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RECONNAISSANCE OF THE GROUND-WATER RESOURCES OF DELTA COUNTY, MICHIGAN

By

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ABSTRACT

Delta County is on the north shore of Lake Michigan in the south-central part of Michigan's Northern Peninsula. The county is sparsely inhabited, except for the Escanaba-Gladstone area along the west shore of Little Bay de Noc. Large areas of the county are forested.

The county is in the northwestern part of the Michigan basin, where Paleozoic rocks of Ordovician and Silurian age form the bedrock surface. During the Pleistocene epoch, a discontinuous mantle of glacial drift of varying thickness was deposited on the bedrock surface.

Most of the ground-water supplies of Delta County are derived from various bedrock aquifers. Several deep and relatively large-capacity wells tap the sandstones of the Munising and Au Train formations in the western part of the county. About half the wells in the county, however, obtain small to moderate supplies at shallow depth from limestone of the Black River and Trenton formations. Shale of the Collingwood formation and the basal members of the Richmond group yield small amounts of highly saline water. Limestone and dolomite of the Richmond group locally are a source of fresh ground water on the Stonington Peninsula and northeastern part of the county. The Cataract formation yields small to moderate

supplies of water to wells in the southeastern part of the county, but the water is very hard and has a high sulfate content. On the Garden Peninsula, the Burnt Bluff and Manistique formations are sources of hard to very hard water, which is otherwise of good chemical quality. In many parts of the county, the glacial drift is a source of small supplies. These deposits have considerable potential as a source of moderate to large supplies in the presently undeveloped northeastern part of the county.

Although adequate quantities of ground water are available throughout Delta County, adequate supplies of good quality may be difficult to obtain in various areas. Fresh-water aquifers tapped at depth must be protected from vertical leakage of saline water through uncased wells penetrating shales of the Richmond group and Collingwood formation or saline-water-bearing zones in other aquifers. Pumping from various parts of fresh-water aquifers may result in local changes in ground-water regimen and may cause migration of water of inferior chemical quality from adjacent aquifers. In this manner, water of high sulfate content from the Cataract formation has entered basal members of the Burnt Bluff formation. Lastly, the shallow limestone and dolomite aquifers of Delta County, which are readily recharged through fractures and crevices, are highly susceptible to contamination from surface sources.

INTRODUCTION

Purpose and Scope of Study

A ground-water reconnaissance of the eastern part of the Northern Peninsula on a county-unit basis was begun in 1955 as part of the continuing cooperative investigation by the Michigan Department of Conservation and the U. S. Geological Survey to determine the general occurrence, availability, quantity, and quality of ground water. Basic ground-water information pertaining to this part of the State is needed for anticipated economic and population growth after completion of the St. Lawrence Seaway and the Mackinac Straits bridge.

This report is the fifth in the series of interim county-reconnissance reports, and it summarizes the ground-water data obtained in Delta County during the 1958 field season. The first four reports of the series, describing in general the ground-water resources of the eastern part of the Northern Peninsula, have been published by the Michigan Geological Survey and are listed below. Pertinent data from those reports are used freely herein.

Progress report	County	Reference 1/
17	Chippewa	Vanlier and Deutsch, 1958a
19	Mackinac	Vanlier and Deutsch, 1958b
21	Luce	Vanlier, 1959
22	Schoolcraft	Sinclair, 1959

1/ See "References Cited", at end of report.

Cooperative ground-water investigations in Michigan by the U. S. Geological Survey are directed jointly by P. E. LaMoreaux, chief of the Ground Water Branch, U. S. Geological Survey, Washington, D. C., and W. L. Daoust, State Geologist, Michigan Geological Survey, Lansing, Michigan, and are under the direct supervision of Morris Deutsch, district geologist of the Federal Survey, in Lansing.

Previous Investigations

Various phases of the geology and hydrology of Delta County are described in several reports of investigations made in the Northern Peninsula of Michigan. An investigation of flowing-well districts in the eastern end of the Northern Peninsula was made by Leverett (1906), who also described the glacial features of the region and their significance (1929). A reconnaissance of the probable effects on ground-water levels of a Lake Superior-level canal from Munising, in Alger County, to Rapid River was made by the U. S. Geological Survey for the Corps of Engineers in 1949. Some of the data used in this report were collected during that survey. Hussey (1936, 1950, 1952) studied the Ordovician rocks underlying most of the county and Ehlers and Kesling (1957) described the Silurian rocks of the Garden Peninsula and adjacent areas.

Acknowledgments

Special thanks are given to the residents of Delta County, to the well drillers of the region, particularly C. O. Rice of Escanaba, and to the State, county, and municipal agencies whose cooperation made this report possible. Appreciation is expressed also to personnel of the

Michigan Geological Survey and Michigan Department of Health, who furnished valuable data and assistance.

Well-Numbering System

The well-numbering system used in this report indicates the location of the wells within the rectangular subdivisions of the public lands, with reference to the Michigan meridian and base line. The first two segments of a well number designate the township and range; the third segment designates the section and the serial number assigned to the well within the section. Thus, well 43N 23W 4-1 is well number 1 in section 4, Township 43 North, Range 23 West. The locations of wells to 40-acre tracts within the section are given in table 3. See also figure 13, which shows the distribution of--and also serves as an index for--Delta County well records, water-level information, logs, and chemical analyses referred to in the text and listed in tables 3, 4, and 5.

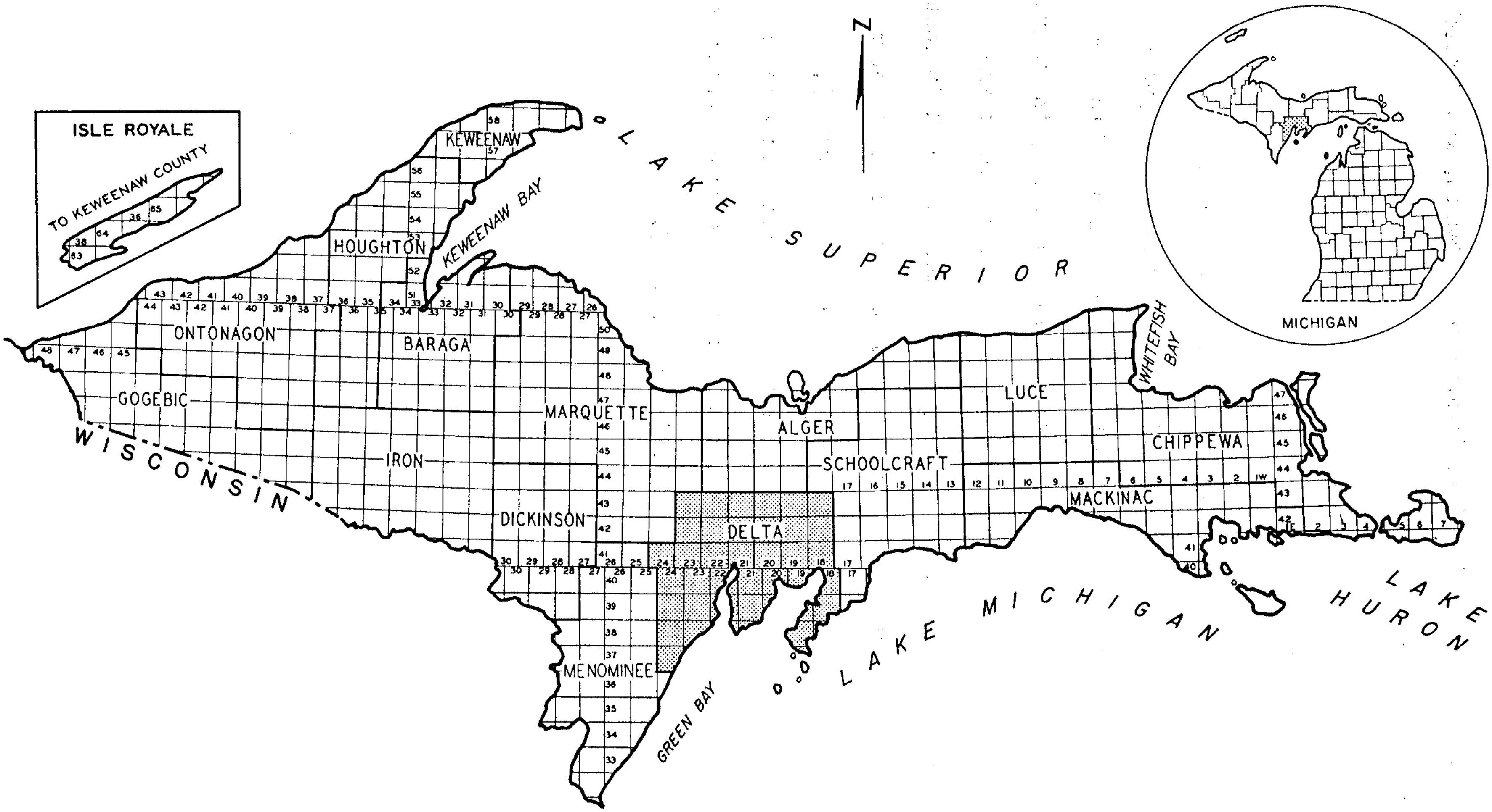


Figure I. Index map showing location of Delta County, Mich.

GEOGRAPHY

Delta County is in the south-central part of the Northern Peninsula along the north shore of Green Bay (fig. 1). It is bordered on the west by Menominee and Marquette Counties, on the north by Marquette, Alger, and Schoolcraft Counties, and on the east by Schoolcraft County. It has an area of 1,180 square miles and a shoreline along Big Bay de Noc, Little Bay de Noc, and Lake Michigan about 200 miles long. Escanaba, on the west shore of Little Bay de Noc, is the county seat. The county includes a chain of small, uninhabited islands lying between Green Bay and Lake Michigan and extending from the tip of the Garden Peninsula toward the Door Peninsula of Wisconsin (fig. 2). Two small islands are located in Big Bay de Noc.

Population and Economic Development

The population of Delta County in 1957 was 31,920, about two-thirds of whom reside in the Escanaba-Gladstone area. The city of Escanaba serves as the major center of State Government for the Northern Peninsula. Large areas of the county are sparsely populated.

One large manufacturer of industrial equipment and several smaller metalworking concerns are located in the Escanaba-Gladstone area. The tourist industry is of growing importance to the economy of the county. The remaining industry in Delta County is largely related to the county's natural resources; production of lumber, pulpwood, paper, and other forest products constitutes a major industry. Some of the limestone in Delta County is used for road metal and aggregate (Smith, 1916). Building stone has been quarried from the Manistique dolomite in the vicinity of Fairport. Sand and gravel for construction is produced from glacial deposits throughout the county.

Farms constitute 22 percent of the land area of the county, and most of the farmland is used for the production of dairy products. In 1954 there were about 900 farms in Delta County, most of which were in the western part of the county, but by 1960 the number of farms declined to about 600. The only known irrigator in the county is located on the Garden Peninsula and pumps water from Big Bay de Noc.

Transportation

The county is served by the Chicago and North Western; the Escanaba and Lake Superior; and the Minneapolis, St. Paul and Sault Ste. Marie Railroads (fig. 2).

U. S. Highway 2 links the area with Sault Ste. Marie and Michigan's Southern Peninsula by way of the Mackinac bridge. U. S. 2 and 41 provide access to Michigan's iron- and copper-mining regions and to the North-Central and Northwestern States. These roads, along with State Highway M-35, U. S. Forest Highway 13, and several county roads, provide a network of hard-surfaced roads in the county.

Delta County is served by North Central Airlines through the Escanaba Airport and by interstate bus and truck lines. The harbor at Escanaba is an important shipping point for iron ore and, along with docking facilities at Gladstone and Kipling, receives much of the petroleum, coal, and other products shipped to the area by way of the Great Lakes Waterways and St. Lawrence Seaway.

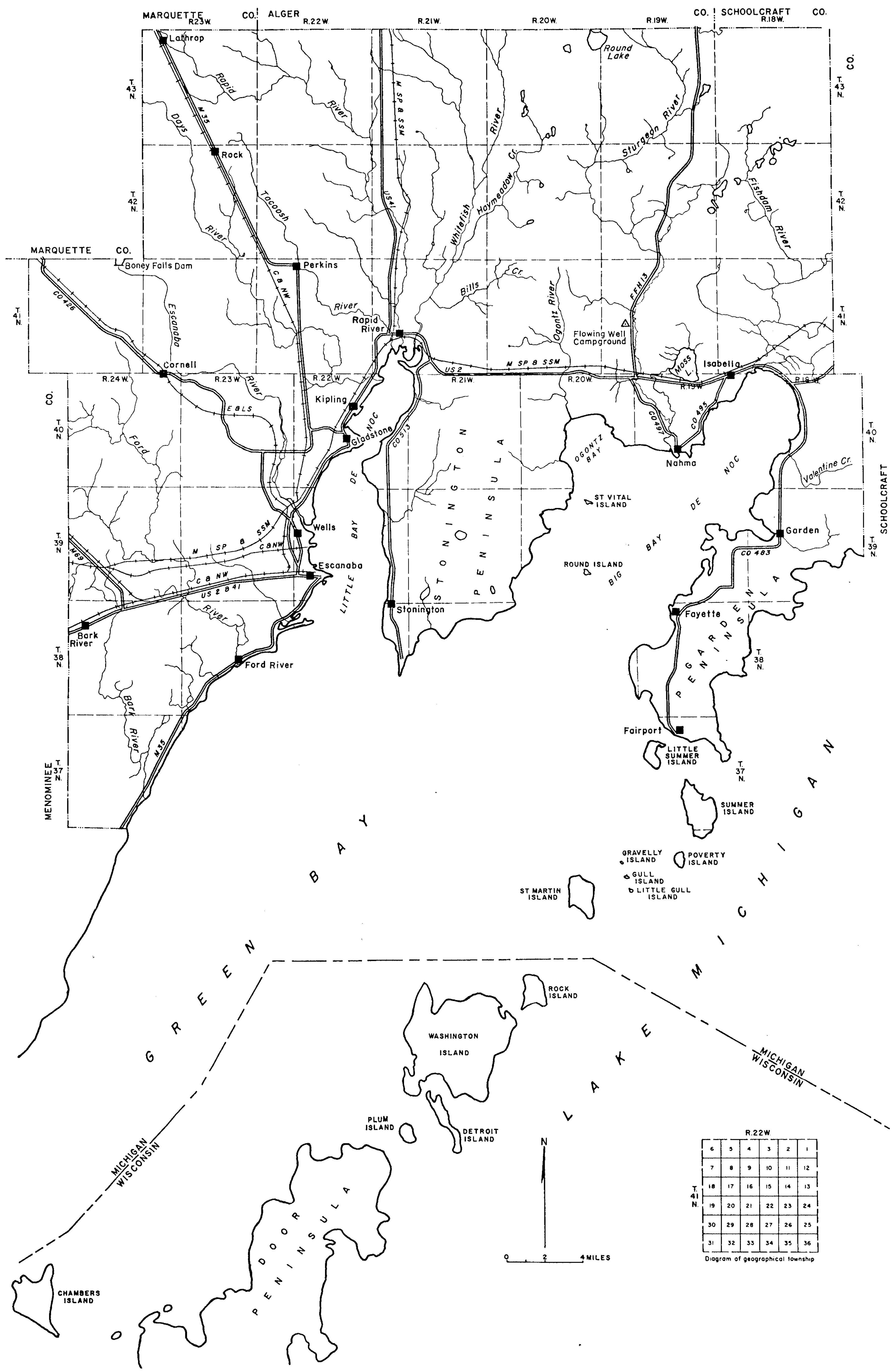


Figure 2. Map of Delta County, Mich.

Physiography and Relief

The shoreline and much of the surface configuration of Delta County result from differences in resistance to erosion of the underlying bedrock formations, as illustrated by figure 4. The formations crop out in roughly parallel bands trending southwest-northeast and dipping gently to the southeast.

The bluffs, which form the west shore of Garden Peninsula and outlying islands, are part of the prominent Niagara Escarpment, a major physiographic feature which may be traced across the northern rim of the Michigan basin, from the type locality at Niagara Falls, N. Y., to the Door Peninsula of Wisconsin. The bluffs and islands are composed of hard, resistant limestone and dolomite formations of the Niagara series. The soft gypsum and shaly dolomite members of the Cataract formation, which have been eroded to about 100 feet below lake level, form the trough occupied by Big Bay de Noc. The Stonington Peninsula is formed by a resistant limestone ridge of the Richmond group. The limestones of the Richmond group are underlain by shale, which also has been eroded to about 100 feet below Lake Michigan level and forms the trough occupied by Little Bay de Noc. West of Little Bay de Noc, the limestone and dolomite of the Black River and Trenton formations form the bedrock surface, which rises rather evenly toward the northwest and attains an elevation of 1,000 feet above sea level (420 feet above Lake Michigan) in the vicinity of Lathrop in the northwest corner of the county.

Delta County was glaciated during the Pleistocene epoch--a time when many of its physiographic features were formed. In the northeastern part of the county, glacial deposits form highlands and ridges of considerable relief. West of the valley of the Whitefish River, the land surface generally reflects the configuration of the underlying bedrock and is more subdued. Extensive swamps cover much of the lowlands of the county as well as poorly drained areas in the uplands. A large part of the county was covered by the waters of early glacial lakes, as indicated by lake plains, beaches, and sand dunes, which are important physiographic features in some areas.

Drainage

The surface drainage of Delta County is divided into several narrow watersheds all draining to Lake Michigan by way of Big Bay and Little Bay de Noc. Natural drainage in much of the county, however, is in an early stage of development, as indicated by numerous and extensive swamps. The drainage divides in some areas are obscured by low relief and the extensive swamps. In the western part of the county, the streams follow the dip slope of the underlying bedrock, but the Whitefish, Sturgeon, and other rivers to the east flow along old glacial drainageways.

Climate

Delta County receives an average of 29.2 inches of precipitation a year. Temperature ranges and precipitation totals at Escanaba for 5-day periods from July 1958 through December 1959 are shown in figure 9. The annual mean temperature is 41.9°F. Recorded temperature extremes range from -31°F to 100°F. The average date of the last killing frost in the spring is estimated to be May 12, and that of the first killing frost in the fall, October 5.

GEOLOGY

The sedimentary rocks of Paleozoic age including the Jacobsville sandstone of possible Precambrian age that underlie Delta County rest upon Precambrian igneous, metamorphic, and sedimentary rocks and are mantled discontinuously by glacial deposits of Pleistocene age. The areal distribution of the Paleozoic rocks is shown in figure 3 and that of the glacial deposits in figure 5. The lithology and hydrology of the various rock units underlying the county are outlined in table 1 and are described in the section on ground water.

Summary of Geologic History

The Paleozoic rocks that underlie Delta County consist of limestone, dolomite, shale, sandstone, and gypsum. These rocks were deposited in the shallow seas that covered the Michigan basin during most of the Paleozoic era. The wide diversity of the sediments deposited is evidence of fluctuating sea levels, oscillating shorelines, and a variety of sediment sources.

During the Mesozoic and most of the Cenozoic eras, the Paleozoic sediments were subjected to erosion, which resulted in the creation of some of the major physiographic features of Michigan. These features, later modified by Pleistocene glaciation, include the Niagara Escarpment and the major valleys now largely occupied by the Great Lakes.

A period of glaciation (the Pleistocene epoch) followed the long interval of erosion. During this epoch, ice migrated southward from accumulation centers in Canada during the course of at least four

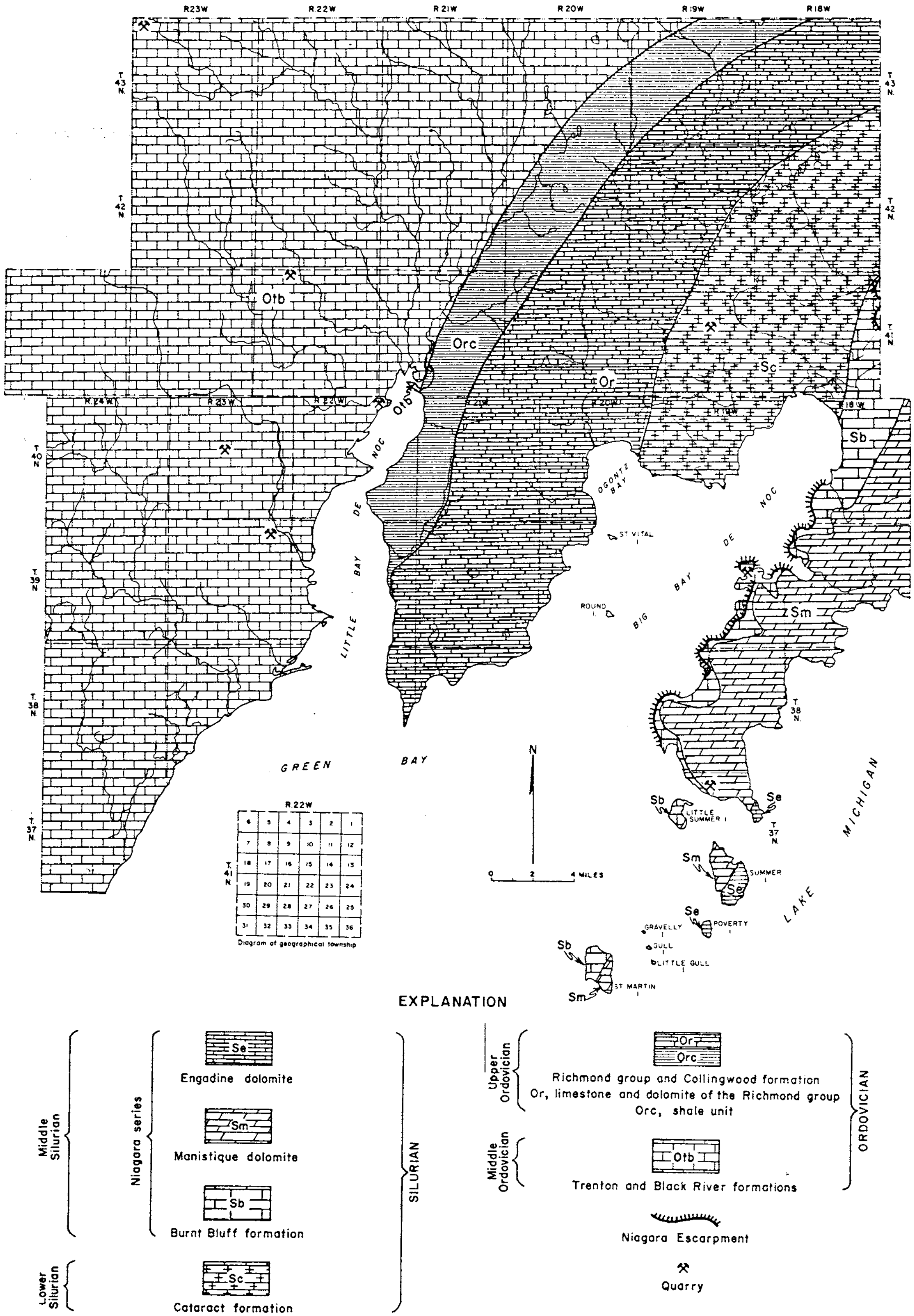


Figure 3. Bedrock geology of Delta County.

Table 1.--Lithology and hydrology of the rocks underlying Delta County.

AGE			NAMES AND SYMBOLS USED IN THIS REPORT LITHOLOGY	THICK-NESS (feet)	HYDROLOGY
Cenezoic	Quaternary	Pleistocene	Glacial drift Undifferentiated (Qgd) Sand (Qs); Gravel (Qg) Sand and gravel (Qsg) Varied deposits of poorly sorted till ranging in composition from clayey to bouldery; sand and gravel outwash, sandy lake deposits, and dune sand, all of which are relatively well sorted.	0 to 200±	In most of the southern and western parts of the county, the drift is thin and discontinuous, and hence is a source of very small supplies of fresh ground water. The thickest and most permeable drift deposits, which have considerable potential for future development, are in the northeastern part of the county.
Paleozoic	Silurian	Middle (Niagara)	Engadine dolomite (Sm) Massive hard bluish-white dolomite	10±	Not an important source of water because of its small areal extent and thickness.
			Manistique dolomite (Sm) Thinly bedded to massive light-buff to brown and gray cherty dolomite.	150	Potentially important as a source of water in the sparsely inhabited eastern half of the Garden Peninsula.
			Burnt Bluff formation (Sb) Thinly bedded to massive light-gray to buff calcitic dolomite.	250±	Important aquifer in the Garden Peninsula. Yields moderate to large supplies of water of good quality, although generally hard. Basal strata connected hydraulically with the underlying Cataract formation.
		Early	Cataract formation (Sc) Buff to gray dense cherty, shaly dolomite and gray shale interbedded with thin layers of gypsum.	250±	Yields moderate supplies of water of poor quality--very hard, and high in calcium and sulfate content.
	Ordovician	Late	Limestone and dolomite of Richmond group (Or) Thinly bedded shaly limestone and dolomite interbedded with shale and a few massive beds of limestone.	300±	Yields small amount of hard, but generally not objectionable, water to large-diameter shallow wells. Locally yields water high in sodium and chloride content.
			Shale unit of the Richmond group and Collingwood formation (Orc) Gray to dark-brown shale interbedded with limestone.	135 to 300	Permeability low. Contains highly saline water.
		Middle	Trenton and Black River limestones (Otb) Thin, irregular beds of gray to buff limestone and dolomite interbedded with thin shale layers or lenses.	300±	Yields moderate amounts of hard, but not objectionable, water throughout the western part of the county. Locally contains saline water.
		Early and Middle	Au Train formation (Oat) Thin- to medium-bedded sandy dolomite and dolomitic sandstone with many thin lenses of quartzose sandstone.	300±	These rocks are connected hydraulically and form a single aquifer which will yield moderate to large supplies of water of good quality in much of the county. Salinity may increase basinward. The water is under considerable pressure and will flow from wells in low areas along the Great Lakes shoreline.
	Cambrian	Late	Munising sandstone (Єm) Fine- to medium-grained white to gray sandstone with lenses of silt and shale.	50 to 200+	
Precambrian or Cambrian			Jacobsville sandstone (Єj) Red and white quartzose sandstone.	?	Of small areal extent in county, if present at all. Not a potential source of water.
Precambrian			Metamorphic and igneous rocks	?	Not a source of water.

major glacial stages. The glaciers scoured and abraded the surface and transported vast amounts of material plucked from the surface. With melting of the ice sheets, this material was deposited over the eroded Paleozoic rocks.

The glacial features of Delta County resulted largely from the Green Bay lobe of the last of the major continental ice sheets (Wisconsin glacier) that covered the Northern Peninsula. The Green Bay lobe invaded the area now occupied by Delta County along a general north-south axis marked by the valleys of the Au Train (in Alger County) and Whitefish Rivers. During periods of relative stability while the Green Bay lobe was melting, large moraines were deposited in the county along the ice front. Most of the moraines are segments of the Marquette and Sturgeon morainic systems (Martin, 1957), although not enough field work has been done to distinguish between them in Delta County. A portion of the Newberry moraine that extends into Delta County from Schoolcraft County (Sinclair, 1959) probably is correlative with the Sturgeon moraine.

At the close of the Pleistocene epoch, a succession of glacial lakes covered much of Delta County, and at one stage water flowed directly into the Lake Michigan Basin from the Lake Superior Basin along valleys presently occupied by the Au Train and Whitefish Rivers. Uplift of the land, which had been depressed by the ice, changed drainage patterns, lake elevations, and shoreline positions (Leverett and Taylor, 1915, and Hough, 1958). The result of these changes was a succession of glacial upper Great Lakes. Lakes Superior, Huron, and Michigan represent the modern stage of this succession. Bars, beaches, wave-cut terraces, and dunes, which are present throughout the county, mark various shorelines of this succession of lakes.

Bedrock Structure

The Precambrian surface upon which the sedimentary rocks of Delta County are deposited slopes generally southeastward toward the center of the Michigan basin. The Paleozoic rocks of the basin were deposited in nearly horizontal layers, but gradual subsidence and compaction of the beds, which was contemporaneous with deposition and greatest in the center of the basin, produced a bowl-shaped structure. The youngest beds are exposed at the surface in the central part of this structure in the center of the Southern Peninsula, and the older formations crop out in roughly concentric bands. Delta County is near the northwest edge of the basin, where the oldest sedimentary rocks are exposed. The regional dip of the formations in Delta County is to the southeast at about 40 feet per mile. The formations tend to become thicker toward the center of the basin.

