GROUND-WATER SURVEY OF THE BUXTON AREA

TRAILL COUNTY, NORTH DAKOTA

SWC PROJECT NO. 741

NORTH DAKOTA GROUND-WATER STUDIES

NO. 71

By
Charles E. Naplin
Ground-Water Geologist

Published By
North Dakota State Water Commission
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Bismarck, North Dakota 58501

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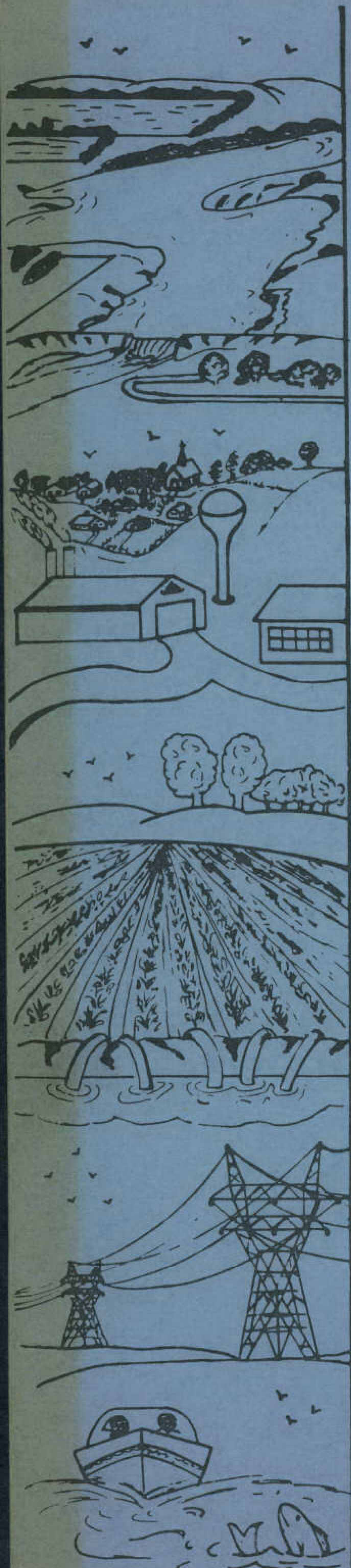

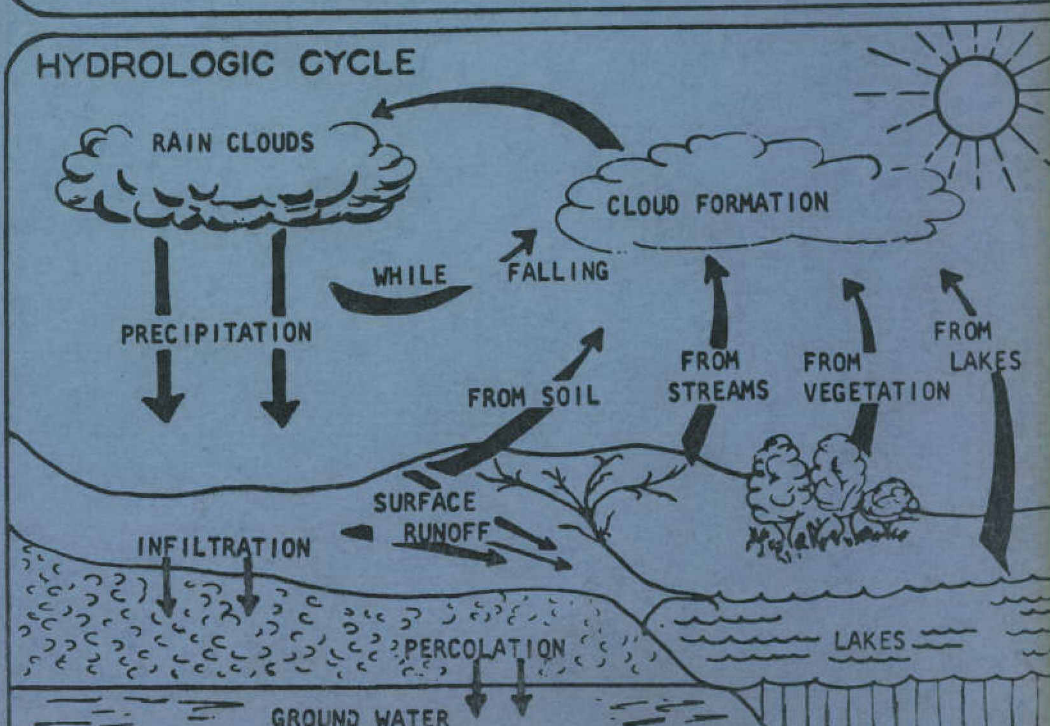

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GROUND-WATER SURVEY OF THE BUXTON AREA

TRAILL COUNTY, NORTH DAKOTA

INTRODUCTION

Purpose and Scope

In July 1967 the Buxton City Council requested the State Water Commission to conduct a ground-water survey for the city. A contract was enacted on July 19, 1967 and fieldwork began in late August 1967. Additional test drilling was initiated in May 1968 and completed in early June.

The investigation consisted of a study of existing data, test drilling, a partial well inventory, installation of observation wells, chemical analyses of selected water samples, and the preparation of this report. New data on subsurface conditions in the Buxton area were obtained from 28 test holes drilled during the survey. Additional information obtained from earlier reports and topographic maps supplemented the evaluation of ground-water conditions in the area. The purpose of this investigation was to evaluate ground-water potential in the Buxton area and to find a dependable supply of water for the municipality.

Test drilling and associated fieldwork was under direct supervision of the author. Test drilling was accomplished by Lewis Knutson and Hugh Jacobson using the State-owned forward hydraulic rotary drilling machine. Chemical analyses were performed by Garvin Muri, State Water Commission Chemist, at the North Dakota State Laboratories in Bismarck.

Location and General Features

The Buxton area described in this report consists of 159 square miles in a portion of T. 148 N., R. 49 W. and all of Tps. 147 and 148 N., Rs. 50 and 51 W. in northeastern Traill County. The area is located in the Agassiz Lake Plain

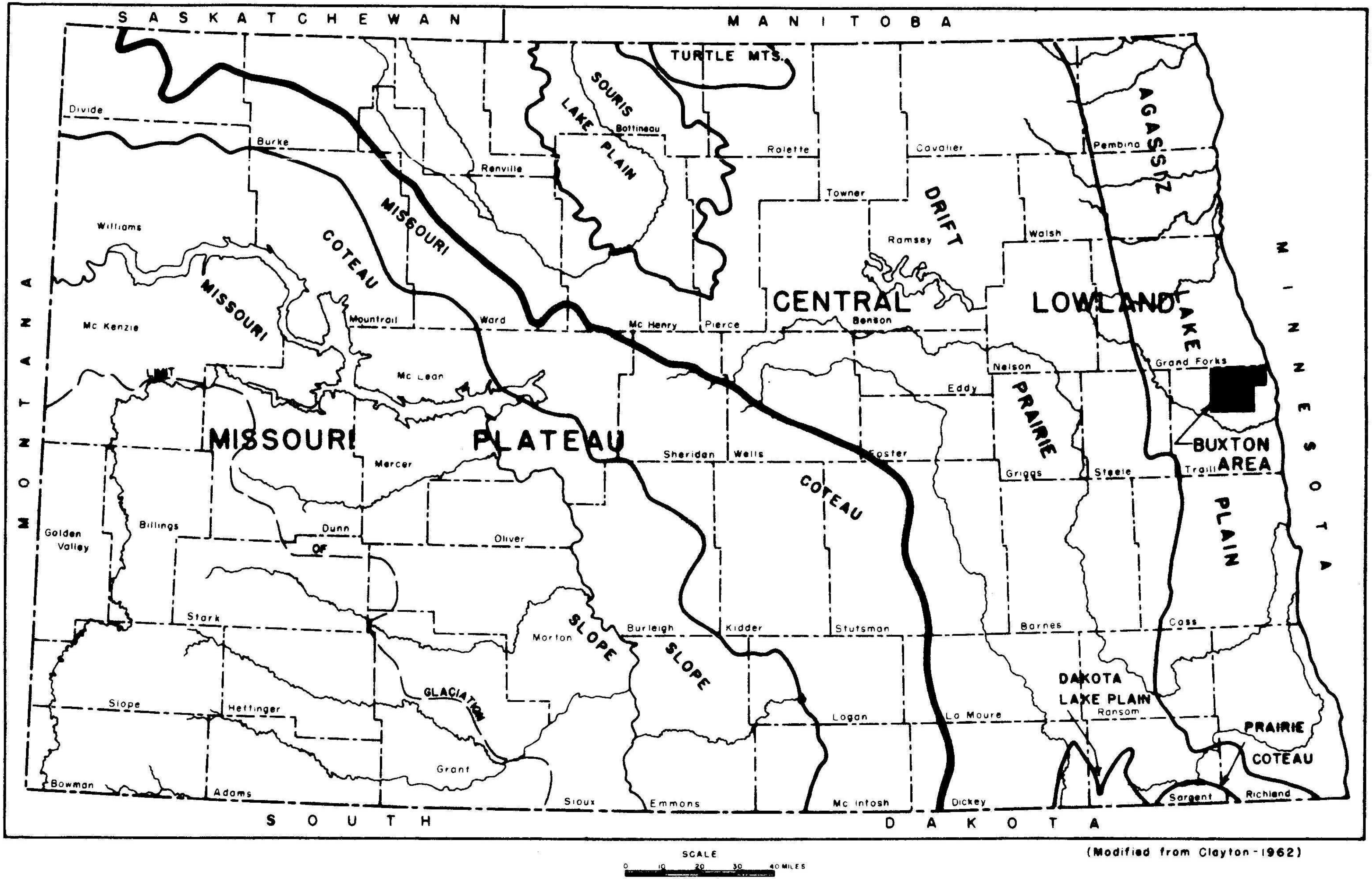

FIGURE I--MAP OF NORTH DAKOTA SHOWING PHYSIOGRAPHIC PROVINCES AND LOCATION OF THE BUXTON AREA division of the Central Lowland Physiographic Province of North Dakota, as shown in figure 1. Surface elevations range from slightly less than 850 feet above mean sea level along the North Dakota-Minnesota border on the east to approximately 975 feet in the northwest corner of sec. 6, T. 148 N., R. 51 W.

Streams in the area are intermittent. Buffalo Coulee with its few minor tributaries, including numerous agricultural drainage ditches, generally drains the area east of Buxton and flows northeastward to the Red River. West of Buxton runoff follows a southerly gradient and includes several unnamed streams that flow into the Goose River south of State Highway 7.

Buxton, an agricultural community, has a population of 321 (1960 census). U. S. Highway 81, 1 mile east of the municipality, and the Great Northern Railway serve the city. Climatological data based on a period of record from 1931-1960 show the average annual temperature to be 40.5°F. Average annual precipitation based on the same period of record is approximately 20 inches (Jensen, unpublished maps, 1968).

Well-Numbering System

The well-numbering system used in this report, illustrated in figure 2, is based upon the location of the well in the federal system of rectangular surveys of public lands. The first number denotes the township north of the base line that passes laterally through the middle of Arkansas; the second number denotes the range west of the fifth principal meridian; the third number denotes the section in which the well is located. The letters a, b, c, and d designate respectively the northeast, northwest, southwest, and southeast quarter section, quarter-quarter section, and quarter-quarter-quarter section (10-acre tract). Consecutive terminal numerals are added if more than one well is located in a 10-acre tract. Thus well 148-51-15daa is in the NE$\frac{1}{4}$NE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 15, T. 148 N., R. 51 W.

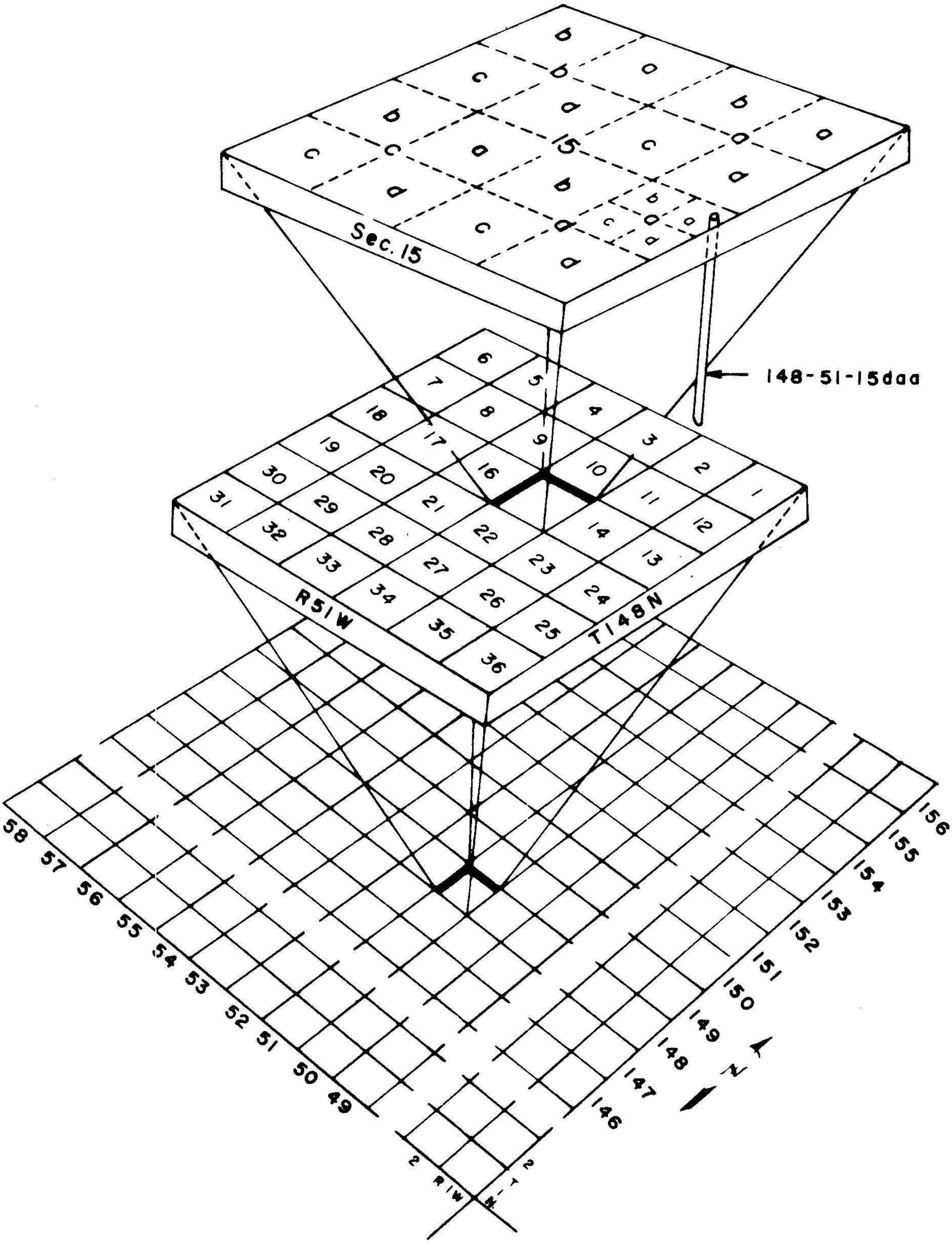

FIGURE 2--SYSTEM OF NUMBERING WELLS AND TEST HOLES.

Previous Investigations

Numerous writers have discussed the geology of the glacial Lake Agassiz area in much detail. However, most of the published data on the Buxton area of Traill County has been written primarily on the glacial geology of Lake Agassiz and only recently has any emphasis been placed on the assessment of ground-water resources.

A general study of the Traill County geology and ground-water resources was made by Simpson (1929, pp. 240-243) in which he discusses the water-yielding lacustrine silts and sandy beach deposits. Emphasis was placed upon flowing wells and the geology of the Dakota artesian system. The publication lists a well inventory of selected municipal and farm wells and the chemical analyses of a few water samples.

The Buxton area was investigated by Dennis in the summer of 1946 and the report was published in 1947 (Dennis, 1947). This investigation was very general and most of the data were obtained primarily through well inventory. Subsurface exploration was limited to seven shallow test holes drilled into the beach deposits west and southwest of Buxton. The information derived from the study was not sufficient to allow an accurate determination of the occurrence of ground water in the area.

A ground-water survey of Traill County was initiated in July 1965 and completed in June 1967. The investigation was a cooperative program between the U. S. Geological Survey, the North Dakota State Water Commission, the North Dakota Geological Survey, and the Traill County Water Management District. The published report, Geology and Ground-Water Resources of Traill County - County Ground-Water Studies 10, consists of Part 1 - Geology, Part 2 - Basic Data, and Part 3 - Ground-Water Resources. Parts 1 and 2 have been published and are available at

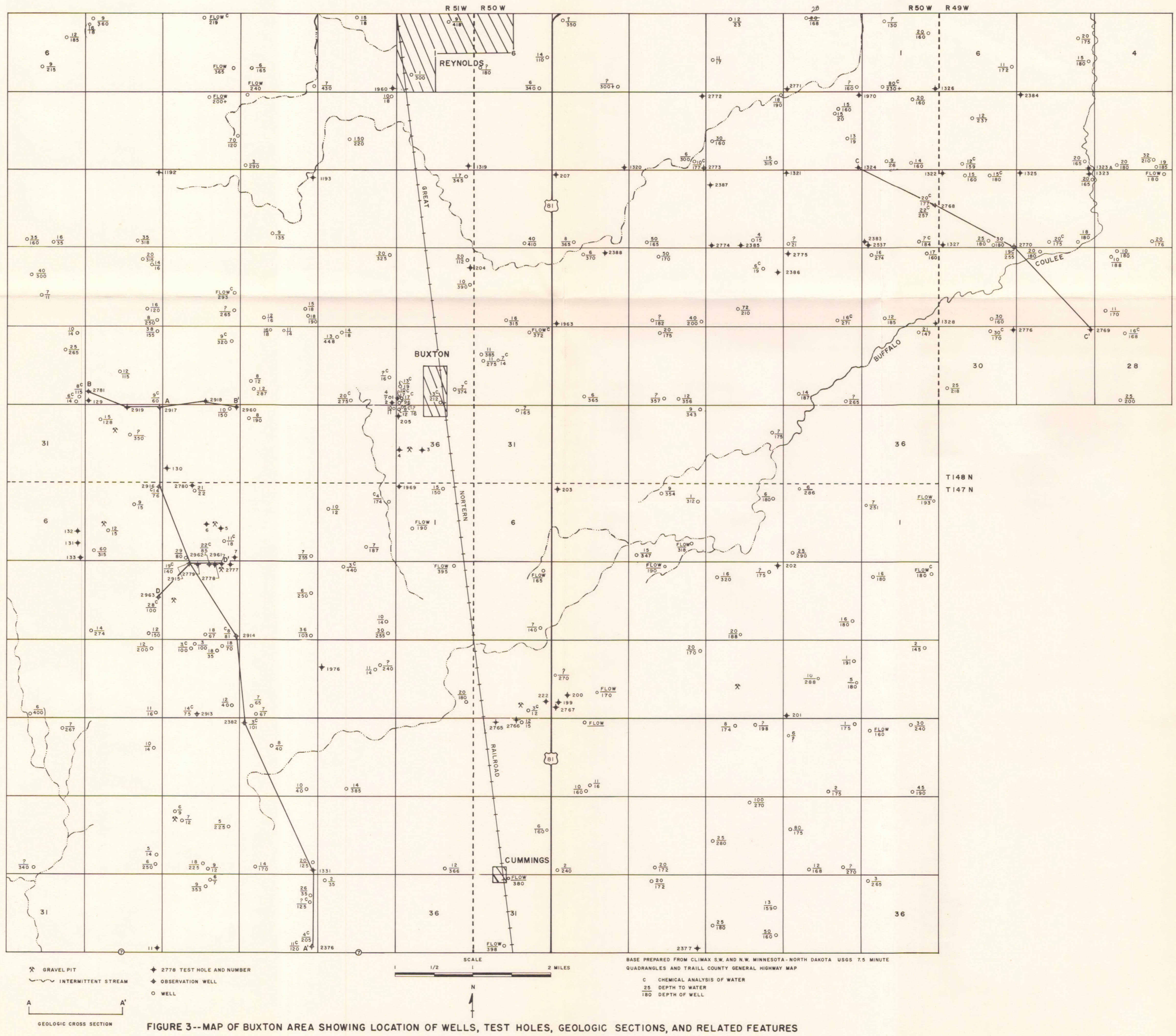

FIGURE 3--MAP OF BUXTON AREA SHOWING LOCATION OF WELLS, TEST HOLES, GEOLOGIC SECTIONS, AND RELATED FEATURES

the North Dakota State Water Commission in Bismarck and the North Dakota Geological Survey in Grand Forks. Ground-water reports on several municipalities adjacent to the Buxton area are also available.

