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GEOLOGY AND OCCURRENCE OF GROUND WATER IN THE STREETER AREA, STUTSMAN, LOGAN, AND KIDDER COUNTIES, NORTH DAKOTA

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NORTH DAKOTA GROUND-WATER STUDIES NO. 20

PREPARED COOPERATIVELY BY THE UNITED STATES GEOLOGICAL SURVEY, THE NORTH DAKOTA STATE WATER CONSERVATION COMMISSION, AND THE NORTH DAKOTA STATE GEOLOGICAL SURVEY

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ABSTRACT

The Streeter area as described in this report, is located between 99°15' and 99°30' west longitude, and 46°30' and 46°45' north latitude, and covers approximately the southwest quarter of the Streeter quadrangle. Streeter is the only community in the area.

Glacial deposits underlie the surface of the entire area, generally to a depth of more than 100 feet. The youngest glacial deposits are of late Wisconsin age and comprise rugged end moraines, outwash deposits, ground moraine, and ice-contact features. End moraines tentatively assigned to the Altamont and Gary systems extend across the area in a southeasterly direction and are separated by a flat outwash plain which is underlain by sand and gravel deposits known to be at least 64 feet thick in one location.

An older drift sheet, underlying the late Wisconsin drift and believed to be of pre-Wisconsin age, was penetrated in some of the test holes drilled west of Streeter. The older drift, where penetrated by test drilling ranges in thickness from 7 to 91 feet and is much weathered.

The Pierre shale of late Cretaceous age underlies the older drift and forms the bedrock over most of the area except in the extreme western part where the Fox Hills sandstone, also of late

Cretaceous age but younger than the Pierre shale, may be present. The Pierre shale is the oldest formation penetrated by test drilling but oil and gas explorations in near-by areas indicate the presence in the Streeter area of the Niobrara formation, Benton shale, and Dakota sandstone, all of Cretaceous age. The Cretaceous formations are underlain by Jurassic and Paleozoic formations which overlie the pre-Cambrian crystalline complex.

A shallow aquifer in the late Wisconsin drift in the immediate vicinity of Streeter was outlined by test drilling and geologic investigation. The aquifer, which consists of coarse sand and gravel, has an estimated area of three-fourths of a square mile and an average saturated thickness of 15 feet. It is estimated that about 500 million gallons of water, or about 1,500 acre-feet, is contained in transient storage in the aquifer. The aquifer is favorably situated for replenishment.

The outwash deposits cover about 30 square miles in the area covered by the report and constitute the most important aquifer. Where penetrated by the test drilling, the outwash deposits are unusually coarse and relatively free of clay and silt. The average saturated thickness of the deposits is estimated to be not less than 20 feet and the amount of water contained in them in transient storage is estimated to be not less than 75,000 acre-feet.

Gravel associated with the older drift apparently is a source of water for a number of farm wells west of Streeter. However, little is known concerning the amount of water available from this source.

The Pierre shale constitutes a weak aquifer in most of the area, from which a rather large number of farm wells obtain water.

The chemical quality of the ground water available from the different aquifers in the area varies widely, and even the water from wells believed to tap the same geologic source varies widely in mineral content. Dissolved solids in five water samples collected from wells in the shallow aquifer at Streeter ranged from 330 to 3,600 parts per million. This water generally is excessively hard and, in the closely populated parts of the village, very high in nitrate. Water in the outwash deposits is hard but is generally moderate in dissolved solids. Water obtained from wells thought to end either in older drift or in the Fox Hills sandstone is generally low in dissolved solids and is moderately hard. The Pierre shale yields water that is moderately to exessively hard and somewhat highly mineralized.

Exessive quantities of iron were observed in samples from several sources, particularly from the Pierre shale.

INTRODUCTION

Purpose and Scope of the Investigation

This is a progress report covering a part of the study of the geology and ground-water resources of Stutsman, Logan, and Kidder Counties, N. Dak., being made by the United States Geological Survey in cooperation with the State Water Conservation Commission and the State Geological Survey, as a part of a State-wide series of investigations. The purpose of these general studies is to determine the occurrence, movement, discharge, and recharge of the ground water, and the quantity and quality of such water available for all purposes, including municipal, domestic, irrigation, and industrial. At present, the most critical need is for adequate and perennial supplies for many towns and small cities throughout the State wishing to construct municipal water-supply and sewage-disposal systems. For these reasons, the county-wide studies are being started in the vicinity of those communities requesting the help of the State Water Conservation Commission and the State Geologist in locating suitable ground-water supplies. Progress reports, such as this one, are being released before the completion of the general studies so that the data may be available as soon as possible for use in connection with immediate problems.

The investigation in the Streeter area was made in 1949 and 1950 under the general supervision of A. N. Sayre, chief, and P. D. Akin, district engineer, Ground Water Branch, Water Resources Division, U. S. Geological Survey. The field work and test drilling were done under the direct supervision of the writer.

All the chemical analyses of water samples were made by the North Dakota Department of Health. Various publications and bulletins were made available by the North Dakota State Geological Survey and the University of North Dakota. Saul Aronow, geologist, U. S. Geological Survey, visited the area, giving helpful suggestions concerning the geology, and also gave valuable criticism during the preparation of the report.

Field work in the area was facilitated by the excellent cooperation of all the residents and particularly by the interest and assistance of Mayor Bitterman of Streeter and of other members of the village council.

Previous Investigations

No intensive investigation of the geology and ground-water resources in the Streeter area had been made previously. Todd (1896) mapped the outer morainic systems in North Dakota as far north as the latitude of Jamestown (about 20 miles north of Streeter) and he described generally some of the glacial features in the Streeter area. His work is extremely valuable in showing the relation of the glacial deposits in the Streeter area to those of the much larger area of the Missouri Coteau.

Simpson (1929, pp. 148-149, 155-156, 230-236) described the area generally in his report on the geology and ground-water resources of North Dakota. Abbott and Voedisch (1938, pp. 80-81) listed chemical analyses of water taken from two wells in Streeter.

In 1946 the Independent Drilling Co. of Aberdeen, S. Dak. drilled seven test holes at Streeter for the purpose of locating a well water supply for municipal use. All the test holes were drilled to the shale bedrock and some were drilled to considerable depth into the shale. None of the test holes was reported to have yielded water in sufficient quantity for municipal use, although one was reported to have been pumped at the rate of about 20 gallons a minute for a short period. The test holes are listed in the well tables, where an approximate log of each is given. Their locations are shown in figure 13.

Location and General Features of the Area

The area described in this report is located between 99°15' and 99°30' west longitude and 46°30' and 46°45' north latitude and covers approximately the southwest quarter of the Streeter quadrangle of the U. S. Geological Survey's topographic atlas. Parts of three counties are included. By townships, the area includes the followings: all of T. 137 N., R. 69 W., parts of T. 138 N., Rs. 68 and 69 W., and T. 137 N., R. 68 W., in Stutsman County; parts of Tps. 137 and 138 N., R. 70 W., in Kidder County; all of T. 136 N., R. 69 W., and parts of T. 136 N., Rs. 68 and 70 W., and T. 135 N., Rs. 68, 69, and 70 W., in Logan County. The total area covered is approximately 216 square miles.

Streeter, the only community, is in the north-central part of the area. According to preliminary census figures, the population of Streeter was 647 in 1950. The village is near State Highway 30, sixteen miles south of U. S. Highway 10. A spur of the Northern

Pacific Railway serves the village from the east.

The nearest U. S. Weather Bureau station is at Napoleon, about 20 miles southwest of Streeter. The average annual precipitation recorded there is 17.29 inches, based on data from 1891 to 1950, inclusive. Temperatures in the area commonly reach 90° F. or higher during the summer and often dip to 30° F. or lower during the long winter season. (U. S. Weather Bureau, 1951).

Although farming is the chief occupation in the area, considerable tracts of land, especially the more rugged and bouldery portions of the end-moraine areas, are devoted entirely to the grazing of cattle and sheep. Wheat is the chief crop. Other grains also are raised, and hay crops are harvested several times a year from many of the low, poorly drained areas.

Physiographic Features

The report area is in the glaciated section of the Missouri Plateau (Fenneman, 1931, pp. 72-79). The portion of the glaciated section between the Missouri River on the west and the Drift Prairie of the Central Lowlands on the east is called the Coteau du Missouri (see fig. 1). The Coteau du Missouri is characterized largely by end moraines deposited during the last great ice invasion. The region is rugged, comprising steep-sided hills and ridges separated by undrained or poorly drained depressions, many of which contain perennial lakes.

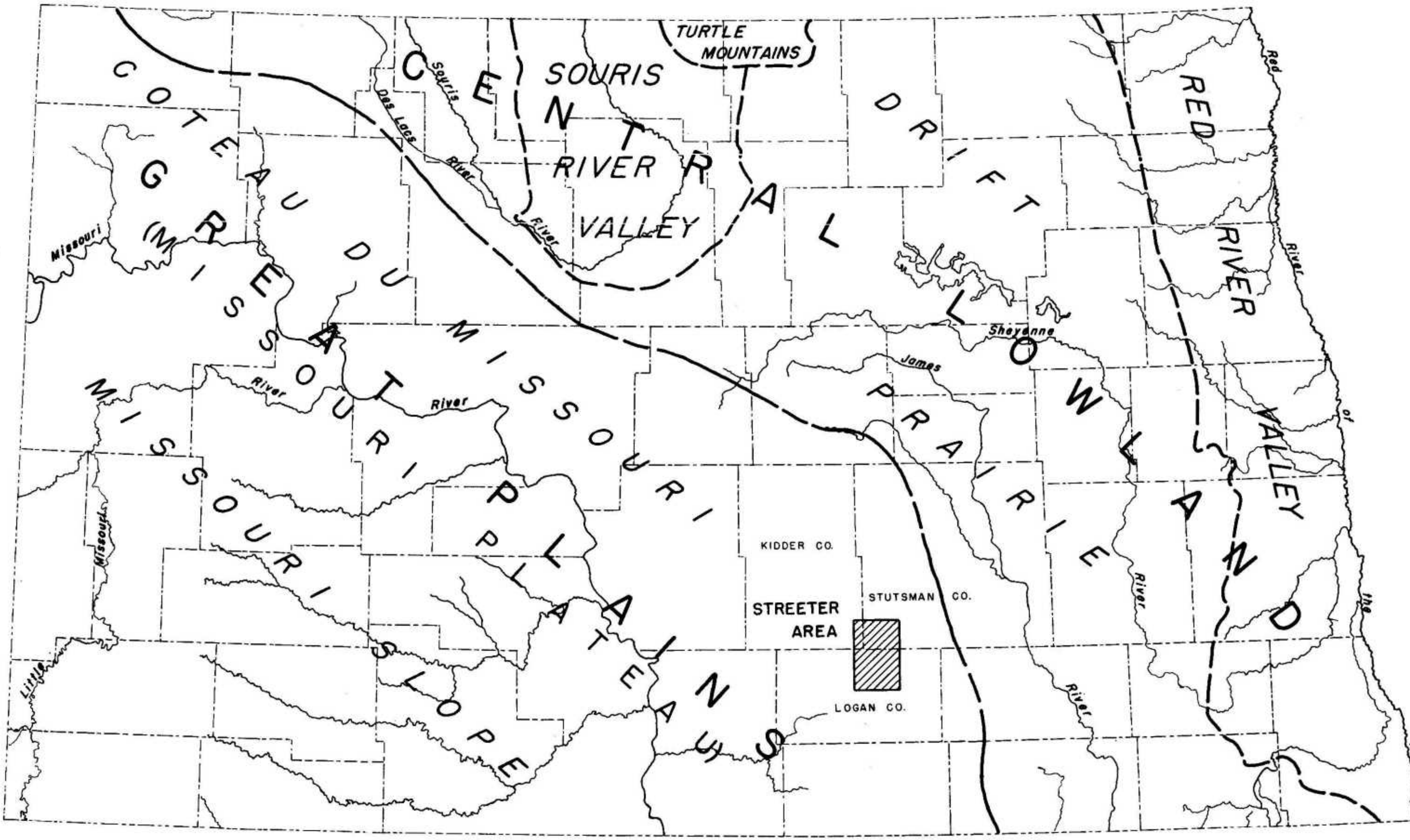


FIGURE 1.—MAP OF NORTH DAKOTA SHOWING PHYSIOGRAPHIC DIVISIONS, AS MODIFIED FROM SIMPSON, AND LOCATION OF THE STREETER AREA.

In the Streeter area, two belts of end moraine separated by an extensive flat area of glacial outwash were recognized and mapped (see fig. 2). These moraines are believed to correspond to the Altamont, or first, moraine and the Gary, or second, moraine, according to terminology used by previous workers (Chamberlin, 1883; Todd, 1896).

Because there has been no detailed mapping of the outer moraines in areas adjacent to the Streeter area, there may be some question as to whether the end moraines in this area actually belong to the Altamont and Gary systems. As shown on Todd's reconnaissance map of the outer moraines on the Missouri Coteau (Todd, 1896, pl. 1), the Altamont moraine does not extend into the Streeter area, but its eastern edge is shown to be only a few miles southwest of the area. Although the general shapes and trends of the Altamont and Gary moraines in the Streeter area as shown on Todd's map are correct, the actual widths of the moraines are considerably greater than he indicated.

The nearest areas in which detailed geologic mapping has been done are the Jamestown (Willard, 1909) and Edgeley and LaMoure (Hard, 1929) quadrangles. The western boundaries of these quadrangles are about 10 miles east of the Streeter area. From the southwestern and northwestern parts of the Jamestown and Edgeley quadrangles, respectively, end moraines believed to belong to the Altamont and Gary systems are reported to extend northwestward into Logan, Stutsman, and Kidder Counties.

There is some reason, therefore, to assume the presence of both the Altamont and Gary moraines in the Streeter area, and these names are used in this report to identify the two moraines in the area. Extensive outwash deposits in the western and southern parts of the area separate the two moraines.

The end moraine southwest of the outwash deposits is assigned to the Altamont system. In the Streeter area the Altamont probably is not as prominent as it is elsewhere in North Dakota, although the local relief is generally 50 to 100 feet.

The comparatively flat sandy plain separating the Altamont and Gary moraines is underlain by deposits of glacial outwash. The southern and extreme northern ends of the plain are moderately rolling. Most of the drainage from the outwash plain is toward Alkaline Lake, a few miles west of the Streeter area, but a part is toward Lake George, which extends into the northwest corner of the area.

The Gary moraine is well developed and constitutes the largest and most prominent physiographic feature in the area. It attains a relief and ruggedness unusual for end moraines deposited by continental ice sheets. The moraine is especially well developed in a comparatively narrow belt of near-parallel ridges crossing the area from northwest to southeast, marking successive portions of minor lobes and reentrants in the ice front. For purposes of discussion the belt of ridges has been divided into two areas, marking sub-lobes "A" and "B", and, to the southeast, an interlobate moraine "C" (see fig. 2).

Although the individual ridges are rarely more than 50 feet higher than the intervening troughs, the entire mass of ridged moraines in sub-lobes "A" and "B" is about 200 feet higher than the outwash plain areas, and the interlobate moraine "C" is 300 to 400 feet higher.

Most of the area east and northeast of the ridged end moraine consists of knob-and-kettle end moraine. There are, however, a few small, isolated areas of flat to gently rolling ground moraine and some small areas of outwash. In the northeast corner of the area the ground moraine is modified so greatly by deep kettle depressions as to have a relief rivaling that of the end moraine areas.

Present Water Supply and Future Needs

Residents in the Streeter area are almost entirely dependent upon ground water as a source of water supply. There are no streams of any significance in the area and practically all surface water occurs as small lakes or swamps, most of which have no surface outlets. Most wells in the area obtain water from sand and gravel associated with the glacial drift. Many, however, obtain water from the upper part of the bedrock underlying the drift, the Pierre shale in most of the area and the Fox Hills sandstone in the western part. Wells that obtain water from sand or gravel in the glacial drift range in depth from only a few feet to 160 feet. Wells that obtain water from the shale are generally reported to be more than 160 feet deep. The deepest well in the area ends in shale and is reported to be 400 feet deep.

At present the greatest demand for water in the area is in the village of Streeter, where it is estimated that a dependable supply of approximately 65,000 gallons per day would be necessary to maintain an adequate water-supply and sewage-disposal system. There is no public-supply system at present. Most farm residents in the area report dependable well supplies, although some of the shallower wells are reported to have gone dry or to have been inadequate during the recent dry years.

Except for several drilled wells more than 300 feet deep, all domestic and industrial supplies in Streeter are obtained from shallow dug or bored wells. The shallow wells range in depth from 8 to 35 feet and the average depth is 20 feet. The total number of wells in Streeter exceeds 100. Most are equipped with hand pumps but some are equipped with automatic pressure systems.

