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September 27, 1965

Mr. Max Eastman
Willen Corporation
2075 Pioneer Court
San Mateo, California

Dear Max:

We were glad to hear that the test on well 1-28 was satisfactory. That makes water prospects at Sunizona look pretty good.

I am enclosing two copies of the sample descriptions from that well. We are still waiting on copies of the edited E-Logs from Southwestern Geophysics. You were to receive copies of the E-Logs directly from them. These items were completed, or received, some time ago and were being held for inclusion in a report on Well 1-28.

Do you want us to keep on accumulating data for future analyses? If not, we can either forward the well cutting samples from 1-28 and 1-32 to you or give them to the local U.S.G.S. to file. They would be glad to have them.

Sorry I missed your call the other day. Stop and see us if you go through Tucson again.

Sincerely yours,

HEINRICHS GEOEXPLORATION COMPANY

Richard W. Davis

Encs:
pr

September 7, 1965

Anderson Irrigation Drilling Co.
P. O. Box 840
Douglas, Arizona

Dear Doc:

I just finished looking over the samples, etc. from the Willen Well in Sec. 28. There doesn't seem to be any clay or fines in them and this is not logical. Possibly we are losing the fines with the present collecting system. As I recall you catch samples at the mud return pipe. Do you suppose you could rig up a trap of some type? One of Baroid's gas detectors uses an impeller placed in a box which receives mud diverted from the return pipe. Perhaps you have seen one. The box has a sliding gate on one end so it can be flushed periodically. We used to catch samples from the box and flush it out after each sample. The samples were representative of the full 10 ft. interval and the fines were not lost. A sketch is enclosed. If you have another idea we could try it, but the present method makes the samples look better than they should be.

The samples, E-log, and drilling time log indicate you penetrated at least one rhyolite flow at about 1,080 feet in Well 1-28. Above and below the flows was a well-sorted, fine-medium grained sand. I suspect the conglomerates have a lot of interstitial clay and silt. The E-logs don't look too good through such intervals.

Sincerely yours,

R. W. Davis
Geologist

RWD:jh
Encl: 1

September 3, 1965

Southwestern Geophysics, Inc.
2302 N. 27th.
Phoenix 40, Arizona

Attn: Mr. Ed. Dodd

Dear Ed:

Enclosed are the E-logs on the Willen Well 1-28 in NE 1/4, NE 1.4, Sec. 28, T 17 S, R 27 E. Cochise County, Arizona. Distribution should be as follows:

Willen Corporation, 2075 Pioneer Court, San Mateo, Calif, one sepia and six bluelines.

Willen Corporation, Sunioona Acres, Pearce, Arizona, three bluelines.

Heinrichs Geoexploration Company, P. O. Box 5671, Tucson, Arizona, the original, one sepia and two bluelines.

Please edit the logs to show the zero line for both S. P. and resistivtty curves.

Sincerely yours,
HEINRICHS GEOEXPLORATION COMPANY

R. W. Davis
Geologist

RWD:jh
Encl: 1

August 25, 1965

Willen Corporation
2030 Pioneer Court
San Mateo, California

Attn: Mr. Kay Richardson

Gentlemen:

As explained over the phone, evidence to date indicates that Gilbert Pump had a system that met their asserted oral guarantee to Mr. Al Erickson. It could, and did, pump at 2200 gallons per minute. However, if you paid a premium for their services in order to have reliable equipment for the test, then they did not furnish it. The Gilbert personnel indicated that the motor on the pump was giving trouble Saturday after they had developed the well according to their standards. Monday morning at 10:00 we started a test which was stopped at approximately 12:30 P.M. due to motor trouble. Shortly after 3:00 P.M., another test was started and stopped at about 4:30 P.M. because of motor trouble. Data from this test is essentially worthless. On ~~Monday~~ Tuesday another test was begun about 4:30 P.M. and stopped almost immediately due to pump motor trouble. This latter test attempt is at their expense.

To gain useable data from a drawdown test, a constant, unfluctuating flow of water is essential. Gilbert Pump offers a well testing service and should be aware of this. One breakdown could be excused but a continual series of them should place some obligation on them to make an adjustment. Two and a half or three hours of the nine hours run on Monday should be at their expense if a premium was paid to gain reliability.

To place the affair in perspective, the Gilbert Pump personnel did cooperate freely in the test efforts. They did make a rather expensive alteration on the pump in an attempt to improve the pumping rate. This was explained to Mr. Irving Hamberger and I as being free-of-charge except for three or four hours of machinist's time. The effort was unsuccessful, but none of the pumping time on ~~Monday~~ Friday is to be charged to Willen.

Altogether, there were approximately four hours of test pumping, and five hours of pumping and surging for development, on Monday.

If you need more information, please let me know.

Sincerely yours,

HEINRICHS GEOEXPLORATION COMPANY

R. W. Davis

cc: Mr. Irving Hamberger

WILLEN CORP. ROUGH DRAFT 8-25-65
2030 PIONEER COURT
SAN MATEO, CALIFORNIA
ATTN: MR. KAY RICHARDSON

Orig & 2cc

GENTLEMEN:

AS I EXPLAINED OVER THE PHONE, ~~THE~~ EVIDENCE TO DATE INDICATES THAT GILBERT PUMP HAD A SYSTEM THAT MET THEIR ASSERTED ORAL GUARANTEE TO MR. AL ERICKSON. IT COULD, AND DID, PUMP AT 2200 GALLONS PER MINUTE. HOWEVER, IF YOU PAID A PREMIUM FOR THEIR SERVICES IN ORDER TO HAVE A RELIABLE EQUIPMENT FOR THE TEST, THEN THEY DID NOT FURNISH IT. THE GILBERT PERSONNEL INDICATED THAT THE MOTOR ON THE PUMP WAS GIVING TROUBLE SATURDAY AFTER THEY HAD DEVELOPED THE WELL ACCORDING TO THEIR STANDARDS. MONDAY MORNING AT 10:00 WE STARTED A TEST WHICH WAS STOPPED at APPROXIMATELY 12:30 A.M. DUE TO MOTOR TROUBLE. SHORTLY AFTER 3:00 P.M., ANOTHER TEST WAS STARTED AND STOPPED AT ABOUT 4:30 P.M. BECAUSE OF MOTOR TROUBLE. DATA FROM THIS TEST IS ESSENTIALLY WORTHLESS. ON MONDAY, ANOTHER TEST WAS BEGUN ABOUT 4:30 P.M. AND STOPPED ALMOST IMMEDIATELY DUE TO PUMP MOTOR TROUBLE. THIS LATTER TEST ATTEMPT IS AT THEIR EXPENSE.

TO GAIN ~~MEANINGFUL~~ useable DATA FROM A DRAWDOWN TEST, A CONSTANT, UNFLUCTUATING FLOW OF WATER IS ESSENTIAL. GILBERT PUMP OFFERS A WELL TESTING SERVICE AND SHOULD BE AWARE OF THIS. ONE BREAKDOWN COULD BE EXCUSED BUT A CONTINUAL SERIES OF THEM SHOULD PLACE SOME OBLIGATION ON THEM TO MAKE AN ADJUSTMENT. TWO AND A HALF OR THREE HOURS OF THE NINE HOURS RUN ON MONDAY ~~SHOULD BE AT THEIR~~ Should be at their EXPENSE IF A PREMIUM WAS PAID TO GAIN RELIABILITY.