GEOLOGY AND GROUND-WATER CONDITIONS

Preglacial History

The surficial geology of the Buxton area represents only a very small portion of the total geologic history of the region (fig. 3). Present-day topographic relief is indicative of geologic events dating back approximately 12,000 years B.P. (Before Present). However, much older sedimentary and crystalline rocks underlie the surficial glacial materials at depths ranging from 170 feet in test hole 1193 (148-51-15aaa) to 324 feet in test hole 2765 (147-50-19bab). Chronologically, the oldest rocks underlying the Buxton area are igneous and metamorphic crystalline rocks dating back more than 600 million years B.P.

Underlying the mantle of glacially derived clay, silt, sand, gravel, and boulders in the Buxton area are several hundred feet of stratified sedimentary rocks collectively termed bedrock. The sedimentary strata are underlain by an igneous and metamorphic crystalline rock complex, which is termed basement rock. The preglacial surface of northeastern Traill County may have been characterized by a broad, northward-trending valley with Precambrian age basement rocks exposed on the valley floor and younger sedimentary rocks sloping gently toward the valley from both the east and west. However, none of the test holes drilled in conjunction with the municipal investigation encountered basement rock.

The Buxton area is geographically situated on the extreme eastern edge of the Williston Basin, a structural basin containing a thick sequence of sedimentary rocks. Deposition of clay, silt, sand, and carbonate material occurred in the Williston Basin during alternating periods of submergence of the land beneath warm relatively shallow seas. Lithification of these unconsolidated materials through the processes of compaction, cementation, and mineralization produced a sequence of consolidated sandstone, limestone, and shale formations. Each distinct rock unit, which can be mapped areally and is consistent in lithologic composition, is called a formation. Two or more formations stratigraphically situated together and deposited during a similar sequence of geologic time are called a group.

Precambrian Crystalline Rocks:

The oldest rocks in the Buxton area are schists and granites of Precambrian age. None of the test holes drilled during this study encountered Precambrian rocks, but several test holes drilled in conjunction with the Traill County ground-water study penetrated into the basement material. The depth to Precambrian rocks in the Buxton area ranges from 275 feet in test hole 2377 (147-50-33ddd) to 466 feet in test hole 1193 (148-51-15aaa). Drill cuttings indicate that the basement material ranges from weathered greenish- to bluish-gray sandy and clayey igneous rock to hard, unweathered, greenish chloride and hornblende schists and greenish-gray granite. The weathered zone on the surface of the basement rocks indicates a long period of erosion prior to deposition of sedimentary strata.

Winnipeg Formation:

The Winnipeg Formation of Ordovician age immediately overlies the basement rocks only in the extreme western portion of the Buxton area. At one time the formation probably covered a much larger area but has long since been removed by erosion. In eastern North Dakota the formation is primarily a greenish-gray, fossiliferous shale underlain in places by a thin calcareous sandstone (Bluemle, 1967, p. 5). None of the test holes drilled during the current study encountered the Winnipeg Formation.

Cretaceous Undifferentiated:

Sedimentary rocks of Cretaceous age immediately underlie the cover of glacial material in the Buxton area. Six test holes drilled during the investigation encountered Cretaceous sediments. The thicknesses penetrated ranged from 6 feet in test hole 2765 (147-50-19bab) to 98 feet in test hole 2960 (148-51-33aaa). The lithologic composition of Cretaceous bedrock material indicated considerable variability from one test hole location to the next. Drill cuttings from four test holes located east of U. S. Highway 81 indicated a clayey, light bluish- to greenish-gray calcareous siltstone interbedded with fine- to medium-grained quartzose sandstone. Two test holes west of U. S. Highway 81 encountered a grayish- to brownish-black noncalcareous shale interbedded with fine- to medium-grained quartzose sandstone.

The Cretaceous bedrock in Traill County has been identified and subsequently assigned the appropriate stratigraphic nomenclature by Bluemle (1967, p. 5). He subdivides the Cretaceous sedimentary formations into the Colorado Group and the Dakota Group. The geologically younger rocks, Colorado Group, underlie approximately the western one-forth of the Buxton area while older Dakota Group rocks underlie the eastern part. During this investigation no differentiation was made and all Cretaceous materials are defined as undifferentiated.

Glacial History

The North American Continent was subjected to widespread glaciation during the Pleistocene Epoch, which lasted from approximately 1 million years to less than 10,000 years ago. Four major stages of glaciation took place during this time. They are, from oldest to youngest: Nebraskan, Kansan, Illinoian, and Wisconsinan. Each stage of glaciation is known to have been separated by an interglacial period. Three interglacial periods are recognized by some geologists. They are, from oldest to youngest: The aftonian, which occurred between the Nebraskan and Kansan glacial stages; the Yarmouth, which occurred between the Kansan and Illinoian glacial stages; and the Sangamon, which occurred between the Illinoian and Wisconsinan glacial stages.

Glaciers, in the form of large continental ice sheets, advanced southward into the Red River Valley from Canada during the Pleistocene Epoch. Glacial debris, clay- to boulder-sized material transported within the slowly moving ice, was deposited as drift during interglacial periods when moderating temperatures forced the retreat of glaciers. Three horizons of glacial drift were recognized by Bluemle (1967, p. 19) in Traill County. They are, from youngest to oldest: Horizon 1 - consisting of the silt and clay that was deposited in glacial Lake Agassiz, an underlying sandy till, a buried sequence of lake sediments, and a buried layer of sand and gravel; Horizon 2 - consisting of a gravelly till, the surface of which has been oxidized; Horizon 3 - a buried sequence of lake sediments, the surface of which is oxidized. The buried lake sediments of Horizon 3 are thought to have been deposited in conjunction with a proglacial lake environment. They are geologically older due to their low stratigraphic position and are not to be confused with the glacial Lake Agassiz sediments of Horizon 1. Test drilling during this investigation did not reveal the buried lake-sediment horizon.

Glacial drift refers to all stratified or unstratified materials deposited directly or indirectly by glacial action. Glacial drift in the Buxton area ranges in thickness from 170 feet in test hole 1193 (148-51-15aaa) to 324 feet in test hole 2765 (147-50-19bab). The mantle of glacial drift is oxidized from the surface to a minimum depth of 6 feet in test hole 2765 (147-50-19bab) and a maximum of 28 feet in test hole 2376 (147-51-34ddd).

Till and Associated Sand and Gravel Deposits:

Till is defined as an unconsolidated, unstratified, heterogeneous mixture of clay, silt, sand, gravel, cobbles, and boulders deposited directly by melting ice or by ice action with little or no transportation by water. Till, or "blue clay" as it is frequently referred to, is olive gray in color when encountered below the water table. Yellowish-brown oxidized till or "yellow clay" reflects chemical changes that have occurred in the "zone of oxidation" above the water table. Clay and silt, the two predominant constituents of till, are extremely fine grained, relatively impermeable, and will not readily yield water to wells. In the Buxton area, till is exposed at the surface west and southwest of town (fig. 4).

Sand and gravel deposits are frequently associated with till. Several test holes encountered thin lenses of sand and gravel. However, due to their small areal extent and limited recharge potential, these deposits would not yield sufficient quantities of water for a municipality. There are several large-diameter dug or bored farm wells completed in the till, but they only yield small quantities of water for domestic or stock use.

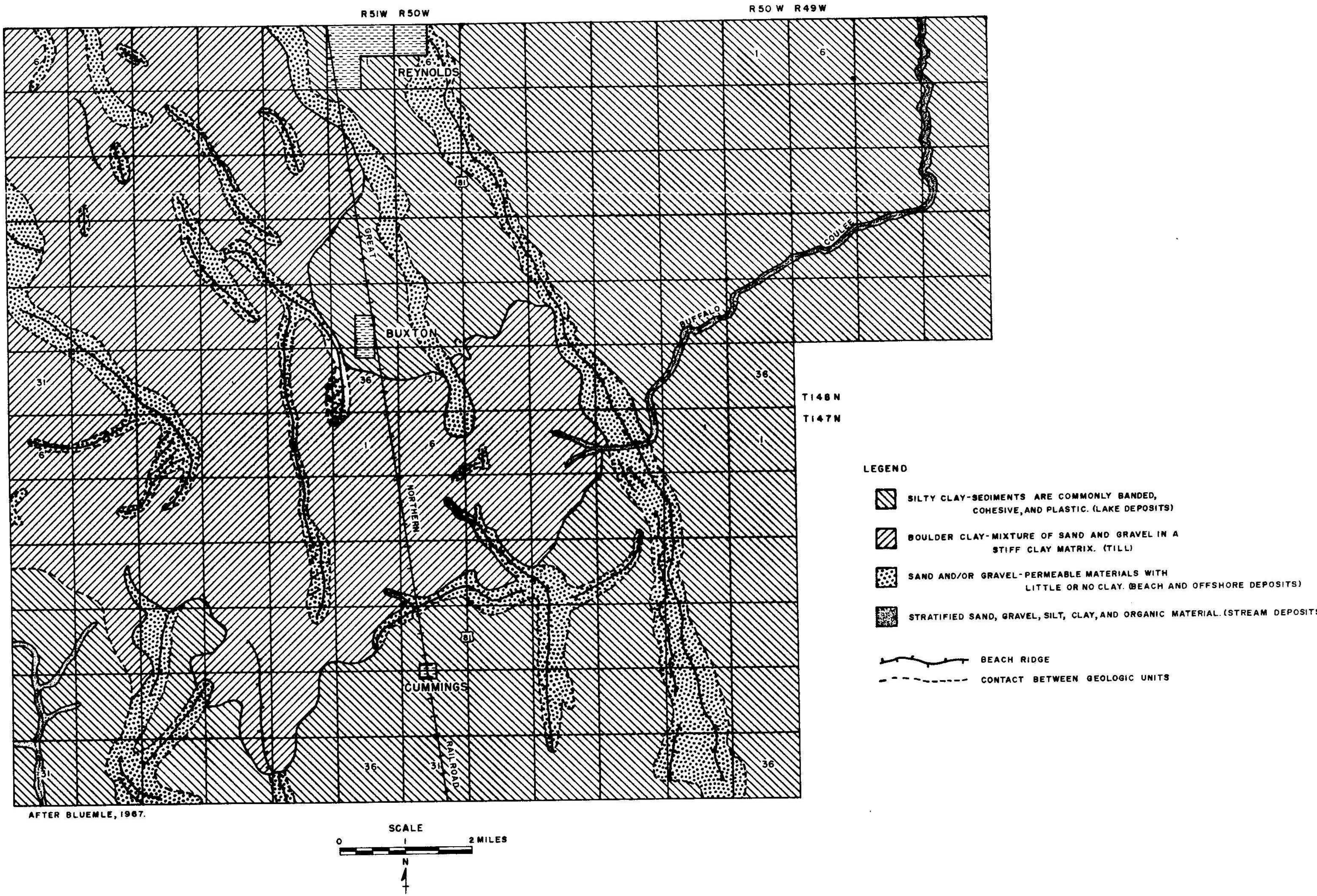

FIGURE 4--GEOLOGIC MAP OF BUXTON AREA

Buried-Channel Deposits:

Six test holes did encounter significant thicknesses of sand and gravel in an area northeast of Buxton. Test holes 1322, 1327, 2768, 2770, 2773, 2774 penetrated sand and gravel intervals ranging in thickness from 26 feet in test hole 2773 (148-50-9ddd) to 161 feet in test hole 2768 (148-50-13add). The permeable materials range in size from fine sand to coarse gravel. Stratigraphically, this deposit directly overlies Cretaceous bedrock and is overlain by a thick sequence of lake sediments (fig. 7). Deposition of the sand and gravel is believed to be proglacial and may have occurred during an interglacial period when regional drainage to the north was not blocked by ice. This channel deposit may also have been formed contemporaneously by the eroding action of melt-water issuing from a receding ice front. The deposit was in place prior to the deposition of glacial Lake Agassiz sediments.

Glacial Lake Agassiz Deposits:

Lacustrine or lake deposits occur over approximately two-thirds of the area. The predominant constituent is silty clay that is commonly laminated, banded or varved, and has a very plastic and cohesive consistency. Occasional pebbles and infrequent sandy lenses occur in the clay matrix. The banding and laminations are probably due to seasonal environmental conditions and most likely reflect fluctuations in the quantity of water flowing into the lake during summer and winter months.

Deposition of silty clay on the bottom of glacial Lake Agassiz occurred as silt and clay particles, transported into the lake by streams and rivers, gradually settled out of suspension to accumulate as sediment. Thicknesses

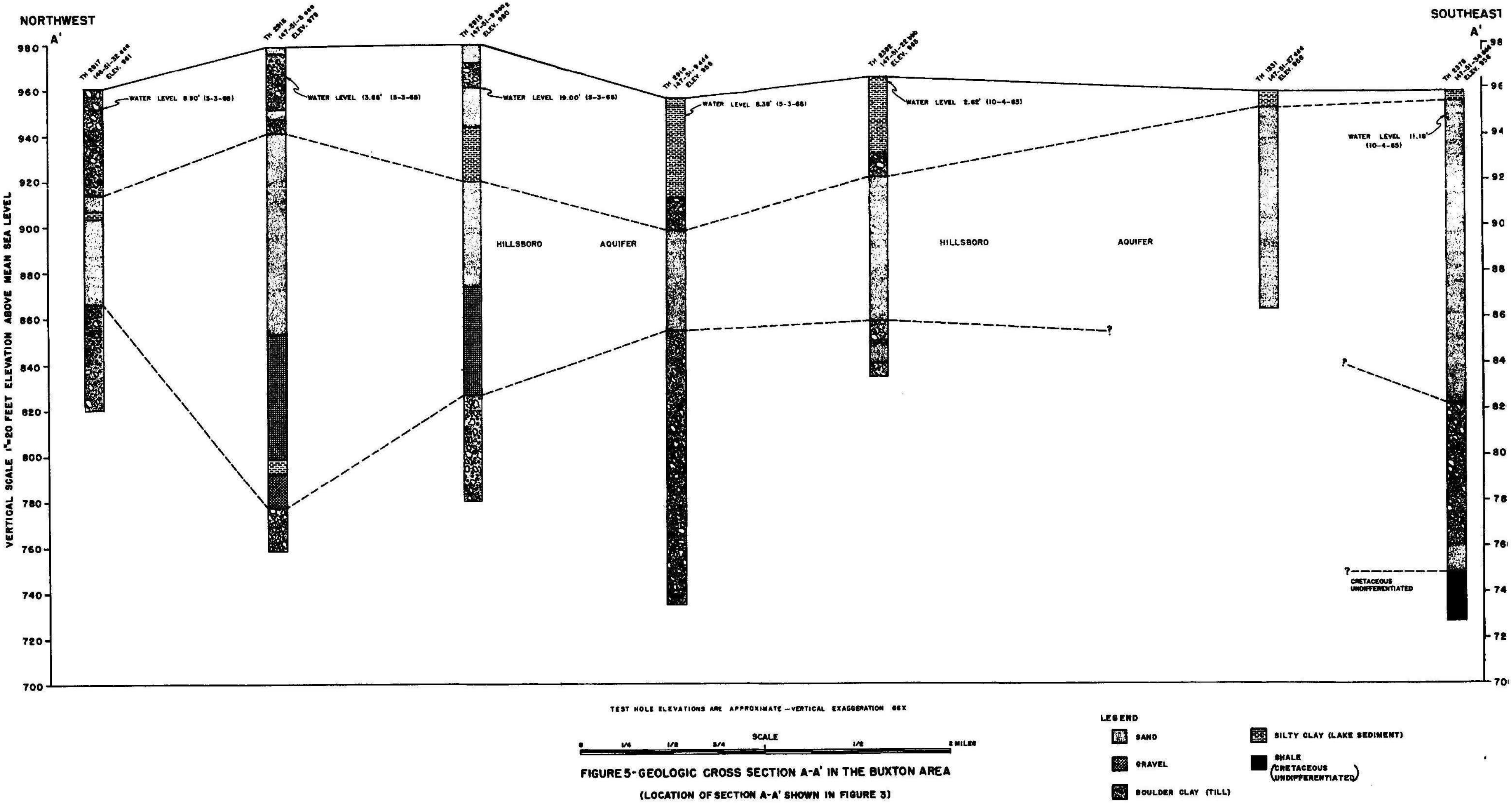

FIGURE 5 - GEOLOGIC CROSS SECTION A-A' IN THE BUXTON AREA

(LOCATION OF SECTION A-A' SHOWN IN FIGURE 3)

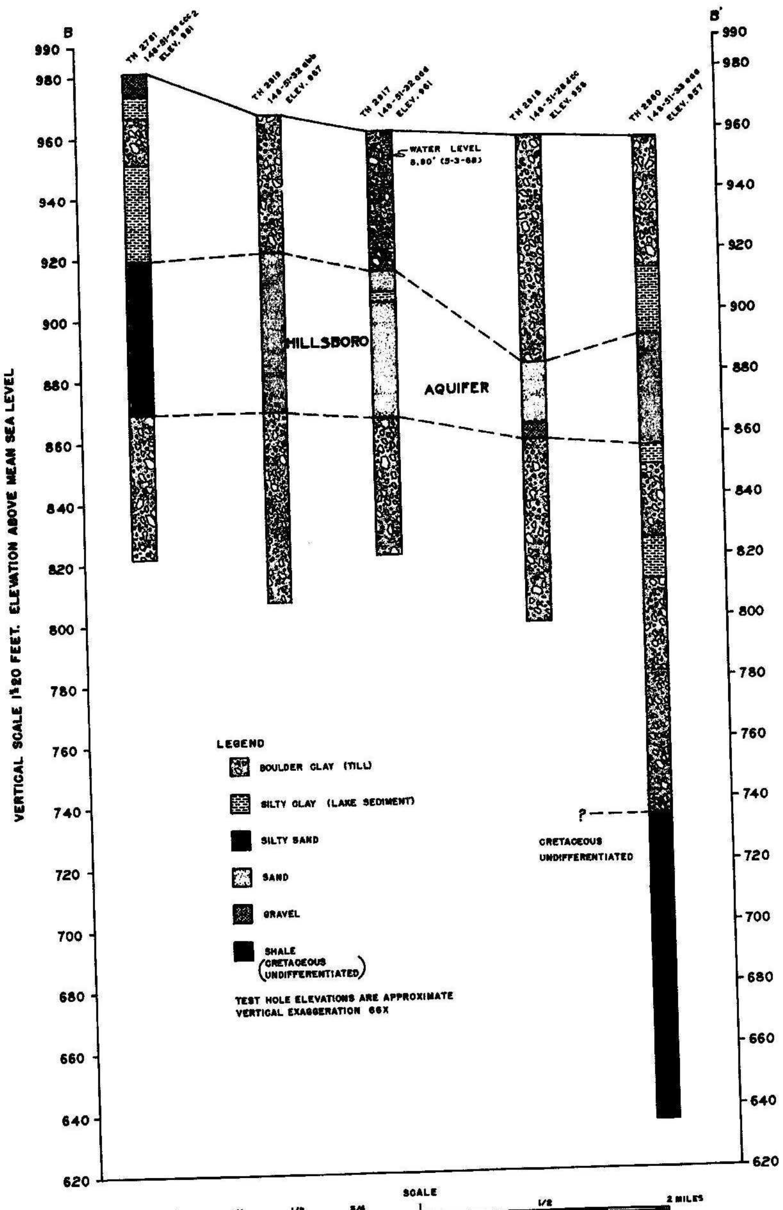

FIGURE 6-GEOLOGIC CROSS SECTION B-B' IN THE BUXTON AREA

(LOCATION OF SECTION B-B' SHOWN IN FIGURE 3)

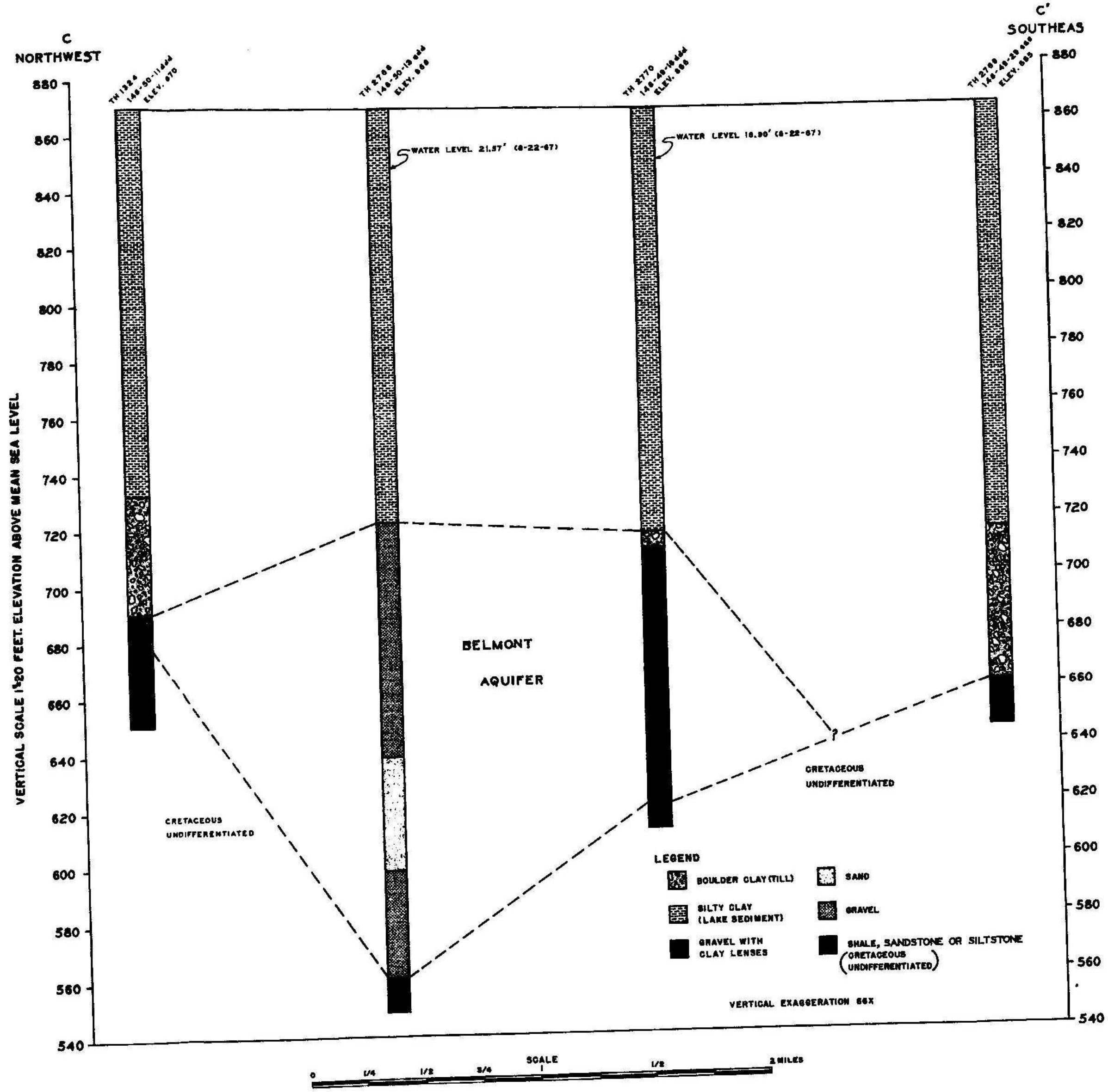

FIGURE 7-GEOLOGIC CROSS SECTION C-C' IN THE BUXTON AREA

(LOCATION OF SECTION C-C' SHOWN IN FIGURE 3) of lacustrine sediment penetrated during field exploration range from 20 feet in test hole 2962 (147-51-9aba) to 219 feet in test hole 2765 (147-50-19bab). Generally the thickness of lacustrine sediments becomes progressively greater toward the Red River, indicating that the lake was considerably deeper in this area than west of Buxton where only a few feet of silty clay was encountered.

