

SOUTH DAKOTA

STATE GEOLOGICAL SURVEY

E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

No. 24

A SHALLOW WATER SUPPLY

for

HURON, SOUTH DAKOTA

By

E. P. Rothrock
and
Bruno C. Petsch

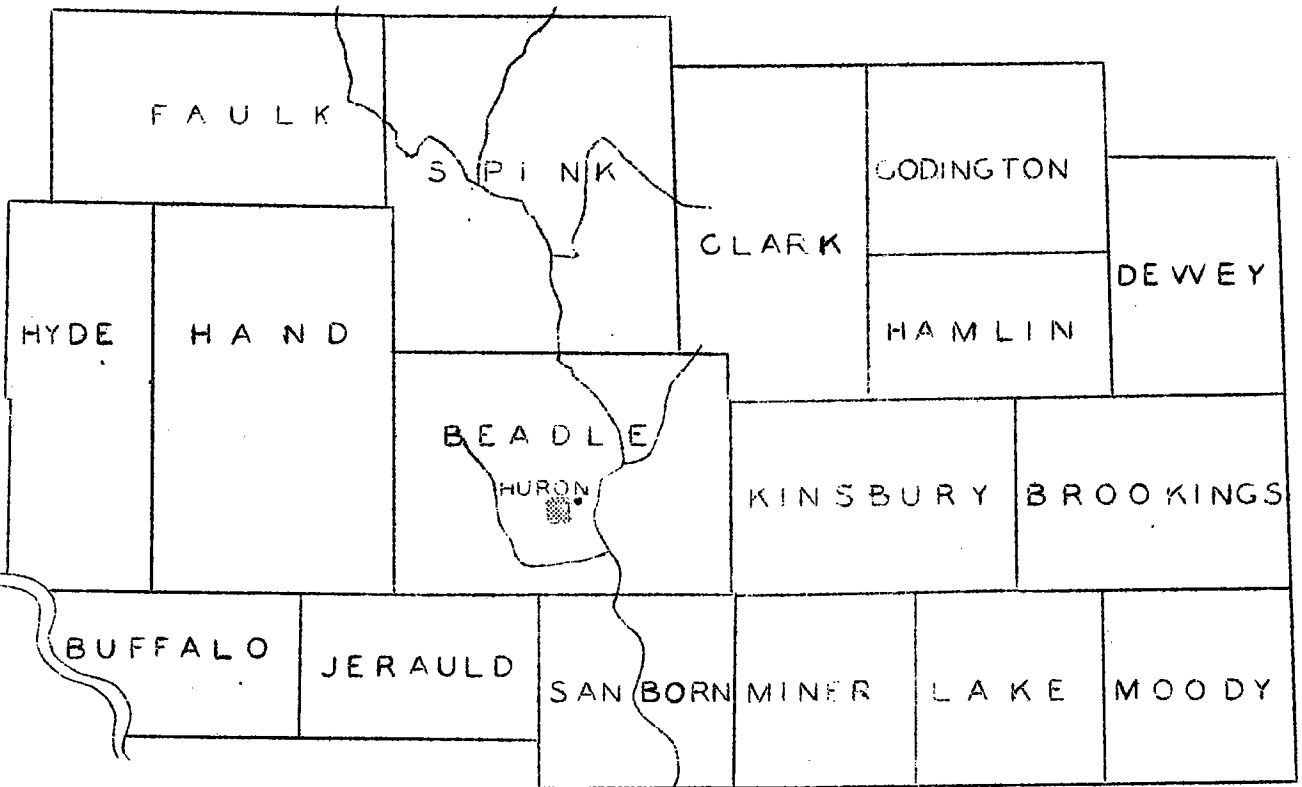
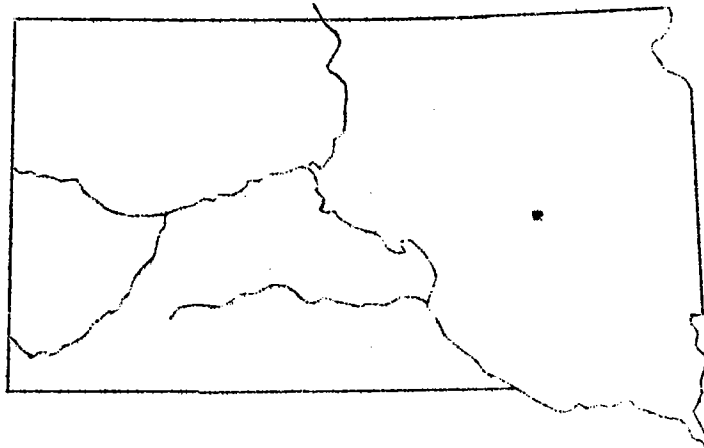
University of South Dakota
Vermillion, S. Dak.


January, 1935

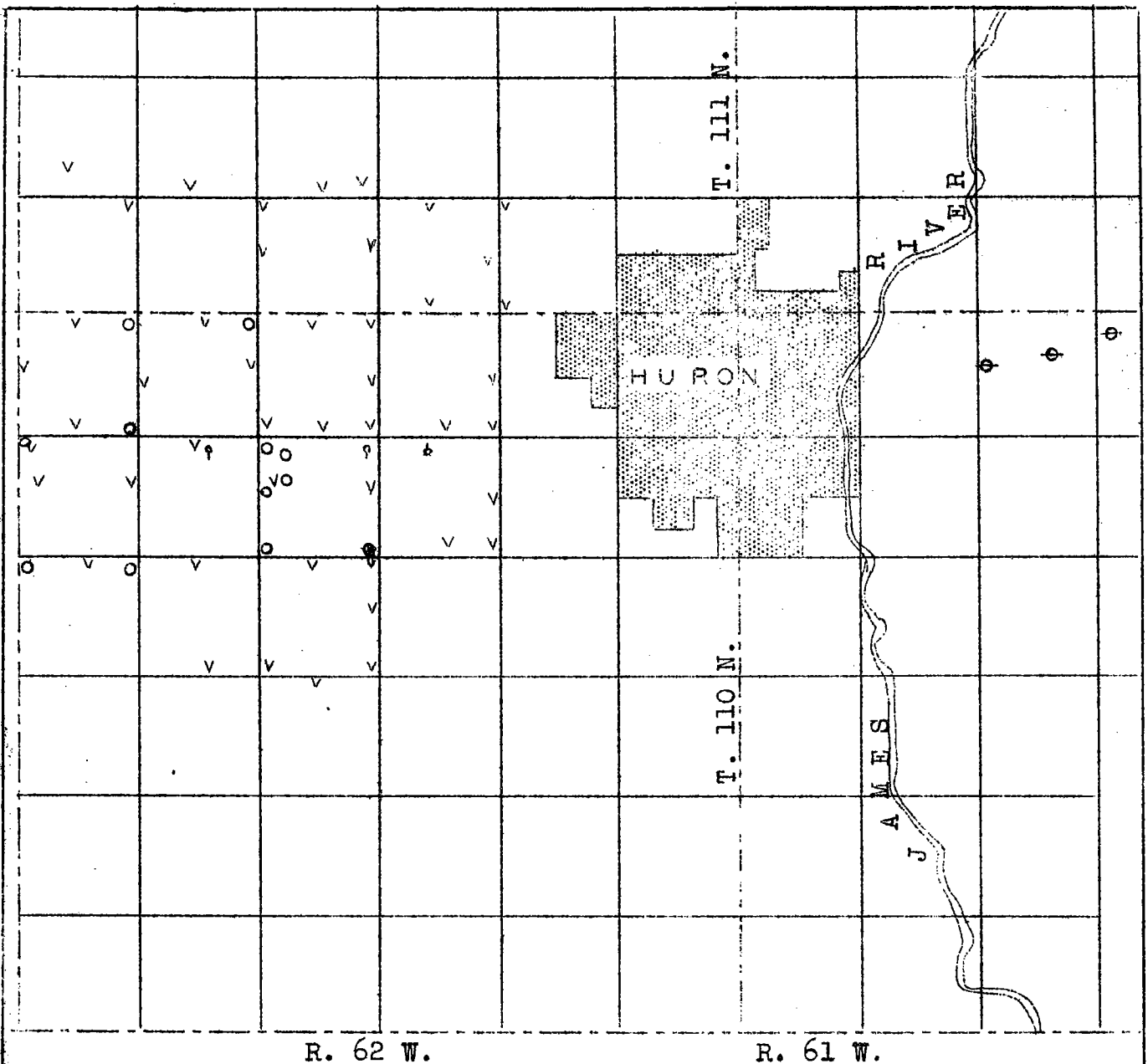
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Index Map of South Dakota
Showing Location
of Huron



 - Area covered by this report



R. 62 W.

R. 61 W.

Map of the vicinity of Huron, S. D.