TO PLACE THE AFFAIR IN PERSPECTIVE, THE GILBERT PUMP PERSONNEL DID COOPERATE FREELY IN THE TEST EFFORTS. THEY DID MAKE A RATHER EXPENSIVE ALTERATION ON THE PUMP IN AN ATTEMPT TO IMPROVE THE PUMPING RATE. THIS WAS EXPLAINED TO MR. IRVING HAMBERGER AND I AS BEING FREE OF CHARGE EXCEPT FOR THREE OR FOUR HOURS OF MACHINIST'S TIME. THE ~~EFFORT~~ EFFORT WAS UNSUCCESSFUL, BUT NONE OF THE PUMPING TIME ON MONDAY IS TO BE CHARGED TO WILLEN.

ALTOGETHER THERE WERE APPROXIMATELY FOUR HOURS OF TEST PUMPING, AND FIVE HOURS OF PUMPING AND SURGING FOR DEVELOPMENT.

IF YOU NEED MORE INFORMATION, PLEASE LET ME KNOW.

SINCERELY YOURS,

R. W. DAVIES

CC: MR. IRVING HAMBERGER, SUNIZONA

DEVELOPMENT OF WILLEN WELL
NE ¼, NE ¼, SECTION 32
T 17 S, R 27 E

For

Willen Corporation

August 1965

by

Heinrichs Geoexploration Company
P. O. Box 5671 Tucson, Arizona

TABLE OF CONTENTS

August 27, 1965

Willen Corporation
2030 Pioneer Court
San Mateo, California

Attn: Mr. Kay Richardson

Gentlemen:

Enclosed are two copies of the report and pump test data on the latest well test at Sumizona. Another copy is being sent to Mr. Hamberger.

Enough data was obtained from the tests to fairly evaluate the well. The step drawdown test is commonly called for by groundwater engineering firms in the East. It does give a reasonably reliable evaluation of the well and aquifer. Theory has proven very applicable in groundwater work, perhaps because the permeabilities and flows are so high that observational errors tend to be of no consequence.

As is stated in the report, I believe that before any more is done with this well, you should await results of drilling and development of other wells in the section.

Judging from converstions with Herb Garlitz, Doc Anderson, and various farmers in the area, 2000 gpm is a better than average well and very good for Sulphur Springs Valley.

If the report is not clear to you in any respect, please let me know.

Sincerely yours,
HEINRICHS GEOEXPLORATION COMPANY

R. W. Davis

cc: I. Hamberger
pr

DEVELOPMENT OF WILLEN WELL

For Willen Corporation August 1965

INTRODUCTION

Heinrichs Geoexploration Company was requested to outline the procedures for developing a well drilled at Sunizona Acres in the NE ¼, NE ¼, Section 32, T 17 S, R 27 E. These procedures were carried out by Gilbert Pump of Tucson, Inc., Tucson, Arizona.

Testing was started about August 20, 1965 by Gilbert. On August 23, 1965, R. W. Davis of Geoex went to Sunizona to observe a step drawdown test. Some minor development work was done also to see if yields could be increased. Development and testing were halted on August 24, 1965. The test records were analyzed by R. W. Davis.

SUMMARY AND CONCLUSIONS

The well appears to be capable of producing at least one and a half times what it is now. Present specific capacity is about 10.5 gallons per foot of drawdown. The main deterrent to good production is probably drilling mudcake and/or bentonite.

Three methods of further development are offered for consideration:

1. If the well could be pumped down to 400 or 500 feet, some of the mud might come loose.

2. Water could be pumped under high pressure into a zone between two packers and forced at high velocity into the gravel pack. The jetting action might break up any drilling mudcake.

3. Compressed air might be used to set up a more efficient surging action.

4. Pumping from opposite the deeper aquifers would be beneficial.

Before proceeding with more development, however, the results of developing another well should be evaluated. It is understood that another is planned in this section. If that well is completed as the present one, and then developed by somewhat different techniques, the relative worth of the two methods could be evaluated. Also, if tests show that further development would not eliminate

the need for a third or fourth well, this would have a bearing on the final decision.

PROCEDURE

Gilbert Pump was instructed to develop the well according to their standard procedures. When they felt that it was sufficiently developed, a step drawdown test was run. Gilbert pumped the well for ten hours. After approximately nine hours, the well cleared. Gilbert personnel did not feel that surging or other development would improve yields.

A step drawdown test is a fairly common method of evaluating the efficiency of a well. In order to obtain reliable results, at least three steps are ordinarily demanded. Only two definitive steps were obtained in this test, although three attempts were made to get more. However, enough information was gained to reach some conclusions. A chart of the step drawdown tests is included with this report.

During the course of the test, five hours were used to alternately pump and surge the well. A pumping rate of 2200 gpm was maintained for as much as thirty minutes at a time. The surge cycle was about 50-60 seconds in period. The well was pumped until water reached the surface, usually about ten seconds, and then the water was allowed to drain back. This produced a strong inwash, but a rather weak backwash. The surging action did produce some sand and is believed to have increased the specific capacity about 10% although this is hard to evaluate positively.

CALCULATIONS

A method devised by Jacob for the U. S. Geological Survey from empirical data gives the most conservative estimate of flow losses:

$$s = BQ + CQ^2$$

where s = residual drawdown
Q = pumping rate (gpm)
B = laminar flow loss factor
C = turbulent flow loss factor

Taking data from the test begun on August 23 at 10:00 and using drawdowns at 20 minutes after start of each step:

Step	Formula	At C=0	At B=0
1	$43=740B + (550X10^{3})C$	$B=7.81X10^{-2}$	$C=12.8X10^{-5}$
2	$137=1450B + (210X10^{4})C$	$B=9.45X10^{-2}$	$C=6.5X10^{-5}$
3	$161=1600B + (256X10^{4})C$	$B=10.1X\ 10^{-2}$	$C= 6.29X10^{-5}$

Step three was not large enough to be definitive. A faulty pump motor prevented adequate drawdown from being achieved.

Figure I is a graph of the three equations. At the best intersection of the lines, ($B=6.2X10^{-2}$), the reciprocal of B is the ideal specific capacity of the well. That is, it indicates the maximum specific capacity to be expected. In this case, 16.4 gallons per foot of drawdown is apparently maximum. It should be kept in mind that this is a conservative method. Using other common methods, higher ideal specific capacities could be derived.

Using another of Jacob's equations, and the portion of the drawdown curves 15 minutes or more after start of pumping, an aquifer transmissibility of 45,500 gpd/ft. was calculated. This is an average for the total formation: shales, siltstones, sands, etc. Some of the conglomerates probably have much higher values, while the clays and shales would be much lower. Transmissibility is just another way of measuring permeability, and is directly proportional to permeability. Transmissibility is the term used in groundwater work and will be used in this report.

Using an effective well radius of 13-3/8", a curve was plotted of drawdown (s) versus radius and time (r^2/t). The data used was a composite of data from several test attempts. Matching this curve against the theoretical "type" curve showed that the rapid initial drawdown gives a transmissibility of approximately 10,000 to 15,000 gpd/ft. Thi is a sharp contrast with aquifer transmissibility. Since it was obtained from the initial portion of the drawdown before the cone of influence has moved out very far, it is a fairly accurate indicator of transmissibilities near the well face.

DISCUSSION

E-log resistivity and self potential data show the best water potential in aquifers at 462-468, 592-598, 760-780, and below 900 feet. Probably only one or two of the upper zones have opened up under present development and have absorbed most of the energy of development efforts to date. This often happens when the surging action is weak, or not prolonged enough.

During the tests, a check was made of water temperatures at the various pumping rates. Temperatures were steady throughout the test at 80° F. The basal zone contains water with temperatures of 130° F. It is believed that if this zone were producing as it should, water temperatures of 90°, or better, should have been measured at the surface.

