GEOLOGY AND GROUND-WATER RESOURCES OF THE UPHAM AREA MC HENRY COUNTY, NORTH DAKOTA

BY

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AND
J. E. POWELL, ENGINEER

GEOLOGICAL SURVEY
UNITED STATES DEPARTMENT OF THE INTERIOR

NORTH DAKOTA GROUND-WATER STUDIES NO. 26

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

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CONTENTS

ILLUSTRATIONS

TABLES

GROUND WATER IN THE UPHAM AREA
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ABSTRACT

The Upham area includes about 99 square miles of northern McHenry County in north-central North Dakota. The surficial deposits are principally glacial drift of late Wisconsin age. In small, isolated areas the drift is covered with alluvium and slopewash of Recent age.

The glacial drift is subdivided into deposits in the valley of the Souris River, deposits of glacial Lake Souris, and till and associated sand and gravel deposits. The deposits in the valley of the Souris River are water-bearing deposits of medium to coarse sand and range in thickness from a few feet near the edges of the valley to about 20 feet near the center of the valley. The valley deposits are about 3 miles wide, and more than 3,000 acre-feet of ground water is estimated to be in transient storage in each mile of the valley's length.

Deposits of glacial Lake Souris lie at the surface except in the stream valleys. They constitute a poor but widespread aquifer.

Till and associated sand and gravel deposits underlie the deposits of glacial Lake Souris in the entire area. It is believed that aquifers occurring in these deposits are restricted in volume but that some probably have relatively high transmissibilities. Northwestward-trending, elongated deposits of sand and gravel are enclosed by glacial till near Upham.

The Cannonball member of the Fort Union formation of Paleocene age or the Fox Hills(?) sandstone of Late Cretaceous age (or both) underlie the glacial drift in the Upham area west of the Souris River. The Cannonball member and the Fox Hills sandstone are poor aquifers.

The Pierre shale of Late Cretaceous age underlies the glacial drift in the area east of the Souris River and the Cannonball member of the Fort Union formation and Fox Hills sandstone west of the river. The Pierre shale is not an aquifer in the Upham area.

Older Cretaceous rocks, as well as rocks of Jurassic, Triassic and Mississippian age, also underlie the area in descending order. Of these, only the Dakota sandstone of Early Cretaceous age is considered to be of any potential importance as an aquifer.

Ground water in the glacial-drift aquifers ordinarily is of the calcium bicarbonate or sulfate type and is hard. Ground water in the bedrock aquifers is believed to be very highly mineralized, with sodium and chloride constituting a large proportion of the dissolved minerals. Ground water leakage from the bedrock aquifers into the overlying glacial drift has caused some water in the glacial drift to become highly mineralized.

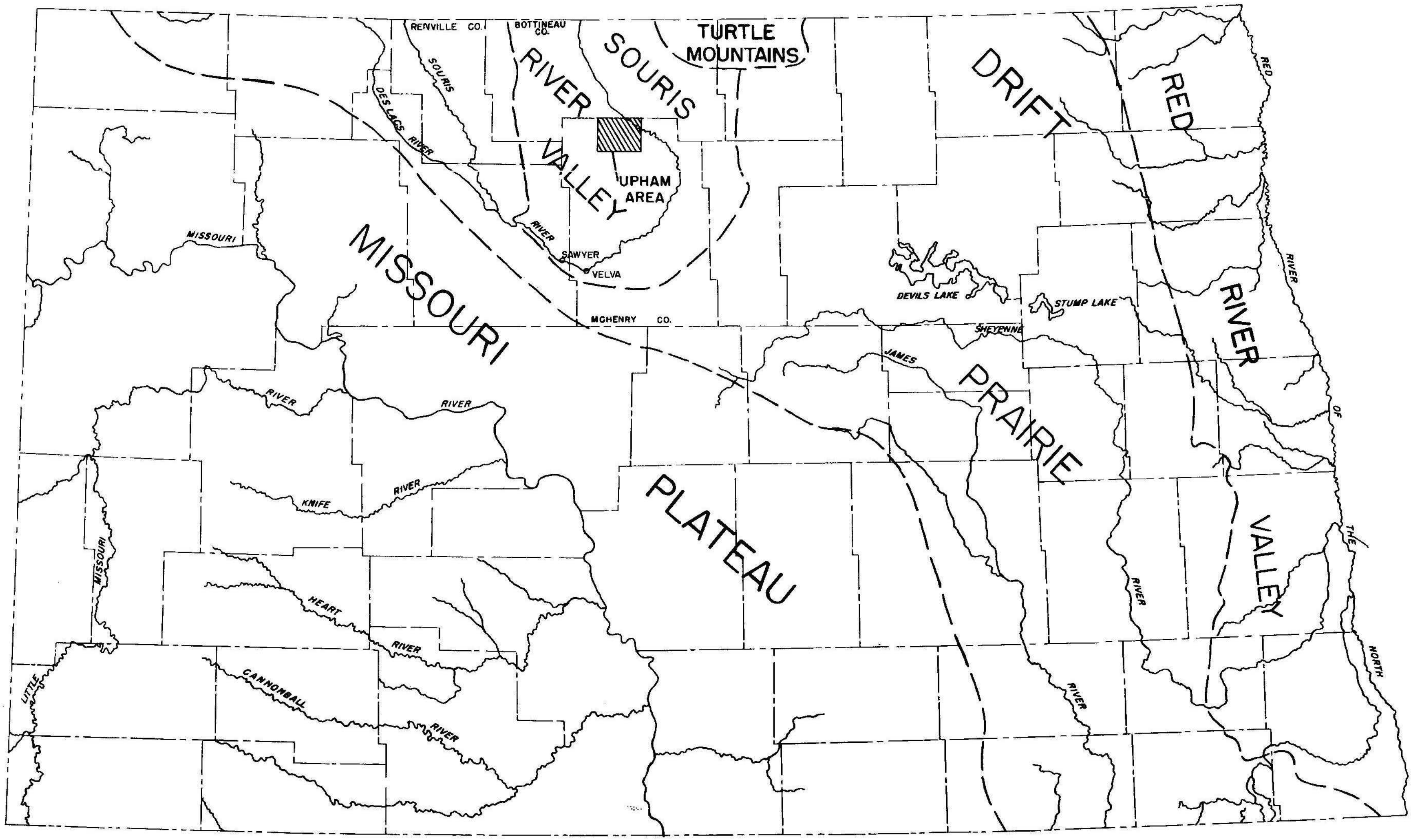


FIGURE 1.—MAP OF NORTH DAKOTA SHOWING PHYSIOGRAPHIC DIVISIONS, AS MODIFIED FROM SIMPSON, AND LOCATION OF THE UPHAM AREA.

INTRODUCTION

Location and General Features of the Area

The Upham area, about 99 square miles in the northern part of McHenry County, north-central North Dakota, includes all of T. 159 N., R. 78 W., parts of T. 158 N., Rs. 77, 78, and 79 W., and parts of T. 159 N., Rs. 77 and 79 W. The area is served by State Highway 14 and a branch line of the Great Northern Railway, both of which cross the area in a northwesterly direction. Upham, the only municipality in the report area, is in the central part of the area and had a population of 403 in 1950. It is a shopping and trading center for the surrounding area. Farming is the chief occupation in the area and wheat and flax are the main crops. Forage crops are grown on considerable tracts of land bordering the Souris River.

The average annual precipitation at Towner, N. Dak. (about 20 miles southeast of Upham), based on a 52-year record through 1953, is 16.05 inches. The 52-year average annual temperature at Towner is 38.9°F (U. S. Weather Bureau, 1953).[1/]

The area is in the Western Young Drift section of the Central Lowlands physiographic province of Fenneman (1938, p. 559) and is in the central part of the Souris River Valley physiographic division of Simpson (1929, p. 5, 8-9). The Souris River Valley physiographic

1/See References at end of report.

division is a broad basin that slopes gently northward toward the long axis of the basin. The basin was occupied by glacial Lake Souris, probably during the last part of the Mankato substage of the Pleistocene epoch.

The Upham area is essentially a depositional lake plain. However, it has considerable relief which, in places, exceeds 25 feet in half a mile. Geologic processes other than deposition in the glacial lake probably were active in the area during and subsequent to the formation of the lake plain. The lake probably was very shallow, and even disconnected in places, so that erosion could occur concurrently with, as well as after, lake deposition.

The Upham area is drained by the northwestward-flowing Souris River and two of its tributaries, Deep River and Cut Bank Creek. Dams have been constructed across the valley of the Souris River by the United States Fish and Wildlife Service; the resultant reservoirs serve as refuges for migratory waterfowl.

Purpose and Scope of the Investigation

A study of the geology and ground-water resources of McHenry County, N. Dak. is being made by the United States Geological Survey in cooperation with the North Dakota State Water Conservation Commission and the North Dakota Geological Survey as part of a series of investigations in the State. The purposes of these studies are to determine the occurrence, movement, discharge, and recharge of the ground water, and the quantity and quality of ground water available for all needs, including municipal, domestic, irrigation, and industrial. The most critical current need is for adequate and perennial water supplies for many towns and small cities throughout the State. For this reason, countywide studies are begun in the vicinity of towns that request the help of the State Water Conservation Commission and the State Geologist in locating suitable ground-water supplies. Progress reports, such as this one, are prepared before the completion of the general studies so that current data may be available for use in connection with immediate problems.

The work that was done for this report was accomplished during 1952 and consists of a study of the surface geology of the area, an inventory of the wells in the area, test drilling, the collection and chemical analysis of water samples, and a study of the available data.

Previous Investigations and Acknowledgments

The geology and ground-water resources of McHenry County, N. Dak., were described generally by Simpson (1929, p. 156-161). Abbott and Voedisch (1938, p. 64-66) presented chemical analyses of water samples from two wells in Upham. The Upham area is part of a much larger area, the Crosby-Mohall area, that will be discussed in a comprehensive report now being written.

The geology of a considerable area in northwestern and north-central North Dakota was mapped recently by members of the U. S. Geological Survey (Lemke and others), and much of the geologic information in preliminary maps resulting from that work has been used to prepare this report.

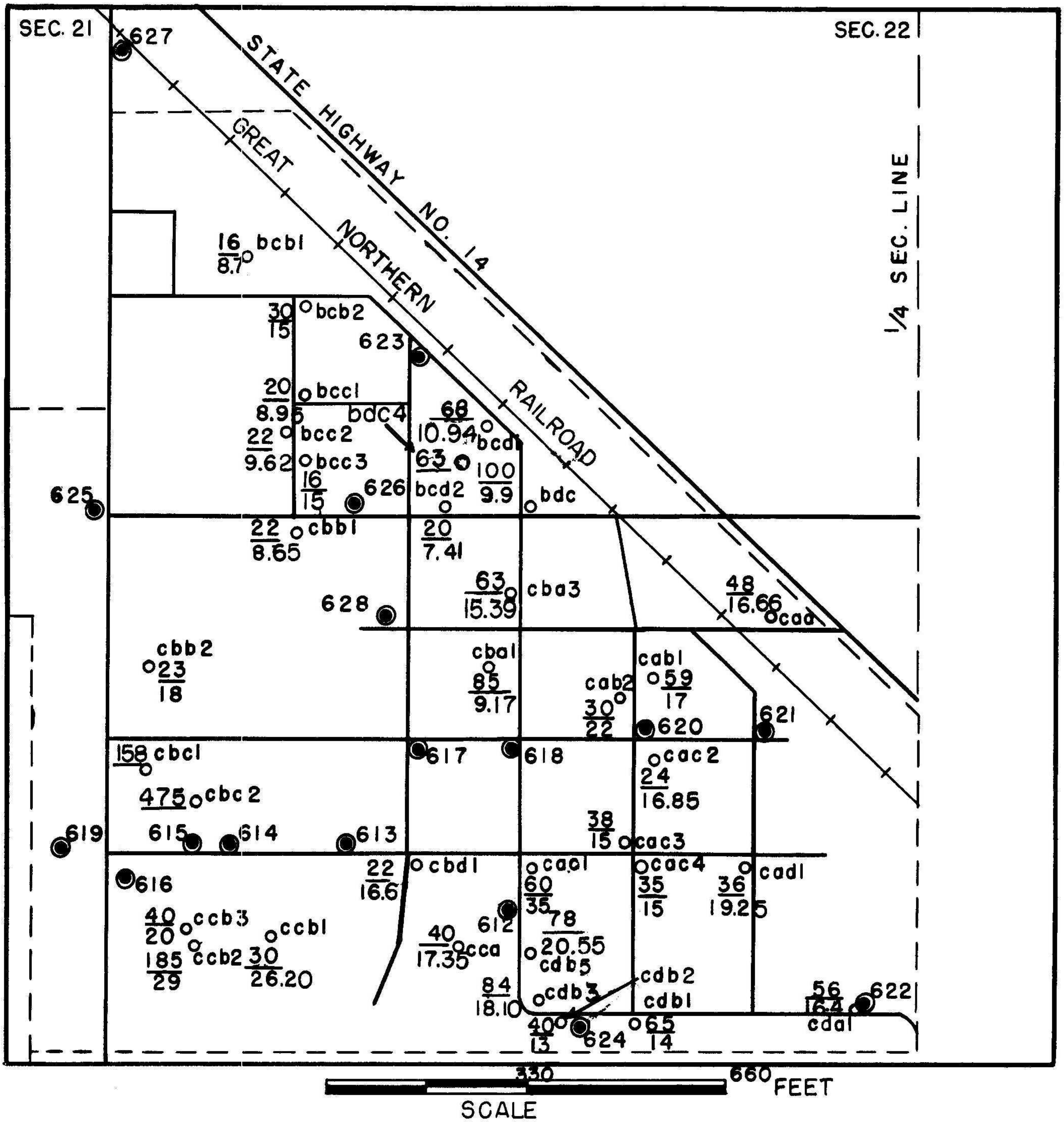
The investigation was facilitated greatly by the cooperation of the residents of the Upham area, particularly the members of the village council.