Two phases of Lake Agassiz are recognized. Phase 1 occurred from approximately 12,500 years B.P. to 11,500 years B.P. Between 11,500 years B.P. to 10,000 years B.P. Lake Agassiz was partially drained, and about 10,000 years B.P. to 9,000 years B.P. the lake again became filled with water. The final draining of Lake Agassiz was completed about 9,000 years B.P. (Bluemle, 1967, p. 22, 26). Numerous beach and offshore deposits of sand and gravel are indicative of a fluctuation in water levels of the lake. The beach deposits are generally oriented in a northwest to southeast direction, suggesting that the lake gradually subsided from southwest to northeast. Offshore beach or bar deposits have attained a northeast to southwest directional trend, indicating that wave action resulting from prevailing westerly and northwesterly winds shaped these deposits into their present orientation. The western portion of the Buxton area contains numerous offshore bar deposits (fig. 4).

The beach and associated bar deposits are composed generally of well-sorted, rounded sand and gravel. Test drilling indicates that the sand and gravel is quite variable in thickness and ranges from a minimum of 6 feet in test hole 2767 (147-50-17ccb$_2$) to a maximum of 34 feet in test hole 7 (147-51-4ddd). There are numerous shallow farm wells constructed in the beach deposits. However, because the level of the water table in these narrow and shallow deposits is almost wholly dependent upon the local infiltration of annual precipitation, an adequate quantity of water for domestic use is not always assured.

Glaciofluvial Deposits:

This investigation revealed a significant buried deposit of sand and gravel southwest of Buxton. Several test holes completely penetrated the deposit and a considerable amount of data was compiled on thickness, lithology, areal extent, and water quality. A graphic view of the deposit is represented in cross sections A-A' and B-B' (figs. 5 and 6).

Subsurface information indicates that the deposit may be encountered at depths ranging from 4 feet bls (below land surface) in test hole 2376 (147-51-34ddd) to 78 feet bls in test hole 2963 (147-51-8add). Thickness of the sand and gravel ranges from 25 feet in test hole 2918 (148-51-28dcc) to 152 feet in test hole 2916 (147-51-5aaa). Samples of permeable materials taken during test drilling indicate a size range of very fine-grained sand to coarse gravel. Loss of drilling fluid into the sand and gravel indicated high permeability and porosity at several locations.

The buried sand and gravel appears to be part of the Hillsboro aquifer. Similarities in lithology, stratigraphic position, water quality, and water levels support this assumption. The areal extent of the Hillsboro aquifer was partially defined during the Traill County ground-water survey but escaped detection in the Buxton area. The aquifer trends generally northwest to southeast and directly underlies portions of a ridge of sand called the Hillsboro Beach. The aquifer is extremely difficult to trace on the land surface because in many places it is covered by silty lake clay or till.

Figures 5 and 6 show that the section of sand and gravel is mantled by an overlying layer of till in seven test holes and lacustrine clay in four test holes. The aquifer immediately overlies till in all test holes with the

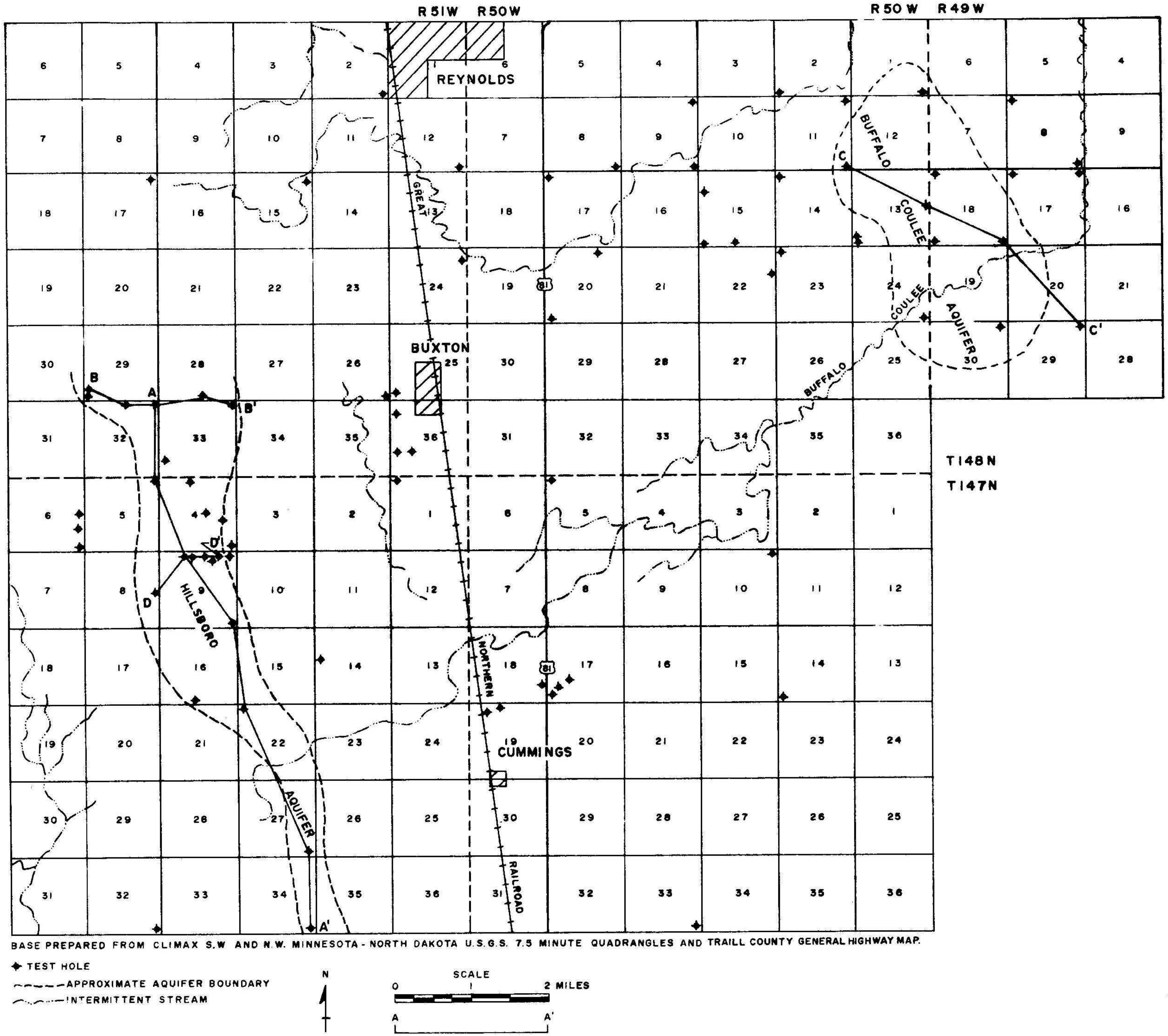

FIGURE 8--GLACIAL DRIFT AQUIFER MAP OF BUXTON AREA

possible exception of test hole 1331 (147-51-27ddd), which did not completely penetrate the aquifer. Deposition of sand and gravel in the Hillsboro aquifer probably resulted as a glacial melt-water stream eroded an irregular channel into the surface of the till. Over a period of time, sand and gravel washed into the channel, eventually filling it. A readvance and subsequent withdrawal of glacial ice deposited overlying layers of till and lacustrine clay.

Geohydrology

Subsurface exploration has revealed that almost all continental areas are underlain, at varying depths, with porous materials saturated with water. Any porous sedimentary rock or deposit of sand and gravel that will yield water to wells in sufficient quantity to be of importance as a source of supply is called an "aquifer."

Characteristics of Aquifers:

There are two fundamental types of aquifers - artesian and water table. Materials composing these two aquifer types may be lithologically similar, but differences in fluid pressure, stratigraphic position, water yielding capabilities, and conditions for recharge and discharge are dissimilar.

Artesian aquifers are permeable formations or deposits in which water is confined by impermeable strata. Water occupying pore spaces between grains in aquifers of this type is said to be under artesian conditions because water in a well tapping the aquifer rises above the top of the formation or deposit. The confined volume of material saturated with ground water is subject to hydrostatic pressure. Withdrawal of ground water from an artesian aquifer by pumping a well will lower the pressure head, but the aquifer will remain saturated if sufficient artesian head or pressure exists. The quantity of water held in storage is dependent upon the porosity and permeability of the material, the volume of water removed by pumping wells, and the rate of recharge. Numerous wells in the Buxton area are completed in sandstone formations of the Dakota Group and are under artesian conditions. In some instances the hydrostatic pressure is great enough to cause flowing wells.

If the water in an aquifer is not confined by impermeable strata, the water is considered to occur under water-table conditions. Water held in storage may be removed from a water-table aquifer by lowering the water level, as occurs in the vicinity of a well being pumped. This results in gravity drainage toward the well. The quantity of water stored is dependent upon the porosity and volume of the aquifer. The "specific yield" is the volume of water that will drain by gravity from a unit volume of saturated aquifer thickness. However, the saturated thickness of water-table aquifers is dependent upon the water-table level, which reflects seasonal changes in precipitation. Ground water in the beach deposits of the Buxton area is under water-table conditions and seasonal fluctuations in water levels are common.

Recharge and Discharge:

Recharge, water entering an aquifer, occurs when water infiltrates porous materials either by direct absorption of precipitation at the surface of an aquifer or by percolation from streams, lakes, and ponds. Recharge also occurs to a limited extent through relatively impermeable clay and silt overlying sand and gravel deposits, but the rate of recharge is slow.

Discharge, water leaving an aquifer, occurs when ground water is removed from porous materials by surface evaporation from soils, lakes, ponds, sloughs;

as transpiration from vegetation; by seepage to streams; or by springs. Discharge may also be induced through pumping wells. Some of the water removed from an aquifer for domestic, stock, and irrigation purposes may return to the aquifer in the form of recharge.

Ground-Water Potential in the Buxton Area:

Hillsboro Aquifer

Analysis of subsurface data collected during this investigation indicates that the Hillsboro aquifer southwest of Buxton is a potentially favorable area for future ground-water development. The most promising portion of the aquifer appears to be in the vicinity of test holes 2962 (147-51-9aba) and 2915 (147-51-9baa$_2$). Test hole 2962 penetrated 70 feet of very fine to fine sand from 50 feet to 120 feet bls (below land surface). Test hole 2915 penetrated 46 feet of fine to coarse sand overlying 48 feet of fine to coarse gravel from 60 feet to 154 feet bls. Several other test holes penetrated significant intervals of sand and gravel in the Hillsboro aquifer, but would not be as favorable for municipal development because of water quality.

Cross sections A-A' and B-B' (figs. 5 and 6) indicate the irregular surfaces of the upper and lower boundaries of the aquifer. The following table lists water levels in observation wells at different locations in the Hillsboro aquifer. Column 7 lists the artesian head in feet at different observation wells. The term "head," as used in this report, is the distance in feet a column of water will rise above the surface of a confined aquifer. The ground water contained in the Hillsboro aquifer is generally under artesian conditions, however, in some portions of the aquifer water-table conditions exist. This

TABLE 1 - SELECTED DATA ON OBSERVATION WELLS IN THE HILLSBORO AQUIFER IN THE BUXTON AREA

Well number	Location	*Elev. of land surface (in feet above MSL)	Water level (elev. in feet above MSL)	Date of water level measurement	Top of sand interval in which wells are completed (elev. in feet above MSL)	**Artesian head in feet (water level elev.minus sand elev.)
2916	147-51-5aaa	979	965.34	6- 6-68	941	+ 24.34
2963	147-51-8add	984	956.34	6- 6-68	906	+ 50.34
2962	147-51-9aba	975	952.75	6- 6-68	925	+ 27.75
2915	147-51-9baa$_2$	980	961.00	6- 6-68	920	+ 41.00
2914	147-51-9ddd	956	947.62	6- 6-68	898	+ 49.62
2913	147-51-16cdd	960	945.92	6- 6-68	947	- 2.92
2382	147-51-22bbb	965	962.38	10- 4-65	921	+ 41.38
2376	147-51-34ddd	958	946.82	10- 4-65	952	- 5.18
2917	148-51-32aaa	961	952.10	6- 6-68	914	+ 38.10

* Elevations are approximate values

** Positive values indicate artesian conditions; negative values indicate water-table conditions. The values are calculated using the top of the aquifer as the reference point zero.

MSL - Mean Sea Level

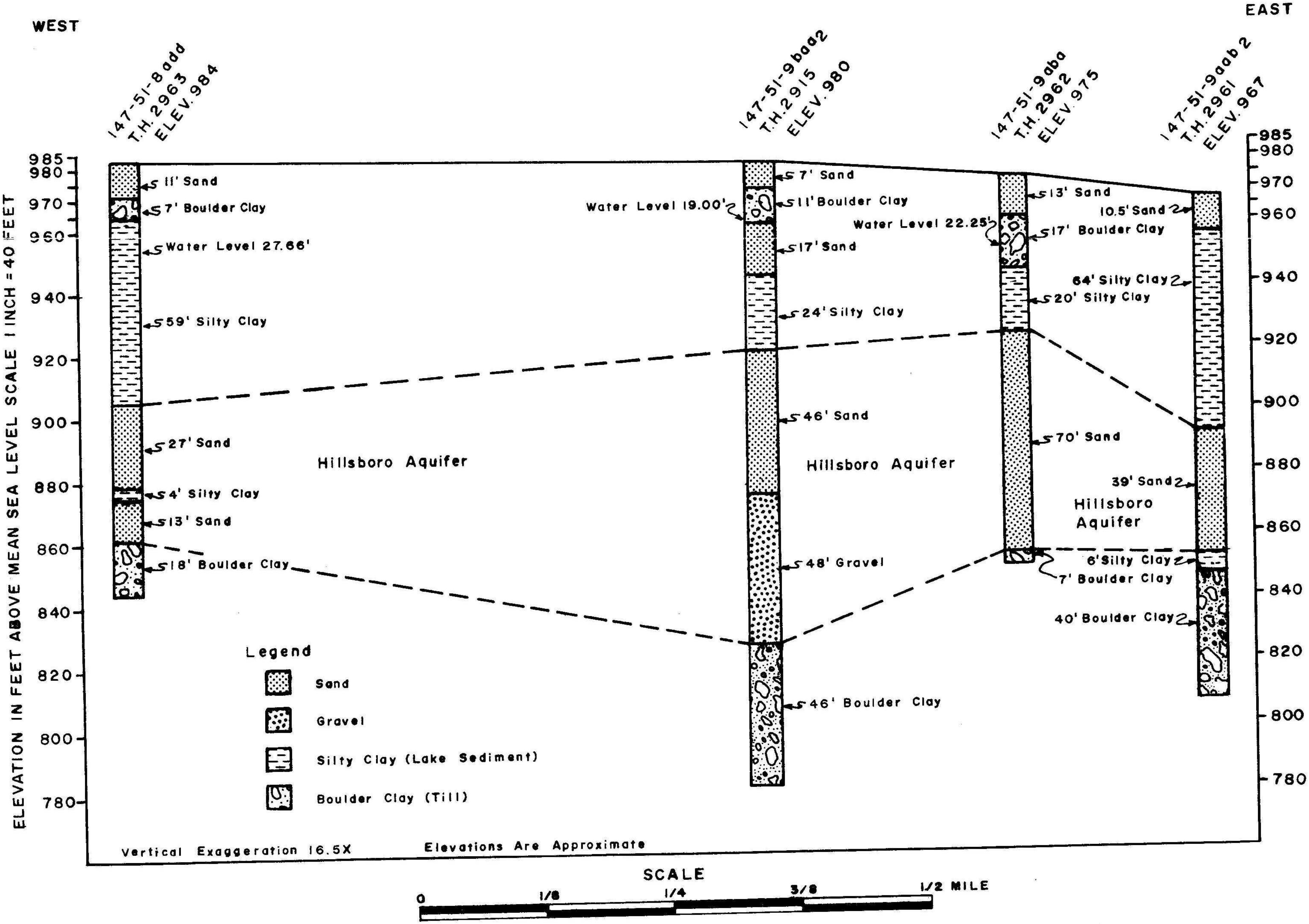

FIGURE--9 GEOLOGIC CROSS SECTION D-D' IN THE BUXTON AREA

(LOCATION OF SECTION D-D' SHOWN IN FIGURE 3) is caused by differences in elevation of the land surface, variation in stratigraphic position of permeable materials, and areas of recharge and discharge.

Figure 8 shows the approximate areal extent of the Hillsboro aquifer in the Buxton area. Cross section D-D' (fig. 9) illustrates how the aquifer body is situated stratigraphically. The aquifer pinches out rapidly to the east and west and widens northward. Lithologically, the materials generally become more coarse with depth and grade into very fine sand and silt northward and on the flanks of the aquifer. Because the gradation of particle size, the occurrence of favorable thicknesses of sand and/or gravel, and water quality are quite variable, future ground-water development in any area of the aquifer may require additional study.

Belmont Aquifer

The buried-channel deposit encountered during field exploration northeast of Buxton underlies the area shown in figure 8. Cross section C-C' (fig. 7) illustrates the stratigraphic sequence of sand and gravel penetrated in test holes 1324, 2768, 2769 and 2770. Because this buried deposit of sand and gravel covers a relatively large area, is saturated with water, and provides a number of farms with water for domestic and stock purposes, it is called the Belmont aquifer.

Large fluid losses were experienced during drilling operations at some of the test hole locations, indicating very good permeability and porosity of the sand and gravel. On the basis of current data, it is quite logical to assume the deposit would yield an adequate quantity of water for a municipality. However, the quality of water in the Belmont aquifer is inferior to water contained in the Hillsboro aquifer.

WATER QUALITY

Ground water is derived from rainfall and snowmelt. The mineral content of ground water, referred to as total dissolved solids, is related to the chemical and physical composition of rocks coming into contact with the ground water, its duration of contact, temperature, pressure, and gases and minerals already in solution.

Fifteen water samples were collected for complete chemical analysis during the investigation at Buxton. Seven of these are indicative of water quality in the Hillsboro aquifer. Eight water samples, four from observation wells and four from farm wells, indicate the quality of water in the Belmont aquifer.

The following summary gives the significance of selected constituents of water for a domestic or municipal water supply in North Dakota. (Schmid, unpublished report, March 1965):

Silica (SiO_2):

No physiological or esthetic significance.