Scale: $\frac{3}{4}$ " = 1 mile

Legend

- v Earth Resistance Station
- o Test well drilled by City
- o Artesian well deep
- o Artesian well shallow
- e Chalk test wells

A SHALLOW WATER SUPPLY FOR HURON, SOUTH DAKOTA

PURPOSE OF REPORT

By the summer of 1934 the protracted drouth in South Dakota had dried the James River to a point where it was unsafe to use its water as a source of supply for the City of Huron. In the search for another suitable supply, the city attempted the development of a shallow well supply which was found a short distance west of Huron. A pumping test was made on a well drilled for that purpose in the N. W. $\frac{1}{4}$ of section 9, T. 110 N., R. 62 W., $\frac{1}{2}$ mile south and $2\frac{1}{2}$ miles west of the southwest corner of the State Fair grounds. The well was pumped for 20 days and seemed to offer a satisfactory water supply, but the question of the extent and porosity of the sand reservoir was still in doubt. Since sands of this type are notably patchy, it was desirable to know something of the extent and character of this one before attempting to make it the source of a permanent supply.

In compliance with a request from the city council, the State Geological Survey undertook to ascertain whether the sand body was of sufficient extent to supply the needs of a city as large as Huron. Three weeks were spent in field work mapping the sand by electrical methods and investigating well records and other data which would throw light on the problem. Details of the methods of work will be described later in this report.

The authors wish to acknowledge the valuable information and the many courtesies extended by the city officials and the residents of the area in which the work was conducted. The assistance of Mr. O. A. Ricker, city engineer of Huron, was very much appreciated. His knowledge of the region and technical information was generously given and added much that would otherwise have been unobtainable.

DEEP WELL SUPPLIES

With the exhaustion of surface supplies the City of Huron has three possible sub-surface sources from which it might obtain water, the artesian sandstone, the chalk formation, and glacial sands.

Artesian Water:

Artesian wells are being used in and about Huron and have furnished a copious flow of very usable water. These artesian sands lie at depths of 800 feet to 1100 feet below the surface. Hard and soft water horizons occur in them, but the waters from both are highly charged with the salts which are common to artesian waters throughout the state. For fear of jeopardising the supply of the present users of artesian water, the city wished to find another source, if possible.

The log of a well drilled into the artesian sands for the City of Huron some years ago, reads as follows:

Log of Huron Well #3, Sec. 1, T. 110 N., R 61 W.

0-80	feet	Yellow and blue till
80-90	feet	Sand and gravel (water)
90-276	feet	Shale and Probably grey chalk
276-283	feet	Sand rock, soft water
283-483	feet	Grey shale
483-500	feet	Hard sand rock, water
500-738	feet	Shale
738-748	feet	Hard sand rock, strong flow
748-798	feet	Sandy shale
798-810	feet	Hard sand rock
810-875	feet	Sand rock flow
875-964	feet	Not definitely reported
964-974	feet	Sandstone, flow
974-1035	feet	Unreported
1035-1050	feet	Sandrock, flow
1050-1065	feet	Shale quartz
1065-1090	feet	White sand with brownish grain
1090-1091	feet	Hard rock

Water from the Chalk Formation:

The second source, the chalk rock, supplies soft water and can be struck at depths of approximately 250 feet. It is variously described by drillers as chalk rock, soap stone, or an alternation of chalk and shale. It is light grey in color and contains water in what are designated as "tubulars". Tubulars may be porous layers of chalk between soapstone layers or sandy beds at the bottom of the chalk.

Several test wells were sunk into the chalk by the city and one gave sufficient water to assist materially in supplying

the city during the dry summer months of 1934. Due to conditions in the sand or to the vigorous pumping which had to be done, the water could not be cleared of a fine colloidal sediment without treatment at the city plant. Drillers report water in all the chalk rock tests made, but not in large quantities.

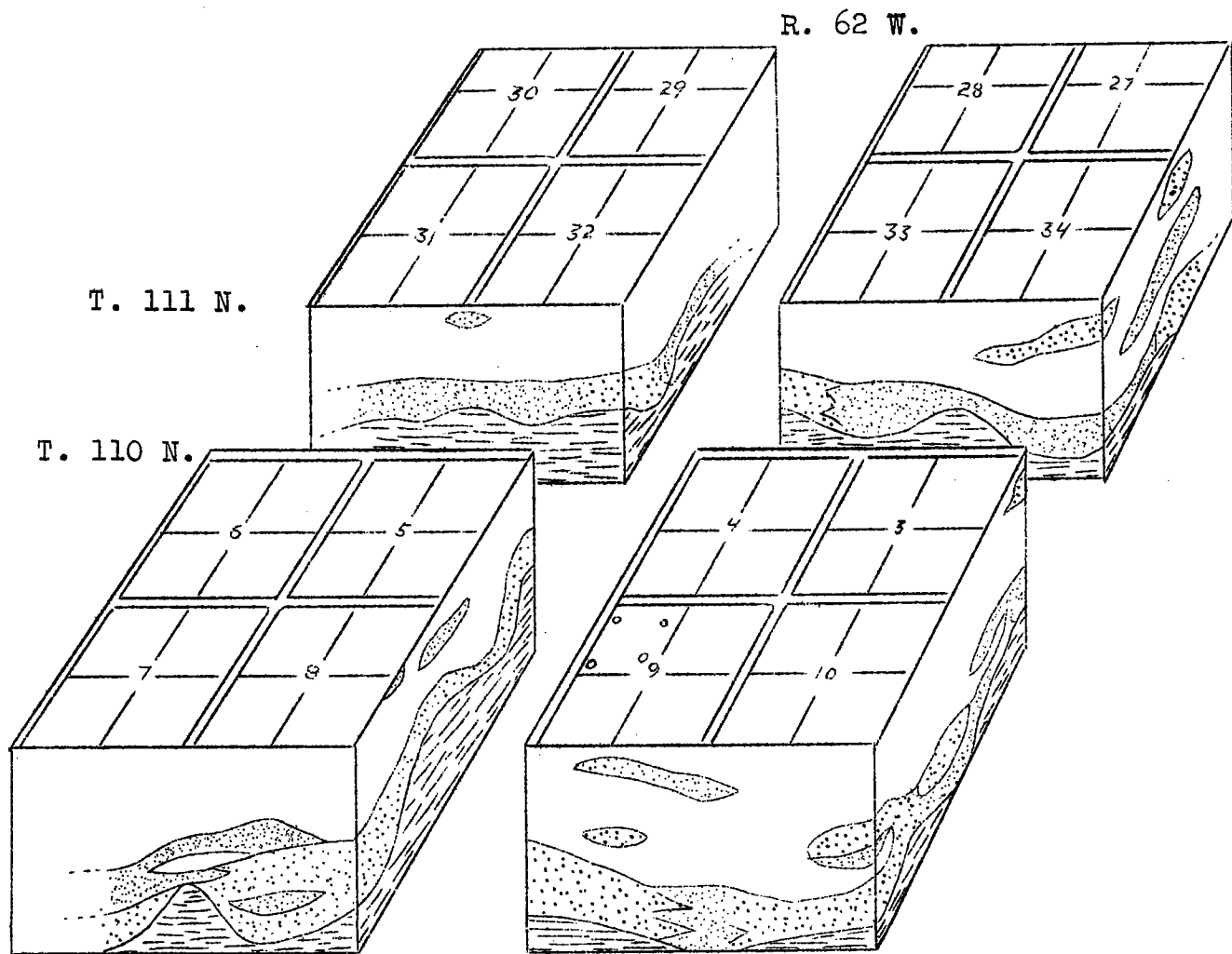
A log of the well mentioned above and of another drilled at the western edge of the city follows:

Test Well at Huron
NE $\frac{1}{4}$, Sec. 4, T. 110 N., R. 61 W.
Sea level elevation of well curb
Approximately 1308 feet

0-20	feet	Soil and rock
20-30	feet	Sand
30-35	feet	Mud, shale
35-60	feet	Sand
60-80	feet	Shale
80-90	feet	Sand
90-120	feet	Shale
120-156	feet	Sand
156-205	feet	Soapstone, furnished soft water rather high in total solids.

Log of Gravel Pit Well at Huron
Center Section 2, T. 110 N., R. 62 W.
Sea level elevation of well curb
Approximately 1288 feet

0-10	feet	Gravel and sand
10-50	feet	?
50-58	feet	Fine sand
58-178	feet	Stone, gravel and clay
178-223	feet	Chalk



