, and that there is danger of the quality deteriorating after sustained pumping.

PERMANENCE OF GROUND-WATER SUPPLY NEAR THE AIRPORT

The aquifers that furnish water to the wells at the air base and nearby cannot be traced in outcrop. Further, the deposits in which the aquifers occur have been extensively slumped so that the aquifers also cannot be traced in the sub-surface between wells some distance apart. Hence the extent of the aquifers and their thickness cannot be accurately determined. However, west of Dark Canyon the fill in which the aquifers occur is thin and in all probability the aquifers do not extend to the west of it. The aquifers extend possibly 2 miles north and probably about 10 miles south of the airport, about to Black River. The boundary between known good water and known bad water in the valley fill is irregular but seems to approximate the range line between R. 26 E. and R. 27 E. West of this line there appears to be about 40 square miles in which water of good quality may be expected to be found. Over this area there is probably sufficient water to sustain a demand of 1,000,000 gallons a day for many years although, as little is known about the thickness of the valley fill in the southern part of the area, the supply cannot be considered assured.

The amount of good water that can be taken from any one locality without drawing in highly mineralized water from the east is, however, limited. A single well or well field must intercept from the normal flow in the aquifer the amount of water that it withdraws. In order to do so it must lower the pressure in the aquifer for a considerable distance down the normal pressure gradient in the aquifer. The direction of flow of water for some distance down gradient in the aquifer is reversed and the water that lies normally down gradient is drawn into the well.

The boundary between good and bad water in the valley fill appears to lie about a mile east of the airport well. The head on the bad water is only a foot or two lower than the normal head at the airport well. Whether or not the bad water will, in time, move into wells at the air base under a demand of 1,000,000 gallons a day will depend upon the amount of recharge and the normal flow of ground water in the vicinity, factors which are unknown, but it appears to the writers that there is considerable probability that it will.

As has been noted, the aquifer yielding water to the present airport well probably does not extend far west of Dark Canyon. Any extensive pumping from this aquifer must almost inevitably draw upon storage in its outcrop area, with a consequent lowering of pressure in the aquifer in this neighborhood. It is unfortunate that the pumping test on the airport well did not produce definite evidence as to whether or not there was a significant lowering of water level. If, as is possible, there was a lowering of 0.1 foot during the pumping of about 800,000 gallons of water during this test, it is evident that after a few months pumping at 1,000,000 gallons a day, the water levels in wells in this aquifer may lower seriously, with attendant westward movement of the bad water to the east. A program of observations would be necessary to detect the onset of this condition.

To the southwest of the proposed air base the distance between the probable outcrop of the aquifers and the edge of the highly mineralized water in the fill is greater than it is farther north. There are very few wells to the southwest and little is known about the thickness of the valley fill in this area. It is known that in considerable areas the underlying Rustler formation is near the surface and the valley fill is, as a consequence, quite thin. Although an adequate supply of good water could probably be obtained in this area, it would be necessary to explore the area rather thoroughly by means of test drilling and test pumping before such a supply would be assured.

RECOMMENDATIONS

1. Because the water near the airport is of the best quality obtainable in the vicinity of Carlsbad, wells should be constructed near the present airport well. The wells should be adequately spaced and should be drilled to the base of the valley fill, which is at about 200 feet. Probably two wells will furnish a total of 1,000,000 gallons a day. It is possible that some holes will be relatively unproductive or absolutely dry. In order to determine the permanence of the supply a program of measuring water levels and analyzing water samples from the air base wells and nearby wells to the east should be carried out. Continuous increase of chloride will indicate probable movement of water of poorer quality from the east toward the air base.

2. In case the water supply from wells at the air base is found to be failing, the possibility of obtaining water from the area southwest of the air base should be investigated. Evidence at present is not sufficient to indicate whether water of good quality occurs in this area and whether such a supply, if found, would be permanent.

3. If the water supply southwest of the airport is found to be inadequate or complete investigation is not justified, an adequate quantity of water could be obtained from the Carlsbad limestone about 2 to 3 miles north of the air base. The quality of this water will be about equivalent to that of the Carlsbad City supply, that is, poorer than that at the site of the airport.