The investigation was made under the general supervision of P. D. Akin, District Engineer, Ground Water Branch, Water Resources Division, U. S. Geological Survey. The test drilling and other field work were done under the direct supervision of the authors during the 1952 field season.

Present Water Supply and Future Needs

Ground water is used for all municipal and domestic supplies in the Upham area. Water for livestock is obtained from ponds, wells, and streams.

Water supplies of large magnitude are not in demand at the present time (1952). The village of Upham does not have a municipal water-supply system. On the basis of current population figures, it is estimated that about 50,000 gpd would be adequate for a municipal water supply.



o EXISTING WELL

● COOPERATIVELY DRILLED TEST HOLE

cda 48/16.66 UPPER NUMBER INDICATES DEPTH OF WELL OR TEST HOLE; LOWER NUMBER INDICATES DEPTH TO WATER BELOW LAND SURFACE; LETTERS INDICATE LOCATION IN SECTION.

PLATE 3 MAP OF VILLAGE OF UPHAM SHOWING LOCATIONS OF WELLS AND TEST HOLES

Wells in the area range in depth from a few feet to a known maximum of 210 feet. The shallow wells generally are dug or driven, those of intermediate depth generally are bored or drilled, and all the deeper wells are drilled. The dug and bored wells usually are several feet in diameter but the driven and drilled wells rarely exceed 5 inches in diameter. The driven and drilled wells generally are equipped with screens and some are enveloped with sorted gravel, which prevents the entrance into the well of the finer particles of the aquifer.

Most of the water used in Upham is obtained from privately owned wells. Two community wells furnish water for public use and one furnishes water for public-school supply.

The locations of most of the wells in the Upham area are shown on plate 1 and information concerning them is given on pages 32 through 42. Wells in the village of Upham are shown on plate 3.

Well-Numbering System

The well-numbering system used in this report is illustrated in figure 2 and is based upon the location of the well within the United States Bureau of Land Management's survey of the area. The first numeral denotes the township north of the base line; the second numeral denotes the range west of the fifth principal meridian; and the third numeral 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 sections, the quarter-quarter sections, and the quarter-quarter-quarter sections (10-acre tracts). Consecutive terminal numerals are added if more than one well is located within a 10-acre tract. Thus, well 158-77-6bca is in the northeast quarter of the southwest quarter of the northwest quarter of section 6, T. 158 N., R. 77 W. Similarly, well 159-78-23baa is in the northeast quarter of the northeast quarter of the northwest quarter of section 23, T. 159 N., R. 78 W.

GEOLOGY AND OCCURRENCE OF GROUND WATER

Principles of Occurrence of Ground Water

Essentially all ground water is derived from precipitation. Rain or melting snow enters the ground by direct penetration or by percolation from streams and lakes that lie above the water table. Ground water generally moves laterally from areas of recharge to areas of natural discharge.

Ground water discharge occurs by evaporation from lakes and ponds into which the water seeps, by transpiration by plants and evaporation from the land surface in areas where the ground-water level is near the land surface, by seepage to streams, and by discharge from wells.

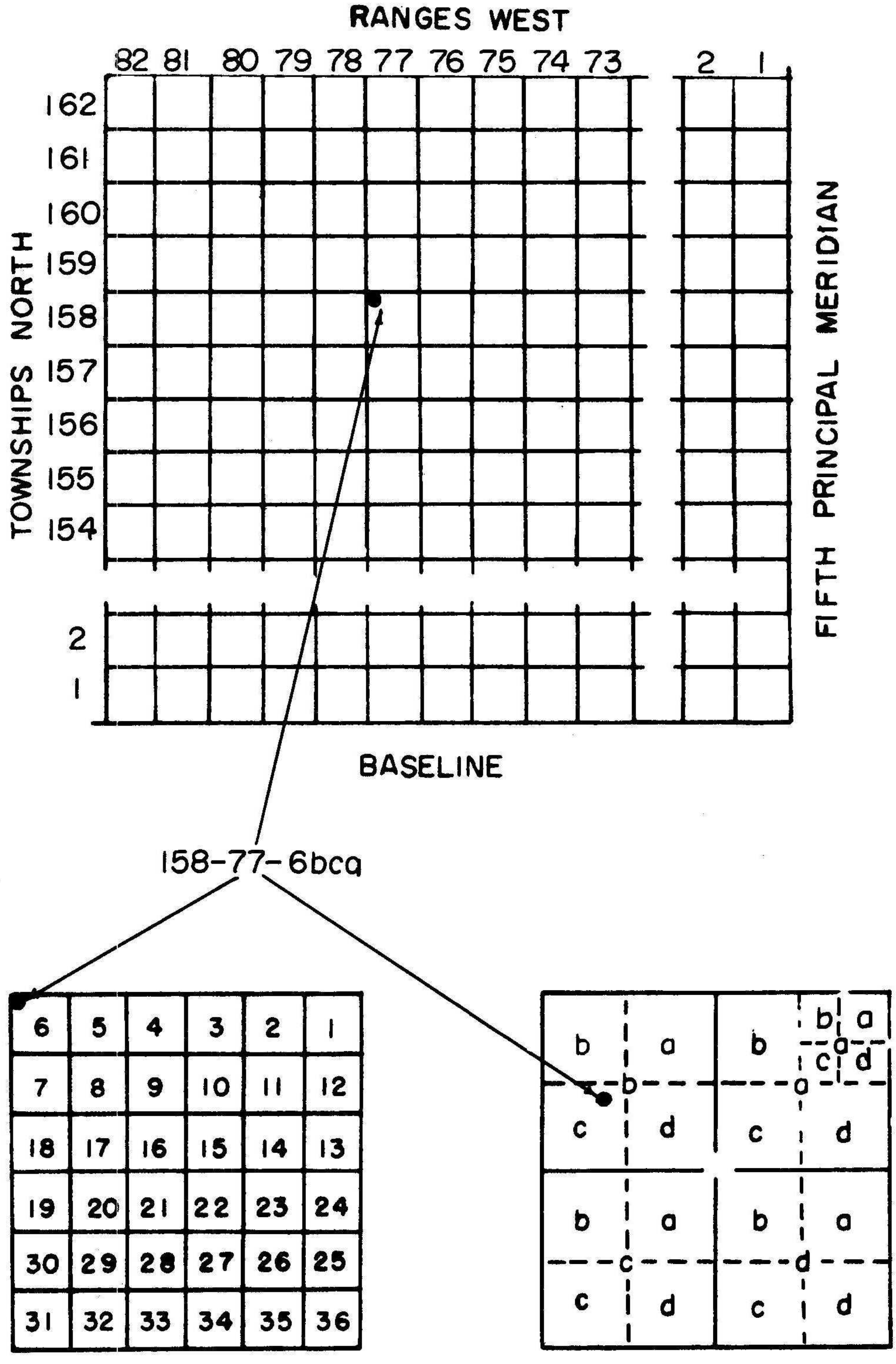


Figure 2 --Sketch illustrating well-numbering system.

Any rock formation or stratum that will yield water in sufficient quantity to be important as a source of supply is called an "aquifer" (Meinzer, 1923, p. 52). Water moving in an aquifer from recharge to discharge areas may be considered to be in "transient storage."

The amount of water that a rock can hold is determined by its porosity. Unconsolidated material such as clay, sand, and gravel generally is more porous than consolidated rocks such as sandstone and limestone; however, consolidated rocks in some areas are highly porous.

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

If the water in an aquifer is not confined by overlying impervious strata, the water is said to be under water-table conditions. Under these conditions, water can be obtained from storage in the aquifer by gravity drainage; that is, by lowering the water level as in the vicinity of a pumped well.

Water is said to be under artesian conditions if it is confined in the aquifer by an overlying impermeable stratum. Under these conditions, hydrostatic pressure will raise the water in a well penetrating the aquifer above the top of the aquifer and water is yielded as the water level in the well is lowered by pumping. However, the aquifer remains saturated, and the yield of water from storage in it occurs because the water expands and because the aquifer is compressed as the head is decreased. Gravity drainage does not occur so long as artesian conditions persist. The water-yielding capacity of an artesian aquifer is called the "coefficient of storage" and generally is very much smaller than the specific yield of the same material under water-table conditions. The coefficient of storage of an aquifer is the volume of water it released from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

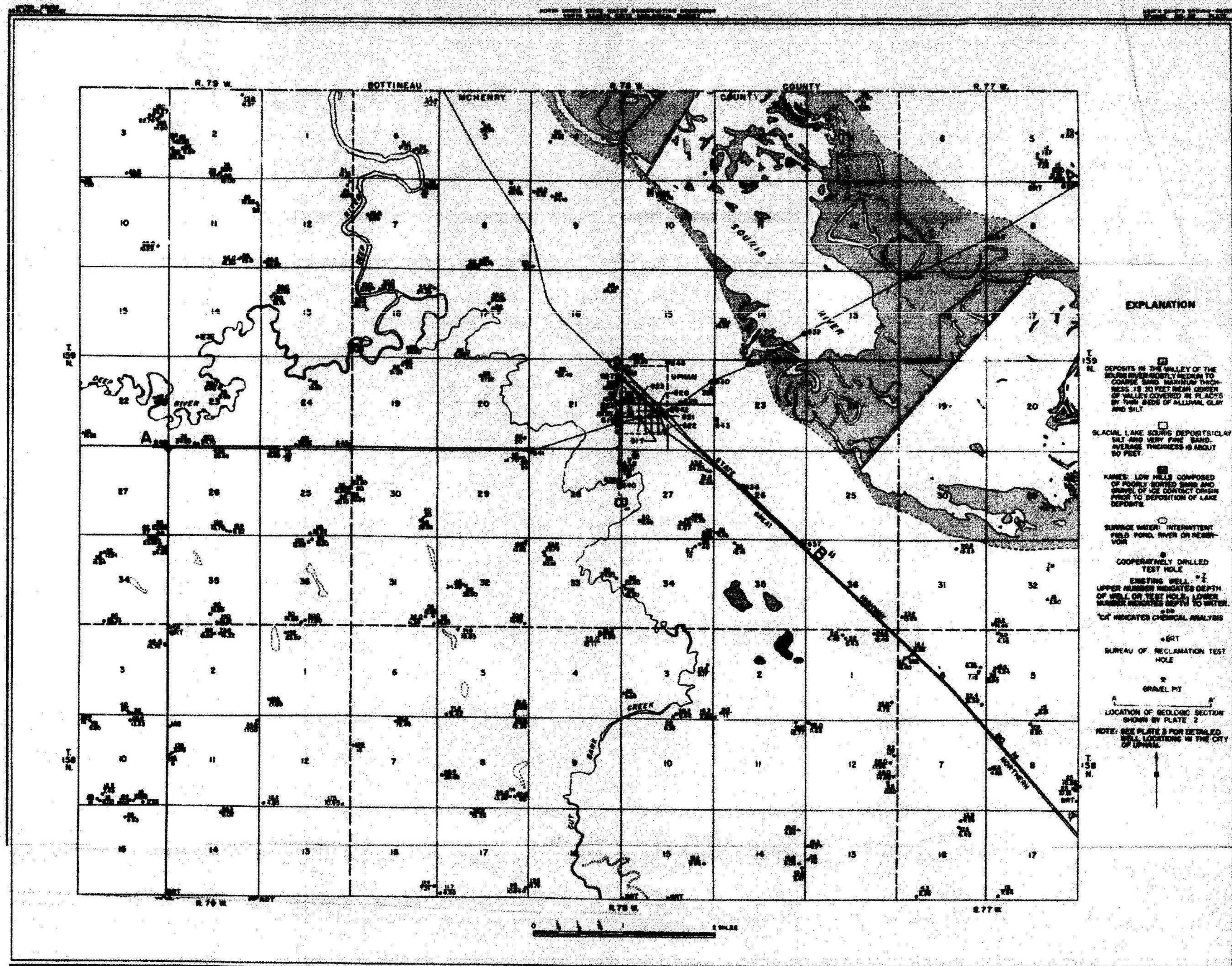
The frictional resistance to the movement of water through pore spaces that are relatively large, as in coarse gravel, is not great and the material is said to be permeable. However, the resistance to the movement of water through small pore spaces, as in clay or shale, may become very great and the material then is said to be impermeable or to have low permeability. Permeability is expressed quantitatively, for field use, as the number of gallons of water per day that will pass through a cross-sectional area of 1 square foot under unit, or 100 percent, hydraulic gradient at the local temperature of the ground water.

The "coefficient of transmissibility" is convenient to use in ground-water studies because it indicates a characteristic of the aquifer as a whole rather than of a small section. It is the average field permeability of the aquifer multiplied by the thickness, in feet, of the saturated part of the aquifer, and is expressed in gallons per day per foot.

The suitability of an aquifer as the source of a water supply is governed by the transmissibility of the aquifer; by its thickness, depth, and areal extent; and by its capacity to store and release water. Recharge to the aquifer also must be adequate if the water supply is to last indefinitely, because even a small rate of withdrawal will eventually deplete the water in storage unless there is equal or greater recharge. Aquifers that are of high permeability, but are small in areal extent and completely enclosed in relatively impermeable material, have been pumped nearly dry in a comparatively short time, to the detriment and disappointment of those concerned. The rather high initial yield of a well may give an erroneous impression that a great volume of water will be available from the aquifer indefinitely. Thus, before a ground-water development is made, sufficient test drilling, aquifer tests, and other studies should be made to determine the capabilities of and recharge to the aquifer being considered.