Block Diagram of the Glacial Sand Zone
at Huron Water Supply Project

Legend

- - - Glacial Clay
- - - Fine Sand
- - - Coarse Sand
- - - Shale bed rock

Vertical Scale

1" = 80 feet

GLACIAL SUPPLIES

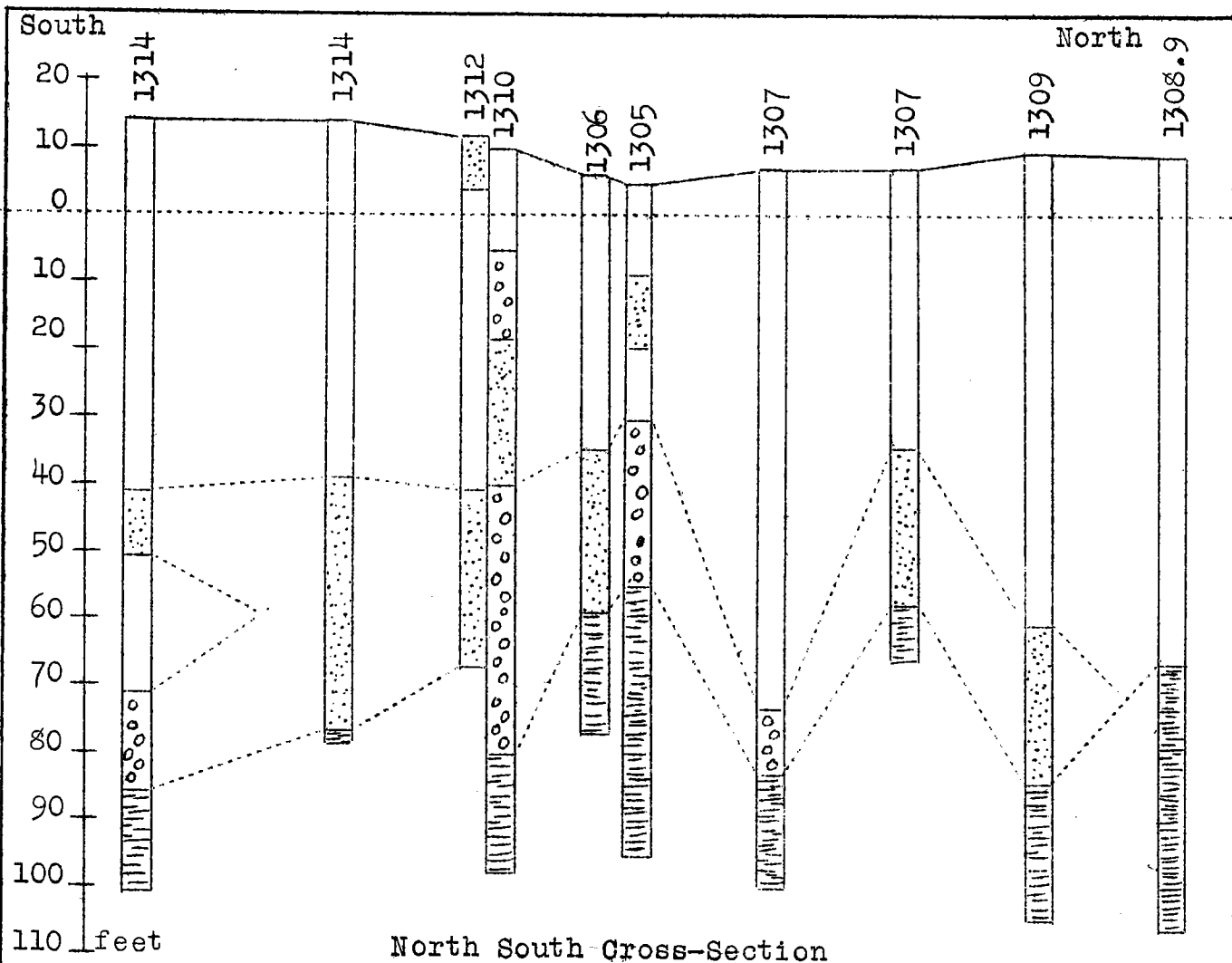
The third supply, that from glacial sands, is the one with which this report concerns itself, as it is the supply which the city is attempting to develop. The bed-rock in the vicinity of Huron is covered with about 100 feet of drift deposited by a continental glacier which covered this region. This drift consists largely of boulder clay, which in the area covered by this report, has a maximum thickness of 75 feet. Between it and the shale bed-rock lies a body of sand of varying thickness and composition, from which the water supply is to be obtained. Other sand pockets occur at the surface and in the boulder clay, but the one to be described here is the only sand large enough to offer a possible water supply for the city.

As is customary with glacial sands and gravels, this deposit is very patchy and varies greatly in composition from place to place. According to drillers' reports, it is missing in the City of Huron and northeast of the test wells in section 9. It is missing in the northern part of the area mapped and thickens and thins in the 16 square miles covered by the survey. Areas of thin sands occur in the northwest quarter of section 9, the southwest quarter of section 4, and in the eastern half of section 16. To the east and west of these areas, the sand zone thickens to a maximum of 65 and 75 feet.

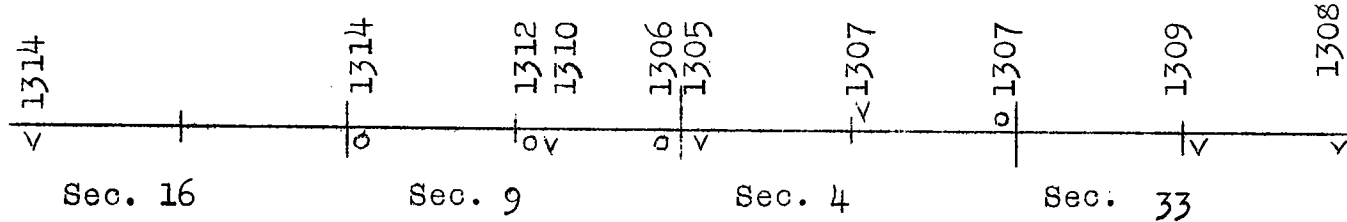
These thicknesses are important, as they indicate the positions in the sand body where wells can be located to furnish the maximum amount of water. The exact position of thick portions is shown on the convergence map accompanying this report.

Character of the Sand Zone:

Samples taken from test wells and the curves of the resistance measurements show that the sand is variable in composition with a corresponding variation in the volume which the sands can deliver. The variations consist of two types, horizontal clay partings and variations in texture. In some test holes coarse and fine sands occur at different depths, separated by clay partings, which are often indicated as shale in drillers' logs, because of shale pieces frequently found in them. These partings make it appear that there are several veins of water in the sand body. The same separation into layers, recorded from the drill holes and electrical measurements, in the Huron area can be seen in outcrops of sand lying



North South Cross-Section

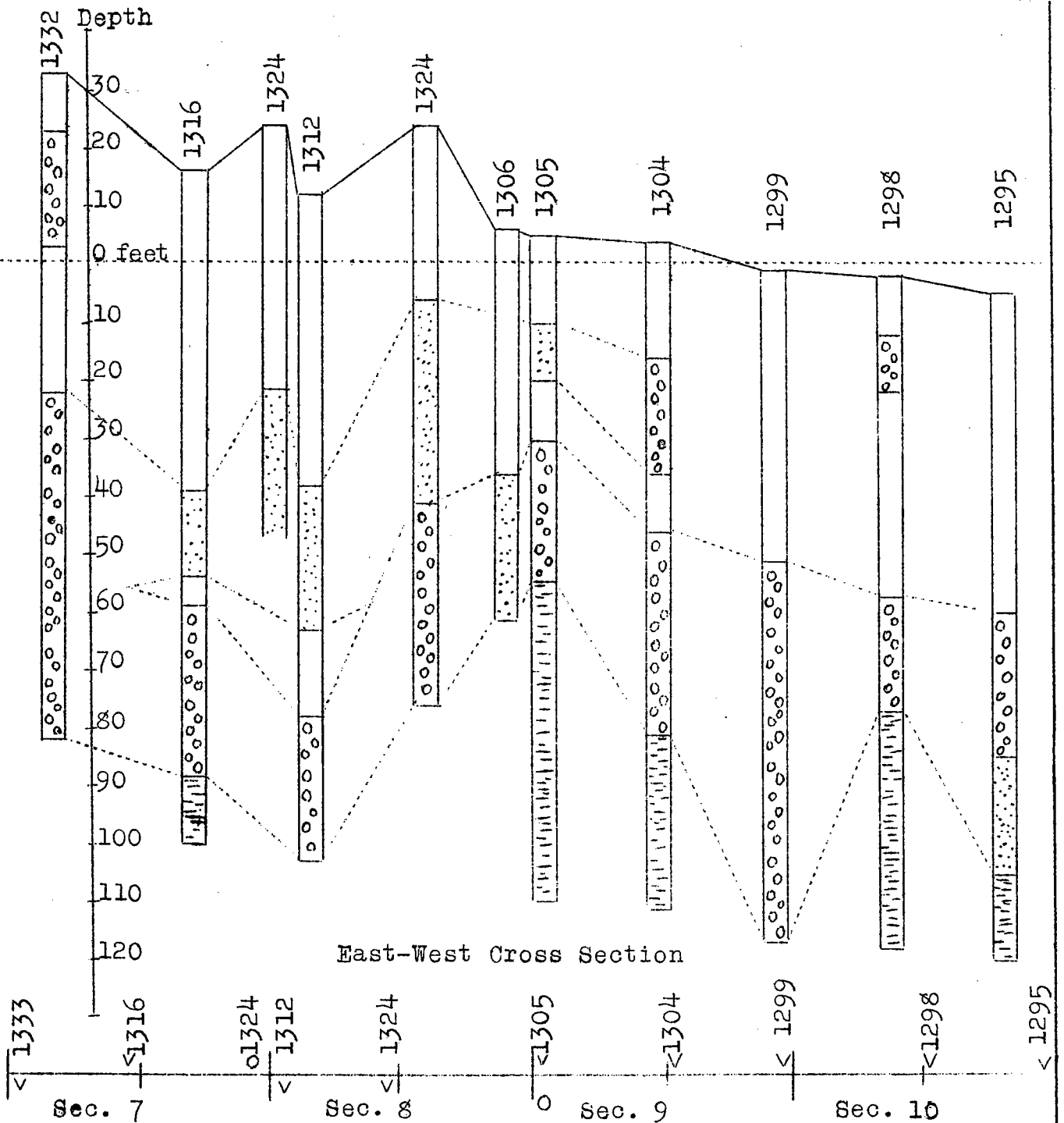


T. 110 N. - R. 62 W. T. 111 N. R. 62 W.

Cross Section Derived From Interpretation of Resistivity Curves

Legend

- Clay - - - - -
- Sand - - - - -
- Gravel - - - - -
- Shale - - - - -
- Resistivity Station - v
- Test Well - - - - - o
- Surface Elevation - 1309



T. 110 N. R. 62 W.

Cross Section Derived From Interpretation of the Resistivity Curves

Legend

- Clay - - - - -
- Sand - - - - -
- Gravel - - - - -
- Shale - - - - -



- Resistivity Station - v
- Test Well - - - - - o
- Surface Elevation 1304

between the boulder clay and the bedrock in other places along the James valley and on the Coteau escarpment in Day and Clark counties.