The shape of the drawdown curve indicates very low transmissibility of the overall aquifer and the evidence from E-logs suggest that a few of the beds have a very high transmissibility. The best conclusion seems to be that the drilling mud has invaded these good production zones, carrying bentonite into the pores and building up a thick mudcake which has not yet broken down. Transmissibility data show a potential yield three to four times the present one. If the aquifers can be opened up, a realistic goal would be one and a half to two times present production rates.

Various methods of development might be tried, as follows:

1. If the well could be pumped down to 400 or 500 feet, some of the mudcake and bentonite might be removed. A pumping volume of about 2700 or 2800 gpm should suffice, for specific capacity is dropping sharply as the drawdown increases, and a heavy drawdown can be expected about 2500 gpm.

2. Perhaps the casing perforations could be used to obtain a jetting action. Two packers could be set at short distances apart. Water pumped from the surface under high pressure and out through the perforations might break up the cake. However, costs would be high. Surging techniques would still be necessary to open up the formation completely.

3. A surging method could be tried using air. Use the same pumping setup as tried already, put an airtight cap over the well, and with an air compressor and three way valve, alternately pump air into the well and release it. A much more effective surging action could be generated in this manner than with a pump. The pump would be necessary for intermittent well clean up and testing. This should develop the well and increase the yield enough to be worthwhile. The method would be best in combination with the heavy pumping already described in the first method.

4. If the water could be pumped from 1000 feet opposite the lower aquifers, some benefit might ensue. Setting pump bowls at this depth would be very expensive, however. An air lift pump could be tried and this would allow the well to be effectively surged also.

It would take a very large air compressor to pump much water from this depth.

References:

Wenzel, L. K., 1942, "Methods for Determining Permeability of Water Bearing Materials." U. S. Geological Survey Water Supply Paper 887

Ferris, J. G., et al, 1962, "Theory of Aquifer Tests". U. S. Geological Survey Water Supply Paper 1536-E

Respectfully submitted,

HEINRICHS GEOEXPLORATION COMPANY

R. W. Davis, Geologist

WELL TEST DATA
TABLE I

a. Depths measured from surface by air line
b. Pump bowls set at 444
c. Water temperature was consistently 76.5° F.

Cochise County, Arizona
NE¼, NE½, Section 32
T17S, R27E

Date: August 23, 1965

TIME	VOLUME (gpm)	WATER LEVEL (ft.)
9:58	0	
10:00	720	134.5
10:02	750	167
10:03	738	171.4
10:04	750	174
10:05	738	174
10:10	738	174
10:15	750	176
10:20	738	176
10:25	738	177
10:30	738	177
10:35	765	177
10:40	738	177
10:45	765	176
10:50	738	176
10:55	750	177
11:00		178.35
CHANGE SPEED		
11:00.50		233
11:00.67		241
11:00.83		250
11:01.00		255
11:06	1400	267.29
11:10	1450	268
11:15	1450	270.75
11:20	1500	272.67
11:25	1430	272
11:30	1430	270.75
11:35	1450	272
11:45	1450	274.22
11:50	1450	274.22
CHANGE SPEED		
12:01		
12:03	1600	294
12:04	1600	294
12:05	1575	295

TIME		VOLUME (gpm)	WATER LEVEL (ft.)
12:15		1600	294
12:25		1600	295
12:37		1300	291.54
12:42		950	273
12:45		1040	250
12:50	SHUT DOWN		
12:53			162.2
12:54			150.7
12:55			150.7
12:56			148.5
12:57			148.5
12:58			146
1:00	PM		144
1:05			144
1:10			141.39
1:20			141.39
1:30			139
1:40			139
1:50			137
2:05			135
3:24			
3:25		0	134
3:27		720	190
3:29		750	185.28
3:32		700	183
3:37		700	187.59
3:42		700	190
3:47		830	194.5
3:52		790	194.52
3:55		815	197
3:56	CHANGE SPEED	815	197
3:57			
3:58		1450	259.2
4:00		1450	265
4:04		1575	267.29
4:09		1540	273
4:14		1540	274.22
4:19		1510	275
4:24		1510	275.37
4:27	CHANGE SPEED		
4L27.5			
4:28		2100	312.33
4:30		1850	317
		1720	317

TIME	VOLUME (gpm)	WATER LEVEL (ft.)
4:32	1660	305.40
4:34	1690	307
4:41	1640	307
4:44	1850	317
4:47	1850	325
AUGUST 24, 1965		
4:29	1160	134
4:29.33	1160	
4:29.50	1160	
4:29.67	1160	210
4:30	1160	211.5
4:30.33	1160	215.3
4:30.67	1160	216.5
4:31	1160	217.5
4:32	1140	220
4:34	1140	221.3
4:39	1140	223.8
4:44	1160	225.7
4:48	1080	224.1
CHANGE SPEED		
4:48.33	1600	256.2
4:48.50	1600	263.4
4:48.67	1600	268.9
4:49	1600	271.9
4:49.33	1560	272.6
4:49.67	1540	273.1
4:50	1500	270.3
4:51	1500	262.2
4:53	1655	274.9
4:58	1600	268.4
5:03	1400	279.3
5:08	1275	263.4
5:16	1210	269.4
5:28	ENGINE TROUBLE, SHUT DOWN	
STARTED PUMPING ABOUT 6:30 P.M. - HOLDING STEADY VOLUME		
7:15	1600	290.2