The water from the shallow wells in Streeter is used for most domestic purposes. Rain water, collected and stored in cisterns, is used for purposes for which softer water is desired.

The glacial-outwash area in the western part of the Streeter area appears to be potentially irrigable through the use of ground water. Most of the outwash area is a comparatively flat, sandy plain that slopes gently to the west. The surface of the plain probably would require very little modification in order to make it suitable for irrigation. The soil and underlying deposits of sand and gravel are loose-textured and would permit excellent subsurface drainage, so that there would be small danger of waterlogging.

Little quantitative information is available at present concerning the permeability of the outwash materials and the amount of water available from them on a continuing basis. The results of the well inventory and test drilling, however, indicate that fairly large amounts of ground water should be available from this area for irrigation or other purposes.

Well-Numbering System

The well-numbering system used in this report is based upon the location of the well with respect to the land-survey divisions used in North Dakota. The first number is that of the township north of the base line which extends laterally across the middle of Arkansas. The second number is that of the range west of the fifth principal meridian. The third number is that of the section within the designated township. The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarter sections, quarter-quarter sections, and quarter-quarter-quarter sections, depending on their position in the well number. If more than one well occurs in a 10-acre tract (quarter-quarter-quarter section) consecutive numbers are given to them as they are scheduled. This number follows the letters. Thus, well 135-70-22ddd1 is in Township 135 North, Range 70 West, Section 22. It is in the southeast quarter of the southeast quarter of the southeast quarter of that section and was the first well scheduled in the 10-acre tract. Similarly, well 137-69-28abb (see USGS test 313, fig. 2) is in the NW¼NW¼NE¼ sec. 28, T. 137 N., R. 69 W. Numbers for wells not accurately located within the section in the field may contain only one or two letters after the section number, indicating that the location of such wells is accurate only to the quarter section or the quarter-quarter section, respectively.

The following diagram, showing the method of numbering the tracts within a section, may be helpful to the reader in referring from the illustrations to the well tables and logs.

bbb	bba	bab	baa	abb	aba	aab	aaa
(b)		(a)		(b)		(a)	
bbc	bbd	bac	bad	abc	abd	aac	aad
	b				a		
bcb	bca	bdb	bda	acb	aca	adb	ada
(c)		(d)		(c)		(d)	
bcc	bcd	bdc	bdd	acc	acd	adc	add
cbb	cba	cab	caa	dbb	dba	dab	daa
(b)		(a)		(b)		(a)	
cbc	cbd	cac	cad	dbc	dbd	dac	dad
	c				d		
ccb	cca	cdb	cda	dcb	dca	ddb	dda
(c)		(d)		(c)		(d)	
ccc	ccd	cdc	cdd	dcc	dcd	ddc	ddd

GEOLOGY

Nineteen test holes were drilled in the area with a hydraulic rotary rig in order to determine the nature of the underlying formations, especially their water-bearing properties. Additional information concerning the formations was obtained through the well inventory and by field investigations of the surface geology. The logs of the test holes are given on pages 63-72, and a fairly complete inventory of the existing wells in the area is given on pages 51-61.

Because the most promising ground-water potentialities in the Streeter area lie in the glacial drift, test holes were drilled only to the top of the bedrock. In some places shallow test holes, approximately 50 feet deep and not reaching the bedrock, were drilled to investigate the extent and thicknesses of near-surface aquifers.

The surface formation is glacial drift of late Wisconsin age and includes end moraine, glacial-outwash deposits, small patches of ground moraine, and various ice-contact features. Underlying the late Wisconsin drift are scattered remnants of an older drift sheet. The older drift is deeply weathered in some places and appears to be more stony than the younger drift. The age of the older drift is not definitely known but it is believed to have been deposited during one of the pre-Wisconsin stages of glaciation.

The older drift, where penetrated in test drilling, rests directly on the bedrock, which in most of the area is the Pierre shale of Late Cretaceous age. In the extreme western part of the area a younger formation, possibly the Fox Hills of Late Cretaceous age overlies the Pierre shale. Available information from nearby areas indicates tha presence in the Streeter area, below the Pierre shale, of the Niobrara formation, the Benton shale, the well-known Dakota sandstone, and Paleozoic formations. The oldest Paleozoic formations are underlain by igneous or metamorphic rocks of pre-Cambrian age.

Late Wisconsin Drift

End Moraine

Altamont moraine

The end moraine in the extreme southwestern part of the area (see fig. 2) is tentatively assigned to the Altamont system. The Altamont moraine was named by Chamberlin (1883, pp. 378, 385, 393, 403) for its prominent occurrence near Altamont, S. Dak. It is the name given to the outer or first moraine of late Wisconsin age that extends southeastward through North and South Dakota east of the Missouri River and approximately parallel to it.

The moraine was mapped by Todd (1896) as far north as the Northern Pacific Railway, which crosses North Dakota near the 47th parallel. It appears evident from Todd's description and map, and from a study of the aerial mosaics of the area southwest of the Streeter area, that the Altamont moraine has a southeasterly trend and is about 10 miles wide in the Streeter and adjacent areas.

The portion of the moraine in the Streeter area has largely a knob-and-kettle surface and the local relief is generally 50 to 100 feet. The moraine becomes increasingly rugged and complex toward the southwest, where the relief is estimated to be in excess of 100 feet. The surface of the moraine is extremely stony and it is not particularly suited to cultivation.

Along its northern and eastern edges in the Streeter area, the Altamont moraine is rather subdued and merges gradually into the adjoining outwash deposits. In many places it is necessary to distinguish between the two types of glacial deposits mostly on the basis of soil lithology: the light, sandy, loose-textured, well-drained soil of the outwash deposits is readily distinguished from the darker, heavier-textured, clay-rich soil of the end moraine.

Integrated drainage in the moraine is practically nonexistent, and many small lakes lie at different elevations with no surface interconnection.

Gary moraine

The largest part of the Streeter area is included in the Gary moraine. The Gary moraine was named by Chamberlin for its prominent occurrence near Gary, S. Dak. (Chamberlin, 1883, p. 393). It is northeast of and parallel to the Altamont moraine and, in North Dakota at least, it is probably the second moraine deposited by the continental ice sheet during late Wisconsin glaciation.

In the Streeter area the Gary moraine exhibits two strikingly different types of end-moraine topography as shown on figure 2. They consist of a rather narrow belt of near-parallel morainic ridges formed along the western edge of the moraine and a much larger area of knob-and-kettle topography east of the belt of ridges. The area

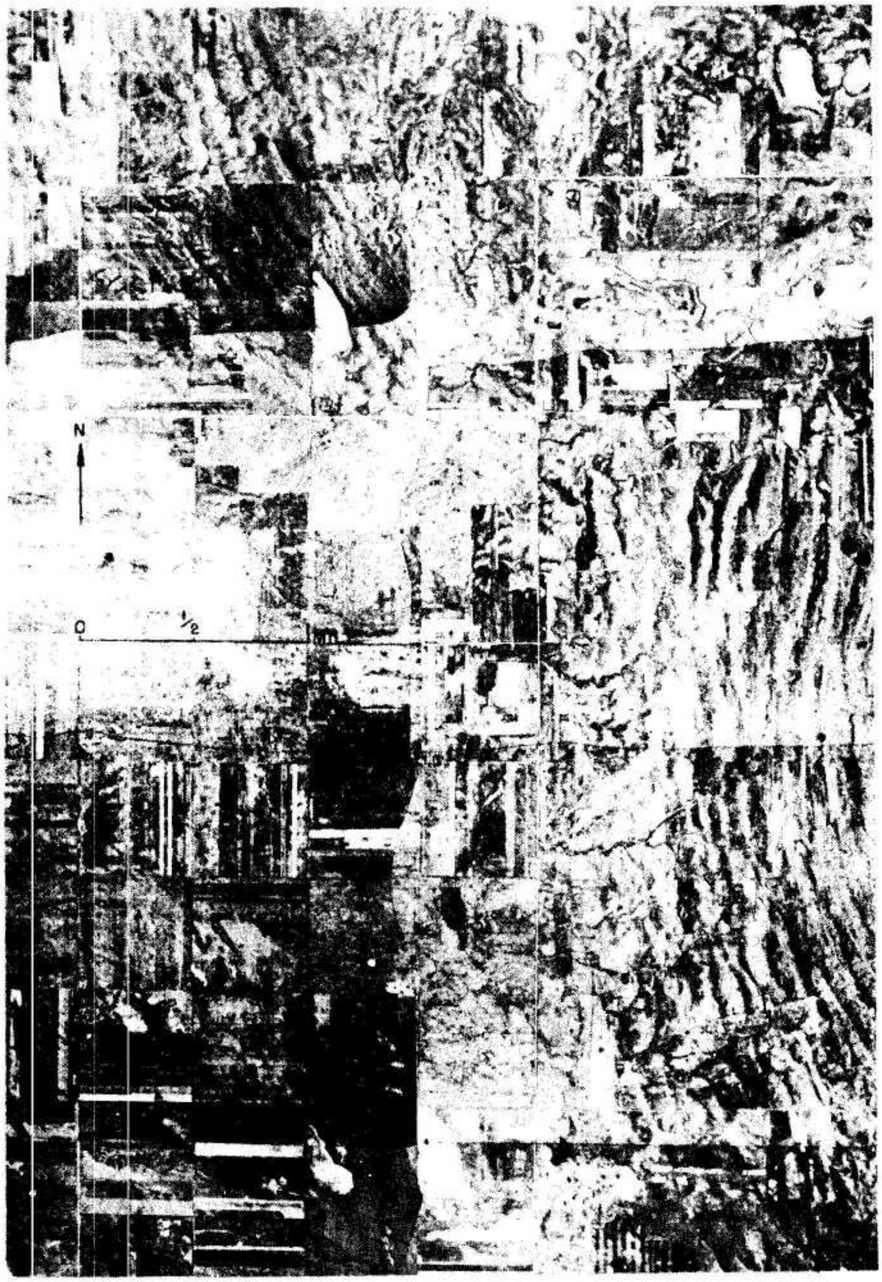


Figure 3.--Aerial view of ridged end moraine. "A" sub-lobe in upper left and "B" sub-lobe in lower right part of photograph.

of ridged moraine includes small patches of knob-and-kettle topography, and vice versa.

The belt of near-parallel ridges generally is the most rugged and has the greatest amount of relief in the Streeter area. The belt ranges in width from less than a mile at its northern end to nearly 3 miles at its southern end. It crosses the lower two-thirds of the area from northwest to southeast, marking a series of minor lobes and reentrants. For ease of reference it is divided into sub-lobes "A" and "B" and, to the southeast, an interlobate moraine "C".

In sub-lobes "A" and "B" the ridges are the longest and most clearly defined, being easily discernible on the ground and in aerial photographs (fig. 3). The individual ridges range in length from several hundred feet to more than 3 miles if gaps are included. Some of the ridges are terminated by intersection with other ridges or are cut through by glacial-meltwater channels. Most of the ridges, however, end without any apparent relationship to other land-surface features.

The crests of the ridges are, on the average, about 500 feet apart and are generally about 50 feet higher than the intervening troughs. In sec. 12, T. 136 N., R. 70 W., one of the most prominent ridges is known to have an altitude of 2 075 feet, which is about 200 feet higher than the outwash area adjacent on the southwest.

A rather spectacular development of end moraine is found in the interlobate moraine "C" in the southeastern part of the area. In aerial view, it forms a triangular reentrant whose apex points east (see figs. 2 and 4). As seen on the ground from either the north or

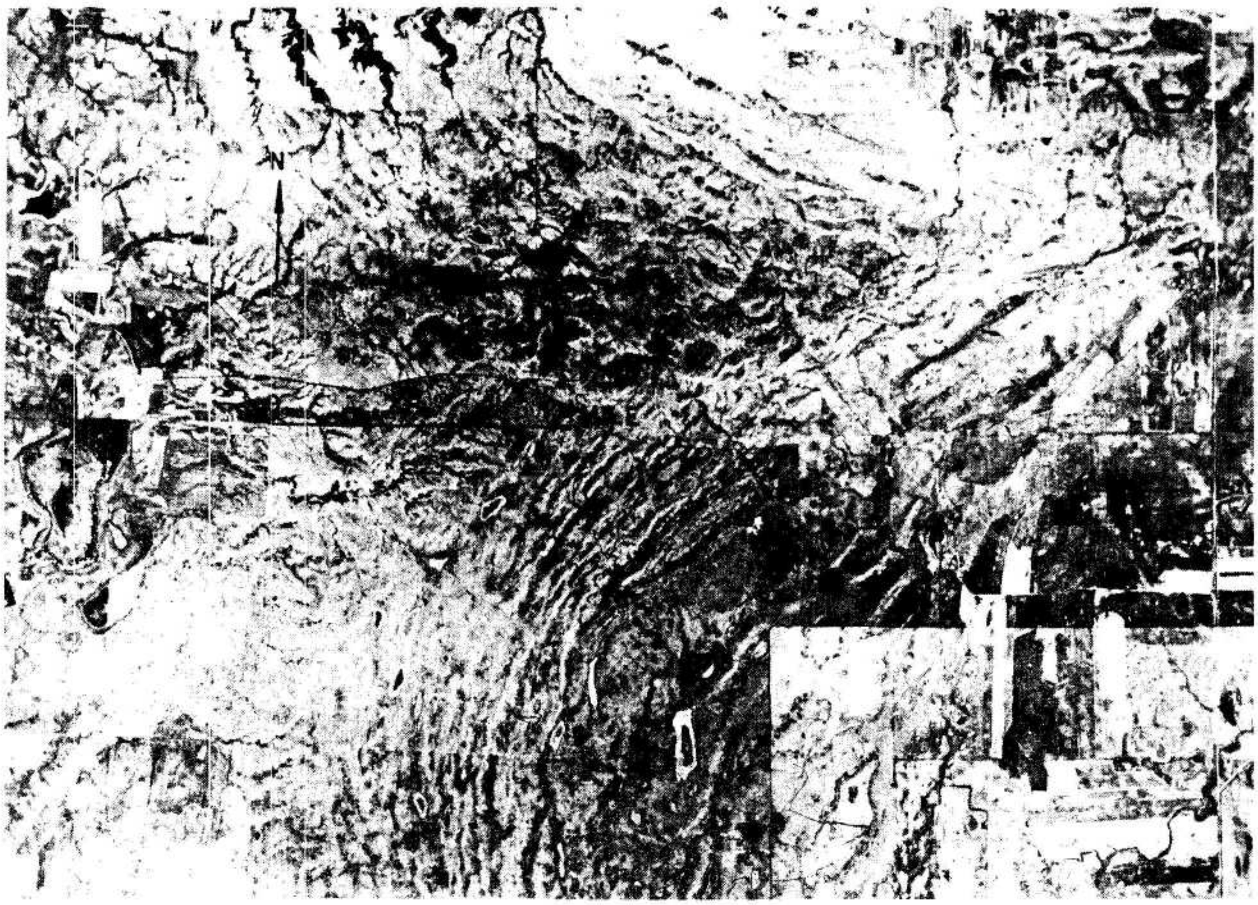


Figure 4.--Aerial view of interlobate moraine.

the south, the interlobate moraine appears as a massive east-west ridge (see fig. 5) which can be traced several miles. One of the higher morainic hills near the center of sec. 13, T. 134 N., R. 68 W., was determined by altimeter to be about 400 feet higher than the ground moraine adjacent on the north. The unusual height and massiveness of the moraine in this area is due to the fact that, in effect, it is a composite of two moraines formed in a reentrant in the ice sheet. It appears possible that the Altamont moraine may have been responsible, in part, for the formation of the reentrant, inasmuch as that moraine formed a barrier impeding the westward advance of the ice. The Gary and Altamont moraines are generally separated by less than 2 miles, and in places they are in actual contact with each other.

The ridges in the interlobate moraine are not as well defined in areal view as are those of sub-lobes "A" and "B". Few of the ridges can be traced for more than half a mile. Rather large areas, as in sec. 14, T. 135 N., R. 69 W., contain no ridges that are apparent on the aerial photographs. These areas have a rugged knob-and-kettle surface which, in places, is rather deeply incised by glacial-meltwater channels.

Glacial-meltwater channels issue from several places along the western edge of the belt of ridged moraine and also from the northern edge of the interlobate moraine. The channels are generally broad and shallow (see fig. 6) and most of them are less than a mile long. Most of the channels examined contain sand and gravel and their floors are approximately at the same elevations as the adjacent outwash deposits.