ANALYSES OF WATER SAMPLES COLLECTED FROM VARIOUS WELLS IN THE GENERAL VICINITY OF THE CARLSBAD AIRPORT

ANALYSES IN PARTS PER MILLION

Location		Owner	Depth of well (feet)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na-K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Date
T. 21 S., R. 26 E.		**WELLS IN CARLSBAD LIMESTONE**											
SE¼SW¼NE¼	sec. 35	W. C. Brandon	86	157	63	84	266	386	152	....	973	651	9-25-39
NE¼SW¼SE¼	sec. 35	Dickson	114	159	67	113	148	500	196	....	1,108	672	9-25-39
T. 21 S., R. 27 E.													
NW¼NW¼NE¼	sec. 31	W. H. Merchant	302	157	57	121	231a	429	180	....	1,058	626	4-26-40
T. 22 S., R. 26 E.													
SW¼SW¼NE¼	sec. 1	City of Carlsbad	150	125	55	85	214	331	144	....	845	538	10-6-39
Do.		Do.	230	133	64	88	162	398	170	....	933	595	10-6-39
SE¼SW¼NE¼	sec. 2	J. F. Hunick	105	....	....	....	258	....	78	....	....	....	4-5-38
NE¼SW¼NE¼	sec. 3	Happy Valley Farms	345	214	63	221	198a	709	264	....	1,568	793	8-10-38b
SW¼SE¼NW¼	sec. 11	S. H. Taylor	172	....	....	....	....	....	113	....	....	....	3-17-42
SE¼NE¼NE¼	sec. 11	T. Marquess	116	187	121	218	275	593	422	....	1,675	964	3-21-42
SW¼NW¼NE¼	sec. 14	H. E. Stephenson	130	94	37	47	292	149	64	3.5	554	386	2-27-42
	sec. 14	Plowman	125	82	36	47	288	119	66	3.0	508	352	3-12-42
Do.		Ed Bryant	152	89	40	45	320	128	60	2.0	542	386	2-27-42
Do.		Joe Ausley	114	....	....	....	....	....	61	....	....	....	2-26-42
		WELLS IN RUSTLER LIMESTONE											
T. 22 S., R. 26 E.													
SE¼	sec. 15	T. J. Lovejoy	315	109	42	....	228a	249	14	....	....	445	12-15-39
		WELLS IN VALLEY FILL NEAR SOUTHERN CANAL											
T. 22 S., R. 27 E.													
NW¼SW¼NW¼	sec. 20	W. E. Hellyer	125	436	154	348	138	1,455	603	....	3,060	1,721	9-17-39
SW¼SE¼NW¼	sec. 20	Gibson	127	370	128	300	196a	1,146	530	....	2,570	1,450	3-26-40
	sec. 20	Pruit	206	100	74	....	....	506	281	....	....	553	12-14-39
		WELLS IN VALLEY FILL NEAR CARLSBAD AIRPORT											
T. 22 S., R. 26 E.													
NE¼SE¼NE¼	sec. 25	K. Cass	150	113	54	....	....	254	65	....	....	504	12-15-39
SW¼NE¼	sec. 25	R. V. Barfield	140	84	37	24	380	79	15	0.3	440	362	2-28-42
SE¼SE¼	sec. 25	W. M. Martin	140	88	37	30	326	104	28	25.0	494	372	2-26-42
NE¼NE¼	sec. 35	City Airport	155	88	31	8.5	350	42	5	34.0	394	347	3-9-42
T. 22 S., R. 27 E.													
SW¼SW¼NW¼	sec. 30	W. H. Merchant	207	138	56	55	252	354	79	6.7	830	575	2-28-42
NW¼SW¼SW¼	sec. 31	K. Cass	160	164	106	....	....	498	205	....	....	845	12-15-39
T. 23 S., R. 26 E.													
SE¼	sec. 3	K. Cass	300	60	37	27	243	117	28	....	....	302	5-14-40

a Includes small amount of carbonate
b Water analyses obtained from Southwestern Public Service Company