General Stratigraphic Relationships

Information concerning stratigraphy in the Upham area was obtained principally by studying samples of material from test holes and from the logs of other deep borings in or near the area. The



MAP OF UPHAM AREA SHOWING GEOLOGY AND LOCATIONS OF WELLS AND TEST HOLES test holes were drilled with hydraulic-rotary drilling machines and ranged in depth from 60 to 210 feet. Thirty-five test holes were drilled with a State-owned drilling machine in cooperation with the North Dakota State Water Conservation Commission and the North Dakota Geological Survey. Four test holes were drilled under the direction of the United States Bureau of Reclamation. The logs of 6 other wells also were available for study. The locations of the test holes are shown by plate 1 and 3 and their logs are given on pages 43 through 65. Geologic cross sections compiled from the test holes are shown by plate 2.

The following partial stratigraphic section in the Upham area was determined by test drilling in the area and by extrapolation of information from logs of deep borings in nearby areas:

- Cenozoic era
  - Quaternary system
    - Recent series
      - Alluvium
    - Pleistocene series
      - Deposits in the valley of the Souris River
      - Deposits of glacial Lake Souris
      - Till and associated sand and gravel deposits
  - Tertiary system
    - Paleocene series
      - Cannonball member of Fort Union formation

- Mesozoic era
  - Cretaceous system
    - Upper Cretaceous series
      - Fox Hills(?) sandstone
      - Pierre shale
      - Niobrara formation
      - Benton shale equivalents
      - Dakota sandstone

Alluvium

Thin beds of dark-colored clay, silt, and very fine sand are present in the valleys of the Souris River and its tributaries, Deep River and Cut Bank Creek. These deposits were laid down by streams during postglacial time. They generally are less than 5 feet in thickness, are extremely lenticular, and contain no important aquifers.

Glacial drift

The surficial deposits over most of the Upham area consist of glacial drift except in the stream valleys where thin deposits of alluvium overlie the drift. The drift has been divided, according to its lithology and origin, into three units which from youngest to oldest are: Deposits in the valley of the Souris River, deposits of glacial Lake Souris, and till and associated sand and gravel deposits. The deposits in the valley of the Souris River and the deposits of glacial Lake Souris are of late Wisconsin age. The till and associated deposits of sand and gravel also are probably of late Wisconsin age in part, but they probably include deposits formed during one or more earlier substages of the Pleistocene epoch.

The total thickness of glacial drift in the area generally is between 80 and 100 feet. However, 125 feet of drift was penetrated in test hole 633, in the valley of the Souris River, and 179 feet of drift was penetrated in test hole 619 near the western edge of Upham.

The unusually great thicknesses of drift at those locations occupy buried valleys or depressions in the underlying bedrock (see pl. 2).

Deposits in the valley of the Souris River.--Clean, well-sorted sand, ranging in texture from very fine to coarse, underlies the thin beds of fine-grained Recent alluvium in the valley of the Souris River. The contact between the Recent alluvium and the underlying deposits is gradational and the thicknesses of the deposits cannot be ascertained readily. The sand deposits commonly are about 20 feet thick in the central part of the valley, but they are considerably thinner near the edges of the valley.

The valley of the Souris River is believed to have functioned in the Upham area as a northward-draining outlet for glacial Lake Souris. Most of the sand underlying the valley probably represents lake sediments redeposited in a fluvial environment. However, part of the sand deposits may be outwash material deposited by glacial melt-water flowing down the west limb of the Souris River loop (Lemke, R. W., 1954, personal communication).

The sand deposits that underlie the valley of the Souris River are water bearing and probably are an important aquifer of considerable size.

The approximate volume of water-bearing fluvial deposits in a 1-mile length of the valley was computed from available geologic and test-drilling data. More than 3,000 acre-feet[2/] of ground water

2/One acre-foot of water is equal to about 326,000 gallons.

is estimated to be in transient storage in each mile length of the valley if the specific yield of the aquifer is assumed to be about 20 percent.

The rate at which water can be withdrawn from a well constructed in the sand deposits primarily depends upon their coefficient of transmissibility. No data regarding the coefficient of transmissibility and other hydrologic characteristics of the sand deposits are available.

Deposits of glacial Lake Souris.--Loosely consolidated deposits of clay, silt, and very fine to fine sand, the deposits of glacial Lake Agassiz, constitute the surficial sediments in the Upham area except where they have been removed from the valley of the Souris River by stream erosion. Drill cuttings of the deposits show definite laminations. The deposits are believed to be lake deposits because of their sorting and lamination.

As shown by test drilling, the deposits of glacial Lake Souris range in thickness from 21 to 128 feet and average about 50 feet. The deposits are considerably thicker in the vicinity of Upham than elsewhere in the area. The greater thickness apparently is due to the presence of a buried channel. (See pl. 2.)

Most of the deposits of glacial Lake Souris are silty clay which generally is light-gray in color. However, very fine to fine sand is common, especially in the upper part of the deposits. Clay beds, which in drill cuttings exhibit laminar markings, generally occur at the bottom of the deposits.

Because of their wide distribution, aquifers in the deposits of glacial Lake Souris probably are utilized more than any other aquifer in the area. Wells that produce water from the deposits generally are relatively large in diameter and less than 50 feet deep. Wells of this type are more numerous in the southeastern part of the area, where the deposits probably are more sandy and where the water table is shallower than at other places in the area. However, some water generally is obtainable from the glacial-lake deposits in all parts of the area.

An aquifer test was made on a farm well (158-77-35ada) which taps the lake deposits several miles south of the Upham area (LaRocque, G. A., U. S. Geol. Survey, personal communication, 1951). The well is 28 feet deep and penetrated 24 feet of sand which underlies 4 feet of clay. The coefficient of transmissibility of the aquifer was determined to be 1,970 gpd/per foot and the coefficient of storage was determined to be 0.085.

Till and associated sand and gravel deposits.--In most parts of the area, till and associated sand and gravel deposits underlie the deposits of glacial Lake Souris, but in the valley of the Souris River they underlie the fluvial deposits. The deposits are the oldest units of glacial drift and rest directly on the bedrock in all parts of the area. The average thickness of the till and associated sand and gravel deposits, as indicated by test drilling, is about 60 feet. However, the deposits thicken to about 100 feet under the Souris River valley.

Rock debris, picked up and carried by the glacier as it moved southward across the area, was deposited by the glacial ice without significant sorting action of melt water. Therefore, the till is unstratified and poorly sorted. The till is chiefly light-gray clay, silt, and very fine sand, but it contains also larger rock fragments which range in size from fine gravel to boulders several feet in diameter. Large amounts of water undoubtedly are held in the interstices of the till; however, it will not yield water readily to wells because it is composed predominantly of very fine-grained particles.

Water-yielding sand and gravel deposits of various sizes and shapes are more or less commonly associated with the till. The occurrence and extent of these deposits probably were controlled largely by the amount of melt water available when they were deposited and by the type of rock material available to form the sand and gravel particles. The deposits commonly are completely enclosed within the till and have no surface expression; thus they are very difficult to locate and delineate, except by test drilling.

Detailed test-hole drilling and well-inventory data indicate that a number of water-bearing deposits, which consist of coarse sand and fine gravel, occur in association with the till in the vicinity of Upham. These deposits supply water to wells that range in depth from 50 to 100 feet. However, the sand and gravel in the drill cuttings usually contain a considerable amount of clay, and the material actually may be gravelly till, rather than clean sand and gravel and may not yield water to wells at high rates.

The sand and gravel bodies apparently are elongated in a northerly or northwesterly direction (see pl. 2). It is not known whether the individual deposits are parts of a single, large body of sand and gravel, or are more or less isolated. They appear to be confined to the edges of a bedrock depression or buried channel which extends along the western boundary of Upham and apparently has a northwesterly trend (see pl. 2). Their relationship to the buried channel suggest that the deposits may be ice-contact deposits or normal stream-terrace deposits, which were covered by a readvance of glacial ice after they were laid down.

Regardless of the geologic occurrence of the sand and gravel deposits, they are believed to be interconnected hydraulically and to function essentially as a single aquifer. Aquifer-test data are not available to determine the coefficients of transmissibility and storage of the aquifer. However, the materials composing this aquifer in the vicinity of Upham probably are the most permeable of any in the Upham area.

A municipal supply well was constructed by the city of Upham approximately at the location of test hole 623 during August 1953, after the field work incident to this investigation was completed.

The well is 63 feet deep and has a 10-inch casing perforated from 45 to 63 feet, and is reported to yield 90 gpm with about 10 feet of drawdown. However, the duration of pumping at that rate is not known. The initial yield of this well was adequate for a municipal supply. Test drilling suggests, however, that the volume of the aquifer and, consequently, the amount of water stored in it may be relatively small.

Bedrock

Cannonball member of Fort Union formation.-- The Cannonball member of the Fort Union formation of Paleocene (early Tertiary) age probably underlies the entire Upham area south and west of the valley of the Souris River. The nearest outcrops of the formation are reported (Brown and Lemke, 1948, p. 624-625) to occur along the Souris River near the towns of Sawyer and Velva, which are about 40 miles southwest of Upham (see fig. 1). The Cannonball member consists of light-gray clay, silty clay, and very fine sand and sandstone. Most of the sand grains are angular fragments of quartz and of basic igneous rocks.

The Cannonball member is believed to have been found in most of the test holes drilled in the Upham area west of the Souris River. In test holes 612 and 620 the member was completely penetrated. However, the exact thickness is not known because the contact between the Cannonball member and the underlying formation, which possibly is the Fox Hills sandstone, could not be recognized from the drill cuttings. However, the top of the Pierre shale was recognized, and the total thickness of bedrock deposits above the Pierre shale in test holes 612 and 620 was 56 and 65 feet, respectively.

The considerable number of wells 100 to 150 feet deep in the southwestern part of the Upham area indicate the presence of an extensive aquifer. Data obtained from test holes in areas just north and east of the Upham area indicate that the aquifer is part of the Cannonball member.

Quantitative data concerning the hydrologic characteristics of the Cannonball member are not available. However, a large amount of ground water is believed to be in transient storage in the member because of its large areal extent, especially in the southwestern part of the area. Ground water is believed to move toward the northeast from the recharge area where the member crops out along the Souris River near Velva and Sawyer (LaRocque, G. A., personal communication, 1951).

Fox Hills(?) sandstone.--Although the Fox Hills sandstone was not identified during this study, it may be present between the Cannonball member and the Pierre shale. The formation was not distinguishable in test-hole cuttings, unless a grayish-green silt and very fine sand just above the Pierre shale in test holes 612 and 620, are sediments of the Fox Hills sandstone. Additional test holes extending to areas of known Fox Hills sandstone probably will be required to resolve the problem unless index fossils are found. The Fox Hills sandstone generally is water bearing where present in other parts of North Dakota.

Pierre shale.--The oldest formation reached by test drilling in the Upham area is the Pierre shale. The formation underlies the entire area and is the bedrock directly underlying the glacial drift in the valley of the Souris River and in the area northeast of the valley.

Well-indurated medium-light-gray to medium-dark-gray clay and siltstone make up most of the formation. Drill cuttings of the Pierre shale from test hole 612 contained fragments of bentonite and selenite (gypsum). In the Sohio-Nelson oil test No. 1 (158-81-34cd), which was drilled in Renville County about 20 miles southwest of Upham, 1,350 feet of Pierre shale was penetrated (Smith, 1954, p. 1-2).

The Pierre shale is not considered to be an aquifer in the Upham area. However, beds of brittle clay or shale may be present in the formation and, if fractured, might yield small amounts of water to wells.

Older rocks.--The Pierre shale is underlain in the Sohio-Nelson oil test well by older Cretaceous rocks as well as by rocks of Jurassic, Triassic, and Mississippian age (Smith, 1954, p. 1-6). The well, which is 4,951 feet deep, was not drilled below the Mississippian strata, although older rocks probably lie between the Mississippian and the Precambrian. However, only the Dakota sandstone of Early Cretaceous age is important insofar as ground water in the Upham area is concerned.

The Dakota sandstone was reported to be present in the Sohio-Nelson well between 2,692 and 2,994 feet. The formation in North Dakota generally consists of quartz sandstone interbedded with gray pyritiferous shale. Water in aquifers associated with the Dakota sandstone in North Dakota invariably is under considerable hydrostatic pressure, which often produces flowing wells. However, it is believed that the hydrostatic pressure in the formation under the Upham area is not great enough to produce flowing wells.

Recharge, Movement, and Discharge of Ground Water

Most recharge to aquifers above the Pierre shale in the Upham area probably is derived from downward percolation of water falling upon or passing over the surface of the area; however, a part of the water in the aquifers may have percolated laterally into the area. The sandy surficial deposits are conducive to downward percolation of water, and particularly good recharge conditions are believed to exist in the southeastern part of the area where surficial deposits are extremely sandy and grade into prominent sand dunes farther southeast.

The regional movement of ground water in the area appears to be northeasterly. However, the local direction of movement is controlled by streams, lakes, and swamps, which are areas of ground-water discharge, and undoubtedly also by local differences in the transmissibility of the aquifers.

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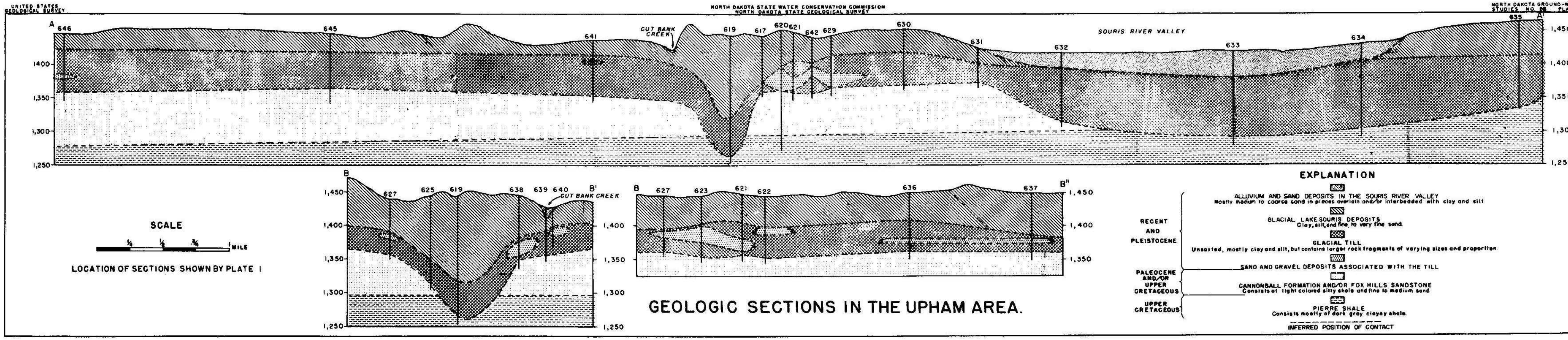
NORTH DAKOTA GROUND-WATER STUDIES PLATE 2



GEOLOGIC SECTIONS IN THE UPHAM AREA.