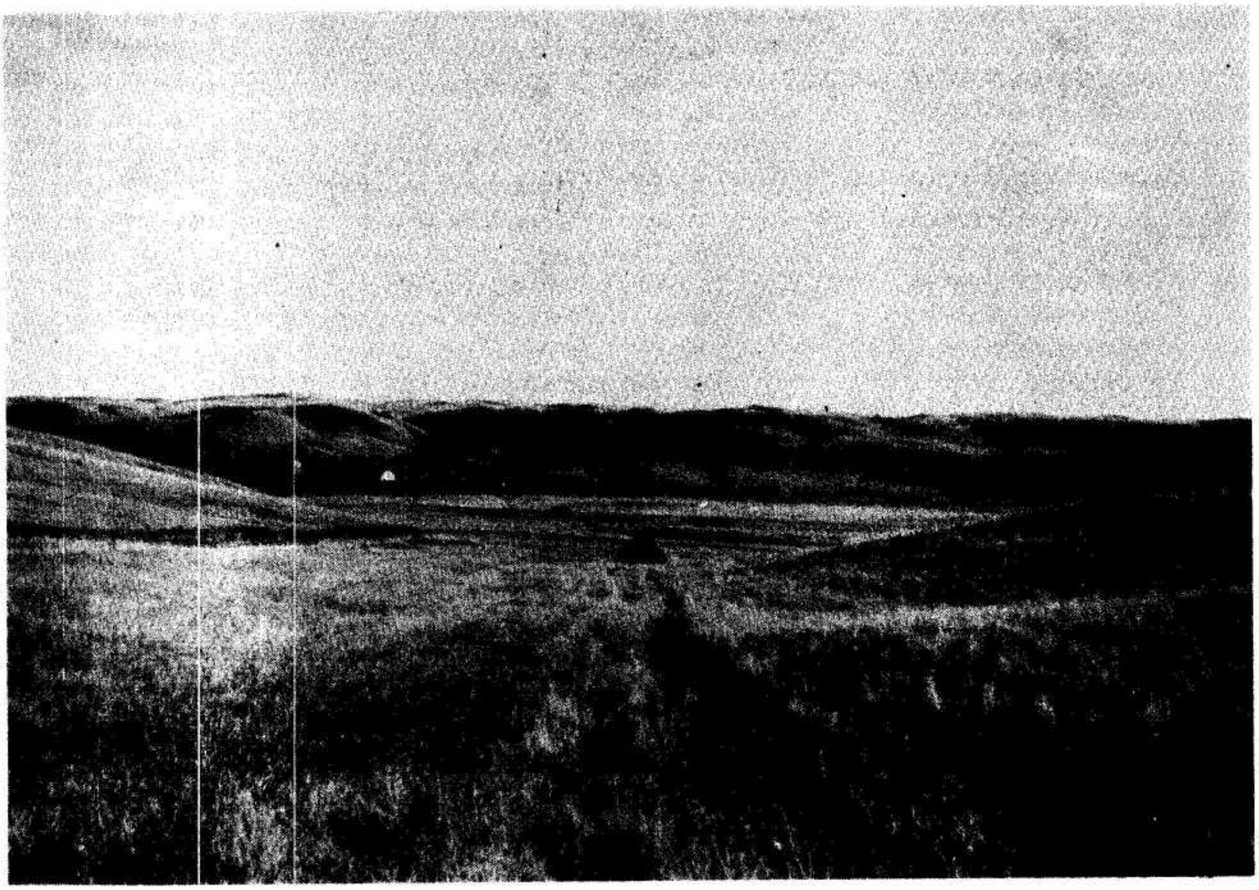


Figure 5.--View of northern edge of interlobate moraine "C", looking south from a point a quarter of a mile south of State Highway 34 in the NE$\frac{1}{4}$ sec. 10, T. 135 N., R. 69 W.

Figure [illegible] [illegible]stern edge of [illegible]ary moraine, looking southeast from a point nea[illegible] [illegible] junction of a meltwater channel and the outwash plain near cente[illegible] [illegible] sec. 15, T. 135 N., R. 69 W.

Thin deposits of Recent alluvium and slope wash probably occur in the meltwater channels and in some of the deeper troughs separating the ridges, but these deposits were not mapped during the present investigation.

At present, stream flow occurs intermittently along most of the meltwater channels. Small intermittent streams occupy some of the deeper and more continuous troughs of the ridged moraine which lie at right angles to the meltwater channels, forming in places a somewhat rectangular drainage pattern.

All the ridges examined are composed of till and their surfaces are strewn with boulders of crystalline rock, limestone, and dolomite. In sec. 18, T. 135 N., R. 68 W., near the end of the apex of the interlobate moraine, the ground surface is especially bouldery. The boulders are heaped up in east-west ridges.

The belt of ridged moraine constitutes a type of end moraine which appears to be unusual in both origin and topographic form. Similar types of end moraine occur in scattered areas in the form of "swell and swale" patterns in Iowa, and as "minor moraines" in Minnesota and South Dakota (Gwynne, 1942, pp. 200-208; Gwynne, 1951, pp. 233-250). They occur in late Wisconsin drift and have been interpreted as annual end moraines caused by the seasonal fluctuations of the margin of the ice sheet. Apparently during the summer months, when the greatest amount of ice wastage occurred, the ice front receded, dropping glacial debris of clay, sand, gravel, and boulders along its margin. During the following winter the ice front readvanced, covering part of the deposits laid down earlier and probably "bulldozing" the ridge formed earlier, accentuating its sharpness. During the succeeding summer, melting again prevailed along the ice margin, causing more till to be deposited, and the process was repeated. Thus, the ridges in sub-lobes "A" and "B", at least, may be annual end moraines deposited for the most part during the summer months but probably accentuated during the winters by the readvance of the ice front.

The area east and north of the belt of ridged end moraine consists mostly of typical knob-and-kettle end moraine similar to that described in the section on the Altamont moraine. Small areas of ground moraine, outwash, and ice-contact deposits are also present. Relief in the knob-and-kettle moraine probably exceeds 100 feet in places.

Outwash Deposits

Outwash sand and gravel flanks the western edge of the Gary moraine along most of its extent in the Streeter area (see fig. 2). The deposits form a broad, comparatively featureless plain or apron (see fig. 7). In the southern part of the area the outwash deposits narrow to a band 2 to 3 miles wide between the Altamont and Gary moraines. The deposits in this area and those in the extreme northern part of the area may be relatively thin and are characterized by a somewhat rolling topography.

Practically everywhere in the area the eastern limits of the outwash are sharply defined by the abrupt slope of the Gary moraine. The western and southern edges are more gradational and are not

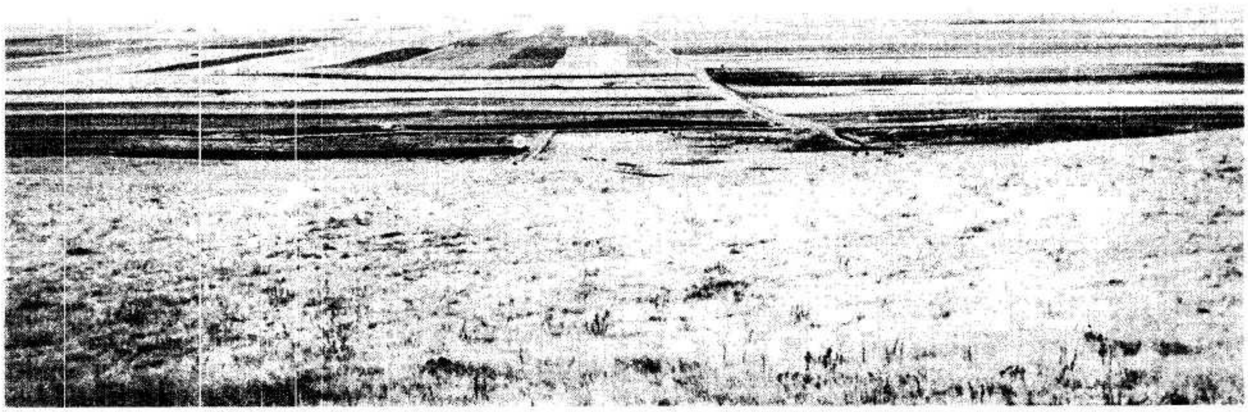


Figure 7.--View of outwash plain, looking west from the Gary moraine in the NE cor. NW¼ sec. 30, T. 136 N., R. 69 W.

easily determined. Because the deposits are bounded on both east and west by morainic hills, the impression is given of a broad, flat valley trending northwest.

Approximately 30 square miles of the Streeter area is underlain by the outwash sand and gravel. The deposits extend west of the area mapped during the present investigation so that its entire extent is not known, although it probably exceeds 50 square miles in total area.

The plain formed by the outwash deposits slopes gently to the northwest. Alkaline Lake, which is several miles west of the Streeter area, receives most of the present-day drainage from the plain. However, very little surface runoff occurs because most of the precipitation in the area is absorbed by the outwash deposits.

Two test holes, USGS tests 307 (136-70-15ddd) and 308 (136-70-22ddd), were drilled in the outwash. The locations of the test holes are shown in figure 2. A geologic section including them is shown in figure 8. USGS test 307 was drilled about a mile southwest of the front edge of the Gary moraine. The thickness of the outwash deposits at this location is 64 feet, and they consist of stratified sand and gravel. USGS test 308 was drilled slightly more than a mile southwest of 307 and penetrated 39 feet of coarse sand and gravel. The logs of the test holes are given on page 63.

In order to illustrate more clearly the nature of the outwash deposits, samples of drill cuttings taken from USGS test 307 were grouped together in 15-foot sections and were photographed to scale. The "photo-log" is shown in figure 9. The deposits range from fine to very coarse sand in the upper 20 feet and grade downward into very

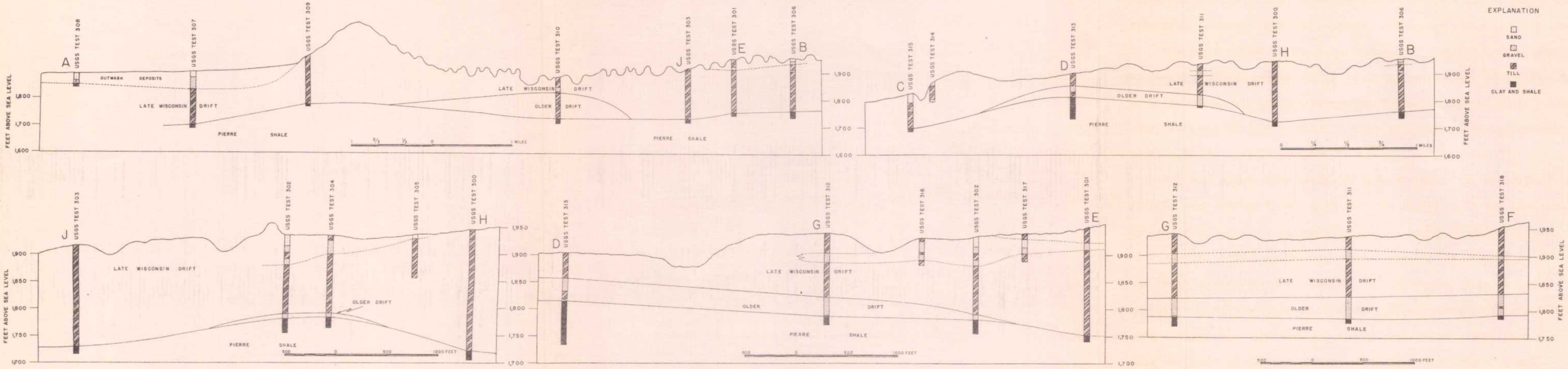


FIGURE 8.-GENERALIZED GEOLOGIC SECTIONS IN THE STREETER AREA.

(LOCATIONS OF SECTIONS SHOWN IN FIGURE 2)

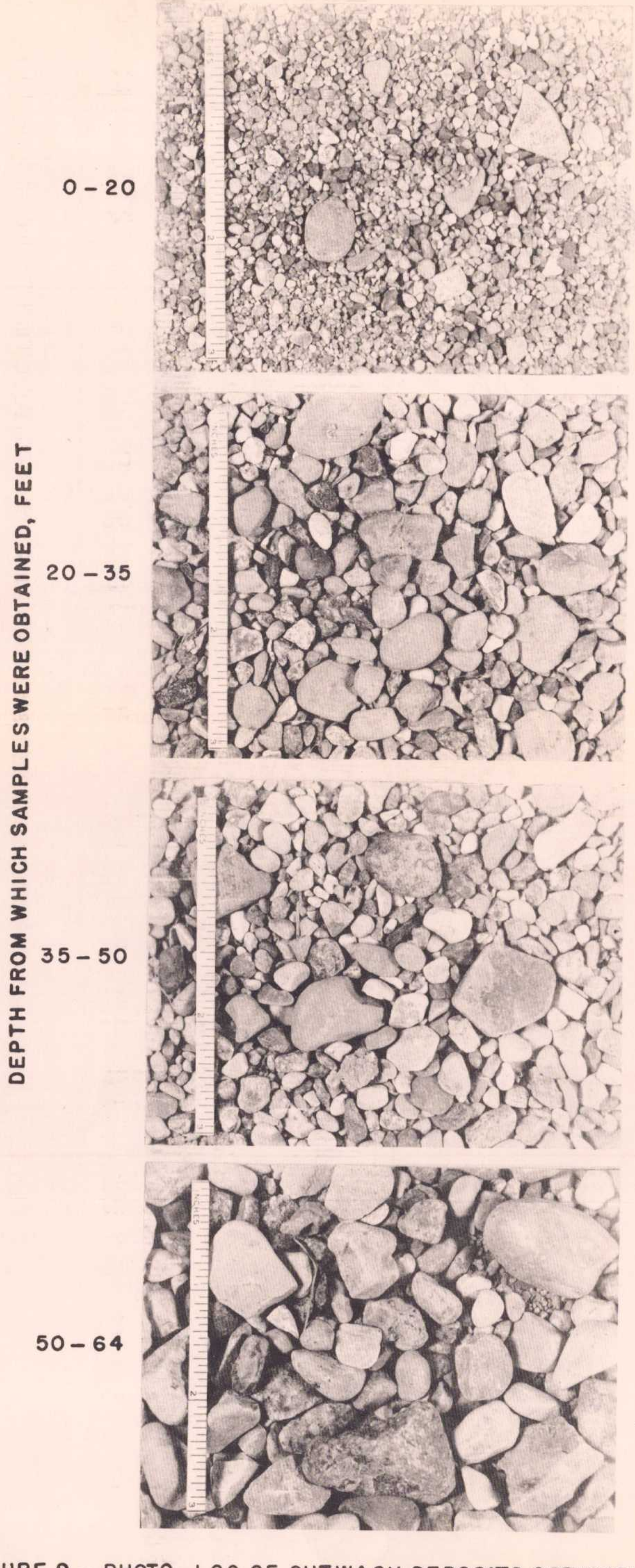


FIGURE 9.- PHOTO - LOG OF OUTWASH DEPOSITS OBTAINED FROM USGS TEST 307 (136-70-15ddd).

coarse gravel and layers of pebbles half an inch to an inch in diameter. The deposits are unusually free of clay and silt, containing less than 1 per cent of these constituents. During the test drilling it became necessary to use several 100-pound sacks of drilling compound in order to thicken the drilling fluid and effectively seal off the coarse sand and gravel.

The outwash deposits were laid down by meltwater streams issuing from various points along the ice front at the time it occupied the position now marked by the Gary moraine and possibly for some time after. The streams furnishing the sediments probably originated some distance back from the ice front. However, only the lower parts of the channels are preserved, as most of the upper reaches were formed in close contact with the glacial ice and consequently were obliterated by meltwater or movement of the ice.

During the initial stages of deposition, the outwash probably was accumulated in alluvial fans at the mouths of the various streams. Most of the debris held in suspension was quickly dropped as the streams lost their velocity on reaching the floor of the outwash. Particularly favorable places for the accumulation of alluvial fans apparently were located at the junctions of the sublobes; one such place is located at the reentrant in the Gary moraine in the NE$\frac{1}{4}$ sec. 22, T. 135 N., R. 69 W. (see figs. 2 and 4). The thickness of the deposits in this alluvial fan is unknown, but the upper 3 feet was determined by means of augering to consist of very coarse sand, pebbles, and cobbles. The surface of the deposits exhibit fossil-current and channel markings which are readily discernible in the aerial photographs.

Apparently, as alluviation progressed, the separate fans, extending outward and laterally, coalesced to form a broad apron or outwash plain whose deposits are thick enough to mask effectively the configuration of the underlying topography over many square miles. The drainage was mostly northwest to the elongate depression in which lie Alkaline and George Lakes. Aerial mosaics of the Alkaline Lake area show a broad channel trending northwest from the northern end of the lake. The channel connects the outwash plain in the Streeter area with a much larger body of outwash to the north and west, on which the villages of Tappen and Dawson are situated. It seems likely that much of the meltwater from the ice sheet escaped via this route and contributed to the Long Lake drainage system, which trends southwestward and is tributary to the Missouri River.