Although the structure of the Paleozoic rocks throughout the county has not been studied in detail, Hussey (1950, 1952) described several small east-west-trending anticlines in the Stonington Peninsula.

GROUND WATER

A rock formation, part of a formation, or group of formations that yields water in usable quantities is called an aquifer. The imaginary surface consisting of all points to which water would rise in wells tapping an aquifer is called the piezometric surface. Aquifers may be classed as water-table or artesian. In a water-table aquifer, ground water is unconfined; its surface is termed the "water table" and may be considered to be the piezometric surface of that aquifer. The zone of saturation is that portion of the formation in which openings are filled with water. In an artesian aquifer, ground water is confined under pressure between relatively impermeable strata. Under natural conditions, the water in a well that is finished in an artesian aquifer and is tightly cased through the overlying confining bed will rise above the bottom of that bed, and therefore the piezometric surface is above the top of the aquifer. In topographically low areas, wells tapping artesian aquifers may flow at the surface. An artesian aquifer is full of water at all times, even when water is being removed from it, although an artesian aquifer may be dewatered locally by heavy pumping.

Porosity is the ratio of the volume of open spaces in a rock to the total volume of the rock. Porosity is generally described as primary or secondary. Primary porosity is that present in rocks when they are first formed. Secondary porosity is developed by processes that affect rocks after they are formed. The porosity of unconsolidated deposits is generally greatest where they are well sorted, and least where they are poorly sorted. In consolidated rocks, the extent of fracturing and solutional openings and the degree of cementation and mineral encrustation around primary and secondary openings are generally the most important factors determing porosity.

The capacity of a material to transmit water under pressure is called its permeability. The degree of permeability depends on the size and shape of the openings and the extent to which they are interconnected. The coefficient of permeability (P), as used herein, is reported in meinzers and is defined as the number of gallons of water per day that will move through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent at a temperature of 60°F. The field coefficient of permeability is the same except that it is measured at the prevailing temperature of the water. Coefficients of permeability of most important water-bearing materials are greater than 10 meinzers. The permeability of some sand and gravel samples collected in Delta County was as high as 5,000 meinzers (fig. 8).

The ability of the aquifer to yield water to a well is related also to its thickness and extent. A measure of the capacity of a given aquifer to transmit water is called its transmissibility. The coefficient of transmissibility (T) is defined as the number of gallons of water per day, at the prevailing temperature, that will move through a vertical strip of the aquifer 1 foot wide and of a height equal to the thickness of the aquifer under a hydraulic gradient of 100 percent, or 1 foot per foot. Hence, the transmissibility of an aquifer is the average field permeability of the rock multiplied by the thickness of the aquifer in feet.

The yield of a well is a function of the transmissibility of the aquifer and the efficiency of the well. It is commonly expressed in terms of the specific capacity--the yield of water in gallons per minute for each foot of drawdown in water level caused by pumping of the well. The specific capacities of 14 wells tapping some of the bedrock aquifers in the county are given in table 2.

The aquifers underlying Delta County consist of a variety of consolidated and unconsolidated rocks. The chief consolidated rock aquifers are composed of strata of sandstone, limestone, or dolomite. In sandstone aquifers, water may move through both primary openings between individual sand grains and secondary openings along fractures and bedding planes. Water in limestone and dolomite aquifers moves predominantly along fractures and bedding planes and other permeable zones developed by weathering and solution.

Shale interbedded with limestone and dolomite commonly is of low permeability and yields very little water to wells. Shale is important, however, as a confining bed in an artesian system and because the contact zones between beds of shale and limestone or dolomite commonly are paths of ground-water movement.

Aquifers in the glacial drift are the most accessible source of water in some parts of the county. The water is contained in the spaces between rock particles, and the permeability of the drift varies with the size, shape, and degree of sorting of the particles.

Table 2.--Specific capacities reported for wells in Delta County

Well number	Formation 1/	Lithology	Drawdown (feet)	Rate of discharge (gpm)	Duration of test (hours)	Specific capacity (gpm/ft)
42N 23W 31-1	Otb	Limestone	45	2.5	-	0.06
41N 22W 23-1	Oat	Sandstone	100	165	36	1.65
40N 22W 22-2	€m	do.	180	400	720	2.2
40N 18W 4-3	Sc	Limestone	25	20	1	.8
39N 22W 6-5	Otb	do.	35	8	12	.2
6-7	Otb	do.	5	10	.1	2.0
29-1	€m	Sandstone	100	300	-	3.0
30-2	€m	do.	12	660	-	2/ 5.5
30-3	€m	do.	230	560	-	2.4
31-1	€m	do.	160	590	-	3.7
39N 18W 7-6	Sc	Limestone	5	17	5	3.4
38N 23W 14-1	Otb	do.	21	10	1	.5
16-2	€m	Sandstone	150	42	-	.3
16-2	€m	do.	90	26	-	.3

1/ See table 1.

2/ Average of several tests.

Ground Water in Consolidated Rocks

Precambrian Rocks

Precambrian igneous, metamorphic, and sedimentary rocks underlie all of Delta County but are everywhere mantled by consolidated Paleozoic sedimentary rocks of varying thickness. (See figs. 3 and 4.) The depth to the Precambrian rocks near the village of Rock in the northwestern part of the county was logged at 610 feet in well 43N 23W 35-1 (table 4), but well 41N 19W 20-1, at the Flowing Well Campground in the eastern part of the county, drilled to a depth of 1,160 feet, failed to reach the Precambrian rocks. There is little doubt, however, that the total range in depth to these rocks in Delta County is greater than indicated by the above information.

The composition of these rocks is known only at a few scattered areas where test holes for iron ore have been drilled. Future development of Precambrian rocks in the county as a source of water is unlikely because of their depth and probable low permeability and because they lie beneath two relatively permeable sandstone formations.

Jacobsville Sandstone of Precambrian or Cambrian Age

The Jacobsville sandstone is a red and white quartzose sandstone, which overlies the Precambrian rocks along the south shore of Lake Superior. Although the Jacobsville sandstone attains a thickness of more than 1,000 feet in Alger County, it thins rapidly to the south and has not been identified in any wells in Delta County. Hamblin (1958, fig. 2) shows the formation pinching out along the northern boundary of the county. Hence, the Jacobsville sandstone cannot be an important potential source of water in Delta County, although it is tapped as a source of supply in Alger and Marquette Counties.

Munising Sandstone of Late Cambrian Age and Au Train Formation of Early and Middle Ordovician Age

The Munising sandstone and Au Train formation form extensive aquifers and are potential sources of fresh water throughout Delta County. Because they have similar lithologic characteristics and in some areas may be hydraulically connected, and because subsurface data necessary to distinguish between them is sparse, they are treated herein as a single aquifer. The Munising is composed of fine- to medium-grained white to gray sandstone and includes some lenses of shale and siltstone. The sandstone commonly is cemented with silica. The Munising ranges in thickness from 50 to 200 feet in the county.

A 300-foot sequence of thin- to medium-bedded sandy dolomite and dolomitic sandstone with lenses of quartz sand overlies the Munising sandstone. Van Hise and Bayley (1900) proposed the term "Hermansville" for this sequence of rocks. More recently, Hamblin (1958, p. 115) suggested that this term be abandoned and replaced by the term "Au Train", as the thickest sections and best exposures known are at Au Train Falls in Alger County and because no type section for the "Hermansville" was given by Van Hise and Bayley. The name Au Train formation is therefore accepted for use in this and subsequent reports of this series of studies and hence supersedes the term "Hermansville" used in previous reports of the series.

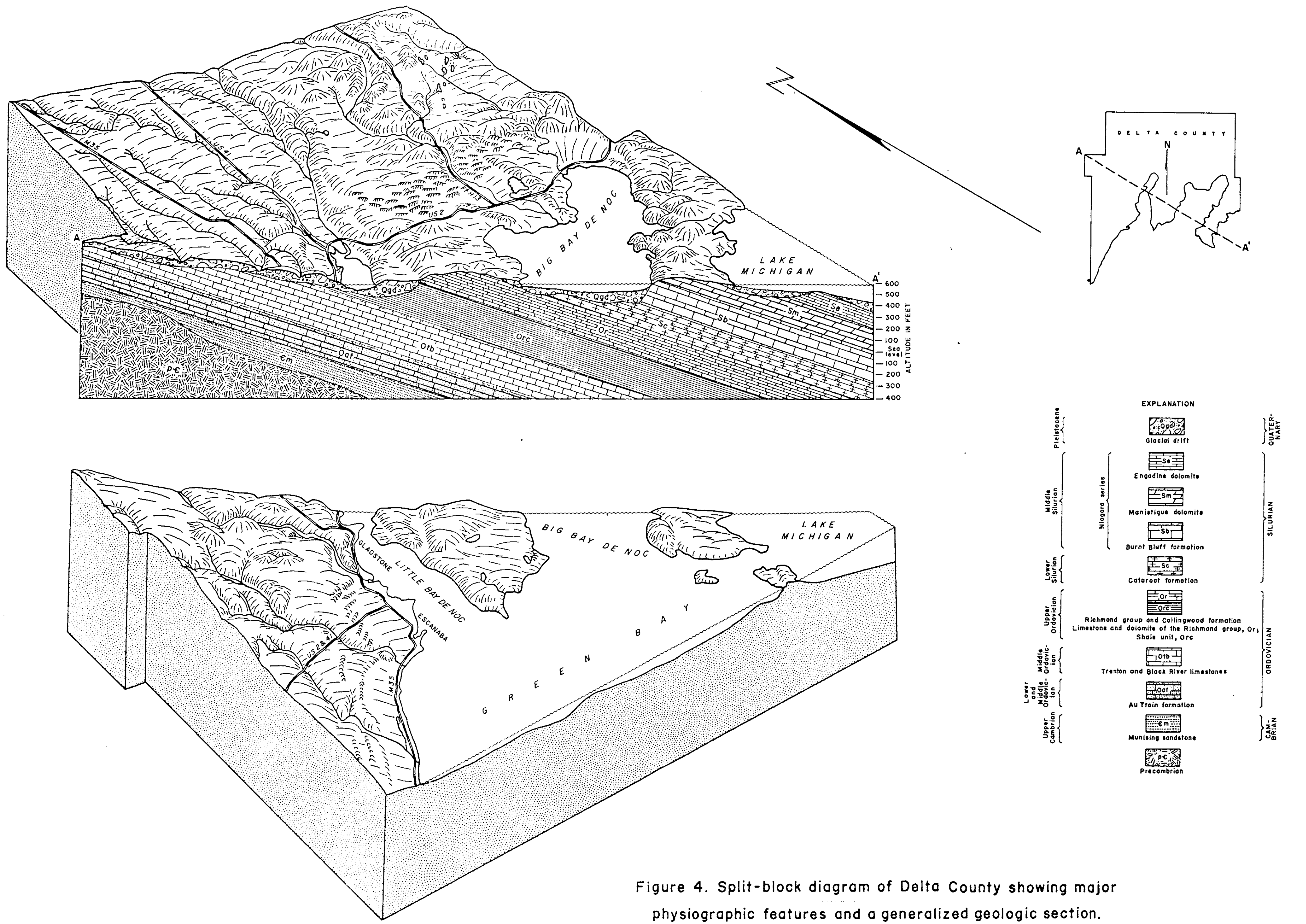


Figure 4. Split-block diagram of Delta County showing major physiographic features and a generalized geologic section.

The Munising and Au Train formations crop out in adjacent areas of Alger and Marquette Counties, at elevations of about 1,000 feet above sea level, but dip beneath the younger consolidated rocks in Delta County. In the Escanaba-Gladstone area, the top of the Au Train formation is about 275 feet below the level of Lake Michigan. Water in this aquifer is confined by overlying beds of dense dolomite and shale of the Black River limestone. In many parts of the county, wells tapping the sandstone flow at the surface, and yields as great as 250 gpm (gallons per minute) have been reported (table 3). The sandstone beds of both the Munising and the Au Train formations yield most of the water produced from this aquifer. However, fractures and solution openings in the dolomite beds of the Au Train may yield some water.

These formations are tapped by more than 60 wells in Delta County. Most are privately owned domestic wells in the western part of the county. Several public and industrial wells also tap this aquifer. The city of Escanaba obtained its main source of supply from this aquifer during and after World War II. Later, however, the city abandoned its ground-water supply system, because of inadequate yields, hardness, high iron content, and civil actions against the city by owners of wells finished in the Au Train formation at depths of 325 to 350 feet.

Black River and Trenton Limestones of Middle Ordovician Age

The Black River and Trenton formations overlie the Au Train formation and form the bedrock surface in Delta County west of Little Bay de Noc and the valley of the Whitefish River (fig. 3). These formations have been described in detail by Hussey (1936, 1950, 1952). Hussey differentiated between the Black River and the overlying Trenton limestone primarily on fossil evidence. However, the lithologic and hydrologic characteristics of the two formations are so similar that in this report no distinction is made between them.

The Black River and Trenton formations are composed of thin, irregular beds of gray to buff limestone and dolomite interbedded with thin layers and lenses of shale. The thickness of these rocks in Delta County ranges from 150 to 300 feet. Where the entire section is present (overlain by younger formations), it is about 300 feet.

These formations are the chief sources of water in the western part of the county, where the water is commonly obtained at moderate depth. A few wells in the eastern part of the county tap the Black River and Trenton limestones at depth, although most wells in this area tap overlying aquifers. The water moves almost exclusively in openings along bedding planes and joints or other fractures. These secondary openings have been enlarged through solutional activity of percolating ground water.

The specific capacity of wells tapping the Black River and Trenton formations is generally low (table 2), and, although the many wells tapping this aquifer are adequate for domestic and farm needs, in most places the rocks would not yield an adequate supply for large industrial users or irrigators.

Collingwood Formation and Richmond Group of Late Ordovician Age

Shale unit.--A sequence of shale strata including the Collingwood formation and the basal members of the Richmond group overlies the Trenton rocks in the eastern half of Delta County. Where exposed, in the banks of Bills Creek and Haymeadow Creek and in the cliff that forms the east shore of Little Bay de Noc near Stonington, the shale is thinly bedded, fissile, and generally soft, although the sequence contains a few beds of hard shale as thick as 6 inches. The color varies from light gray to dark brown on fresh surfaces, which weather to a light blue. In many places the shale grades into a dark-brown limestone, which is moderately hard, coarsely crystalline, and, in some places, very fossiliferous. The thickness of the shale unit varies greatly; sections of 135 and 300 feet have been reported (wells 41N 19W 20-1 and 39N 21W 29-1, table 4).

The shale beds are of low permeability, and the water contained in them is of poor quality. The yield of well 39N 22W 36-1 near Stonington, drilled to a depth of 300 feet and completed in the shale unit, was so small that the well was never used. It is unlikely that the shale unit is a potential source of fresh ground water at any place in Delta County.

Limestone and dolomite of the Richmond group.--The upper 300 feet of the Richmond group is composed of numerous thin layers of shaly limestone and dolomite interbedded with thin layers of shale.

A few of the limestone beds are massive, hard, and cherty. (Hussey, 1926, 1950). The beds range in color from light gray to dark brown, although many of the rocks turn bluish gray upon weathering. These rocks lie at or near the surface throughout most of the Stonington Peninsula, and form the bedrock surface in a band 6 to 8 miles wide that extends through the northeast corner of the county (fig. 3).

The permeability of these rocks is low compared to that of other beds of limestone and dolomite in the county. This is due in part to the numerous shale layers, which impede the movement of ground water. Secondary openings along bedding planes and joints or other fractures are not well developed in the soft shaly limestone and dolomite, as these rocks are not sufficiently competent to support such openings. Some water, however, does move through secondary openings in the few hard massive limestone and dolomite beds in this rock sequence.

Several dozen wells in the Stonington Peninsula and a few scattered wells to the northeast (table 3) obtain small supplies of water from the limestone and dolomite in the Richmond group. About half of these are dug wells of large diameter. Because of the low permeability, ground water in this aquifer moves into wells very slowly. Large dug wells may yield adequate supplies from such an aquifer because of their relatively great entrance areas and storage capacities. The Michigan Department of Health (Faust, 1937, p. 13), however, discourages the use of dug wells, primarily because they are especially susceptible to contamination from surface sources.

Cataract Formation of Early Silurian Age

The Cataract formation is composed of three members. The basal dolomite is gray to buff gray, massive to thinly bedded, and cherty in the upper part. It is overlain by a gray shale, which contains many thin beds of gypsum and dolomite. The upper member is a gray and buff cherty dolomite interbedded with layers of gypsum and shale (Ehlers and Kesling, 1957, p. 6). The Cataract formation is about 250 feet thick in eastern Delta County.

The basal dolomite probably does not crop out in the county. The shale is at or near the surface in the sandy plains north of Moss Lake. The upper dolomite member is at or near the surface in the area between Isabella and Nahma and forms the bluff along the east side of Moss Lake. The rocks of the Cataract formation dip gently toward the southeast beneath the rocks of the Niagara series near the western shore of the Garden Peninsula.

Many of the wells near the northern end of Big Bay de Noc in the Nahma-Isabella area obtain water from the Cataract formation. The Cataract is permeable as a result of solution openings formed by leaching of the gypsum beds. The soluble gypsum in the formation is the source of calcium and sulfate, which commonly reach objectionable concentrations in water taken from the formation. (See "Quality of Water".)

Niagara Series of Middle Silurian Age

Rocks of the Niagara series form the prominent cliffs that line the western shore of the Garden Peninsula and form the bedrock surface throughout the Garden Peninsula and adjacent islands. The glacial drift in much of this area is thin and discontinuous.

The rocks of the Niagara series are predominantly hard, resistant limestones and dolomites. Wells drilled into them obtain water from permeable zones formed largely by solution and weathering at the surface and by solutional activity of percolating ground water at depth. Solution probably was greatest along beds of limestone, which is more soluble than dolomite. Not all beds of limestone, however, have been made permeable by solutional activity. Development of solution openings in some strata probably was blocked by the initial impermeability of the bed or by restriction of ground-water flow by adjacent strata of low permeability.

Generally, permeable zones in the Niagara rocks are thin and are separated by relatively thick beds of low permeability. Thus, the yield of a well tapping a permeable zone in these formations does not increase significantly until the next permeable zone is reached. This contrasts with the yield of a well tapping permeable glacial drift, which increases roughly with the amount of the formation penetrated.

Burnt Bluff formation.--The Burnt Bluff formation is composed of about 250 feet of thinly bedded to massive light-gray to buff calcitic dolomite. More than 200 feet of these rocks is exposed in the cliffs at various places along the east shore of Big Bay de Noc. The formation is present in Delta County only in the Garden Peninsula and offshore islands and in a small area northeast of the head of Big Bay de Noc.

Generally, moderate supplies of fresh water can be obtained from this formation, and locally it will yield large water supplies. Most of the drilled wells on the Garden Peninsula tap the Burnt Bluff formation. Records available from the early 1900's indicate that artesian pressures in this aquifer were sufficiently high to produce flows above the land surface from wells along the shore of the bay. Data in table 4, however, indicate that the artesian pressure has declined considerably since that time.

Well 39N 18W 17-1, owned by the village of Garden, penetrated the Burnt Bluff formation and was completed in the underlying Cataract formation. The water obtained from this well is a mixture of water from both formations. As the quality of water from the Burnt Bluff formation is far superior to that from the Cataract, precautions should be taken to avoid complete penetration of the Burnt Bluff when drilling for water. (See "Quality of Water".)

Manistique dolomite.--The Manistique dolomite is a thin-bedded to massive light-buff to brown or gray cherty dolomite. In Delta County it is present only on the Garden Peninsula and offshore islands. The formation is thickest (possibly as much as 150 feet) on the extreme south tip of the Garden Peninsula and on Summer Island, where it is overlain by the Engadine dolomite. On the west edge of the Garden Peninsula, all but a thin remnant of the formation has been removed by erosion. This remnant lies above the regional water table. The Manistique dolomite is of significant thickness and of potential importance as an aquifer only in the presently undeveloped areas along the Lake Michigan side of the peninsula. Hence, the formation is a source of supply for only a few wells in the county. These wells tap the relatively large interconnected secondary openings that are characteristic of the formation from Delta County to Mackinac County.

Engadine dolomite.--The Engadine is a massive hard bluish-white dolomite and is an extensive and important aquifer in the eastern part of the Northern Peninsula. In Delta County, however, only a thin remnant of the basal part of the formation is present on the southeast tip of Garden Peninsula, Poverty Island, and part of Summer Island. No wells in the county are known to tap the Engadine. It has little potential for development as an aquifer in Delta County, because it is thin and small in areal extent.

Ground Water in Unconsolidated Sediments

The mantle of unconsolidated rock material that covers much of Delta County (fig. 5) was deposited by the Green Bay lobe of the Wisconsin ice sheet, which pushed down the valleys now occupied by the Au Train and Whitefish Rivers during the Pleistocene epoch. This

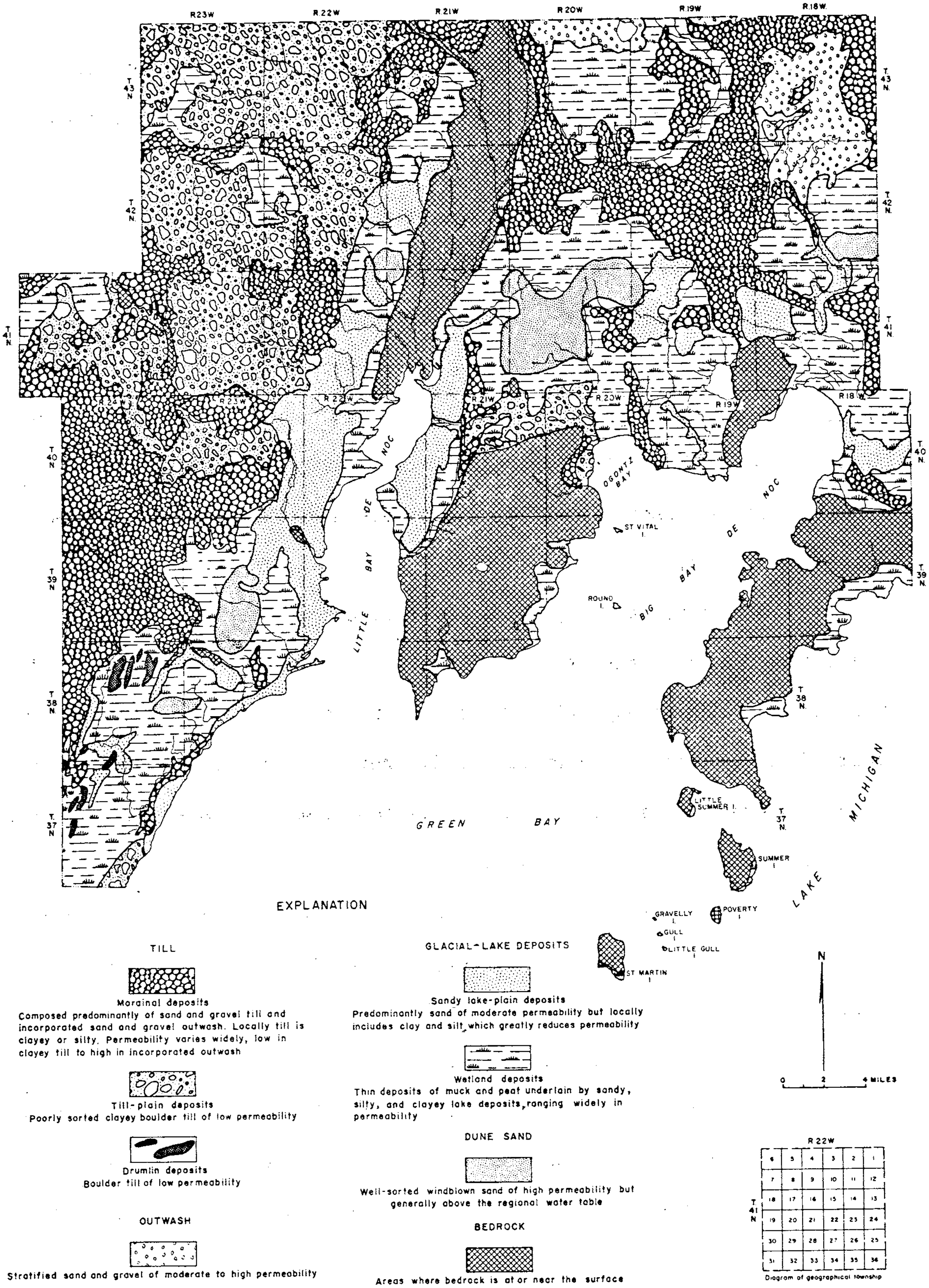


Figure 5. Surface geology of Delta County.

material was plucked from the surface by moving ice and redeposited as till, outwash, glacial-lake sediments, and dunes. These deposits are differentiated on the basis of their mode of deposition. Till is generally unstratified drift that was deposited directly from the ice, with water playing a minimum part in the process. Outwash is stratified rock material deposited by meltwater draining from the glacier. Glacial-lake sediments are stratified fine-grained materials laid down in glacial lakes. Dunes are composed of well-sorted sand deposited by wind. Most of the dunes in Delta County are associated with the glacial epoch. The general term used to describe all these unconsolidated sediments is glacial drift.

The physical and, hence, hydraulic characteristics of the drift deposits vary also with the type of material from which the drift was derived. The sandy drift, which is predominant in the southeastern part of the county, was derived mainly from the Cambrian and Ordovician sandstone formations and to a lesser extent from the Precambrian igneous rock in the Lake Superior region.

Clayey drift deposits, such as the clayey till in the western part of the county, were derived largely from the Ordovician limestone, dolomite, and shale formations described above and perhaps from clay deposits in the Lake Superior Basin.

The permeability of the drift deposits varies with the size of the individual grains and with the degree of sorting. The most permeable drift sediments are the outwash deposits, which are composed of larger particles of rock and are relatively well sorted. Sandy and gravelly till that contains only minor amounts of clay and silt is generally of moderate permeability. Clayey till, however, is of low permeability. Dune sand and lake-deposited sand, which are well sorted although relatively fine-grained, also are of moderate permeability. Lake-deposited silt and clay or silty, clayey sand is generally of low permeability.

The drift mantle of Delta County varies greatly in thickness, as shown in figure 6. The glacial drift is thickest in the northeastern part of the county and in an area west of Little Bay de Noc; in at least one place, it is more than 200 feet thick. In the western part of the county and in the Stonington and Garden Peninsulas, the drift is generally thin or discontinuous.

Figure 7, which shows the generalized configuration of the bedrock surface, was constructed largely from well records and bedrock-outcrop data and calculated on the basis of preliminary topographic sheets available at the time of the field study. Figures 6 and 7 indicate preglacial valleys in the bedrock surface extending northeastward from Big Bay de Noc and Little Bay de Noc, both of which probably represent submerged extensions of these bedrock valleys. Parts of these valleys are buried under 100 to 200 feet of glacial sediments.