QUALITY OF THE GROUND WATER

Ground water dissolves a part of the soluble mineral constituents of the rock particles as the water moves through an aquifer. The amount of mineral matter dissolved depends on the amount of soluble materials in the aquifer and the length of time the water is in contact with those materials. Therefore, in a homogeneous aquifer, water that has been stored underground the longest time or that has traveled the greatest distance is more highly mineralized than water that is recovered relatively near the recharge area.

In the Upham area water samples were collected from eight wells that range in depth from 13 to 125 feet and tap glacial drift. Chemical analyses of these samples are given in table 1. The analyses show a wide range in the degree of mineralization of the water and in the relative proportions of dissolved constituents. Dissolved solids ranged from 406 to 3,330 ppm, and hardness as $CaCO_3$ ranged from 72 to 1,970 ppm. Most samples contained large amounts of calcium, magnesium, bicarbonate, and sulfate and are representative of typical ground water in glacial drift. However, several of the samples contained large proportions of sodium and chloride, the presence of which probably is caused by leakage of ground water from bedrock aquifers into the overlying glacial drift. Although samples of water from bedrock were not obtained in the Upham area, investigations in nearby areas show that aquifers in the Cannonball member of the Fort Union formation yield water that has high concentrations of chloride and sodium (Akin, 1951, p. 30-31).

The U. S. Public Health Service (1946) has established standards for drinking water used on common carriers in interstate traffic and for public water supplies in general. Listed below are the limits for some of the chemical substances commonly present in drinking water.

Chemical constituent	Concentration ppm
Iron (Fe) and manganese (Mn) together	0.3
Magnesium (Mg)	125
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	1.5
Dissolved solids	500

Dissolved solids of 1,000 ppm are permitted if water of better quality is not available.

The chemical analyses of ground water in the Upham area given in table 1 show that the recommended limits of some chemical constituents are exceeded in water from the majority of the wells sampled. However, water containing more than the recommended concentrations limits of certain chemical constituents has been used in some areas, including North Dakota, for many years without noticeable ill effects.

High concentrations of nitrate in ground water may be indicative of the presence of decaying organic matter in the well, in the aquifer, or on the ground surface in the vicinity of the well. It may also be due to such inorganic material as mineral fertilizers. Water containing more than about 44 ppm of nitrate may cause cyanosis in infants when used in feeding formulas and for drinking (Comly, 1945; Silverman, 1949).

The consumption of water containing fluoride in concentrations of 0.8 to 1.5 ppm is believed to lessen the incidence of tooth decay, especially in children. However, the consumption by children during calcification of the teeth of water containing concentrations higher than about 1.5 ppm may cause mottling of tooth enamel (Dean, 1936).

Essentially all ground water contains at least small amounts of minerals causing hardness. Hardness in water is caused principally by calcium and magnesium and to a lesser extent by iron, aluminum, strontium, barium, zinc, and free acid. Hard water is undesirable, especially when used for cleansing purposes, because it causes increased soap consumption as well as soap scum. Water having a hardness of about 100 ppm as $CaCO_3$ generally is considered to be moderately hard; water having a hardness of 200 ppm or more is considered very hard. Such water requires softening to be satisfactory for most uses.

Water of good quality for domestic use is difficult to find in the report area. Water from most parts of the report area has a high concentration of dissolved solids (above 1,000 ppm) and is very hard.

Even water that contains less than 1,000 ppm of dissolved solids is very hard. The concentrations of magnesium exceeded the recommended limits in 2 of the samples and sulfate in 4 of the samples. Two of six of the water samples contained very high nitrate concentrations, and two contained concentrations near or slightly higher than the safe upper limit for water used in feeding infants. However, fluoride concentrations were less than 1.5 ppm.

Water containing large amounts of sodium relative to total cation concentration (high percent sodium) is undesirable for irrigation because it may cause soils to become impermeable. The relative proportion of sodium is expressed as a percentage, in which the concentrations of all cations are in equivalents per million, as follows:

$$\text{Percent Na} = \frac{\text{Na} \times 100}{\text{Ca} + \text{Mg} + \text{Na} + \text{K}}$$

The continued use of irrigation water in which the percent sodium is in excess of 50 may cause damage to the soil. However, other factors are involved, such as salinity of the water, porosity of the soil, drainage, irrigation practices, and crop management. In general, the higher the percent sodium the lower the value of the water for irrigation.

In the Upham area the surface deposits consist largely of clay and silt. Subsurface drainage is slow in this type of soil; consequently considerable caution should be used in applying water having a high percent sodium, or a high salinity.

The salinity of water is determined by the dissolved salts it contains. Salinity is closely related to electrical conductivity. The value for electrical conductivity, therefore, may be used to indicate the salinity of water. A close approximation of the value for electrical conductivity may be obtained by using the following formula: Dissolved solids (ppm) + 0.65 = electrical conductivity (micromhos/cm). Nearly all irrigation waters that have been used successfully for a considerable time have conductivity values less than 2,250 micromhos/cm. Waters of higher conductivity are used occasionally, but crop production, except in unusual situations has not been successful (U. S. Salinity Laboratory Staff, 1954, p. 70).

SUMMARY OF GROUND WATER CONDITIONS

The alluvium of Recent age in the Upham area is too thin and fine grained to contain significant aquifers.

The glacial drift is considered in three units, from youngest to oldest the deposits in the valley of the Souris River, deposits of glacial Lake Souris, and till and associated sand and gravel deposits. More or less productive aquifers occur in all three units.

The thickness of the sand deposits that underlie the alluvium in the valley of the Souris River ranges from a few feet along the edges of the valley to about 20 feet near the center. The average width of the deposits is about 3 miles. More than 3,000 acre-feet of water is estimated to be in transient storage in each mile length of the valley.

The deposits of glacial Lake Souris, which consist of clay, silt, and very fine sand, lie at the surface throughout the area except where thin deposits of alluvium were deposited over them in the valleys of the Souris River and its tributary streams. Ground water occurs generally throughout the deposits of glacial Lake Souris, but the yield of wells in the deposits is small because the water-bearing materials are relatively fine grained.

Till and associated sand and gravel deposits underlie the deposits of glacial Lake Souris and the deposits in the valley of the Souris River. Aquifers in the till usually are restricted bodies of sand and gravel and are difficult to locate and define. Elongated aquifers of sand and gravel underlie the area in the vicinity of Upham and yield water to wells in that area. A municipal-supply well recently constructed in those aquifers is reported to yield 90 gpm.

Aquifers are present in bedrock west and south of the Souris River. Test-hole drilling indicated the presence of the Cannonball member of the Fort Union formation of Paleocene age, or the Fox Hills(?) sandstone of Late Cretaceous age, or both. The bedrock aquifers appear to be rather extensive and probably contain a considerable amount of water in transient storage.

The Dakota sandstone underlies the area at depths probably between 2,600 and 3,000 feet. Moderate to large supplies of water should be recoverable from it, but the water probably is too highly mineralized for many purposes.

Most recharge to the aquifers is derived from the penetration of rainfall and snow and ice melt. Recharge to the Cannonball member may occur also where the member crops out about 40 miles southwest of Upham. The general ground-water movement is toward the northeast. Ground water is discharged by seepage into streams, lakes, and swamps, and by evapotranspiration in areas where the water table is shallow.

The mineralization of the ground water in the glacial drift is variable in the report area. The water generally is very hard and contains large amounts of sulfate and bicarbonate; some of the water also contains considerable sodium and chloride, which probably are derived from bedrock aquifers. Chemical analyses of water from the bedrock aquifers were not made for this report, but investigations in nearby areas show that the water in the bedrock aquifers usually is highly mineralized.

TABLE 1.--CHEMICAL

Aquifer: L, deposits of glacial Lake Souris
T, till and associated sand and gravel deposits
Results in parts per million except as indicated

Location number	Owner or name	Aquifer	Depth of well (feet)	Date of collection	Source of analysis	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)
158-77-8ddal	K. C. Halley	L	25	6- 7-51	A	18	0.39	58	33
158-78-8ddcl	Leonard Brandt	T	34	6-11-51	A	19	1.9	247	132
158-79-2bbb	U. S. Bureau of Reclamation	L	23	....	B	..	....	328	280
158-79-22aaa	....	L	13	6-11-51	A	21	2.6	174	47
158-79-23aaa	U. S. Bureau of Reclamation	L	25	....	B	..	....	102	46
159-78-22 2/	O. M. Anderson	T	65	1938	C	..	3.0	127	50
22 2/	City of Upham	T	125	1938	C	..	....	18	6.6
22bc3 2/	....	T	62	6-15-51	A	26	0.48	48	123

1/Residue on evaporation at 180°C.
2/Specific location unknown.

ANALYSES OF GROUND WATER

Source of analysis: A, U. S. Geological Survey, Lincoln, Nebr.; B, U. S. Bureau of Reclamation, Bismarck, N. Dak.; C, North Dakota State Department of Health, Bismarck, N. Dak.

Sodium (Na)	Potassium (K)	Bicarbonate (HCO$_3$)	Carbonate (CO$_3$)	Sulfate (SO$_4$)	Chloride (Cl)	Fluoride (F)	Nitrate (NO$_3$)	Total hardness as CaCO$_3$	Dissolved solids (sum of determined constituents)	Percent sodium	Specific conductance (micromhos at 25°C)
22	2.3	214	14	72	17	.2	41	280	406 1/	14	609
214	7.5	190	0	468	430	.2	478	1,160	2,090	29	3,060
312		376	19	2,180	28	...	...	1,970	3,330	26	.....
33	132	446	0	222	59	.2	219	628	1,080	8	1,630
24		232	18	254	8	...	...	444	566	10	.....
12		429	..	143	27	.2	13	523	586	5	.....
423		810	..	43	194	.6	8.8	72	1,090	93	.....
156	3.5	264	18	378	193	.4	61	626	1,140	35	1,720

Depth of well; measured depths given in feet and tenths; reported depths given in feet.

Type: Dr, drilled; Du, dug; Dv, driven

Depth to water: Measured depths given in feet and hundredths; reported depths given in feet.

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
158-77						
5bbb	....	8.0	2	Dr	....	4.10
5bcc1	Emil Johnson	15.9	48	Du	....	4.24
5bcc2	Do	36	48	Du	1951	8.90
5dcc	Garfield Johnson	19	36 to 2½	Dv	....	8.91
6add1	Emil Johnson	.....	36 by 36	Du	....	5.55
6add2	Do	.....	30	Du	....	7.18
6bca	Alex Goodman	15.1	30 by 72	Du	....	6.55
6bcb1	Do	22	30 by 72	Du	....	15.60
6bcb2	Do	360	6	Dr	....	.....
6dda	Ellen Johnson	22.4	30	Du	....	15.30
8baa	Garfield Johnson	17.0	36	Du	....	6.90
8cbb	Walter Goodman	16.0	24	Du	....	4.66
8dda1	K. C. Halley	25	30	Du	....	10.55
8dda2	Do	25	30	Du	....	10.15
8ddd	Bureau of Reclamation test hole	50	....	Dr	....	.....
17aaa	Aaron Torr	17	1¼	Dv	....	7
17ccc	Ole Goodman	15	30	Du	....	7.64
18aba	Joseph Hannesson	13.8	30 by 30	Du	....	9.95
18abd	Do	17.5	48 by 48	Du	....	4.42
18ccd	....	4.3	48 by 60	Du	....	2.35

Use: D, domestic; S, stock; U, unused;
T, test hole.
Aquifer: S, sand; C, clay; Gr, gravel;
B, bedrock; Si, silt; R, rock.

Elevation of land surface determined from
U. S. G. S. topographic maps.