In the southern part of the Streeter area, a part of the Altamont moraine evidently was near enough to the ice front to act as a drainage divide (as well as a barrier to the advance of the ice) causing most of the meltwater from the ice in that part of the area to be diverted toward the southwest. Aerial mosaics of the area southwest of the Streeter area show a well-defined glacial channel trending southwest, which probably is tributary to the Beaver Creek drainage system.

Ground Moraine

Ground moraine occurs only in several relatively small, isolated areas, as shown in figure 2. The ground moraine in the area is similar to the end moraine in both lithology and water-bearing properties. However, its topographic expression is different enough to permit it to be mapped separately.

The ground moraine is generally composed of till and forms long, smooth hills having a gently undulating or "swell and swale" topography.

In the northeast corner of the area the ground moraine is deeply pitted by kettle depressions many of which contain lakes. The kettle depressions are apparently due to the melting of detached blocks of stagnant ice which were subsequently overridden by a readvance of the ice sheet and buried by till. Although there is considerable relief in the area, the topography can be distinguished from that of end moraine by the over all general accordance of the surface and by the relatively gentle slopes of the hills.

Ice-Contact Deposits

Ice-contact deposits form a very small part of the area. They include eskers, kames, and crevasse-fillings. An esker system in secs. 33 and 34, T. 138 N., R. 69 W. (see fig. 2) consists of two ridges about $1\frac{1}{2}$ miles long and shorter adjoining ridges. The ridges are sinuous and narrow (generally less than 200 feet wide at the base) and have the typical steep sides of gravel-bearing ridges. The main ridges trend southwest which, according to the pattern of the end moraine, appears to have been the direction of movement of the last ice sheet. The material in the ridges is mostly gravel and sand interbedded with thin beds of laminated clay and silt, as shown in figure 10. In places, slumping has caused separation and displacement of beds.

Most eskers generally are believed to have been deposited by meltwater streams flowing in tunnels at the base of the ice. The heavily laden streams deposited beds of clay, sand, and gravel, which were left standing as sinuous ridges after melting of the ice and consequent destruction of the tunnel walls.

Kames are steep-sided hills of irregularly stratified sand and gravel. They assume various sizes and shapes but are typically conical. Kames, like eskers, were formed in contact with ice and, consequently, many contain blocks of till and show extreme range in texture and strong deformation of bedding.

An example of a kame is in the NW¼ sec. 10, T. 135 N., R. 70 W. A gravel pit has been opened in it and the sediments are well exposed (see figs. 11 and 12). The sediments are unusually coarse and range in size from very coarse sand to cobble gravel. The beds dip about 30° to the south. At the time the kame was formed it apparently was bounded by ice on the north, and possibly it should be regarded as a frontal kame as defined by Antevs and MacClintock (Rice, 1948, p. 201).

An unusually large kame deposit occurs in sec. 21, T. 136 N., R. 69 W. In plan it is shaped roughly like an inverted L, the legs extending west and south. Each leg consists of an elongated hill

Figure 10.--Section of esker deposits, showing stratification and slumping. Dark thin beds consist of laminated clay and silt. Intervening beds consist of sand and gravel. Note separation of thin beds along fault. SE¼ sec. 33, T. 138 N., R. 69 W.

Figure 11.--Section of kame in Altamont moraine, showing inclined bedding. NW$\frac{1}{4}$ sec. 10, T. 135 N., R. 70 W.

Figure 12.--Close-up view of kame shown in Figure 11, showing degree of sorting.

approximately three-fourths of a mile long and at least 50 feet high. Unconsolidated beds of very clean and well-sorted coarse sand crop out along its flanks. The eastern and northern edges of the feature are rather steep and concave and appear to be ice-contact faces.

A group of gravel-bearing ridges lies in sec. 27, T. 137 N., R. 69 W., and extends into the western part of Streeter. The ridges are generally less than a quarter of a mile long and are about 100 feet wide. They are relatively straight and their tops have a general accordance in level. Most of the ridges have an east-west orientation. The entire field of ridges is less than half a mile wide and is about three-fourths of a mile long. It is possible that the ridges are partly buried by till in places so that their extent may be greater than indicated by their surface expression. This possibility is discussed further in the section on the Shallow aquifer in the late Wisconsin drift.

Apparently these ridges are ice-contact features and, because of their short lengths and their general accordance of level, should be regarded as crevasse fillings. Crevasse fillings generally are believed to be deposits made by streams flowing in open-topped crevasses developed along the margins of ice sheets where the ice had become relatively thin and stagnant.

Most of the ice-contact deposits in the area are being exploited for road-building materials. The locations of the gravel pits are shown in figure 2.

Older Drift

Buried gravel and gravelly till, resting directly on the bedrock and believed to be the remnants of a drift older than late Wisconsin, was penetrated by most of the test holes drilled west of Streeter and in one test hole, USGS test 310 (137-69-33ddd), drilled southwest of Streeter. The relation of the older drift to the other formations in the area is shown in the geologic sections in figure 8.

The older drift, where penetrated by test holes, ranges in thickness from 7 to 91 feet. The thinnest section of the older drift was penetrated in USGS test 304 (137-69-26bcb) in Streeter; it thickens to the west and southwest. However, several test holes drilled a considerable distance west and southwest of Streeter did not penetrate the older drift above bedrock.

Very coarse sand and gravel are the chief constituents of the older drift. The deposits are rather difficult to drill through and drillers report them as "cemented gravel." A small amount of tan and white clay is present in most of the deposits. It is probable that the older drift is composed largely of a very stony till containing small amounts of clay, or it may be composed of layers of relatively clean gravel separated by thin beds of clay.

It seems likely that the upper part and, in some places, possibly the entire thickness of the older drift is extensively weathered. Tan and white clay, which generally indicates rock weathering, is present throughout most of the deposits. Some of the clay has patches of red or green representing weathered fragments of rock.

The rock fragments are mainly igneous or metamorphic, in contrast to the shale and limestone detritus typical of the late Wisconsin drift.

In USGS test 313 (137-69-28abb) numerous black, partly carbonized pieces of wood and other plant remains were encountered at a depth of 71 feet below the land surface. They may indicate the presence of a fossil-soil zone at the top of the older drift in that locality.

The Pleistocene stratigraphy of North Dakota is not well known at present. Glacial-drift sheets older than late Wisconsin have been reported in various localities within the State, but their widely scattered occurrence and questionable relationships to contiguous deposits make correlations uncertain. However, because of the extensive weathered zone developed in the upper part of the older drift in the Streeter area and because of its position directly above the bedrock, it perhaps should be regarded as being of pre-Wisconsin age.

Bedrock Formations

In all the test holes that were drilled to the bedrock, the glacial drift was underlain by the Pierre shale of Late Cretaceous age. However, in the extreme western part of the area the Fox Hills sandstone, also of Late Cretaceous age, may overlie the Pierre shale and form the bedrock. A sandstone having characteristics similar to those of the Fox Hills sandstone crops out in the NE$\frac{1}{4}$ sec. 5, T. 137 N., R. 70 W., about 2 miles west of the Streeter area. Possibly several wells in the western part of the area obtain water from this sandstone bedrock.

The Pierre shale is predominantly a bluish-gray shale, but it may contain beds of fine sand and sandy clay. Some of the shale contains glauconite. In some of the test holes a layer of tan sandy clay streaked with limonite, ranging in thickness from 7 to 27 feet, occurs at the top of the Pierre shale. The tan clay may represent the weathered preglacial surface of the shale or it may be the remnant of a younger formation overlying the shale.

The total thickness of the Pierre shale in the Streeter area is not known, inasmuch as the test holes were drilled only to the top of the shale or for a short distance into it. Data obtained from records of oil and gas explorations in nearby areas (Laird, 1941, pp. 22-23), indicate a thickness in excess of 1,000 feet in the Streeter area.

The Pierre shale is underlain by the Niobrara formation and Benton shale. These in turn are underlain by a sandstone-shale sequence collectively known as the Dakota sandstone. The Dakota sandstone is an important aquifer in North Dakota in areas east of the longitude of the Streeter area. According to Ballard's structural map (Ballard, 1942, p. 1568) the top of the Dakota sandstone should be about 2,000 feet below the land surface in the Streeter area.

Deep well records (Towse, 1952 p. 6) indicate that in the Streeter area the Dakota sandstone is underlain by formations of Jurassic, Mississippian, Devonian, Silurian, and Ordovician age. The entire section of sed' entary rocks probably has a thickness of more than 4,000 feet and lies directly on pre-Cambrian crystalline rocks.

The age of the older drift is not definitely known, but because of the extensive weathered zone developed on its surface, it is thought to be pre-Wisconsin. In USGS test 313 (see log, p. 66) a fossilized soil zone containing carbonized bits of stems and wood was encountered on top of the older drift. The weathered zone and fossil soil represent a relatively long period of time during which the glacier must have receded from the area to a position some distance to the north, or perhaps was dissipated completely.

Apparently, climatic changes again caused a glacier to move across the area, depositing the upper drift. The upper drift, which is bluish gray and more clayey than the lower, was deposited during late Wisconsin time. It is not known whether the area has been subjected to only two stages of glaciation or whether there were others, the deposits of which were removed by erosion before or during the last glaciation. A great deal more subsurface information is needed for a full understanding of the glacial history of the Streeter area and the rest of North Dakota.

The glacial deposits in the Streeter area are primarily the results of the last glaciation. Geologically speaking, the interval since the last glaciation has been so brief that the processes of erosion have had little effect on the topography of the area.

During the early part of the late Wisconsin time, glacial ice covered the Streeter area probably to great thickness. At the time of maximum extent, the glacier front was west and southwest of the area but may have been within 10 miles. While it was at that position, a great, massive end moraine was deposited along most of the glacier's periphery, extending in a southeasterly direction through North Dakota. This outermost system of end moraines, which is known as the Altamont, probably marks the farthest extent of the late Wisconsin ice sheet in North Dakota. Apparently the ice front retreated very slowly from this position, as is evidenced by the great width of the end moraine in many places.

It is not known how far the ice front retreated before a reactivation of the ice sheet caused the deposition of the second or Gary moraine. The ice front may have retreated only as far as the position of the Gary moraine or it may have retreated far enough to leave the Streeter area free of active ice. At any rate, the position of another culmination of the ice sheet is marked by the Gary moraine. At that time the ice front extended southeast across the lower two-thirds of the Streeter area.

The ice front was in the form of several sub-lobes, as shown by the lobate shape of the Gary moraine. During the early stages of formation of the moraine, the junctions of the sub-lobes may have been favorable locations for glacial streams. Although there are no well-defined stream channels at these locations at present, there are general trains of depressions and sags, some of which contain elongate lakes, extending through the moraine at these points.

The unusual character of the outer portion of the Gary moraine in the Streeter area indicates a remarkably delicate balance between expansion and shrinkage of the ice sheet at the time of formation of that part of the moraine. Seasonal changes in weather may have been the cause of the apparent rhythmic cycles of morainic deposition which, in turn, caused the formation of a series of near-parallel morainic ridges separated by narrow troughs. The ridges may be annual end moraines deposited mostly during the summer when shrinkage occurred along the margins of the glacier. The separating troughs represent the intervening winter periods of reduced-deposition when the glacier evidently renewed its forward movement and partly ridged and partly covered the preceding summer's deposit.

If such an interpretation is correct, the rate of retreat of the glacier front at the time of formation of the ridges may be determined by counting the number of ridges or annual moraines that occur in a unit length, say in a mile. About 10 ridges occur per mile of length, indicating a rate of retreat of about 1 mile in 10 years.

The bulk of the outwash was deposited contemporaneously with (and probably, also, for some time after) the formation of the Gary moraine. Glacier-fed streams issued from between the sub-lobes and from numerous other places along the glacial front. Although most of the streams probably were short-lived, a large amount of meltwater and glacial debris was discharged, and broad, deep channels were incised through the end moraine in numerous places. In some of the channels, outwash deposits extend for some distance upstream from the channel mouths indicating that the streams were depositing part of their loads before leaving the moraine. Individual alluvial fans were probably built at the mouths of the glacial streams and, as they were extended out and laterally, they coalesced, forming a broad, flat apron or outwash plain.

Evidently the complete withdrawal of the ice front from the Streeter area was accomplished very slowly. Numerous kettle depressions in the end-moraine and ground-moraine areas indicate that large masses of marginal ice became detached and stagnant and were overridden by live ice during minor readvances of the ice sheet. Upon the melting of these stagnant masses of ice, the cover of glacial drift deposited during the readvance of the ice sheet slumped and caved in, forming kettle-like depressions.

OCCURRENCE OF GROUND WATER

Principles

Essentially all ground water of economic importance is derived from precipitation. The water may enter the ground by direct penetration of rain or melted snow, or surface water from streams may enter the ground by downward or lateral percolation if the water level in the stream is higher than the ground-water level.

Practically all ground water is moving through the ground from a place of intake or recharge to a place of disposal or discharge. The rate of movement may vary considerably from one area to another but velocities of a few tens to a few hundreds of feet a year probably are most common under natural conditions.

Discharge of the ground water may occur by direct evaporation from the soil surface or from lakes and ponds, by transpiration of plants in areas where the ground-water level is near the surface, and by seepage to streams. In some places where the physical situation is suitable, water may discharge from one ground-water reservoir to another by slow percolation through the separating formations.

Any rock formation or stratum that will yield water in sufficient quantity to be of importance as a source of supply is called an "aquifer" (Meinzer, 1923, p. 52). The water moving in an aquifer from recharge areas to discharge areas may be thought of as being in "transient storage" in the ground. The amount of water that can be thus stored in an aquifer is dependent upon the porosity of the material composing the aquifer and upon the dimensions of the aquifer as a whole.

The unconsolidated rocks such as clay, sand, and gravel are generally more porous than consolidated rocks such as sandstone and limestone and, therefore, generally are more important as ground-water reservoirs. In some areas, however, the consolidated rocks are highly porous and permeable and function as important reservoirs.

The capacity of a rock to yield water by gravity drainage may be much less than would be indicated by its porosity, because part of the water is held in the pore spaces by molecular attraction between the water and the rock; the smaller the pore, the greater the proportion of water thus held. The amount of water, expressed as a fraction of a cubic foot, that will drain by gravity from 1 cubic foot of the saturated rock material is called its "specific yield."

If the water in an aquifer is not confined by impervious strata above, the water is said to occur under water-table conditions. In this case, water may be obtained from storage in the aquifer by causing a lowering of the water level, as in the vicinity of a pumping well, which results in gravity drainage.

If water is confined in the aquifer by an overlying impermeable stratum, however, so that the water in a well or other conduit penetrating the aquifer rises above the top of the aquifer under hydrostatic pressure, the water is said to occur under artesian conditions. In this case, water is yielded as the water level in the well is lowered, but the aquifer remains saturated and the water is yielded because of its own expansion and of the compression of the aquifer due to lowered pressure, rather than by gravity drainage. The water-yielding capacity is called the "coefficient of storage" and is generally very much smaller than the specific yield of the same material when drained by gravity. The coefficient of storage is defined as the amount of water, expressed as a fraction of a cubic foot, that will be released from storage in each vertical column of the aquifer having a base 1 foot square when the water level falls 1 foot.

If the pore spaces are large and interconnected, as they commonly are in sand and gravel, the water is transmitted more or less freely and the rock is said to be permeable, but if the pore spaces are very small or not connected, as they are in clay, the water is transmitted very slowly or not at all, and the rock is said to be impermeable.

<u>Shallow Aquifer in the Late Wisconsin Drift at Streeter</u>

Before the test drilling was begun, considerable evidence was available to indicate the existence of a shallow sand and gravel aquifer, associated with the late Wisconsin drift, underlying the village of Streeter and extending into adjacent areas. A large number of shallow wells throughout the village and in the area west of the village tap this aquifer.

Test drilling was begun in the village for the purpose of determining the thickness and extent of the aquifer and to obtain information concerning the nature of the water-bearing materials. Consequently, some of the test holes in this area were drilled only to the bottom of the shallow aquifer or a short distance below it. The locations of test holes drilled in Streeter are shown in figure 13.