Till

About half of Delta County is underlain by deposits of till. On figure 5, these deposits underlie areas mapped as till plains, moraines, and drumlins, which are distinguished basically by physiographic

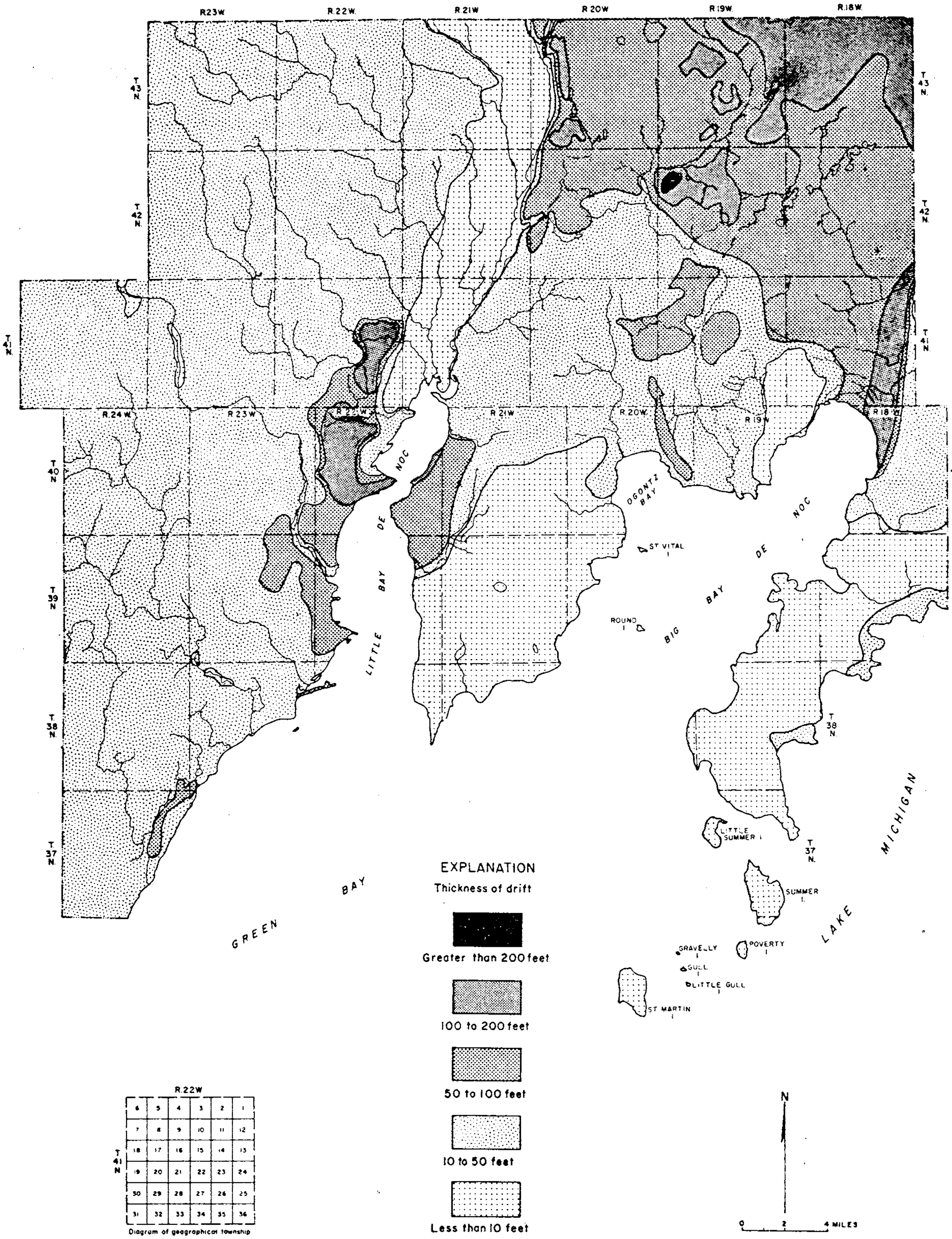


Figure 6. Generalized isopach map showing thickness of the glacial drift in Delta County.

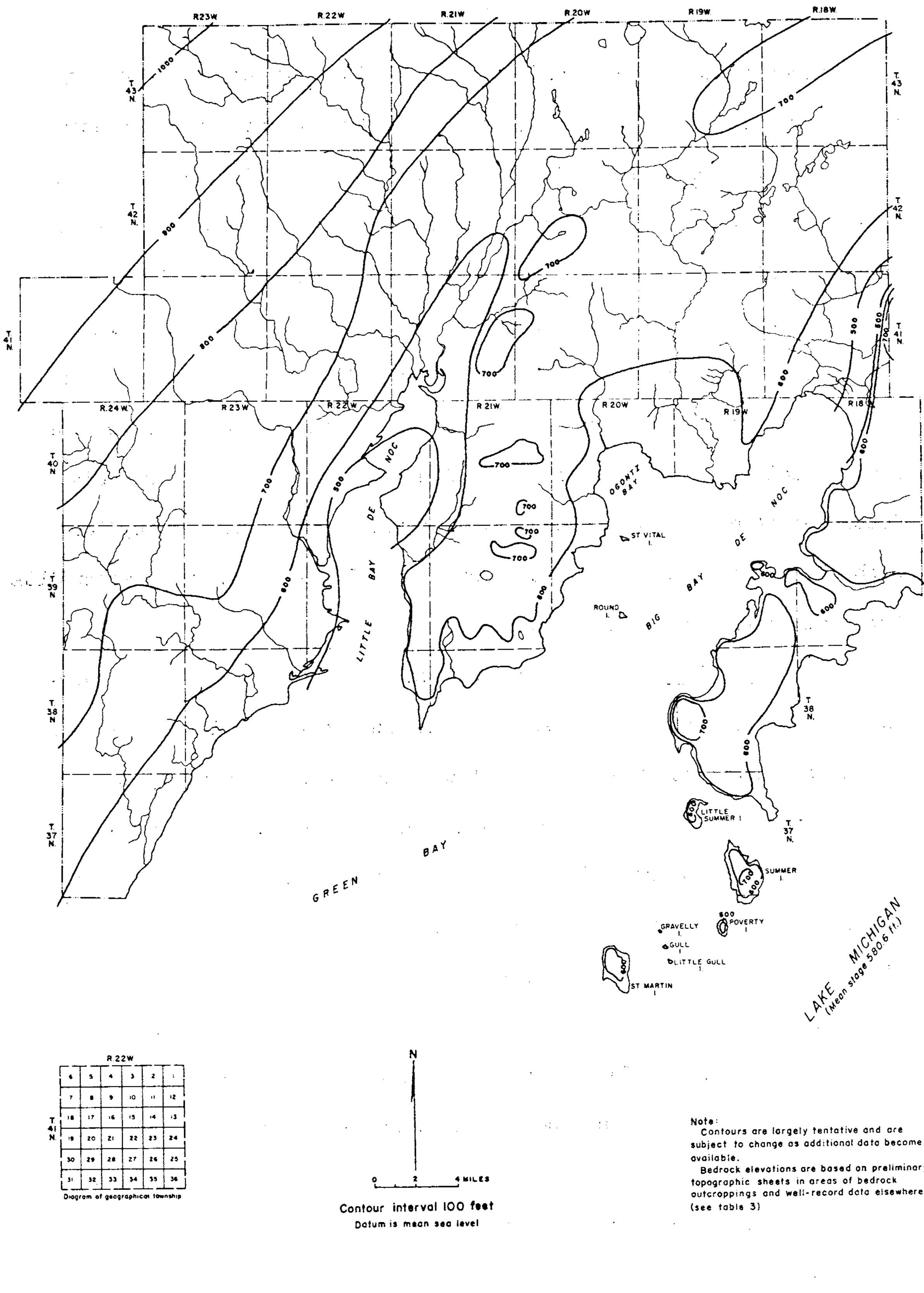


Figure 7. Map showing generalized contours on the bedrock surface of Delta County.

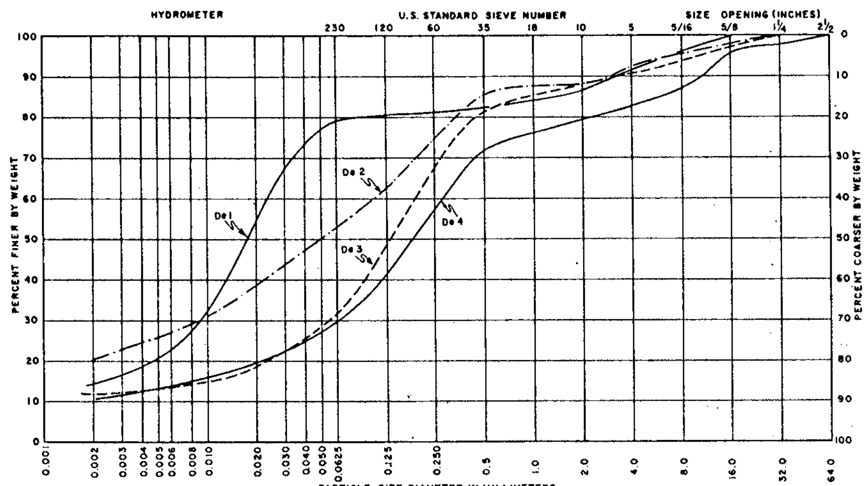
differences rather than by differences in lithology or water-bearing characteristics. Till plains (also called "ground moraines" on some maps) are areas of relatively low relief having gently rolling surfaces that are underlain by till deposited during relatively warm intervals in the glacial stages, when the ice front was wasting back toward its source. Moraines are ridges composed predominantly of till. Till plains commonly lie adjacent to and between the moraines, which were built up by deposition during temporary halts in the recession of the ice. Drumlins are elongated, streamlined deposits of till probably deposited beneath outer parts of moving ice sheets. The moving ice probably eroded the deposits to their typical shapes and was responsible for their marked parallel orientation.

Till plains.--The northwestern part of the county is underlain by a till plain (fig. 5), which extends northward into Alger and Marquette Counties. The low relief of this plain is interrupted in many places by hills and ridges formed by the underlying Trenton and Black River formations. These rocks lie at relatively shallow depth (fig. 6) throughout nearly all the area of the till plain. Another till plain lies at the north end of the Stonington Peninsula. Till deposits are present elsewhere in Delta County, especially on the Stonington and Garden Peninsulas, but these deposits are discontinuous or form only a veneer over the bedrock surface; hence, they are not shown on figure 5. Because the deposits underlying the till plains in Delta County are generally thin and of low permeability, they will not yield supplies of water adequate for most uses.

Three samples of till-plain deposits were collected in Delta County for analysis of permeability and particle-size distribution by the Hydrologic Laboratory of the U. S. Geological Survey at Denver. The analyses (De 1, 2, and 3, fig. 8) show that the sorting of the till-plain deposits is generally poor and the permeability is low. Sample De 1 was composed of almost 80 percent of clay and silt by weight and had a permeability of 4 meinzers. Sample De 2 contained nearly 50 percent sand and gravel particles by weight and had a lower permeability (0.2 meinzer) than sample De 1, which contained less clay and was better sorted in the silt-size range. The permeability of sample De 3 was not determined in the laboratory, but probably was higher than that of samples De 1 and 2, because of its lower clay and silt content and better sorting in the fine- and medium-sand range.

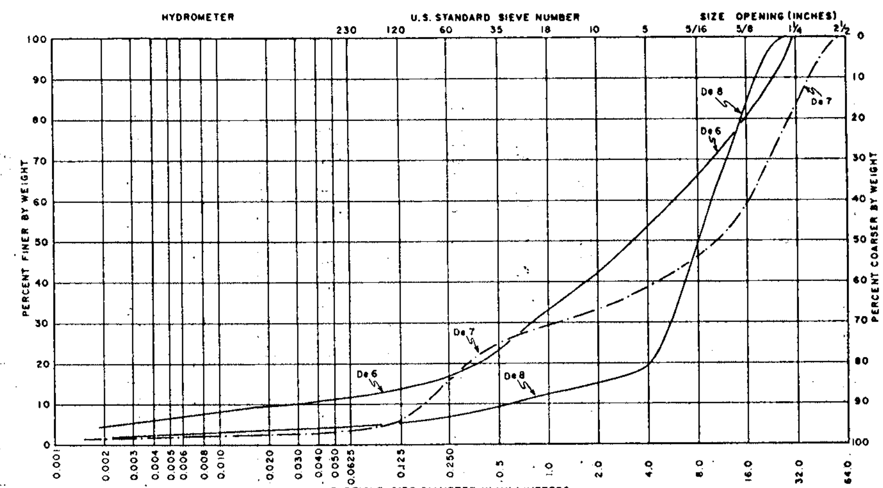
Drumlins.--Several drumlins composed of glacial till are present in the southwestern part of the county, in Tps. 37 and 38 N., R. 24 W. The till is very similar in composition to the till-plain deposits described above. Sample De 4 (fig. 8) was almost identical in clay and silt content to sample De 3 but had a somewhat higher content of larger sized particles. The permeability of this sample was determined as 17 meinzers. Because of the generally low permeability of the drumlin till, the drumlins are not a potentially important source of ground water.

Moraines.--Moraines are ridges composed predominantly of glacial till deposited along the relatively static front of a glacier. Commonly they include, and are associated with, deposits of stratified



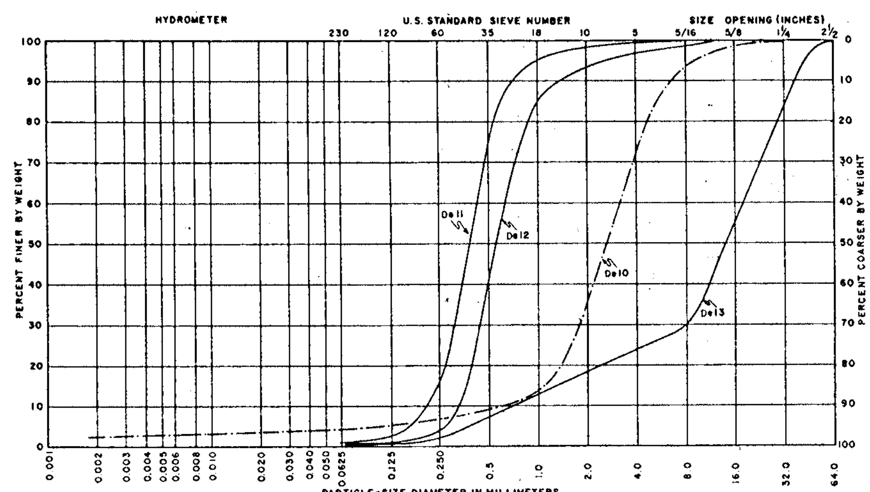
NO.	CLAY SIZES less than 0.004	SILT SIZES 0.004-0.0625	SAND SIZES V.fine .0625-.125	Fine .125-.25	Medium .25-.5	Coarse .5-1	V.coarse 1-2	GRAVEL SIZES V.fine 2-4	Fine 4-8	Medium 8-16	Coarse 16-32	V.coarse 32-64
De 1	19.0	60.2	1.1	1.0	1.1	2.0	2.1	5.1	4.3	3.5	0.6	–
De 2	24.8	28.1	9.9	12.6	10.2	2.3	–	4.7	3.1	2.4	2.2	–
De 3	12.8	19.1	16.5	19.4	14.0	3.9	2.3	2.6	2.9	3.5	3.0	–
De 4	12.6	18.1	11.2	16.1	14.1	4.3	3.0	3.7	4.2	8.8	1.8	2.1

PERCENT OF SIZE



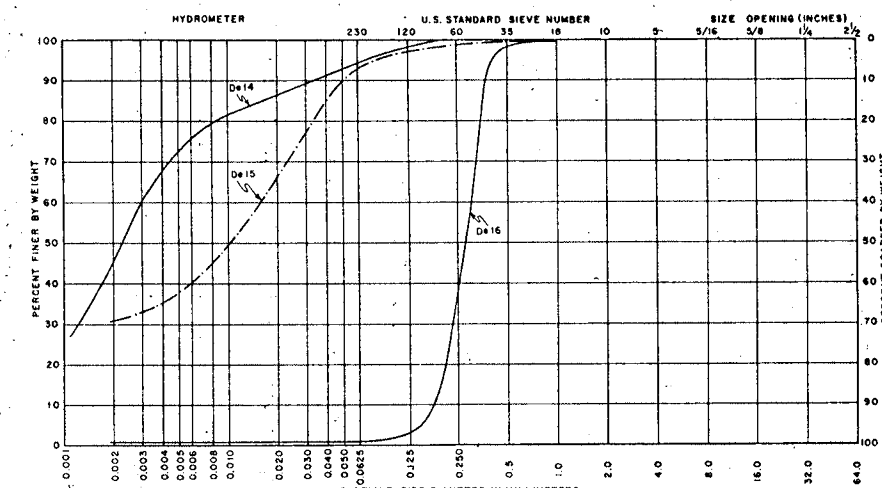
NO.	CLAY SIZES less than 0.004	SILT SIZES 0.004-0.0625	SAND SIZES V.fine .0625-.125	Fine .125-.25	Medium .25-.5	Coarse .5-1	V.coarse 1-2	GRAVEL SIZES V.fine 2-4	Fine 4-8	Medium 8-16	Coarse 16-32	V.coarse 32-64
De 6	6.0	5.8	1.7	3.3	6.9	9.1	9.0	12.0	11.7	14.6	19.9	–
De 7	2.0	1.3	3.2	8.8	9.7	4.0	4.0	5.6	7.4	12.0	24.6	17.4
De 8	2.2	2.5	0.8	1.2	2.8	3.2	2.6	4.4	30.3	31.7	18.3	–

PERCENT OF SIZE



NO.	CLAY SIZES less than 0.004	SILT SIZES 0.004-0.0625	SAND SIZES V.fine .0625-.125	Fine .125-.25	Medium .25-.5	Coarse .5-1	V.coarse 1-2	GRAVEL SIZES V.fine 2-4	Fine 4-8	Medium 8-16	Coarse 16-32	V.coarse 32-64
De 10	3.2	1.7	0.6	1.5	2.6	3.8	19.9	38.4	20.9	6.0	1.4	–
De 11	←1.6→		1.2	13.4	58.1	20.7	3.3	1.3	0.4	–	–	–
De 12	←0.5→		0.3	3.0	36.7	43.7	9.6	3.4	1.3	1.5	–	–
De 13	←0.4→		0.2	1.2	6.3	5.6	5.1	5.2	15.6	15.8	27.1	17.5

PERCENT OF SIZE



NO.	CLAY SIZES less than 0.004	SILT SIZES 0.004-0.0625	SAND SIZES V.fine .0625-.125	Fine .125-.25	Medium .25-.5	Coarse .5-1	V.coarse 1-2	GRAVEL SIZES V.fine 2-4	Fine 4-8	Medium 8-16	Coarse 16-32	V.coarse 32-64
De 14	690	25.2	4.0	1.8	–	–	–	–	–	–	–	–
De 15	36.0	57.8	3.4	2.0	0.4	0.2	0.2	–	–	–	–	–
De 16	1.0	0.2	2.0	330	620	1.8	–	–	–	–	–	–

PERCENT OF SIZE

EXPLANATION

De 1. Silty, clayey till from depth of 4 feet in the SE$\frac{1}{4}$ sec. 31, T. 41 N., R. 18 W. Permeability = 4 meinzers.

De 2. Clayey, silty till from depth of 2 feet in the SE$\frac{1}{4}$ sec. 31, T. 41 N., R. 18 W. Permeability = 0.2 meinzer.

De 3. Sandy till from depth of 4 feet in the SE$\frac{1}{4}$ sec. 22, T. 43 N., R. 22 W.

De 4. Sandy till from depth of 3 feet in drumlin in the NW$\frac{1}{4}$ sec. 32, T. 38 N., R. 24 W. Permeability = 17 meinzers.

De 6. Boulder till from depth of 40 feet in moraine in the SE$\frac{1}{4}$ sec. 27, T. 39 N., R. 24 W. Permeability = 33 meinzers.

De 7. Sandy boulder till from depth of 5 feet in moraine in the NE$\frac{1}{4}$ sec. 6, T. 40 N., R. 24 W. Permeability = 440 meinzers.

De 8. Boulder till from depth of 2 feet in gravel pit at edge of moraine in the NE$\frac{1}{4}$ sec. 7, T. 43 N., R. 18 W. Shale boulders disintegrating to clay.

De 10. Sand and gravel outwash from gravel pocket at depth of 3 feet in moraine in the SW$\frac{1}{4}$ sec. 32, T. 40 N., R. 23 W. Permeability = 2,500 meinzers.

De 11. Stratified sandy outwash from lens at depth of 6 feet in moraine in the SW$\frac{1}{4}$ sec. 32, T. 40 N., R. 23 W.

De 12. Sand outwash from depth of 10 feet in the SW$\frac{1}{4}$ sec. 33, T. 42 N., R. 19 W.

De 13. Gravel and sand outwash from depth of 2 feet in the NE$\frac{1}{4}$ sec. 17, T. 41 N., R. 23 W. Permeability = 5,000 meinzers.

De 14. Varved lake clay from depth of 2 feet in the SW$\frac{1}{4}$ sec. 33, T. 42 N., R. 19 W.

De 15. Silt and clay lake deposit from depth of 5 feet in the SW$\frac{1}{4}$ sec. 33, T. 42 N., R. 19 W.

De 16. Sand from lake-plain at depth of 10 feet in the NW$\frac{1}{4}$ sec. 10, T. 37 N., R. 24 W. Permeability = 600 meinzers.

Note: Particles larger than 2$\frac{1}{2}$ inches in diameter were not sampled.

Figure 8. Particle-size-distribution curves of glacial-drift samples from Delta County.

outwash. The distribution of the moraines in Delta County is shown in figure 5. One large moraine trends southward along the western part of the county from near the city of Marquette in Marquette County to the vicinity of the village of Ford River. This moraine consists of numerous low hills and ridges composed of a characteristically red till. Samples De 6 and 7 (fig. 8) indicate that till from this moraine contains a larger percentage of coarse materials by weight and is considerably more permeable than the adjacent till-plain deposits. The relatively high permeability of sample De 7 does not indicate that the moraine in the vicinity of the sampling point is a source of large quantities of water, as morainal deposits in the western part of the county are considerably thinner than those in the eastern part. Most wells drilled in the areas mapped as moraine in the western part of the county tap the underlying Trenton and Black River formations. A few domestic supplies of water are obtained from these morainal deposits by dug wells of large diameter.

In the northeastern part of the county, several large discontinuous moraines extend from the Alger and Schoolcraft County lines along the Sturgeon and Whitefish Rivers to the shore of Ogontz Bay, west of Nahma. The portion of the moraine along the Sturgeon River is a continuation of the Newberry moraine of Schoolcraft and Alger Counties described by Bergquist (1936, p. 69-75). The portion along the Whitefish River appears to be a continuation of the Munising moraine, also described by Bergquist (p. 79-80). In the northeastern part of the county, the moraine is characterized by rugged relief and deep pot-hole lakes. The topography of the southern part of the moraine is much more subdued, as a result of wave erosion by the succession of glacial Great Lakes. The composition of this moraine is predominantly sand and gravel, although some clay is present. Sample De 8 contained less than 5 percent of clay and silt by weight and 85 percent of gravel- and boulder-sized particles. The clay content, however, generally increases toward the south. In one area, the drift deposits underlying this moraine are 200 feet thick or more (fig. 6). The morainal deposits in this area may yield moderate quantities of water to wells, although there are local variations in composition and permeability. A few domestic wells obtain small supplies of water from these deposits, but for the most part the area is very sparsely populated and generally undeveloped. The water table is controlled by the level of the surrounding lakes and streams, and much of the morainal till lies above the regional water table.

A segment of a moraine in T. 41 N., R. 18 W., is an extension of the Cooks moraine, most of which lies in Schoolcraft County (Bergquist, 1936, p. 68-69). This moraine ranges in composition from a clayey till to a boulder till, although it is composed predominantly of a silty sand. As much as 200 feet of drift underlies the moraine along the trace of a bedrock valley extending northward from Little Bay de Noc. Moderate quantities of water, sufficient for domestic use, may be available to wells that are properly constructed to screen out the silt and fine sand.

Outwash

Large deposits of outwash sand and gravel occur in the northeastern part of the county (fig. 5). Smaller outwash deposits are present in many parts of the county, especially along the flanks of the moraines. Lenses of outwash are included within morainal deposits or are buried under swamp and lake sediments. Detailed field mapping necessary to delineate these smaller outwash deposits accurately was beyond the scope of the present reconnaissance; hence, only the large areas underlain by outwash deposits in the northeastern part of the county are shown on figure 4.

The outwash deposits are the most permeable of the glacial-drift deposits of Delta County, as they contain little or no clay and silt and are well sorted (fig. 8). Sample De 11 contained 58 percent of medium sand by weight, and sample De 12 contained 90 percent of medium to very coarse sand. Samples De 10 and 13 had permeabilities of 2,500 and 5,000 meinzers, respectively.

Glacial-Lake Deposits

Large areas in Delta County are underlain by sand, silt, and clay deposited in the glacial Great Lakes. For the most part, the surficial lake sediments are composed of sand, and hence the lake-plain areas shown on figure 5 are mapped as "sandy lake plain". Over large areas of the county, the lake deposits are saturated with water and are covered by a thin mantle of swamp deposits.

Permeability is controlled by the size and degree of sorting of the component particles and is affected greatly by relatively small percentages of silt or clay. Samples De 14 and 15 (fig. 8), collected from the sandy lake plain north of Big Bay de Noc contained 69 and 36 percent clay, and 25 and 58 percent silt, respectively, and undoubtedly were of very low permeability. In general, however, the lake deposits are sandy and are sources of supply for domestic wells in various places throughout the county. Most of the wells tapping the lake sand are shallow, small-diameter driven wells equipped with sand points.

A sand sample collected from a swamp-covered lake plain in sec. 10, T. 37 N., R. 24 W., had a permeability of 600 meinzers (sample De 16, fig. 8). The sample was extremely well sorted, consisting of 95 percent of fine- and medium-sized sand grains. It appears that the deposit from which the sample was taken was originally a dune, but was subsequently submerged in the waters of the glacial Great Lakes.

Dune Sand

Areas of windblown sand are prevalent in the county. Although very permeable, these deposits are above the water table in most areas, and thus cannot be considered as a source of water to wells. However, because of high infiltration capacities they are important as avenues of ground-water recharge to the areas they occupy.

Source and Recharge Areas

The initial source of all fresh ground water in the aquifers of Delta County is precipitation, and the average annual precipitation over the county is 29.2 inches. Most of the precipitation, however, does not enter the ground-water reservoirs but is dissipated by evaporation, transpiration, and direct runoff into streams.

The amount of precipitation that does enter the ground-water reservoirs is influenced by several factors, including the duration, intensity, and type of precipitation; the density and types of vegetation; the topography; and the porosity and permeability of the soil, subsoil, and underlying rock formations. Also, an aquifer that is already full to overflowing obviously cannot receive additional water.

Conditions for recharge are favorable in the parts of the county that are underlain by permeable glacial sediments (fig. 5) and in large areas of the county where permeable limestone and dolomite at or near the surface have large infiltration capacities. Some areas of the county are underlain by clayey glacial sediments, which impede infiltration of precipitation into the ground-water reservoirs. Infiltration is retarded also in areas where shale or shaly limestone or dolomite is at or near the surface, such as in the Stonington Peninsula.

Movement of Ground Water

The movement of water underground is similar to movement in surface streams, by gravity from high to low levels. Percolation of water through and around rock particles below the surface involves a great amount of friction, and hence is much slower than the flow of water upon the surface. Rates of ground-water movement differ greatly, from a few feet per year to many feet per day. Water may travel considerable distances underground from recharge areas to areas downgradient, where it may once more reach the land surface--appear as seeps or springs, join the flow of streams, enter lakes, or escape to the atmosphere by evaporation and transpiration. Where undisturbed by manmade diversions, the water table conforms generally to the configuration of the overlying land surface and exactly to the piezometric surface. In the deeper artesian aquifers, however, the shape of the piezometric surface may differ considerably from that of the land surface. Where more than one aquifer underlies the same area, water may migrate from an aquifer of high head, to one of lower head.

Discharge of Ground Water

Water is discharged from ground-water reservoirs by evaporation and transpiration and through wells, springs, and drains. Because much of the county is covered by dense growths of forest and swamp vegetation, the amount lost by evapotranspiration is presumed to represent a large percentage of the total discharge. It is likely, also, that large amounts of ground water are discharged at depth directly to Lake Michigan and associated bays.

Water-Level Fluctuations

Effects of Climate

Although long-term records of changes in water levels in wells in Delta County are not available, the relation between levels and the influences of climate for the short period of record is shown in figures 9 and 10. According to available data, ground-water levels in Delta County fluctuate with seasonal changes in the rate of recharge to and discharge from the aquifers. During the spring, water from snow-melt and rainfall infiltrates into the ground, and water levels in wells rise. This infiltration to the aquifers is reduced by greatly increased evapotranspiration during the warm weather and the growing season. Water levels, therefore, usually decline throughout the summer and early fall. The end of the growing season in the fall combined with precipitation greater than is needed to satisfy soil-moisture requirements may result in some recharge to the aquifers. Below-freezing temperatures in late fall and in the winter preclude any further appreciable recharge, as the ground is frozen and precipitation is in the form of snow.