Some clay partings are small lenses, while others have been traced for a half mile or more. They vary in thickness from a few inches to twenty feet. Only the thicker ones are shown in the logs and cross sections accompanying this report. The higher partings are made largely of fine clays, but many of the lower ones contain so much shale from the bedrock that they have been mistaken for it. They naturally drill somewhat as does the bed-rock and the flakes of shale, coming up with the sludge, make the mistake a very natural one. In some outcrops in other parts of the state, such shale partings occur in the gravels as high as ten or twenty feet above the true bed-rock.

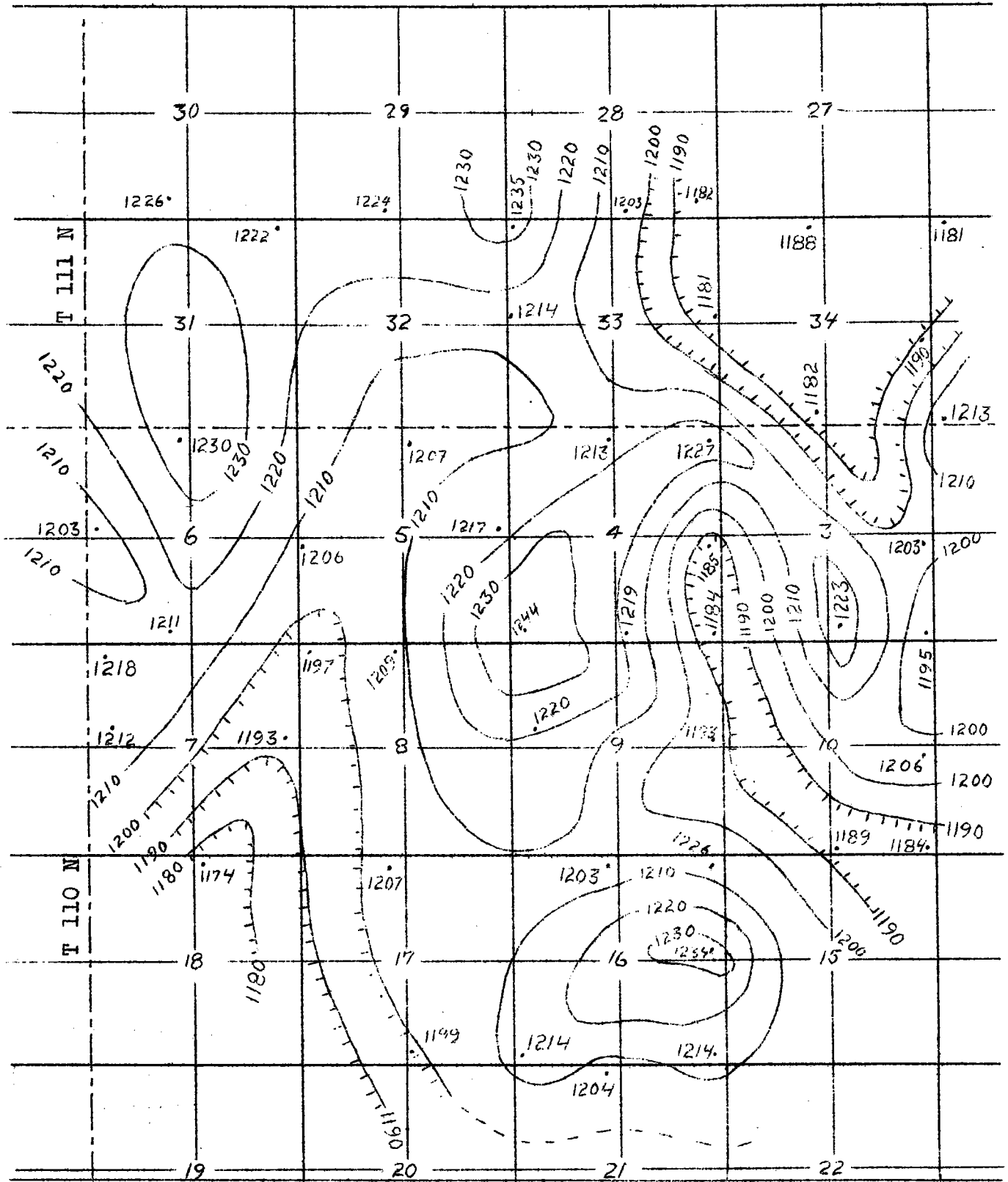
There is a great variation in the character of the sand itself. Streaks of coarse sand and gravel occur interbedded with fine sand. Lenses of coarse sand or gravel may be encountered, surrounded by the opposite sort of material. Coarse sand may be made tight by the inclusion of sufficient amounts of clay to prevent easy passage of water through the pores. A study of the cross sections and logs contained in this report will indicate the depth and position of the larger bodies of these materials.

DEVELOPMENT OF WATER SANDS

The efficiency of this sand reservoir as a source of city water supply will depend largely upon the way in which it is developed. The question of its continuity is quite important since isolated patches of sand and gravel might make an ample farm supply but would not furnish sufficient water for a city.

This survey has demonstrated that though a zone of sand underlies the entire 16 miles investigated, it is not an ideal water sand for a city supply. The large variation in thickness tends to isolate portions of the zone by making it patchy. It also reduces the area of sand which might recharge the wells from which the city supply was pumped. It also restricts the area in which the wells can be located to the best advantage, since the thicker portions of the zone are to be preferred in most cases.

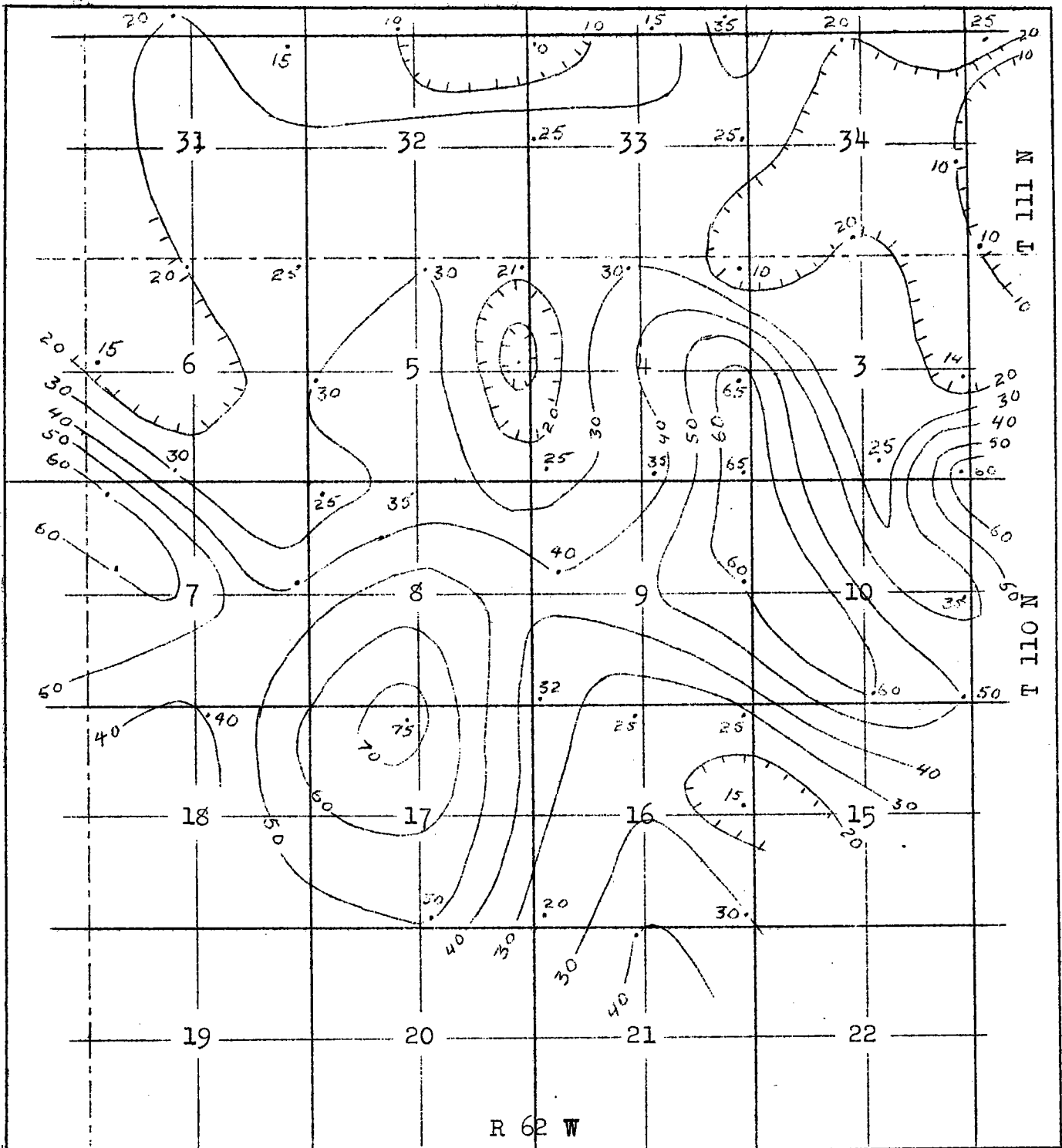
A second factor of importance in developing this supply is the isolation of beds ("veins") of water sand by clay and shale parting. As has been pointed out these partings are numerous and often attain thicknesses of 10 to 20 feet. Such



CONTOUR MAP
of the
BED ROCK SURFACE

Contour Interval 10 ft.