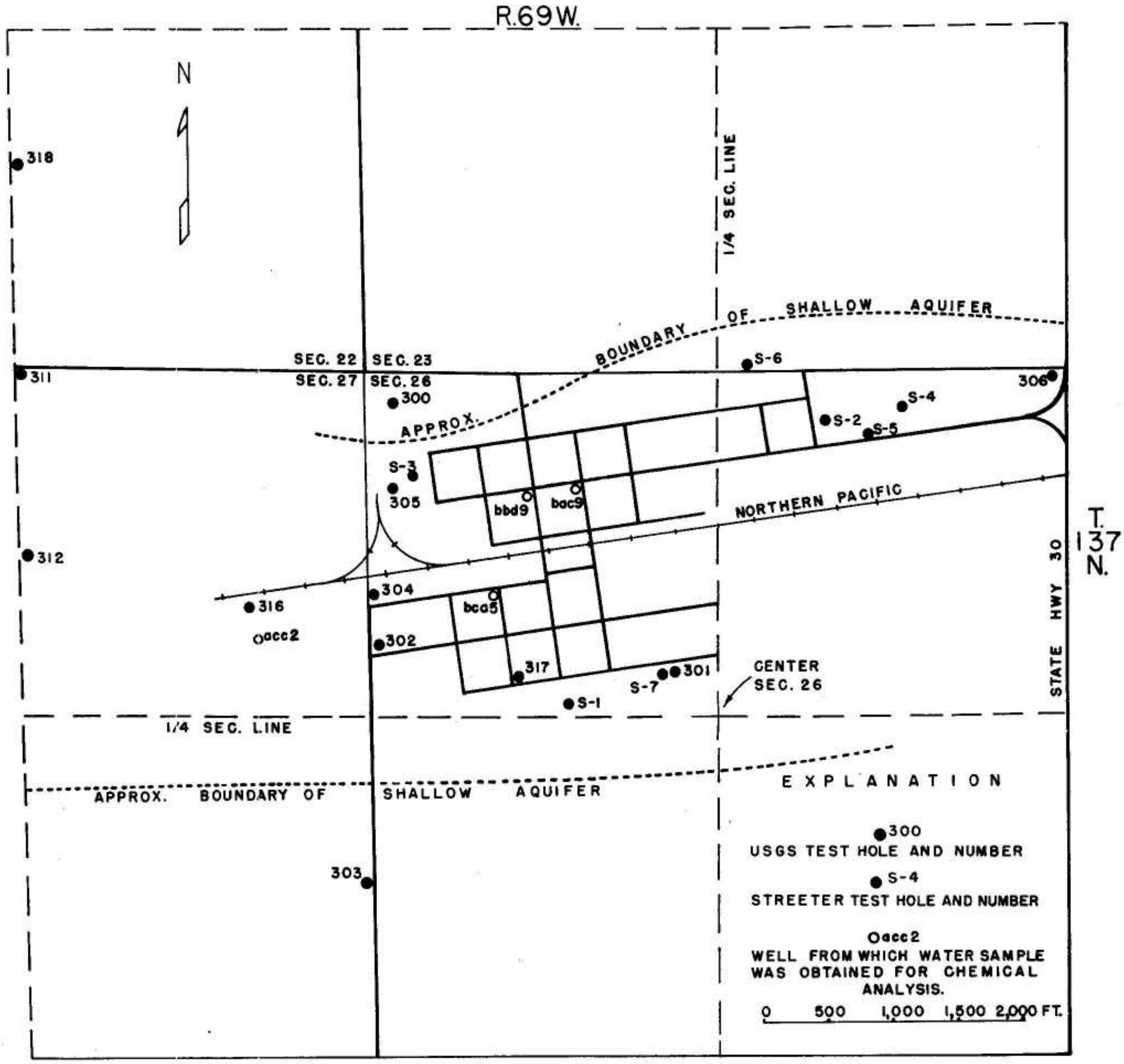


FIGURE 13.- SKETCH MAP OF STREETER SHOWING LOCATIONS OF TEST HOLES AND WELLS SAMPLED FOR CHEMICAL ANALYSIS.

Sand or gravel was found at shallow depths in all the test holes drilled in the village except one. The one test hole that did not penetrate the aquifer was USGS test 300 (137-69-26bbb2). Sand and gravel, probably part of the same aquifer, was also penetrated in several test holes drilled about half a mile west of the village. The thickness of the sand and gravel, as determined from test drilling, ranges from 9 feet at USGS test 305 (137-69-26bbc4) to 43 feet at USGS test 302 (137-69-26bcb), which is about 1,000 feet south of USGS test 305. Till was penetrated from 32 to 44 feet in USGS test 302, but gravel was again encountered from 44 to 55 feet.

Available information indicates that the aquifer may be linear in ground plan. USGS test 300 (137-69-26bbb), in the northwest corner of the village, and USGS test 303 (137-69-27dda), about three-tenths of a mile south of the village, did not penetrate any sand or gravel. However, the aquifer occurs fairly consistently within the boundaries of the village and, as indicated by the test drilling, for at least half a mile west. The results of the test drilling suggest a linear body of sand and gravel about half a mile wide and $1\frac{1}{2}$ miles or more long. The long axis is oriented in an east-west direction. A sectional view of the aquifer is shown in figure 8.

The material of the aquifer ranges in texture from coarse sand to very coarse gravel and pebbles. The coarser material generally occurs near the bottom. Most of the sand and gravel is comparatively free of clay and silt.

The origin of the shallow aquifer is not entirely clear.

There seems to be a relation between the shallow sand and gravel beneath the village and the gravel-bearing ridges west of the village. However, the presence of till interbedded with the sand and gravel in some places and the presence of a till cover 10 feet or more in thickness in other places suggest a somewhat complex origin. The gravel ridges west of the village have been interpreted as a series of crevasse-fillings, and it is possible that the shallow sand and gravel beneath the village is an eastward extension of those deposits. The till cover that overlies the aquifer in some places, may have been deposited during a readvance of the ice from the east or northeast. It is also possible, however, that the lower part of the shallow sand and gravel represents a small body of outwash which antedates the ice-contact features.

The aquifer is situated favorably for recharge because it is exposed at the surface in several places. The most extensive outcrops are along the western edge of Streeter in the vicinity of USGS test 302 (137-69-26bcb) and in the area of gravel ridges west of Streeter (assuming that the gravel ridges are connected with the aquifer). During the late spring months a large part of the water from rainfall and melted snow penetrates the ground in the outcrop areas and, moving downward and laterally, contributes to the ground-water storage in the aquifer. As a result, the water levels in the shallow wells throughout the village rise noticeably at that time. Heavy rains during the summer and early fall months also contribute water to the aquifer but not in as great amount because more of the water is evaporated or transpired by vegetation and so does not reach the water table. Rains in the late fall may contribute rather large amounts of water to the aquifer, as evaporation and transpiration rates have declined by that time of the year. Little or no recharge normally occurs during the winter, inasmuch as practically all the precipitation is in the form of snow, which does not melt until the spring thaw.

Although the shallow aquifer may be quite small in area, it is thick enough in some places to indicate that a considerable amount of ground water is in transient storage in it. However, because of the extreme variation in thickness of the sand and gravel within the small area involved, only a very rough approximation of the amount in storage can be made.

The aquifer is estimated to cover an area of about three-fourths of a square mile and the average saturated thickness probably is about 15 feet. For water-bearing materials such as coarse sand and gravel, the specific yield, or the amount of water that would be yielded through gravity drainage of the aquifer, generally ranges from 20 to 40 percent of the volume of the aquifer. If a conservative estimate of 20 percent is made for the specific yield at Streeter, the amount of water in transient storage in the aquifer would amount to about 500 million gallons. If used at a rate of about 65,000 gallons a day, this amount of water would not be entirely used up over a period of 20 years. On the other hand, not all the water in transient storage could be economically withdrawn for use by wells, and the natural discharge of the stored water to springs and ponds west of Streeter would continue to some extent.

Recharge to the aquifer, however, would occur annually so that the amount taken from storage would be replenished to some extent each year. No quantitative information is available concerning the amount of recharge that the aquifer receives each year. Residents in the village report that the water levels in the wells are several feet higher in the late spring than in the fall of the year. It would be necessary to obtain accurate periodic measurements in selected wells over a period of years, as well as information on the specific yield and other data, to determine the amount of replenishment to be expected annually.

The ground-water flow is to the west and southwest in the direction of the surface drainage. The actual slope of the water table is not known but indications are that it may be as much as 20 feet per mile.

That part of the water in the shallow aquifer which has not been intercepted by wells discharges into the low area of ponds and marshes just west of the village. Springs occur at the bases of some of the gravel ridges and hills which extend through the area in an east-west direction. Residents of the area report that the ponds and marshy areas have never completely dried up. The spring water is used by several families for domestic purposes and has been used extensively by the Northern Pacific Railway for boiler pumps during the period when stean locomotives were in use.

Aquifer in the Outwash Deposits

The large body of sand and gravel constituting the outwash deposits in the southwestern part of the Streeter area contains an extensive aquifer of considerable thickness. All existing wells in the outwash deposits were reported adequate, in both quantity and quality of the water, for farm purposes.

Most of the wells in the outwash area are shallow and the usual methods of obtaining water from shallow, unconsolidated water-bearing deposits are used. Dug wells are the most common, although bored wells and driven wells with sand points also are in use.

The outwash deposits in the Streeter area cover an area of about 30 square miles. With the exception of the data from the logs os USGS test 307 and 308, which completely penetrated the outwash deposits, there is very little information concerning the thickness of the deposits. In view of the thicknesses of 64 feet in USGS test 307, and 39 feet in USGS test 308, perhaps a minimum average thickness of 30 feet of sand and gravel may be safely assumed for the entire area. Of this thickness an average of about 20 feet probably would be saturated. If the deposits penetrated in USGS test 307 (see fig. 9) are fairly representative of the texture of the deposits over much of the area, then a specific yield of at least 20 percent probably is conservative. Using the above figures, it is estimated that there is at least 75,000 acre-feet of water (one acre-foot equals approximately 326,000 gallons) in transient storage in the outwash deposits.

Recharge to the aquifer in the outwash deposits is accomplished by direct penetration of rain and snow melt. Owing to the very sandy texture of the soil, not much of the precipitation would be expected to be lost through evaporation. However, a part of the precipitation and meltwater will not contribute to the recharge because of losses by transpiration.

The outwash area appears to be potentially irrigable through the use of ground water. Inasmuch as the area is relatively flat and slopes gently to the west, it probably would require very little surface modification to make it suitable for irrigation. The soil and underlying deposits of sand and gravel are loose-textured and would permit excellent subsurface drainage, so that there would be small danger of water logging.

Little quantitative information is available at the present concerning the permeability of the outwash materials.

Aquifers in the Older Drift

Gravel associated with the older drift was penetrated by most of the test holes drilled west of the village. The thickest sections of this material were encountered half a mile west of Streeter in USGS tests 311, 312, and 318. The thickness of the gravel in the three test holes ranges from 33 to 41 feet (see fig. 8, section G-F).

It is not definitely known that any wells in the Streeter area now obtain water from the older drift deposits. The deposits are either very thin or are altogether absent beneath the village itself.

However, it is reported that a number of wells west of Streeter obtain water from a brown sand below blue clay at depths ranging from 60 to 140 feet. Although it seems likely that these wells probably end in older drift, there is a possibility that the material may represent a bedrock formation, possibly the Fox Hills sandstone.

Because the gravel and very coarse sand belonging to the older drift apparently is cemented in some places, the drilling characteristics are similar to those of a coarse sandstone or conglomerate.

Two farm wells, 137-69-20aab and 137-69-20cac, that possibly end in the older drift are reported to flow 2 and 3 gallons a minute, respectively. Well 137-69-20cac was sampled for chemical analysis and the results are given on page 50.

Aquifers in the Pierre Shale

The Pierre shale yields water in small amounts to a fairly large number of wells in the area. Most of the wells are in the northern part of the area and range in depth from 180 to 400 feet. The water-bearing beds are generally reported as "slate" or "soapstone."

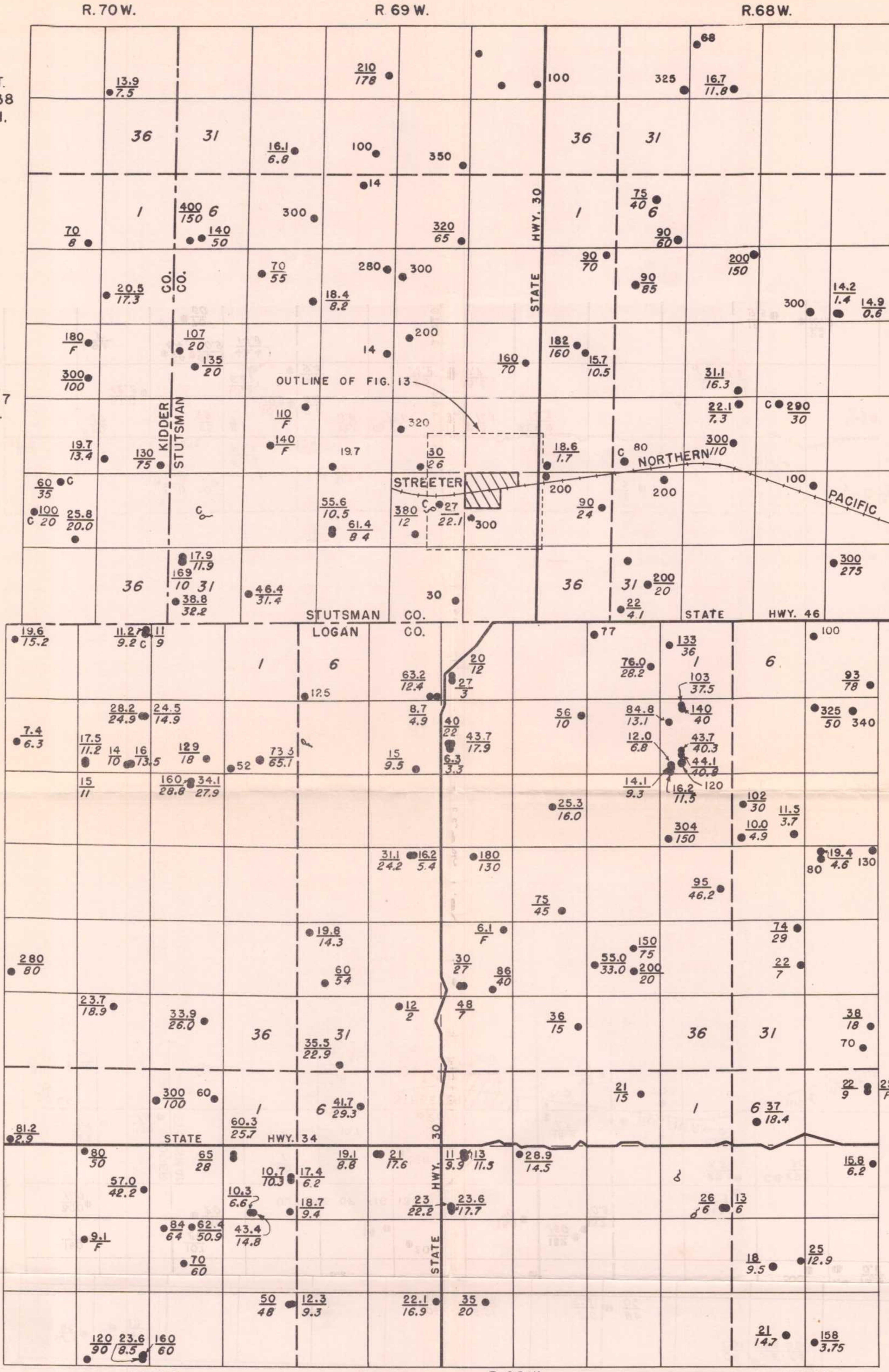
The sediments that make up the Pierre shale are generally very fine grained, consisting mostly of blue clay and shale which, upon penetration by wells, will yield small amounts of water, rarely in excess of 5 or 10 gallons a minute. This amount, although generally adequate for ordinary farm and domestic uses, would be insufficient for larger-scale uses.

Four wells obtaining water from the Pierre shale were sampled for chemical analysis. The analyses are listed in the table of chemical analyses and are discussed in the section on Quality of the ground water.

Other Bedrock Aquifers

If, as suggested previously in the section dealing with bedrock formations, the Fox Hills sandstone overlies the Pierre shale in the extreme western part of the Streeter area, it may be a source of water for some of the farm wells in that part of the area. However, available well information concerning the source of water for most of the deep wells is usually indefinite, and additional test drilling probably would be necessary in order to ascertain whether the Fox Hills sandstone is present in the area.

Of the formations that underlie the Pierre shale, probably only the Dakota sandstone would be of interest as a possible source of water. The Dakota sandstone probably underlies the Streeter area at a depth of approximately 2,000 feet. It becomes progressively deeper toward the west because of the regional dip of the bedrock formations in that direction. Flowing wells probably could not be obtained from it in the Streeter area. In other areas in the State, the water from most wells in the Dakota sandstone is so highly mineralized as to make it undesirable for most domestic and industrial uses.



EXPLANATION

C 22.1/16.9

EXISTING WELL. UPPER NUMBER (22.1) INDICATES DEPTH OF WELL. LOWER NUMBER *(16.9)* INDICATES DEPTH TO WATER. LETTER "F" INDICATES FLOWING WELL. LETTER "C" INDICATES WELL FROM WHICH WATER SAMPLE WAS OBTAINED FOR CHEMICAL ANALYSIS.