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
6-22-50	U	...	1,455	Probably drilled for oil-test hole.
6-22-50	D,S	...	1,455	
8-11-52	D,S	S	1,455	Reported to yield 50 gpm.
6-23-50	D	...	1,460	
6-22-50	D	...	1,455	
6-22-50	S	...	1,455	
6-23-50	S	S	1,455	Supplies 125 head of stock.
6-23-50	D	...	1,461	Reported good supply of water.
....	U	...	1,460	Reported dry in 1946. Plugged in 1950.
6-22-50	S	...	1,466	
6-23-50	S	...	1,457	
6-23-50	D,S	S	1,455	Reported good supply of water.
6-23-50	D	...	1,463	Chemical analysis made.
6-23-50	S	S	1,465	Supplies 100 head of cattle.
....	T	...	1,460	See log.
....	D	S	1,461	
6-22-50	D,S	S	1,460	
6-22-50	D	...	1,459	
6-22-50	S	...	1,449	
6-22-50	U	...	1,454	

TABLE 2.--RECORDS OF WELLS

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
158-78						
1aba	Steinun Hillman	24.6	36	Du	....	12.48
1baa1	G. T. Christianson	20	24	Du	....	4.42
1baa2	Do	22	24	Du,Dr	1940	6.43
						6.99
1dda	....	15.8	24	Du	....	4.72
2ccc1	Benny Amon	60	18	Dr	1946	17
2ccc2	Do	15.3	24	Du	....	2.05
3add	John Asmundson	13.6	36 by 36	Du	....	6.17
3cbc	Walter Arnason	38	18	..	....	9.08
3dcc1	Do	50.3	24	Dr	....	5.62
3dcc2	Do	48	18	Dr	1910	9.33
4aab1	Mettler	26.6	18	Dr	....	9.90
4aab2	Do	23.0	36 by 60	Du	....	10.11
5bba	....	71.0	18	Dr	....	10.83
5ccc	....	71.2	12	Dr	....	11.42
5ddc1	Albert Brandt	21.0	18	Dr	....	10.56
5ddc2	Do	38.5	18	Dr	1948	12.38
7abb	....	116.0	4	Dr	....	12.46
7bcb	....	120	4	Dr	....	15
8cbc	Edward Pedul	80.0	18	Dr	....	38.48
8ddc1	Leonard Brandt	34.0	24	Du	....	13.38
8ddc2	Do	110	6	Dr	....	15
11aaa	George Rice, Jr.	41.0	18	Dr	....	12.77
12add1	Phillip Torr	28.0	...	Du	....	17.99
12add2	Do	9.2	40	Du	....	1.17
12bbb	....	42.0	24	Du	....	11.63
12dad1	R. C. Brock	9.5	36 by 36	Du	....	0.60
12dad2	Do	46.0	18	Du	....	14.86
13bcc	Cecil Torr	18.3	24 to 48	Du	....	8.27
13cbb	John Vormerstran	20	36	Du	....	10
14aad	O. S. Lunderwald	19.0	36	Du	....	4.86
						5.91

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
7- 6-50	D,S	...	1,456	
7- 6-50	D	...	1,452	
7- 6-50	S	S	1,453	
8-12-52	...	...	.....	
7- 6-50	U	...	1,450	
....	D,S	Gr	1,440	
7- 6-50	S	S	1,434	
7- 6-50	S	S	1,436	
8- 8-52	U	...	1,440	
7- 6-50	S	S	1,436	
8- 8-52	U	C,Gr	1,436	
7- 6-50	U	...	1,455	
7- 6-50	D,S	S	1,455	
7- 6-50	S	...	1,443	
7- 6-50	U	...	1,445	
7- 7-50	S	...	1,455	
8- 8-52	D	...	1,455	
7- 7-50	U	...	1,452	
....	D	...	1,470	
7- 7-50	S	...	1,455	
7- 7-50	D	...	1,454	Chemical analysis made.
....	S	...	1,453	
7- 6-50	U	...	1,449	
7- 6-50	D	...	1,461	
7- 6-50	S	S	1,455	
8-12-52	U	...	1,455	
7- 6-50	S	S	1,459	
7- 6-50	D	...	1,457	
7- 6-50	D,S	...	1,455	
....	D,S	...	1,456	
7- 6-50 8-12-52	D,S	S	1,452	Supply inadequate for farm use. Can be pumped dry. Equipped with cylinder pump and 1/3 h.p. electric motor. Quality reported good.

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
158-78 - Cont.						
14daa	G. R. Garnant	16.0	72 to 30	Du	....	8.09 11.36
14dad	Do	13.6	36	Du	....	9.47
15ccc	Bureau of Reclamation test hole	150	...	Dr	....	.....
15daa	....	19.3	60 to 24	Du	....	9.98
15dcc	Bureau of Reclamation test hole	152	...	Dr	....	.....
17baa	Julius Brodehl	52.0	36 to 24	Du	....	13.25
17ccc	William Long	11.7	60 to 36	Du	1920	6.50
17ddd1	Calmer Braaten	93	4	Dr	....	10.64
17ddd2	Do	19.5	24	Du	....	8.76
18dda	Walter Erven	17.4	36	Du	1937	7.21 10.42
158-79						
1bab	Bernart Mettler	140	4	Dr	....	23.20
1ccb	William Schell	180	4	Dr	....	17.00
2abb1	Rubin Mettler	73	4	Dr	....	15.90
2abb2	Do	73.0	4	Dr	....	15.22
2bbb	Bureau of Reclamation test hole	23	...	...	....	.....
3aad	....	46.0	12	Dr	....	14.74
3dcc1	Henry Frishman	40	4	Dr	....	20
3dcc2	Do	30	20	Du	....	.....
10abb	Inga Burns	59.0	4	Dr	....	13.33
10bbb1	Julia Thompson	141	4	Dr	1952	5.80
10bbb2	Do	69	4	Dr	....	15
10ccd1	Clarence Donnelly	15	36 by 36	Du	....	6.00
10ccd2	Do	170	4	Dr	1952	18

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
7- 6-50 8-12-52	S	S	1,450	
7- 6-50	D	S	1,453	
....	T	...	1,442	See log.
7- 6-50	U	...	1,453	
....	T	...	1,452	See log.
7- 7-50	D	...	1,451	
7- 5-50	D,S	S	1,467	Reported yield 1,000 gpd; supplies stock and turkeys.
8- 5-52	S	...	1,452	
8- 9-52	...	S	1,452	
7- 5-50 10-16-52	D,S	S	1,465	Reported yield about 1,500 gpd; supplies stock.
6-30-50	D,S	B	1,461	
6-30-50	D,S	...	1,462	
8-16-49	D,S	Gr	1,463	Water from gravel between 145 and 150 feet.
6-30-50	D,S	B	1,462	
....	...	...	.....	
6-30-50	S	...	1,460	
....	D,S	...	1,460	
....	D,S	S	1,467	
6-30-50	D,S	...	1,461	
10-15-52	D	S	1,455	Water from fine blue sand between 120 and 141 feet.
....	S	Gr	1,455	
7- 4-50	D	...	1,473	
....	D,S	S	1,473	

TABLE 2.--RECORDS OF WELLS

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
158-79 - Cont.						
10cdc	Clarence Donnelly	12.5	48 by 48	Du	....	7.43
10dcd1	Adolph Wahl	154	4	Dr	1952	15
10dcd2	Do	18	48 by 48	Du	....	10.03
10dcd	Elmer Page	...	24	Du	....	11.24
11aaa	Lawrence Mettler	24.0	24	Dr	....	17.00
11bbc	Woodward School	140	4	Dr	....	.....
11bcc1	Clarence Herman	148	4	Dr	1952	8
11bcc2	Do	135	3	Dr	....	8.60
12ccc	....	15.2	48 by 48	Du	....	4.85
12ddd	August Zeretzke	175	4	Dr	1930	10.60
14abb	Roy Long	50.3	20	Du	....	6.02
						7.09
15abc	Elmer Paige	25	24	Du	1920	7.58
22aaa	Bureau of Reclamation					11.53
	test hole	13	...	...	1951	.....
23aaa	Do	25	...	...	....	.....
159-77						
5add	Alfred Boehnke	50	24	Du	....	8.00
5dbc1	Arnason	12.5	60	Du	....	7.28
5dbc2	Do	12	42 by 42	Du	....	7.57
5dcd1	Ed Wittmeier	10	36 by 36	Du	....	8.80
5dcd2	Do	15	36 by 36	Du	....	12.50
8aaa	Test hole 635	130	5	Dr	1952	.....
8abb	Bureau of Reclamation					
	test hole	55	...	Dr	....	.....
8cbb	Test hole 634	140	5	Dr	1952	.....
18bbb	Test hole 633	140	5	Dr	1952	.....
31aba	Raymond Natwick	30.6	24	Dr	....	13.23

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
7- 4-50	S	S	1,471	
....	D,S	S	1,466	
7- 4-50	S	S	1,467	
7- 4-50	D,S	S	1,467	
6-30-50	D,S	...	1,457	
....	D	S	1,455	
....	D	S	1,457	Coarse sand from 113 to 148 feet.
10-15-52	S	S	1,457	Supplies 67 head of cattle.
6-30-52	S	...	1,466	
6-30-50	D,S	...	1,470	
6-30-50	U	...	1,460	
10- 9-52				
7- 4-50	D,S	S	1,476	
10- 9-50				No log available.
....	T	...	.....	Chemical analysis made.
....	T	...	.....	No log available. Chemical analysis made.
8-12-52	D	S	1,460	
8-13-52	U	...	1,460	
8-13-52	U	...	1,460	
8-13-52	D	S	1,460	
8-13-52	S	C	1,460	
....	T	...	1,460	See log.
....	T	...	1,460	See log.
....	T	...	1,435	See log.
....	T	...	1,420	See log.
8-11-52	...	...	1,440	

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
159-77 - Cont.						
31ccb	Julian Simmons	23.0	48 to 36	Du	....	11.08 13.89
32aca	Barthi Goodman	7	$2\frac{1}{4}$	Du	....	4
32ccc	Raymond Natwick	25.2	36	Du	....	14.46 10.29
32dbd	Barthi Goodman	15	24	Du	....	3.90
159-78						
1aab1	Ephraim Brandt	96	24	Dr	....	7.90
1abb2	Do	21	12	Dr	....	8.90
4cba	T. R. Jeune	90	4	Dr	....	19.92
5bda	Berry Faa	48	18	Dr	....	28.55
6aaa	Karren Hanson	42	12	Dr	....	23.05
6dbd1	Arne Simengaard	34	12	Dr	....	15.62
6dbd2	Do	31.0	12	Dr	....	15.03
7aaa1	B. Skar	30	18	Dr	....	9.22
7aaa2	Do	30	18	Dr	....	16
7bcd	O. Peterson	35.0	12	Dr	....	8.86
8aab	W. J. Johnson	48.0	12	Dr	....	39.40
8cdd1	Andrew Burlog	82	12	Dr	....	29.05
8cdd2	Do	78	12	Dr	....	18.70
9bbb	T. R. Jeune	32.0	12	Dr	....	5.15
9bbd	Do	80	24	Dr	....	34.45
9ccc	T. T. Kongslie	80	24	Dr	....	30
10bad1	U. S. Fish & Wildlife Service	54	36	Dr	....	20
10bad2	Do	54	18	Dr	....	19.78
14cab	E. Latendresse	60	36	Dr	....	5
14cba	Do	30	72 to 36	Du	....	20.20 19.39
14dad	Test hole 632	110	5	Dr	1952	.....
15ccc	Melvin Smette	45.0	36	Dr	....	32.95
16aad	J. Benson	85	18	Dr	....	39.10

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
6-29-50	D,S	S	1,455	
8-11-52				
6-29-50	D	S	1,446	
6-29-50	...	...		
8-11-52	S	S	1,455	
6-29-50	S	S	1,443	
9-12-49	S	...	1,441	
9-12-49	D	S	1,440	
9- 8-49	U	...	1,445	
9- 8-49	D,S	Gr	1,445	
9- 9-49	D,S	...	1,440	
9- 9-49	D,S	S,Gr	1,434	
9- 9-49	U	...	1,433	
9- 9-49	S	Gr	1,430	
8-23-49	D	Gr	1,430	
9- 9-49	U	...	1,431	
9- 8-49	S	...	1,460	
9- 9-49	D	S	1,455	
9- 9-49	S	Gr	1,445	
9- 8-49	U	...	1,448	
9- 8-49	D,S	S	1,451	
....	D,S	S	1,457	
....	U	S	1,435	
9-12-52	D	S	1,435	
....	S	C,S	1,425	
9-12-49	D,S	S	1,440	
9-12-52				
....	T	...	1,417	See log.
9- 2-49	D,S	...	1,473	
9- 2-49	D,S	...	1,469	

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
159-78 - Cont.						
17acc1	E. E. O'Brien	49.0	12	Dr	....	24.03
17acc2	Do	58	18	Dr	....	5
17cdc	Selmer Braaten	28	18	Dr	....	9.00
18aad	Henry Brandt	44.0	24	Dr	....	24.38
18bac1	George Kongslie	30.0	12	Dr	....	12.98
18bac2	Do	10.0	7	Dr	....	6.70
18bcd	O. O. Fjeldberg	38.5	18	Dr	....	28.15
18ccb	Leonard Rolkolm	18.0	18	Dr	....	11.80
18dca	Carl Smette	68	24	Dr	....	22.80
19abb1	I. Smette	90	24	Dr	....	20
19abb2	Do	58	18	Dr	....	21.30
20bad	Norman Smette	50	24	Dr	....	27.52
20ddd	Henry Schepp	60	24	Dr	....	20
21aaa	Charlie Serr	27	12	Dr	....	14.16
21aad1	H. J. Goodman	63	24	Dr	....	10.05
21aad2	Do	63	6	Dr	....	12.85
21bab	John Thorson	80	5	Dr	....	22.42
21daa1	John Vormesterand	36	18	Dr	....	24.32
21daa2	Oliver Vormesterand	33	18	Dr	....	20.90
21daa3	Do	31	18	Dr	....	20
21daa4	Test hole 625	140	5	Dr	1952	.....
21dad	Test hole 619	190	5	Dr	1952	.....
22	O. M. Anderson	65	...	...	....	.....
22	City of Upham	125	...	...	....	.....
22aad	Test hole 630	90	5	Dr	1952	.....
22abb	Test hole 644	100	5	Dr	1952	.....
22acd	Test hole 629	90	5	Dr	1952	.....
22ada	Jacob Bertsch	...	$1\frac{1}{2}$	Dv	....	3.26
22bbc	Test hole 627	90	5	Dr	1952	.....
22bc	....	62	...	...	....	.....