From Geophysical Soundings



CONVERGENCE MAP

Showing Lines of Equal Thickness of Sand and Gravel

LEGEND

- | | |
|---|--|
| <p>25. Resistance Station</p>  <p>Thin Sand and Gravel</p> |  <p>40 — Thickness contour
Figure indicates
thickness of sand
and gravel</p> |
|---|--|

Contour Interval 10 ft.

partings can effectively shut off water from the various sands thus reducing the amount of water obtainable from the zone. It is obvious that to fully utilize such a reservoir, wells must penetrate all sand "veins" coarse enough to supply water. Screens must be so placed that they draw water from each sand. Since water from the upper sands can not be drawn through the clay partings into the sand at the bottom of the zone. This sand zone is in reality a series of sand masses, most of them lenticular in shape and must be treated as such in development.

The third factor which must be considered in the location of wells is the unevenness of the bedrock surface. Water will seek the lowest possible level and, if the supply is to tide over dry seasons, wells should be placed to use water from the lowest sands. It also happens that the sands in these lowest levels are often coarse and allow a larger volume of water to be pumped because of the ready flow through such material.

Records of drilled wells and resistance data indicate two such depressions crossing the area diagonally. One of them trends southeastward to the west $\frac{1}{2}$ of Sec. 10, the other southwestward through the western $\frac{1}{2}$ of Sec. 5, 7, and 8. They are like great shallow troughs one to two miles across and about 50 or 60 feet deep. These wide sloping areas allow a movement of water into the troughs which, in places, have formed artesian heads. Wells in the western part of section 7 and 8 showed a rise of water well above the sand reservoirs. On the eastward slope in the NE $\frac{1}{4}$ of Sec. 9 sufficient head developed to cause a 70 foot well on the MacDaniel farm, in the extreme NE corner of the section, to flow for a short time. Where these bedrock valleys contain sands therefore, they should have water during a longer dry period than in sands above the bedrock hills and on the intervening slopes.

From the foregoing it will be seen that the best chances of developing a city supply will be found where the sand zone is thickest and where its bottom is at the lowest elevation. Wells must be screened to draw from all sand beds encountered to produce a maximum flow.

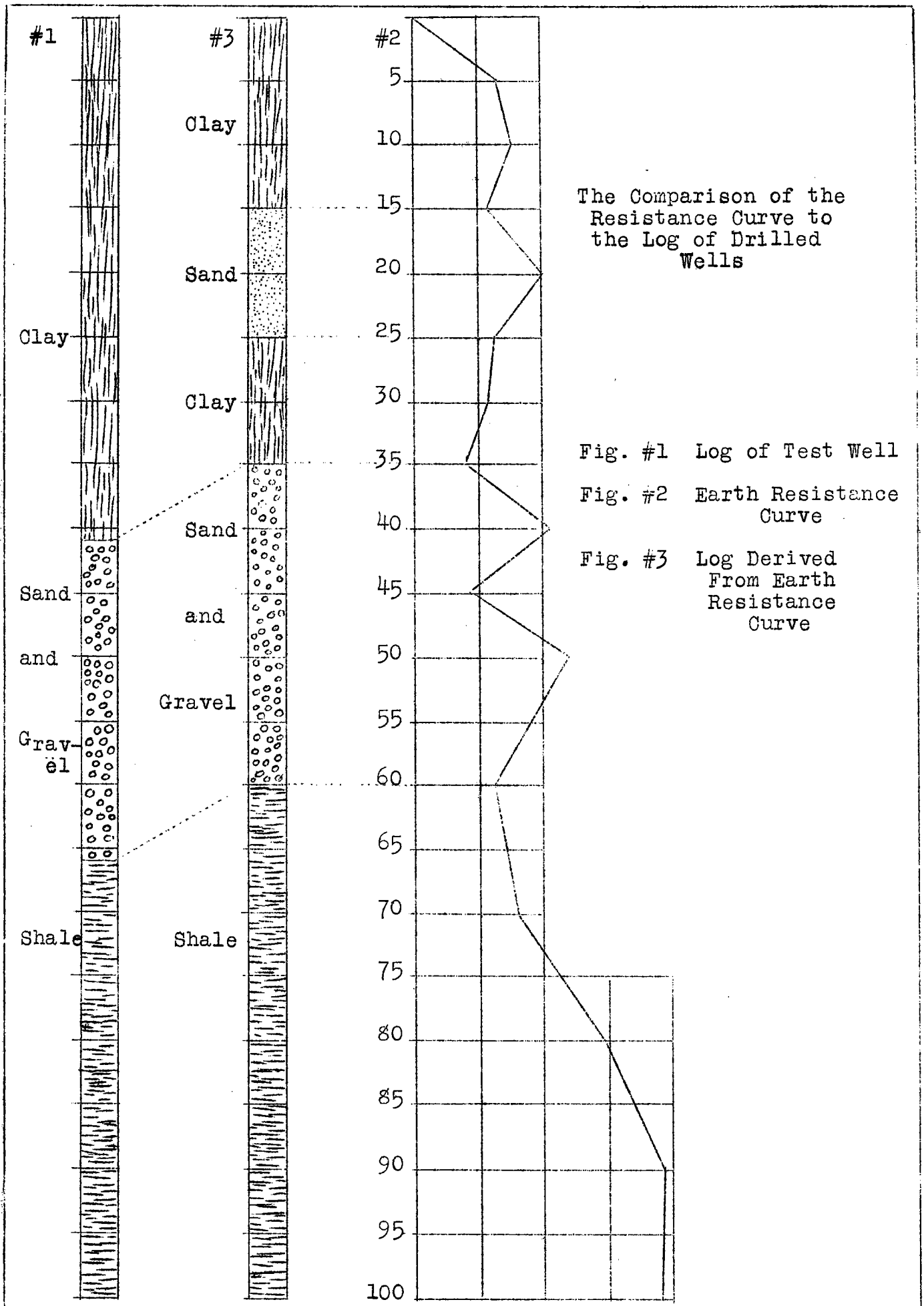
EXPLANATIONS OF SECTIONS AND PROSPECTING METHODS

The accompanying map and cross sections are, for the most part, records of geophysical prospecting. Test holes, drilled with a small jetting machine owned by the city of Huron, were used as guide stations with which to compare the logs obtained by electrical soundings. All sections are plotted to scale and at their correct elevations, a line of sea level elevations having been carried to each location.

This is the first use of an earth resistance meter for prospecting in South Dakota, though it has been in common use by many oil and mining companies, as well as other State Geological Surveys and private investigators. The process consists of sending a known current into the ground and measuring the resistance to its flow offered by the underlying rocks at various depths. In this survey resistances were measured at five foot intervals from the surface to a maximum depth of 115 feet.

The main feature of the instrument used is the revised Poggendorff method of measuring unknown voltages. This resistance is an accurately calibrated bank of number 22 manganin wire wound on maple sticks that were boiled in wax. The entire assembly was then impregnated with wax, to protect it from moisture. The manganin wire was used because of its low temperature coefficient. The resistance bank, which consisted of exactly twenty ohms of number 22 manganin wire, was divided into ten accurate divisions of two ohms each; one of these two ohm divisions being further divided into ten parts of exactly 0.2 ohms each.

With this instrument it is possible to determine the position of the watersand because, as it is well known, electricity flows more easily through certain materials than through others. Experiments have shown that an electrical current will flow more readily through fine grained rocks, such as clay or shale than through grained rocks, like sand or gravel, because the multitude of fine pores in the clay allows it to hold a larger volume of water than does the smaller number of large openings of sands and gravels. Therefore, if a current of electricity were sent through the clay only, and the resistance measured at uniform intervals, say five feet each, the resistance to its flow would rise gradually with the increase in depth of penetration. If, however, the current should encounter a bed of sand beneath the clay, the resistance at this depth would suddenly increase. If these resist-



ances were plotted as a curve, this sharp increase would appear as a sudden rise of the curve. Encountering clay below the sand would cause the curve to fall again.