SPRING. LETTER "C" INDICATES SPRING FROM WHICH WATER SAMPLE WAS OBTAINED FOR CHEMICAL ANALYSIS.

0 1 2 3 4 MILES

FIGURE 14.— MAP SHOWING LOCATIONS OF WELLS AND SPRINGS, DEPTHS OF WELLS, AND DEPTHS TO WATER IN WELLS IN THE STREETER AREA.

(SEE FIGURE 13 FOR LOCATIONS OF KEY WELLS AND TEST HOLES IN STREETER)

QUALITY OF THE GROUND WATER

In order that the reader may more easily understand the significance of the chemical analyses given on page 50 of this report, the following partial list of chemical standards, promulgated by the U. S. Public Health Service for water used by interstate carriers, is given:

Chemical Constituent	Maximum concentration permitted (parts per million)
Dissolved solids	500 (1,000 permitted if necessary)
Chloride (Cl)	250
Sulfate (SO_4)	250
Magnesium (Mg)	125
Fluoride (F)	1.5
Iron (Fe) and Manganese (Mn) together	0.3

The presence of nitrate in ground water may indicate organic contamination. Also, water containing more than about 45 parts per million of nitrate (as NO_3), as listed in the table of chemical analyses should not be used for feeding infants, because of the danger of infant cyanosis (Comly, 1945, pp. 112-116; Silverman, 1949, pp. 94-97).

The presence of fluoride in drinking water in excess of 1.5 parts per million may cause mottling of the enamel of the teeth in growing children, but fluoride in lesser concentrations may benefit the teeth in the formative stage by reducing decay.

Eleven samples of water from wells in the area were analyzed for chemical content by the North Dakota Department of Health.

The locations of the wells are shown in figures 13 and 14.

The shallow aquifer in the late Wisconsin drift in and near Streeter generally yields water that contains large amounts of dissolved solids and is very hard. Nitrate is excessively high, especially in that part of the aquifer beneath the more heavily populated part of the village. Among five water samples collected from the shallow aquifer, dissolved solids ranged from 330 to 3,600 parts per million and averaged about 1,660 parts per million. Total hardness ranged from 180 to 1,140 parts per million and averaged 720 parts per million.

Samples from two wells (136-70-3aaa and 136-70-9cba) in the outwash deposits contained 760 and 320 parts per million of dissolved solids, respectively. The total hardness expressed as calcium carbonate was 420 and 240 parts per million, respectively, which is rather high for domestic purposes. The water may be satisfactory for irrigation and certain other uses, however.

Analyses were made for two wells tapping an aquifer that probably is either cemented coarse sand in the older drift or sandstone overlying the Pierre shale, possibly the Fox Hills sandstone. Samples from the two wells (137-70-26aab and 137-70-26cba) contained 540 and 430 parts per million of dissolved solids, respectively. The total hardness, 250 and 200 parts per million, respectively, is generally lower than in any other waters analyzed from the area but is still rather high. Other distinctive characteristics of the water are the minute quantities of sulfate and a fluoride content slightly more than from other sources, although none of the samples contained more than 0.5 part per million of fluoride.

The Pierre shale, as it occurs in the Streeter area, yields water that is rather highly mineralized and hard, though generally softer than the water in the glacial drift, with the possible exception of the water in the older drift. Samples from wells 137-68-19ccd, 137-68-21bab, 137-69-26cbb, and 137-70-14aad contained 1,480, 1,780, 1,180, and 1,160 parts per million of dissolved solids, respectively. Total hardness in the four samples was 340, 100, 320, and 310 parts per million, respectively. The samples contained large amounts of sulfate and iron.

CHEMICAL ANALYSES OF GROUND
(Parts Per Million;
(Analyses by North Dakota State

Location number	Owner	Date of analysis	Depth of well (feet)	Aquifer
136-70-3aaa	A. Kirschenmann	12-29-50	11	Late Wisconsin outwash
136-70-9cba	Art Dewald	3-16-51	7.4	........do............
137-68-19ccd	Edwin Fischer	2-17-50	80?	Pierre shale
137-68-21bab	Walter Fischer	12-27-50	290	........do............
137-69-26bac9	Rev. F. Alf	11-21-49	25	Shallow aquifer in late Wisconsin drift
137-69-26bbd9	Streeter Hotel	12-29-50	20	........do............
137-69-26bca5	Fred Miller	12-29-50	22	........do............
137-69-27aac2	Edward Deutcher	12-15-50	Spring	........do............
137-69-30caa	Fred Schultes	12-29-50	Spring	........do............
137-70-26abb	Emil Wieland	12-29-50	60	Older drift (?)
137-70-26cba	W. and A. Schwartzwalter	12-29-50	100	........do............

WATERS IN THE STREETER AREA
Abbreviation: T, trace)
Department of Health, Bismarck, N. Dak.)

Dissolved solids	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Fluoride (F)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Percent sodium
760	–	86	51	46	–	25	160	T	47	350	420	19
320	0.20	23	45	T	.10	–	190	T	30	33	240	–
1,480	1.7	88	28	312	–	–	380	630	36	2.1	340	67
1,780	1.3	23	10	530	–	45	580	240	340	8.6	100	91
3,600	.35	180	150	690	–	–	570	1,340	280	390	1,070	58
2,230	–	120	200	250	–	24	270	1,110	210	43	1,140	32
1,380	–	60	120	140	–	17	340	590	47	56	650	31
750	1.2	82	85	17	–	–	170	360	40	T	560	6
330	.36	40	17	21	–	–	250	T	5.6	–	180	21
540	.20	51	31	50	.50	9	310	T	24	65	250	30
430	.55	28	31	43	.35	21	300	T	5.2	–	200	32

Depth of well: Measurements given to hundredths or tenths are measured well depths. Those given in whole numbers only are reported.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
135-68				
5adb1	Charlie Dorr	22	36 by 36	Dug
5adb2	......do......	25	24	Bored
6cab	Jacob Veil, Jr.	37	18	..do...
8adb	Richard Presler	15.8	42	Dug
18caa	A. Forsty	18	36	..do...
18daa	W Kinzler	25	24	Bored
19dbb	Jake Batch	21	30	..do...
20ccc	John Dorr	158	4	..do...
135-69				
2aca	Rudolf Dorr	21	...	Dug
6add	Gerhart Deutscher	41.7	32	..do...
8bbb1	F. C. Kettarling	19.1	32	..do...
8bbb2	......do.........	21	32	..do...
9bab1	Ervin Becker	11	48 by 48	..do...
9bab2	......do.........	13	24	..do...
9ccc1	Ben Miller	23.6	24	..do...
9ccc2	......do.........	23	48 by 48	..do...
10bbb	Walvin Diede	28.9	24	Bored
12bcd	Peter Miller, Jr.	Spring	...	....
12cdd	Joe P. Miller	Spring	...	....
12ddd1	......do.........	26	30	Bored
12ddd2	......do.........	13	36	Dug
20aaa	H. E. Schenk	22.1	62 by 62	Dug
21abb	William Diede, Jr.	35	32	..do...

HOLES IN THE STREETER AREA

Depth to water: Measurements given to hundredths or tenths are measured water levels. Those given in whole numbers only are reported.

Use of water: D, domestic; S, stock; T, test hole U, unused.

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
....	9	8-11-49	D	Adequate.
1945	Flow	8-11-49	S	Adequate. Gravel from 0-10 ft. Sand at bottom.
....	18.4	8-11-49	D,S	Adequate.
....	6.2	8-11-49	D,S	Do.
....	9.5	8-11-49	D,S	Do.
....	12.9	8-11-49	D,S	Inadequate; has been pumped dry.
....	14.7	8-11-49	D,S	
1929	3.75	8-11-49	D,S	Adequate. Aquifer, fine gray sand.
1934	15	8-11-49	D,S	
1946	29.3	8-15-49	D,S	Adequate.
....	8.8	8-15-49	S	Adequate. Aquifer, sand and gravel.
....	17.6	8-15-49	D	Do.
....	9.9	8-15-49	S	Adequate.
1940	11.5	8-12-49	D,S	Do.
1924	17.7	8-12-49	D	Adequate. Aquifer, sand.
1946	22.2	8-12-49	S	
1939	14.5	8-12-49	D,S	Inadequate.
....	.....	....	D,S	Adequate.
....	.....	....	S	
1936	6	8-11-49	D,S	Adequate. Aquifer, gravel.
1933	6	8-11-49	S	Several springs on farm.
....	16.9	8-12-49	D,S	Adequate.
1917	20	8-12-49	D,S	Do.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
135-70				
2ada	Fred Findich	60	24	Bored
2bcc	Roland Becker	300	3	Drilled
4cc	John G. Grenz	81.2	32	Bored
10bbb	Katherine Zimmerman	80	2½	Drilled
10daa	Melvin Spotts	57.0	30	Bored
12add1	Andrew Perman	10.7	32	Dug
12add2	......do...........	17.4	32	..do...
12bbc1	Albert Ketterling	65	14	Bored
12bbc2	......do...........	60.3	24	..do...
12cdd1	Jake Freier	43.4	30	Dug
12cdd2	......do...........	10.3	48 by 48	..do...
12ddd	Henry Perman	18.7	32	..do...
14abb	Edward Freier	62.4	24	Bored
14bbb	Gust Freier	84	3	Drilled
14caa	Jake Grene	70	4	..do...
15bcb	Adam Pfeifle	9.1	32	Dug
22ccc	Theodore Graff	120	3	Drilled
22ddd1	John Jundt	23.6	36	Dug
22ddd2	Jacob Jundt	160	2½	Drilled
24aaa1	Chris Kinzle	50	24	Bored
24aaa2	......do...........	12.3	32	Dug
136-68				
5bbc	Edwin Mayer	100 ±	...	....
5dda	Walter Morlock	93	24	Bored
8abb	Gust Mayer	340	3	Drilled
8bbb	L. Morlock	325	2½	..do...
18bcc	John Dewald	102	3	..do...
18ccc	Helmuth Dewald	10.0	36 by 60	Dug
18ddd	Jake Miller	11.5	30 by 60	..do...
20aaa	Richard Miller	130	...	Driven
20bbb1	Emil Miller	19.4	30	Bored
20bbb2	......do...........	80±	...	Drilled

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
....	......	....	S	Reported to be strongly alkaline.
....	100	8-15-49	D, S	Water contains much iron.
....	2.9	8-15-49	D, S	Adequate.
1907	50	8-15-49	D, S	Do.
....	42.2	8-15-49	D, S	Do.
1929	10.3	8-15-49	D	Do.
1899	6.17	8-15-49	S	Do.
1948	28	8-15-49	D	Do.
1945	25.7	8-15-49	S	Do.
1938	14.8	8-15-49	S	Do.
1948	6.6	8-15-49	D	Do.
1919	9.4	8-15-49	D, S	Adequate. Aquifer, gravel.
....	50.9	8-15-49	D, S	
1939	64	8-15-49	D, S	
....	60	8-16-49	D, S	
1946	Flow	8-15-49	D, S	Well flows 3 g.p.m.± Aquifer, gravel.
1904	90	8-15-49	D, S	Water contains much iron.
1929	8.5	8-15-49	D, S	
1935	60	8-15-49	S	
1921	48	8-15-49	S	
1948	9.3	8-15-49	D	Aquifer, gravel.
....	......	....	D, S	
1903	78	8-15-49	D, S	Aquifer, gravel.
1918	......	....	S	Aquifer shale. Water, salty.
1924	15 50	1924 1942	D, S	Aquifer, shale. Water a little salty.
....	......	8-4-49	D, S	
....	4.9	8-4-49	D, S	Aquifer, sand.
....	3.7	8-10-49	D, S	Aquifer, sand and gravel.
....	......	....	D, S	Aquifer, gray fine sand.
....	4.6	8-10-49	D, S	
....	......	....	D, S	

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
136-68				
30aaa	John G. Veil	74	24	Bored
30daa	......do..........	22	24	..do...
32add	Victor Anderson	38	20	..do...
32ddd	R. Holstrom	70	24	..do...
136-69				
1bab	Leonhardt Mayer	133	3	Drilled
2bbc	Jacob Ackerman	77	...	..do...
2dab	August Meirer	76.0	24	Bored
4ccb1	W. M. Zenker	20	6	Drilled
4ccb2	......do..........	27	24	Bored
5ddc1	Fred Schultz	63.2	22	..do...
5ddc2	......do..........	8.7	48 by 48	Dug
6ccc	Edwin Geinger	125	3	Bored
7cbb	T. H. Graf	Spring	...	....
8dcd	Sam Schultes	15	36	Dug
9bcc1	August Dockter	6.3	38 by 38	..do...
9bcc2	......do..........	40	...	..do...
9bcc3	......do..........	43.7	24	Bored
10aad	Bill Rivinius	56	3	..do...
12bab1	John Dewald	103	12	..do...
12bab2	......do..........	140	3	..do...
12bcb	Jacob Jpocter	84.8	24	..do...
12cac1	Henry Opp	43.7	48	Dug
12cac2	......do..........	44.1	32	..do...
12ccc1	Thobalt Veil	12.0	54	..do...
12ccc2	......do..........	16.2	10	..do...
12ccc3	......do..........	14.1	36	..do...
12cda	Edward Wentz	120	3	Drilled
13ccc	G. Stolzer	304	2½	..do...
15caa	Reinhold Buck	25.3	36 by 36	Dug
20abb1	Jacob Schultes	31.1	30	Bored
20abb2	......do..........	16.2	36 by 36	Dug
21baa	Arthur J. Dockter	180	3	Drilled

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
1929	29	8-11-49	D, S	Aquifer, gravel
....	7	8-11-49	S	
1909	18	8-11-49	D, S	Do.
....	....	....	D, S	
1934	36	8- 4-49	D, S	Do.
1941	....	....	D, S	
1938	28.2	8- 4-49	D, S	Aquifer, sand and gravel.
9-48	12	8- 4-49	D	
10-47	3	8- 4-49	S	
5-48	12.4	8- 5-49	U	Water salty and bitter, unfit for animals.
7-49	4.9	8- 5-49	D, S	Aquifer, gravel.
....	....	....	D, S	Water contains much iron.
....	....	....	D, S	
1934	9.5	8- 5-49	D, S	Aquifer, gravel.
....	3.25	8- 4-49	S	Aquifer, gravel. Flows intermittently.
1934	22	8- 4-49	S	Inadequate.
1947	17.9	8- 4-49	D, S	Do.
1918	10	....	D, S	Water contains iron.
1947	37.5	8- 9-49	D	Aquifer, gravel.
....	40	8- 4-49	S	
....	13.1	8- 4-49	D, S	
....	40.3	8- 5-49	S	Inadequate.
1948	40.8	8- 5-49	D	
1909	6.8	8- 4-49	S	Aquifer, gravel.
1918	11.5	8- 4-49	D	Do.
1929	9.3	8- 4-49	D	Do.
....	....	....	S	
1934	150	8- 4-49	D, S	Aquifer, shale. Water reported salty.
....	16.0	8- 4-49	D, S	
1943	24.15	8- 5-49	D	Aquifer, gravel.
....	5.4	8- 5-49	S	
1929	130	8- 5-49	D, S	

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
136-69				
22dca	Ed. J. Dockter	75	22	Bored
24dab	G. M. Dockter	95	32	..do....
26acc	Jacob Diede	150	3	Drilled
26cbb	L. Dockter	55.0	30	Bored
26dbb	Art Stelzer	200	3	Drilled
28aaa	Henry Olson	6.1	52	Dug
28cdb1	Joseph Schaffer	30	30	Bored
28cdb2	......do...........	48	30	Dug
28dcd	John Schaffer	86	3	Drilled
30bbb	Jake Ketterling	19.8	30	Bored
30cdb	Herbert Flemmer	60	20	..do...
31dcc	Henry Rub	35.45	36	Dug
32baa	Valentine	12	36 by 36	..do...
34add	Edwin Lang	36	24	Drilled
136-70				
3aaa1	Adam Kirschenmann	11	...	Dug
3aaa2	......do..........	11.2	32	..do...
4bbc	L. Spitzer	19.6	24	..do...
9cba1	Art Dewald	7.4	...	..do...
10aad1	Ed. H. Brenneise	28.2	30	..do...
10aad2	......do..........	24.5	32	..do...
10ccc1	Fred Flemmer	17.5	32	..do...
10ccc2	......do..........	15	32	..do...
10dcc1	David Kaiser	14	36	..do...
10dcc2	......do..........	16	36	..do...
11dca	Adolf Dewald	129	...	Drilled
11ddd	USGS test 309	190	5	..do...
12ccc	Wm. Schuler	52	...	Bored
12cda	Ed Wentz	73.3	24	..do...
14bac1	Fred Schuler	160	14	..do...
14bac2	......do..........	34.1	30	..do...
15ddd	USGS test 307	210	5	Drilled
22ddd	USGS test 308	50	5	..do...