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
9- 9-49	D,S	...	1,440	
....	D,S	Gr	1,423	
9-10-49	D,S	Gr	1,425	
9- 9-49	S	...	1,436	
9- 9-49	S	Gr	1,425	
9- 9-49	D	S	1,420	
8-18-49	S	S,Gr	1,433	
9-10-49	U	...	1,425	
9-10-49	D,S	Gr	1,440	
....	D,S	S	1,439	0.5 ft. of gravel at 52 feet.
9-10-49	S	S	1,439	Do.
9-10-49	D,S	...	1,445	
....	D,S	...	1,440	Supplies 100 head of cattle.
9- 2-49	D	S	1,445	
9- 2-49	S	Gr	1,445	
9- 2-49	D	Gr	1,445	
9- 2-49	D,S	...	1,442	Town of Upham obtains water from this well.
9- 2-49	D	...	1,452	
9- 2-49	U	S	1,455	
....	D	S	1,452	
....	T	...	1,445	See log.
....	T	...	1,443	See log.
....	...	...	.....	Chemical analysis made. Definite location unknown.
....	...	...	.....	Chemical analysis made. Definite location unknown.
....	T	...	1,452	See log.
....	T	...	1,458	See log.
....	T	...	1,443	See log.
9-12-49	U	...	1,445	
....	T	...	1,445	See log.
....	...	...	.....	Chemical analysis made.

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
159-78 - Cont.						
22bcb1	Lyle Johnson	16	48 by 36	Du	....	8.70
22bcb2	O. C. Johnson	30	30	Dr	....	15
22bcc1	Fred Brandt	20	18	Dr	....	8.95
22bcc2	Emma Podall	22	24	Dr	1947	9.62
22bcc3	Igmund Smette	16	24	Dr	....	15
22bcd1	Fred F. Rice	68	18	Dr	....	10.60 10.94
22bcd2	John Green	20	18	Dr	....	7.41
22bcd3	Test hole 623	100	5	Dr	1952	.....
22bcd4	City of Upham	63	10	Dr	1953	.....
22bcd5	Test hole 626	90	5	Dr	1952	.....
22bdc	City of Upham	100	4	Dr	....	9.90
22caa	Great Northern RR	48	...	Dr	....	16.66
22cab1	Henry Mettler	59	6	Dr	1949	17
22cab2	John L. Becker	30	12	Dr	....	22
22cac1	Louis Moen	60	10	Dr	....	35
22cac2	Morgan Erickson	24	12	Dr	....	16.85
22cac3	Richard Wolff	38	16	Dr	....	15
22cac4	W. B. Shoemaker	35	8	Dr	1940	15
22cac5	Test hole 620	180	5	Dr	1952	.....
22cad1	F. R. Nielsen	36	...	Dr	....	19.25
22cad2	Test hole 621	100	5	Dr	1952	.....
22cba1	City of Upham	85	6	Dr	1949	9.17
22cba2	Test hole 628	100	5	Dr	1952	.....
22cba3	Joe Bell	63	6	Dr	1949	15.39
22cbb1	Chris Amon	22	6	Dr	....	8.65
22cbb2	Harry Rice	23	24	Dr	....	18
22cbc1	Upham Public School	158	6	Dr	1949	.....
22cbc2	Do	475	6	Dr	1949	.....
22cbc3	Test hole 614	150	5	Dr	1952	.....
22cbc4	Test hole 615	180	5	Dr	1952	.....
22cbc5	Test hole 616	190	5	Dr	1952	.....
22cbd1	Adam Shroier	22	8	Dr	....	16.70 16.67

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
9-13-49	U	...	1,445	
....	D	S	1,445	
10-15-52	D	S	1,443	
10-15-52	D	S	1,443	
....	D	S	1,443	
9-13-49 9-14-52	D	S	1,443	
10-14-52	U	...	1,444	
....	T	...	1,445	See log.
....	D	S	1,445	See log.
....	T	...	1,442	See log.
8-31-49	D	...	1,445	
8-31-49	S	S	1,450	
....	D	S,Gr	1,447	
....	D	S,Gr	1,450	
....	D	...	1,445	
9-13-49	D	S	1,446	
....	U	S	1,445	
....	D	S	1,445	
....	T	...	1,452	See log.
8-31-49	D	...	1,447	
....	T	...	1,448	See log.
8-22-49	U	S,Gr	1,445	
....	T	...	1,442	See log.
9- 8-49	D	Gr	1,449	See log.
10-15-52	D	S	1,441	
....	D	C	1,450	
....	D	S,Gr	1,450	
....	T	...	1,450	See log.
....	T	...	1,450	See log.
....	T	...	1,450	See log.
....	T	...	1,450	See log.
8-31-49 10-15-52	D	S	1,443	

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
159-78 - Cont.						
22cbd2	Test hole 618	90	5	Dr	1952	.....
22cbd3	Test hole 617	90	5	Dr	1952	.....
22cbd4	Test hole 613	120	5	Dr	1952	.....
22cbd5	Test hole 612	210	5	Dr	1952	.....
22cca	Tom Lawson	40	18	Dr	....	17.35
22ccb1	S. H. Haugen	30	18	Dr	....	26.20
22ccb2	Jacob Bertsch	185	4	Dr	....	29
22ccb3	Do	40	18	Dr	....	20
22cda1	Marvin Knopfle	56	18	Dr	....	16.40
22cda2	Test hole 622	100	5	Dr	1952	.....
22cdb1	Henry Schnabel	65	12	Dr	....	14
22cdb2	Herb Bertsch	40	12	Dr	....	13
22cdb3	Elmer Lundervold	84	6	Dr	....	18.10
22cdb4	Test hole 624	120	5	Dr	1952	.....
22cdb5	Emil Anderson	78	6	Dv	1949	20.55
22dbb	Test hole 642	90	5	Dr	1952	.....
23baa	Test hole 631	60	5	Dr	1952	.....
23cbc	Test hole 643	95	5	Dr	1952	.....
26bdc	Test hole 636	100	5	Dr	1952	.....
26ccc	Julius Osmundson	35	72	Du	....	11.45
27aad1	J. A. Wik	51.0	18	Dr	1952	18.45
27aad2	Do	33.0	36	Du	....	24.05
27bbb	G. E. Benedikson	32	18	Dr	....	20
27bcb	Do	25.0	24	Du	....	7.15
27cca	Elmer Lundervold	50	18	Du	....	9.95
27dca1	Oliver Lunde	35.0	18	Dr	....	13.25
27dca2	Do	94.0	24	Dr	....	11.67
27ddd	Do	38	36	Du	....	5.85
28aad	Test hole 638	110	5	Dr	1952	.....
28ada	Test hole 639	80	5	Dr	1952	.....
28add	Test hole 640	60	5	Dr	1952	.....
28bbb	Test hole 641	90	5	Dr	1952	.....

Date of measure-ment	Use	Aquifer	Elevation of land surface(feet above mean sea level)	Remarks
....	T	...	1,445	See log.
....	T	...	1,443	See log.
....	T	...	1,448	See log.
....	T	...	1,445	See log.
9-12-49	S	...	1,447	
9-12-49	D,S	...	1,449	
9-12-49	D,S	Gr	1,451	
....	S	S	1,451	
10- 9-52	D	Gr	1,445	
....	T	...	1,445	See log.
....	D	Gr	1,448	
....	D	S,C	1,448	
10-14-52	D	Gr	1,446	
....	T	...	1,445	See log.
8-31-49	U	S,Gr	1,445	Test hole drilled to 140 feet. See log.
....	T	...	1,440	See log.
....	T	...	1,425	See log.
....	T	...	1,450	See log.
....	T	...	1,450	See log.
9-12-49	D,S	S	1,455	
9-10-49	S	S	1,448	
9-10-49	D	C	1,450	
....	D	S,Si	1,450	
9- 2-49	S	S,C	1,430	
9- 2-49	S	S	1,437	Supplies 20 head of stock.
9- 3-49	S	...	1,457	
9- 2-49	U	...	1,457	
9- 2-49	U	Gr	1,445	
....	T	...	1,447	See log.
....	T	...	1,428	See log.
....	T	...	1,428	See log.
....	T	...	1,436	See log.

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
159-78 - Cont.						
29aaa1	Chester Serr	45	18	Dr	....	14.70
29aaa2	Do	45	12	Dr	....	20
30ddb1	August Mottler	90	24	Dr	....	32.55
30ddb2	Do	60	24	Dr	....	20
31ddd1	Ronald Erdman	55	24	Dr	....	12.55
31ddd2	Do	55	...	Dr	....	18.25
31ddc	Do	32.0	16	Dr	....	11.35
32aaa	....	100 +	10	Dr	....	13.92
32cab1	Adam Shoyer	45	18	Dr	....	34.25
32cab2	Do	80	16	Dr	....	28.50
32ddd	Vernon Brandt	30.0	12	Dr	....	13.55
33add	Donald Olson	65	18	Dr	....	24.93
33bbd1	Rubin Erdman	83	12	Dr	....	20.18
33bbd2	Do	53.0	12	Dr	....	25.79
34aab1	Oliver Lunde	80	18	Dr	1905	40
34aab2	Do	87	24	Dr	....	12
34cbb1	J. M. Jacobson	55	18	Dr	....	16.20
34cbb2	Do	60	18	Dr	....	22.40
35aaa	Test hole 637	100	5	Dr	1952	.....
35bba	F. C. Grimes	50	18	Dr	1905	13.16
159-79						
2aab	John Gearn	73.0	12	Dr	....	18.55
2cbb1	E. J. Bethke	25	18	Dr	....	12.00
2cbb2	Do	150	6	Dr	1949	.....
2cbc	Do	100	4	Dr	1944	26.65
2cbd	Do	68	18	Dr	....	8.89
2dcc1	Olie Mickelson	76	18	Dr	1909	9.60
2dcc2	Do	50	18	Dr	....	12.00
2dcc3	Do	30	18	Dr	....	14
3ada1	Einar Einarson	120	6	Dr	1949	22.27
3ada2	Do	96	18	Dr	....	22.76
3ada3	Do	120	4	Dr	1944	18.60
3dcc	J. Rice	45.0	18	Dr	....	7.46

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
9- 6-49	S	...	1,435	
....	D	S	1,435	
9- 6-49	S	S	1,445	
....	D	...	1,445	
9- 6-49	S	S	1,450	
9- 6-49	D	S	1,455	
9- 6-49	S	...	1,455	
9- 6-49	U	...	1,448	
9- 6-49	D,S	Gr	1,448	
9- 6-49	U	R	1,448	
9- 6-49	D	...	1,446	
9- 2-49	D,S	Gr	1,440	
9- 6-49	U	...	1,448	
9- 6-49	D,S	Gr	1,449	
....	D	Gr	1,462	
....	S	Gr	1,455	
9- 2-49	D	Gr	1,445	See log.
9- 2-49	U	Gr	1,450	
....	T	...	1,448	See log.
9- 2-49	S	...	1,451	
8-17-49	U	...	1,446	
8-18-49	S	S	1,451	
....	...	...	1,449	Well under construction at time of visit. See log.
8-18-49	D,S	Gr	1,450	
8-18-49	S	...	1,440	
8-19-49	S	Gr	1,448	See log.
8-19-49	U	Gr	1,448	See log.
....	D	C	1,448	
8-18-49	D	...	1,451	See log.
8-18-49	D,S	...	1,451	
8-18-49	D	...	1,451	
8-19-49	S	C	1,450	

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
159-79 - Cont.						
10bbb	M. Gessner	68	18	Dr	1945	7.50
10dda	Orris Moen	45.0	12	Dr	....	10.25
11ada1	Albert Roalkvam	85	18	Dr	....	16.05
11ada2	Do	90	18	Dr	....	.....
11ddc1	I. P. Pederson	96	5	Dr	....	23.15
11ddc2	Do	46.0	18	Dr	....	12.20
12aaa1	Andrew Halvorson	91	18	Dr	....	14.12
12aaa2	Do	84	18	Dr	....	18.99
12ccc	Leonard Roalkvam	90.0	18	Dr	....	24.02
13bca	A. O. Alnquist	80.0	18	Dr	....	27.85
13bcb	Do	100	18	Dr	....	15.70
14cdb	Norman Glinz	...	12	Dr	....	12.45
22adc	Walter Torno	40	18	Dr	....	10.00
22ccb	Eric Rosenau	113	18	Dr	....	14.62
23acb1	Herman Torno	70	12	Dr	....	9.55
23acb2	Do	56.0	12	Dr	....	9.46
23cdc1	Mrs. Ostrowsky	75	...	Dr	....	24.60
23cdc2	Do	47.0	18	Dr	....	24.70
24acb	Edwin Brandt	70	12	Dr	....	13.50
24cdd	Inga Kutt	165	4	Dr	1910	18.65
24ddd	Test hole 645	100	5	Dr	1952	.....
25add1	Hermand Brandt	25	36 by 36	Du	....	22.60
25add2	Do	35	24	Dr	....	12.26
25add3	Do	60	5	Dr	....	.....
25add4	Do	25.0	18	Dr	....	10.96
25add5	Do	90	5	Dr	....	20.10
25bab1	Henry Schnabel	23.0	18	Dr	....	15.68
25bab2	Do	130	4	Dr	....	19
25dcc	Robert Schnabel	110	5	Dr	....	10.32
26abb	William Ahner	54	12	Dr	1908	20.85
26bbb	Test hole 646	100	5	Dr	1952	.....
26dcd1	Daniel Mettler	130	3	Dr	....	13.70

Date of measurement	Use	Aquifer	Elevation of land surface (feet above mean sea level)	Remarks
8-19-49	D,S	Gr,S	1,461	
8-19-49	S	...	1,450	
8-18-49	D,S	Gr	1,443	
....	D,S	Gr	1,443	
8-18-49	S	Gr	1,446	
8-18-49	S	...	1,446	
8-18-49	D,S	...	1,448	
8-18-49	S	...	1,445	
8-18-49	S	Gr	1,446	
8-17-49	U	Gr	1,448	
8-17-49	S	Gr	1,444	
8-19-49	U	...	1,435	
8-16-49	D,S	S	1,443	
8-16-49	D,S	C	1,462	
8-16-49	S	...	1,440	
8-16-49	U	...	1,440	
8-16-49	S	Gr	1,454	
8-16-49	D	S	1,453	
8-15-49	D,S	S	1,438	
8-15-49	D,S	...	1,453	
....	T	...	1,442	See log.
8-15-49	D	S	1,460	
8-15-49	D	...	1,455	
....	U	S	1,455	
8-15-49	U	S	1,454	
8-15-49	U	S	1,457	
8-15-49	U	S	1,456	
....	D,S	...	1,455	
8-15-49	U	...	1,451	
8-16-49	D,S	...	1,454	See log.
....	T	...	1,446	See log.
8-15-49	D,S	Gr	1,457	