Iron (Fe):

Over 0.3 ppm (parts per million) iron may cause staining of laundry fixtures. Over 0.5 ppm may be tasted by persons unaccustomed to water with a high iron content. A water with a high iron content will adversely affect the taste of coffee and tea made from such water. Iron removal systems are available.

Calcium and Magnesium (Ca) and (Mg):

Are the primary causes of hardness. Over 125 ppm magnesium may have a laxative effect on persons unaccustomed to this type of water.

Sodium (Na):

No physiological or esthetic significance except for persons on salt-free diets.

Potassium (K):

Small amounts are essential to animal nutrition.

Bicarbonate and Carbonate (HCO_3) and (CO_3):

No definite significance in natural water; there are, however, certain standards to be maintained in water treatment plants. A water with high bicarbonate content will tend to have a flat taste.

Sulfate (SO_4):

A 250 ppm limit is set by the U. S. Public Health Service; however, a survey by the North Dakota State Department of Health indicates no laxative effect is noticed until sulfates reach 600 ppm. Over 750 ppm there is generally a laxative effect. The following is a classification established by the North Dakota State Department of Health:

0 - 300 ppm SO_4	Low
300 - 700 ppm SO_4	High
Over 700 ppm SO_4	Very High

Chloride (Cl):

Over 250 ppm may taste salty to persons unaccustomed to high concentrations. People may become accustomed to higher concentrations.

Fluoride (F):

It is believed to prevent decay in children's teeth within the limits of 0.9 to 1.55 ppm in North Dakota. Higher concentrations may cause mottled teeth.

Nitrate (NO_3):

Over 45 ppm can be toxic to infants, much larger concentrations can be tolerated by adults. Nitrate in excess of 200 ppm may have a deleterious effect on livestock health.

Boron (B):

No physiological or esthetic significance.

Total Dissolved Solids:

A limit of 500 to 1,000 ppm is set by the U.S. Public Health Service; persons may become accustomed to water containing 2,000 ppm or more total dissolved solids. The following is a classification established by the North Dakota State Department of Health survey:

0 - 500 ppm	Low
500 - 1,400 ppm	Average
1,400 - 2,500 ppm	High
Over 2,500 ppm	Very High

Hardness:

Calcium and magnesium are the primary causes of hardness. Hardness which increases soap consumption can be removed by a water softening system. The following is a general hardness scale established by the North Dakota State Department of Health:

0 - 200 ppm (as $CaCO_3$)	Low
200 - 300 ppm (as $CaCO_3$)	Average
300 - 450 ppm (as $CaCO_3$)	High
Over 450 ppm (as $CaCO_3$)	Very High

pH:

Should be between 7.0 and 9.0 for domestic consumption.

Percent Sodium; Sodium Adsorption Ratio; Specific Conductance:

Are factors used in determining irrigation feasibility.

Ground-water quality in the Buxton area is variable. Chemical analyses of water samples from the Hillsboro aquifer indicate total dissolved solids range from 426 ppm (parts per million) in test hole 2914 (147-51-9ddd) to 3,850 ppm in test hole 2917 (148-51-32aaa). Water quality in the Hillsboro aquifer can be summarized as low to very high in hardness, low to very high in sulfates, and average to very high in total dissolved solids. The dissolved iron content ranges from 0.10 ppm in test holes 2962 (147-51-9aba) and 2915 (147-51-9baa$_2$) to 5.20 ppm in a farm well (147-51-16bab$_2$). Quality of water changes from location to location in the aquifer and varies with well depth, indicating chemical stratification. The water quality ranges from a calcium bicarbonate sulfate type of water in upper portions of the aquifer to a sodium bicarbonate sulfate type in lower portions of the aquifer.

The quality of ground water in the Belmont aquifer ranges from 1,200 ppm total dissolved solids in a farm well (148-49-30aba) to 4,420 ppm in test hole 2768 (148-50-13add$_2$). Water contained in the aquifer is a sodium chloride type and is high to very high in hardness, low to very high in sulfates, and average to very high in total dissolved solids. Chemical stratification resulting in a deterioration in water quality with depth is also present in the Belmont aquifer.

TABLE 2 - CHEMICAL ANALYSES

(Analytical results in parts per million except as indicated)

Location	Well depth (feet)	Aquifer	Date of collection	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Total dissolved solids	Total hardness As $CaCO_3$	Total hardness Noncarbonate	Percent sodium	Sodium-adsorption ratio	Specific conductance (micromhos at 25°C)	pH	Source* of analysis	Analysis** by
147-50-12aad	180	Sand	3-27-59	27	1.60	178	73	895	21	256	0	1,080	984	0.5	8.6	2.30	3,400	744	534	72	14	5,170	7.0	TC	USGS
147-50-18dcd	12	Sand & Gravel	10- 6-65	28	0.60	75	42	8.2	28	452	222	22	12	0.2	0.1	0.06	438	358	0	4	0.2	726	8.0	TC	USGS
147-51-2adc	174		10- 8-46		3.60	27	7	423		405	34	283	376				1,553	96						B	SLD
147-51-4dac	18		10-15-46		1.20	81	11	46		359	22	349	114				1,235	250						B	SLD
147-51-5aaa	76	Sand	5- 7-68	27	2.20	111	44	170	16	480	0	299	102	0.9	1.0	0.73	990	460	66	44	3.5	1,500	8.2	CR	SLD
147-51-8add	100	Sand	6- 6-68	28	0.24	157	42	263	14	355	0	475	284	0.0	0.0	1.00	1,410	565	274	50	4.8	2,180	7.9	CR	SLD
147-51-9aba	85	Sand	6- 5-68	29	0.10	90	22	120	11	435	0	119	81	0.2	2.0	0.59	670	314	0	44	2.9	1,100	8.1	CR	SLD
147-51-9baa2	140	Gravel	5- 3-68	28	0.10	32	6.1	241	11	416	0	229	44	0.6	1.0	0.44	814	105	0	81	10	1,210	8.2	CR	SLD
147-51-9ddd	81.5	Sand	5- 2-68	27	1.20	84	23	35	5.3	357	0	36	42	0.3	0.0	0.20	426	306	13	20	0.9	713	8.2	CR	SLD
147-51-11bab	440		10- 8-46		4.40	140	23	1,207		200	7	1,360	1,633				5,375	213						B	SLD
147-51-16bab2	100	Sand	10-18-65	27	5.20	128	65	60	6.4	356	0	285	81	0.3	0.1	0.18	833	585	293	18	1.1	1,270	7.6	TC	USGS
147-51-16cdd	75.5	Sand	5- 2-68	24	0.92	195	53	205	13	368	0	506	254	0.3	0.0	0.83	1,540	705	403	38	3.4	2,130	8.0	CR	SLD
147-51-22bbb	100	Sand	8- 9-65	17	0.36	101	38	582	20	314	0	800	458	2.2	2.2	1.9	2,180	408	151	74	13	3,280	8.0	TC	SLD
147-51-34ada2	125		7-11-58		0.8	95	40	61	6.5	282	0	149	130	0.2	1.6	0.1	694	400	169	24	1.3		7.6	TC	SLD
147-51-34ddd1	120	Sand & Gravel	8- 2-65	16	0.98	196	63	712	22	283	0	1,130	667	1.0	2.1	2.1	2,950	750	519	67	11	4,200	7.6	TC	SLD
147-51-34ddd2	205	Sand & Gravel	8- 2-65	18	1.7	129	40	996	16	349	0	1,240	818	0.7	1.1	3.5	3,440	485	199	81	20	5,140	7.7	TC	SLD
148-49-7ccd	159	Sand	10- 6-65	19	2.6	80	33	174	9.6	289	142	70	293	0.4	2.8	0.77	827	336	99	52	4.1	1,510	7.9	TC	USGS

TABLE 2 - CHEMICAL ANALYSES (cont.)

(Analytical results in parts per million except as indicated)

Location	Well depth (feet)	Aquifer	Date of collection	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Total dissolved solids	Total hardness As $CaCO_3$	Total hardness Noncarbonate	Percent sodium	Sodium-adsorption ratio	Specific conductance (micromhos at 25°C)	pH	Source* of analysis	Analysis** by
148-49-17cdd	175	Sand	11- 3-67	27	1.8	106	33	419	14	308	0	340	522	1.1	3.5	1.1	1,620	401	149	69	9.1	2,680	7.6	CR	SLD
148-49-18aab	180	Sand	11- 3-67	26	0.74	115	41	500	10	239	0	364	727	1.2	0.0	0.81	1,910	455	259	70	10	3,220	7.7	CR	SLD
148-49-18bbb	230		6-11-58		0.48	83	39	245	11	282	22	179	309	0.4	2.7	1.1	1,120	370	102	58	5.5		8.3	TC	SLD
148-49-18ddd	255	Gravel	8-20-67	24	0.40	117	30	795	19	258	0	628	942	1.0	0.0	1.5	2,700	414	203	80	17	4,360	7.6	CR	SLD
148-49-28bab	168	Sand	6-21-66	28	2.2	77	31	110	7.5	545	0	62	32	0.3	2.7	0.94	650	318	0	42	2.7	1,060	7.4	TC	SLD
148-49-30aba	170	Gravel	11- 3-67	27	3.7	110	35	255	8.9	329	0	228	348	0.8	3.0	0.55	1,200	419	150	56	5.4	1,970	7.6	CR	SLD
148-50-1cdc	230+	Sand	6-21-66	1.0	6.3	78	41	1,140	21	68	0	612	1,600	0.2	2.4	2.0	3,430	363	308	86	26	5,770	8.2	TC	SLD
148-50-9ddd	177	Gravel	8-21-67	26	3.4	295	98	892	16	232	0	875	1,460	0.2	0.0	1.1	3,740	1,140	951	63	12	5,850	7.6	CR	SLD
148-50-13add$_1$	177	Sand & Gravel	8-19-67	25	0.76	172	37	303	16	336	0	248	524	0.2	0.0	0.55	1,500	581	306	52	5.5	2,510	7.3	CR	SLD
148-50-13add$_2$	257	Sand & Gravel	8-19-67	25	2.2	251	85	1,130	25	270	0	1,080	1,520	0.7	0.0	1.9	4,420	975	754	71	16	6,490	7.6	CR	SLD
148-50-13dcd	184	Sand	11- 3-67	25	3.1	268	76	1,110	28	280	0	1,130	1,440	2.3	0.0	1.7	4,210	983	754	70	15	6,550	7.6	CR	SLD
148-50-22adb	19	Sand	6-17-58		0.6	62	31	4.0	3.0	324	0	37	0.0	0.3	4.3	0.2	372	280	14	3	0.1		7.7	TC	SLD
148-50-23dcc	271	Sand	6-21-66	9.1	7.5	197	94	652	18	152	0	667	1,090	0.3	12	1.2	3,100	878	754	61	9.6	4,590	7.1	TC	SLD
148-50-30abb	372		10-15-46		0.3	63	13	966		212	31	1,293	816				3,592	213						B	SLD
148-50-30bcd	14		10-15-46		0.9	60	10	0.0		243	22	124	50				789	189						B	SLD
148-51-4baa	219	Sand	8-15-58		0.6	487	339	1,044	44	204	30	1,431	1,011	1.8	1.8	2.4	4,063	826					8.3	R	SLD
148-51-21daa	293	Sand	10- 2-46		1.0	264	124	862		244		1,470	930				4,004	1,100						B	SDH

TABLE 2 - CHEMICAL ANALYSES (cont.)

(Analytical results in parts per million except as indicated)

Location	Well depth (feet)	Aquifer	Date of collection	Silica (SiO_2)	Total iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Total dissolved solids	Total hardness As $CaCO_3$	Total hardness Noncarbonate	Percent sodium	Sodium-adsorption ratio	Specific conductance (micromhos at 25°C)	pH	Source* of analysis	Analysis** by
148-51-25ccc$_1$	17		6-24-21		Trace	56	18	6.9		232	0.0	24	2.0				250	214						B	S
148-51-25ccc$_2$	19		1937?		0.6	87	25	3		278		64	8.3				345	276						B	A&V
148-51-25ccc$_3$	10		10- 2-46		0.08	230	46	90		402		108	375				1,196	764						B	SDH
148-51-25dac	374		10-15-46		1.0	126	23	1,286		146	26	1,331	1,721				5,145	410						B	SLD
148-51-25dcd	212		1937?		4.8	261	88	1,302		312		1,340	1,551				4,825	1,020						B	A&V
148-51-26cdd	275		10- 8-46		8.4	50	10	491		344	38	525	472				2,109	164						B	SLD
148-51-26dda	16		10- 8-46		0.9	172	41	229		856	0.0	801	518				3,871	598						B	SLD
148-51-28aad	320		10- 2-46		1.0	236	55	968		249		1,363	765				3,690	825						B	SDH
148-51-30ddd$_1$	115		10-15-46		1.4	30	5	226		134	22	86	376				978	96						B	SLD
148-51-30ddd$_2$	14		10-15-46		0.4					151	22	131	43				800	419						B	SLD
148-51-32aaa	61	Sand	5- 7-68	25	4.0	232	72	914	31	249	0	1,360	908	1.8	0.0	2.6	3,850	877	673	68	13	5,240	8.1	CR	SLD
148-51-36bbb$_1$	16		10- 2-46		0.0	80	34	0.1		249		76	20				354	340						B	SDH

* B - Buxton Report --- Dennis, 1947.
CR - Current Report
R - Reynolds Report --- Jensen, 1962.
TC - Traill County Report --- Jensen, 1967.

** A&V - Abbott and Voedisch, 1938.
S - Simpson, 1929.
SDH - State Department of Health, Bismarck, North Dakota.
SLD - State Laboratories Department, Bismarck, North Dakota.
USGS - U. S. Geological Survey, Quality-of-Water Branch, Lincoln, Nebraska.

CONCLUSION AND RECOMMENDATION

Subsurface and water quality data indicate that the Hillsboro aquifer exhibits favorable potential as a future source of water for the municipality of Buxton. This data also indicates that secs. 5, 8, and 9, T. 147 N., R. 51 W. constitute the most favorable area of the aquifer. Straight-line distances from the city of Buxton to the Hillsboro aquifer in secs. 5, 8, and 9 are approximately 3.50 to 3.75 miles.

Cross section D-D' (fig. 9) graphically illustrates the variability of aquifer thickness in secs. 8 and 9, T. 147 N., R. 51 W. It is recommended that the aquifer be completely penetrated if a city well is installed in this area. Complete penetration of the aquifer during initial installation of a well would eliminate the possibility of deepening the well should water levels decline, after excessive pumping, to a point where the aquifer may be dewatered to well screen depth. This area appears most favorable because of water quality. Chemical analyses of ground water at test holes 2962 (147-51-9aba) and 2915 (147-51-9baa$_2$) indicate only a slight variation in parts per million of total dissolved solids (670 ppm at test hole 2962 vs. 814 ppm at test hole 2915). Dissolved iron content is 0.10 ppm at both locations and is acceptable for domestic and culinary use.

The Hillsboro aquifer in this area should provide a sufficient quantity of water for the city of Buxton. Any changes in the quality of ground water withdrawn from this portion of the aquifer would be negligible.

TABLE 3 - RECORDS OF WELLS AND TEST HOLES

Depth to water: Measured water levels in feet and tenths or hundredths; reported water levels in feet.

Type of well: Dr, drilled; Du, dug; Dv, driver; Bo, bored.

Depth of well: Measured depths in feet and tenths; reported depths in feet.

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

Remarks: C, chemical analysis; gpm, gallons per minute; SC, specific conductance in micromhos per centimeter at 25°C.

Location no. (1)	Owner (2)	Depth (feet) (3)	Diameter (inches) (4)	Type (5)	Date completed (6)	Depth to water below land surface (feet) (7)	Date of measurement (8)	Use of water (9)	Aquifer (10)	Remarks (11)
147-50-1aad	Leonard Boyer	193	3	Dr	1938	Flow	6-18-58	D	Sand	
147-50-1bcb	Theodore Wheeler	251	4	Dr	1937	7	6-18-58	D,S	Sand	
147-50-2bba$_1$	Eunice Johnson	286	2	Dr	1942	6	6-19-58	D,S	Sand	
147-50-2bba$_2$	Eunice Johnson	285		Dr	1915	16	6-19-58	U		
147-50-2ccc	Lars Smette	290	2	Dr	1952	25	6-19-58	S		SC 5,880
147-50-3aac	Ruben Gunderson	180	2	Dr	1939	6	6-19-58	D,S	Sand	
147-50-4ada	Lynn Nettum	312	2	Dr	1951	1	6-19-58	S	Sand	
147-50-4baa	Stanley Lerom	354	3	Dr		9	6-19-58	D,S	Sand	
147-50-4ccd	Wallace Nygaard	347	2	Dr	1945	15	6-19-58	S	Sand	SC 7,300

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
147-50-4dac	John Seablom	318	2	Dr	1957	Flow	9-17-57	S	Sand	SC 6,000
147-50-5bbb	Test Hole 203	12	4 3/4	Dr	1960		6-27-60	T		See Log
147-50-7aaa	Ted Matson	165	2	Dr	1946	Flow	7- 5-60	S	Sand	
147-50-7ddc	Obort Hettervig	140	2	Dr	1950	7.2	6-30-60	S	Sand	
147-50-9baa	E. B. Tilton	190	2	Dr		Flow	6-19-58	S	Sand	
147-50-10aa	Clarence Finneseth	175		Dr				D,S	Sand	SC 3,720
147-50-10aaa	Test Hole 202	22	4 3/4	Dr	1960			T		See Log
147-50-10bbc	Christ N. Smith	320	2	Dr	1948	16	6-18-58	S	Sand	SC 5,880
147-50-10cdd	Duane Davis	188	2	Dr	1954	20	9-17-57	D,S	Sand	
147-50-11dad	Art Jeglum	180	2	Dr	1937	16	6-18-58	D,S	Sand	
147-50-12aad	Estella Mohn	180	3	Dr		Flow	6-18-58	D,S	Sand	C
147-50-12bcb	Benny Johnson	180+	2	Dr	1890	16	9-17-57	S	Sand	
147-50-13aba	E. Johnson	145	2	Dr		2	9-17-57	D,S	Sand	
147-50-14ada	William Tronson	191	2	Dr	1957	1	9-17-57	S	Sand	
147-50-14bdd	Heller Halvorson	288	2	Dr	1952	10	6-18-58	S	Sand	
147-50-14ccc	Test Hole 201	30	4 3/4	Dr	1960			T		See Log
147-50-14daa	Art Jeglum	180	2	Dr	1946	5	6-18-58	D,S	Sand	
147-50-16aad	Andreas Jorstad	170		Dr	1939	20	6-19-58	D,S	Sand	
147-50-17bcc	Kenneth O. Lilleberg	270		Dr				S	Sand	SC 4,800