Date completed	Depth to water level feet below land surface	Date [illegible]	Use of water	Remarks
1947	45	8-12-49	D,S	Aquifer, sand.
1948	46.18	8-12-49	D,S	Do.
....	75	8-11-49	D,S	Water contains much iron.
1946	33.0	8-12-49	D,S	Aquifer, sand and gravel.
....	20	8-12-49	D,S	Aquifer, shale. Water contains much iron and is highly mineralized.
....	Flow	8-15-49	D,S	
1949	27	8-12-49	D	Aquifer, sand.
1909	7	8-12-49	S	
1926	40	8-12-49	D	
....	14.3	8-15-49	S	
1941	54	8-16-49	D,S	Aquifer, sandy gravel.
....	22.9	8-15-49	D,S	
....	2	8-16-49	S	Aquifer, gravel.
....	15	8-11-49	D,S	
....	9	8- 5-49	S	See chemical analysis.
....	9.18	8- 5-49	D	
....	15.2	8-15-49	D,S	Aquifer, sand.
....	6.3	8-15-49	S	Aquifer, fine yellow sand.
1946	24.9	8- 5-49	D	Aquifer, sand.
1944	14.9	8- 5-49	S	
1939	11.2	8-15-49	S	Aquifer, gravel.
1947	11	8-15-49	D	Do.
1939	10	8-15-49	D	Aquifer, sand.
1930	13.5	8-15-49	S	Aquifer, sand and gravel.
1934	18	8- 5-49	D,S	
5-29-50	....	....	T	See log.
....	....	....	D,S	Aquifer, fine gray sand.
1948	65.1	8- 5-49	D	
....	28.8	8-15-49	D	Aquifer, gravel in blue clay.
....	27.87	8-15-49	S	
5-24-50	....	....	T	See log.
5-26-50	....	....	T	Do.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
136-70				
28cbc	Ed. Opp	280	3	Drilled
34abb	Art Rudolf	23.7	24	Bored
35adb	John Ghonranz	33.9	36	Dug
137-68				
6acc	Ben Graf	75	24	Bored
6ddd	Wilburt Adam	90	24	..do...
7bdc	Evert Brunner	90	3	Drilled
8aaa	A. J. M. Dockter	200	3	..do...
9dcd	Christine Peifley	300	3	..do...
10ccc1	Albert Kerner	14.2	24	Dug
10ccc2	......do..........	14.9	48 by 48	..do...
17dcd	Wm. Stuckle	31.1	32	Dug
19ccd	Edwin Fischer	80	3	Drilled
20aba	Wm. Stuckle	22.1	48 by 48	Dug
20dbd	Fred Veil	300	3	Drilled
21bab	Walter Fischer	290	3	..do...
28aaa	John Kubler	100	3	..do...
30aba	Albert Kubler	200	3	..do...
31bbd	S. Schulter	....	3	..do...
31caa	Harry Wolff	200	3	..do...
31cca	George Becker	22	36 by 36	Dug
34bcb	James Clemmens	300	3	Drilled
137-69				
3ddd	E. Dewald	320	3	..do...
4abb	B. L. Hoffer	14	42 by 42	Dug

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
....	80	8-16-49	D, S	Aquifer, sand.
....	18.9	8-15-49	D, S	
....	26.0	8-15-49	U	
....	40	8-15-49	D, S	
1926	60	8-15-49	D, S	
....	85	8- 8-49	D, S	
....	150	8- 8-49	D, S	Aquifer, shale. Water is salty and has a yellow color.
....	....	....	U	Aquifer, shale.
1929	1.4	8- 8-49	D, S	
....	.6	8- 8-49	U	
....	16.3	8- 8-49	S	
1933	....	....	D, S	Aquifer, gravel. See chemical analysis.
....	7.25	8- 8-49	D, S	Inadequate.
1934	110	8- 8-49	D, S	Aquifer, shale. Water reported to be yellow and bitter.
1929	30	8- 8-49	D, S	Aquifer, shale. See chemical analysis.
....	....	....	D, S	
....	....	....	D, S	Easily pumped dry.
....	....	....	D, S	Adequate.
....	20	8- 5-49	D, S	Aquifer, gravel.
....	4.1	8- 5-49	S	Inadequate.
....	275	8- 8-49	D, S	
6-49	65	8- 4-49	D, S	Aquifer, shale. Encountered shale at 290 feet after passing through "soapstone."
....	....	8-10-49	S	Water unfit for domestic use.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
137-69				
5dac	Emil Schauer	300	...	Drilled
6ccd	Gene Schwecke	400	2.5	..do...
6cdb	A. Schwecke	140	2.5	..do...
8bca	A. Dewald	70	3	..do...
8daa	Peter Dewald	18.4	48 by 48	Dug
9ada	Hubert Williams	280	3	Drilled
10bcc	Jake Engzminger	300	3	..do...
12aaa	Gottlieb Kammerer	90	36	..do...
13acb	Jacob Remmick	182	3	..do...
13acd	......do..........	15.7	32	Dug
14dab	Carl Remmick	160	2	Drilled
15bbd	Jake Wieland	200 ±	...	..do...
16add	Phillip Dewald	14	30	Dug
18bcb	Edwin Schaner	107	2	Drilled
18cab	Herbert Schlecht	135	3	..do...
20aab	Otto Dewald	110	...	..do...
20cac	John Nelson	140	3	..do...
20cdc	USGS test 315	140	5	..do...
22bcc	Fred Weiland	320	3	..do...
22cdd	August Opp	30	20	Bored
22dbc	USGS test 318	170	5	Drilled
23dcc	Independent Drilling Co. Test No. 6	500	5	..do...
24ccc	Max Kramer	18.6	30	Bored
25bbb	......do..........	200	3	Drilled
25adc	Sam Schultes	90	3	..do...
26aaa	USGS test 306	220	5	..do...
26aab	Independent Drilling Co. Test No. 4	100 ±	5	..do...
26aba1	C. Bufink	10	36	Bored
26aba2	Caroline Hoffer	15	36 by 24	Dug
26aba3	W. E. Fischer	22	...	Bored
26aba4	Adam Dewald	20	32	Dug

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
....	....	....	D, S	Aquifer, shale.
1917	150	8-10-49	S	Aquifer reported to be "soapstone."
1933	50	8- 9-49	D, S	Aquifer, gravel.
....	55	8- 9-49	D, S	
....	8.2	8- 4-49	D, S	
1949	....	....	D, S	Aquifer, shale.
....	....	....	D, S	Do,
....	70	8- 8-49	D, S	
1917	160	8- 8-49	D, S	Aquifer, sand. Water sometimes black.
....	10.45	8- 8-49	D	
....	70	8- 8-49	D, S	Aquifer, gravel.
....	....	....	D, S	
....	....	....	D, S	
4-40	20	8- 9-49	D, S	Aquifer, brown sand.
1919	20	8- 9-49	D, S	Aquifer, coarse sand. Water soft; slight "iodine" taste.
1931	Flow	8- 4-49	D, S	Aquifer, brown sand below blue clay. Flows 2 g.p.m.
1949	Flow	8- 4-49	D, S	Aquifer, coarse sand below blue clay. Flows 3 g.p.m.
6-8-50	Flow	8- 4-49	T	See log.
1938	....	....	D, S	
....	26	8- 4-49	D, S	
6-10-50	....	....	T	See log.
1946	....	....	T	Drilled into shale several hundred feet.
....	1.7	8- 5-49	S	
....	....	....	D, S	
1931	24	8- 8-49	D, S	
5-22-50	....	....	T	See log.
1946	....	....	T	Probably drilled to shale.
1943	6.1	8- 2-49	D	Aquifer, yellow sand.
....	6.00	8- 2-49	D	Aquifer, coarse gravel.
....	7	8- 2-49	D	Aquifer, yellow sand.
1935	12	8- 2-49	D	Aquifer, sand and gravel.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
137-69				
26aba5	Julius Meidinger	20	...	Bored
26aba6	Wm. Ackerman	30	30	..do...
26aba7	Jacob L. Buck	35	...	Drilled
26aba8	Alvin Remmick	....	36 by 36	....
26aba9	Theo. Meisch	22	...	....
26aba10	L. Job	13.0	...	Dug
26aba11	Ed. Weber	18.0	...	....
26aba12	Jack Deutcher	15.0	36 by 36	Dug
26aba13	Independent Drilling Co. Test No. 5	....	5	Drilled
26aba14	Independent Drilling Co. Test No. 2	300	5	..do...
26abb1	A. Stockdurger	12.5	24	Bored
26abb2	Rubin Tarnasby	....	...	....
26abb3	Ludwig Schatz	11	30	Dug
26abb4	Mrs. Adam Schatz	18.0	24	..do...
26abb5	C. Morlock	16.0	30	....
26abb6	John Kraft	18	36	Bored
26abb7	Rubin Helluis	9.5	...	Dug
26abb8	Edward Schultz	12.5	36 by 36	..do...
26abb9	Mrs. B. Martin	16.0	18	..do...
26abb10	H. A. Dockter	11.8	...	....
26abb11	Rev. G. H. Rueb	11.2	36	Dug
26abc1	John Buck	14.4	30 by 30	..do...
26abc2	George Opp	17	30	Bored
26abc3	Adam C. Dewald	14.6	30	..do...
26abc4	Sam Schultes	12.4	30	..do...
26abc5	Paul Giener	8.8	30	..do...
26abd	Carl Siedel	10	36	..do...
26acb.	Jacob Enzminger	13.5	27	Dug
26acc1	H. C. Wentz	312	3	Drilled
26acc2	Adam Schumacker	....	...	....
26baa1	August Mayer	13.9	36 by 36	Dug
26baa2	Emanuel Wieland	14	...	..do...

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
....	15	8- 2-49	D	
1948	11.7	8- 2-49	D	Aquifer, yellow sand.
....	....	....	...	
....	17.6	8- 2-49	...	
....	13.7	8- 2-49	D	
....	7.8	8- 2-49	D	Aquifer, gray fine sand.
....	13.5	8- 2-49	...	
....	9.2	8- 2-49	...	
1946	....	....	T	Drilled to shale.
1946	....	....	T	Yellow clay and gravel, 0-40 ft.; blue clay, stones, 40-190 ft.; shale 190-300 ft. Pumped 20 g.p.m. from gravel in upper 40 feet for period of 9 hours.
....	7.15	8- 2-49	U	Aquifer, yellow fine sand.
....	....	....	D	
1917	6.0	8- 2-44	D	Aquifer, yellow sand.
1910	7.9	8- 2-49	D	
....	6.5	8- 2-49	D	
1944	13.1	8- 2-49	D	
1948	6	8- 2-49	D	Aquifer, gravel.
....	6.0	8- 2-49	D	
....	6.5	8- 2-49	D	Aquifer, sand.
....	2.8	8- 3-49	D	Aquifer, gravel.
1-48	5.7	8- 3-49	D	Do.
....	4.23	8- 2-49	D	Do.
....	3	8- 2-49	D	
1930	5.5	8- 2-49	U	Aquifer, sand and gravel.
....	7.5	8- 2-49	D	Do.
....	3.55	8- 2-49	D	Do.
....	5.6	8- 2-49	D	
1946	10.1	8- 3-49	D	Do.
1934	....	....	D, S	Water obtained from sand below shale?
....	....	....	D, S	
....	3.9	8- 3-49	D, S	
1940	6.4	8- 3-49	D	Aquifer, gravel.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
137-69				
26bab1	G. J. Bender	16	...	Drilled
26bab2	John Kammerer	19	...	Bored
26bab3	Henry Hach	16.7	27	..do...
26bac1	Chris Hochhalter	18.7	38	..do...
26bac2	John George	18.3	26	..do...
26bac3	Ludwig Buck	20.5	30	..do...
26bac4	....	20.5	24	..do...
26bac5	Wm. Oberlander	....	...	Dug
26bac6	Jacob Rau	22	36	Bored
26bac7	J. B. Fischer	23	...	Dug
26bac8	John Kubler	19.8	27	....
26bac9	Rev. F. Alf	2.5	36 by 36	Dug
26bad1	Calvin Vilharier	15.7	36 by 36	..do...
26bad2	S. E. Graf	20	36	Bored
26bad3	Rivenius	20	...	Dug
26bad4	Phillip Meyer	15	...	..do...
26bad5	Wm. Rivenius	16	...	..do...
26bba1	Erwin Buck	12.0	36	Bored
26bba2	......do..........	12.8	...	Dug
26bba3	Clarence Wentz	9.6	...	....
26bba4	Henry Klundt	35.3	20	Bored
26bba5	Francis Grig	10.14	33	..do...
26bba6	John Bachman	11.7	33	..do...
26bba7	Rosa Dewald	14.7	31	Dug
26bbb1	Gus Whitmier	10	30	..do...
26bbb2	USGS test 300	240	5	Drilled
26bbc1	Adolf Veil	14.0	31	Bored
26bbc2	David Kubler	25.4	36 by 36	Dug
26bbc3	Emil A. Wentz	20.45	14	Bored
26bbc4	USGS test 305	80	5	Drilled
26bbc5	Independent Drilling Co. Test No. 3	160	5	..do...
26bbd1	Fred Schauer	31.7	32	Dug
26bbd2	Jake Bitterman	30	48 by 48	..do...

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
....	....	....	D	
1942	....	....	D	
....	8.8	8- 3-49	D	Aquifer, gravel.
....	14.2	8- 2-49	D	
....	12.6	8- 2-49	D	
....	14.6	8- 2-49	D	Aquifer, fine sand.
....	15.4	8- 2-49	...	
....	13.2	8- 2-49	D	
1939	11.2	8- 2-49	D	
1947	13	8- 2-49	D	Not used for drinking purposes.
....	9.2	8- 3-49	D	
....	....	....	D	See chemical analysis.
1934	3.9	8- 3-49	D	
....	9.3	8- 2-49	U	Contaminated.
....	10.1	8- 2-49	D	Aquifer, sand. Not used for drinking purposes.
....	10.5	8- 2-49	D	
....	7	8- 2-49	D	Aquifer, gravel. Not used for drinking.
....	5.9	8- 2-49	D	
....	6.6	8- 2-49	S	Aquifer, gravel.
....	8.19	8- 2-49	S	Do.
1947	30.0	8- 2-49	D	Do.
1947	6.87	8- 2-49	D	Aquifer, sand and gravel.
1946	9.4	8- 2-49	D	Do.
1947	11.1	8- 2-49	D	
1947	6.5	8- 2-49	D	
4-22-50	....	....	T	See log.
....	12.05	8- 2-49	D	
....	14.3	8- 3-49	D	
....	16.3	8- 3-49	D	Inadequate.
5-22-50	....	....	T	See log.
1946	....	....	T	Sand, gravel, and clay, 0-28 ft.; blue clay, stones, 28-160 ft.; shale, 160-161 ft.
....	25.3	8- 3-49	D	
....	....	8- 3-49	D	Aquifer, sand.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
137-69				
26bbd3	Emil Brenneise	30	36	Dug
26bbd4	Jacob Grossman	30	36 by 36	..do...
26bbd5	John Schatz	20	24	Bored
26bbd6	Carl Arndt	20.8	36	Dug
26bbd7	Oscar Seher	30.5	36	..do...
26bbd8	G. P. Stokes	380	...	Drilled
26bbd9	Streeter Hotel	20	...	....
26bca1	Harry Machin	27.1	21.6	Bored
26bca2	Jacob Meidinger	21	24	..do...
26bca3	......do..........	16.7	24	..do...
26bca4	Aaron Betsch	17.4	21	..do...
26bca5	Fred H. Miller	22	30	Dug
26bca6	John G. Graf	22.8	40 by 40	..do...
26bca7	Nick Nienoff	24.3	30	..do...
26bcb1	USGS test 302	180	5	Drilled
26bcb2	USGS test 304	170	5	..do...
26bcb3	Conrad Beir	25	...	Bored
26bcd1	William Wutzke	20.2	44 by 44	Dug
26bcd2	G. Weisser	21.4	28	..do...
26bcd3	Alfred F. Deutscher	25.5	28	..do...
26bcd4	Peter Deutscher	23.1	28	..do...
26bcd5	......do..........	21.8	26.4	..do...
26bcd6	Jacob Mattheis	24.8	23	Bored
26bcd7	USGS test 317	50	5	Drilled
26bdb1	George J. Wentz	....	...	Dug
26bdb2	G. Fischer	26.2	...	Bored
26bdb3	A. Fercho	38	...	....
26bdb4	G. M. Iszler	20.4	24	Bored
26bdb5	Adam Schwartzwalter	22.6	21.6	Dug
26bdb6	Farmers Co-op Elev.	20.9	24	....
26bdb7	Ted Dewald	....	...	Drilled
26bdb8	John F. Dockter	16	...	Dug
26bdc1	Wm. Wentz	27	24 by 24	..do...
26bdc2	C. Stienstra	27.6	...	..do...