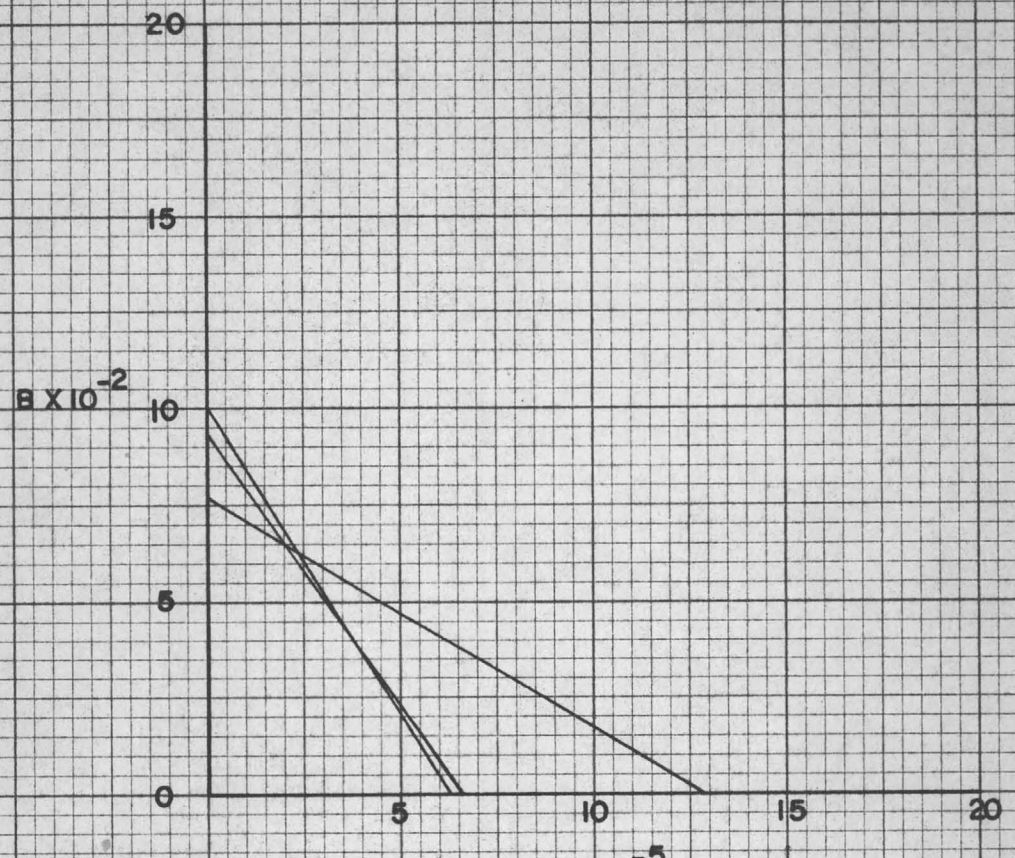
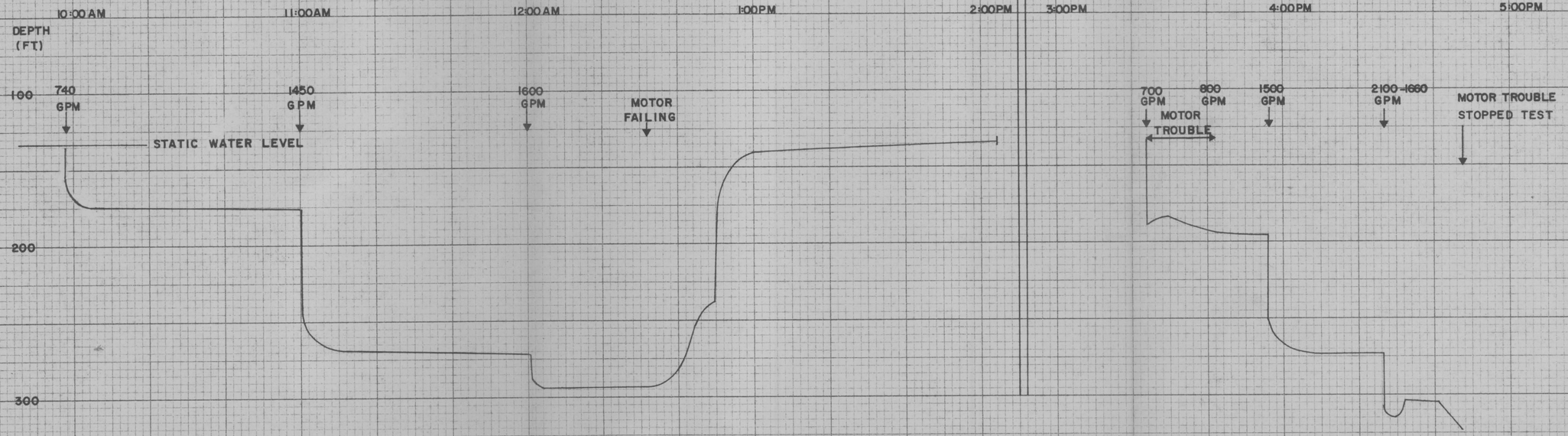


FIG. 1

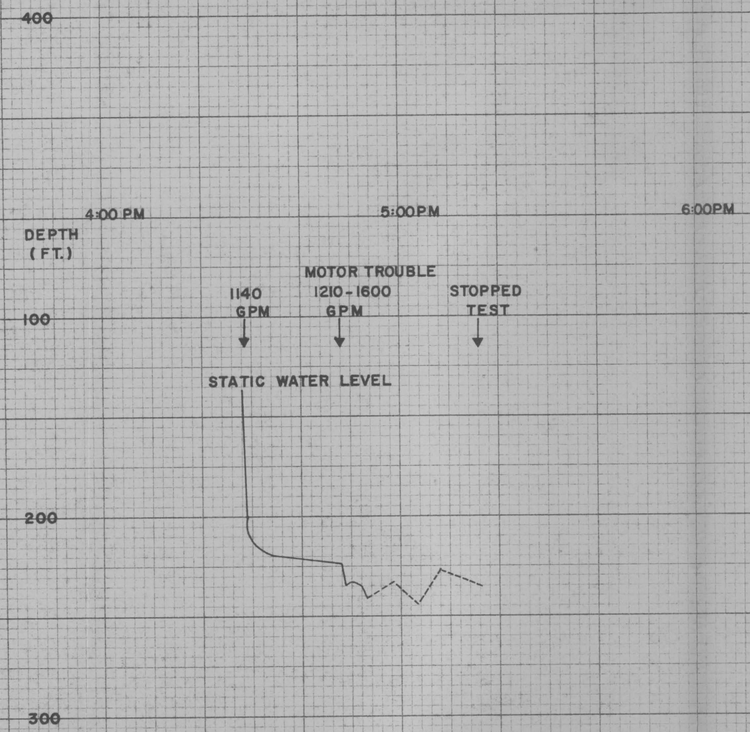
HEINRICHS GEOEXPLORATION CO.
BOX 5671 TUCSON, ARIZONA 85703
Phone: (AREA 602) 623-0578

GRAPHICAL SOLUTION OF FLOW LOSS COEFFICIENTS. IDEAL SPECIFIC CAPACITY EQUALS RECIPROCAL OF B

FOR
WILLEN CORP.
AUGUST 1965



TEST OF AUGUST 23, 1965



TEST OF AUGUST 24, 1965

HEINRICHS GEOEXPLORATION CO.
POST OFFICE BOX 5671, TUCSON, ARIZONA, 85703

STEP DRAWDOWN TESTS
NE 1/4 NE 1/4 SEC. 32 T17S - R27E
COCHISE COUNTY, ARIZONA
FOR
WILLEN CORP.

Scale | Date AUG 1965

August 17, 1965

Willen Corporation
2075 Pioneer Court
San Mateo, California

Attn: Mr. Kay Richardson

Gentlemen:

As mentioned yesterday on the phone, I may have been confused in regard to your objectives in the present drilling program. I suspect I have also caused some confusion, so will try to explain in some detail courses which are open to you in the development of water resources at Sunizona.

First, I believe much of your trouble with wells to date is inadequate development. It is possible that redevelopment would increase production in these older wells, but it might also cause them to make more sand when pumped.

Second, there are two possible ways which are practical for future wellsdevelopment: either with well screen or by gravel pack. The gravel pack is an effective compromise when one does not know exactly which rock layer is supplying the water. Since well screen is expensive, its use is not practical except through producing zones. The gravel pack allows one to perforate several hundred feet of casing, and also serves to distribute the water flow toward a maximum number of openings in a more or less efficient manner.

If one knows just which beds are the aquifers, well screen is the most efficient method of completion. However, in the case of Sunizona, an electric log would be necessary on such a well. In addition, one of the wells would have to have a flowmeter log run on it. Using the flowmeter data, it would be possible to calculate yields from specific aquifers observed on an electric log.

Before going too far in this program, it is necessary to define, if possible, the final objectives. If only a few closely spaced wells are to be developed, then an integrated testing and logging program is not economic. If, however, the whole area is to be ultimately developed by Willen, then one well and possibly more in each section should be electric logged. The tests suggested on this well are not necessarily to be repeated on other wells.

In addition, if an extensive program is planned, the first well which does not produce all the water which can be economically distributed onto the surface near it should be tested to see if it might yield more water if better developed. Two poorly developed wells can easily produce less than one properly developed. In connection with this point, after talking to Max Eastman yesterday, I arranged for a test to evaluate the degree of development on the latest well. If the initial drawdown check indicates that there is more water than the irrigation engineers can use, I plan to cancel the test. The decision as to what constitutes an adequate yield will be left to the driller, the irrigation engineer and Gilbert Pump. My training and experience are in locating, analyzing and developing wells only. According to Doc Anderson, the bailing tests show a specific capacity of approximately 40 gpm/ft.