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
147-50-17cbc	Test Hole 200	22	4 3/4	Dr	1960			T		See Log
147-50-17ccb$_1$	Test Hole 199	27	4 3/4	Dr	1960		6-24-60	T		See Log
147-50-17ccb$_2$	Test Hole 2767	20	4 3/4	Dr	1967			T		See Log
147-50-17dbc	Rueben Gunderson	170	1 1/4	Dr	1918	Flow	6-19-58	D,S	Sand	
147-50-18dcd	Ansgar Bjerkland	12	84	Du	1964	3.0	8-26-65	PS	Sand & Gravel	C
147-50-18dda	Test Hole 222	112	4 3/4	Dr	1961		8-17-61	T		See Log
147-50-19abb$_1$	Wilson & Crane	15	36	Du		12	6-29-60	D	Sand & Gravel	
147-50-19abb$_2$	Wilson & Crane	15.35	30	Du	1910	12.25	6-30-60	D,S	Sand & Gravel	
147-50-19abb$_3$	Wilson & Crane	16.20	72	Du	1936	10.34	6-30-60	S	Sand & Gravel	
147-50-19abb$_4$	Test Hole 2766	20	4 3/4	Dr	1967			T		See Log
147-50-19bab	Test Hole 2765	330	4 3/4	Dr	1967			T		See Log
147-50-20baa	Harvey Lilleberg			Dr		Flow	6-20-58	S	Sand	
147-50-20cdd$_1$	Christ Smith	160	2	Dr		10	6-20-58	D,S	Sand	
147-50-20cdd$_2$	Christ Smith	16	48	Du		11	6-20-58	U	Sand	Inadequate Supply
147-50-22abb	Melvin Waslien	198	4	Dr	1918			S	Sand	
147-50-22bba	Rudolph Lilleberg	174	2	Dr	1955	8	6-19-58	S	Sand	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
147-50-23aaa	Henry Pauls	175	3	Dr	1938	1	6-19-58	S	Sand	
147-50-23bbc	Ole Anderson		2	Dr	1920	6	6-19-58	U		
147-50-23dcc	Carl W. Olson	175	2	Dr	1937	2	6-19-58	S	Sand	
147-50-24abb	Bennet Mohn	240	2	Dr	1954	30	6-19-58	S	Sand	SC 6,000
147-50-24bbc	Inga Gunderson	160	2	Dr	1942	Flow	6-19-58	S	Sand	
147-50-24ddc	M. B. Johnson	190	2	Dr	1926	45	6-19-58	S	Sand	
147-50-26bcc	Frank B. Cecka	175	1 3/4	Dr		80	7- 1-58	S	Sand	
147-50-26cdc	Gilbert Gunderson	168	2	Dr	1950	12	6-26-58	S	Sand	
147-50-26ddc	Ervin Lilleberg	270	2	Dr				S	Sand	
147-50-27abb	James Enger	270	2	Dr	1952	100	6-19-58	S	Sand	
147-50-27cbb	Julian Harstad	280	2	Dr	1943	25	6-26-58	S	Sand	
147-50-28cdc	John Kozojed	172	3	Dr	1932	20	6-26-58	D,S		SC 3,120
147-50-29ccc	L. H. Ross	240	3	Dr	1923	2	6-27-58	S	Sand	
147-50-30add	Lyng Brothers	160	3	Dr		6	6-29-60	S	Sand	
147-50-31baa	Earl Mueller	380		Dr	1952	Flow	1952	S	Sand	Flows 0.5 gpm
147-50-31cdd	L. T. Rohman	398	3	Dr	1950	Flow	7-11-58		Sand	SC 5,040 Flows 3 gpm
147-50-33bab	Percy Foss	172	3	Dr		20	6-26-58	D,S		SC 3,720
147-50-33ddd	Test Hole 2377	276	5	Dr	1965			T		See Log
147-50-34add	Walter H. Vettel	159	3	Dr	1918	13	6-26-58	D,S	Sand	
147-50-34cbb	Oscar Holland	180	2	Dr		25	6-26-58	S	Sand	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
147-50-34dda	Paul Smith	160	2	Dr		50	6-27-58	S	Sand	
147-50-36bbb	Mrs. Clara Anderson	265	2	Dr		3	6-19-58	S		
147-51-1aba	Waldemar Huus	150	1	Dr		15	7- 5-60	S	Sand	
147-51-1bbb	Test Hole 1969	210	5	Dr	1961			T		See Log
147-51-1cba	Alvin Molvig	190	2	Dr	1945	Flow	7- 1-60	S	Sand	
147-51-2adc	J. Soderberg	174	2	Dr		4.01	8- 8-46	S		C
147-51-2bdb	Milton Eliason	12	24	Du		10	7- 5-60		Sand	
147-51-2dbc	E. Larson	187	2	Dr	1915	7	1946	S		
147-51-3ddd	Adolph Soderberg	255	2	Dr	1934	7	7- 5-60	S	Sand	
147-51-4bab$_1$	Howard Spaeth	22	36	Du		20.8	8-15-60	D,S		
147-51-4bab$_2$	Test Hole 2780	60	4 3/4	Dr	1967			T		See Log
147-51-4cdc	A. M. Birkeland	80	3	Dr	1936	29.4	8-15-46	D,S		SC 1,400
147-51-4dac	J. Seablom	18.0	8	Bo	1936	11.19	8-15-46	D		C
147-51-4dba	Test Hole 5	45	4 3/4	Dr	1946			T		See Log
147-51-4dbb	Test Hole 6	39	4 3/4	Dr	1946			T		See Log
147-51-4ddd	Test Hole 7	52	4 3/4	Dr	1946			T		See Log
147-51-5aaa	Test Hole 2916	76	1 1/4	Dr	1968	13.66	5- 3-68	T	Sand	See Log, C, Observation Well
147-51-5acb	Theodore Enrud	15		Du	1953	9	7- 1-60	D,S	Sand & Gravel	
147-51-5caa	Alvin Balkan	15	72	Du	1930	12	7- 1-60	D,S	Sand & Gravel	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
147-51-5ccb	Theodore Enrud	315	2	Dr	1935	60	7- 1-60	S	Sand	
147-51-6dad	Test Hole 132	22	4 3/4	Dr	1960			T		See Log
147-51-6dda	Test Hole 131	22	4 3/4	Dr	1960			T		See Log
147-51-6ddd	Test Hole 133	20	4 3/4	Dr	1960			T		See Log
147-51-8add	Test Hole 2963	100	1 1/4	Dr	1968	27.66	6- 6-68	T	Sand	See Log, C, Observation Well
147-51-8ccb	Lawrence Devold	274	2	Dr	1939	14	7- 5-60	S	Sand	
147-51-8dcd	Albert Lunde	150	2	Dr		12	7- 1-60	S	Sand	SC 4,800
147-51-9aaa	Test Hole 2777	40	4 3/4	Dr	1967			T		See Log
147-51-9aab$_1$	Test Hole 2778	40	4 3/4	Dr	1967			T		See Log
147-51-9aab$_2$	Test Hole 2961	160	4 3/4	Dr	1968			T		See Log
147-51-9aba	Test Hole 2962	85	1 1/4	Dr	1968	22.25	6- 6-68	T	Sand	See Log, C, Observation Well
147-51-9baa$_1$	Test Hole 2779	40	4 3/4	Dr	1967			T		See Log
147-51-9baa$_2$	Test Hole 2915	140	1 1/4	Dr	1968	19.00	5- 3-68	T	Gravel	See Log, C, Observation Well
147-51-9dcc	E. Olson	67	3	Dr	1930	18	6-30-60	D,S	Sand	
147-51-9ddd	Test Hole 2914	81.5	1 1/4	Dr	1968	8.38	5- 3-68	T	Sand	See Log, C, Observation Well
147-51-10ada	O. C. Nydahl	250	2	Dr	1929	6	7- 1-60	S	Sand	
147-51-10ddd	Peder O. Foss	103	2	Dr	1925	36	6-30-60	S	Sand	SC 3,600
147-51-11bab	Hilma Eliason	440	2	Dr	1942	3	1946	S		C
147-51-11ddb$_1$	C. Moger	14	36	Du	1937	10	6-30-60	D	Sand & Gravel	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
147-51-11ddb$_2$	C. Moger	14	48	Du	1937	8	6-30-60	S	Sand & Gravel	Inadequate Supply
147-51-11ddd$_1$	C. Moger	255	3	Dr	1905	30	6-30-60	S	Sand	
147-51-11ddd$_2$	C. Moger	15	36	Du	1905	12	6-30-60	D	Sand & Gravel	Inadequate Supply
147-51-12aab	Gilbert M. Spillum	395	2	Dr	1945	Flow	7- 1-60	S	Sand	Flows 1.75 gpm
147-51-13dad	Alfred Skrivseth	180	2	Dr	1948	20	6-30-60	S	Sand	
147-51-14aca$_1$	Anna Locken	240	3	Dr	1925					
147-51-14aca$_2$	Anna Locken	14	36	Du	1920	11	6-30-60	D	Sand & Gravel	
147-51-14bcb	Test Hole 1976	170	5	Dr	1961			T		See Log
147-51-15ccd$_1$	H. Monroe	67	2	Dr	1954	7	6-30-60	S	Sand	SC 640
147-51-15ccd$_2$	H. Monroe	65	2	Dr	1953	7	6-30-60	S	Sand	
147-51-15ccd$_3$	H. Monroe	14	48	Du		8	6-30-60	S	Sand	
147-51-16abb$_1$	Joseph Olson	70	3	Bo	1930	18	6-30-60	S	Sand	SC 600
147-51-16abb$_2$	Joseph Olson	35	3	Bo	1940	18	6-30-60	D,S	Sand	
147-51-16bab$_1$	Phillip Egge	100	2	Dr	1956	2.84	10-18-65		Sand	Observation Well
147-51-16bab$_2$	Phillip Egge	100	2	Dr	1960			D,S	Sand	C
147-51-16cdd	Test Hole 2913	75.5	1 1/4	Dr	1968	14.08	5- 3-68	T	Sand	See Log, C, Observation Well
147-51-16dad	Mrs. H. Finstrom	40	2	Dr		12	6-30-60	D,S	Sand	SC 780
147-51-17aab	Joseph Egge	200	4	Dr	1957	12	7- 1-60	S	Sand	SC 4,920

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
147-51-17ddd	Martin Ulland	16		Du	1910	11	6-30-60	D,S	Sand & Gravel	
147-51-18ccd	Arthur Endrud	400	2	Dr	1900	6	6-30-60	S	Sand	
147-51-19abc	M. Anderson	267	2	Dr	1956	7	6-29-60	D,S	Sand	
147-51-20add	Melvin Nelson	14	40	Du	1935	10	6-29-60	D,S	Sand & Gravel	
147-51-22bbb	Test Hole 2382	100	1 1/4	Dr	1965	2.62	10- 4-65	T	Sand	C, Observation Well, See Log
147-51-22bdd	Mrs. H. Finstrom	40	2	Dr	1948	8	6-30-60	S	Sand	
147-51-22dcd	Clarence Anderson	40	36	Du	1960	10	6-29-60	D,S	Sand	
147-51-23cdc	Christ Schmaltz	385	4	Dr	1943	14	6-30-60	S	Sand	SC 4,320
147-51-25dcc	H. Sorley	366	3	Dr	1943	12	7- 8-48	D,S	Sand	
147-51-27ccd	L. Anderson	170	3	Dr	1946	14	6-29-60	S	Sand	
147-51-27ddd$_1$	Test Hole 1331	95	5	Dr	1958			T		See Log
147-51-27ddd$_2$	Mrs. Carl Nelson	125	3	Dr	1932	20	6-29-60	S	Sand	SC 3,480
147-51-28add	Nels Johnson	225	2	Dr		5	6-29-60	S	Sand	
147-51-28bbd$_1$	Carl Hovland	9.4	48	Du	1915	5.8	6-29-60	D,S	Sand & Gravel	
147-51-28bbd$_2$	Carl Hovland	12	48	Du	1915	7	6-29-60	D,S	Sand & Gravel	
147-51-28dcc$_1$	John Johnson	12	36	Du	1930	9	6-27-60	D	Sand	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
147-51-28dcc$_2$	John Johnson	225	2	Dr	1925	18	6-29-60	S	Sand	
147-51-29dad$_1$	F. C. Larson	14	36	Du	1915	5	6-29-60	D	Sand & Gravel	
147-51-29dad$_2$	F. C. Larson	250	2	Dr	1935	6	6-29-60	S	Sand	
147-51-30cdd	Joe Schultz	340	2	Dr	1944			S		
147-51-32ddd	Test Hole 11	190	5	Dr	1948			T		See Log
147-51-33abb$_1$	Mrs. H. Anderson	7	36	Du	1930	6	6-29-60	D	Sand	
147-51-33abb$_2$	Mrs. H. Anderson	353	2	Dr	1954	9	6-29-60	S	Sand	
147-51-34ada$_1$	C. A. Anderson	35		Du	1956	26	7-11-58	D	Sand	
147-51-34ada$_2$	C. A. Anderson	125	3	Dr	1957			S		C
147-51-34ddd$_1$	Test Hole 2376	120	1 1/4	Dr	1965	11.18	10- 4-65	T	Sand	C, Observation Well, See Log
147-51-34ddd$_2$	Test Hole 2376	205	1 1/4	Dr	1965	3.62	10- 4-65	T	Sand & Gravel	C, Observation Well, See Log
147-51-35bbb$_1$	Willard Burnett	35	72	Du		2	7-11-58	S		
147-51-35bbb$_2$	Willard Burnett	35	60	Du		2	7-11-58	D		
148-49-5adb$_1$	Arthur Sondreal	175	2	Dr		20	8-28-57	D,S	Sand	SC 2,400
148-49-5da	Myhre Brothers	180	3	Dr		15	6-16-58	D,S	Sand	
148-49-6dda	Otto M. Larson	172	2	Dr		11	8-28-57	D,S	Sand	
148-49-7bad	Ole Danielson	237	2	Dr		12		D	Sand	Plugged

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-49-7ccd	Julius Erickson	159	2	Dr		12	8-28-57	D,S	Sand	C
148-49-8bbb	Test Hole 2384	231	5	Dr				T		See Log
148-49-8ddd$_1$	Edwin Cooper	165	2 1/2	Dr		20	8-28-57	S	Sand	Inadequate Supply
148-49-8ddd$_2$	Test Hole 1323A	262.5	5	Dr	1958			T		See Log
148-49-9ccd	Ole Aamodt	180	2	Dr		20	8-28-57	D	Sand	
148-49-9dcd$_1$	Ole Aamodt	185	3	Dr		19	8-28-57	D,S	Sand	
148-49-9dcd$_2$	Ole Aamodt	210	3	Dr	1965	32	7-16-65	D,S	Sand & Gravel	
148-49-16aaa	Willard Thompson	180	2	Dr	1917	Flow	6-16-58	S	Sand	
148-49-16dcc	Elmer Sondrol	176	2	Dr		20	8-28-57	D,S	Sand	SC 1,440
148-49-17aaa$_1$	Edwin Cooper	165	2 1/2	Dr		20	8-28-57	D,S	Sand	
148-49-17aaa$_2$	Test Hole 1323	63	5	Dr	1958			T		See Log
148-49-17bbb	Test Hole 1325	215	5	Dr	1958			T		See Log
148-49-17cdd	George Keller	175	2	Dr	1947	20	8-28-57	D,S	Sand	C
148-49-17ddb	Ed Whitwer	180	2	Dr	1954	18	8-28-57	D,S	Gravel	
148-49-18aab	Olaf Ertsgard	180	2	Dr		15	8-28-57	D,S	Sand	C
148-49-18bab	James Nesvig	160	2	Dr		15	8-28-57	D,S	Sand	
148-49-18bbb	Test Hole 1322	230	5	Dr	1958			T		C, See Log
148-49-18ccc	Test Hole 1327	225	5	Dr	1958			T		See Log
148-49-18dcc	Ferdinand Johnson	180	2	Dr	1947	25	8-28-57	D,S	Sand	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-49-18dcd	I. H. Nesvig	180	2	Dr		30	8-28-57	D,S	Sand	
148-49-18ddd	Test Hole 2770	255	1 1/4	Dr	1967	18.90	8-22-67	T	Gravel	C, See Log, Observation Well
148-49-19dcd	Morris Rogenes	160	2	Dr		30	9-16-57	D,S	Gravel	SC 2,160
148-49-20baa	Dennis Mickelson	180	2	Dr	1954	20	8-28-57	D,S	Gravel	
148-49-21bab$_1$	Jerome Nesvig	180	2	Dr	1954	10	8-28-57	S	Sand	
148-49-21bab$_2$	Jerome Nesvig	188	3	Dr	1951	10	8-28-57	D	Sand	
148-49-21cac$_1$	L. Sondreal	170	2	Dr	1951	11	8-28-57	D,S	Sand	
148-49-21cac$_2$	L. Sondreal	170	2	Dr	1915	11	8-28-57	S	Sand	
148-49-28bab	Marlo Sondrol	168	3	Dr		16	8-28-57	D,S	Sand	C
148-49-28cdd	Stanley Erickson	200	2	Dr	1904	25	8-28-57	D,S	Sand	
148-49-29aaa	Test Hole 2769	220	4 3/4	Dr	1967			T		See Log
148-49-30aaa	Test Hole 2776	200	4 3/4	Dr	1967			T		See Log
148-49-30aba	Arthur Rogenes	170	2 1/2	Dr		30	8-28-57	D,S	Gravel	C
148-49-30cbb	Oscar Rogenes	218	2	Dr		25	8-28-57	D,S	Gravel	SC 4,200
148-50-1adb	Bentru Brothers	160				20	8-29-57	U	Sand	
148-50-1bab	Evela & Agnes Botten	130	2	Dr	1924			S	Sand	SC 5,040
148-50-1cdc	Arnold Jenson	230+				80	6-16-58	S	Sand	C
148-50-1ddd	Test Hole 1326	168.5	5	Dr	1958			T		See Log
148-50-2bab	Bert Jenson	168	2	Dr	1908	28	6-16-58	S	Sand	SC 3,600

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-50-2ccc	Test Hole 2771	315	4 3/4	Dr	1967			T		See Log
148-50-2ddd	M. Peterson	160	3	Dr				U		
148-50-3bba	Henry Brekke	23	48	Du		12	8-29-57	S		
148-50-3cbb	George Moen	17.5	48	Du		11.3	6-16-58	S	Sand	
148-50-5bbb	Matt Von Ruden	350	2	Dr				U	Sand	Flowed At One Time
148-50-5ddc	B. Knutson	300+	2	Dr				U	Sand	
148-50-6cbb	Ole Sondrol	180		Dr				S		
148-50-6daa	Bertel Kvitne	110	2	Dr	1935	14	7- 6-60	S	Sand	
148-50-6dcd	Ralph Weigel	340	2	Dr	1920	6	6-17-58	U	Sand	
148-50-8ddd	Test Hole 1320	220+	5	Dr	1958			T		See Log
148-50-9aaa	Test Hole 2772	240	4 3/4	Dr	1967			T		See Log
148-50-9dcd	Howard Brieland	300+		Dr		6	9-16-57	S	Sand	
148-50-9ddd	Test Hole 2773	177	1 1/4	Dr	1967	10.18	8-22-67	T	Gravel	C, See Log, Observation Well
148-50-10aaa	Vic Horne	190	3	Dr	1951	18	6-16-58	D,S		
148-50-10cbb	Milford Hovet	160	2	Dr	1950	30	9-13-57	S	Sand	
148-50-10ddd	Thelmer & Ordan Hovet	315	2	Dr	1918	15	9-13-57		Sand	
148-50-11aaa	Test Hole 1970	210	5	Dr	1961			T		See Log
148-50-11abd$_1$	Knute Kjelmeland	160	2	Dr		15	6-16-58	S	Sand	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-50-11abd$_2$	Knute Kjelmeland	20	6	Dr	1922	15	6-16-58	D	Clay	
148-50-11dab	Osmund Roiland	19		Dr	1944	13	6-16-58	D	Clay	
148-50-11ddd	Test Hole 1324	220	5	Dr	1958			T		See Log
148-50-12abb	Martin Bartelson	160				20	8-29-57	U	Sand	
148-50-12cdd	E. Hedde	25.58	3	Dr		8.76	9-13-57	U		
148-50-12ddc	Clifford Erickson	160	2	Dr		14	6-16-58	U	Sand	
148-50-13add$_1$	Test Hole 2768	177	1 1/4	Dr	1967	20.37	8-22-67	T	Sand & Gravel	C, See Log, Observation Well
148-50-13add$_2$	Test Hole 2768	257	1 1/4	Dr	1967	21.57	8-22-67	T	Sand & Gravel	C, See Log, Observation Well
148-50-13ccc$_1$	Test Hole 2383	283.5	5	Dr	1965			T		See Log
148-50-13ccc$_2$	Test Hole 2537	390	5	Dr	1966			T		See Log
148-50-13dcd	L. M. Mikkelson	184	3	Dr	1950			D,S	Sand	C
148-50-14bbb	Test Hole 1321	189	5	Dr	1958			T		See Log
148-50-14ccc	Clara & Emma Hovet	21	8	Du				D		
148-50-15bbc	Test Hole 2387	42	5	Dr	1965			T		See Log
148-50-15ccc	Test Hole 2774	300	4 3/4	Dr	1967			T		See Log
148-50-15cdd	Test Hole 2385	42	5	Dr	1965			T		See Log
148-50-15dcc	William Omlid	15	42	Du		3.73	8- 5-65	U		
148-50-16ccd	R. B. Camrud	165	2	Dr	1952	50	9-16-57	S	Sand	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-50-17bbb	Test Hole 207	22	4 3/4	Dr	1960	15.7	6-27-60	T	Sand	See Log
148-50-17ccd	H. Haug	365	2	Dr		8	9-16-57	S	Sand	
148-50-18dcb	C. Thompson	410	2	Dr	1953	40	7- 5-60	S	Sand	
148-50-19ccd	R. Gregorie	315	2	Dr	1934	16		S		
148-50-20abb	Test Hole 2388	63	5	Dr	1965			T		See Log
148-50-20bab	Alfred Hagelie	370	3	Dr	1950	6	9-16-57			
148-50-20ccc	Test Hole 1963	210	5	Dr	1961		10-21-61	T		See Log
148-50-21bab	R. B. Camrud	170	2	Dr	1915	50	9-16-57	S	Sand	
148-50-21ccd	Alfred Jacobson	182	3	Dr				D,S		SC 2,160
148-50-21ddd	L. L. Breiland	200	2	Dr	1895	40		S		SC 3,120
148-50-22ada	Test Hole 2386	43	5	Dr	1965			T		See Log
148-50-22adb	Township Well	19	72	Du	1907	6	6-17-58	PS	Sand	C
148-50-22cca	C. L. Riveland	210	2	Dr	1943	72	6-17-58	S	Sand	
148-50-23bbb	Test Hole 2775	220	4 3/4	Dr	1967			T		See Log
148-50-23dcc	George B. Gunderson	271	2	Dr	1930	16	9-13-57	S	Sand	C
148-50-24aaa	Mrs. Inga Ingwalson	160	3	Dr	1950	17	6-17-58	D,S	Sand	
148-50-24bbb	Tom A. Brooke	274	2	Dr	1949	16	9-13-57	S	Sand	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-50-24cdd	Oliver Odegard	185	2	Dr	1905	12	6-17-58	S	Sand	SC 4,080
148-50-24ddd	Test Hole 1328	189	5	Dr	1958			T		See Log
148-50-25aba	Ernest L. Odegard	147		Dr	1949	21	9-13-57	D,S	Sand	SC 1,380
148-50-26cca	Cliff Odegard	187		Dr	1943	14	9-16-57	S	Sand	
148-50-26dcc	Gaylord Olson	265	2	Dr				S	Sand	
148-50-28bab	Inez Hauge Estate	175	2	Dr		20	6-17-58	U	Sand	
148-50-28cdd	Orlin Gunderson	357	3	Dr	1938			S	Sand	SC 6,240
148-50-28ddc	Marth Gunderson Estate	356	3	Dr	1938	12	9-15-57	S	Sand	
148-50-29cdc	Art Mehl	365	3	Dr		6	6-17-58	S	Sand	
148-50-30abb	Henry Hagelie	372	2	Dr	1940	Flow	1946	S		C
148-50-30bcc$_1$	O. J. Sorlie	385	2	Dr	1943	11	8-15-46	S		
148-50-30bcc$_2$	O. J. Sorlie	275	2	Dr	1927	11	8-15-46	S		
148-50-30bcd	O. J. Sorlie	14	48	Du	1925	6.51	8-15-46	D		C
148-50-31baa	W. Page	165	3	Dr		6.7	8-15-46	S		
148-50-33aaa	Wilford Gunderson	343	2	Dr	1943	9	6-17-58	U	Sand	Plugged
148-50-34add	Clifford Gunderson	175	2	Dr				D,S	Sand	SC 4,080
148-51-1aba	Tony Scholand	418	2	Dr	1947	9	9-17-57	S		
148-51-1cdb	Mrs. Cora Braete	300	2	Dr	1890	1	7-15-58	U	Sand	
148-51-2baa	J. Renners	18	48	Du	1955	15	7-10-58	S	Gravel	