The curves accompanying this report show many such sudden changes in direction. The drawing which compares resistivity curves with the logs of wells drilled nearby, brings out this relation of resistance curve to the rocks through which the current passes.

Characteristic clay curves appear as the upper parts of the two upper curves on the page showing the resistance in a body of coarse sand with clay partings. The high resistances encountered on these curves indicate the presence of coarse sands, while the low smooth curves are typical of clay.

The curves indicating very fine sands or sands containing large amounts of clay and therefore, poor water conductors, show no great change in resistivity. Minor irregularities represent thin, sandy beds which cause the curve to rise only a little above the normal increase which the clay would show as depth increased.

None of the curves in this area show a typical smooth rise through the zone of coarse sand and gravel. They are characteristically jagged because the coarser beds are separated by beds of low resistance. These latter beds may be either clay, clayey sand, or very fine sand. "Shale" streaks lying between sand-beds were encountered in some well logs and illustrate the conditions which give rise to the breaks in the line. This patchy condition of the sands is characteristic of glacial sands and gravels, and its persistence wherever curves were plotted makes it doubly important that any development of this sand zone for large supplies of water, use all the sands available. Otherwise water bearing lenses will be shut off and much water lost.

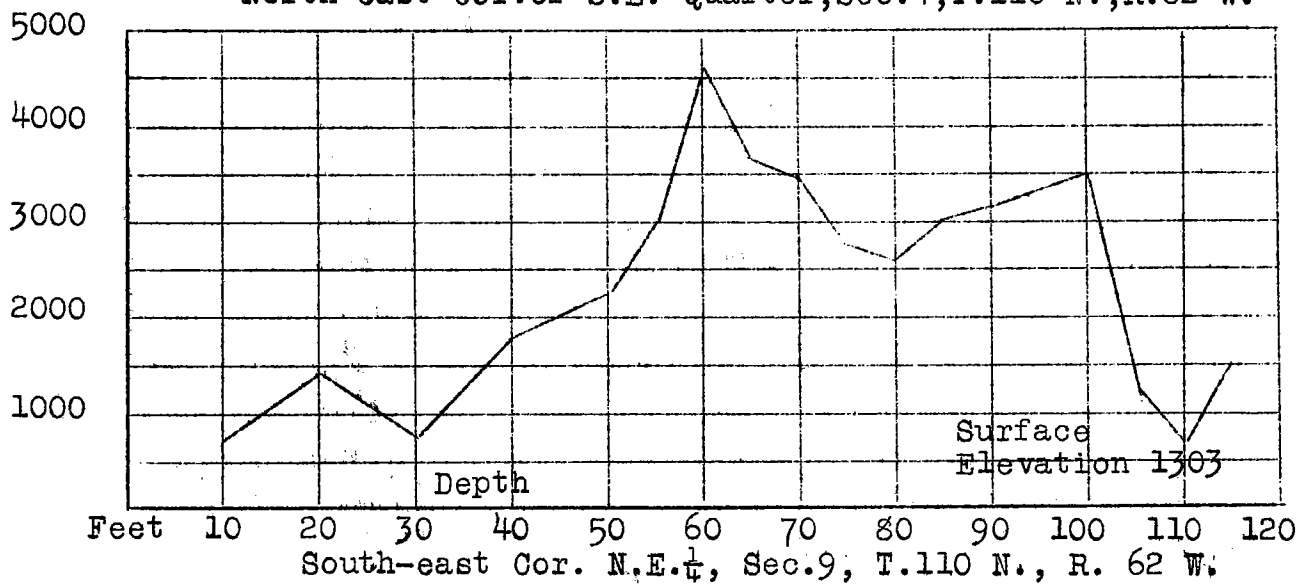
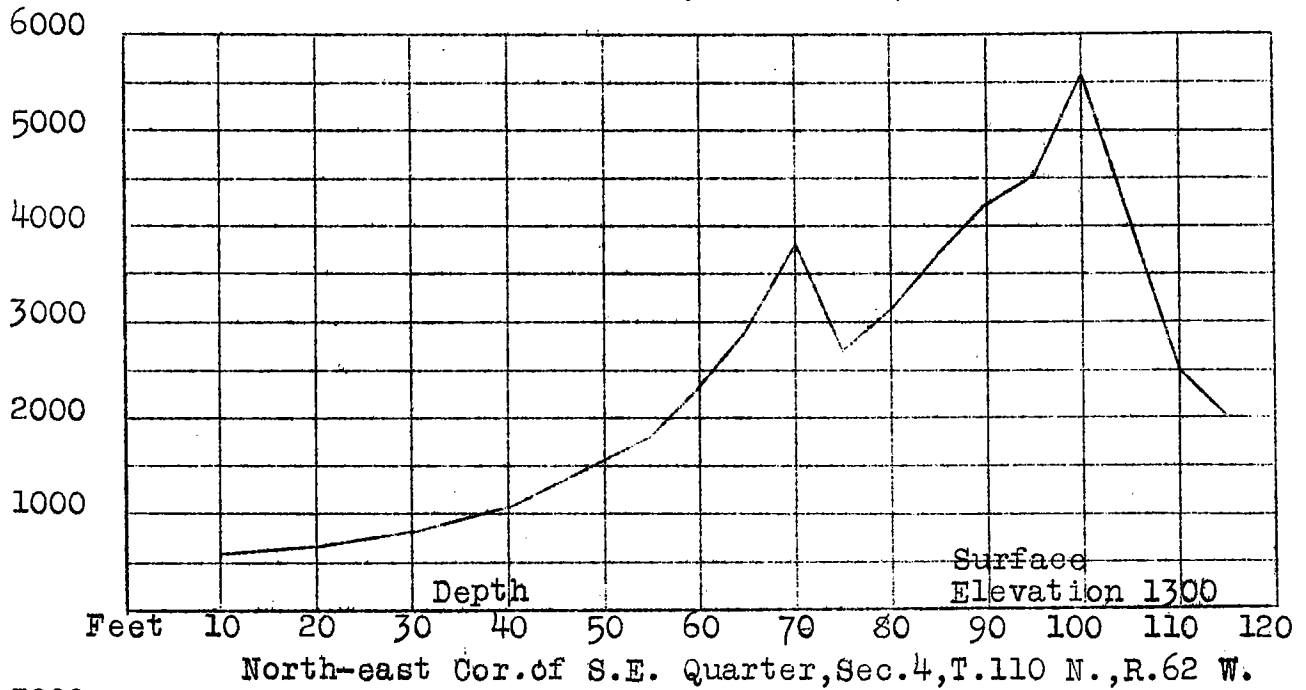
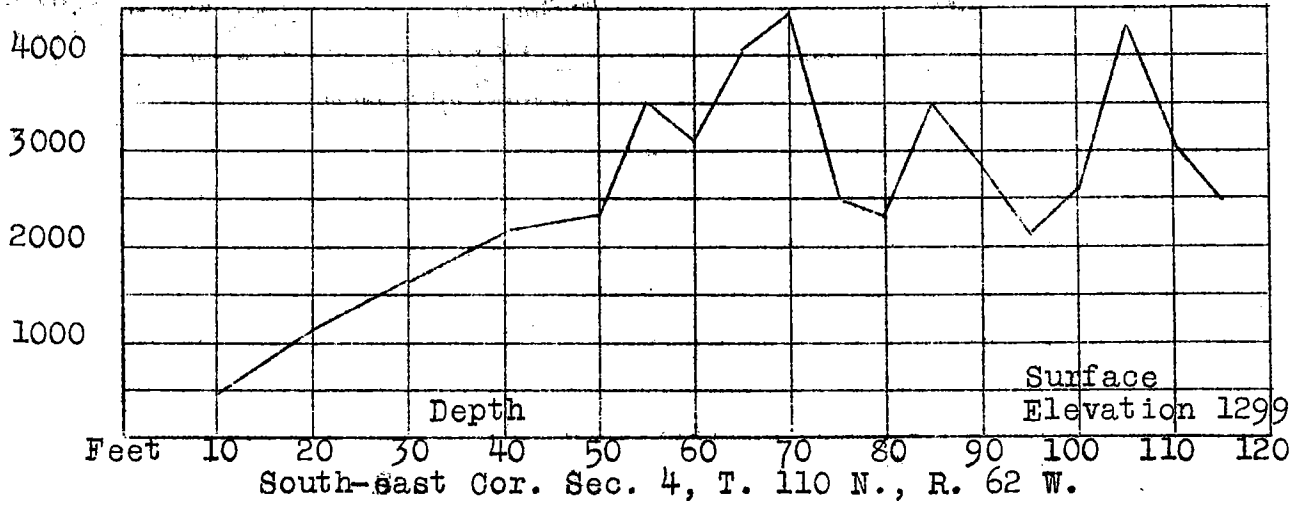
The extreme variability of the sand is shown in the S. E. corner of the surveyed area where a resistivity curve showed 65 feet of alternating sand and clay. A jetted well about 500 feet away showed the top of the sand at the same elevation as in the resistivity sounding but failed to note those lower in the zone.