I am enclosing a couple of items which should indicate that there is more than one practical method of well development. One is from an Army tech manual, titled "Wells". The other is from a bulletin published by Edward E. Johnson, Inc. These methods are not used in this area for the same reason that rotary rigs are only now coming into use. The problem of well development has been left up to the drillers who still use the same basic methods imported from the East 50 years ago, and now discarded there.

The method of development which I described on the phone is a combination of the two compressed air development methods. It should not put undue strain on the casing and is practical for use in this well where the gravel pack around the outside of the casing leaves the well somewhat open to the atmosphere. The most important factor in surging is the number of surges accomplished, not their amplitude.

I might also bring to your attention the 130° bottom hole temperature of the just drilled well. This is about 25° above what it should be. It probably indicates inflow of a possibly artesian source. With the present conditionsin the well, it would be hard to tell. I assume the water is "sweet" but the irrigation engineer may have a problem if it has to be cooled.

Sincerely yours,

HEINRICHS GEOEXPLORATION COMPANY

Richard W. Davis

cc: Mr. Eastman w/enc:

pr

July 13, 1965

Willen Corporation
2030 Pioneer Court
San Mateo, California

Attn: Mr. Leonard Erickson

Gentlemen:

Enclosed please find an original and one copy of the report covering Phase I of our groundwater investigation at Sunizona Acres. Another copy is being concurrently mailed to your Mr. Kay Richardson at Sunizona. I hope this will answer any questions you may have on Phase I of the water development program at Sunizona Acres. If not, please let us know.

Grover tells me that you desired some general information on the mining exploration activity being conducted by Bear Creek Mining Company in the vicinity of Sunizona Acres. To date the activity seems to be of a purely regional nature--checking out some of the mineralized workings located southwest of your sales office. We have heard that an induced polarization anomaly, indicating sulphides, was found in the area. This possibly explains the drilling. For now, it seems extremely unlikely that the exploration has detected anything economic. However, I should emphasize that this is speculative opinion. When the drilling activity increases to a degree where four or so, drilling rigs are located within a half mile of each other, the presence of a significant commercial ore deposit may be indicated. At present we have no information from Bear Creek Mining regarding water levels or production, but will continue to try to obtain such data.

Until we hear further from you we shall continue to accumulate data for use during Phases II and III. It has been a pleasure to work on this project and I look forward to beginning the next phases shortly.

Sincerely yours,
HEINRICHS GEOEXPLORATION COMPANY

R. W. Davis, Geologist

RWD:jh
cc: Sunizona Acres

REPORT ON

A GEOPHYSICAL AND GEOLOGICAL INVESTIGATION OF GROUNDWATER POTENTIAL

SUNIZONA ACRES, ARIZONA

for

WILLEN CORPORATION
San Mateo, California

July 1965

by
HEINRICHS GEOEXPLORATION COMPANY
P. O. Box 5671 Tucson, Arizona

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INTRODUCTION

This study was undertaken at the request of Mr. L. Erickson and Mr. K. W. Richardson of the Willen Corporation, San Mateo, California. The Willen Corporation has a number of sections of land in Sulphur Springs Valley on which it desires to develop water wells of large production (1,000 gpm or more). GEOEX has been retained to conduct geophysical surveys, evaluate and pick the most likely well sites, and supervise the drilling operations.

The initial phase of the work has been to run a mobile magnetometer survey, review all of the data available and outline the next phase of drilling and geophysical work.

Work on this first phase began June 14, 1965. Mr. E. Grover Heinrichs has had over-all charge of the work and has been often consulted during the interpretational phases. Mr. R. Palmer conducted the magnetometer survey and the writer did the bulk of the data interpretation and integration.

Three maps are included with this report. One shows the location of the mobile magnetometer traverses and the magnetic contours. A second shows the water table contours and the reliably known specific capacities of wells. A third map, summary in nature, shows second layer resistivities and analytical second layer resistivity depths along the 1962 traverses. Elevations above sea level of apparent, marked lithological changes in the deeper wells are noted and the possible location of the northern edge of an andesite unit is plotted. Finally, this map indicates zones worthy of consideration for water well development. These zones are denoted alphabetically in the order of their evaluated worth. This map will be discussed in detail later in the report.

A copy of the well specifications recommended for distribution to drillers for bid is attached as Appendix A.

CONCLUSIONS AND RECOMMENDATIONS

The broad magnetic high or "plateau" in the southeastern portion of the area is probably due to an igneous flow or sill in the subsurface. Correlations between high resistivities, good aquifers, and "canyons" extending into the broad magnetic high are good. These may be the sites of old gravel-filled stream channels and, hence, good aquifers.

Based on the conclusions, it is recommended that the next phase of development be dual in nature. A well near the northeast corner of Sec. 32 in Zone A is suggested. At the same time, a resistivity survey as an extension from present data should be conducted. This survey would begin on the northeastern end of line 5, Spread 9 of the 1962 survey and extend to the northeastern corner of Section 22. It should pass over the site of Well G. Two other northwest-southeast trending resistivity lines would run through the centers of Sections 21 and 27, and of Sections 29 and 33. These proposed lines are shown on the data summary map.

Based on the data obtained by new surveys and wells, stepout locations could then be picked. Hydraulic rotary drilling rigs are recommended for the first few holes for two reasons:

a. More rapid evaluation and development is possible.
b. Electrical logs could be obtained from rotary-drilled holes. Such logs are believed to be invaluable aids in planning development and cannot be obtained from a cased hole, used with a cable tool rig.

The wells to be drilled under this initial program are planned for reservoir evaluation purposes. For that reason, an economical program of bail tests, cuttings sampling and at least one pumping test is strongly urged. Reasonably complete information on the first wells will make succeeding drilling more successful and economical. Among the information which would be sought are:

1. The degree of connection between aquifers.
2. The exact thickness and vertical locations of stratigraphic units.
3. Some notion of the total long-term water potential of the area.

PROCEDURE

To begin the study for this report, all of the old data available were reviewed. This included resistivity surveys, well logs, U.S.G.S. files, and geologic reports of the general vicinity. To these data are added newer well logs and mobile magnetometer records.

A water table contour map was constructed to determine the shape of the free water surface and to note subsurface drainage directions.

Well production data were reviewed. Specific capacities given by drillers appeared to be too high by comparison with Mr. G. E. Anderson's* work and were rejected as unreliable.

Drillers logs were studied intensively to locate any "marker" horizons. A unit which might possibly correlate with the base of the loose Tertiary material was noted. The elevation above sea level of this base is plotted with the wells on the Summary Data Map.

Next, an analytical approach to interpreting the resistivity data was tried. From this, depths to second layers and resistivities were derived. It should be emphasized that such depths and resistivities are good only for comparison purposes and cannot be used as absolute values. In other words, by comparing the second layer depth and resistivity at two different points, it is possible to determine at which point the layer is deepest and most resistive.

Finally an exploration program was outlined. The program has already been presented in the previous section of this report. In conjunction with this last step, the recommended drilling specifications have been drawn up and are attached as Appendix A.

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*/ Anderson, Gene E., SUNIZONA ACRES SUBDIVISION REPORT ON UNDERGROUND WATER SUPPLY. Dec. 19, 1961

INTERPRETATION

No anomalous subsurface drainage patterns were noted on the water table contour map. General water table gradients are toward the southwest. Apparently water from the area near Arizona State Highway 181 does not drain into Willcox Playa but goes south. If further drilling in the northern portions

of Willen Corporation acreage does not show a reversal of gradients toward the north, there may be reason to suspect a subsurface barrier between Willcox Playa and Sulphur Springs Valley.