Figure 9 shows the fluctuations of water levels in two wells along with records of precipitation and temperature at Escanaba. The fluctuations of water levels in well 39N 23W 28-3, finished in the sandstone, are not as large as those in well 41N 18W 31-2, finished in the limestone and dolomite, owing to the greater storage capacity of the sandstone. The limestone is dense, and storage is confined largely to cracks, crevices, and fissures, whereas water in the sandstone is

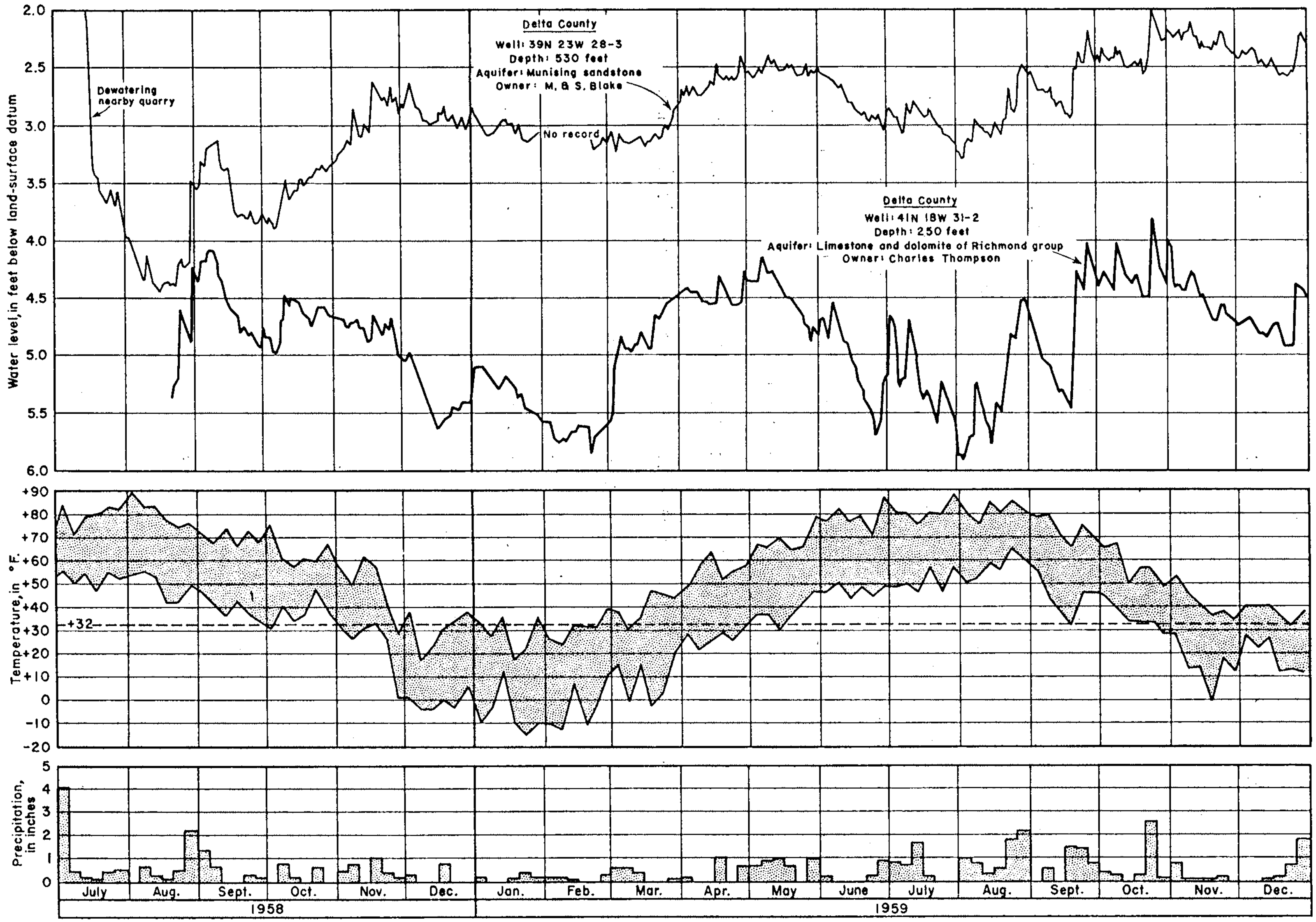


Figure 9. Hydrographs of wells 41N 18W 31-2 and 39N 23W 28-3, 5-day temperature ranges, and 5-day precipitation totals at Escanaba, 1958-59.

stored in both primary and secondary openings. Heavy rains in late August and early September of 1958 caused water levels to rise sharply in both wells. During the fall, water levels in the Thompson well declined, but those in the Blake well rose because of recovery after dewatering of a nearby quarry. (See "Effects of Discharging Wells.") Water stages in both wells declined until early March 1959, when above-freezing daytime temperatures resulted in recharge to the aquifers from the melting of about 5 inches of the snow cover. The rising trend continued, as the remainder of the snow cover melted during March. The seasonal decline that began in May was frequently interrupted by heavy rainfall and was reversed in August after the first of about 15 inches of precipitation that was received in the period August through October. Seasonal declines resumed in November, but these were temporarily halted by recharge from more than half an inch of rainfall during a brief thaw late in December.

Infrequent measurements of water level in two shallow wells in the limestone and dolomite of the Richmond group (fig. 10) show markedly sharper fluctuations in water level, but in general the levels in these wells react to the same climatic factors. (See well 41N 18W 31-2, fig. 9.)

The fluctuations of water level in well 42N 18W 17-2 (fig. 10), finished in the glacial drift, are typical of fluctuations in other wells finished in drift aquifers in the Northern Peninsula, which respond primarily to climatic conditions. Heavy precipitation in the late summer and fall of 1959 resulted in unseasonal rises of water level in the well.

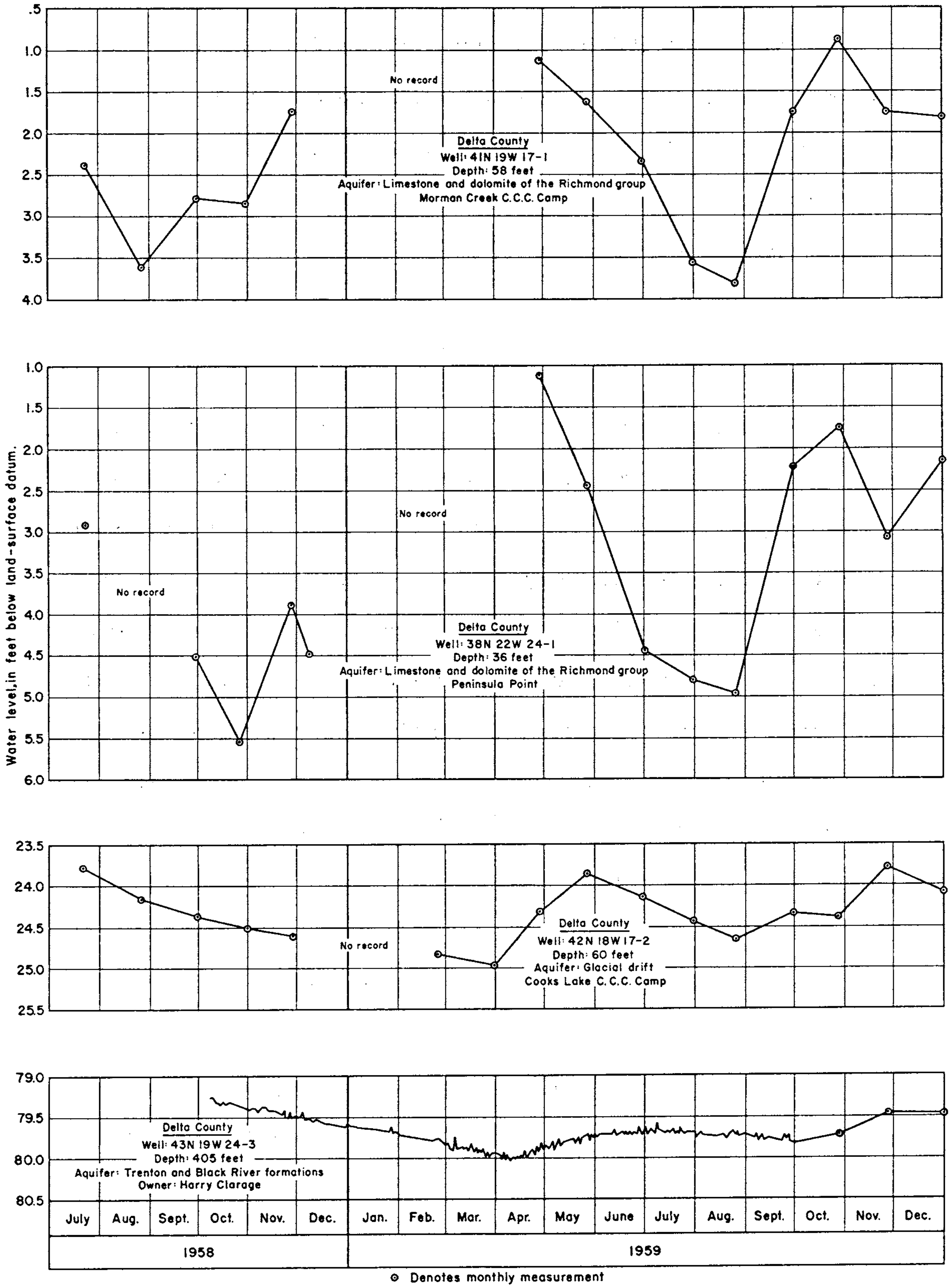


Figure 10. Hydrographs of observation wells in Delta County, 1958-59.

In well 43N 19W 24-3, finished in the Trenton and Black River formations, the fluctuations of water level are similar to but smaller than those in the drift aquifer. The water-level record for this well was derived from a continuous recording gage until October 1959, when monthly measurements were begun.

Effects of Pumping

Generally, ground water is a renewable natural resource because it is replenished, directly or indirectly, by precipitation. Under natural conditions, an aquifer is in a state of equilibrium with respect to recharge and discharge. However, when water is withdrawn from an aquifer by a well, a temporary increase in the total discharge from the aquifer results. This discharge by the well causes a cone-shaped depression in the water table or piezometric surface around the pumped well. Continued discharge expands the cone until the resultant decline of the piezometric surface causes a decrease in natural discharge from the aquifer or an increase in recharge, which may restore the aquifer to a state of equilibrium. If the discharge from an aquifer exceeds the recharge, the water level will continue to decline.

A decline of the piezometric surface always results from the discharge of water from a well. Where several wells are pumped or allowed to flow, a composite cone of depression is formed, which may extend over a large area. Water levels in other wells within this cone of depression are thus lowered. This is illustrated by the hydrograph of observation well 39N 23W 28-3 (fig. 9), which was affected by dewatering operations in a nearby quarry in July and August 1958. The dewatering was the same in effect, as pumping a well of very large diameter. The water level in the observation well recovered during October and November of that year, although this was a period of normal decline of water levels, as illustrated in the hydrograph of well 41N 18W 31-2. Whereas a decline of the piezometric surface always results from the development of an aquifer, an unnecessary decline of the piezometric surface is caused by the waste of water, as from unrestricted flowing wells or by underground leakage from poorly constructed wells or deteriorated well casings. Such waste may cause wells to cease flowing, decrease yields, and increase the cost of pumping water.

Use of Ground Water

The cities of Escanaba and Gladstone obtain their municipal water supplies from Little Bay de Noc. The village of Nahma obtains its supply from Big Bay de Noc. Ground water is used for the municipal supply in the villages of Ford River and Garden. The rest of the county is supplied by privately owned wells or springs.

Stock and domestic use, including the use by the tourist industry, accounts for most of the ground water used in the county. Only a small amount of the water is used by industry. Although large untapped supplies of ground water are available in many areas of Delta County, the most populated and developed areas are located where large ground-water supplies for municipal and industrial use are not readily available.

QUALITY OF WATER

Ground Water

The minerals in ground water are acquired primarily by solution of minerals in the rock or soil through which the water percolates. In general, the degree of mineralization of the water is determined by the composition and solubility of the rock or soil; the duration of contact; and such factors as pressure, temperature, and the amount of mixing, if any, with connate water (water entrapped at the time the sediment was deposited). Water that contains more than 1,000 ppm (parts per million) of dissolved mineral matter is herein considered saline regardless of its composition.

The hardness of waters sampled in the county is listed in table 5. Hardness of water is due principally to salts of calcium and magnesium in solution. Limestone and dolomite strata and gypsum-bearing formations in the county are the major sources of calcium and magnesium ions in ground water.

Water is classified with respect to hardness by the Michigan Department of Health (1948) as follows:

Class	Hardness (parts per million)
Very soft	Less than 50
Soft	50-100
Moderately hard	100-200
Hard	200-300
Very hard	More than 300

Hardness is commonly computed also in grains per gallon. One grain per gallon equals 17.1 ppm.

The remainder of the chemical analyses of ground-water samples collected in Delta County also are given in table 5. Geochemical interpretation of these analyses is aided by the diagrams on figure 11. These are drawn by plotting the concentrations of six key ions, in equivalents per million (epm), and connecting the points plotted according to a technique devised by Stiff (1951). The diagrams are plotted on a diminishing scale in order to confine those of the highly mineralized samples to a reasonable size. Differences in water of various chemical types are apparent by comparison of the shape of the diagrams. The size of the diagram indicates the concentration of the chief minerals in the sample, although differences between samples are not as readily apparent as they would be if the diagrams would be plotted to an arithmetic scale such as is used in figure 12. Diagrams of this type are useful in determining the source of the sampled water, the general chemical character of the aquifer, and variations in chemical composition of water within a given aquifer. They may be used also to detect interformational leakage or movement of water from one aquifer to another through uncased wells.

The Munising sandstone may contain water of good quality throughout the county, although much additional geochemical information is needed to determine whether the downdip portions of the formation contain saline water. Well 40N 22W 21-3 is cased through overlying formations and probably draws water only from the Munising sandstone. The diagram of a water sample collected from this well

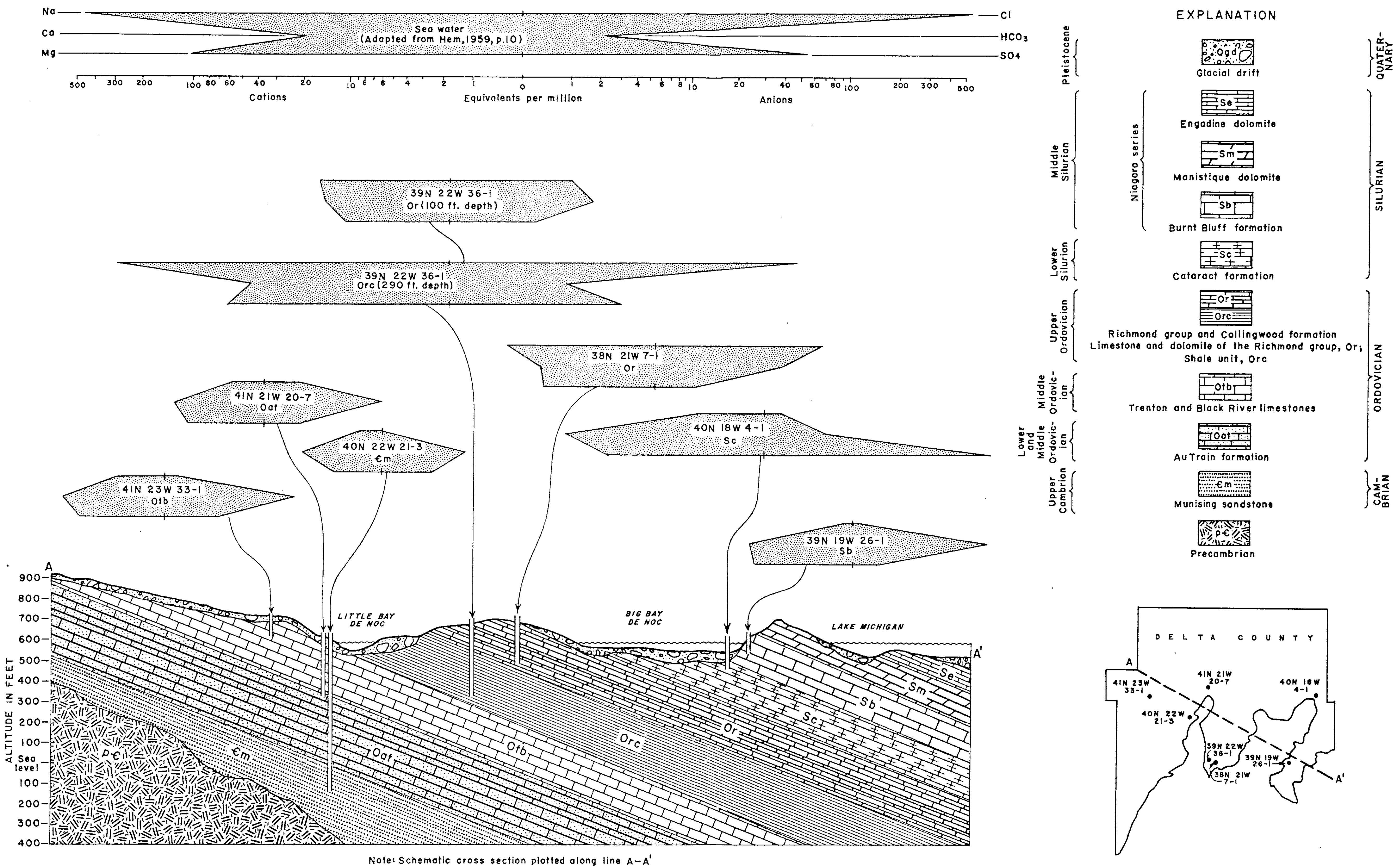


Figure 11. Diagrams showing typical chemical composition of water from the major bedrock aquifers of Delta County.

(fig. 11) shows that water from the Munising sandstone is of the calcium magnesium bicarbonate type. Analyses of samples of water from uncased wells that also tap the Munising sandstone (table 5) show higher mineral content, probably due to admixtures of water from overlying aquifers.

The Au Train formation yields water similar in composition to that from the Munising, although water taken from the more dolomitic parts of the Au Train tend to be somewhat harder and are higher in calcium, magnesium and bicarbonate content.

Most of the water from the Black River and Trenton limestones is of the calcium magnesium bicarbonate type and generally is suitable for most uses. Locally, however, these formations contain water high in chloride content (well 41N 21W 6-1, table 5). Data adequate to delineate the vertical and lateral distribution and to determine the origin of chloride water within the Black River and Trenton limestones are not available. The differences in chemical composition of water within these formations is illustrated by the analyses of water from wells 40N 23W 32-1 and 32-2. These wells are within 200 feet of each other, but well 32-1 is 13 feet deeper (table 3) and yields water containing almost 25 times as much chloride as the water from well 32-2 (table 5).

A sample of water obtained from well 42N 23W 3-1 at Rock on October 21, 1958, had a calcium and chloride content of 224 and 190 ppm, as compared to concentrations of 1,440 and 2,500 ppm of the same ions in a sample taken on December 12, 1958. An investigation of the site was made by the Escanaba office of the Michigan Geological Survey. It was found that the Delta County Road Commission maintained a stockpile of sand treated with calcium chloride for spreading on roads during the winter. Occasionally, a part of this sand is used to fill in low spots or puddles in the parking and driving area around the garage in the spring or summer. It was concluded that calcium chloride was leached from the sand and carried into the aquifer by rainfall. Complaints by homeowners in the vicinity suggest that contamination has migrated for a considerable distance through the aquifer.

Shale of the Collingwood formation and Richmond group may yield water that is partly connate in origin, as is indicated by a comparison of present-day sea water (from a depth of 100 feet) and the sample from a depth of 290 feet in well 39N 22W 36-1 (fig. 11). Saline water from the shale may contaminate water drawn from uncased wells tapping deeper fresh-water aquifers. The shale may have been the source of most of the sodium and chloride in water samples from wells 39N 21W 29-1 and 30-1 (table 5), which tap the Au Train and Munising formations, respectively.

Water from the limestone and dolomite of the Richmond group varies greatly in chemical composition. Some wells yield potable water of the calcium magnesium bicarbonate type; others yield water high in sodium and chloride, possibly partly connate in origin. A few wells yield water high in calcium and sulfate, probably leached from gypsum in the formation. A single well may yield water that is a mixture of all the above types, as illustrated by the diagram of the sample collected at a depth of 100 feet in well 39N 22W 36-1 (fig. 11). Sufficient data are not available to delineate sources of sodium chloride or calcium sulfate waters within the limestone and dolomite of the Richmond group. In areas where water of a quality suitable for most purposes can be obtained from these rocks, precautions should be taken to avoid tapping the underlying shale, which contains saline water. This is illustrated by the analyses of 6 samples collected from well 39N 22W 36-1 at depths ranging from 50 to 290 feet (table 5). The samples from depths of 50, 100, and 150 feet within the limestone and dolomite may be classed as potable, but samples from depths of 200, 250, and 290 feet where the well penetrated the underlying shale (fig. 11), were saline.

The Cataract formation includes beds of gypsum, which are readily dissolved by percolating ground water. The Cataract, therefore, yields water of poor quality high in calcium and sulfate content (fig. 11).

Water from the Burnt Bluff formation generally is hard or very hard but otherwise is suitable for most uses. The water is commonly of the calcium magnesium bicarbonate type, although some wells tapping the Burnt Bluff yield water high in calcium and sulfate content, which probably results from admixtures of calcium sulfate water from the underlying Cataract formation. Well 39N 18W 17-1 (table 5), owned by the village of Garden, taps the basal part of the Burnt Bluff and yields water high in sulfate content. Pumping or unrestricted artesian flow from the basal members of the Burnt Bluff formation induces a flow of water to wells from the Cataract formation, which is hydraulically connected to the Burnt Bluff. If a well completely penetrates the Burnt Bluff formation and enters the Cataract formation, water high in calcium sulfate enters the well directly. The water from wells tapping the upper members of the Burnt Bluff contains relatively little sulfate.

Only one chemical analysis of water from the Manistique dolomite in Delta County is available. A sample of water from well 39N 18W 12-1 apparently was soft and very low in mineral content. This sample, however, may not be representative of water from these rocks, as the formation in neighboring Schoolcraft County yields harder water having a higher degree of mineralization (Sinclair, 1959).

The quality of water from the glacial-drift aquifers of the county varies considerably. The quality is determined by the composition of the drift and by the water in aquifers hydraulically connected. The drift aquifers, however, generally yield water having a lower dissolved-mineral content than that yielded by the bedrock aquifers of the county. One notable exception is the high concentration of calcium and sulfate in the sample taken from well 41N 18W 13-1 (table 5). The analysis of this sample indicates that the water has migrated from the gypsiferous Cataract formation or has been mixed with water from that aquifer.

The iron content in two samples of water from the glacial drift was very high--14 and 17 ppm, and greater than the iron contained in water taken from any other aquifer. As a total iron and manganese content of 0.3 ppm in drinking water is considered objectionable (Hem, 1959, p. 238), and will cause staining on plumbing fixtures and various fabrics, treatment of water high in iron is generally desirable.

The temperature of water from most wells in Delta County ranges from 45° to 48°F (table 5). The range in temperature of water from several deep wells tapping the Munising sandstone was from 46° to 52°F.

Surface Water

Chemical analyses of water from lakes, streams, and springs in Delta County are listed in table 6 and diagrammed in figure 12. Figure 12 shows the relative uniformity in chemical content of surface water from various sources throughout Delta County; the water is predominantly of the calcium magnesium bicarbonate type. Variations in composition are small, as the rapid flow of surface water permits rather thorough mixing of water from different sources. Spring water taken at or near the point of discharge is generally higher in mineral content than water from the various streams into which they empty, which reflects the influence of ground-water discharge on stream quality. In addition, the composition of the spring water may indicate the chemical quality of ground water in the source aquifer. This is illustrated by the sample from Moss Lake, which is fed largely by springs issuing from the Cataract formation.

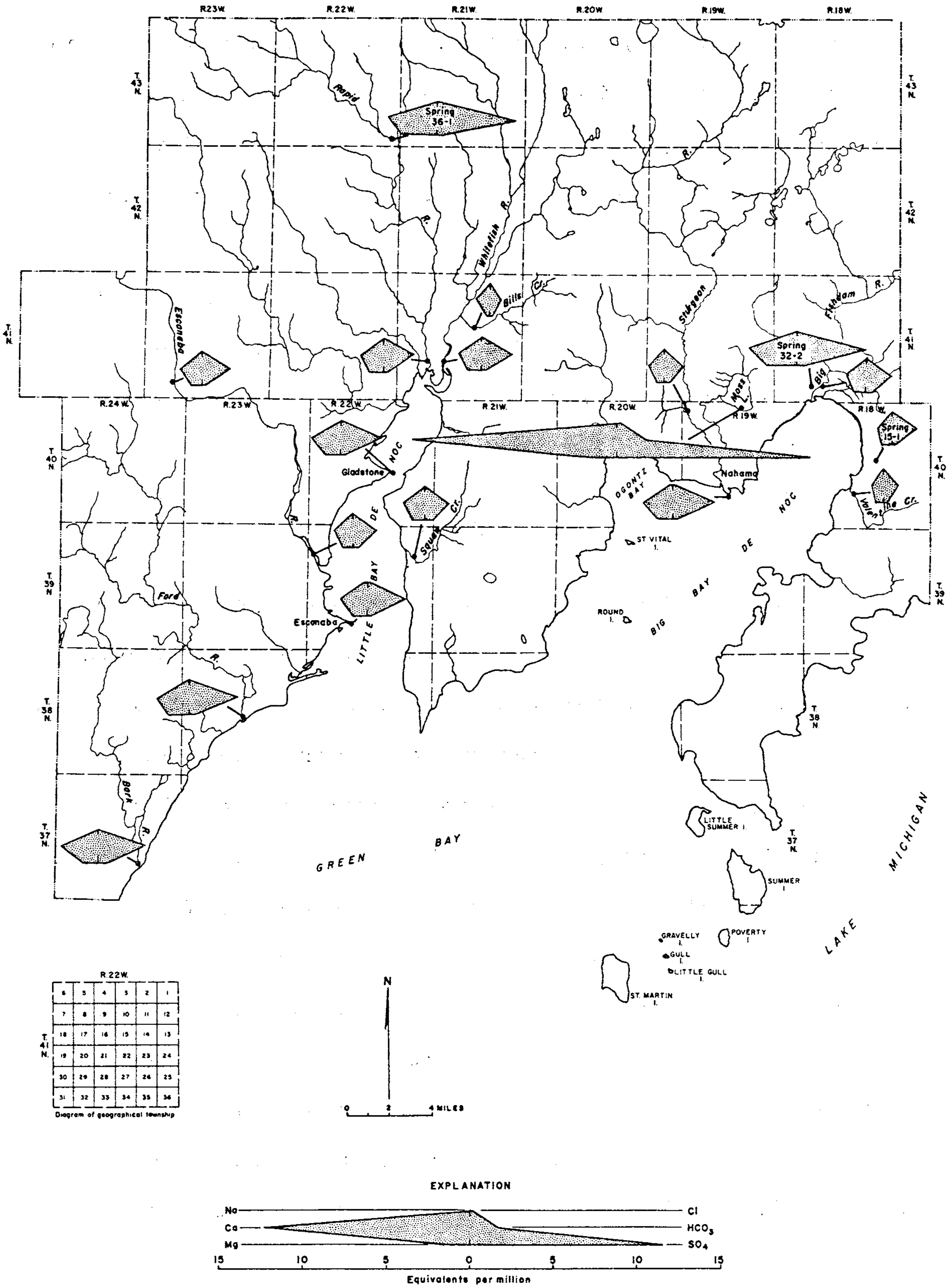


Figure 12. Diagrams showing chemical composition of surface water in Delta County.

CONCLUSIONS

The development of the ground-water resources of Delta County will involve more quality-of-water problems than problems of locating adequate quantities of water. In most areas of the county, it is possible to obtain adequate quantities of ground water suitable for most purposes. Although the Munising and Au Train formations yield fresh water in the northern and western parts of the county, the southeastward extent of the fresh water in these formations is not known. Wells drilled to these aquifers should be cased through overlying saline-water-bearing formations. The Black River and Trenton formations also are sources of fresh water in the northern and western parts of the county, but they yield saline water where they are overlain by younger bedrock formations. Limestone and dolomite of the Richmond group yield both fresh and saline water in the area where these rocks form the bedrock surface, and the distribution of fresh water cannot be determined from presently available data. In area where wells obtain fresh water from these rocks, penetration to the underlying shale probably will permit the entrance of saline water into the well. The Cataract formation yields water high in calcium and sulfate content, and hence is not a source of suitable ground-water supplies. It has not been determined if any of the aquifers underlying the Cataract formation in the southeastern part of the county contain fresh water. Fresh water can be obtained from the Burnt Bluff and Manistique formations if precautions are taken to prevent encroachment of high-sulfate water from the underlying Cataract formation.