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
....	15	8- 3-49	D	
1929	28	8- 3-49	D	Inadequate.
....	18	8- 3-49	D	
1945	16.5	8- 3-49	D	
1933	22.8	8- 3-49	D	Aquifer, gravel.
1927	....	8-49	D	Aquifer, shale. Drawdown of 100 feet after 24 hours pumping.
....	....	....	D	See chemical analysis.
1947	19.7	8- 3-49	D	
1946	17	8- 3-49	D	Aquifer, sand and gravel.
....	15.1	8- 3-49	D	Not used for drinking purposes.
8-46	11.5	8- 3-49	D	Aquifer, gravel.
....	14.9	8- 3-49	D	See chemical analysis.
....	12.25	8- 3-49	S	Water unfit for human consumption.
....	17.75	8- 3-49	D	
5-15-50	....	....	T	See log.
5-18-50	....	....	T	Do.
....	....	....	D	
....	11.03	8- 3-49	D	
....	12.4	8- 3-49	D	Aquifer, sand and gravel.
....	13.6	8- 3-49	D	Do.
....	11.47	8- 3-49	S	Do.
....	10.4	8- 3-49	D	
....	17.25	8- 3-49	D	
6-10-50	....	....	T	See log.
1910	....	....	...	
....	15.7	8- 3-49	...	
....	....	....	...	
1948	15.7	8- 3-49	D	Aquifer, gravel.
1947	15.33	8- 3-49	D	
....	11.3	8- 3-49	...	
....	....	....	U	
....	12	8- 3-49	D	
....	20.2	8- 3-49	D	Aquifer, sand and gravel.
....	19.1	8- 3-49	...	Do.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
137-69				
26bdc3	Mrs. J. Schwartzwalter	30	...	Dug
26bdc4	Streeter Elev. Co.	26	15	Bored
26bcd5	Independent Drilling Co. Test No. 1	380	5	Drilled
26bdd1	USGS test 301	210	5	..do...
26bdd2	Independent Drilling Co. Test No. 7	200 ?	5	..do...
26caa	Emil Wentz	20	30	Bored
26cbb	Art Bender	300	3	Drilled
27aac1	Edward Deutcher	27	36	Bored
27aac2	......do..........	Spring	...	....
27adb	USGS test 316	50	5	Drilled
27baa	USGS test 311	160	5	..do...
27dba	USGS test 312	170	5	..do...
27cdb	Rheinhold Rau	380	3	..do...
27dda	USGS test 303	200	5	..do...
28abb	USGS test 313	170	5	..do...
28cca1	Anton F. Ruff	55.6	32	Bored
28cca2	......do..........	61.4	32	..do...
29abb	USGS test 314	74	5	Drilled
30caa	Fred Schulter	Spring	...	....
31bbd1	August Fischer	169	6	Drilled
31bbd2	......do..........	17.9	32	Dug
31cbc	Raymond Fischer	38.8	32	..do...
32cbc	Allen Reese	46.4	32	Drilled
33ddd	USGS test 310	170	5	..do...
34dad	Gus Dorr	30	...	....
137-70				
2ddd	John Neinow	70	3	Drilled
12cbb	John Schwecke	20.5	36 by 36	Dug
14aad	August Schauer	180	3	Drilled
14dad	Walter Schauer	300	3	..do...

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
1934	20.9	8- 3-49	D	
1948	22	8- 2-49	...	Inadequate. Easily pumped dry.
1946	....	....	T	Gravel, 0-16 ft.; blue clay, stones, 16-200 ft.; shale, 200-380 ft.
5-1-50	....	....	T	See log.
1946	....	....	T	Drilled to shale.
....	....	....	U	
....	....	....	D,S	Aquifer, shale.
1948	22.1	8- 4-49	D,S	
....	....	....	S	See chemical analysis.
6-9-50	....	....	T	See log.
6-1-50	....	....	T	Do.
6-2-50	....	....	T	Do.
....	12	8- 3-49	D,S	Aquifer, shale.
5-17-50	....	....	T	See log.
6-6-50	....	....	T	Do.
1947	10.5	8- 9-49	D	
1948	8.4	8- 9-49	S	Aquifer, gravel.
6-7-50	....	....	T	See log.
....	....	....	D,S	See chemical analysis.
1926	10	8- 9-49	S	Aquifer, shale.
1921	11.9	8- 9-49	D	Aquifer, gravel.
....	32.2	8- 9-49	D,S	Aquifer, sand and gravel.
5-47	31.35	8- 9-49	D,S	Adequate. Aquifer, sand.
5-31-50	....	....	T	See log.
....	....	....	D,S	
....	8	8-11-49	D,S	Aquifer, gravel.
....	17.3	8-11-49	D,S	
1943	Flow	8-11-49	D,S	Aquifer, shale. Water contains much iron.
1929	100	8-11-49	D,S	Aquifer, shale.

Location number	Owner or name	Depth of well (feet)	Diameter (inches)	Type
137-70				
24ccb	Emil Schwartzwalter	19.7	32	Dug
24ddd	Gilbert Fischer	130	3	Drilled
26abb	Emil Wieland	60	3	..do...
26cba	W. & A. Schwartzwalter	100	3	..do...
26dcd	Milton Schwartzwalter	25.8	41 by 41	Dug
138-68				
29bbb	Albert Donat	68	3	Drilled
29dcc	Herbert Job	16.7	48 by 48	Dug
30ddd	Walter T. Dockter	325	3	Drilled
138-69				
26bcc	Richard Schultes	....	3	..do...
26cda	Richard Dockter	....	3	..do...
26ddd	Jacob Dockter	100	3	..do...
28dad	Wm. Handel	210	3	..do...
32dbc	August M. Dockter	16.1	36 by 30	Dug
33dca	Henry Morlock	100	3	Drilled
34ddd	Jacob F. Hoffer	350	3	..do...
138-70				
25ccc	....	13.94	32	Dug

Date completed	Depth to water level feet below land surface	Date	Use of water	Remarks
1947	13.4	8-11-49	D	
....	75	8-11-49	D, S	Inadequate.
1943	35	8-11-49	D, S	Water believed to come from sandstone. See chemical analysis.
1927	20	8-11-49	S	Aquifer may be sandstone. See chemical analysis.
....	20.0	8-11-49	D, S	
1916	....	....	D, S	
....	11.75	8-10-49	D, S	
1928	....	....	D, S	
....	....	....	D, S	Aquifer, shale.
....	....	....	D, S	Do.
....	....	....	D, S	
....	178	8-10-49	D, S	
....	6.8	8-10-49	D, S	
....	....	....	D, S	
....	....	....	D, S	Aquifer, sand and gravel?
....	7.53	8-11-49	S	Stock well in pasture.

LOGS OF TEST HOLES IN THE STREETER AREA

The logs of the test holes are composite logs obtained by combining the drillers' logs with descriptions and analyses made in the laboratory. The samples as obtained with the hydraulic-rotary rig used in the test drilling are not always truly representative of the rock materials as they occur in nature. Water-sorted materials, especially such as sand and gravel, may be somewhat cleaner in the samples than in their natural occurrence in the ground because of the tendency of the drilling fluid to wash the cuttings as they are being carried to the surface from the bottom of the hole.

Generally, the sand and gravel as it occurs in the samples is poorly sorted so that it cannot readily be classified as to texture. However, where a fair degree of sorting is evident, the Wentworth size classification is used.

The term "till" as used in this report refers to a heterogeneous mixture of clay, silt, sand, gravel, and boulders. Clay and silt are the most predominant constituents of the till and form the matrix throughout which the larger fragments are scattered without sorting or stratification.

136-70-11ddd
USGS test 309

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, black, clayey.................	1	1
	Till, tan..........................	8	9
	Gravel.............................	2	11
	Till?, clay, buff to dark-gray containing very few pebbles, may be lacustrine clay..................	39	50
	Till, bluish-gray,.................	134	184
Pierre shale			
	Clay, bluish-gray,.................	6	190

136-70-15ddd
USGS test 307

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, black, sandy.................	4	4
	Sand, fine to medium...............	1	5
	Sand, coarse to very coarse, and gravel............................	15	20
	Gravel, mostly shale,..............	5	25
	Pebble gravel......................	25	50
	Pebble gravel, coarser than above...	14	64
	Till, bluish-gray. Layers of shale gravel occur from 125 to 130 feet and from 155 to 160 feet..........	132	196
Pierre shale			
	Shale, bluish-gray.................	14	210

136-70-22ddd
USGS test 308

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, sandy.................	2	2
	Sand, mostly medium to coarse, but also some very coarse sand........	23	25
	Pebble gravel, becoming very coarse at bottom..........................	14	39
	Till, bluish-gray,.................	11	50

LOGS OF TEST HOLES IN THE STREETER AREA
STUTSMAN COUNTY

137-69-20cdc
USGS test 315

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, sandy	2	2
	Sand, fine to medium, quartzose, rather well sorted and rounded	18	20
	Sand, fine to very coarse, and gravel, fine	13	33
	Till, gray, with much sand and gravel	9	42
	Gravel	3	45
	Till, gray	12	57
	Gravel	9	66
	Till, gray	61	127
Pierre shale			
	Shale, bluish-gray	13	140

137-69-22dbc
USGS test 318

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown	1	1
	Till, tan	27	28
	Till, bluish-gray	26	54
	Gravel	7	61
	Till, bluish-gray	64	125
Older drift			
	Gravel and sand, composed mostly of resistant rock material. Seems to be weathered. Few shale fragments	6	131
	Gravel and sand, same as overlying material but mixed with small amounts of tan clay. (May be till)	16	147
	Gravel with small amount of white clay	3	150
	Sand, gravel, and boulders. A little tan clay	14	164
Pierre shale			
	Shale, bluish-gray	6	170

137-69-26aaa
USGS test 306

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, sandy	1	1
	Sand, fine to very coarse	9	10
	Gravel, fine to very coarse	9	19
	Till, gray	22	41
	Gravel, fine	8	49
	Till, gray, very gravelly	21	70
	Till, bluish-gray	100	170
	Till, bluish-gray. Large amount of shale gravel	24	194
Pierre shale			
	Clay, tan	26	220

137-69-26bbb2
USGS test 300

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Till, light-tan to buff, silty, pebbly	18	18
	Till, bluish-gray, pebbly	42	60
	Till, bluish-gray, numerous shale pebbles	163	223
Pierre shale			
	Clay, yellowish-tan, sandy, with streaks of limonitic clay	7	230
	Clay or shale, bluish-gray	10	240

137-69-26bbc4
USGS test 305

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, sandy	½	½
	Sand, fine to very coarse	4½	5
	Sand, coarse	4	9
	Till, buff, sandy	10	19
	Till, bluish-gray, clayey	61	80

LOGS OF TEST HOLES IN THE STREETER AREA
STUTSMAN COUNTY - - Continued

137-69-26bcb1
USGS test 302

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, dark gray, sandy..............	1	1
	Clay, tan, with sand and gravel mixed...........................	4	5
	Sand, brown, medium................	10	15
	Sand, coarse to very coarse.........	5	20
	Gravel, fine, becoming very coarse near bottom.....................	12	32
	Till, gray.........................	12	44
	Gravel, fine.......................	6	50
	Gravel, coarse.....................	5	55
	Till, gray.........................	62	117
	Sand, very coarse, derived mostly from shale.......................	8	125
	Till, bluish-gray, composed of ground-up shale and shale pebbles..........................	20	145
Older drift			
	Sand, very coarse, with a little tan clay (Hard drilling)..........	9	154
Pierre shale			
	Clay, tan..........................	10	164
	Shale, bluish-gray, soft...........	16	180

137-69-26bcb2
USGS test 304

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, black, clayey..................	2	2
	Till, yellowish-brown, sandy.........	8	10
	Gravel, fine, and sand, fine to very coarse......................	7	17
	Gravel, fine, and sand, very coarse.	8	25
	Gravel, very coarse..................	7	32
	Gravel, fine to medium...............	3	35
	Till, gray at top, becoming dark bluish-gray at bottom.............	108	143
Older drift			
	Gravel, fine, and sand, very coarse, composed of resistant rock material. May be slightly cemented.........................	7	150
Pierre shale			
	Clay, gray and brown with red streaks of limonite...............	10	160
	Shale, bluish-gray, soft.............	10	170

137-69-26bcd7
USGS test 317

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, dark-gray......................	1	1
	Till, tan............................	8	9
	Sand, medium to coarse...............	15	24
	Gravel...............................	11	35
	Till, bluish-gray....................	15	50

137-69-26bdd1
USGS test 301

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, black, clayey	1	1
	Till, light-tan	15	16
	Till, gray	12	28
	Gravel, fine to medium, poorly sorted, mostly limestone and dolomite	13	41
	Till, bluish-gray, much gravel	9	50
	Till, bluish-gray	90	140
	Till?, mostly sand and gravel derived from shale	58	198
Pierre shale			
	Clay, brown, sandy	5	203
	Shale, bluish-gray, soft. Core obtained from 203-210	7	210

137-69-27adb
USGS test 316

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, clayey	1½	1½
	Till, brown	3½	5
	Sand and gravel	21	26
	Till, gray	4	30
	Gravel, shaly	11	41
	Till, gray	9	50

137-69-27baa
USGS test 311

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, sandy..................	1	1
	Till, tan..........................	16	17
	Till or lake clay, hard and compact with few pebbles.................	8	25
	Sand, fine to very coarse...........	5	30
	Gravel.............................	12	42
	Till, bluish-gray..................	71	113
Older drift			
	Mostly gravel and sand, (may be stony till), composed primarily of resistant rock materials and has a low proportion of shale fragments. A small amount of tan clay in sample from 125 to 130 feet and persists in small quantities to bottom. Some zones in clay are red and yellow, and retain shapes of minerals which have rotted out. (Drillers report "cemented gravel" drilling characteristics).................	41	154
Pierre shale			
	Shale, bluish-gray, soft...........	6	160

137-69-27bda
USGS test 312

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, black, clayey......................	1	1
	Till, yellowish-brown..................	27	28
	Till, gray..............................	9	37
	Sand, medium to coarse, and pebble gravel..............................	17	54
	Till, gray..............................	65	119
Older drift			
	Gravel and sand. Considerable amount of gray clay in top 15 feet which may have caved from above..................................	33	152
	Till, tan...............................	2	154
Pierre shale			
	Shale, gray.............................	16	170

137-69-27dda
USGS test 303

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, black, clayey....................	1	1
	Soil, brown............................	2	3
	Soil, grayish-white, highly calcareous............................	2	5
	Till, tan...............................	16	21
	Till?, bluish-gray, very few pebbles................................	14	35
	Till, gray to bluish-gray. Color changes gradually from gray near the top to a dark bluish-gray towards the bottom, at which depth the pebbles and till matrix are made up almost entirely of shale.................	152	187
Pierre shale			
	Shale, bluish-gray...................	13	200

137-69-28abb
USGS test 313

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, clayey..................	1	1
	Till, grayish-white..................	2	3
	Till, tan............................	15	18
	Till, gray...........................	10	28
	Sand, very coarse....................	2	30
	Till, gray...........................	17	47
Older drift			
	Gravel...............................	13	60
	Pebble gravel........................	11	71
	Till and possible soil zone, yellowish-tan and black, some parts (tan) calcareous and other (grayish) non-calcareous. Numerous bits of black, partly carbonized vegetation and black clay..............................	11	82
	Till, bluish-gray. (Hard drilling)........................	8	90
Pierre shale			
	Clay or shale, bluish-gray..........	20	110
	Shale, bluish-gray, not so sandy....	60	170

137-69-29abb
USGS test 314

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, sandy...................	½	½
	Gravel and sand......................	15½	16
	Till, tan............................	13	29
	Till, dark-gray......................	35	64
	Gravel and numerous boulders which forced discontinuance of drilling at 74 feet............................	10	74

137-69-33ddd
USGS test 310

Formation	Material	Thickness	Depth
Late Wisconsin drift			
	Soil, brown, clayey..................	2	2
	Till, tan.........................	16	18
	Till, bluish-gray..................	20	38
	Sand, very coarse, and gravel.......	7	45
	Gravel.............................	9	54
	Till, gray.........................	3	57
	Gravel, shaly......................	3	60
Older drift			
	Till, yellowish-tan................	5	65
	Till, light-gray...................	5	70
	Till, pink, white and light-green clay and fairly numerous quartz granules..........................	4	74
	Till, gray.........................	21	95
	Gravel or gravelly till............	6	101
	Clay, dark-gray....................	7	108
	Till, bluish-gray..................	43	151
Pierre shale			
	Clay or shale, bluish-gray. Contains some glauconite and gypsum..........................	19	170

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