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-51-2dcd	Test Hole 1960	210	5	Dr	1961			T		See Log
148-51-3cbc	Anton Linneman	165	2	Dr	1925	6	7-15-58	S	Sand	
148-51-3ddd	Fred Ackerman	430	2	Dr	1938	7	7-15-58	S	Sand	
148-51-4baa	Alvis Schultz	219		Dr	1953	Flow	7-17-58	S	Sand	C, Flows 5 gpm
148-51-4dad	Anton Linneman	365	3	Dr		Flow	7-17-58	S	Sand	
148-51-5bbb$_1$	Chris Landa	360	3	Dr	1950	9	7-10-58	S	Sand	
148-51-5bbb$_2$	Chris Landa	18	48	Du		16	7-19-61	D	Sand	Small Supply
148-51-6acc	Hubert Von Ruden	185	3	Dr		12	7-10-58	S	Sand	
148-51-6cac	Leo Schultz	215	3	Dr	1953	9	7-10-58	S	Sand	
148-51-9abb	Alfonse Adams	200+		Dr	1931	Flow	7-15-58	S	Sand	Flows 0.25 gpm
148-51-9daa	Leo Breidenbach	120	3	Dr	1955	70	7-15-58	S	Sand	
148-51-10bbb	V. Ackerman	240	2	Dr	1920	Flow	7-15-58	S	Sand	Flows 12 gpm
148-51-10ccc	Joe Linneman	290	2	Dr	1948	3	7-15-58	S	Sand	
148-51-11aaa	C. Ellingson	18.15	48	Du		9.90	7-15-58	U	Sand	On Beach Ridge
148-51-11caa	V. Leddige	220		Dr	1950	150	7-17-58	S	Sand	Inadequate Supply
148-51-12ddd	Test Hole 1319	210	5	Dr	1958			T		See Log
148-51-13aab	Helmer Knudsvig	345	2	Dr	1945	17	7- 5-60	S	Sand	
148-51-15aaa	Test Hole 1193	468	5	Dr	1957			T		See Log
148-51-15cad	Louis Berthold	135	2	Dr	1933	9	7- 6-60	S	Sand	SC 4,400
148-51-17aaa	Test Hole 1192	189	5	Dr	1957			T		See Log

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-51-17dcc	Fuglesten Bros.	318	2	Dr	1945	35	7- 5-60	S	Sand	
148-51-18cdc	Anton Regenes	160	2	Dr	1920	35	7- 6-60	S	Sand	
148-51-18dcc	Alvin Lerfald	35	48	Du		15.5	7- 6-60	S	Sand	
148-51-19bdd	Mancur Olson	300	2	Dr	1942	40	7- 5-60	S	Sand	
148-51-19cda	John Renners	11.5	42	Du	1952	7.0	7- 5-60	D,S	Sand	
148-51-20aac$_1$	Chris Knudsvig	16	40	Du	1920	14	7- 6-60	S	Sand	
148-51-20aac$_2$	Chris Knudsvig	315	2	Dr	1906	20	7- 6-60	S	Sand	
148-51-20ddb	Fuglesten Bros.	120	2	Dr	1920	16	7- 5-60	S	Sand	SC 7,000
148-51-20ddd	Fuglesten Bros.	250	3	Dr	1910	8	7- 5-60	S	Sand	
148-51-21daa	Eken Brothers	293	2	Dr	1946	Flow	1946	S	Sand	C
148-51-21dda	George Finstrom	265	1 1/2	Dr	1949			S		
148-51-22cdd	George Finstrom	16		Du		12	7- 5-60	S		
148-51-22dbd$_1$	A. Schultz	18	48	Du	1881	15	7- 5-60			
148-51-22dbd$_2$	A. Schultz	190	2	Dr	1925	18	7- 5-60	S		
148-51-23aaa	Martha Molvig	325	2	Dr	1936	20+	7- 6-60	S	Sand	
148-51-24aad$_1$	Ray Kloster	112	2	Dr	1928	20	7- 6-60	S	Sand	
148-51-24aad$_2$	Test Hole 204	22	4 3/4	Dr	1960	9.5	6-27-60	T		See Log
148-51-24add	Ray Kloster	390+	2	Dr	1952	9.6	7- 6-60	S	Sand	
148-51-25ccc$_1$	Village of Buxton	17	96	Du	1921	10.24	8- 2-46	U		C

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-51-25ccc$_2$	Village of Buxton	19	144	Du	1936	13.24	8- 2-46	D,PS		C
148-51-25ccc$_3$	Henning Johnson	10	72	Du		8.52	8- 2-46	D,S		C
148-51-25ccc$_4$	Test Hole 1	29	4 3/4	Dr	1946			T		See Log
148-51-25dac	Leroy Kubbervig	374	2	Dr		7.23	8-15-46			C
148-51-25dcd	Village of Buxton	212	2	Dr	1914	3.32	8- 2-46	PS		C
148-51-26bab$_1$	Tommy Thompson	18	36	Du		13.9	8- 2-46	U		
148-51-26bab$_2$	Tommy Thompson	448	2	Dr	1936	12.6	8- 2-46	S		
148-51-26cdd	G. Spaeth	275	2	Dr		20	8- 2-46	S		C
148-51-26dda	Jens Molvig	16	48	Du				U		C
148-51-26ddd$_1$	Jens Molvig	7	72	Du		4.09	8- 2-46	U	Gravel	
148-51-26ddd$_2$	Test Hole 2	17	4 3/4	Dr	1946			T		See Log
148-51-27abb	Asheim Estate	14	42	Du	1920	11	7- 5-60	S		
148-51-27baa	T. & M. Asheim	18		Du	1932	16	7- 5-60	D,S		
148-51-27cbc$_1$	Manford Knudsvig	12	24	Du	1922	8	7- 5-60	D		
148-51-27cbc$_2$	Manford Knudsvig	287	2	Dr	1947	12	7- 5-60	S	Sand	
148-51-28aad	T. & M. Asheim	320	2	Dr	1944	9	8- 2-46			C
148-51-28dcc	Test Hole 2918	160	4 3/4	Dr	1968			T		See Log
148-51-29aaa	Oscar Kjorlie	155	2	Dr	1950	38	7- 6-60	D,S	Sand	
148-51-29caa	Gust Johnson	115	2	Dr	1956	12	7- 5-60	S	Sand	SC 4,800
148-51-29ccc$_1$	Test Hole 129	42	4 3/4	Dr	1960			T		See Log

TABLE 3 - RECORDS OF WELLS AND TEST HOLES (Cont.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
148-51-29ccc$_2$	Test Hole 2781	160	4 3/4	Dr	1967			T		See Log
148-51-30aaa	Melvin Finstrom	14	24	Du		10	7- 1-60	D,S	Sand & Gravel	
148-51-30acb	Clara Asheim	265	2	Dr	1955	25	7- 5-60	S	Sand	
148-51-30ddd$_1$	Ernest James	115	4	Dr	1941	8	8- 2-46	S		C
148-51-30ddd$_2$	Ernest James	14	6	Dr	1941	6	8- 2-46	D,S		C
148-51-32aaa	Test Hole 2917	61	1 1/4	Dr	1968	8.90	5- 3-68	T	Sand	See Log, C, Observation Well
148-51-32abb	Test Hole 2919	160	4 3/4	Dr	1968			T		See Log
148-51-32acc	Otto Bjerke	350	2	Dr	1918			S		
148-51-32bbd	Ludvig Knudsvig	128	2	Dr		15	7- 5-60	S	Sand	SC 4,800
148-51-33aaa	Test Hole 2960	320	4 3/4	Dr	1968			T		See Log
148-51-33aab	Melford Asheim	150	2	Dr	1950	10	7- 5-60	S	Sand	SC 5,040
148-51-33ccb	Test Hole 130	27	4 3/4	Dr	1960	13.9	5-24-60	T		See Log
148-51-34bbc	Melford Asheim	190	2	Dr	1945	8	7- 5-60	S	Sand	SC 3,840
148-51-35aaa	Jens Molvig	11	60	Du		10.32	8- 8-46	U		
148-51-36bbb$_1$	Walter Vleck	16	48	Du				D		C
148-51-36bbb$_2$	Walter Vleck	12	60	Du		8.22	8- 2-46	S		
148-51-36bbb$_3$	Test Hole 205	32	4 3/4	Dr	1960			T		See Log
148-51-36cab	Test Hole 3	14	4 3/4	Dr	1946			T		See Log
148-51-36cbb	Test Hole 4	35	4 3/4	Dr	1946			T		See Log

TABLE 4 - LOGS OF TEST HOLES

The following test hole logs are a summary of data from the driller's logs, geologist's sample descriptions, and the resistivity and potential electric logs.

Color descriptions are for wet samples and are based on the classification used by the Geological Society of America (Goddard, 1948).

Grain size classification is C. K. Wentworth's scale from Pettijohn (1957).

Elevations are based on mean sea level datum as represented on the Climax SW and NW Minnesota - North Dakota, United States Geological Survey topographic maps.

147-50-5bbb
Test hole 203

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, sandy, black	1	0	1
	Sand, fine to coarse	9	1	10
	Clay, smooth, gray	2	10	12

147-50-10aaa
Test hole 202

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, black	1	0	1
	Sand, very fine to fine, silty and clayey, light-brown	19	1	20
	Clay, smooth, light-gray	2	20	22

147-50-14ccc
Test hole 201

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, sandy, black -------------	1	0	1
	Sand, very fine to fine, silty, light-brown to buff -----------	11	1	12
	Sand, very fine to fine, silty, buff to light-gray, more clayey with depth --------------------	13	12	25
	Clay, smooth, light-gray ----------	5	25	30

147-50-17cbc
Test hole 200

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, sandy, black -------------	1	0	1
	Sand, very fine to fine, silty, light-brown -------------------	11	1	12
	Sand, very fine to fine, clayey, light-gray --------------------	5	12	17
	Clay, smooth, light-gray ----------	5	17	22

147-50-17ccb$_1$
Test hole 199

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, sandy, black -------------	1	0	1
	Gravel, fine to coarse ------------	2	1	3
	Sand, very fine to coarse, fine gravel ------------------------	12	3	15
	Clay, smooth, gray ----------------	12	15	27

147-50-17ccb$_2$
Test hole 2767

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, sandy, brownish-black ------------------------	1	0	1
	Gravel, fine to coarse, subangular to subrounded, poorly sorted, mostly granitics, limestone, dolostone and shale -----------	6	1	7
	Clay, olive-gray to medium light-gray, very cohesive, plastic, calcareous (lake sediment) ----	13	7	20

147-50-18dda
Test hole 222

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Clay, very silty and somewhat sandy, light-gray --------------	7	0	7
	Clay, olive-gray, plastic, small coarse sand-size limestone inclusions ---------------------	15	7	22
	Clay, smooth, olive-gray, plastic --	90	22	112

147-50-19abb4
Test hole 2766

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, sandy, brownish-black --------------------------	1	0	1
	Gravel, sandy (approximately 20-30 percent coarse to very coarse, subangular to subrounded, poorly sorted sand), fine to coarse, subangular to subrounded, fair sorting, mostly limestone, dolostone, granitics and some shale --------------------------	12	1	13
	Clay, silty, medium dark-gray, very cohesive, plastic, calcareous (lake sediment) ---------------	7	13	20

147-50-19bab
Test hole 2765

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, sandy, brownish-black --------------------------	1	0	1
	Clay, silty, moderate yellowish-brown, moderately cohesive -----	2	1	3
	Gravel, sandy (approximately 20-30 percent coarse to very coarse, subangular to subrounded, oxidized sand), fine to medium, subangular to subrounded, fair sorting, approximately 50-60 percent limestone and dolostone, remainder shale and granitics --	3	3	6
	Clay, silty, medium-gray to medium dark-gray, cohesive, plastic, calcareous (lake sediment) -----	29	6	35

147-50-19bab (Cont.)
Test hole 2765

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Clay, silty, olive-gray to medium dark-gray, very cohesive, very plastic, calcareous (lake sediment) ----------------	190	35	225
	Clay, medium dark-gray, moderately cohesive, plastic, calcareous, interbedded throughout section with sand and gravel lenses, poor samples (till) ------------	67	225	292
	Clay, sandy, silty, olive-gray with light-brown laminations, cohesive, non-plastic, very calcareous (till) --------------	32	292	324
Cretaceous undifferentiated:				
	Shale, grayish-black, indurated, non-calcareous -----------------	6	324	330

Electric and gamma ray logs

147-50-33ddd
Test hole 2377

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black ---------------------	1	0	1
	Clay, silty, yellow-brown to dusky yellow ------------------------	19	1	20
	Clay, olive-gray to dark greenish-gray -------------------------	42	20	62
	Clay, sandy, olive-gray to dark greenish-gray, calcareous (till)	34	62	96
	Clay, sandy, olive-gray, occasional boulders (till) ---------------	64	96	160
	Sand, fine to coarse, poorly sorted	8	160	168
	Silt, sandy, olive-gray ------------	4	168	172
	Clay, gravelly, light olive-gray (till) -------------------------	34	172	206
	Sand, fine to coarse, gravelly, interbedded till ---------------	20	206	226
Cretaceous undifferentiated:				
	Clay, silty, dark greenish-gray, slightly calcareous ------------	49	226	275
Precambrian rocks:				
	Granite ----------------------------	1	275	276

147-51-1bbb
Test hole 1969

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, black	1	0	1
	Clay, silty, mottled yellowish-gray and brown, some fine limestone, gravel, and coal fragments (till)	13	1	14
	Clay, silty, olive-gray, small amount of limestone sand grains (till)	47	14	61
	Clay, silty, light olive-gray, fine sand fraction of limestone with occasional limestone boulder (till)	33	61	94
	Clay, olive-gray to medium dark-gray sand to granule gravel-size limestone fragments (till)	40	94	134
	Clay, silty, dark-gray, less sand than above (till)	13	134	147
	Clay, medium to dark-gray, coarse sand and fine gravel-size limestone and shale fraction with cobbles and boulders (till)	11	147	158
	Clay, silty, dark-gray to light olive-gray, mottled with white calcareous spots lower 5 feet (till)	16	158	174
Cretaceous undifferentiated:				
	Clay, smooth, greenish-gray to light olive-gray, very calcareous, tough	36	174	210

147-51-4bab2
Test hole 2780

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, sandy, gravelly, grayish-black	1	0	1
	Gravel, sandy (approximately 15-25 percent coarse to very coarse, subangular to rounded sand), fine to coarse, subangular to rounded, fair sorting, oxidized to medium-brown, approximately 35-45 percent limestone and dolostone, 15-25 percent shale, remainder light-colored granitics and quartz	16	1	17

147-51-4bab2 (Cont.)
Test hole 2780

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Clay, silty, sandy, olive-gray, cohesive, plastic, calcareous (till)	10	17	27
	Clay, silty, olive-gray, cohesive, plastic, calcareous (lake sediment)	33	27	60

147-51-4dba
Test hole 5

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Gravel, medium, well-sorted	10	0	10
	Sand	2	10	12
	Clay, gray, with interbedded sand	8	12	20
	Gravel and sand	24	20	44
	Clay, sticky, blue	1	44	45

147-51-4dbb
Test hole 6

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, clay, black, sandy	1½	0	1½
	Gravel	18½	1½	20
	Clay, gray, with interbedded sand	16	20	36
	Clay, sticky, blue	3	36	39

147-51-4ddd
Test hole 7

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Gravel and sand	8	0	8
	Gravel with interbedded clay	17	8	25
	Gravel, fine, well-rounded, well-sorted	9	25	34
	Clay, gray, with interbedded silt layers, some sand and gravel	18	34	52
	Boulder		52	

147-51-5aaa
Test hole 2916
Elevation 979 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, clayey, sandy, black	1	0	1
	Sand, clayey, fine to medium-grained, moderately well-sorted, angular to rounded, oxidized	3	1	4
	Clay, very silty, sandy, moderate yellowish-brown with light olive-gray laminations, cohesive, plastic, numerous limestone and shale fragments, oxidized (till)	8	4	12
	Clay, silty, sandy, olive-gray, cohesive, plastic, numerous limestone and shale fragments (till)	16	12	28
	Sand, fine to coarse-grained, poorly sorted, angular to subrounded, mostly quartz and shale with some limestone	4	28	32
	Clay, silty, sandy, olive-gray, cohesive, plastic to semi-plastic, numerous limestone and shale grain sand granules (till)	6	32	38
	Sand, fine to coarse-grained (predominantly medium-grained), angular to rounded, well-sorted, mostly quartz and shale with some limestone, dolostone and granitics, occasional thin clay lenses, taking water	8.7	38	125
	Gravel, sandy (approximately 25-35 percent coarse to very coarse-grained, angular to subrounded sand), fine grading to coarse with depth, angular to rounded, moderately well-sorted, taking water rapidly	55	125	180
	Clay, sandy, silty, pebbly, olive-gray, moderately cohesive, semi-plastic, calcareous (till)	6	180	186
	Gravel, abundant cobbles, fine to coarse (predominantly coarse), subangular to subrounded, fair sorting, mostly limestone, dolostone and shale, some granitics, taking water rapidly	15	186	201

147-51-5aaa (Cont.)
Test hole 2916
Elevation 979 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift: (Cont.)				
	Clay, silty, sandy, gravelly, olive-gray, moderately cohesive, moderately plastic, calcareous, numerous shale, limestone and granitic fragments, (till) -----	19	201	220

Observation well
Electric log

147-51-6dad
Test hole 132

Formation	Material	Thickness (feet)	From	To
Glacial drift:				
	Topsoil, black --------------------	1	0	1
	Sand, very fine to fine, brown to dark-brown --------------------	4	1	5
	Clay, sandy, brown to yellow -------	15	5	20
	Clay, smooth, gray -----------------	2	20	22

147-51-6dda
Test hole 131

Formation	Material	Thickness (feet)	From	To
Glacial drift:				
	Topsoil, sandy, black --------------	1	0	1
	Sand, very fine to coarse, fine and medium gravel ------------------	9	1	10
	Sand, very fine to fine, brown to dark-brown --------------------	10	10	20
	Clay, gray, smooth -----------------	2	20	22

147-51-6ddd
Test hole 133

Formation	Material	Thickness (feet)	From	To
Glacial drift:				
	Topsoil, black --------------------	1	0	1
	Sand, very fine to fine, tan to brown, more clayey with depth --	9	1	10
	Clay, smooth, brown to blue --------	5	10	15
	Clay, smooth, gray -----------------	5	15	20