A series of seeps in the eastern half of Section 23 were mentioned to Mr. E. G. Heinrichs. These probably represent a subsurface barrier to water flow. The nature of the barrier and its orientation should be checked before developing too many wells in Section 22. Such a barrier, properly oriented, could possibly reduce markedly the long term potential in the area west of it.

A sample of igneous material from the base of Well G was tested by Mr. E. G. Heinrichs and was found highly magnetic. The igneous material, labeled "andesite" is believed responsible for the broad magnetic high in the southeastern portion of the area. Well G was a poor one and it is doubtful if any good wells will be developed in areas underlain by the andesite unless water could be found below it. Its thickness is uncertain but according to data reported on the Idazona well south of the area it is sixty feet thick there.

It is interesting to note that Well 5, which all the data suggest is above or very close to the edge of the andesite, is not as good as either of Wells 6 or 7. These latter two are in a magnetic low area. This is another reason for suspecting that wells completed above the andesite will have low yields.

There also seems to be some correlation between high second layer resistivities, conglomeratic material, and "canyons" into the edge of the broad magnetic high. However, this correlation is rather tenuous at the moment. It is true that high resistivities in general were only found in areas of relatively good water production.

Examination of well logs shows that reasonably good specific capacities were measured only at wells which penetrated a comparatively coarse layer of material which usually appeared at depths greater than 350 ft. beneath the surface. The depth and thickness of the layer were highly variable. This is quite possibly the more resistive layer noted during resistivity surveys.

Three reasonable interpretations of the subsurface stratigraphy have been considered. All of these assume the validity of an andesite layer:

1. The andesite layer is a flow or sill whose horizontal extent is essentially the same as it was after original deposition.

It was intruded into or extruded over unconsolidated and semi-consolidated Tertiary material which was and still is laterally continuous (Fig. 1). By this interpretation, laterally continuous aquifers could exist both over and under the andesite.

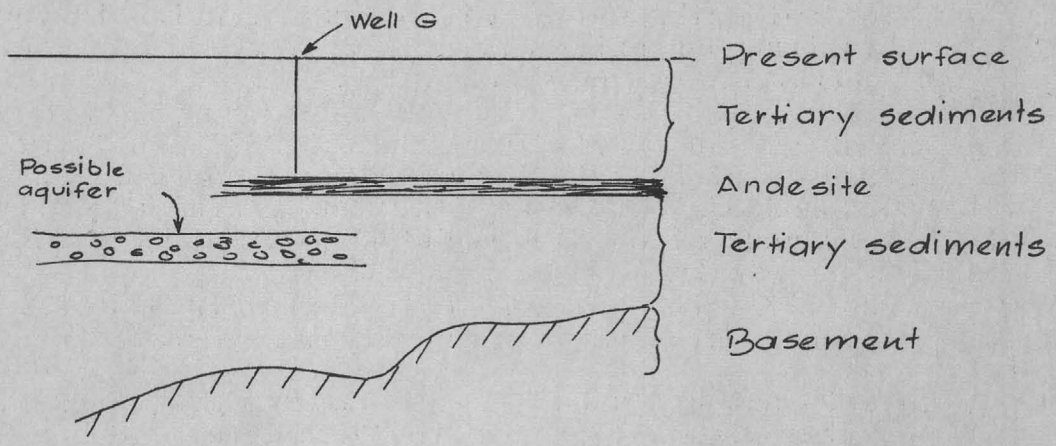


Fig. 1 Schematic cross section of first interpretation

2. The andesite is a resistant cap on an old topographic plateau or bench. Material eroded from this high area was carried into the lower areas. Coarser material would ordinarily be found along the valley bottoms. Later depositions buried every trace of this ancient erosion surface. The magnetic map by this interpretation is roughly similar to a topographic map of the ancient landscape. In this case the best aquifers should lie opposite the magnetic "canyons" at the edge of the magnetic "plateau". There is some inconclusive evidence from well production and well log comparisons that this is the case.

If this second interpretation is true, then there is not necessarily any correlation or connection between aquifers above the old erosion surface and those below it. There could be artesian water beneath the andesite but there is no data available on this zone at present. Figures 2 and 3 illustrate interpretation two.

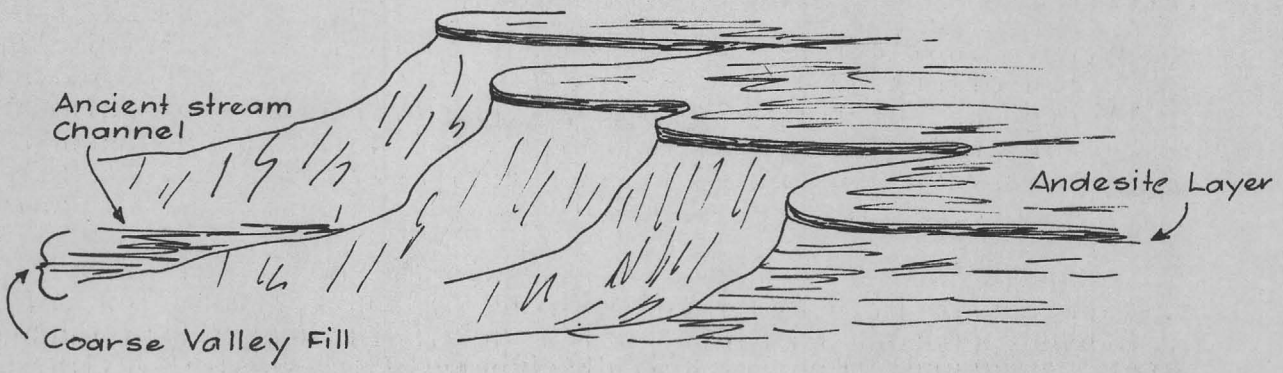


Figure 2: Schematic diagram of ancient topography

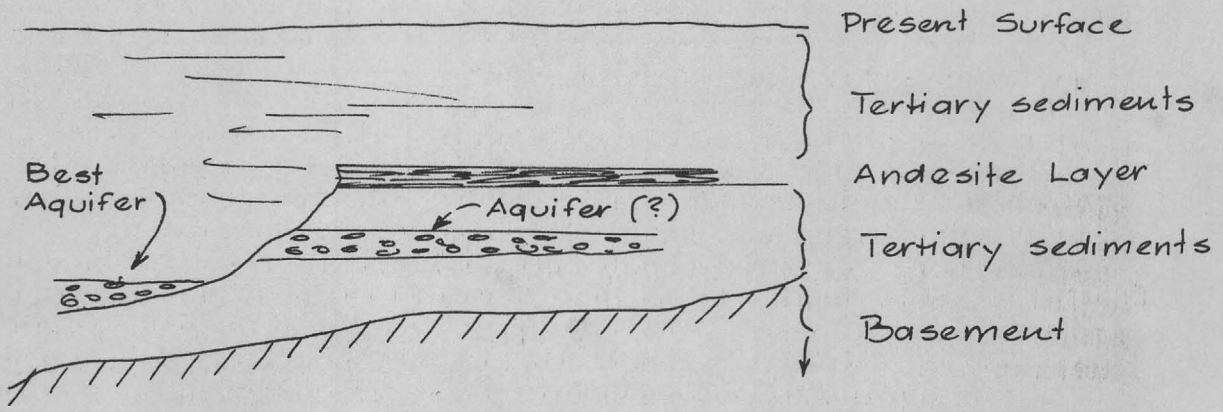


Figure 3: Schematic cross section of buried topography as it might be today.