Moderate to large yields of ground water can be obtained from the glacial-drift aquifers in many parts of the county, but in areas where the drift is absent, thin, of low permeability, or above the regional water table, ground water must be obtained from the various bedrock aquifers described above. Drift deposits having the greatest potential for future development are in the presently undeveloped northeastern part of the county.

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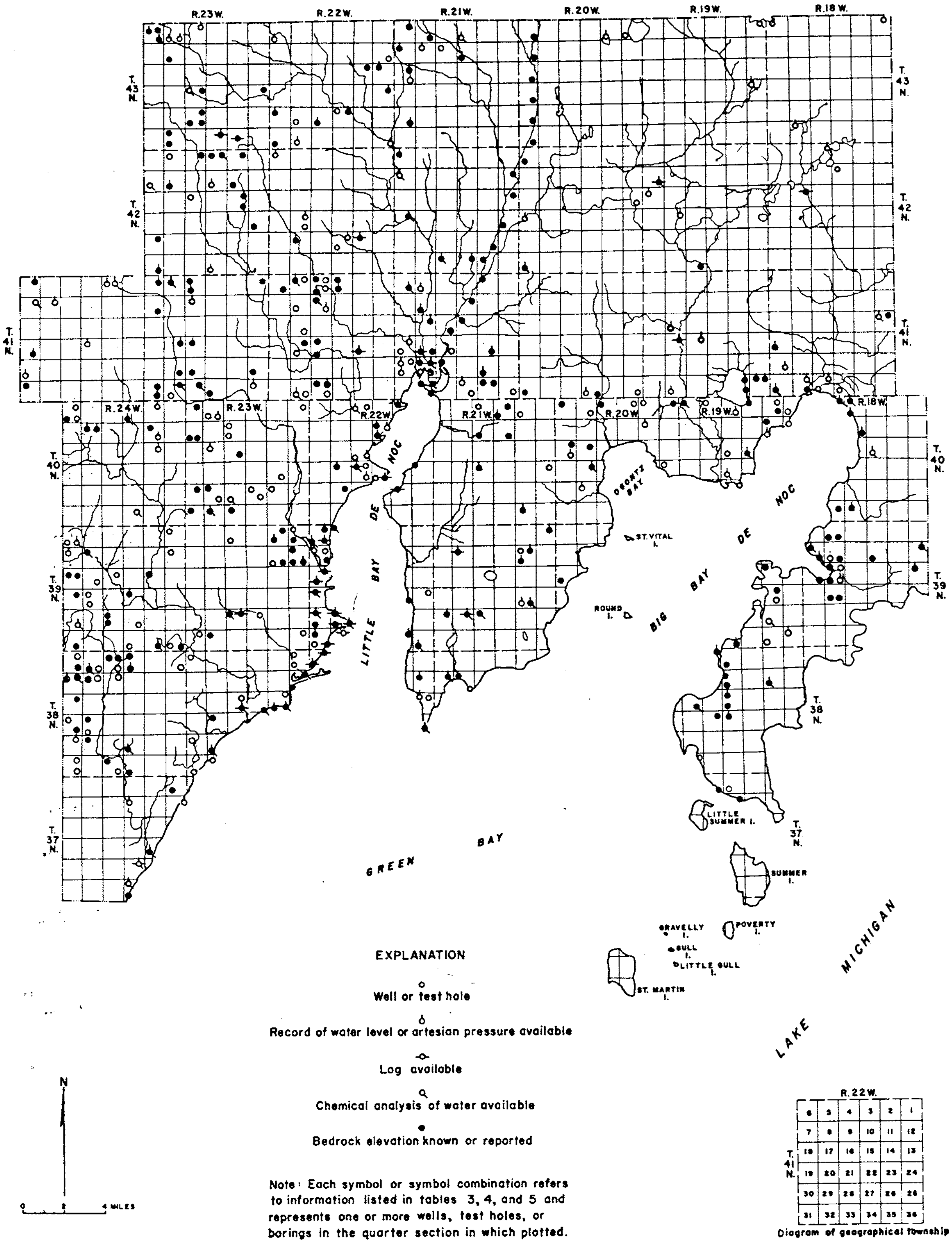

Figure 13. Map of Delta County showing availability of hydrologic, geologic, and quality-of-water data.

Table 3.--Records of wells and test holes in Delta County

Well location: See explanation on page

Chief aquifer: See table 1.

Use: D, domestic; S, stock; P, public supply; I, industrial; To, oil test; Ti, iron ore test; B, foundation boring; Tw, water test.

Water level: In feet below or above (+) land-surface datum; M, measured; R, reported.

Altitude: In feet above mean sea level (estimated from advance prints of U. S. Geological Survey topographic maps).

Well number	Location in section ¼ ¼	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
43N 23W													
4-1	SE NE	H. Hansen	-	-	12	48	Qgd	DS	7	M	10-24-58	1,005	Abandoned.
5-1	SE SE	Mrs. Leech	-	-	16	60	Qgd	D	9	M	10-24-58	1,020	
5-2	SW SW	Lathrop School	-	-	150	6	Otb	P	21	M	10-24-58	1,040	Do.
6-1	NE SE	G. R. Stegath	-	-	85	6	Otb	D	-	-	-	1,040	
6-2	NW NE	C and NW RR.	-	-	9	-	-	B	-	-	-	1,051	Bedrock at 9 ft.
6-3	NE SE	Berthyl Hansen	Tom Rice and Son	1942	98	6	Otb	P	16	R	10-24-58	1,040	
6-4	NW NW	David Williamson	D. Williamson	-	11	60	Qgd Otb	D	7	M	10-27-58	1,055	Bedrock at 10 ft.
8-1	SE SW	C and NW Ry.	-	-	11	-	-	B	-	-	-	1,008	Bedrock at 11 ft.
8-2	SW NW	do.	-	-	10	-	-	B	-	-	-	1,024	Bedrock at 10 ft.
21-1	SW NE	John Niemi	Tom Rice and Son	1944	84	5	Otb	DS	-	-	-	980	
21-2	NW NW	J. C. Bartlett	Fred Rice	1956	40	-	Otb	D	-	-	-	980	
21-3	NW NW	do.	-	-	10	1½	Qgd	D	-	-	-	980	
24-1	NW NE	Toivo Lampi	-	1928	22	36	Qgd	D	-	-	-	940	Bedrock at 30 ft.
28-1	NW NE	C and NW Ry.	-	-	7	-	-	B	-	-	-	978	Bedrock at 7 ft.
28-2	NW SW	Victor Kallio	Tom Rice and Son	1943	30	5	Otb	DS	-	-	-	990	Bedrock at 10 ft.
28-3	SE SE	John Toyra	do.	1944	41	5	Otb	DS	-	-	-	975	Bedrock at 11 ft.
28-4	SW SE	Charles Valeen	do.	1943	102	5	Otb	DS	-	-	-	980	Bedrock at 12 ft.
32-1	NW SW	Sulo Auer	do.	1948	122	5	Otb	DS	-	-	-	980	Bedrock at 20 ft.
32-2	NW NW	Andrew Topala	do.	1943	84	5	Otb	DS	-	-	-	990	Bedrock at 9 ft.
34-1	SW NE	F. H. Mattila	do.	1940	365	4	Oat	DS	40	R	1940	960	
35-1	- -	-	-	1954	625	-	-	Ti	-	-	-	970	
43N 22W													
6-1	SW SW	Erick Osterburg	-	-	7	60	Qgd	DS	3.4	M	10-24-58	950	Abandoned.
12-1	NW SE	Arthur Skinner	Ben Noel	-	85	-	Otb	D	-	-	-	870	
13-1	SW NW	Joseph Clabots	William Nance	1958	26	5	Otb	D	6	R	10-20-58	865	
14-1	SW NE	Clarence Cayre	Tom Rice and Son	1944	45	5	Otb	DS	-	-	-	870	
24-1	NW NE	Fred Chenail	F. Chenail	1896	15	144	Qgd	DS	10	R	10-20-58	845	Bedrock at 12 ft.
27-1	NE NE	Delmar McIntyre	Tom Rice and Son	1938	70	5	Otb	DS	10	R	10-20-58	850	Bedrock at 10 ft.
27-2	SW NW	Clarence Reamer	William Nance	1957	30	-	Otb	D	-	-	-	885	
28-1	SE SW	C. O. Romig	-	-	55	4	Otb	D	20	R	10-20-58	885	Bedrock at 5 ft.
29-1	SW SW	Roy Klies	-	-	56	4	Otb	-	-	-	-	900	
30-1	SW NW	Fred Nelson	-	1913	50	6	Otb	DS	10	R	10-20-58	925	High iron content.
31-1	NE SW	Emil Kentta	Tom Rice and Son	1943	110	5	Otb	DS	-	-	-	910	Abandoned.
32-1	SW SW	Walter Manntie	-	-	6	36	Qgd	DS	3	M	10-29-58	890	Do.
36-1	NW SE	Theodore Black	-	-	3	24	Qgd	DS	0	M	11- 3-58	785	Spring, flow 1 gpm.
43N 21W													
3-1	NE SW	Albert Trott	William Nance	1945	58	4	Otb	DS	0	R	10-20-58	820	
5-1	SE SE	A. B. Whybrew	-	1926	85	6	Otb	DS	-	-	-	850	
5-2	SE SE	do.	O. Deganeffe	1956	135	6	Otb	DS	58	R	10-20-58	850	Bedrock at 20 ft.
6-1	SW NE	Antoine Gornick	Nance Sr.	1915	45	4	Otb	D	20	R	10-20-58	875	Bedrock near surface.
7-1	SW NW	Henry Martenson	O. Deganeffe	1957	73	5	Otb	D	20	R	10-20-58	870	
8-1	SW NW	Bert Bennett	-	-	30	6	Otb	DS	10	R	10-20-58	845	
9-1	SE NW	Glenn Seymour	Hakala	1953	45	-	Otb	D	-	-	-	825	
10-1	SW SW	Orville Lockhart	Bruenig	1928	32	-	Otb	DS	12	R	10-20-58	795	
18-1	NW NE	Charles Wnuck	C. O. Rice	1958	273	5	Oat	D	-	-	-	840	Flows. Bedrock at 5 ft. Sulfate at 36 ft.
18-2	SW SE	M. H. Hogue	-	1940	16	48	Qgd	D	10	R	10-20-58	820	
30-1	SW SE	Potvin Bros.	William Nance	1953	87	4	Otb	DS	11	R	10-20-58	800	
43N 20W													
1-1	NE SW	Round Lake Club	-	1943	25	1½	Qs	D	-	-	-	800	

Table 3.--Records of wells and test boles in Delta County

Well number	¼ ¼ Location in section	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
43N 20W													
2-1	SW SW	U. S. Forest Service	G. Brunner	1941	28	4	Qs	P	13	R	8-14-41	795	80-gauge screen.
6-1	NE SE	-	Corps of Engineers	1949	7	-	-	B	-	-	-	752	Bedrock at 7 ft.
7-1	SE SE	-	do.	1949	7	-	-	B	-	-	-	710	Do.
18-1	NE SE	-	do.	1949	2	-	-	B	-	-	-	692	Bedrock at 2 ft.
19-1	NE SE	-	do.	1949	7	-	-	B	-	-	-	691	Bedrock at 7 ft.
30-1	NE SE	-	do.	1949	4	-	-	B	-	-	-	685	Bedrock at 4 ft.
31-1	NW SE	-	do.	1949	3	-	-	B	-	-	-	660	Bedrock at 3 ft.
43N 19W													
1-1	NE NE	Kathleen Brophy	F. H. Ruska	-	30	-	Qgd	D	-	-	-	780	
24-1	SW NW	Floyd Dickman	Ted Nance	-	70	4	Qgd	D	-	-	-	865	
24-2	SW NW	do.	Floyd Dickman	1948	67		Qgd	O	56.2	M	8- 5-58	865	
24-3	NW NW	Harry Clarage	Ted Nance	1948	405	4	Otb	O	78.3	M	8-22-58	960	
43N 18W													
1-1	NE NE	H. H. Mintonye	H. H. Mintonye	-	30	-	Qgd	P	20	R	8- 5-58	765	
6-1	NW NW	Mrs. W. Elgland	-	-	32	1¼	Qgd	P	12	R	8- 5-58	770	
32-1	NW NW	L. C. Buchtel	-	1955	21	-	Qgd	P	8	R	8- 5-58	790	
42N 23W													
2-1	SW NE	Helma Anderson	Tom Rice and Son	1947	30	5	Otb	D	-	-	-	935	Abandoned.
2-2	NW NE	Richard Sjolund	-	-	35	5	Otb	DS	-	-	-	945	
3-1	NE NE	Co. Rd. Comm.	Tom Rice and Son	1944	70	5	Otb	P	-	-	-	965	
3-2	NE NW	Mrs. O. Kleiber	-	-	30	-	Otb	D	-	-	-	970	
3-3	SE NW	Leo Enberg	Tom Rice and Son	1943	47	5	Otb	D	-	-	-	970	
3-4	NE NE	Walter Manntie	do.	1943	64	5	Otb	D	-	-	-	965	
3-5	NE NW	San Martilla	do.	1945	52	5	Otb	D	-	-	-	965	
3-6	NE NE	Rock High School	-	1929	60	4	Otb	P	-	-	-	970	
3-7	SE NE	Emil DeBacker	Tom Rice and Son	1947	58	5	Otb	D	-	-	-	950	
3-8	SW NE	August Larson Jr.	-	1940	75	4	Otb	D	-	-	-	970	
3-9	SW NE	Herbert Westlane	-	-	40	6	Otb	P	-	-	-	965	
3-10	SW NE	Larson Bros.	Tom Rice and Son	1948	62	5	Otb	P	-	-	-	965	
3-11	SW NE	John Larson	C. O. Rice	1958	67	5	Otb	D	-	-	-	970	
3-12	NW NE	Rock Fire Hall	Tom Rice and Son	1949	70	6	Otb	P	-	-	-	965	
3-13	NW NE	Herman Johnson	do.	1945	80	-	Otb	D	-	-	-	970	
3-14	NW NE	Frank Campbell	do.	1945	40	5	Otb	P	-	-	-	970	
3-15	NW NE	Lions Club	do.	1947	60	5	Otb	P	-	-	-	965	
3-16	NW NE	Martin Kaminen	do.	1943	48	5	Otb	D	-	-	-	970	
3-17	NW NE	August Larson Sr.	-	-	99	6	Otb	D	-	-	-	965	
3-18	NW NE	Herman Hakkila	Tom Rice and Son	1943	38	5	Otb	D	-	-	-	970	
3-19	NW NE	Rock Co-op Garage	-	-	200	4	Otb	P	-	-	-	970	
3-20	NW NE	Northland Co-op	-	-	300	6	Otb	P	-	-	-	970	
4-1	SW NE	Edward Kaminen	Tom Rice and Son	1946	52	-	Otb	D	-	-	-	940	
5-1	NW NW	Asko Hamalainen	-	-	9	36	Qgd	D	5.5	M	10-29-58	970	
7-1	SW SW	Eino Maki	-	1922	32	6	Otb	DS	-	-	-	940	
8-1	SW SW	Clarence Johnson	-	-	60	6	Otb	DS	20	R	10-29-58	930	Not used.
10-1	SE SW	Carl Kestila	-	-	19	5	Otb	DS	4	M	10-29-58	925	
11-3	SE SW	C and NW Ry.	-	-	10	-	-	B	-	-	-	906	Bedrock at 10 ft.
14-1	NW NE	Trombley Hotel	-	-	55	-	Otb	P	-	-	-	910	
14-2	NE SE	C and NW Ry.	-	-	9	-	-	B	-	-	-	870	Bedrock at 9 ft.
16-1	NE NW	Jerry Kleiber	-	-	50	6	Otb	-	-	-	-	940	
24-1	NW SW	George Mattela	Tom Rice and Son	1943	53	5	Otb	D	-	-	-	870	
30-1	NE NE	Victor DeGrande	-	1920	52	6	Otb	DS	-	-	-	910	Fissure at 52 ft.
31-1	SW SE	Valere VanDamme	C. O. Rice	1954	60	6	Otb	I	11	R	3-16-55	855	Low capacity.
34-1	SW SW	Henry LaChapelle	Fred Rice	1954	43	6	Otb	DS	10	R	1954	860	
42N 22W													
6-1	NW NW	G. Halonen	-	-	9	60	Qgd	DS	8	M	10-20-58	910	Abandoned.
20-1	SE SE	Gustafson School	-	-	12	2	Qgd	P	-	-	-	820	Destroyed.
20-2	SE NE	F. Drossart	-	-	8	60	Qgd	D	8	M	10-31-58	830	
26-1	SW NW	Harry Clausen	Elvin Anderson	1945	302	6	Oat	DS	5	R	1948	770	Formerly flowed.
26-2	SW NW	do.	-	1954	590	5	Cm	Ti	+3	M	10-31-58	770	
27-1	SE NE	Carl Ottlen	-	1918	14	60	Qgd	D	5	M	10-31-58	770	
27-2	SW SW	Hall School	-	-	10	1½	Qgd	P	-	-	-	780	Destroyed.
29-1	NE NW	Joseph DeCremer	J. DeCremer	1907	15	48	Qgd Otb	DS	6	M	10-31-58	820	Bedrock at 7 ft.

Table 3.--Records of wells and test holes in Delta County

Well number	Location in section ¼ ¼	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
41N 21W													
28-4	NE NW	Mich. Hwy. Dept.	-	-	8	-	-	B	-	-	-	579	Bedrock at 8 ft.
28-23	NE NW	-	Corps of Engineers	1949	33	-	-	B	-	-	-	594	Bedrock at 33 ft.
29-5	SE NW	Rapid River	-	-	305	5	Oat	P	-	-	-	590	
29-6	NE NW	do.	L. C. Wolfe	1897	273	-	Oat	P	-	-	-	588	Flow, 4 gpm.
29-7	SW NW	do.	do.	1898	275	4	Oat	P	+3	R	1906	590	Flow, $1\frac{1}{2}$ gpm.
29-12	NE NE	William Nelson	-	1945	44	5	Otb	D	-	-	-	590	
29-13	SE NE	Ole Sundquist	-	1945	105	4	Otb	D	-	-	-	590	
29-14	NE NW	Leslie Caswell	-	-	300	5	Oat	P	-	-	-	590	
29-16	SE NW	Dan Oberg	-	1945	120	6	Otb	D	-	-	-	590	
29-17	NW NE	Nels Westling	-	-	249	5	Oat	P	-	-	-	590	Flows.
29-18	NE SE	Gust. Carlson	-	1945	100	5	Otb	D	-	-	-	590	
29-19	NE SW	Swallow Inn	-	-	150	5	Otb	P	-	-	-	590	
29-22	NE NE	U. S. Forest Service	George Brunner	1936	273	5	Oat	P	-	-	-	600	Do.
29-23	NE NW	A. Connor	L. C. Wolfe	1895	270	-	Oat	-	+4	R	1906	588	Flow, 314 gpm.
29-24	SW NE	Lloyd Vendron	-	1942	258	5	Oat	-	-	-	-	590	
29-25	NE NW	H. W. Coles	L. C. Wolfe	1897	258	-	Oat	-	-	-	-	586	Flow, 2 gpm.
29-26	NW NW	A. L. Laing	do.	1903	273	-	Oat	D	-	-	-	590	Do.
29-27	NW NW	Adam Schaible	do.	1904	273	-	Oat	D	-	-	-	588	Flow, 6 gpm.
29-28	SW NW	M.St.P. and S.S. M. RR.	Rice	1952	230	5	Otb	P	-	-	-	590	Flows.
29-29	NE NW	Rapid River Fire Hall	Tom Rice and Son	1943	303	-	Oat	P	-	-	-	590	
30-1	NE NW	Lester Duncan	-	1946	285	5	Oat	D	-	-	-	600	Do.
30-2	NE NE	Delta County	-	-	12	60	Qgd Otb	P	-	-	-	595	
30-3	SE SW	Arthur Bergeron	-	1948	300	6	Oat	P	-	-	-	610	Do.
30-4	NW NE	Mich. Hwy. Dept.	-	1940	450	5	Oat	P	-	-	-	605	
32-2	NE SE	-	Corps of Engineers	1949	32	-	-	B	-	-	-	586	Bedrock at 32 ft.
32-3	SE NW	A. R. Wickham	O. Deganeffe	1957	60	5	Otb	P	-	-	-	585	
32-4	SW NE	C. G. Raymont	C. O. Rice	1957	45	6	Qgd	D	-	-	-	585	
32-5	NE NE	-	Corps of Engineers	1949	10	-	-	B	-	-	-	585	Bedrock at 10 ft.
34-1	SW SE	M. A. Wegner	-	1942	100	4	Otb	-	-	-	-	650	
34-2	SW NW	Mich. Hwy. Dept.	-	-	13	-	Qs	B	3	R	1949	634	
34-3	SW NW	Scott's Motel	-	1956	35	-	Qg	P	-	-	-	630	
35-1	NE NW	Alfred Lundberg	-	-	20	36	Qgd Or	DS	-	-	-	690	
35-2	NW NE	Carl Wickstrom	-	-	20	48	Qgd	DS	-	-	-	690	
35-3	NE NW	Peter Stenlund	-	-	19	3	Qgd Or	DS	-	-	-	690	
36-1	SE SE	Oscar Magnusson	-	1924	200	6	Otb	D	-	-	-	710	
36-2	SE SE	Magnusson's Store	-	-	20	4	Qgd Or	P	-	-	-	710	
41N 20W													
31-1	SW SW	Robert Olson	-	-	20	48	Or	D	-	-	-	710	
34-1	SW SW	Urban Hebert	-	-	44	$1\frac{1}{4}$	Qgd	P	-	-	-	640	
34-2	SW SW	do.	-	-	14	18	Qgd	P	5.3	M	10-15-58	640	
34-3	SE SE	Julius Kallman	Tom Rice and Son	1947	75	5	Or	D	-	-	-	610	
36-1	SE SE	Emil Juneau	-	-	62	$1\frac{1}{4}$	Qgd	D	-	-	-	640	
41N 19W													
17-1	NE SW	U. S. Forest Service	-	1935	58	6	Or	PO	3.5	M	8-25-58	640	
20-1	SE NE	do.	Carl Prather	1929	1160	10	Єm	P	-	-	-	630	Flows.
21-1	NE NE	do.	-	1939	94	5	Qs	P	72.4	M	8-28-58	750	80-gauge screen.
32-1	SW SW	do.	-	-	16	-	Qgd	P	-	-	-	620	
32-2	SW SW	do.	G. M. Gullickson	1948	11	$1\frac{1}{4}$	Qs	P	7	R	1948	620	
35-1	SE SE	Elmer Lake	Tom Rice and Son	1938	45	-	Sc	DS	-	-	-	640	Bedrock near surface.
35-2	NE NE	Rubin Sunderling	-	-	-	48	Sc	S	0-	M	9- 4-58	620	Spring; flow, 3 gpm.
36-1	SE NE	Nick Bonifas	-	-	5	96	Sc	DS	2	M	8-15-58	640	Improved spring.
36-2	SE NE	do.	Casper Rhinewood	1928	30+	6	Sc	DS	-	-	-	640	

Table 3.--Records of wells and test holes in Delta County

Well number	¼ ¼ Location in section	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
41N 19W													
36-3	SW NW	Rubin Sunderling	G. W. Gray	-	128	6	Sc	DS	16	R	1958	640	
41N 18W													
13-1	NW NW	Otto Schuttke	C. O. Rice	1940	200	6	Qs	DS	-	-	-	690	
13-2	NW NW	do.	-	-	43	6	Qs	-	34.5	M	9-16-58	690	
13-3	NE NE	K. M. Cutler	-	-	123	5	Sc	DS	-	-	-	770	
19-1	SE SW	Albert Watchorn	O. Deganeffe	-	56	6	Sc	DS	9	R	1955	650	
30-1	NW SE	Ruth Sundin	-	1950	8	30	Qgd	D	5.5	M	8-15-58	640	
31-1	SE SW	Charles Thompson	-	-	18	60	Qgd	P	-	-	-	620	Improved spring.
31-2	SE SW	do.	-	1938	250	5	Sc Or	O	3.1	M	8-15-58	620	
32-1	NE SE	Mich. Hwy. Dept.	-	-	24	-	-	B	-	-	-	583	Bedrock at 24 ft.
32-2	NE NE	Elmer Hall	-	-	3	60	Qgd	-	0	M	8-15-58	600	Spring.
33-1	NE SW	Mich. Hwy. Dept.	-	-	45	-	-	B	-	-	-	581	Gravel at 45 ft.
33-4	SW NE	Delta Co. Park	-	-	19+	5	-	P	5	M	8-28-58	590	
34-1	SW SW	Bay deNoc Co.	-	-	25	1½	Qg	P	-	-	-	590	
40N 24W													
2-1	NE NE	Manzer Way	-	-	12	48	Qgd	DS	6	M	11- 6-58	830	
3-1	SW SW	John Ring Sr.	Tom Rice and Son	-	75	5	Otb	DS	12	M	11- 6-58	825	
6-1	SE SE	Charles Schrader	-	-	18	48	Qgd	D	-	-	-	875±	
6-2	SE NE	Ed White	Tom Rice and Son	1940	40	-	Otb	D	-	-	-	885±	Abandoned.
6-3	SE SW	Walter Fleury	do.	-	40	5	Otb	DS	-	-	-	875±	Bedrock at 10 ft.
8-1	NE NE	John Ring Sr.	Fred Rice	1957	25	6	Otb	D	6	R	1957	840±	Bedrock at 20 ft.
8-2	SW NW	Charles Hodge	C. Hodge	-	16	-	Qgd	D	6	R	1958	875±	Bedrock at 16 ft.
11-1	NE NW	Henry Rose	Tom Rice and Son	1944	78	5	Otb	-	-	-	-	850±	
11-2	SE SE	Mrs. J. Carlson	-	-	16	5	-	D	4.4	M	11-10-58	822	Abandoned.
14-1	NE NE	Lincoln School	-	-	100+	5	Otb	P	3	M	11-10-58	822	
34-1	NE NE	Isadore Guenette	John Zavada	1953	85	6	Otb	DS	-	-	-	810	
40N 23W													
1-1	NW NE	Earl Credlund	-	-	60	6	Otb	-	-	-	-	740	
1-2	NW NE	do.	-	1943	115	6	Otb	-	-	-	-	740	
5-1	NW SW	Emma Schire	Tom Rice and Son	-	110	5	Otb	DS	-	-	-	800	
5-2	SE SE	Joseph Stefl	-	-	105	5	Otb	DS	5	R	1958	780	
5-3	SE SE	do.	-	-	49	-	Otb	D	-	-	-	780	
6-1	SE NE	Louis Tuyls	Tom Rice and Son	1943	110	5	Otb	D	-	-	-	780	
7-1	SE SW	Frank Harrison	C. O. Rice	1958	93	5	Otb	D	-	-	-	785	Bedrock at 36 ft.
7-2	SW SE	Walter Harrison	do.	1958	155	5	Otb	D	-	-	-	785	
9-1	NE NW	Chandler School	-	-	50	6	Otb	P	-	-	-	780	Destroyed.
9-2	NE SW	Chandler Tavern	-	-	55	5	Otb	P	-	-	-	780	
16-1	NW SE	Patrick Miron	Tom Rice and Son	1944	175	5	Otb	D	-	-	-	750	
17-1	NW NW	State of Mich.	-	-	16+	5	-	DS	3.9	M	11-10-58	775	
23-1	SW SE	Carroll School	-	-	100	5	Otb	P	-	-	-	730	
26-1	NE NW	Earl Paguin	Tom Rice and Son	1937	38	-	-	-	-	-	-	750	
27-1	SE NW	Louis Burcar	-	-	160	6	Otb	-	-	-	-	750	
27-2	SE SE	Howard School	-	-	100	6	Otb	P	-	-	-	730	
28-1	SE SW	Larry Nelson	Tom Rice and Son	1944	260	-	Otb	DS	-	-	-	770	
29-1	NE SE	Sovey School	-	-	80	5	Otb	P	-	-	-	770	
29-2	SW NW	Nadon School	-	-	100	5	Otb	P	-	-	-	760	
29-3	NW NW	Fred Umland	Tom Rice and Son	1943	117	4½	Otb	D	-	-	-	795	
30-1	NE NE	Adrian Beauchamp	do.	1946	182	5	Otb	D	-	-	-	795	
31-1	NE NW	Moses Theoret	do.	1945	110	5	Otb	D	-	-	-	750±	
32-1	NW NW	Donna Roberts	C. O. Rice	1958	160	5	Otb	D	-	-	-	770	Bedrock at 10 ft.
32-2	NW NW	Fred Roberts	do.	1958	147	4	Otb	D	50	R	1958	770	
33-1	NE NW	Dr. Hughes	Tom Rice and Son	1946	240	5	Otb	D	-	-	-	770	
40N 22W													
2-1	NW NW	-	Mich. Hwy. Dept.	-	2	-	-	B	-	-	-	582	Bedrock at 2 ft.
2-8	SW NW	Mrs. Andrew Johnson	C. O. Rice	1953	267	6	Oat	D	-	-	-	595	Flows.
4-1	SE NE	Sanders Larson	-	-	20	3	Qgd	D	-	-	-	620	
4-2	NE NW	U. S. Forest Service	-	1941	40	5	Qgd	P	22.8	M	8- 6-58	650	80-gauge screen.
4-3	NE NW	do.	-	1941	30	5	Qgd	P	22	R	12-18-41	650	Do.
4-4	NE NW	do.	-	1941	34	5	Qgd	P	17	R	1941	650±	Do.
10-2	NE SW	John A. Barrette	C. O. Rice	1956	40	6	Otb	P	2	R	5-29-56	595	
10-3	SW SW	Hagas Grocery	-	-	300+	6	Oat	P	-	-	-	585	Flows.