147-51-8add
Test hole 2963
Elevation 984 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, sandy, gravelly, brownish-black ----------------	1	0	1
	Sand, gravelly (approximately 20-30 percent fine to medium gravel, angular to subrounded), medium to very coarse-grained, subangular to subrounded, oxidized -----------	11	1	12
	Clay, sandy, silty, pebbly, moderate yellowish-brown, moderately cohesive, moderately plastic, calcareous, numerous limestone and shale fragments, oxidized (till)	4	12	16
	Clay, sandy, silty, olive-gray, moderately plastic, cohesive, numerous limestone and shale fragments (till) -------------	3	16	19
	Clay, very silty, olive-gray, very cohesive, very plastic, calcareous (lake sediment) -----------	59	19	78
	Sand, very fine to fine-grained, subangular to rounded, well-sorted, predominantly quartz with some limestone, shale and lignite, a few mica flakes, taking small amount of water ---	27	78	105
	Clay, very silty, olive-gray, cohesive, plastic, calcareous, (lake sediment or fluvial sediment) --	4	105	109
	Sand, very fine to fine-grained, well-sorted, subangular to rounded, predominantly quartz with some limestone, shale and lignite, occasional mica flakes, interbedded with very sandy, silty clay --------------------------	13	109	122
	Clay, silty, sandy, pebbly, olive-gray, moderately cohesive, moderately plastic, calcareous, numerous limestone and shale fragments, a few limestone cobbles (till) ----------------	18	122	140

Observation well
Electric log

147-51-9aaa
Test hole 2777

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, sandy, brownish-black	1	0	1
	Clay, silty, sandy, moderate yellowish-orange, cohesive, plastic, oxidized (lake sediment)	12	1	13
	Clay, silty, olive-gray, very cohesive, plastic, a few limestone grains and granules (lake sediment)	28	12	40

147-51-9aab1
Test hole 2778

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, sandy, gravelly, brownish-black	0.5	0	0.5
	Clay, silty, sandy, moderate yellowish-brown, moderately cohesive, oxidized (till)	2.5	0.5	3
	Sand, fine to medium-grained, subangular to rounded, moderately well-sorted, oxidized, approximately 60-70 percent quartz, remainder limestone, shale and granitics	6	3	9
	Clay, silty, sandy, olive-gray cohesive, non-plastic (till)	9	9	18
	Clay, silty, olive-gray, very cohesive, plastic, calcareous (lake sediment)	22	18	40

147-51-9aab2
Test hole 2961
Elevation 967 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, sandy, gravelly, brownish-black	0.5	0	0.5
	Sand, gravelly (approximately 15-25 percent fine to medium, angular to subrounded gravel), medium to very coarse-grained, subangular to subrounded, mostly quartz, some limestone, dolostone, shale, and granitics, oxidized	10.5	0.5	11

147-51-9aab2 (Cont.)
Test hole 2961
Elevation 967 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Clay, very silty, olive-gray, very cohesive, very plastic, calcareous, thinly laminated, (lake sediment)	64	11	75
	Sand, silty, very fine-grained, well-sorted, subangular to rounded, mostly quartz, some limestone, shale and lignite, a few mica flakes	39	75	114
	Clay, very silty, olive-gray, very cohesive, plastic, calcareous (lake sediment)	6	114	120
	Clay, sandy, silty, gravelly, olive-gray, cohesive, slightly plastic, calcareous, numerous limestone and shale fragments, a few cobbles (till)	40	120	160

147-51-9aba
Test hole 2962
Elevation 975 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Sand, gravelly (approximately 25-35 percent fine to medium, angular to subrounded gravel), medium to very coarse-grained, subangular to subrounded, oxidized	13	0	13
	Clay, silty, sandy, pebbly, olive-gray, moderately plastic, calcareous (till)	17	13	30
	Clay, very silty, olive-gray, very cohesive, plastic, thinly laminated, very calcareous (lake sediment)	20	30	50
	Sand, very fine to fine-grained, well-sorted, subangular to rounded, mostly quartz, some limestone, shale and lignite, a few mica flakes, sand becomes finer with depth, taking some water	70	50	120
	Clay, sandy, silty, pebbly, olive-gray, moderately cohesive, moderately plastic, numerous shale and limestone fragments (till)	7	120	127

Observation well
Electric log

147-51-9baa$_1$
Test hole 2779

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, sandy, brownish-black -----	1	0	1
	Clay, silty, sandy, moderate yellowish-orange, cohesive, moderately plastic, oxidized (till) --------	1	1	2
	Sand, fine to medium-grained, subangular to rounded, moderately well-sorted, approximately 70-80 percent quartz, remainder being limestone, shale, and light-colored granitics ---------	6	2	8
	Clay, silty, olive-gray, cohesive, non-plastic (till) --------------	12	8	20
	Sand, fine to medium-grained, subangular to rounded, moderately well-sorted, approximately 75-85 percent quartz, 2-6 percent shale, remainder light-colored granitics-	4	20	24
	Clay, silty, olive-gray, cohesive, slightly plastic, calcareous (till) ------------------------	16	24	40

147-51-9baa$_2$
Test hole 2915
Elevation 980 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, sandy, gravelly, brownish-black --------------------------	1	0	1
	Sand, clayey, silty, very fine to medium-grained, angular to subrounded, poorly sorted, oxidized, abundant wood fragments ---------	7	1	8
	Clay, sandy, silty, pebbly, olive-gray, moderately cohesive, moderately plastic, calcareous, numerous shale and limestone fragments (till) ----------------	11	8	19
	Sand, fine to medium-grained, angular to subrounded, moderately well-sorted, interbedded with silty clay, mostly quartz and shale, some limestone -----------------	17	19	36
	Clay, very sandy, very silty, olive-gray to light olive-gray, slightly cohesive, very slightly plastic, interbedded with fine-grained sand lenses throughout --	24	36	60

147-51-9baa2 (Cont.)
Test hole 2915
Elevation 980 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Sand, fine to coarse-grained (grades to coarse-grained with depth), subangular to rounded, moderately well-sorted, mostly quartz and shale, some limestone, dolostone and lignite, a few mica flakes, interbedded with silty clay	46	60	106
	Gravel, sandy (approximately 30-40 percent medium to very coarse-grained, subangular to subrounded sand), fine to coarse with a few cobbles, angular to subrounded, moderately well-sorted, mostly shale and limestone, some granitics, small amount of chalcedony and agate, taking water rapidly	48	106	154
	Clay, silty, sandy, pebbly, olive-gray, cohesive, slightly plastic, calcareous, numerous limestone and shale fragments (till)	46	154	200

Observation well
Electric log

147-51-9ddd
Test hole 2914
Elevation 956 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, clayey, black	1	0	1
	Clay, very silty, slightly sandy, moderate yellowish-brown with light olive-gray laminations, cohesive, moderately plastic, calcareous, a few shale and limestone fragments, oxidized (lake sediment)	11	1	12
	Clay, very silty, slightly sandy, olive-gray, very cohesive, plastic, laminated (lake sediment)	32	12	44
	Clay, silty, sandy, olive-gray to dark greenish-gray, very cohesive, plastic to moderately plastic, calcareous (till)	14	44	58

147-51-9ddd (Cont.)
Test hole 2914
Elevation 956 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift: (Cont.)				
	Sand, very fine to medium-grained (predominantly fine-grained), subangular to rounded, well-sorted, mostly quartz, some limestone and dolostone, a few granitics ----------------	46	58	104
	Clay, sandy, silty, pebbly, olive-gray to dark greenish-gray, moderately cohesive, moderately plastic, calcareous, a few cobbles (till) ---------------	116	104	220

Observation well
Electric log

147-51-14bcb
Test hole 1976

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty and sandy, black ---	1	0	1
	Clay, silty, light-gray, yellowish-brown, dark-brown, mottled, oxidized, fine to coarse quartz and limestone sand ------------	19	1	20
	Clay, silty, olive-gray, few very fine quartz sand grains -------	64	20	84
	Clay, silty and sandy, olive-gray, fine to medium quartz sand and limestone grains (till) -------	16	84	100
	Clay, silty, olive-gray, tough, shale pebbles and fine to coarse limestone fraction (till) -----	52	100	152
	Clay, silty, dark olive-gray, fine to coarse shale, quartz, and limestone sand (till) ---------	18	152	170
	Abandoned at 170 feet, granite boulder ----------------------			

147-51-16cdd
Test hole 2913
Elevation 960 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, sandy, gravelly, black ----	1	0	1
	Clay, very silty, sandy, moderate yellowish-brown, slightly to moderately cohesive, slightly plastic, calcareous, oxidized ---	12	1	13
	Sand, fine to coarse-grained (predominantly medium-grained), angular to rounded, well-sorted, mostly quartz and shale with some limestone and granitics, oxidized -----------------------	10	13	23
	Sand, fine to coarse-grained, angular to rounded, well-sorted, mostly quartz and shale with some limestone and granitics, taking water -------------------	58	23	81
	Clay, very silty, sandy, olive-gray, slightly cohesive to non-cohesive, non-plastic, poor samples -	28	81	109
	Gravel, sandy (approximately 25-35 percent medium to very coarse-grained, angular to subrounded sand), fine to coarse, angular to rounded, fair sorting, mostly limestone, dolostone, and shale, some granitics, a few cobbles ---	11	109	120
	Clay, sandy, silty, pebbly, olive-gray, moderately cohesive, lightly plastic to plastic, calcareous, a few cobbles (till) -	10	120	130

Observation well
Electric log

147-51-22bbb
Test hole 2382
Elevation 965 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, black -------------	1	0	1
	Clay, pale olive to dark yellow-orange, oxidized, very calcareous, soft ---------------------	10	1	11
	Clay, olive-gray to dark greenish-gray --------------------------	23	11	34
	Clay, dark greenish-gray to olive-gray (till) --------------------	10	34	44

147-51-22bbb (Cont.)
Test hole 2382
Elevation 965 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Sand, medium, well-sorted, angular to subangular ------------------	63	44	107
	Clay, olive-gray to dark greenish-gray (till) --------------------	10	107	117
	Sand, medium, moderately well-sorted	8	117	125
	Clay, bouldery (till) ---------------	6	125	131

Observation well

147-51-27ddd
Test hole 1331
Elevation 958 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black ---------------------	2	0	2
	Clay, yellow -----------------------	5	2	7
	Sand, fine, medium, and coarse	88	7	95
	Lost circulation at 95 feet, abandoned -------------------------			

147-51-32ddd
Test hole 11

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black, sandy --------------	1	0	1
	Sand, fine	8	1	9
	Sand, fine, silty, clayey -----------	21	9	30
	Clay, blue-gray --------------------	40	30	70
	Clay, gray with shale and limestone pebbles (till) -----------------	29	70	99
	Gravel, chiefly shale pebbles -------	1	99	100
	Clay, bouldery (till) ---------------	68	100	168
	Sand and gravel --------------------	12	168	180
	Clay, gravelly (till) ---------------	10	180	190

147-51-34ddd
Test hole 2376
Elevation 958 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black ---------------------	1	0	1
	Clay, grayish-orange to dark yellowish-orange, oxidized, calcareous, soft --------------------------	3	1	4
	Sand, medium, moderately well-sorted, oxidized ----------------------	24	4	28

147-51-34ddd (Cont.)
Test hole 2376
Elevation 958 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Sand, medium, moderately, well-sorted, unoxidized, shale fraction increases downward --------	98	28	126
	Sand, coarse to very coarse, some gravel ------------------------	10	126	136
	Clay, olive-gray to dark greenish-gray (till) --------------------	62	136	198
	Sand, coarse to very coarse, some gravel ------------------------	12	198	210
Cretaceous undifferentiated:				
	Clay, dark greenish-gray, cohesive, soft --------------------------	21	210	231

148-49-8bbb
Test hole 2384
Elevation 861 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black --------------------	2	0	2
	Clay, silty, sandy, dark yellow-orange to pale and light olive-gray, oxidized ----------------	17	2	19
	Clay, olive-gray to dark greenish-gray, slightly calcareous, soft	130	19	149
	Sand, fine to coarse, some gravel	3	149	152
	Clay, silty, sandy, gravelly, olive-gray to dark greenish-gray, occasional boulders (till) -----	21	152	173
	Clay, very sandy, olive-gray (till)	58	173	231

148-49-8ddd
Test hole 1323A
Elevation 866 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black --------------------	1	0	1
	Clay, smooth, yellow ---------------	15	1	16
	Clay, silty and sandy, blue, lost circulation, no sand samples (apparently interbedded silts and sands) --------------------	152	16	168

148-49-8ddd$_2$ (Cont.)
Test hole 1323A
Elevation 866 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Clay, gray, fine and medium limestone gravel and cobbles (rough drilling), more gravel at 238 feet (till) ------------	74	168	242
Cretaceous undifferentiated:				
	Clay, light-gray ------------------	20	242	262
Precambrian rocks:				
	Granite --------------------------	0.5	262	0.5

148-49-17aaa$_2$
Test hole 1323
Elevation 865 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black --------------------	2	0	2
	Clay, smooth, yellow --------------	12	2	14
	Clay, smooth, blue, apparently sandy, lost circulation at 15 feet, abandoned at 63 feet ----	49	14	63

148-49-17bbb
Test hole 1325
Elevation 861 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black -------------	4	0	4
	Clay, smooth, yellow --------------	13	4	17
	Clay, silty, gray -----------------	137	17	154
	Clay, gray (till) -----------------	61	154	215

148-49-18bbb
Test hole 1322
Elevation 862 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black -------------	1	0	1
	Clay, smooth, yellow --------------	14	1	15
	Clay, silty, blue -----------------	99	15	114

148-49-18bbb (Cont.)
Test hole 1322
Elevation 862 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:	(Cont.)			
	Clay, smooth, gray	6	114	120
	Clay, gray (till)	38	120	158
	Gravel, fine, medium and coarse, some boulders	72	158	230

148-49-18ccc
Test hole 1327
Elevation 869 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, black	2	0	2
	Clay, smooth, yellow	10	2	12
	Clay, smooth, gray	122	12	134
	Gravel, fine to medium, dirty	5	134	139
	Clay, gray (till)	9	139	148
	Gravel, fine, medium and coarse, cemented from 191-225 feet, hit granite rock and abandoned hole	77	148	225

148-49-18ddd
Test hole 2770
Elevation 866 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, sandy, grayish-black	1	0	1
	Clay, silty, moderate yellowish-brown, calcareous, cohesive, plastic, oxidized (lake sediment)	15	1	16
	Clay, silty, medium dark-gray to olive-gray, cohesive, very plastic, calcareous (lake sediment)	134	16	150
	Clay, silty, olive-gray to medium dark-gray, calcareous, cohesive, non-plastic (till)	5	150	155
	Gravel, interbedded with clay throughout section, sandy (approximately 5-10 percent coarse to very coarse angular to subrounded, poorly sorted sand), fine to coarse, angular to subrounded, fair sorting, approximately 50-60 percent limestone and			

148-49-18ddd (Cont.)
Test hole 2770
Elevation 866 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift: (Cont.)	dolostone, 15-25 percent shale, remainder granitics and sandstone, rapidly taking water and caving --------------------	90	155	245
Cretaceous undifferentiated:				
	Sandstone, fine to coarse-grained, indurated, very well cemented, pale yellowish-brown, hard drilling ----------------------	2	245	247
	Siltstone, very light-gray, indurated, slightly calcareous, hard drilling ----------------------	4	247	251
	Sandstone, grayish-red, fine to medium-grained, indurated, calcareous, hard drilling -----	4	251	255

Electric log
Observation well

148-49-29aaa
Test hole 2769
Elevation 865 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, grayish-black -----	1	0	1
	Clay, silt, moderate yellowish-brown, cohesive, plastic, calcareous, oxidized -------------	13	1	14
	Clay, silty, medium dark-gray to olive-gray, very cohesive, plastic, calcareous (lake sediment) -------------------------	136	14	150
	Clay, silty, sandy, olive-gray to medium dark-gray, cohesive, non-plastic, very calcareous (till) -----------------------	10	150	160
	Clay, silty, sandy, gravelly, medium dark-gray to olive-gray, cohesive, non-plastic, very calcareous (till) -------------	37	160	197
	Clay, sandy, grayish-red, cohesive, plastic, calcareous (till) ----	7	197	204
	Boulder, granite ------------------	1	204	205

148-49-29aaa (Cont.)
Test hole 2769
Elevation 865 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Cretaceous undifferentiated:				
	Siltstone, pale blue-green, indurated, very calcareous, feels slippery like talc when dry ---------------------	15	205	220

Electric log

148-49-30aaa
Test hole 2776
Elevation 868 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, grayish-black -----	1	0	1
	Clay, silty, moderate yellowish-brown, very cohesive, plastic, a few limestone grains (lake sediment) --------------------	14	1	15
	Clay, silty, olive-gray to medium gray, very cohesive, plastic, calcareous (lake sediment) ----	100	15	115
	Clay, silty, sandy, olive-gray to medium gray, cohesive, non-plastic, calcareous (till) ----	15	115	130
	Clay, silty, olive-gray to medium gray, cohesive, a few limestone and granite boulders, rough drilling (till) --------------	26	130	156
	Gravel, fine to coarse, angular to subrounded, poorly sorted, approximately 45-55 percent limestone and dolostone, 25-35 percent shale, remainder sandstone, granitics and quartz -	20	156	176
	Clay, silty, sandy, olive-gray to medium gray, cohesive, non-plastic, calcareous (till) ----	24	176	200

Electric log

148-50-1ddd
Test hole 1326
Elevation 860 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black	2	0	2
	Clay, smooth, yellow	14	2	16
	Clay, silty and sandy, gray	126	16	142
	Clay, gray (till)	26.5	142	168.5

148-50-2ccc
Test hole 2771

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, sandy, grayish-black	1	0	1
	Clay, silty, moderate yellowish-brown, very cohesive, plastic, calcareous, oxidized (lake sediment)	15	1	16
	Clay, silty, olive-gray to medium dark-gray, cohesive, plastic, calcareous (lake sediment)	118	16	134
	Clay, silty, sandy, medium dark-gray, cohesive, non-plastic, calcareous (till)	20	134	154
	Gravel, fine to medium, angular to subrounded, fair sorting, approximately 30-40 percent limestone and dolostone, 25-35 percent shale, remainder granitics and sandstone	6	154	160
	Clay, very sandy, medium dark-gray with a few light-brown laminations, cohesive, non-plastic, calcareous, some poorly sorted gravel towards bottom of section, poor samples (till)	146	160	306
Cretaceous undifferentiated:				
	Sandstone, fine to medium-grained, light-brown, calcareous, very hard drilling	3	306	309
	Siltstone, clayey and sandy towards bottom of section, light greenish-gray to light-brown, indurated, calcareous, very hard drilling	5	309	314
	Shale, black, indurated, non-calcareous, very hard drilling	1	314	315

Electric log

148-50-8ddd
Test hole 1320

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black	4	0	4
	Clay, silty, yellow, oxidized	12	4	16
	Clay, silty, gray, shale pebbles and a few cobbles (till)	93	16	109
	Clay, silty, gray, fine and medium gravel and cobbles (till)	52	109	161
	Clay, sandy, light-gray	53	161	214
Cretaceous undifferentiated:				
	Clay, silty, gray	6	214	220

148-50-9aaa
Test hole 2772

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, clayey, black	1	0	1
	Clay, silty, moderate yellowish-brown, very cohesive, plastic, calcareous, oxidized (lake sediment)	16	1	17
	Clay, silty, olive-gray, very cohesive, plastic, calcareous, very silty from 122-130 feet (lake sediment)	105	17	122
	Clay, silty, sandy, medium dark-gray, cohesive, calcareous (till)	23	122	145
	Gravel, fine to coarse, subangular to subrounded, fair sorting, approximately 25-35 percent limestone and dolostone, 20-30 percent shale, remainder granitics and sandstone	7	145	152
	Clay, silty, sandy, gravelly, olive-gray to medium dark-gray, cohesive, non-plastic, calcareous (till)	88	152	240

Electric log

148-50-9ddd
Test hole 2773

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, clayey, grayish-black	1	0	1
	Clay, silty, moderate yellowish-brown, very cohesive, plastic, oxidized (lake sediment)	15	1	16
	Clay, silty, olive-gray to medium light-gray, very cohesive, plastic, calcareous (lake sediment)	82	16	98
	Clay, silty, medium dark-gray to olive-gray, cohesive, non-plastic (till)	42	98	140
	Clay, silty, very sandy, o ive-gray to medium dark-gray, calcareous, cohesive, non-plastic (till)	26	140	166
	Gravel, sandy (approximately 25-35 percent coarse to very coarse, subangular to subrounded sand), fine to coarse, fair sorting, subangular to subrounded, approximately 25-35 percent limestone and dolostone, 20-25 percent shale, remainder granitics, sandstone and quartz	26	166	192
	Clay, very silty, dark-gray, cohesive, non-plastic, gives off odor of hydrogen sulfide gas with 10 percent HCL (sediment)	16	192	208
	Clay, silty, sandy, dark yellowish-brown, cohesive, non-plastic, calcareous (till)	32	208	240

Electric log
Observation well

148-50-11aaa
Test hole 1970
Elevation 860 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, black	1	0	1
	Clay, plastic, mottled yellow-brown, light-gray, oxidized	15	1	16
	Clay, olive-gray, plastic	26	16	42
	Clay, silty, sandy, olive-gray to medium dark-gray (till)	101	42	143