Location number	Owner or name	Depth of well(feet below land surface)	Diameter or size (inches)	Type	Date completed	Depth to water(feet below land surface)
159-79 - Cont.						
26dcd2	Daniel Mettler	15.5	12	Dr	....	9.32
27ddd1	Gideon Mehlhoff	42	24	Dr	....	22.00
27ddd2	Do	42	18	Dr	1943	27
34aaa1	Arvel Mettler	43.0	12	Dr	....	22.36
34aaa2	Do	44.0	15	Dr	....	24.65
34bac1	Ted Pfau	48	12	Dr	1946	17.94
34bac2	Do	48	18	Dr	....	14.84
34cdc	Emil Raw	60	...	Dr	....	25.33
35cdd	Gideon Mettler	60	16	Dr	....	16.99
35dcc	Do	140	4	Dr	....	15.12
36abb1	Robert Schnabel	130	3	Dr	1928	13.68
36abb2	Do	52	7	Dr	....	18.50
36cdd1	Ben Mettler	50	12	Dr	....	17.60
36cdd2	Do	50.0	15	Dr	....	14.95

Date of measurement	Use	Aquifer	Elevation of land surface(feet above mean sea level)	Remarks
8-15-49	U	...	1,457	
8-16-49	D,S	Gr	1,466	
....	D	S	1,466	
8-15-49	D	...	1,465	
8-16-49	S	Gr	1,465	
8-15-49	D,S	Gr	1,460	
8-16-49	U	...	1,460	
8-15-49	D,S	...	1,470	
8-15-49	D,S	S	1,463	
8-15-49	D,S	...	1,460	
8-15-49	S	S	1,454	
8-15-49	D	Gr	1,454	See log.
8-15-49	D	Gr	1,459	See log.
8-15-49	D	...	1,459	

TABLE 3.--LOGS OF TEST HOLES AND WELLS

Bureau of Reclamation test hole
158-77-8ddd

Material	Thickness (feet)	Depth (feet)
Topsoil, sandy	1	1
Sand, silty, brown	9	10
Sand, fine, silty, gray	23	33
Silt and clay, gray	12	45
Till, gray	5	50

Bureau of Reclamation test hole
158-78-15ccc

Material	Thickness (feet)	Depth (feet)
Topsoil, sandy	2	2
Clay, sandy, buff	3	5
Clay, silty, sandy, light-brown	14	19
Clay, plastic, gray	16	35
Till, gray	17	52
Sand, fine, gray, with coarse gravel	8	60
Till, gray	26	86
Sand, compact, silty, gray	64	150

Bureau of Reclamation test hole
158-78-15dcc

Material	Thickness (feet)	Depth (feet)
Topsoil, sandy	2	2
Sand, fine, buff	3	5
Sand and silt, buff	9	14
Clay, plastic, gray	39	53
Till, gray	34	87
Sand, compact, silty, gray	65	152

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 635
159-77-8aaa

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, almost all sand, pale yellowish-brown	2	2
	Sand	2	4
	Silt, grayish-orange	7	11
	Clay, silty, medium-gray	7	18
	Silt, sandy, medium-gray	4	22
	Clay, silty, medium-gray	28	50
Till and associated sand and gravel deposits			
	Till, varying amounts of sand and gravel, medium light-gray	78	128
Pierre shale			
	Clay, fine-grained and uniform, non-calcareous, light-gray	2	130

Bureau of Reclamation test hole
159-77-8abb

	Material	Thickness (feet)	Depth (feet)
	Topsoil	1	1
	Sand, silty, brown	18	19
	Sand, silty, gray	9	28
	Clay, gray	25	53
	Till, sandy and silty, gray	2	55

Test hole 634
159-77-8cbb

Unit	Material	Thickness (feet)	Depth (feet)
Alluvium			
	Soil, sandy, very dark-brown..........	1	1
	Sand, very fine to fine, yellow.......	4	5
	Sand, very fine to fine, light-gray...	12	17
	Sand, very fine, pale yellowish-brown, and considerable clay...............	8	25
Till and associated sand and gravel deposits (?)			
	Clay, silt, and very fine sand, poorly sorted, yellowish-brown.............	25	50
	Till (?), mostly fine to very coarse sand and considerable clay and silt.	15	65
	Till, medium light-gray..............	13	78
	Sand, clayey.........................	6	84
	Till, varying amounts of sand, medium light-gray.........................	42	126
Pierre shale			
	Clay and silt, medium-gray...........	14	140

Test hole 633
159-77-18bbb

Unit	Material	Thickness (feet)	Depth (feet)
Alluvium			
	Soil, peaty, dark-brown..............	2	2
	Clay, medium-gray....................	8	10
	Clay, highly calcareous, white........	2	12
	Silt, with white specks, light-olive-gray..............................	4	16
	Sand, very fine......................	6	22
	Sand, medium to coarse...............	8	30
	Sand and gravel. Numerous shale and lignite fragments..................	7	37
Till and associated sand and gravel deposits			
	Till, medium light-gray to medium-gray, varying amounts of sand and gravel.............................	90	127
Pierre shale			
	Clay and silt, gritty, medium dark-gray..............................	13	140

Test hole 632
159-78-14dad

Unit	Material	Thickness (feet)	Depth (feet)
Alluvium			
	Soil, peaty, dark-brown................	1	1
	Clay, some vegetation, medium dark-gray................................	2	3
	Clay, highly calcareous, white........	1	4
	Clay, medium dark-gray................	3	7
	Sand, medium to coarse. Numerous well-rounded lignite pebbles up to 1½ inches in diameter...............	15	22
Till and associated sand and gravel deposits			
	Till, medium-gray.....................	80	102
Cannonball member or Fox Hills(?) sandstone			
	Silt, medium light-gray...............	8	110

Test hole 625
159-78-21daa4

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil and artificial fill..............	5	5
	Silt, yellowish-gray..................	12	17
	Silt, medium light-gray...............	8	25
	Clay, medium-gray to medium dark-gray.	10	35
	Clay and silt, light-gray.............	25	60
	Clay, light olive-gray, becoming very light olive-gray near bottom. Forms thin flaky chips....................	30	90
	Clay, very light olive-gray...........	7	97
Till and associated sand and gravel deposits			
	Till, medium light-gray with a slight yellowish tinge....................	33	130
Cannonball member or Fox Hills(?) sandstone			
	Clay, medium light-gray (drillers report "green sandy clay" for last 3 feet, not apparent in samples)....	10	140

Test hole 619
159-78-21dad

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, very sandy, dark-brown..........	1	1
	Clay, silty, yellowish-gray...........	13	14
	Clay, silty, olive-gray...............	4	18
	Sand, very fine to fine and light-gray silt..............................	22	40
	Clay, silty, light-gray...............	40	80
	Clay, silty, light-gray, same as above, but mixed with yellow clay..........	10	90
	Clay, very silty, light-gray..........	36	126
Till and associated sand and gravel deposits			
	Till, sandy and gravelly, medium-gray.	53	179
Pierre shale			
	Clay, dense, plastic, dark-gray.......	11	190

Test hole 630
159-78-22aad

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown...............	1	1
	Silt, yellowish-gray..................	6	7
	Sand, very fine.......................	3	10
	Silt, yellowish-gray..................	9	19
	Silt, light olive-gray................	14	33
Till and associated sand and gravel deposits			
	Till, medium light-gray, with considerable very coarse sand from 55 to 65 feet..............................	49	82
Cannonball member or Fox Hills(?) sandstone			
	Sand, very fine and very light-gray silt..............................	8	90

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 644
159-78-22abb

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, very sandy, dark-brown..........	3	3
	Silt, yellowish-gray..................	4	7
	Sand, very fine to fine, pale-brown...	16	23
	Clay, medium light-gray...............	17	40
	Clay, light-gray......................	15	55
Till and associated sand and gravel deposits			
	Till, medium light-gray...............	38	93
	Sand, and gravel......................	1	94
Cannonball member or Fox Hills(?) sandstone			
	Silt, gritty, light-gray..............	6	100

Test hole 629
159-78-22acd

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown...............	1	1
	Silt, yellowish-gray..................	2	3
	Clay, highly calcareous, white........	1	4
	Silt, yellowish-gray..................	4	8
	Clay, medium light-gray...............	20	28
Till and associated sand and gravel deposits			
	Till, medium light-gray...............	28	56
	Sand and gravel, poorly sorted........	9	65
	Granule gravel........................	5	70
	Granule gravel and very coarse sand...	7	77
Cannonball member or Fox Hills(?) sandstone			
	Siltstone, light-gray.................	13	90

Test hole 627
159-78-22bbc

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, dark-brown	1	1
	Silt, yellowish-gray	1	2
	Clay, highly calcareous, nearly white	2	4
	Silt, yellowish-gray	12	16
	Silt, medium light-gray	9	25
	Clay, medium gray to medium dark-gray	21	46
	Sand	3	49
Till and associated sand and gravel deposits			
	Till, sandy, light-gray	4	53
	Sand and gravel, poorly sorted	8	61
	Till, light-gray	23	84
Cannonball member or Fox Hills(?) sandstone			
	Clay, light-gray	6	90

Test hole 623
159-78-22bcd3

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown	3	3
	Silt, yellowish-gray	14	17
	Silt, light-gray	8	25
	Clay, medium dark-gray	10	35
	Clay, light-gray to medium-gray	6	41
	Sand, fine	1	42
Till and associated sand and gravel deposits			
	Till, silty, light-gray	3	45
	Sand, medium to coarse	5	50
	Sand, coarse to very coarse	5	55
	Gravel, medium	14	69
	Till, sandy, light-gray	20	89
	Gravel	2	91
Cannonball member or Fox Hills(?) sandstone			
	Clay, light-gray	9	100

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 626
159-78-22bcd5

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil and slopewash, clayey, dark-brown	5	5
	Silt, yellowish-gray..................	7	12
	Silt, medium light-gray...............	12	24
	Clay, medium dark-gray, with layers of light-gray clay. Flaky..........	34	58
Till and associated sand and gravel deposits			
	Till, light-gray......................	4	62
	Sand and gravel, poorly sorted in samples............................	12	74
	Till, light-gray......................	3	77
	Sand and gravel.......................	2	79
	Till, light-gray......................	6	85
Cannonball member or Fox Hills(?) sandstone			
	Silt and very fine sand, light-gray...	5	90

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 620
159-78-22cac5

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, dark-brown......................	1	1
	Silt, yellowish-gray..................	13	14
	Clay, plastic, grayish-black..........	2	16
	Clay, medium-gray.....................	8	24
	Silt and sand, with lesser amounts of gravel, may be till. Small snail shell found in sample from 30-35 feet	10	34
	Silt, medium light-gray...............	21	55
Till and associated sand and gravel deposits			
	Very coarse sand and medium gravel....	5	60
	Silt, very fine sand, small amount of gravel............................	5	65
	Sand, fine............................	5	70
	Sand, very fine to fine, and gravel; small amount of black, plastic clay.	5	75
	Sand, very fine to medium, possibly some clay...........................	5	80
	Medium gravel, fine sand, and clay....	5	85
	Gravel, medium, same as above but not so much clay.......................	5	90
Cannonball member and/or Fox Hills(?) sandstone			
	Silt, very fine sand, light-gray......	47	137
	Sand, much clay and silt, pale yellowish-brown..........................	5	142
	Silt, very fine sand, light-gray......	8	150
	Silt, very fine sand, grayish-green...	5	155
Pierre shale			
	Clay, medium-gray (poor samples)......	25	180

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 621
159-78-22cad2

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown...............	2	2
	Silt, grayish-yellow..................	17	19
	Clay, silty, medium-gray..............	23	42
Till and associated sand and gravel deposits			
	Till, sandy, light-gray...............	26	68
	Sand, medium to coarse, clayey........	2	70
	Sand, medium to coarse................	10	80
	Gravel and sand.......................	6	86
	Till, sandy, light-gray...............	5	91
Cannonball member or Fox Hills(?) sandstone			
	Clay and silt, light-gray.............	9	100

Test hole 628
159-78-22cba2

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown...............	1	1
	Silt, yellowish-gray..................	13	14
	Clay, silty, medium light-gray........	36	50
	Clay, same as above but intermixed with considerable yellow clay.......	5	55
	Clay, medium light-gray...............	14	69
Till and associated sand and gravel deposits			
	Till, medium light-gray...............	13	82
	Sand, gravel, and clay, yellowish-gray...............................	7	89
	Till, medium light-gray...............	4	93
Cannonball member or Fox Hills(?) sandstone			
	Siltstone, greenish-gray..............	7	100

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Joe Bell
159-78-22cba3

Material	Thickness (feet)	Depth (feet)
Clay	15	15
Sand and clay	10	25
Sand (water)	1	26
Clay (boulder at 30 feet)	14	40
Sand and clay	20	60
Gravel (water)	2	62
Clay	1	63

Upham Public School
159-78-22cbc1

Material	Thickness (feet)	Depth (feet)
Sand and clay	17	17
Quicksand	3	20
Clay, blue	105	125
Sand and clay	27	152
Sand and gravel	6	158

Upham Public School
159-78-22cbc2

Material	Thickness (feet)	Depth (feet)
Sand and reddish sand	30	30
Quicksand	5	35
Clay	135	170
Sand and clay	10	180
Sand (a little water)	2	182
Clay, blue	288	470
Clay, black or shale (very hard)	5	475