Accuracy:

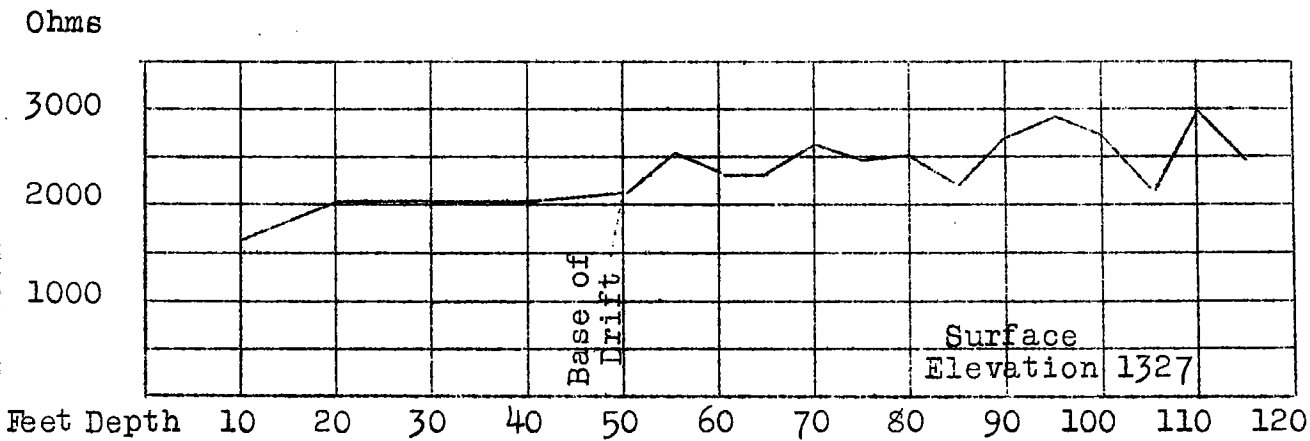
The accuracy of this method of prospecting depends on the spacing of readings and the care with which the readings are taken. Careful checking of the resistance curves against drilled wells gives readings which do not vary more than one or two feet. This is as close as is feasible when dealing

with sand formations of this character. A certain allowance must be made for the spacings necessary between readings. Most of them were taken at 5 foot intervals. This would leave a possible 4 feet between points where the change might actually take place. In general the error is taken as 2-3 feet which is sufficiently accurate for practical purposes.

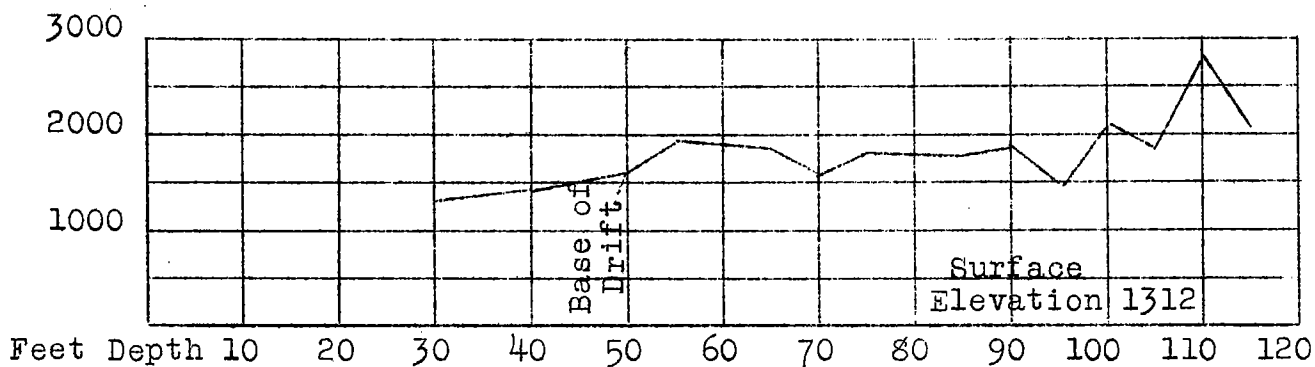
Ohms



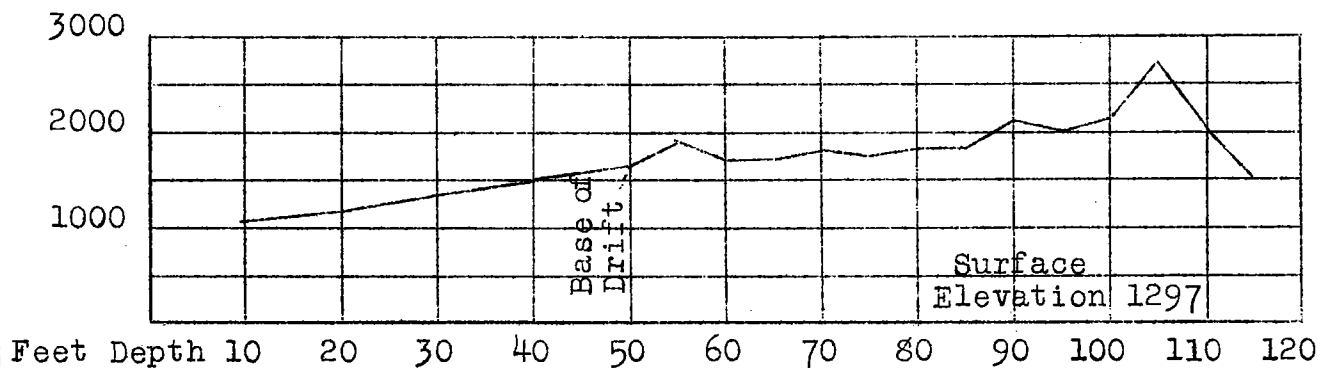
Resistivity Curves Showing Thick Body Containing Coarse Sands Separated by Fine Sands or Clay Partings



S. W. Cor. N. W. $\frac{1}{4}$ Sec. 7, T. 110 N., R. 62 W.



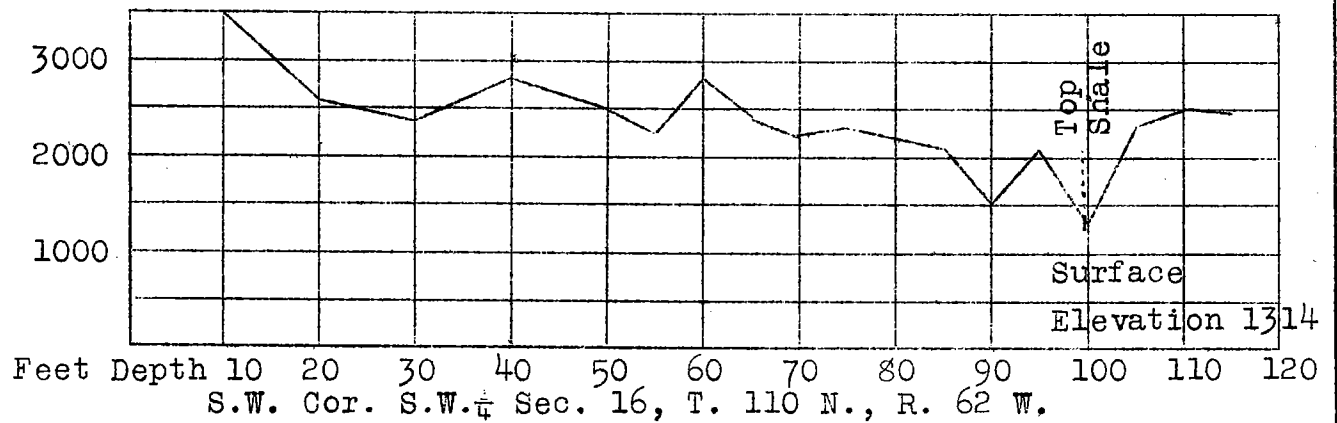
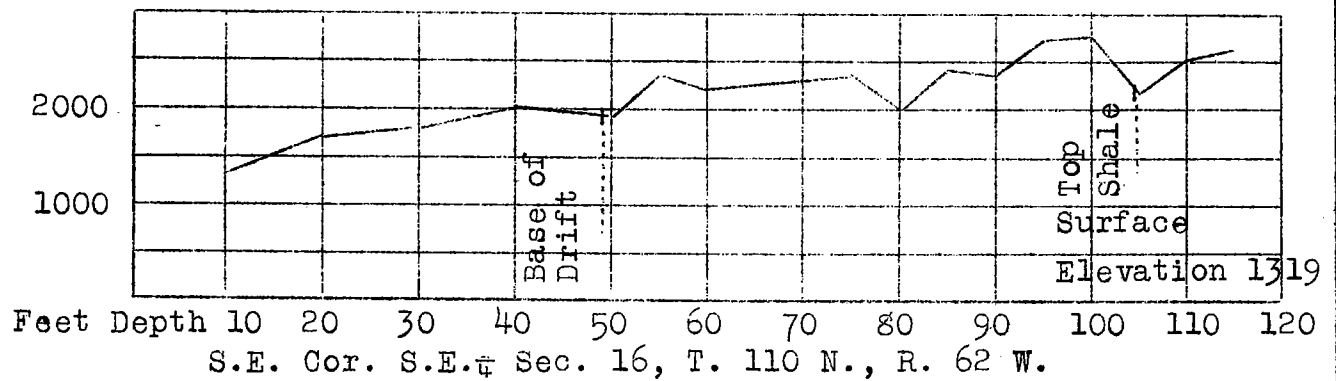
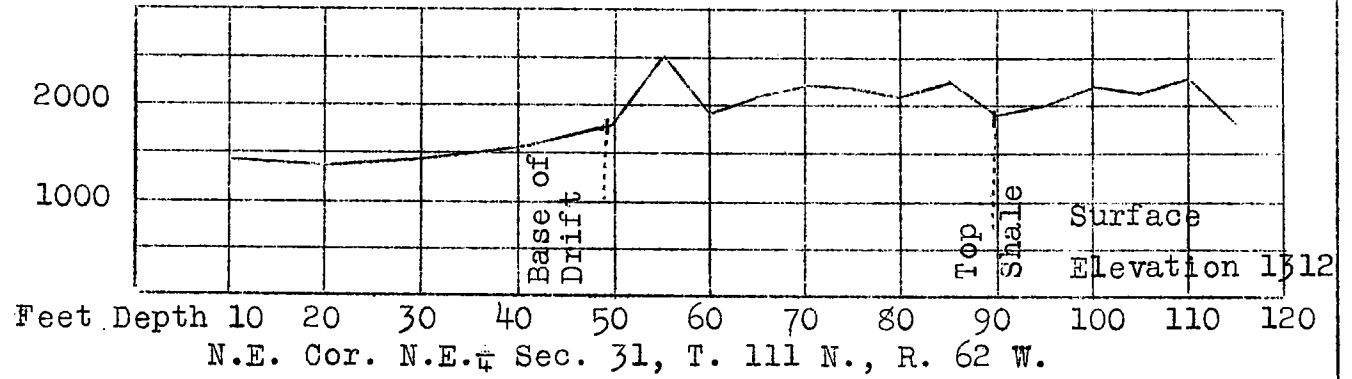
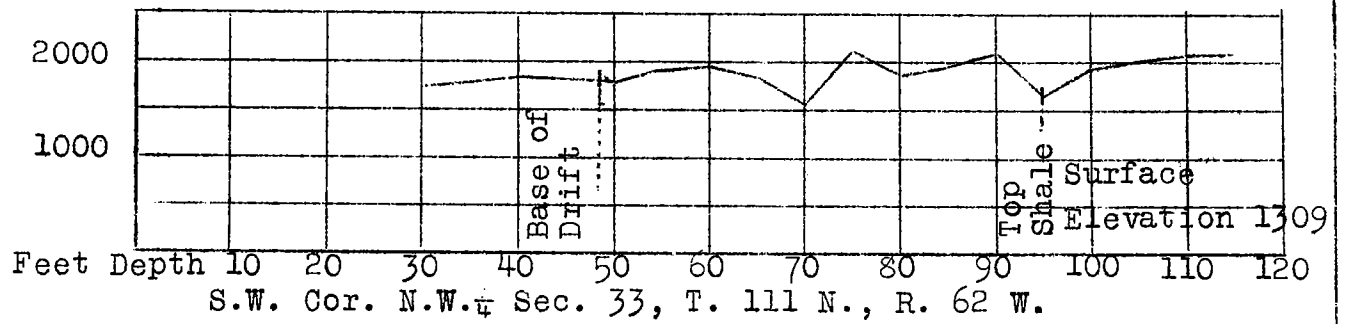
N. W. Cor. N. W. $\frac{1}{4}$ Sec. 8, T. 110 N., R. 62 W.