148-50-11aaa (Cont.)
Test hole 1970
Elevation 860 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Clay, silty, sandy, medium to dark-gray (till) -------------	44	143	187
	Clay, olive-gray to medium dark-gray (till) -----------------	16	187	203
Cretaceous undifferentiated:				
	Clay, moderate brown, grayish-brown, and brownish-gray, cohesive --------------------	7	203	210

148-50-11ddd
Test hole 1324
Elevation 860 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black ------------	4	0	4
	Clay, smooth, yellow -------------	13	4	17
	Clay, smooth, gray ---------------	121	17	138
	Clay, sandy, silty, gravelly, a few cobbles, gray (till) -----	42	138	180
	Gravel, fine and medium, some light-gray clay -------------	13	180	193
Cretaceous undifferentiated:				
	Clay, gray, cohesive -------------	19	193	212
	Clay, gray, shaly ----------------	8	212	220

148-50-13add
Test hole 2768
Elevation 868 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, sandy, grayish-black -----------------------	1	0	1
	Clay, silty, moderate yellowish-brown, slightly cohesive and plastic, very calcareous, oxidized (lake sediment) -----	17	1	18
	Clay, olive-gray to medium gray, very cohesive, plastic, calcareous (lake sediment) ------	129	18	147

148-50-13add (Cont.)
Test hole 2768
Elevation 868 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift: (Cont.)				
	Gravel, sandy (approximately 20-30 percent coarse to very coarse, angular to rounded sand), fine to coarse, subangular to rounded, moderately well-sorted, approximately 40-50 percent limestone and dolostone, 20-30 percent shale, remainder granitics and quartz, taking water ------------	83	147	230
	Sand, medium to very coarse (grades to very coarse toward bottom of section), well-sorted, subangular to rounded, approximately 25-35 percent limestone and dolostone, 35-45 percent quartz, remainder shale and granitics, rapidly taking water -------------------	40	230	270
	Gravel, sandy (approximately 20-30 percent coarse to very coarse, subangular to rounded sand), fine to coarse, subangular to rounded, moderately well-sorted, approximately 40-50 percent limestone and dolostone, 20-30 percent shale, remainder granitics, sandstone, quartz and chalcedony, taking water --------------------------	38	270	308
Cretaceous undifferentiated:				
	Sandstone, grayish-green, fine to medium-grained, very calcareous, well cemented, indurated, interbedded with shale, moderate olive-brown, very calcareous ----	12	308	320

Electric log
Observation well

$148\text{-}50\text{-}13ccc_1$
Test hole 2383
Elevation 873 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, black --------------------	1	0	1
	Clay, silty, dusky yellow, pale yellowish-brown, light olive-gray to pale olive-gray, oxidized ----	20	1	21

148-50-13ccc$_1$ (Cont.)
Test hole 2383
Elevation 873 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift: (Cont.)				
	Clay, dark greenish-gray, contains pockets of unidentified white material	101	21	122
	Clay, dark greenish-gray, few fine to medium sand-size dolomite fragments	16	122	138
	Clay, sandy, silty, olive-gray, dark greenish-gray, gravel stringers, boulders, calcareous (till)	52	138	190
	Clay, very sandy, light olive-gray, very calcareous (till?)	14	190	204
	Clay, sandy, dark yellowish-brown to light olive-gray, very calcareous (oxidized?) (till?)	17	204	221
	Clay, silty, olive-gray, calcareous, cohesive (till?)	33	221	254
Cretaceous undifferentiated:				
	Clay, silty, olive-gray, calcareous	6	254	260
	Sand, medium to coarse, subangular to subrounded quartzitic, some light brown to pale purple clay	23.5	260	285.5

148-50-13ccc$_2$
Test hole 2537
Elevation 873 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, black	2	0	2
	Clay, silty, dusky yellow, mottled oxidized, plastic	19	2	21
	Clay, silty, olive-gray to dark greenish-gray	14	21	35
	Clay, silty, clayey, olive-gray to dark greenish-gray, sand and gravel-size igneous, dolomite, limestone and shale fragments (till)	80	35	115
	Clay, sandy, silty, light greenish and yellowish-gray, limestone and shale rock fragments (till)	10	115	125

148-50-13ccc$_2$ (Cont.)
Test hole 2537
Elevation 873 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Clay, sandy, silty, olive-gray, plastic (till)	13	125	138
	Clay, gravelly, olive-gray, (till)	19	138	157
	Gravel, granules and pebbles, limestone, igneous, and shale fragments	4	157	161
	Clay, silty, sandy, gravelly, olive-gray to dark greenish-gray (till)	19	161	180
	Gravel, many rocks	8	180	188
	Clay, sandy, gravelly, olive-gray (till)	11	188	199
	Clay, silty, sandy, pale brown to light brownish-gray (till)	6	199	205
	Clay, silty, sandy, olive-gray (till)	20	205	225
	Clay, sandy, light to light olive-gray and light brownish-gray (till)	29	225	254
Cretaceous undifferentiated:				
	Clay, silty, light olive-gray to olive-gray	6	254	260
	Clay, silty, sandy, pale brown to light brownish-gray	21	260	281
	Clay, silty, sandy, white, light-gray, light greenish-gray and bluish-gray, fine to coarse, angular to subrounded sand, light-brown siderite (?) pellets, clay looks micaceous	39	281	320
	Clay, silty, sandy, light-gray to light greenish-gray, more sandy than above	27	320	347
Precambrian rocks:				
	Clay, sandy, silty, white to greenish-gray, few chips of chlorite schist (weathered metamorphic rock?)	42.5	347	389.5
	Granite, few rock chips of dark-green, black, rock containing quartz	0.5	389.5	390

148-50-14bbb
Test hole 1321

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, black	1	0	1
	Clay, smooth, yellow	12	1	13
	Clay, smooth, blue	114	13	127
	Clay, sandy, gray, fine and medium limestone gravel (till)	46	127	173
Cretaceous undifferentiated:				
	Clay, shaly, gray	16	173	189

148-50-15bbc
Test hole 2387

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, black	2	0	2
	Clay, silty, mottled, oxidized, calcareous	16	2	18
	Clay, silty, olive-gray	24	18	42

148-50-15ccc
Test hole 2774

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, clayey, grayish-black	1	0	1
	Clay, silty, moderate yellowish-brown, very cohesive, plastic, calcareous, well oxidized (lake sediment)	11	1	12
	Clay, silty, olive-gray to medium gray, very cohesive, plastic, calcareous (lake sediment)	88	12	100
	Clay, silty to sandy, cohesive, non-plastic, calcareous (till)	16	100	116
	Clay, silty, sandy, gravelly, medium dark-gray to olive-gray cohesive, non-plastic, calcareous (till)	34	116	150
	Sand, interbedded with olive-gray clay, fine to medium-grained, subangular to rounded, fair sorting, approximately 75-85 percent quartz, 5-10 percent shale, remainder light-colored granitics	16	150	166

148-50-15ccc (Cont.)
Test hole 2774

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:	(Cont.)			
	Clay, sandy, dark greenish-gray cohesive, non-plastic, calcareous (till)	7	166	173
	Gravel, interbedded throughout section with sandy clay, fine to coarse, angular to subrounded, poorly sorted, approximately 35-45 percent limestone and dolostone, 25-35 percent shale, remainder light-colored granitics and sandstone, poor samples	45	173	218
	Sand, fine to coarse-grained, angular to subrounded, consolidated, possibly cemented?, approximately 75-85 percent quartz, slightly calcareous	22	218	240
	Clay, very silty, medium bluish-gray, cohesive, slightly plastic, calcareous	5	240	245
	Clay, silty, sandy, olive-gray to dark greenish-gray, cohesive, non-plastic, very calcareous (till)	27	245	272
	Clay, silty, sandy, olive-gray to moderate brown, very calcareous, cohesive, non-plastic (till)	28	272	300

Electric log

148-50-15cdd
Test hole 2385

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black	2	0	2
	Clay, silty, dark to moderate yellow-brown, oxidized	8	2	10
	Gravel, granule, fine to coarse sand	3	10	13
	Clay, silty, medium to dark olive-gray	19	13	32

148-50-17bbb
Test hole 207

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black	1	0	1
	Sand, very fine to fine, clayey, brown	4	1	5
	Clay, smooth, brown, oxidized	2	5	7
	Clay, light-brown to light-gray, oxidized (till)	15	7	22

148-50-20abb
Test hole 2388

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black	2	0	2
	Clay, silty, yellowish-brown, mottled, oxidized, calcareous (till)	16	2	18
	Clay, silty, olive-gray to greenish-gray	45	18	63

148-50-20ccc
Test hole 1963

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black	1	0	1
	Clay, silty, grayish-yellow	4	1	5
	Clay, silty to sandy, dark yellowish-orange, shale and limestone pebbles, oxidized (till)	10	5	15
	Clay, as above, olive-gray (till)	94	15	109
	Clay, silty to sandy, olive-gray, cohesive, coarser texture than above	35	109	144
	Gravel, fine to coarse, subangular to subrounded limestone fragments	2	144	146
	Clay, light olive-gray, abundant fine to medium limestone gravel	64	146	210

148-50-22ada
Test hole 2386

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black ------------	2	0	2
	Clay, silty, pale yellowish-brown to light-brown, mottled, ozidized, calcareous ---------	5	2	7
	Sand, fine to coarse, oxidized, coarse, sand and some granules from 11 to 13 feet -----------	9	7	16
	Clay, silty, sandy, olive-gray ---	27	16	43

148-50-23bbb
Test hole 2775

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, clayey, grayish-black -----------------------	1	0	1
	Clay, silty, moderate yellowish brown, very cohesive, plastic, calcareous, oxidized (lake sediment) ------------------	14	1	15
	Clay, silty, olive-gray to medium dark-gray, very cohesive, plastic, calcareous (lake sediment) ------------------	115	15	130
	Clay, silty, olive-gray, cohesive, non-plastic, calcareous (till)	15	130	145
	Clay, silty, gravelly, olive-gray to grayish-orange, moderately cohesive, granite boulder from 145-146 feet (till) ----------	75	145	220

148-50-24ddd
Test hole 1328

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black -------------------	2	0	2
	Clay, smooth, yellow -------------	12	2	14
	Clay, smooth, gray ---------------	128	14	142
	Clay, gray (till) ----------------	13	142	155
	Sand, coarse, some fine gravel ---	11	155	166
	Clay, gray -----------------------	23	166	189

148-51-2dcd
Test hole 1960

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Sand, fine to coarse, rounded, poorly sorted, silty in top 1 foot --------------------	11	0	11
	Clay, very silty, light olive-gray to olive-gray (reworked till)	9	11	20
	Clay, silty and sandy, light olive-gray and olive-gray, shale pebbles (till) ----------------	91	20	111
	Sand, coarse to very coarse, fine gravel -----------------------	2	111	113
	Clay, silty to sandy, cohesive, olive-gray, limestone and shale pebbles (till) ----------	3	113	116
	Gravel, fine, sand, fine to coarse, some light olive-gray, silty, clay -------------------------	8	116	124
	Clay, sandy to gravelly, olive-gray, shale pebbles (till) ----------	26	124	150
	Clay, silty to sandy, brownish-gray, and light olive-gray (till) ---	50	150	200
Cretaceous undifferentiated:				
	Clay, silty, light olive-gray -----	10	200	210

148-51-12ddd
Test hole 1319

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black -------------	2	0	2
	Clay, smooth, light-gray ----------	9	2	11
	Clay, smooth, gray ----------------	93	11	104
	Clay, silty to sandy, gray, fine and medium limestone gravel and shale pebbles (till) ----------	44	104	148
	Sand, fine to coarse, with some gray clay ---------------------	11	148	159
	Clay, smooth, gray ----------------	9	159	168
	Gravel, fine and medium, with very fine silty sand ---------------	23	168	191
	Clay, smooth, bluish-gray ---------	13	191	204
Cretaceous undifferentiated:				
	Clay, shaly, gray -----------------	6	204	210

148-51-15aaa
Test hole 1193

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, black	2	0	2
	Clay, yellow, smooth	10	2	12
	Clay, light-gray, smooth	73	12	85
	Clay, gray, gravel, fine to medium shale pebbles (till)	85	85	170
Cretaceous undifferentiated:				
	Clay, shaly, light-gray	288	170	458
Ordovician and (or) Cambrian:				
	Limestone, lithographic, white and light red, indurated, fine to coarse pink and white sandstone cemented with calcium carbonate	8	458	466
Precambrian:				
	Granite	2	466	468

148-51-17aaa
Test hole 1192

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, black	1	0	1
	Clay, smooth, yellow	15	1	16
	Clay, sandy, gray	54	16	70
	Clay, smooth, blue	25	70	95
	Clay, sandy, gray, fine and medium limestone and shale gravel (till)	80	95	175
Cretaceous undifferentiated:				
	Clay, shaly, gray	14	175	189

148-51-24aad2
Test hole 204

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, sandy, black	1	0	1
	Sand, very fine to fine, light-brown to light-gray, more clayey with depth	19	1	20
	Clay, smooth, gray	2	20	22

148-51-25ccc4
Test hole 1

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Sand and Gravel	11	0	11
	Clay, silty, soft, gray, and sand, fine-grained --------------------	7	11	18
	Clay, silty, gray, with interbedded sand, fine ---------------------	11	18	29

148-51-26ddd2
Test hole 2

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Gravel, mostly pea size -------------	2	0	2
	Sand, with some fine gravel ---------	8	2	10
	Clay, silty, gray, and fine-grained sand ---------------------------	7	10	17

148-51-28dcc
Test hole 2918
Elevation 958 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, sandy, clayey, black	1	0	1
	Clay, silty, sandy, pebbly, moderate yellowish-brown with a few reddish-brown laminations and streaks, moderately cohesive, moderately plastic, oxidized (till) -------------------------	14	1	15
	Clay, silty, sandy, gravelly, olive-gray, cohesive, slightly plastic, numerous shale and limestone fragments (till) ----------------	60	15	75
	Sand, very fine to fine-grained, angular to rounded, moderately well-sorted, interbedded with silty, olive-gray clay, mostly quartz with some shale, limestone, dolostone and granitics -	20	75	95
	Gravel, fine to medium, angular to subrounded, poorly sorted, interbedded with silty clay, mostly limestone, dolostone and shale, some granitics -----------	5	95	100

148-51-28dcc (Cont.)
Test hole 2918
Elevation 958 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:	(Cont.)			
	Clay, very silty, sandy, pebbly, olive-gray to medium dark-gray cohesive, slightly plastic, calcareous, numerous limestone and shale fragments (till) ------	60	100	160

148-51-29ccc[1]
Test hole 129

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, sandy, black --------------	1	0	1
	Gravel, fine, fine and coarse sand -	2	1	3
	Clay, sandy, light-brown to yellow, mottled ------------------------	9	3	12
	Clay, gray, mottled ---------------	30	12	42

148-51-29ccc[2]
Test hole 2781
Elevation 981 feet

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, silty, sandy, grayish-black --------------------------	1	0	1
	Gravel, sandy (approximately 35-45 percent coarse to very coarse, subangular to rounded, oxidized), fine to medium, subangular to subrounded, fair sorting, approximately 45-55 percent limestone and dolostone, remainder light-colored granitics, shale, and sandstone ----------------------	7	1	8
	Clay, silty to sandy, moderate yellowish-brown, cohesive, calcareous, oxidized (lake sediment) ----------------------	7	8	15
	Clay, silty, olive-gray to dark greenish-gray, cohesive, plastic, a few sand grains and granules (till) -----------------	15	15	30
	Clay, silty, olive-gray, very cohesive, plastic, calcareous (lake sediment) ----------------	32	30	62

148-51-29ccc$_2$ (Cont.)
Test hole 2781
Elevation 981 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift: (Cont.)				
	Sand, clayey, very silty, very fine to fine, subangular to rounded, well-sorted, estimate 75-85 percent quartz, remainder shale, limestone and dolostone -----------	50	62	112
	Clay, silty, olive-gray, cohesive, non-plastic, calcareous (till)	48	112	160

148-51-32aaa
Test hole 2917
Elevation 961 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, sandy, brownish-black ------------------------	1	0	1
	Clay, very silty, sandy, moderate yellowish-brown, cohesive, plastic, oxidized (till) ------	11	1	12
	Clay, very silty, sandy, pebbly, olive-gray, cohesive, plastic, numerous shale and limestone fragments (till) -------------	35	12	47
	Sand, very fine-grained, angular to rounded, well-sorted, mostly quartz with small amount of shale, probably some silt -----	7	47	54
	Clay, sandy, silty, olive-gray, moderately cohesive, moderately plastic, calcareous, interbedded with fine-grained sand -	3	54	57
	Sand, very fine to medium-grained, angular to subrounded, mostly quartz with small amount of shale, a few limestone and granitic fragments, taking small amount of water ---------	38	57	95
	Clay, silty, sandy, pebbly, olive-gray to medium dark-gray, cohesive, very slightly plastic, calcareous (till) -------------	45	95	140

Observation well
Electric log

148-51-32abb
Test hole 2919
Elevation 967 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, sandy, silty, black ------	1	0	1
	Clay, sandy, silty, pebbly, moderate yellowish-brown, cohesive, plastic, oxidized (till) ------	11	1	12
	Clay, sandy, silty, pebbly, olive-gray with a few moderate yellowish-brown laminations, cohesive, plastic, numerous shale and limestone fragments (till) -----------------------	34	12	46
	Sand, very fine to medium-grained, angular to rounded, well-sorted, mostly quartz with some shale and limestone, a few mica flakes -----------------------	52	46	98
	Clay, silty, sandy, pebbly, olive-gray to medium dark-gray, cohesive, slightly plastic to non-plastic, calcareous, numerous limestone and shale fragments (till) -----------------	62	98	160

Electric log

148-51-33aaa
Test hole 2960
Elevation 957 feet

Formation	Material	Thickness (feet)	Depth (feet) From	Depth (feet) To
Glacial drift:				
	Topsoil, silty, clayey, black -----	1	0	1
	Clay, silty, slightly sandy, moderate yellowish-brown, slightly to moderately cohesive, moderately plastic, numerous limestone and shale fragments, oxidized (till) --------------	15	1	16
	Clay, silty, olive-gray, moderately cohesive to cohesive, plastic, numerous limestone and shale fragments (till) -------------	28	16	44
	Clay, very silty, olive-gray with light-gray laminations, very cohesive, plastic, very calcareous, a few limestone fragments (lake sediment) --------------	22	44	66

148-51-33aaa (Cont.)
Test hole 2960

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift: (Cont.)				
	Sand, slightly silty, very fine to fine-grained, subangular to rounded, well-sorted, mostly quartz with some shale and limestone, a few mica flakes --	36	66	102
	Clay, very silty, olive-gray to light olive-gray, cohesive, plastic, very calcareous ------	6	102	108
	Clay, silty, slightly sandy, olive-gray, moderately cohesive, moderately plastic, calcareous, numerous limestone and shale fragments, a few pebbles and cobbles (till) ---------------	24	108	132
	Clay, very sandy, silty, olive-gray (lake sediment) --------------	13	132	145
	Clay, silty, sandy, pebbly, olive-gray to dark greenish-gray, moderately cohesive, moderately plastic to slightly plastic, calcareous, a few light brown concretion-like streaks, partially oxidized (till) --------	34	145	179
	Clay, sandy, silty, lignitic, dark greenish-gray, numerous limestone, shale and quartz fragments, slightly cohesive, slightly plastic, slightly calcareous (till) ------------	17	179	196
	Clay, silty, sandy, olive-gray to brownish-gray, moderately cohesive, moderately plastic, calcareous, numerous limestone and shale fragments, a few pebbles (till) ----------------------	26	196	222
Cretaceous undifferentiated:				
	Shale, silty, brownish-black with a few pale yellowish-brown laminations, moderately indurated, non-calcareous, interbedded with fine to medium-grained quartzitic sand --------------	98	222	320

Electric log

148-51-33ccb
Test hole 130

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, sandy, black ------------	1	0	1
	Gravel, fine to coarse, fine and coarse sand ------------------	14	1	15
	Sand, fine to coarse, more clayey with depth ------------------	7	15	22
	Clay, smooth, gray ---------------	5	22	27

148-51-36bbb3
Test hole 205

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Topsoil, sandy, black ------------	1	0	1
	Gravel, fine to coarse, fine and coarse sand ------------------	5	1	6
	Sand, fine to coarse, light-gray, more silty and clayey with depth ------------------------	24	6	30
	Clay, smooth, light-gray ---------	2	30	32

148-51-36cab
Test hole 3

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Sand, fine to very fine ----------	7	0	7
	Clay, soft, gray -----------------	7	7	14

148-51-36cbb
Test hole 4

Formation	Material	Thickness (feet)	Depth (feet) From	To
Glacial drift:				
	Gravel, fine and sand, coarse ----	12	0	12
	Sand, fine to coarse -------------	4	12	16
	Clay, silty, gray, with interbedded fine sand ----------------	16	16	32
	Clay, sticky, blue ---------------	3	32	35

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