3. This is a modification of interpretation number two. In this case the andesite caps a sequence of Paleozoic or Pre-Cambrian material of doubtful value as an aquifer. Such material would be similar to beds in the Swisshelm Mts. south of Sunizona. Some of the drillers logs from deeper wells in the area suggest a change in lithology at depth. Without being

able to examine drill cuttings, it is impossible to say whether these are Tertiary or older material.

Of the three interpretations, the second one is preferred at this time. However, further drilling and geophysical work is necessary to allow us to verify or reject any of them for sure.

Respectfully submitted,

HEINRICHS GEOEXPLORATION COMPANY

R. W. Davis
Geologist

July 13, 1965
P. O. Box 5671
Tucson, Arizona

APPENDIX A

DRILLING SPECIFICATIONS

PURPOSE: The holes covered by these specifications are to be drilled primarily for the purpose of developing reasonably large water production (greater than 1,000 gpm.) from subsurface aquifers.

Since the location and development of successive wells will depend in large measure upon data collected from previous drilling, various types of tests and measurements will be made in order to evaluate the subsurface geology.

DESCRIPTION OF AREA: The wells are to be drilled on property of the Willen Corporation, Sulphur Springs Valley, Cochise County, Arizona. The exact location of the property is shown on the attached map.

The wells will penetrate semiconsolidated Tertiary sands, gravels, silts, shales and clays. In some areas and normally below 300 ft. igneous flow material may be encountered and an attempt may be made to penetrate it. Also, at some depth, well-indurated sediments of Paleozoic or older age may be encountered. However, it is not planned to continue drilling once these beds are reached.

TESTS AND MEASUREMENTS: The driller will be responsible for keeping a log on each drill hole. This driller's log will become the property of GEOEX upon completion of the well. The log will record the general character, thickness, type, and drilling characteristics of materials encountered. This log will also record the number of feet drilled each hour with the driller's explanation for changes in rate of penetration. The driller will also be responsible for collecting reliable and representative drill cuttings every five (5) feet. These cuttings will be washed, sacked and turned over to GEOEX.

Whenever the driller penetrates a possibly significant aquifer, he will measure the static water level and will check the specific capacity of the well, probably using a bailing technique. The exact procedure for these measurements and tests will be decided upon after consultation between the driller and a GEOEX representative. Since it is desired to keep costs at a minimum, it is anticipated that the tests will not be elaborate and time consuming, and that their number may decrease as further knowledge of the area is obtained.

On at least one and probably more holes, it is planned to conduct electrical or resistivity logging, pumping tests for determining drawdown and transmissibility, and/or hydraulic flow tests. The exact tests conducted will depend upon such practical factors as hole conditions, drilling methods, costs, etc. The drilling contractor will cooperate fully with the GEOEX representatives in conducting such tests.

WELL COMPLETION: The methods, materials and specific standards for casing and completing the wells will be decided upon after consultation with the drilling contractor. Materials used must meet AGI or ASTM specifications where applicable and must be of adequate strength and durability for their conditions of service. Casing sizes will vary with depths and proposed uses of wells between 6" and 12" O.D.

GENERAL: Access to the drilling site will be supplied by GEOEX. GEOEX will also furnish any special electrical, radioactivity, or flow velocity devices and be responsible for their recovery from the well provided that the drilling contractor use reasonable care to prevent the loss of such devices while in the well.

GEOEX representatives will be allowed to examine all logs and cuttings at any time during and after drilling.

Bidders are urged to submit bids for both hydraulic and percussion drilling equipment together with a breakdown of charges for the different programs, tests and measurements described.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SQUARETOP HILLS QUADRANGLE
ARIZONA—COCHISE CO.
15 MINUTE SERIES (TOPOGRAPHIC)

INDEX MAP

SUNIZONA ACRES, ARIZONA

July 1965

for
WILLEN CORPORATION

by
HEINRICHS GEOEXPLORATION COMPANY
P. O. Box 5671 Tucson, Arizona
SCALE: 1" = 62,500'

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by ER-55 plotter
Aerial photographs taken 1956. Field check 1958

Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, east zone
1000-meter Universal Transverse Mercator grid ticks,
zone 12, shown in blue

Unchecked elevations are shown in brown

SCALE 1:62500

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

ROAD CLASSIFICATION
Medium-duty — Light-duty
Unimproved dirt
U. S. Route — State Route

APPROXIMATE MEAN DECLINATION, 1958

QUADRANGLE LOCATION

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER 2, COLORADO OR WASHINGTON 25, D. C.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

INTERIOR-GEOLOGICAL SURVEY, WASHINGTON, D. C.-1959-NS
MR 6199

SQUARETOP HILLS, ARIZ.
N3145—W10930/15

1958

MUNICIPAL IMPROVEMENTS

SUBDIVISIONS - SURVEYS

GENE E. ANDERSON

REGISTERED CIVIL ENGINEER AND LAND SURVEYOR

Ken
Here is our
for info
info

December 3, 1962

Willen Corporation
2030 Pioneer Court
San Mateo, California

Dear Sirs:

Inclosed is a well report and drillers statement for Sunizona No.4.

Thank you for your attention in this matter.

Yours very truly,

Gene E. Anderson, P.E.
Civil Engineer

GEA/ks

Mildred
Please set up a new file
for this
Sunizona - Wells 16, 17, 18 & 19"

K

2549 EAST BROADWAY . . . TUCSON, ARIZONA . . . TELEPHONE EA 6-3306

GENE E. ANDERSON
REGISTERED CIVIL ENGINEER AND LAND SURVEYOR

WELL REPORT

Sunizona Acres Subdivision

Wells, 16, 17, 18, 19 and Windmill.

Well #16:

Drilled and cased with 6" casing to 175 feet 3/4 horsepower Reda submersible pump produced 12.5 gallons per minute with five feet of drawdown Static water level 97.2 feet. Theoretical well capacity is 145 gallons per minute. Total cost of well and pumping test was $1259.50 with the test pumping charge averaging $258.50 per well.

$C_s = \frac{12.5}{5} = 2.5$

Well #17:

Drilled and cased with 6" casing to 175 feet. 3/4 horsepower pump produced 12.5 g.p.m. with total drawdown of 2.5 feet from a static water level of 90 feet. Theoretical well capacity is 340 g.p.m. Total cost of well and pumping test was $1295.50.

$C_s = \frac{12.5}{2.5} = 5.0$

Well #18

Drilled and cased with 6" casing to 131.5 feet. This well hit bedrock at 115 feet the rock being similar to that in the hills to the north. Other wells in this immediate will undoubtely hit bedrock at similar and possibly even shallower depths. The formations directly on top of the bedrock generally yield water in good quantities so the 10 g.p.m. guarantee should still be safe. The 3/4 horsepower pump produced 12.5 g.p.m. with 8.5 feet of drawdown from a static water level of 90.5 feet. Theoretical well capacity is 24 g.p.m. Total cost of well and pumping test was $1065.00.

$C_s = \frac{12.5}{8.5} = 1.47$

Well #19:

Drilled to 300 feet and cased to 175 feet. This well was drilled to 300 feet to explore the depth of bedrock and existing formations with the purpose of determining the feasibility of a future large well for a water system in this area. The absence of bedrock and the discovery of some good formations from 212 to 285 feet make this area a good location for some large water supply well. The well was only cased to 175 feet as this much will produce all the water any efficient pump can produce. The 3/4 HP pump produced 13 g.p.m. with 4 feet of drawdown from a static water level of 83 feet. Theoretical well capacity is 240 g.p.m. Total cost of well and pumping test was $1673.50.