S. E. Cor. S. W. $\frac{1}{4}$, Sec. 34, T. 111 N., R. 62 W.

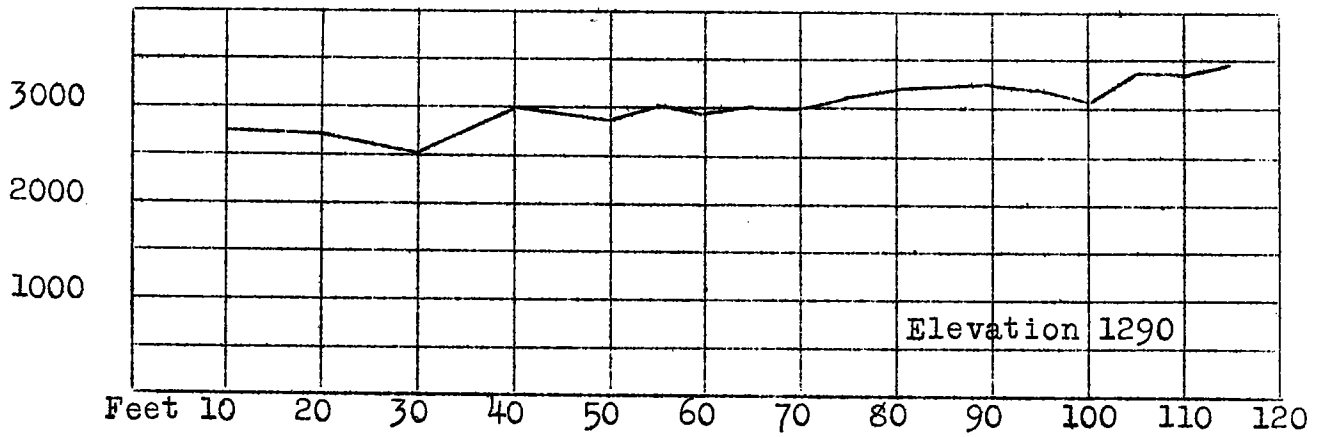
Resistivity Curves Showing Coarse and Fine Sands
Beneath Clay

Ohms

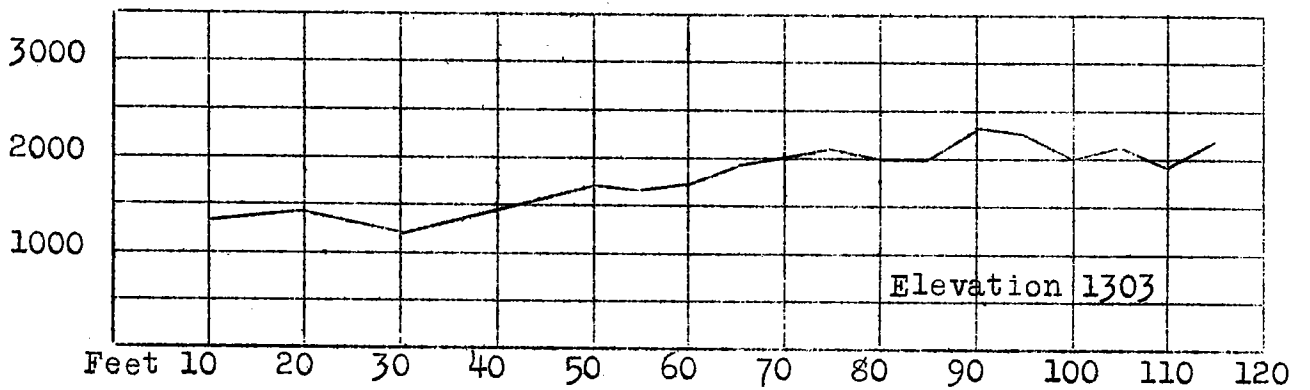


Resistivity Curves Showing
the Top of the Shale Bedrock

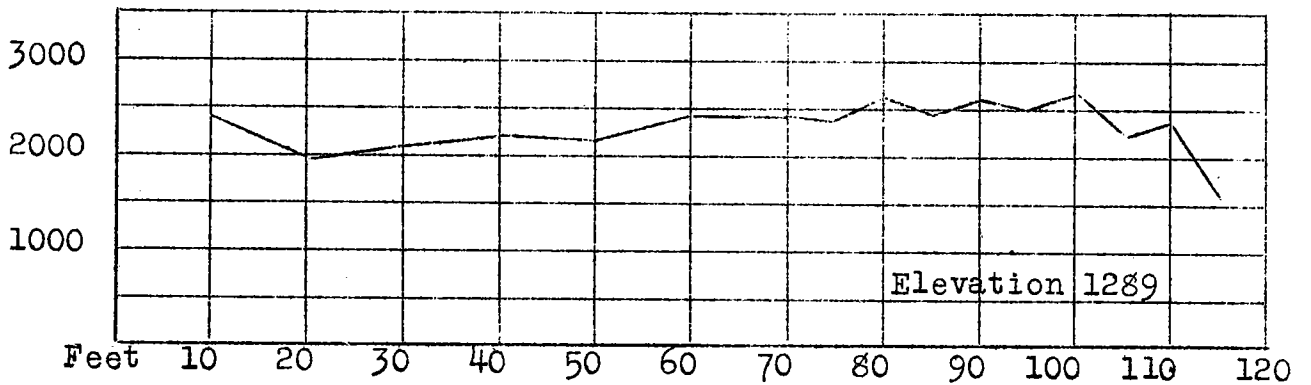
Ohms



N.E. Cor. S.E. Sec. 34, T.111 N., R.62 W.



S.W. Cor. S.E. Sec. 28, T.111 N., R.62 W.



N.W. Cor. N.E. Sec. 18, T.110 N., R.62 W.

Resistivity Curve Showing Minor Lenses of Sand
Separated by Uniform Clays