Table 3.--Records of wells and test holes in Delta County

Well number	Location in section ¼ ¼	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
40N 22W													
10-4	SW NE	Brock's Cabins	C. O. Rice	1954	42	5	Otb	P	1	R	8-20-58	585	
10-5	SE NW	Lewis Brock	do.	-	36	6	Otb	D	5	R	8-20-58	585	
10-6	NE SW	Raymond M. Tackman	-	1933	312	6	Oat	D	+23	R	8-20-58	585	Flows.
10-7	NE SW	Kipling School	-	-	60	6	Otb	P	-	-	-	585	
10-8	NE SW	Ray Alworden	C. O. Rice	1957	58	6	Otb	D	15	R	8-20-58	585	
10-10	SE NW	Victor Brock	Tom Rice and Son	1943	37	4½	Otb	D	-	-	-	595	Bedrock at 35 ft.
16-2	SE SE	-	Mich. Hwy. Dept.	-	28	-	-	B	-	-	-	588	Peat and sand,
16-7	SE SW	Hilding Johnson	-	-	30	2	Qgd	D	-	-	-	600	
16-8	NW SE	Ed Jackson	-	-	72	4	-	DS	-	-	-	600	Flows.
20-1	NW NW	Francis Rabitoy	C. O. Rice	1958	124	5	Qgd	P	30	R	6- 6-58	720	Bedrock at 123 ft.
20-2	NE NW	Oscar Bing	do.	-	138	5	Otb	D	75	R	6- 6-56	720	
21-1	SW NE	Marble Arms.Co.	-	-	465	-	Oat	I	-	-	-	600	
21-2	NW NW	R. N. Sandstrom	-	-	170	5	Otb	D	80	R	6- 6-56	710	
21-3	SE NW	M. St. P. and S. Ste. M. R.R.	-	1915	743	10	Ꞓm	R	-	-	-	605	
21-4	SE SE	Central School	-	-	-	2	Qs	P	-	-	-	595	Flows.
21-5	SE NW	Wm. Hendrickson	-	1934	68	4	Otb	D	+2	R	1949	600	
21-6	NE NE	Fred Johnson	-	-	35	1¼	Qgd	D	-	-	-	600	
22-1	NW SW	Alphonse Iren	-	1914	16	-	Qg	D	-	-	-	590	
22-2	NE SE	City of Gladstone	C. O. Rice	1957	730	8-6	Ꞓm	P	-	-	-	585	Flow, 75-100 gpm.
24-1	NW NW	Dr. Watson	Tom Rice and Son	-	121	5	-	D	-	-	-	585	Bedrock at 120 ft.
24-2	NW NW	Vernon Hentz	do.	1952	130	5	-	D	-	-	-	585	
26-1	NW NW	L. S. and I.R.R.	C. O. Rice	1957	71	-	-	B	-	-	-	580	Drilled through ice on Little Bay deNoc.
29-1	NW NE	George Kelley	-	-	178	6	Otb	D	-	-	-	715	
40N 21W													
2-1	SW SW	Ferdinand Sundberg	-	-	20	24	Qgd Or	D	-	-	-	695	
3-1	SE SW	Alton School	-	-	14	36	Qgd Or	P	3.5	M	10-13-58	700	Not used.
3-2	NE NE	George Weberg	-	-	12	18	Or	D	-	-	-	710	
3-3[3]	SE SW	A. Holmgren	-	1944	12	18	Or	D	-	-	-	700	
4-1	SE NW	Frank Merle	-	-	360	4	Or Otb	DS	-	-	-	660	
9-1	SW SW	Andrew Johnson	-	-	22	36	Or	D	-	-	-	680	
10-1	SW SE	Josephine Burczikowski	C. O. Rice	-	112	4	Or	S	-	-	-	695	
10-2	SW SE	do.	Joseph Schiska	-	69	4	Or	D	-	-	-	695	
10-3	SW SE	do.	-	-	16	36	Qgd Or	D	-	-	-	695	
21-1	NW NW	Waldemar Anderson	Joseph Schiska	1922	40	36	Or	D	16.5	M	10-13-58	690	
24-1	NE NE	Gust Anderson	-	-	14	1¼	Qgd	D	-	-	-	690	
35-1	SE NW	John Hjelm	-	-	16	96	Or	DS	3	M	10-10-58	700	
40N 20W													
1-1	NE NE	R. L. McClinchy	R. McClinchy	1939	40	1¼	Qs	D	-	-	-	615	Destroyed.
1-2	NE NE	do.	do.	1946	12	1¼	Qs	D	-	-	-	615	
1-3	NW NE	L. J. Bramer	C. O. Rice	1958	110	5	Or	D	-	-	-	615	
2-1	NW NW	Mrs. A. Olsen	A. Olsen	1936	48	1¼	Qs	D	40	R	1949	660	
2-2	NW NW	Emil Juneau	-	-	62	1¼	Qgd	D	-	-	-	645±	
3-1	NE NE	Mrs. A. Olsen	-	-	55	5	-	-	-	-	-	650	
4-1	NW NW	-	Mich. Hwy. Dept.	-	28	-	-	B	-	-	-	610	Bedrock at 25 ft.
5-1	NW SE	Fred Holm	-	-	14	36	-	D	-	-	-	610	
6-1	NW NW	Joe Gustafson	-	-	10	48	Or	D	-	-	-	690	
11-1	SE NW	Clyde Hardwick	C. Hardwick	1957	68	4	Qsg	D	65	R	10-10-58	660	
17-1	NE NE	Herman Weberg	H. Weberg	-	15	36	Qgd Or	D	-	-	-	620	
18-1	NW SE	Silverdale School	--	-	15	48	Qgd	P	4.9	M	10-10-58	672	Abandoned.
18-2	NE NE	E. L. Johnston	C. O. Rice	1959	665	5	Oat	DS	-	-	-	665	
20-1	SW NE	Jasper Reinwand	do.	1958	96	5	Or	D	+1	M	10-10-58	600	Flows.
20-2	SW NE	Oliver Broman	do.	1958	-	-	Or	D	-	-	-	600	
24-1	SW NW	Edwin Matson	do.	1957	52	5	Qgd	D	-	-	-	585	
29-1	SE NW	Mary Granholm	-	-	12	72	Qgd	DS	10	M	10-10-58	610	Not used.

Table 3.--Records of wells and test holes in Delta County

Well number	Location ¼ ¼ in section	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
40N 19W													
1-1	SW SW	Peter Forsland	-	-	13	24	Qgd	D	-	-	-	600	
2-1	SW NE	Isadore Bonifas	-	1945	185	5	Sc Or	DS	-	-	-	625	Saline.
2-2	SE SE	Herbert Wester	-	-	12	24	Qgd Sc	D	-	-	-	600	
3-1	SE NW	Oscar Sundling	-	-	8	72	Sc	D	4.7	M	9- 3-58	635	Abandoned.
4-1	NE SE	Donald Clement	-	-	25	1½	Qs	P	15	R	10- 9-58	620	High iron content.
5-3	NW NW	-	Mich. Hwy. Dept.	-	42	-	-	B	-	-	-	608	Gravel at 40 ft.
6-1	NW NW	R. L. McClinchey	C. O. Rice	1958	110	5	Or	P	-	-	-	610	
11-1	NW NW	Pine deNoc School	-	-	250	6	Otb?	P	-	-	-	610	Plugged.
11-2	NW SW	-	-	1957	60	6	Sc	D	6.8	M	10- 9-58	600	
12-1	SE NW	Walter Butler	-	-	13	18	Qgd Sc	P	-	-	-	590	
15-1	NE SW	Walter Zuehlke	Elwin Anderson	1957	192	5	Sc	-	6	R	1957	590	
16-1	SW SW	William Aiker	-	1942	50	-	Sc	D	-	-	-	-	
21-1	SW SW	Bay deNoc Co.	-	1895	80	4	Qgd	P	-	-	-	590	Flow, 10 gpm.
21-2	SW SW	do.	-	1883	133	2	Sc	P	-	-	-	590	Flow, 1 gpm.
21-3	SW SW	do.	-	1910	310	4	Sc Or	P	-	-	-	590	Flows. Hydrogen sulfide odor.
21-4	SW SW	do.	-	-	200	6	Sc	P	+5	R	1958	590	Flows.
28-1	NE NE	do.	-	-	25	1¼	Qgd	P	-	-	-	590	
40N 18W													
4-1	SW NW	Frank Richards	Elwin Anderson	1952	125	6	Sc	P	3	R	1952	585	
4-2	SE NW	J. G. Wilson	C. O. Rice	1956	101	5	Sc	D	-	-	-	590	Flows.
4-3	NE SW	John Kunkel	do.	1956	117	5	Sc	D	+5	R	4-17-56	583	Flows.
4-4	SW NW	Martin Tholen	-	-	200	5	Sc	P	-	-	-	590	
4-5	SW NW	Louis Guertin	Tom Rice and Son	1947	75	5	Sc	P	-	-	-	590	
5-1	NE NE	Robert Porter	do.	1945	426	6	Sc	P	+	R	1958	590	Flows.
5-2	NE NE	do.	C. O. Rice	1952	126	6	Sc	P	+	R	1958	590	Do.
9-1	NW SE	Richard Dams	-	1957	110	2	Sc	P	-	-	-	590	Do.
9-2	SW SE	Norman Evans	Tom Rice and Son	1947	150	5	Sc	D	-	-	-	590	
15-1	NW SW	Deer Spring Lodge	-	-	1	48	Qgd	D	+	M	9-29-58	645	Spring.
32-1	NW NE	Walter Haas	Elwin Anderson	1944	114	6	Sb	D	-	-	-	680	
33-1	SE NW	Gibson Collinson	-	1900	56	4	Sb	DS	7	R	1958	635	Flows in the spring.
39N 24W													
1-1	NW NW	Nels Johnson	-	-	165	5	Otb	I	-	-	-	-	
6-1	NW SE	Agnes Piekutowski	C. O. Rice	1954	300	5	Oat	DS	20±	R	1958	825	
6-2	SW SW	Andrew Bartoszek	Tom Rice	1928	36	6	Otb	DS	-	-	-	825	
7-1	NE NW	Maple Grove School	-	-	20	6	Otb	P	16	M	11- 7-58	825	
8-1	SW NW	Louis Butryn	Tom Rice and Son	1944	50	5	Otb	DS	-	-	-	800±	
12-1	NW NW	Newhall School	-	-	100+	5	-	P	-	-	-	-	
14-1	SE NW	Alex Charon	Tom Rice and Son	1945	195	5	Otb	DS	-	-	-	735	
16-1	NW NE	10 Mile School	-	-	100	5	Otb	P	-	-	-	-	
17-1	NW SE	Schaeffer Dairy	-	-	72	5	Otb	P	-	-	-	-	
18-1	SE NW	Joseph Bartos	-	-	25	36	Qgd Otb	DS	-	-	-	-	
18-2	NW NE	Charles Butryn	Tom Rice and Son	1944	123	5	Otb	D	-	-	-	800±	
19-1	NE NE	Joseph Potvin	do.	1946	129	6	Otb	D	-	-	-	-	
20-1	NW NW	Joseph LaVigne	-	-	100	6	Otb	D	-	-	-	-	
20-2	NE SW	Schaeffer School	-	-	100	5	Otb	P	-	-	-	780	
22-1	SW NW	Charles Robinson	Tom Rice and Son	1945	175	5	Otb	DS	19	M	11- 7-58	730	
27-1	SE SE	Hilding Olson	-	-	44	6	Otb	D	-	-	-	710	
28-1	NE SW	Frank Porath	Tom Rice and Son	1944	90	5	Otb	DS	-	-	-	760	
28-2	SW NW	Thomas Tousignant	do.	1945	88	5	Otb	D	-	-	-	720	
30-1	NW SE	Frances Pilon	do.	-	96	6	Otb	DS	40	R	1958	800	
31-1	NE SE	Lense Richer	do.	1944	95	5	Otb	D	-	-	-	750±	
34-2	SE SW	Lawrence Richer	-	-	113	5	Otb	DS	-	-	-	740±	
35-1	SW SE	Mich. Hwy. Dept.	C. O. Rice	1957	100	5	Otb	P	8	R	1957	690	
36-1	NW SE	Highland Golf Club	-	-	88	5	Otb	P	-	-	-	690	
36-2	NW SW	C and NW RR.	-	-	18	-	-	B	-	-	-	690	Gravel.
36-3	SE SE	Fenlon Bros.	C. O. Rice	1957	105	5	Otb	DS	-	-	-	690	

Table 3.--Records of wells and test holes in Delta County

Well number	¼ ¼ Location in section	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
39N 23W													
1-1	SW NW	Groos School	-	-	25	-	-	P	-	-	-	620	
1-2	SE SW	Leonard Dombrowski	C. O. Rice	1957	41	5	Otb	D	-	-	-	670	Bedrock at 31 ft.
1-3	SE SW	Levi Allard	do.	1957	45	5	Otb	D	-	-	-	670	Bedrock at 25 ft.
1-4	NE SW	Escanaba Paper Co.	Tom Rice and Son	1946	243	5	Otb	I	-	-	-	620	Bedrock at 20 ft..
2-1	SW SW	Gunnar Mattson	-	1953	79	6	Otb	D	17	R	1953	715	Bedrock at 68 ft.
2-2	NE NE	Leslie Carlson	Tom Rice and Son	1946	90	5	Otb	D	-	-	--	680	Bedrock at 55 ft.
4-1	SW SW	Danforth School	-	-	80	5	-	P	-	-	-	760	
11-1	SE SE	Orville Owens	Tom Rice and Son	1945	97	5	Otb	D	-	-	-	700	Bedrock at 93 ft.
11-2	NE SW	Jerry Derusha	J. Derusha	1957	31	1¼	Qs	D	-	-	-	720	High iron content.
12-1	NW SE	Delta Co. Infirmary	-	-	38	1¼	Qgd	P	-	-	-	630	
12-2	NW SE	do.	Elwin Anderson	1949	305	6	Oat	P	12	R	1949	630	Bedrock at 52 ft.
12-3	NW SW	Joe Whitney	Tom Rice and Son	1943	100	6	Otb	DS	-	-	-	700	Bedrock at 77 ft.
12-4	NW NW	David Anderson	C. O. Rice	1957	97	5	Otb	D	-	-	-	700	Bedrock at 72 ft.
27-5	SE NE	C and NW RR.	-	-	8	-	-	B	-	-	-	622	Sand.
28-2	SW NE	Marshall and Sherman Blake	L. N. Schemmel	1914	304	5	Oat	Ti	1.5	M	7-11-58	680	Observation well.
28-3	SW NE	do.	do.	1914	530	5	Єm	O	2.3	M	7- 8-58	680	Do.
28-4	SE NW	Louis Schemmel	-	1919	1109	-	-	Ti	-	-	-	691	Bedrock at surface.
28-5	SE NW	do.	-	-	1165	-	-	Ti	-	-	-	691	
28-6	SE NW	do.	-	1920	943	-	-	Ti	-	-	-	691	
31-8	SW NE	-	Mich. Hwy. Dept.	1939	23	-	-	B	-	-	-	660	
31-9	NW NE	C and NW RR.	-	-	32	-	-	B	-	-	-	679	
32-1	NW NW	Julius Flath	Tom Rice and Son	1946	55	5	Otb	P	-	-	-	690	Bedrock at 52 ft.
36-1	SW NE	W. Erickson	-	-	325	-	Oat	D	-	-	-	600	
39N 22W													
5-1	NW NW	Terrace Gardens	-	1933	300	6	Oat	P	-	-	-	590	
5-2	NW NW	do.	C. O. Rice	1958	120	5	Otb	P	-	-	-	590	Bedrock at 85 ft.
6-1	SE NE	Deer Forest Motel	Tom Rice and Son	1949	280	5	Otb	P	-	-	-	620	Small flow at 115 ft.
6-2	SW SW	Pioneer Trail Park	-	-	100	5	Otb	P	-	-	-	600	
6-3	SW SE	Bay View School	-	-	104	4	Otb	P	-	-	-	610	
6-4	SW SE	C and NW RR.	-	-	13	-	-	B	-	-	-	634	
6-5	SE NE	Deer Forest Motel	C. O. Rice	1958	105	5	Otb	P	35	R	10-29-58	620	Bedrock at 66 ft.
6-6	NE SE	Andy Anderson	do.	1958	134	6	Otb	P	45	R	11- 5-58	630	Bedrock at 78 ft.
6-7	SE SW	Northern Mobile Homes	Fred Rice	1956	89	5	Otb	P	38	R	1956	620	Bedrock at 60 ft.
7-9	SW SE	C and NW RR.	-	-	39	-	-	B	-	-	-	579	Bedrock at 36 ft.
7-10	NW NW	Pioneer Trail Park	-	-	-	-	-	P	-	-	-	640	Flow, 2 gpm.
7-11	SE NW	do.	-	-	100	5	Otb	P	-	-	-	650	
7-12	SW NE	Chemical School	-	-	80	5	Otb	P	-	-	-	590	
18-2	SW NE	E and LS RR.	-	-	790	10	Єm	P	-	-	-	590	Plugged below 665 ft. Flow, 250 gpm.
18-3	NW SW	I. Stephenson Co.	Escanaba Drilling Co.	1927	860	10	Єm	-	-	-	-	620	
19-1	NW NW	City of Escanaba	-	1943	775	-	Єm	P	-	-	-	625	
23-1	NE SE	Peder Pederson	P. Pederson	-	26	96	Or	D	-	-	-	610	Bedrock near surface.
24-1	SE NE	Central School	-	-	28	36	Qgd Or	P	-	-	-	615	Do.
24-2	SE NE	do.	-	-	100	5	Or	P	-	-	-	615	
29-1	NW SE	City of Escanaba	McCarthy	1941	753	16	Єm	P	+22	R	3-19-42	588	Flow, 55 gpm.
29-2	NW SE	do.	Ranney Co.	1948	96	6	Qgd	T	-	-	-	588	
29-3	NE SW	do.	do.	1948	94	6	Qgd	T	-	-	-	587	
29-4	SW SE	do.	do.	1948	70	6	Qgd	T	-	-	-	588	
29-5	SW SE	do.	do.	1948	80	6	Qgd	T	-	-	-	588	
29-6	SW SE	do.	do.	1948	55	6	Qgd	T	-	-	-	588	
29-7	NE SE	do.	do.	1948	92	6	Qgd	T	-	-	-	587	
29-8	NE SE	do.	do.	1948	70	6	Qgd	T	-	-	-	583	
29-9	SW NW	C and NW RR.	D. Curran	1917	855	8	Єm	I	+30	R	1917	590	Flow, 150 gpm.

Table 3.--Records of wells and test holes in Delta County

Well number	¼ ¼ Location in section	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
39N 22W													
30-1	NE SW	Richter Brewing Co.	-	-	810	-	Єm	Ti	-	-	-	612	
30-2	SW NW	City of Escanaba	-	1941	844	19¼	Єm	P	+12	R	3-19-42	611	Flow, 45 gpm.
30-3	SW NW	do.	-	1941	816	19¼	Єm	P	+6	R	3-19-42	615	Flows.
31-1	NE NW	do.	-	1941	720	20	Єm	P	+6	R	3-19-42	607	High iron content. Flow 20 gpm. Bedrock at 85 ft.
31-2	NE SE	do.	Ranney Co.	1948	43	6	Qgd	Tw	-	-	-	585	Bedrock at 43 ft.
31-3	NW SE	Escanaba Brewing Co.	-	-	730	-	Єm	I	-	-	-	595	High iron content.
31-4	NE SW	Ralph Walsh	-	-	19	1½	Qgd	D	-	-	-	600	Do.
31-5	NE SW	Henry VanEnkevart	-	-	20	1½	Qgd	D	-	-	-	600	Do.
32-1	NW NE	City of Escanaba	Ranney Co.	1948	75	6	Qgd	Tw	-	-	-	582	
35-1	NE NE	Trinity Lutheran Church	-	-	12	36	Qgd Or	P	6.3	M	10-14-58	615	Bedrock near surface.
36-1	NW SW	Wilmer Larson	O. Deganeffe	-	300	6	Or	D	5.95	M	10-14-58	615	Do.
39N 21W													
1-1	SE NE	John Fallstrom	-	-	12	72	Qgd Or	DS	5	M	10-10-58	660	Do.
8-1	SW NW	John Wagner	-	1910	640	-	-	Ti	-	-	-	670	
8-2	SW NW	do.	Gunter and Skaug	1910	848	-	-	Ti	-	-	-	670	
8-3	SW NW	do.	-	-	14	72	Qgd Or	D	4	M	10-14-58	670	Bedrock near surface.
11-1	NE NW	Bungalow School	-	1938	29	36	Qgd Or	P	-	-	-	700	Do.
11-2	NE NW	do.	-	-	300	6	Or	P	-	-	-	700	
11-3	NE SW	U. S. Forest Service	G. Brunner	1938	35	6	Or	P	14	R	-	730	Bedrock at 4 ft.
11-4	SW NE	A. V. Purzol	C. O. Rice	1958	745	6	Otb	D	90	R	10-15-58	730	High sulfate content at 90 ft. High chloride content at 400 ft.
23-1	SE SE	Warner Okerlund	do.	1958	40	5	Or	D	1	R	11-25-58	625	Bedrock at 10 ft.
23-2	SE SW	T.B.B. Erickson	-	-	10	96	Qgd Or	D	4	M	10-14-58	630	Bedrock near surface.
28-1	NW NW	Stack Smith	Tom Rice and Son	1948	100	5	Or	D	-	-	-	625	
29-1	NW NE	Mayer Jacobson	C. O. Rice	1953	751	6	Oat	S	-	-	-	615	Flows.
30-1	NE NE	Stanley Thoreson	M. Gunter	1900	1400	3	Єm	Ti	+3	M	10-14-58	610	Do.
39N 20W													
18-1	SE SW	Gerald Strik	C. O. Rice	1958	55	5	Or	D	-	-	-	585	Bedrock at 34 ft.
39N 19W													
14-1	NE NW	A. C. Hoy	Tom Rice and Son	1947	100	-	Sb	D	-	-	-	595	Bedrock at surface.
23-1	NE NE	Leo Mercier	-	-	50	6	Sb	P	-	-	-	600	
23-2	NE SE	Joe Rochefort	-	-	112	6	Sb	P	-	-	-	640	
23-3	SE NE	Puffy Creek School	-	-	100	5	Sb	P	-	-	-	630	Bedrock near surface.
26-1	SE SW	John LaSalle	-	-	165	5	Sb	D	-	-	-	700	
33-1	NE SE	do.	C. O. Rice	1958	79	5	Sb	D	9.87	M	9-30-58	585	Bedrock at 20 ft.
35-1	NW SW	South River School	-	-	120	6	Sb	P	-	-	-	660	
36-1	NW NW	Robert Watchorn	-	-	117	6	Sb	DS	44.35	M	10- 1-58	615	
39N 18W													
5-1	NW SE	Lawrence Anderson	Elwin Anderson	-	84	5	Sb	D	-	-	-	640	Bedrock at 4 ft.
5-2	NE SW	Alpha Thebeau	Tom Rice and Son	1947	80	4	Sb	D	-	-	-	640	Bedrock near surface.
7-1	NW NW	W. C. DeGroot	C. O. Rice	1956	140	5	Sb	D	30	R	9-10-58	610	Bedrock at surface.
7-2	NE SE	William Sweer	-	-	75	6	Sb	P	-	-	-	590	
7-3	NE SE	do.	-	-	260	5	Sb	P	-	-	-	590	
7-4	SE SE	Louis VanWinkle	G. W. Gray	1905	233	5	Sb	P	+18	R	1905	590	Flow, 60 gpm.
7-5	NE SE	Village of Garden	C. O. Rice	1950	295	6	Sc	P	-	-	-	590	
7-6	NE SE	Richard Hermes	do.	1958	212	5	Sb	D	10	R	9-11-58	595	Bedrock at surface.
7-7	SE SE	James Dutch	do.	1958	112	5	Sb	D	-	-	-	-	
8-1	SW SW	Herbert Sill	-	1945	65	4	Sb	D	-	-	-	590	
8-2	SE SE	Paul Guertin	Elwin Anderson	1952	115	5	Sb	D	-	-	-	650	Bedrock at 3 ft.
8-3	SW SW	Alfred LaVallee	-	-	155	5	Sb	D	-	-	-	600	
10-1	SW SW	Harry Greene	Tom Rice and Son	1947	65	5	Sm	DS	-	-	-	640	Bedrock near surface.
12-1	NW NE	Anna Rokowski	Elwin Anderson	1940	100	6	Sm	DS	35	R	- -10-40	670	Bedrock at 20 ft.
13-1	NE NW	-	-	-	20	240	Sm	I	3.5	M	9-11-58	630	Bedrock at surface.