$C_s = \frac{13}{4} = 3.25$

Windmill well:

The windmill well is 116 feet deep with a static water level of 97 feet. The 3/4 HP pump produced 12.5 g.p.m. with a drawdown of 9.0 feet. The pumping level recovered from 108 feet to 106 feet after 12 hours pumping. The windmill was placed back into service after the test although it needs major repairs if it is to continue operation. The cost of repairing the windmill pump and the pumping test was $183.00.

$C_s = \frac{12.5}{9.0} = 1.38$

2549 EAST BROADWAY ... TUCSON, ARIZONA ... TELEPHONE EA 6-3306

MUNICIPAL IMPROVEMENTS SUBDIVISIONS - SURVEYS

GENE E. ANDERSON

REGISTERED CIVIL ENGINEER AND LAND SURVEYOR

Summary:

The total results of the test wells was better than expected. The water guarantee is still good as it stands although the 175 depth is not going to be attainable (except at great cost) in the few areas of shallow bedrock. Whenever bedrock is encountered, the formation directly above it is generally a good producer. In other areas, the 175 depth is still necessary in the opinion of the Driller and the Engineer as the better water producing formations lie at 140 to 150 feet and below. A well could produce 10 g.p.m. with only 110-120 feet of depth, as in the case of the windmill, however this is a very marginal operation.

The northwest corner of Section 11 is going to be good water-producer as the test hole results hear out the conclusion of the geophysical studies.

It is felt the test wells represent the worst conditions that well be encountered in Unit ~~#4~~ N½ Sec. 11. The windmill well area the north line of Section 35 is 104 feet deep and has a static level of 97.5 feet with the capacity estimated at 5 to 10 g.p.m.

For your records, the pump that we purchased for Sunizona has the following nomenclature and data: Motor Serial No. Y 9109, Pump Serial No. Y 9109, H.P. 3/4, Model No. 13A7E, Reda Pump Company, Bartlesville, Oklahoma. Date installed: Nov. 28, 1962. Dealer Myron C. Ingle, Pearce, Arizona.

2549 EAST BROADWAY . . . TUCSON, ARIZONA . . . TELEPHONE EA 6-3306

WILLEN CORPORATION 2030 PIONEER COURT SAN MATEO, CALIFORNIA 341-7401

May 27, 1965

Mr. E. Grover Heinrichs
Heinrichs Geoexploration Company
806 West Grant Road
Tucson, Arizona 85703

Dear Mr. Heinrichs:

Confirming our telephone conversation regarding your proposals of May 21st please go ahead with a magnetic survey to cover the 11 sections of our land outlined on the attached map. This work is to be started within the next two weeks and completed at the earliest practical date. As the results of this work become available, we will reach decisions regarding areas to be investigated using your earth resistivity techniques and about well drilling.

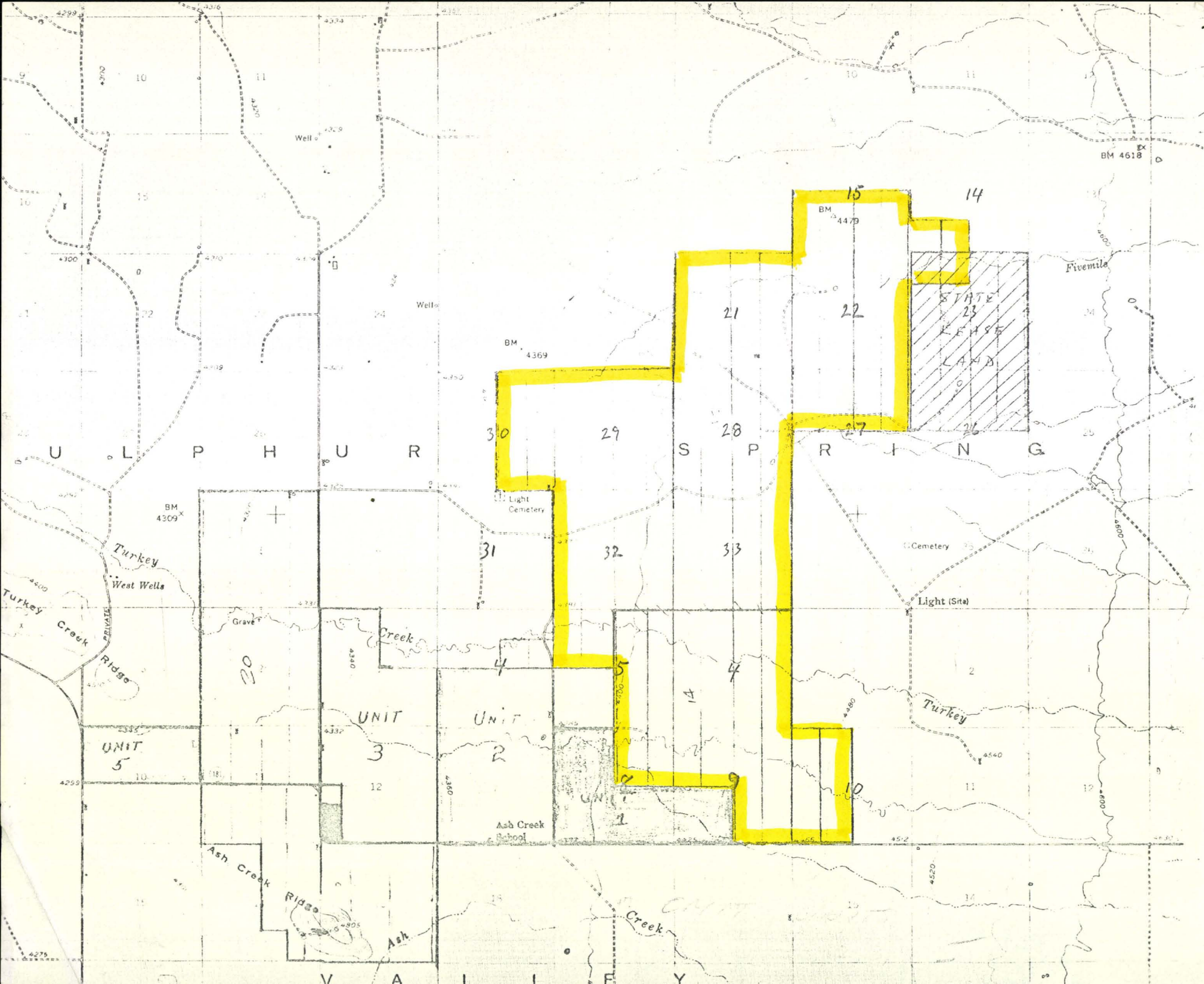
Prior to your starting this field work, Al Erickson will send you a map showing the locations of all wells that have been drilled on or near this land, together with any available well logs and production data. There are other wells now being drilled in the general area and any available pertinent information should be coordinated and taken into account in your survey.

Please advise Al Erickson in advance of arrival of your field men so that accomodations may be provided at the Sunizona Motel.

Yours very truly,

Lennart G. Erickson

cc: Al Erickson


BM 4618
15
14
BM 4479
Fivemile
STATE LEASE LAND
21
22
23
BM 4369
30
29
28
27
26
U L P H U R
S P R I N G
Well
Well
Light Cemetery
BM 4309
31
32
33
Cemetery
Turkey
West Wells
Turkey Creek
PRIVATE
Ridge
Gravel
Creek
20
4
5
14
4
Light (Site)
UNIT 5
UNIT 3
UNIT 2
12
1
2
9
10
Turkey
Ash Creek School
Ash Creek Ridge
Ash Creek
V A L L E Y