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 614
159-78-22cbc3

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, very sandy, moderate yellowish-brown	1	1
	Sand, very fine to fine, yellowish-gray	12	13
	Silt, yellowish-gray	4	17
	Clay and silt, medium-gray	17	34
	Sand, very fine and silt, light olive-gray	11	45
	Silt, gray, very coarse sand	20	65
	Sand, very fine; much silt	10	75
	Clay, silt, very fine sand	27	102
Till and associated sand and gravel deposits			
	Till (?), medium gray, contains very small amounts of sand and gravel	33	135
Cannonball member or Fox Hills(?) sandstone			
	Silt, sandy, light-gray	15	150

Test hole 615
159-78-22cbc4

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, very sandy, dark-brown	1	1
	Silt and very fine sand, dark-yellowish-brown	11	12
	Silt, yellowish-gray	4	16
	Clay, medium-gray	20	36
	Silt and very fine sand, light-gray	14	50
	Clay and silt, medium-gray	10	60
	Silt and very fine sand	10	70
	Clay, and silt, medium-gray	15	85
	Clay, medium-gray to medium dark-gray, appears in samples as angular, curled chips	33	118
Till and associated sand and gravel deposits			
	Till, sandy, light-gray, becoming gravelly and very light-gray near bottom	54	172
Pierre shale(?)			
	Clay, pale-green	8	180

Test hole 616
159-78-22cbc5

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, very sandy, dark-brown	1	1
	Silt, yellowish-brown	17	18
	Clay, silty, light-gray	14	32
	Silt and very fine sand, olive-gray	8	40
	Clay and silt	5	45
	Silt and very fine sand	5	50
	Clay, light olive-gray, appears as angular, curling chips	10	60
	Clay, light olive-gray, same as above but of an overall lighter color in general. Samples seem to be composed of streaked gray and yellowish-gray clay. Some samples give a definite appearance of laminations, the dark layers being clay and the light layers being silt and very fine sand	68	128
Till and associated sand and gravel deposits			
	Till(?) sandy, contains very few pebbles, light-gray	55	183
Pierre shale			
	Clay or shale, medium dark-gray	7	190

Test hole 618
159-78-22cbd2

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown	1	1
	Silt, yellow	8	9
	Clay, silty, medium-gray	52	61
	Sand and clay	20	81
Cannonball member or Fox Hills(?) sandstone			
	Siltstone, medium-gray	9	90

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 617
159-78-22cbd3

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown	1	1
	Silt, yellow	14	15
	Clay, medium-gray	25	40
	Silt, light-gray	10	50
	Clay and silt, probably laminated, medium gray to medium dark-gray	15	65
	Silt, yellowish-gray	7	72
Till and associated sand and gravel deposits			
	Till, sandy, light-gray	12	84
Cannonball member or Fox Hills(?) sandstone			
	Silt, grayish-green	1	85
	Clay, light-gray	5	90

Test hole 613
159-78-22cbd4

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown	2	2
	Silt, yellowish-gray	12	14
	Clay, medium-gray	12	26
	Sand, very fine to fine	15	41
	Silt and very fine sand, olive-gray	62	103
Cannonball member or Fox Hills(?) sandstone			
	Clay or shale, light-gray	17	120

Test hole 612
159-78-22cbd5

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, very sandy, dark-brown..........	2	2
	Clay, highly calcareous, very light-gray with white specks of $CaCO_3$.....	2	4
	Clay, silty, light yellowish-gray.....	7	11
	Sand, very fine to fine...............	29	40
	Silt, medium light-gray...............	20	60
	Clay and silt, medium-gray............	17	77
Till and associated sand and gravel deposits			
	Till, light-gray......................	6	83
	Sand, clayey..........................	7	90
	Till, light-gray......................	8	98
	Sand, clayey..........................	2	100
	Till, light-gray......................	4	104
Cannonball member or Fox Hills(?) sandstone			
	Clay, silty, light-gray...............	49	153
	Sand, very fine or siltstone, grayish-green..............................	7	160
Pierre shale			
	Clay, medium light-gray...............	5	165
	Shale, medium-gray to medium dark-gray, appears as chips in samples not so silty or sandy as overlying materials, contains fragments of nearly white, very fine-grained clay that readily disperses when wetted (probably bentonite).........................	45	210

Note: Core from 200-210 feet, about 75% recovery, consisted mostly of medium light-gray to medium-gray siltstone; no megascopic fossils found.

Test hole 622
159-78-22cda2

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown	3	3
	Silt, grayish-yellow	12	15
	Clay, silty, light olive-gray	10	25
	Clay, may be laminated inasmuch as the cuttings are composed mostly of thin, curly chips or flakes, medium-gray to dark olive-gray	22	47
Till and associated sand and gravel deposits			
	Sand, medium to coarse, samples contain considerable amounts of clay not reported by drillers	11	58
	Till, sandy, gravelly, light-gray	34	92
Cannonball member or Fox Hills(?) sandstone			
	Clay, medium light-gray	8	100

Test hole 624
159-78-22cdb4

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown	3	3
	Silt and very fine sand, yellowish-gray	5	8
	Clay, highly calcareous, white	2	10
	Sand, very fine, yellowish-gray	5	15
	Sand, fine, many lignite fragments, light-gray	15	30
	Sand, very fine to fine, light-gray	6	36
	Silt and very fine sand, light-gray	4	40
	Clay, light olive-gray	27	67
Till and associated sand and gravel deposits			
	Till, sandy, light-gray	10	77
	Sand and gravel	1	78
	Till, light-gray	7	85
	Sand, medium to coarse, clayey	11	96
	Till, light-gray	17	113
Cannonball member or Fox Hills(?) sandstone			
	Clay, silty, light-gray	7	120

Emil Anderson
159-78-22cdb5

Unit	Material	Thickness (feet)	Depth (feet)
	Sand and clay	15	15
	Sand, very fine	3	18
	Clay, blue	42	60
	Sand and clay	18	78
	Sand and gravel (water)	2	80
	Clay, blue	60	140

Test hole 642
159-78-22dbb

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown	1	1
	Silt, yellowish-gray	9	10
	Silt, light olive-gray	7	17
	Clay, silty, medium light-gray	20	37
Till and associated sand and gravel deposits			
	Till, medium light-gray	5	42
	Sand, clayey	8	50
	Sand, very coarse, and medium gravel, clean	6	56
	Till, medium light-gray	28	84
Cannonball member or Fox Hills(?) sandstone			
	Silt, light-gray	6	90

Test hole 631
159-78-23baa

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, dark-gray	1	1
	Clay and silt, yellowish-gray	13	14
	Clay and silt, light olive-gray	9	23
Till and associated sand and gravel deposits			
	Till, medium-gray	29	52
Cannonball member or Fox Hills(?) sandstone			
	Sand, very fine and silt, very light-gray	6	58
	Silt, medium-gray	2	60

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 643
159-78-23cbc

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, very sandy, dark-brown..........	1	1
	Sand, very fine to fine, yellow.......	16	17
	Silt, light olive-gray................	7	24
	Clay, light-gray......................	13	37
Till and associated sand and gravel deposits			
	Till, sandy, light olive-gray.........	24	61
	Sand..................................	1	62
	Till, sandy, hard, light olive-gray...	25	87
Cannonball member or Fox Hills(?) sandstone			
	Silt, light-gray......................	8	95

Test hole 636
159-78-26bdc

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, dark-grayish-brown..............	2	2
	Silt, yellowish-gray..................	1	3
	Clay, highly calcareous, very light-gray,nearly white..................	2	5
	Silt and very fine sand, pale yellowish-brown............................	10	15
	Clay and silt, yellowish-gray.........	5	20
	Silt and very fine sand, yellowish-gray	5	25
	Clay, appears as flaky chips in samples, light olive-gray to olive-gray......	16	41
Till and associated sand and gravel deposits			
	Clay, silt, and sand..................	4	45
	Till, medium light-gray...............	24	69
	Sand and gravel, poorly sorted........	7	76
	Till, medium light-gray...............	12	88
Cannonball member or Fox Hills(?) sandstone			
	Silt, light-gray......................	12	100

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 638
159-78-28aad

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil and slopewash, dark-brown........	1	1
	Silt, yellowish-gray..................	19	20
	Clay, greenish-gray...................	20	40
	Clay, flaky chips, medium-gray........	10	50
	Clay, flaky, medium light-gray, becoming lighter towards the bottom...	13	63
Till and associated sand and gravel deposits			
	Till, medium light-gray...............	6	69
	Sand, medium to very coarse...........	6	75
	Sand, medium to very coarse, and gravel............................	5	80
	Sand, very fine to very coarse, poorly sorted......................	5	85
	Sand, very coarse.....................	5	90
	Clay, yellow, gray....................	5	95
	Clay, and gravel, numerous yellow clay pebbles............................	2	97
Cannonball member or Fox Hills(?) sandstone			
	Silt, medium light-gray...............	13	110

Test hole 639
159-78-28ada

Unit	Material	Thickness (feet)	Depth (feet)
Alluvium and slopewash			
	Soil, clayey, dark-brown..............	1	1
	Silt, sandy, and much calcareous material, medium-gray................	9	10
	Silt and very fine sand, medium dark-gray..............................	5	15
Deposits of glacial Lake Souris			
	Clay and silt, varying shades of gray.	20	35
Till and associated sand and gravel deposits			
	Till, medium light-gray...............	36	71
Cannonball member or Fox Hills(?) sandstone			
	Silt, very light-gray.................	9	80

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Test hole 640
159-78-28add

Unit	Material	Thickness (feet)	Depth (feet)
Alluvium and slopewash			
	Soil, clayey, dark-brown..............	1	1
	Silt, light-gray......................	2	3
Deposits of glacial Lake Souris			
	Silt, yellowish-gray..................	5	8
	Sand, very fine to fine...............	5	13
	Clay, silty, medium light-gray........	14	27
Till and associated sand and gravel deposits			
	Till, medium light-gray...............	3	30
	Sand and gravel, possibly becoming coarser toward the bottom...........	13	43
	Till, medium light-gray...............	17	60

Test hole 641
159-78-28bbb

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, clayey, dark-brown..............	1	1
	Clay, yellowish-gray..................	16	17
	Clay, medium light-gray...............	4	21
Till and associated sand and gravel deposits			
	Till, medium light-gray...............	8	29
	Sand, medium to coarse, and a small amount of gravel....................	7	36
	Till, sandy, medium light-gray........	46	82
Cannonball member or Fox Hills(?) sandstone			
	Clay, silty, light-gray...............	8	90

Jim Jacobson
159-78-34cbb1

Material	Thickness (feet)	Depth (feet)
Loam, sandy, black....................	2	2
Clay, sandy, yellow...................	20	22
Clay, blue............................	32	54

Test hole 637
159-78-35aaa

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, very sandy, dark-brown	2	2
	Sand, very fine to fine, yellowish-brown	13	15
	Silt and very fine sand, yellowish-gray	10	25
	Silt, sandy, light olive-gray	10	35
	Silt, light olive-gray	10	45
	Clay, fine grained and uniform, light-gray	17	62
Till and associated sand and gravel deposits			
	Clay, sandy, and gravel	4	66
	Till, medium light-gray	3	69
	Sand and gravel, poorly sorted	7	76
	Till, medium light-gray	12	88
Cannonball member or Fox Hills(?) sandstone			
	Silt, very light-gray to light-gray	12	100

E. J. Bethke
159-79-2cbb2

Material	Thickness (feet)	Depth (feet)
Loam, sandy	1	1
Sand, red, and clay	9	10
Quicksand	5	15
Sand and blue clay	25	40
Clay, blue	30	70
Clay, blue and sand	20	90
Gravel and blue clay (a little water)	10	100
Clay, blue	50	150

Olie Mickelson
159-79-2dcc1

Material	Thickness (feet)	Depth (feet)
Sand and loam	10	10
Clay, blue	40	50
Gravel	26	76

TABLE 3.--LOGS OF TEST HOLES AND WELLS -- Continued

Olie Mickelson
159-79-2dcc2

Unit	Material	Thickness (feet)	Depth (feet)
	Sand and loam	10	10
	Clay, blue	40	50

Einar Einarson
159-79-3adal

Unit	Material	Thickness (feet)	Depth (feet)
	Sand and loam	10	10
	Quicksand	5	15
	Clay, blue	75	90
	Sand, fine	26	116
	Gravel	4	120

Test hole 645
159-79-24ddd

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, clayey, dark-brown	1	1
	Clay, yellowish-gray	7	8
	Clay, silty, light olive-gray	15	23
Till and associated sand and gravel deposits			
	Till, yellowish-gray	17	40
	Till, light olive-gray	15	55
	Till, very sandy, light-gray	22	77
Cannonball member or Fox Hills(?) sandstone			
	Sand, fine to medium, clayey and silty, grayish-green	23	100

William Abner
159-79-26abb

Unit	Material	Thickness (feet)	Depth (feet)
	No description	14	14
	Quicksand	2	16
	Clay, blue	38	54

Test hole 646
159-79-26bbb

Unit	Material	Thickness (feet)	Depth (feet)
Deposits of glacial Lake Souris			
	Soil, sandy, dark-brown	1	1
	Sand, pale-brown	4	5
	Silt, yellowish-brown	12	17
	Clay, medium light-gray	6	23
Till and associated sand and gravel deposits			
	Till, medium light-gray	34	57
	Sand	1	58
	Till, medium light-gray	3	61
	Sand and gravel	7	68
	Till, medium light-gray	20	88
Cannonball member or Fox Hills(?) sandstone			
	Sand, fine to medium, about 50 percent clay and silt, light grayish-green.	12	100

Robert Schnabel
159-79-36abb2

Material	Thickness (feet)	Depth (feet)
Sand	27	27
Clay and gravel	23	50

Ben Mettler
159-79-36cdd1

Material	Thickness (feet)	Depth (feet)
No description	20	20
Clay, blue	29	49
Gravel	1	50

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