Table 3.--Records of wells and test holes in Delta County

Well number	Location ¼ ¼ in section	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
39N 18W													
17-1	SE NW	Village of Garden	-	1940	247	6	Sb	P	+22	R	1940	590	Flows. Bedrock near surface
17-2	NE SW	do. do.	G. W. Gray	1902	195	-	Sb	P	+6	R	1905	593	Flow, 25 gpm.
17-3	NE SW	do. do.	do.	1903	220	-	Sb	P	-	-	-	595	Flow, at 193 ft.
17-4	NE SW	do. do.	do.	1905	104	5	Sb	P	-	-	-	588	Flow, 8 gpm.
17-5	NE NW	Garden School	Tom Rice and Son	1941	154	-	Sb	P	-	-	-	610	
17-6	NW SE	do.	-	-	58	5	Sb	P	9.6	M	10-10-58	605	Not used.
17-7	SW NE	Antoine Farley	-	-	120	6	Sb	D	-	-	-	600	
17-8	SW NE	Ossie Hazen	-	1944	43	6	Sb	D	-	-	-	600	
17-9	NW SE	Bondreau and Disco	G. W. Gray	1903	199	5	Sb	P	+18	R	1905	588	Flow, 30 gpm. Bedrock at 20 ft.
17-10	SW NE	Pat Purtill	Tom Rice and Son	1936	182	4	Sb	D	-	-	-	600	
17-11	SE NW	W. Stillwagen	G. W. Gray	1902	175	4	Sb	DS	+16	R	1905	592	Flow, 40 gpm.
18-1	SE SE	Fred W. Beach	-	1939	75	3	Sb	DS	-	-	-	625	
18-2	NW SE	Chester Ester	C. O. Rice	1957	66	5	Sb	D	-	-	-	590	
20-1	NW SE	Fred Beaudre	-	-	175	6	Sb	DS	-	-	-	635	
38N 24W													
1-1	NW SE	Carl Dittrich	-	-	15	1¼	Qgd	D	-	-	-	-	
3-1	SW NW	C. A. Carlson	-	1946	125	4	Otb	DS	-	-	-	700	
3-2	NE NW	Tom Tousignant	-	-	15	48	Qgd	D	-	-	-	700	
3-3	NE NW	do.	Tom Rice and Son	1946	88	5	Otb	D	-	-	-	700	High iron content at 25 ft.
3-4	SW SW	Joseph Bock	do.	1947	80	5	Otb	DS	-	-	-	690	Bedrock at 63 ft.
3-5	SW SW	Arthur VanEnkevort	Orton Deganeffe	1956	53	5	Otb	DS	5	R	1956	710	Bedrock at 47 ft.
4-1	SE SE	Wm. Kasblom	-	1944	137	4	Otb	DS	-	-	-	705	
4-2	SE SE	do.	-	-	16	36	Qgd	DS	-	-	-	705	
4-3	NW NE	C and NW RR.	-	-	15	-	Qg	B	-	-	-	699	
4-4	SW NW	Al Smith	Tom Rice and Son	1943	36	5	Otb	D	-	-	-	710	Bedrock at 31 ft.
4-5	NW NE	Fred H.Gasparick	C. O. Rice	1958	40	5	Otb	DS	-	-	-	700	Bedrock at 24 ft.
5-1	SW SW	Mich. Hwy. Dept.	-	1940	144	5	Otb	P	-	-	-	743	
5-2	SW SW	Al. Johnson	-	-	15	36	Qgd	P	-	-	-	740	
5-3	SW SW	L. R. Peltier	-	-	38	4	Otb	DS	-	-	-	740	
5-4	SE SE	E. Peterson	-	-	12	24	Qgd	D	-	-	-	740	
5-5	NW SW	Mrs. Carl Sandell	-	-	200	6	Otb	D	-	-	-	740	
5-6	SW SW	C and NW RR.	-	-	118	5	Otb	I	12.7	M	11-11-58	735	
5-7	SW SW	Bark River Co-op	Tom Rice and Son	1949	230	6	Otb	P	-	-	-	745	Bedrock at 30 ft.
6-1	SE SE	E. J. Bergman	-	-	92	6	Otb	D	-	-	-	740	
6-2	SE SE	Theolander Nelson	-	-	64	6	Otb	D	-	-	-	740	
6-3	SE NE	T. J. Swift	-	-	200	6	Otb	P	-	-	-	740	
6-4	SE SE	A. E. Anderson	-	-	172	5	Otb	P	-	-	-	740	
6-5	SE SE	Bd. of Education	-	-	29	36	Qgd	P	-	-	-	740	
6-6	SE SE	Frank Barr	Tom Rice and Son	1944	125	5	Otb	D	-	-	-	735	Bedrock at 70 ft.
7-1	NE NE	F. W. Knauf	-	1940	40	4	Otb	D	-	-	-	740	
7-2	NE NE	Fred Deracher	-	1945	175	4	Otb	D	-	-	-	740	
7-3	NW NE	Bark River Twp. Bd.	-	-	50	5	Otb	P	-	-	-	740	
7-4	NE NE	Carl Maroczkowski	Tom Rice and Son	1948	115	5	Otb	D	-	-	-	745	Bedrock at 26 ft.
7-5	SW NW	A. Mayer	-	-	-	5	Otb	D	11.1	M	11-11-58	760	Bedrock near surface.
7-6	NE NE	Roy Bergman	Tom Rice and Son	1940	45	-	Otb	D	-	-	-	740	
8-1	SW NW	J. R. Anderson	-	-	170	5	Otb	D	-	-	-	740	
8-2	SE NW	Bark River Cheese Co.	-	-	38	5	Otb	I	-	-	-	740	
8-3	NW NW	William LaVigne	-	-	100	5	Otb	D	-	-	-	740	
8-4	NE NW	Carlson's Gas Station	-	-	60	5	Otb	P	-	-	-	740	
8-5	NW NE	E. E. Erickson	-	1929	72	5	Otb	D	-	-	-	740	
8-6	NW NW	A. E. Anderson	Tom Rice and Son	1943	35	5	Otb	D	-	-	-	745	Bedrock at 32 ft.
8-7	SW NW	Pauly Cheese Co.	do.	1952	199	6	Otb	I	-	-	-	745	
9-1	NW NE	Melvin Iverson	-	1944	82	4	Otb	DS	-	-	-	690	
9-2	NW NE	do.	-	-	22	36	Qgd	D	-	-	-	690	
18-1	NE NE	Frank Myers	Tom Rice and Son	1944	120	5	Otb	DS	-	-	-	740	Bedrock at 46 ft.
19-1	SW NW	Ebrath Peterson	-	-	40	36	Qgd	DS	-	-	-	740	
19-2	SW SE	Peter Kiefasz	Tom Rice and Son	1943	93	5	Otb	DS	-	-	-	720	Bedrock at 26 ft.
20-1	SW SW	F. A. Hahn	-	-	8	36	Qg	DS	-	-	-	720	
20-2	NW SW	Sunnyside School	-	-	29	36	Qgd	P	-	-	-	720	
20-3	SW NW	do..	Tom Rice and Son	1948	130	6	Otb	P	-	-	-	720	Bedrock at 43 ft.

Table 3.--Records of wells and test holes in Delta County

Well number	Location ¼ ¼ in section	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
38N 24W													
27-1	NW SW	Julius Kwaricany	Tom Rice and Son	1944	85	5	Otb	DS	8	R	1944	690	Bedrock at 66 ft.
29-1	SW NW	Andrew Mayrchek	do.	1943	75	5	Otb	DS	-	-	-	715	Bedrock at 30 ft.
30-1	SE NE	Elmer Johnson	-	-	68	72	Otb	DS	30	R	1958	725	
30-2	NE NE	Clarence Anderson	Tom Rice and Son	1943	144	-	Otb	DS	-	-	-	720	
31-1	SW NE	Andrew Anderson	-	-	38	36	Qgd	DS	-	-	-	-	
31-2	SW SE	Arvid Nelson	-	-	32	24	Qgd	DS	-	-	-	-	
33-1	NE NW	Adolph Gonsheski	-	-	96	6	Otb	DS	-	-	-	-	
33-2	NW NW	Stanley Myers	Tom Rice and Son	1943	73	6	Otb	DS	-	-	-	670	Bedrock at 67 ft.
33-3	SE SE	Stanley Bugay	-	1934	12	36	Qgd	DS	-	-	-	660	
33-4	SE SE	do.	-	1944	60	4	Otb	DS	-	-	-	660	
34-1	SW SW	Stanley Grzyb	Tom Rice and Son	1946	46	5	Otb	D	-	-	-	660	Bedrock at 35 ft.
38N 23W													
1-1	SE SW	Mich. Hwy. Dept.	-	-	8	-	-	B	-	-	-	583	
1-5	NE NW	Escanaba Airport	-	-	370	-	Oat	P	-	-	-	590	
6-1	SW NW	Carl Scheenaman	-	-	140	6	Otb	DS	-	-	-	700	
12-1	SW NE	C. O. Rice	C. O. Rice	1952	710	6	Ꞓm	P	+15	R	1958	595	Flow, 130 gpm.
12-2	NE SW	H. E. Flath	do.	-	725	5	Ꞓm	D	-	-	-	595	Flows. Bedrock at 70 ft.
14-1	NW SW	M. Flodin	Orton Deganeffe	1956	75	5	Otb	D	9	M	6-12-56	590	Bedrock at 22 ft.
14-2	NW SE	George Ventura	Fred Rice	1955	44	4	Otb	-	+1	R	5-13-55	590	Bedrock at 4 ft.
14-3	SE NE	Breezy Point Inn	-	-	49	5	-	P	-	-	-	590	
15-1	SE SE	August Janke	C. O. Rice	1957	49	6	Otb	D	-	-	-	590	Bedrock at 32 ft.
16-1	NW SE	Ford River Twp.	-	-	8	96	Qgd	P	0	R	1949	610	Improved spring.
16-2	NW SE	do.	Dunbar and Francis	1949	709	8	Ꞓm	P	+21.2	R	1949	603	
16-3	NE NE	Julius Flath	-	-	66	6	Otb	D	-	-	-	-	
20-1	- NW	Jim Hider	-	-	22	36	Qgd	D	-	-	-	-	
20-2	NE NW	Clarence Landi	Tom Rice and Son	1944	135	5	Otb	DS	-	-	-	610	Bedrock at 43 ft.
29-1	SE SW	Gabriel Nilson	Orton Deganeffe	1956	300	5	{Otb Oat	D	4.5	R	5-31-56	590	Flows. Saline at 120 ft. Flows. Fresh at 300 ft.
30-1	NE NW	G. L. Simpson	-	-	58	5	Otb	P	-	-	-	590	
31-1	SE SW	Island View	-	-	16	4	-	P	-	-	-	595	
32-1	SE NW	Stardust Lodge	-	-	200	6	Otb	P	-	-	-	590	
32-2	SE NW	do.	-	-	250	4	Otb	P	-	-	-	590	
38N 22W													
6-1	NW NE	City of Escanaba	Ranney Co.	1948	41	6	Qgd	Tw	8	R	1948	589	
6-2	NE SW	do.	do.	1948	45	6	Qgd	Tw	5	R	1948	586	
12-1	NE NW	South School	-	-	20	24	Or	P	5.5	M	10-14-58	610	Bedrock at surface.
13-1	NW NE	E. E. Ostrum	-	-	20	60	Or	D	-	-	-	610	Do.
13-2	SE NW	Richard Olsen	-	-	18	48	Or	D	-	-	-	600	Do.
13-3	NE NW	Skaug Bros.	-	-	190	6	Or	DS	9.35	M	10-14-58	610	
24-1	NW SE	U. S. Forest Service	-	1941	36	6	Or	PO	2.91	M	7-24-58	588	Do.
24-2	NW SE	do.	-	1937	95	5	Or	P	-	-	-	587	Plugged.
24-3	NW SE	do.	-	-	39	6	Or	P	6.54	M	7-24-58	587	
38N 21W													
7-1	SW NE	A. E. Hersel	Tom Rice and Son	-	105	5	Or	D	5	R	1958	585	Bedrock at 10 ft.
8-1	NW SE	C. G. Norman	-	-	9	36	Qgd	D	-	-	-	585	
8-2	SE NW	Henry Frost	C. O. Rice	1957	52	5	Or	D	-	-	-	585	Bedrock at 11 ft.
38N 19W													
4-1	SW SW	Carl VanRemortal	Tom Rice and Son	1947	45	-	Sb	D	-	-	-	630	Bedrock at surface.
5-1	NE NE	Escanaba Paper Co.	-	-	41	6	Sb	P	31.15	M	11- 1-58	614	Do.
9-1	SW SW	Donald Zehron	Elwin Anderson	-	61	6	Sb	D	-	-	-	630	Bedrock at 17 ft.
9-2	SW SW	Harley Dalgord	C. O. Rice	1957	107	6	Sb	D	-	-	-	630	
9-3	NW NW	Glen Thill	Elwin Anderson	1952	50	6	Sb	D	-	-	-	603	Bedrock at 31 ft.
11-1	SW SW	John Sowa	do.	-	127	6	Sb	S	31.6	M	10-10-58	630	Bedrock at surface.
16-1	NW NW	Rasmussen School	-	-	80	5	Sb	P	44.4	M	10-10-58	630	
16-2	NW NW	Axel Rasmussen	Elwin Anderson	1949	99	6	Sb	DS	-	-	-	630	Bedrock at 37 ft.
16-3	SW SW	William Smith	Tom Rice and Son	1946	85	5	Sb	DS	-	-	-	620	Bedrock at 16 ft.
18-1	SW SE	Richard Collins	Elwin Anderson	1944	285	6	Sb	DS	-	-	-	770	Bedrock near surface.
20-1	SE NE	Pilgrim Holiness Church	do.	-	115	5	Sb	P	-	-	-	640	Do.
20-2	NE NE	William Watchorn	do.	-	117	5	Sb	DS	-	-	-	630	Do.

Table 3.--Records of wells and test holes in Delta County

Well number	¼ ¼ Location in section	Owner	Driller	Year drilled	Depth (ft.)	Diameter (in.)	Aquifer	Use	Water level	M or R	Date	Altitude	Remarks
38N 19W													
21-1	NW NW	Pauley Cheese Co.	Elwin Anderson	1933	165	5	Sb	I	-	-	-	630	Bedrock at surface.
21-2	NW NW	do.	-	1948	112	6	Sb	I	50	R	1958	630	
31-1	NE NE	Wessels Resort	-	-	65	-	Sb	P	-	-	-	590	
37N 24W													
1-1	SW SW	Ford River Cemetery	Tom Rice and Son	1946	106	5	Otb	P	-	-	-	600	Bedrock at 53 ft.
10-1	SE NW	Ted DeGrave	-	-	51	6	Otb	D	3.4	M	11-11-58	635	
12-1	NE NE	Ernest Dickson	-	-	18	5	-	DS	11.5	M	11-11-58	590	Abandoned.
23-1	SW SW	John Costell	C. O. Rice	1957	43	5	Otb	P	-	-	-	600	High iron content.
23-2	SW SW	do.	Frank Kozikowski	1958	35	4	Otb	P	7.04	M	11-13-58	600	Bedrock at 26 ft.
27-1	NE NE	Mich. Hwy. Dept.	-	-	28	-	Qgd	B	-	-	-	598	
27-9	NE NE	Fuller Park	Tom Rice and Son	1935	286	-	Otb	P	+3	R	1958	600	Flow, 1 gpm.
34-1	SE NW	George Halstead	C. O. Rice	1955	350	5	Oat	P	+40	R	1958	590	Flow, 20 gpm.
34-2	SW SW	Robert Coplan	do.	1958	300	5	Oat	D	-	-	-	590	Flow, 5 gpm.
37N 19W													
4-1	SW SW	Francis Thill	Tom Rice and Son	1948	76	5	Sb	D	-	-	-	590	Bedrock near surface.
5-1	SE SE	Frank Devet	Elwin Anderson	1944	33	6	Sb	D	-	-	-	590	Do.
5-2	SE SE	Fairport School	do.	1948	114	5	Sb	P	-	-	-	590	Do.
9-1	NW NE	Edward Thalman	do.	1944	30	6	Sb	D	-	-	-	590	Do.

Table 4.--Logs of wells and test holes in Delta County

Thickness in feet. Depth in feet below land surface.

Fm, formation (see table 1); Gr, group.

Altitude in feet above mean sea level.

MDC log, Log condensed from detailed log available upon application to the Michigan Department of Conservation, Geological Survey Division, Lansing.

	Thick-ness	Depth
43N 23W 34-1 Alt. 960		
Glacial drift:		
Clay	5	5
Trenton-Black River fms:		
Limestone	295	300
Au Train fm:		
Sandstone	65	365
43N 23W 35-1 Alt. 970		
Trenton-Black River fms:		
Limestone	98	98
Dolomite	32	130
Limestone	10	140
Dolomite	35	175
Limestone	10	185
Dolomite	25	210
Au Train fm:		
Dolomite	30	240
Dolomite, sandy	25	265
Dolomite	25	290
Dolomite, oolitic	10	300
Dolomite, sandy	20	320
Dolomite, oolitic	30	350
Dolomite	10	360
Glauconite	15	375
Dolomite, sandy	25	400
Dolomite	10	410
Dolomite, sandy	10	420
Dolomite	25	445
Dolomite, sandy	15	460
Glauconite	15	475
Dolomite, sandy	10	485
Dolomite	15	500
Glauconite	10	510
Dolomite, sandy	25	535
Munising fm:		
Sandstone, cross-bedded, high garnet content	75	610
Precambrian: at		610
42N 22W 26-2 Alt. 770		
Glacial drift:		
Till	9	9
Trenton-Black River fms:		
Limestone	231	240
Au Train fm:		
Sandstone	10	250
Sandstone, calcareous	16	266
Limestone, sandy	24	290
Sandstone	3	293
Limestone, sandy	7	300
Sandstone, calcareous	16	316
Sandstone	31	347
Limestone	12	359
Sandstone	44	403
Limestone, sandy	17	420
Limestone	76	496
42N 22W 26-2 (Continued)		
Munising fm:		
Sandstone, calcareous	4	500
Sandstone	46	546
Sandstone, pebbly	44	590
Precambrian: at		590
42N 20W 31-1 Alt. 730		
Glacial drift:	12	12
Trenton-Black River fms:		
Limestone, dark, sandy	218	230
Limestone, brown and blue	60	290
No record	12	302
Au Train fm:		
Sandstone, white, rounded quartz grains	18	320
Limestone, white, fine-grained, massive	35	355
Sandstone, white, clean	65	420
Limestone, white, sandy	10	430
Sandstone, white, clean; quartz	20	450
Sandstone, white; dolomitic powder	25	475
Sandstone, white, dolomitic	25	500
Sandstone, dolomitic cement	30	530
Slate, dull blue	25	555
No record	75	630
Munising fm:		
Sandstone, gray; rounded quartz particles	45	675
Sandstone, red to pink	35	710
Sandstone, white	15	725
Sandstone, pink to red, water-bearing	25	750
Sandstone	30	780
Precambrian: at		780
42N 19W 7-1 Alt. 945		
Glacial drift:		
Sand	140	140
Clay, red, and sand	126	266
Trenton-Black River fms (?):		
Rock, soft	3	269
42N 18W 17-1 Alt. 765		
Glacial drift:		
Sand, coarse	30	30
Quicksand	10	40
Sand, fine, and clay	40	80
Sand, fine, clay, pebbly	16	96
Sand, fine, dry	14	110
42N 18W 17-1 (Continued)		
Rock and clay	11	121
Richmond gr:		
Limestone	164	285
41N 23W 32-3 Alt. 800		
Glacial drift:		
Boulders	10	10
Till, red	10	20
Till, white	2	22
Trenton-Black River fms:		
Shale, blue	15	37
Limestone, hard	20	57
41N 22W 23-1 Alt. 720		
Glacial drift:		
Sand, white	75	75
Till, white	10	85
Trenton-Black River fms:		
Limestone	102	187
Shale	63	250
Limestone	80	330
Au Train fm:		
Sandstone with limestone layers	45	375
Limestone with sandstone layers	25	400
Sandstone, purple at		400
41N 21W 20-9 Alt. 595		
Glacial drift:		
Sand, clayey	1	1
Trenton-Black River fms:		
Limestone, light-gray to buff, soft, chalky	44	45
Limestone, gray, shaly; fossiliferous	20	65
Limestone, dark-gray; fossil fragments	10	75
Limestone, dark-gray, shale partings	50	125
Limestone, dark-gray	50	175
Limestone, buff, sugary texture, crystalline, pyritic, water-bearing	5	180
Limestone, gray, soft; shale partings	10	190
Limestone, dark-gray	10	200
Limestone, brown to brownish-gray	10	210
Limestone, gray; shale partings	10	220
Au Train fm:		
Sandstone, medium-grained, rounded, frosted, and limestone	20	240
Sandstone, fine to medium-grained, rounded frosted, very limy	10	250

Table 4.--Logs of wells and test holes in Delta County, Continued

	Thickness	Depth
41N 21W 20-9(Continued)		
Sandstone, medium to coarse-grained, all quartz, frosted, well-rounded, clean, water-bearing	20	270
Sandstone, medium-grained, clean, and limestone, iron-stained	10	280
Sandstone, fine- to medium-grained, very limy	5	285
Sandstone, fine- to medium-grained, limy	10	295
Sandstone, medium-grained, and limestone, clean, iron-stained	10	305
Limestone, and much iron-stained sand	10	315
Limestone, and fine iron-stained sand	10	325
41N 21W 29-22 Alt. 600		
Glacial drift:		
Till, red	7	7
Trenton-Black River fms:		
Rock, blue, layered, hard	16	23
Limestone, white, hard	27	50
Limestone, blue, medium-hard	40	90
Limestone, blue, hard	10	100
Rock, blue, hard	85	185
Au Train fm:		
Sandstone, brown	10	195
Rock, blue, hard	50	245
Sandstone	20	265
Limestone	8	273
41N 19W 20-1 Alt. 630		
Glacial drift:		
Sand	16	16
Richmond gr:		
Limestone	204	220
Shale, light	135	355
Trenton-Black River fms:		
Limestone, white	280	635
Au Train fm:		
Sandstone, water-bearing	145	780
Limestone	20	800
Sandstone, red	5	805
Limestone, sandy	115	920
Sandstone, soft	10	930
Limestone, broken	26	956
Limestone	34	990
Munising fm:		
Sandstone, white, water-bearing	165	1155
Sandstone, red	5	1160
40N 22W 21-3 Alt. 605		
Glacial drift:		
Sand	13	13
Quicksand	38	51
40N 22W 21-3 (Continued)		
Till	11	62
Sand and gravel	15	77
Clay and limestone	10	87
Boulders	4	91
Trenton-Black River fms:		
Limestone	234	325
Au Train fm:		
Limestone and sandstone interlayered, water-bearing at 400 ft.	89	414
Limestone	228	642
Munising fm:		
Sandstone, white, (150 gpm flow of water from 742 ft.)	101	743
40N 22W 22-2 Alt. 585		
Glacial drift:		
Sand	45	45
Clay, brownish-gray, silty	8	53
Clay, buff, limy, silty	33	86
Sand, fine-grained, pebbles masked with clay	15	101
Trenton-Black River fms:		
Limestone, light-gray to buff	24	125
Limestone, very light-gray to white, very soft; resembles chalk (flow of fresh water from 130 ft.)	20	145
Limestone, gray, fossiliferous	5	150
Shale, gray, limy	15	165
Limestone, gray, fossils	5	170
Shale, greenish-gray; lime partings	45	215
Limestone, gray to dark-gray, fossiliferous	5	220
Limestone, brown, dolomitic	5	225
Shale, gray to dark-gray, limy (strong flow of fresh water from 230 ft.)	20	245
Dolomite, buff to brown, silty, (flow of fresh water)	65	310
Au Train fm:		
Dolomite, gray-brown, porous	10	320
Sandstone, white, medium- to fine-grained	40	360
Dolomite, tan	5	365
Sandstone, white, medium- to very fine-grained (flow of fresh water)	55	420
Dolomite, gray, tan, and white; some sandy layers	45	465
40N 22W 22-2 (Continued)		
Sandstone, white, medium-grained	35	500
Dolomite, brown-gray-white, broken, some sandy layers	135	635
Munising fm:		
Sandstone, gray to white, medium- to very fine-grained; some dolomitic cement (flow of fresh water)	95	730
40N 22W 26-1 Alt. 580		
Water (Little Bay de Noc)	32	32
Glacial drift:		
Clay, dark-gray, very sandy	39	71
Trenton fm:		
Limestone at		71
39N 23W 28-5 Alt. 691		
Trenton-Black River fms:		
Dolomite, light- to dark-gray dolomite	240	240
Au Train fm:		
Sandstone, cream-colored; dolomitic cement, porous	2	242
Dolomite, gray and buff	3	245
Dolomite, cream-colored, sandy	20	265
Slate, green and buff, banded	2	267
Dolomite and sandstone, interbedded	5	272
Dolomite, gray	6	278
Sandstone, cream-colored; dolomitic cement, porous	2	280
Dolomite and sandstone, interbedded	5	285
Dolomite, sandy	30	315
Dolomite, gray	15	330
Sandstone, dolomitic	5	335
Dolomite, gray	10	345
Dolomite and sandstone, interbedded	10	355
Dolomite, gray	15	370
Sandstone, dolomitic	10	380
Dolomite; crystal coatings	8	388
Sandstone, dark-gray, dolomitic	27	415
Dolomite, gray	20	435
Dolomite; crystal coatings	55	490
Dolomite, light-red; crystal coatings	5	495
Dolomite, red, sandy	25	520
Munising fm:		
Sandstone, dolomitic cement, very large-grained at 535 ft.	25	545
Precambrian: at		545
39N 23W 28-6 Alt. 691		
Trenton-Black River fms:		
Dolomite, light- and dark-blue to gray	290	290

Table 4.--Logs of wells and test holes in Delta County, Continued

	Thickness	Depth
39N 23W 28-6 (Continued)		
Au Train fm:		
Sandstone, cream-colored, dolomite	40	330
Sandstone, white	10	340
Dolomite, gray, banded	5	345
Sandstone, dolomitic	25	370
Dolomite, sandy	25	395
Sandstone, dolomitic	15	410
Dolomite, sandy	20	430
Sandstone, dolomitic	15	445
Dolomite, sandy	35	480
Dolomite, dark	20	500
Munising fm:		
Sandstone, red and gray	75	575
Sandstone, dolomitic, uniformly coarse grained	5	580
Sandstone, red	40	620
Precambrian: at		620
39N 22W 6-6 Alt. 630		
Glacial drift:		
Sand, fine	25	25
Sand, medium, and fine gravel	10	35
Clay, red	20	55
Till, brown	5	60
Till, light-gray, (gravel near bottom)	18	78
Trenton-Black River fms:		
Limestone, gray, hard (creviced at 85 ft.)	7	85
Limestone, gray, hard	49	134
39N 22W 18-2 Alt. 590		
Glacial drift:		
Sand and gravel	59	57
Sand and clay, yellowish-gray	8	65
Trenton-Black River fms:		
Dolomite, light-gray to gray	220	285
Au Train fm:		
Sandstone, gray, medium- to fine-grained (yields soft water)	65	350
Dolomite, light-gray, sandy	10	360
Sandstone, light-gray, fine- to medium-grained	5	365
Dolomite, light-gray, sandy, (large flow of water from 391 ft.)	61	426
Sandstone, light-gray, fine- to medium-grained, very dolomitic (small flow of water)	19	445
Dolomite, light-gray	30	475
Dolomite, gray to pink, very sandy	130	605
Munising fm:		
Sandstone, light-gray, medium- to coarse-grained, dolomitic, several flows soft water	65	670
39N 22W 18-2 (Continued)		
Sandstone, white, medium-grained, sulfur water at 720 ft.	75	745
Sandstone, white to pink, medium to very coarse grained	11	756
Conglomerate, gray	4	760
Precambrian: at	-	760
Plugged back to 665 ft.		
39N 22W 18-3 Alt. 620		
Glacial drift:		
Sand, light-gray to reddish-yellow, (water from 16-52 ft.)	52	52
Clay, light-brown to red	18	70
Trenton-Black River fms:		
Limestone, gray to buff	174	244
Dolomite, gray to buff	86	330
Au Train fm:		
Dolomite, gray, sandy	15	345
Dolomite, sandy	10	355
Sandstone, gray to white	70	425
Dolomite, gray to buff, sandy	35	460
Sandstone, white to light-gray	10	470
Dolomite, light-buff to gray, sandy	160	630
Munising fm:		
Sandstone, white to gray	165	795
Precambrian: at		795
39N 22W 19-1 Alt. 625		
Glacial drift:		
Sand, yellow, pink, and white, gravelly	84	84
Trenton-Black River fms:		
Limestone, light-brown	6	90
No record	105	195
Dolomite, gray to light-brown	120	315
Au Train fm:		
Sandstone, gray, unsorted	37	352
Dolomite, buff, dense, shale traces	5	357
Sandstone, white, fine- to coarse-grained, a little buff dolomite	20	377
Dolomite, buff, dense to crystalline	78	455
Sandstone, white to gray, dolomitic cement	25	480
Dolomite, brown to buff, crystalline, sandy	142	622
Munising fm:		
Sandstone, gray, fine- to medium-grained, traces of shale	153	775
39N 22W 29-1 Alt. 590		
Glacial drift:		
Sand, yellow, white, and pink, unsorted, gravelly (inflammable gas under thin layer of clay; Upon ignition flame was about 30 ft above casing. Hole filled with water but flow of gas continued for 48 hours.)	89	89
Mud, brown	1	90
Trenton-Black River fms:		
Dolomite, light-brown, crystalline (water rose to surface but did not flow)	55	145
Limestone, gray, dense	20	165
Dolomite, gray to brown, some limestone	153	318
Au Train fm:		
Sandstone, white, medium- to coarse-grained, (flowed 4 gpm in first 10 ft.)	102	420
Dolomite, gray-brown to buff, dense; a little green shale	87	507
Sandstone, white, unsorted; some dolomite; a little green shale	48	555
Dolomite, brown to buff and gray, dense to finely crystalline (flow of water from 656 ft.)	101	656
Munising fm:		
Sandstone, white, unsorted, some brown dolomite (55 gpm flow of water, mainly from 565 to 681 ft.)	97	753
39N 22W 29-2 Alt. 588		
Glacial drift:		
Sand, fine to medium	66	66
Sand, very fine, silty	20	86
Clay	10	96
Trenton-Black River fms: at		96
39N 22W 29-3 Alt. 587		
Fill, fine sand, etc.	20	20
Glacial drift:		
Sand, fine, gray, silty	35	55
Sand, fine, black, clayey, silty	2	57
Sand, fine to medium, gray, clean	13	70
Clay, black	2	72
Sand, fine, yellow	5	77
Clay, black, sticky	6	83
Sand, fine to medium, gray	1	84
Clay, black, soft, with layers of hardpan	10	94
Trenton-Black River fms: at		94

Table 4.--Logs of wells and test holes in Delta County, Continued

	Thickness	Depth
39N 22W 29-5 Alt. 588		
Glacial drift:		
Sand, fine, yellow	60	60
Sand, medium, yellow	8	68
Sand, fine, yellow	8	76
Clay	2	78
39N 22W 29-7 Alt. 587		
Glacial drift:		
Sand, fine to medium, dirty	30	30
Sand, fine to medium	30	60
Sand, fine, and muck	1	61
Sand, fine to medium, gravelly, pieces of muck	14	75
Sand, fine to coarse, gravelly	6	81
Sand, gravel, and boulders	4	85
Sand, fine to medium, gravelly	7	92
Trenton-Black River fms:	at	92
39N 22W 29-9 Alt. 590		
Glacial drift:		
Sand, yellow to red, coarse	40	40
Gravel	10	50
Clay, pink, limy	35	85
Gravel, sandy, very coarse near bottom	21	106
Trenton-Black River fms:		
Limestone, gray to buff, hard, with white crystalline masses, shaly near bottom	54	160
Shale, greenish-gray, limy	10	170
Limestone, buff-gray, shaly	10	180
Shale, gray to dark-gray, limy	80	260
Limestone, light-buff to gray, shaly	60	320
Shale, greenish-gray, limy	50	370
Au Train fm:		
Limestone, light- to dark-buff and gray with sandy phases and streaks of dolomitic sandstone (flow of water)	10	380
Dolomite, light-buff (large flow of water at 391 ft.)	15	395
Sandstone, white, fine-grained, soft, dolomitic	15	410
Dolomite, white, hard; sandy streaks (flow of soft water at 430 and 450-480 ft.)	70	480
Sandstone, white; streaks of dolomite	20	500
Dolomite, buff and gray; sandy streaks	30	530
Sandstone, white, very fine grained, dolomitic	10	540
39N 22W 29-9 (Continued)		
Dolomite, buff to gray; streaks of red shale; sandy at bottom (several shows of soft water 605-635 ft.)	95	635
Munising fm:		
Sandstone, white to gray, limy (flow of soft water at 650 ft; sulfur water at 670 ft.; main water-bearing horizon reported from 730 to 795 ft.)	160	795
Shale, red, slightly limy	5	800
Sandstone, red and white, fine- to medium grained	30	830
Sandstone, gray, probably water-bearing	24	854
Precambrian:	at	854
39N 22W 30-2 Alt. 611		
Glacial drift:		
Sand, pink, yellow, white, unsorted	40	40
Clay, red, limy, gravelly	25	65
Gravel and unsorted sand	10	75
Clay, red, gravelly, sandy	3	78
Gravel	4	82
No record	78	160
Trenton-Black River fms:		
Limestone, gray to brown, dense	60	220
Dolomite, buff, crystalline	50	270
No record	28	298
Au Train fm:		
Dolomite, light-brown, crystalline	42	340
Sandstone, white to buff; streaks of dolomite and green shale	85	425
Dolomite, light-brown to dark-gray, dense to crystalline, thin sandstone lenses	240	665
Munising fm:		
Sandstone, gray	at	665
39N 22W 30-3 Alt. 615		
Glacial drift:		
Sand, gravelly	50	50
Clay, red, limy, and some gravel	20	70
Sand, dolomitic	20	90
Trenton-Black River fm:		
Limestone, light-buff, dense	30	120
Dolomite, light-buff, crystalline	20	140
39N 22W 30-3 (Continued)		
Limestone, gray, dense, shaly	90	230
Dolomite, gray and brown	94	324
Shale, greenish-gray	4	328
Dolomite, buff, dense, some quartz grains, a little green shale	25	353
Au Train fm:		
Sandstone, white to buff, unsorted traces of dolomite and green shale	147	500
Dolomite, gray to buff, dense to crystalline	146	646
Munising fm:		
Sandstone, white to gray, some sandy dolomite	170	816
39N 22W 31-2 Alt. 585		
Glacial drift:		
Sand, fine to medium	30	30
Clay	12	42
Gravel	1	43
Trenton-Black River fms:	at	43
39N 22W 32-1 Alt. 582		
Glacial drift:		
Sand, fine, yellow	35	35
Sand, medium, yellow	25	60
Sand, fine	13	73
Clay	2	75
39N 21W 8-1 Alt. 670		
Glacial drift:		
Gravel and clay	9	9
Richmond gr:		
Shale, blue	45	54
Shale, fossiliferous	13	67
Shale, brown	28	95
Shale, blue	20	115
Shale, brown	8	123
Shale, gray	70	193
Shale, light-gray	8	201
Shale, bituminous	50	251
Trenton-Black River fms:		
Limestone	83	334
Limestone, fossiliferous	55	389
Limestone, white	8	397
Limestone, dark, with quartz geodes (?)	15	412
Limestone, with quartz geodes	45	457
Limestone	24	481
Shale, blue	4	485
Limestone, black	14	499
Limestone	19	518
Shale, blue	4	522
Sandstone, and limestone	38	560
Shale, red	1	561
Shale, sandy	1	562
Limestone, and sandstone	66	628
Limestone, crystalline	12	640
39N 21W 29-1 Alt. 615		
Richmond gr:		
Limestone	20	20

Table 4.--Logs of wells and test holes in Delta County, Continued

	Thickness	Depth
39N 21W 29-1 (Continued)		
Shale	300	320
Trenton-Black River fms:		
Limestone interbedded with shale layers	80	400
Limestone	300	700
Au Train fm:		
Sandstone interbedded with thin hard limestone layers	51	751
38N 23W 16-2 Alt. 601		
Gravel fill:		
Glacial drift:	3	3
Sand, medium, and black muck	7	10
Sand, fine	4	14
Gravel, coarse, and sand, bouldery	3	17
Boulders, clay, and fine sand	2	19
Clay, hardpan, red, gravelly, dry	4	23
Trenton-Black River fms:		
Rock, bears a good flow of red water	1	24
Rock, gray, very hard	2	26
Soft layer	1	27
Rock, grayish-brown, very hard	11	38
Rock, soft	1	39
Rock, gray, very hard (dolomite?)	2	41
Limestone, grayish	5	46
Limestone, grayish, very hard	14	60
Limestone or dolomite, dark-gray	14	74
Limestone, dark-gray	17	91
Limestone, gray, shale layers	24	115
Shale, hard limestone layers, fossils	8	123
Limestone, blue, very hard	11	134
38N 23W 16-2 (Continued)		
Shale and limestone, light-gray, soft	27	161
Limestone, gray, hard	17	178
Limestone, dark-gray; layers of soft shale	27	205
Limestone, light-gray	30	235
Limestone, gray, hard	22	257
Sandstone, interbedded with limestone	28	285
Shale, blue and red layers	4	289
Limestone, gray, very hard	2	291
Shale, red, soft	1	292
Shale, red, interbedded with limestone	3	295
Sandstone, reddish	2	297
Limestone, hard, and sandstone	3	300
Limestone, gray, very hard	5	305
Sandstone, shale and limestone layers	20	325
Limestone, dark-gray, sandstone layers	22	347
Au Train fm:		
Sandstone, white, with gray streaks	3	350
Sandstone, gray, shaly	10	360
Limestone (or dolomite), gray, shaly	65	425
Sandstone, grayish-white	30	455
Limestone, gray, sandstone layers	10	465
Limestone, gray	55	520
Limestone, very light brown	37	557
Munising fm:		
Sandstone, pink, soft	8	565
Clay, cinnamon-colored	3	568
Sandstone, pink	7	575
Sandstone, red	30	605
Sandstone, gray with black flecks	10	615
Sandstone, gray	20	635
38N 23W 16-2 (Continued)		
Shale, red, sandy, soft	10	645
Sandstone, soft, red, grading to pink, (flow of water, 11 gpm)	67	712
Sandstone, pink, fine-grained; no additional water	18	730
Sandstone, pink, strong phenolic medicinal odor, (plugged back to 709 ft.)		
38N 22W 6-1 Alt. 589		
Glacial drift:		
Sand, yellow, fine to medium	22	22
Sand, yellow, medium to coarse, fine to coarse gravel increasing quantity at depth, boulders	12	34
Clay, red	7	41
Trenton-Black River fms:	at	41
38N 22W 6-2 Alt. 586		
Glacial drift:		
Sand, fine to coarse	28	28
Sand, gravel, and boulders	1	29
Clay	16	45
Trenton-Black River fms:	at	45
37N 24W 27-1 Alt. 598		
Glacial drift:		
Sand, yellow, fine	3	3
Gravel, coarse, medium to coarse, and yellow sand	4	7
Clay, red, medium, firm	2	9
Clay, red, firm, sand, and gravel	5	14
Sand, red, medium, and red clay, very gravelly	9	23
Boulders, large, and medium-red sand; bedrock fragments	5	28

Table 5.--Chemical analyses of ground-water samples in Delta County

Aquifer: See table 1.

Depth: Sampling point in well, in feet below land surface. Where depth is not indicated, sample was collected from pump discharge or flow at well head.

Analyst: M, Michigan Department of Health; U, U. S. Geological Survey.

Potassium: + indicates potassium (K) included in value listed under sodium (Na).

Well number	Aquifer	Depth	Analyst	Date collected	Chemical constituents (parts per million)													pH	Specific conductance (micromhos at 25°C)	Temperature (°F)
					Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total solids	Hardness as $CaCO_3$			
43N 23W																				
6-1	Otb	-	M	10-24-58	-	-	56	27	7	-	312	0	2	-	-	-	250	-	500	-
21-3	Qgd	-	M	3- 3-53	-	14	-	-	-	-	-	-	-	-	-	-	490	-	-	-
43N 22W																				
36-1	Qgd	-	M	11- 3-58	-	-	60	26	2	-	288	15	1	-	-	-	255	-	470	-
43N 21W																				
3-1	Otb	-	M	10-20-58	-	0	62	26	2	-	288	15	0	-	-	-	260	-	500	-
43N 19W																				
1-1	Qgd	-	M	8-11-58	-	-	30	10	1.6	-	127	13	0	-	-	-	115	-	245	-
24-3	Otb	200	U	8-20-59	-	-	22	12	21	3.9	139	18	14	-	-	161	105	7.4	293	-
	Otb	250	U	8-20-59	-	-	24	12	25	4.1	150	22	18	-	-	191	110	7.5	328	-
	Otb	300	U	8-20-59	-	-	23	11	33	4.6	142	24	24	-	-	192	103	7.5	348	-
	Otb	350	U	8-20-59	-	-	24	10	42	4.9	148	29	32	-	-	225	101	7.3	400	-
	Otb	380	U	8-20-59	-	-	22	11	23	4.0	134	21	14	-	-	170	100	7.5	298	-
42N 23W																				
3-1	Otb	-	M	10-21-58	-	-	224	-	-	-	-	-	190	-	-	-	725	-	1,400	-
	Otb	-	U	12- 9-58	6.4	.09	1,440	59	52	7.3	318	43	2,500	.2	19	4,600	3840	7.3	7,720	45
7-1	Otb	-	M	10-29-58	-	-	64	24	2	-	304	6	1	-	-	-	260	-	500	-
42N 22W																				
26-2	€m	-	U	-	-	-	57	24	18	-	286	25	15	-	-	-	241	8.0	491	-
	€m	-	U	12- 9-58	9.5	.97	58	24	14	2.3	280	24	12	.2	.5	289	243	6.7	531	45.5
42N 21W																				
7-1	€m	-	M	11- 3-58	-	-	54	23	7	-	264	15	4	-	-	-	230	-	460	-
19-1	Oat	-	M	11- 3-58	-	-	50	26	15	-	264	33	12	-	-	-	230	-	510	-
33-1	Oat	-	M	11- 3-58	-	-	52	24	17	-	260	35	13	-	-	-	230	-	510	-
42N 19W																				
7-1	Or	-	M	8-12-58	-	-	32	16	4.6	-	171	13	0	-	-	-	145	-	315	45.8
41N 24W																				
2-1	€m	-	M	11- 4-58	-	-	52	23	5	-	250	20	6	-	-	-	225	-	450	-
7-1	Otb	-	M	11- 5-58	-	-	64	23	10	-	260	27	11	-	-	-	255	-	530	-
41N 23W																				
5-1	Oat	-	M	11- 4-58	-	-	56	23	4	-	268	20	1	-	-	-	235	-	460	-
33-1	Otb	-	U	12- 9-58	10	.24	63	28	22	3.0	310	53	7	.4	.3	339	272	7.1	575	-
41N 22W																				
4-1	Oat	-	M	11- 6-58	-	-	52	24	14	-	260	20	11	-	-	-	230	-	475	-
5-1	Otb	-	M	11- 6-58	-	-	74	45	22	-	342	25	67	-	-	-	370	-	800	-
9-2	Otb	-	U	8-20-59	15	.82	97	44	22	2.5	412	74	34	.1	.1	498	423	7.2	834	-
32-1	Otb	-	M	11- 6-58	-	-	66	13	4.5	-	260	0	Tr.	-	-	-	220	-	400	-
41N 21W																				
6-1	Otb	-	M	11-12-58	-	-	120	85	920	-	264	370	1,320	-	-	-	650	-	6,100	-
20-7	Oat	-	U	5-28-58	8.8	.20	51	24	14	3.3	248	27	22	.2	.2	273	226	7.5	484	-
29-22	Oat	-	M	11-11-58	-	-	68	30	56	-	190	38	155	-	-	-	295	-	900	-
30-3	Oat	-	M	-	-	-	-	-	-	-	-	-	-10	-	-	-	230	-	-	-
32-3	Otb	-	M	-	-	2.4	-	-	-	-	-	-	43	-	-	-	280	7.2	-	-
32-4	Qgd	-	M	8-26-58	-	17	-	-	-	-	-	-	210	.05	-	-	320	-	-	-
36-1	Otb	-	M	-	-	-	-	-	-	-	-	-	115	-	-	-	525	-	-	-
41N 19W																				
20-1	€m	-	U	11- 4-57	7.8	.11	67	28	66	6.3	188	47	158	.3	.4	467	282	7.6	886	-
41N 18W																				
13-1	Qs	-	M	9-16-58	-	-	170	79	27	-	110	555	52	-	-	-	750	-	1,400	-

Table 5.--Chemical analyses of ground-water samples in Delta County.--Continued

Well number	Aquifer	Depth	Analyst	Date collected	Chemical constituents (parts per million)												Hardness as $CaCO_3$	pH	Specific conductance (micromhos at 25°C)	Temperature (°F)
					Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total solids				
41N 18W																				
31-2	Or	100	M	9-18-58	-	-	2080	634	2550	-	145	1450	7,600	-	-	-	7,800	-	30,000	-
	Or	150	M	9-18-58	-	-	3,120	1,610	8,640	-	148	1,800	21,000	-	-	-	14,400	-	80,000	-
	Or	200	M	9-18-58	-	-	2,960	1,610	7,800	-	110	1,800	20,000	-	-	-	14,000	-	80,000	-
	Or	250	M	9-18-58	-	-	2,880	1,512	7,380	-	130	1,750	19,500	-	-	-	13,400	-	70,000	-
32-2	Qgd	-	M	8-15-58	-	-	58	22	3	-	254	28	Tr.	-	-	-	235	-	500	-
40N 24W																				
3-1	Otb	-	M	11- 6-58	-	-	68	23	2	-	288	20	2	-	-	-	265	-	500	-
34-1	Otb	-	M	11- 7-58	-	-	56	29	14	-	322	30	5	-	-	-	260	-	580	-
40N 23W																				
28-1	Otb	-	M	11-12-58	-	-	72	39	34	-	380	80	16	-	-	-	340	-	800	-
32-1	Otb	-	M	11-10-58	-	-	38	27	185	-	400	85	140	-	-	-	205	-	1,200	-
32-2	Otb	-	M	11-10-58	-	-	70	23	6	-	294	25	6	-	-	-	270	-	510	-
40N 22W																				
4-2	Qgd	-	M	9- 4-58	-	-	30	12	1.4	-	146	13	1	-	-	-	125	-	260	45
10-3	Oat	-	M	8-20-58	-	-	22	12	6.4	-	147	9	2	-	-	-	105	-	230	46
10-6	Oat	-	M	8-20-58	-	-	22	12	5.3	-	-	7	1	-	-	-	105	-	235	47.5
21-3	Єm	-	M	-	15	tr.	41	12	9.5	-	141	53	Tr.	-	-	248	-	-	-	-
22-2	Єm	-	M	6-18-57	8	.1	54	21	14	3.6	254	30	12	0	0	274	220	7.5	500	-
40N 21W																				
10-1	Or	-	U	12- 9-58	9.2	1.8	64	32	63	8.7	346	64	56	.4	1.7	462	291	6.7	803	45.5
40N 20W																				
20-1	Or	-	M	10-10-58	-	-	840	646	3,800	-	108	2,500	7,150	-	-	-	4,750	-	30,000	-
	Or	-	M	11-10-58	-	-	860	610	3,700	-	113	2,300	6,600	-	-	-	4,650	-	32,000	-
20-2	Or	-	M	1958	-	.1	-	-	-	-	-	-	7,400	-	-	-	4,600	-	-	-
40N 19W																				
6-1	Or	-	M	8-22-58	-	-	22	9.2	38	-	127	35	30	-	-	-	92	-	430	-
15-1	Sc	-	M	10-10-58	-	-	560	110	48	-	145	1,750	90	-	-	-	1,850	-	3,000	-
21-4	Sc	-	M	10-10-58	-	-	580	43	16	-	200	1,500	30	-	-	-	1,625	-	2,300	-
40N 18W																				
4-1	Sc	-	U	5-28-58	14	.43	302	97	35	4.5	88	1,100	10	1.2	.9	1750	1,150	7.2	1,870	-
5-1	Sc	-	M	9- 5-58	-	-	240	85	17	-	100	850	10	-	-	-	950	-	1,700	-
39N 24W																				
6-1	Oat	-	M	11- 7-58	-	-	48	24	20	-	262	25	12	-	-	-	220	-	500	-
8-1	Otb	-	M	11- 7-58	-	-	62	28	27	-	316	53	6	-	-	-	270	-	610	-
30-1	Otb	-	M	11- 7-58	-	-	72	32	7	-	300	50	14	-	-	-	310	-	600	-
35-1	Otb	-	M	11- 7-58	-	-	16	33	6	-	220	3	Tr.	-	-	-	175	-	350	-
39N 22W																				
5-1	Oat	-	M	12-16-42	6.4	tr.	33	12	7	-	135	20	7	.1	-	164	130	-	-	-
6-2	Otb	-	M	10-24-58	-	-	32	9.7	3	-	141	7	2	-	-	-	120	-	260	-
6-6	Otb	-	M	11- 5-58	-	-	20	13	9	-	140	10	3	-	-	-	105	-	260	-
6-7	Otb	-	M	11-29-56	-	1.6	-	-	-	-	-	-	12	-	-	-	140	8.0	-	-
18-2	Oat	412	M	6-16-30	45	1.4	70	37	tr.	-	318	35	17	-	-	-	320	-	-	-
	Єm	-	M	10- 6-30	6.4	-	48	24	20	-	246	36	16	-	-	270	218	-	-	-
	Єm	-	M	8-11-38	-	-	50	24	20	-	255	36	14	-	-	280	218	-	-	-
	Єm	-	U	2- 5-52	8.5	.82	50	22	14	3.7	253	29	10	.3	0	253	218	7.8	455	49
19-1	Єm	-	M	-	-	.1	-	-	-	-	-	-	13	2.0	-	-	180	-	-	-
29-1	Єm	-	M	4-16-41	9.2	.25	41	20	11	-	200	37	16	.25	-	245	185	-	-	-
29-9	Єm	-	M	12-28-22	12	-	44	19	22	-	214	36	17	-	-	252	-	-	-	-
30-2	Єm	-	M	1- 7-42	6.4	.1	47	23	12	-	217	40	12	.3	-	250	211	-	-	-
	Єm	-	U	6-19-58	10	.18	42	19	18	3.2	212	35	14	.5	.2	246	183	7.9	426	51
30-3	Єm	-	M	-	-	0	-	-	-	-	-	-	13	.4	-	-	180	-	-	-
36-1	Or	50	M	10-21-58	-	-	84	41	120	-	396	120	180	-	-	-	380	-	1,400	-
	Or	100	M	10-21-58	-	-	96	41	122	-	400	120	160	-	-	-	410	-	1,400	-
	Or	150	M	10-21-58	-	-	74	41	122	-	400	120	155	-	-	-	355	-	1,400	-
	Orc	200	M	10-21-58	-	-	340	262	2,500	-	258	475	4,600	-	-	-	1,925	-	17,500	-
	Orc	250	M	10-21-58	-	-	340	262	2,500	-	254	500	4,600	-	-	-	1,925	-	17,500	-
	Orc	290	M	10-21-58	-	-	330	262	2,500	-	254	500	4,700	-	-	-	1,900	-	17,500	-

Table 5.--Chemical analyses of ground-water samples in Delta County.--Continued

Well number	Aquifer	Depth	Analyst	Date collected	Chemical constituents (parts per million) Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total solids	Hardness as $CaCO_3$	pH	Specific conductance (micromhos at 25°C)	Temperature (°F)
39N 21W																				
23-1	Or	-	U	12- 9-58	9.0	2.3	556	146	598	33	150	1550	1140	1.2	1.7	4270	1990	7.0	5760	47
29-1	Oat	-	U	5-28-58	9.4	0	125	56	140	9	182	59	455	.5	.8	1050	542	7.2	1800	-
30-1	€m	-	M	10-14-58	-	-	104	54	135	-	175	60	400	-	-	-	480	-	1800	-
39N 19W																				
26-1	Sb	-	M	9-15-58	-	-	64	35	3.5	-	340	20	4	-	-	-	305	-	580	-
39N 18W																				
7-1	Sb	-	M	3- 5-57	-	0	-	-	-	-	-	-	1	.5	-	-	360	-	-	-
7-5	Sc	-	M	1-13-50	8	7.0	262	65	20	-	183	776	4	1.6	-	1254	910	-	-	-
12-1	Sm	-	M	9-30-58	-	-	19	9.7	1.8	-	88	7	1	-	-	-	88	-	220	-
17-1	Sb	-	M	11-12-44	5.2	.8	122	36	6.8	-	173	304	6	1.6	-	612	450	-	-	-
	Sb	-	M	9- 5-58	10	.4	126	34	4.4	1.9	153	315	5	1.3	0	618	455	7.5	870	49.2
38N 24W																				
5-1	Otb	-	M	11-11-58	-	-	76	32	46	-	375	85	17	-	-	-	320	-	750	-
	Otb	-	U	12-10-58	9.6	1.3	86	31	42	6.8	398	85	18	.4	.4	482	342	7.1	794	47.5
7-1	Otb	-	M	-	-	.6	-	-	-	-	-	-	10	-	-	-	340	-	-	-
7-2	Otb	-	M	-	-	.2	-	-	-	-	-	-	10	-	-	-	-	-	-	-
27-1	Otb	-	M	11-10-58	-	-	36	16	3	-	175	12	tr.	-	-	-	155	-	300	-
38N 23W																				
12-1	€m	-	M	11-11-58	-	-	36	18	27	-	165	52	21	-	-	-	165	-	450	-
	€m	-	U	12-10-58	7.9	.09	38	18	27	3.6	172	53	22	.7	.1	255	169	7.4	446	52.5
14-2	Otb	-	M	5-13-55	-	Tr.	-	-	-	-	-	-	Tr.	0	-	-	220	-	-	-
15-1	Otb	-	M	11-12-58	-	-	40	16	14	-	200	20	8	-	-	-	165	-	375	-
16-2	€m		M	1948	10	.2	35	16	44	-	160	65	36	.9	-	290	153	-	-	-
	€m	-	M	12- 5-53	7	.2	30	16	40	-	156	60	30	.6	0	278	142	8.1	540	-
	€m	-	M	8-13-58	9	.15	36	15	41	4.5	150	64	33	.7	0	274	156	7.5	480	-
29-1	Otb	120	M	5-31-56	-	.15	-	-	-	-	-	-	1150	-	-	-	700	-	-	-
	Otb Oat	300	M	6-12-56	-	3	-	-	-	-	-	-	375	-	-	-	345	-	--	-
38N 22W																				
24-3	Or	-	U	12- 9-58	5.3	.62	167	80	570	30	258	180	1140	.8	6.1	2420	746	7.1	4170	44
38N 21W																				
7-1	Or	-	M	9-17-58	-	-	80	46	160	-	302	35	330	-	-	-	390	-	1500	-
38N 19W																				
5-1	Sb	-	M	11- 1-58	-	-	84	39	11	-	375	35	13	-	-	-	370	-	720	-
11-1	Sb	-	M	10- 2-58	-	-	54	28	6.4	-	280	23	5	-	-	-	250	-	500	-
18-1	Sb	-	M	10-10-58	-	-	66	36	3	-	340	25	4	-	-	-	315	-	620	-
37N 24W																				
23-1	Otb	-	M	11- 9-58	-	-	82	21	5	-	317	0	22	-	-	-	290	-	580	-
27-9	Otb	-	M	11-13-58	-	-	27	18	20	-	156	30	11	-	-	-	140	-	375	-
34-1	Oat	-	M	11-11-58	-	-	26	14	16	-	132	40	7	-	-	-	125	-	320	-

Table 6.--Chemical analyses of surface-water samples in Delta County

Analyst; M, Michigan Department of Health; U, U. S. Geological Survey

Source	Location Sec. T. R.	Date collected	Analyst	Chemical constituents (parts per million) Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	pH	Specific conductance in micromhos at 25°C.
Bark River	26 37N 24W	11-28-58	U	47	12	3.1	166	26	4.3	167	7.2	313
Big Bay de Noc	Nahma intake	6-19-44	M	35	11	6.0	150	17	4.0	134	-	-
Big Fishdam River	33 41N 18W	11-28-58	U	24	8.5	1.0	93	18	.2	95	6.9	189
Bills Creek	15 41N 21W	11-28-58	U	17	2.1	1.3	42	6.8	2.0	51	6.4	101
Blacks Spring	36 43N 22W	11- 3-58	M	60	26	2.0	288	15	1.0	255	-	470
Deer Spring	15 40N 18W	9-29-58	M	18	7.8	.9	88	5.0	1.0	76	-	160
Escanaba River	32 41N 23W	11-13-58	M	26	7.8	2.0	103	7	Tr.	98	-	220
Do.	7 39N 22W	11-28-58	U	23	7.9	1.2	88	15	.2	90	6.8	171
Ford River	22 38N 23W	11-28-58	U	40	16	1.4	170	20	1.0	166	7.3	300
Little Bay de Noc	Gladstone intake	1-27-33	M	35	12	2.0	141	15	5.0	132	-	-
Do.	Escanaba intake	3- 5-25	M	35	13	tr.	139	12	3.0	-	-	-
Do.	do.	11-23-54	M	32	11	5.7	139	15	4.0	124	8.2	300
Moonshine Spring	32 41N 18W	8-15-58	M	58	22	3.0	254	28	Tr.	235	-	500
Moss Lake	4 40N 19W	11-28-58	U	246	17	2.6	103	554	5.0	685	7.1	1,130
Rapid River	29 41N 21W	11-28-58	U	28	10	1.3	118	13	1.0	111	6.7	213
Squaw Creek	12 39N 22W	11-28-58	U	26	9.4	.8	90	23	1.4	104	6.8	183
Sturgeon River	6 40N 19W	11-28-58	U	19	5.5	1.3	68	14	.3	70	6.8	134
Valentine Creek	28 40N 18W	11-28-58	U	15	6.0	1.2	55	12	.5	62	6.5	115
Whitefish River	28 41N 21W	6-19-57	M	35	12	1.2	159	10	0	140	-	280
Do.	28 41N 21W	11-28-58	U	28	9.7	.8	113	12	3.5	110	7.1	214