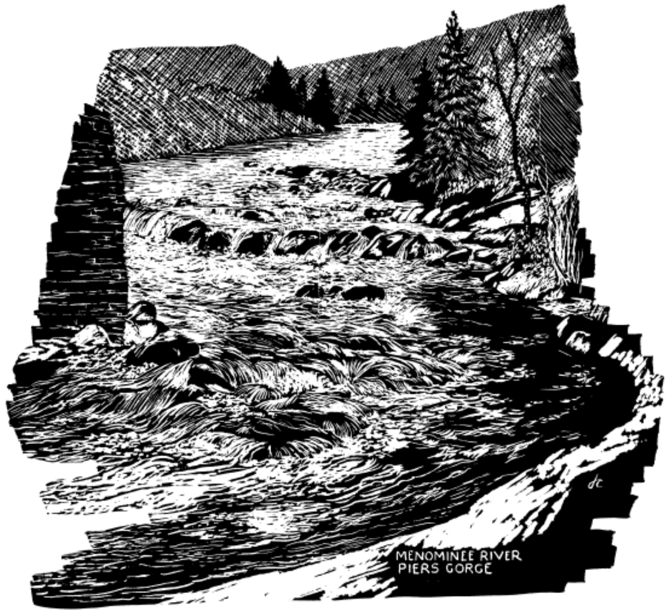
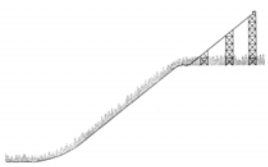


STATE OF MICHIGAN
DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY DIVISION

WATER INVESTIGATION 5
GROUND-WATER RESOURCES OF DICKINSON COUNTY, MICHIGAN

by
G. E. Hendrickson and C. J. Doonan



illustrated by
J. M. Campbell

Prepared in cooperation with the
Geological Survey
United States Department of the Interior

1966

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PREFACE

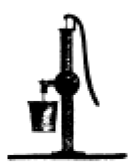
Everyone that uses water has his own particular wants or needs concerning this resource. The rural resident may need to know where he can obtain a new water supply on his farm. The well driller would like to know the kinds of materials that will be encountered if he drills a well at a given locality. The irrigator wants to know if he can obtain water for irrigation, and if so, where? The city water manager may need to plan new well fields to supply large quantities of water for future demands. The industrial engineer would like to find the most favorable areas in Dickinson County for large production wells. And the urban resident may like to know where his water comes from and what its quality is.

It is hoped that this report will enable everyone to better understand the source, the availability, and the quality of the ground-water resource within the county.

The cooperation and assistance of personnel of federal, state and county agencies, municipalities, industrial concerns, well drillers, as well as many other individuals made this report possible. Special credits are due Mr. A. E. Slaughter, geologist with the State Geological Survey, for assistance in defining the geology of the county. Mr. Harry Kleiman furnished data on many wells in the county and reviewed the water-availability maps. Mr. Paul Trione, Norway City Manager, and Messrs. Louis Tomasini, Wm. Peterson and L. J. Alexander, of the Norway Department of Public Works, furnished information on water supply and mine flooding problems. Mr. Anton Kovochich and his staff at the Iron Mountain Water Department contributed public water supply data.

Lansing, Michigan — G. E. Hendrickson
December, 1965 — C. J. Doonan
Water Resources Division
U. S. Geological Survey

INTRODUCTION



Dickinson County has abundant, though unevenly distributed, ground-water resources that are little used at present. In some places enough water for industry or irrigation can be obtained from wells; in others, obtaining the small amount of water needed for a single household, or for a hunting or fishing camp is difficult, if not impossible. The purpose of this report is to provide public officials, industrial developers, farmers, rural residents, well drillers, consultants, and anyone else with basic information on obtaining water from wells and springs.

This report summarizes data on representative wells within the county and describes the geologic and hydrologic relationships. Well data are relatively abundant in the towns and along the major roads of the county, but sparse elsewhere. The description of the occurrence of ground water and the maps showing availability of ground water, therefore, are based largely on geologic information.

Analyses

The scarcity of well data also limits the information on quality of water. Laboratory analyses were made of samples from a few representative wells and one spring. Field analyses were made of samples from most wells visited. Because the low flow of streams is chiefly ground-water discharge, field analyses were also made of samples obtained from the major streams of the county during rainless periods. A few analyses of samples from lakes are included in the report to indicate the general range in the quality of water obtainable in the county.

Well Numbers and Sampling Sites

The well-numbering system used in this report corresponds to the rectangular system of land subdivisions with reference to the Michigan meridian and base line. The first two parts of a well number designate township and range; the last part designates both the section and the well within the section. Thus, 44N 27W 17-1 is well number one in section 17, Township 44 North, Range 27 West.

Surface water chemical data sites are identified by a serial number within the township. For example, site number 44N 30W-3 indicates the third sample collected in Township 44 North, Range 30 West.

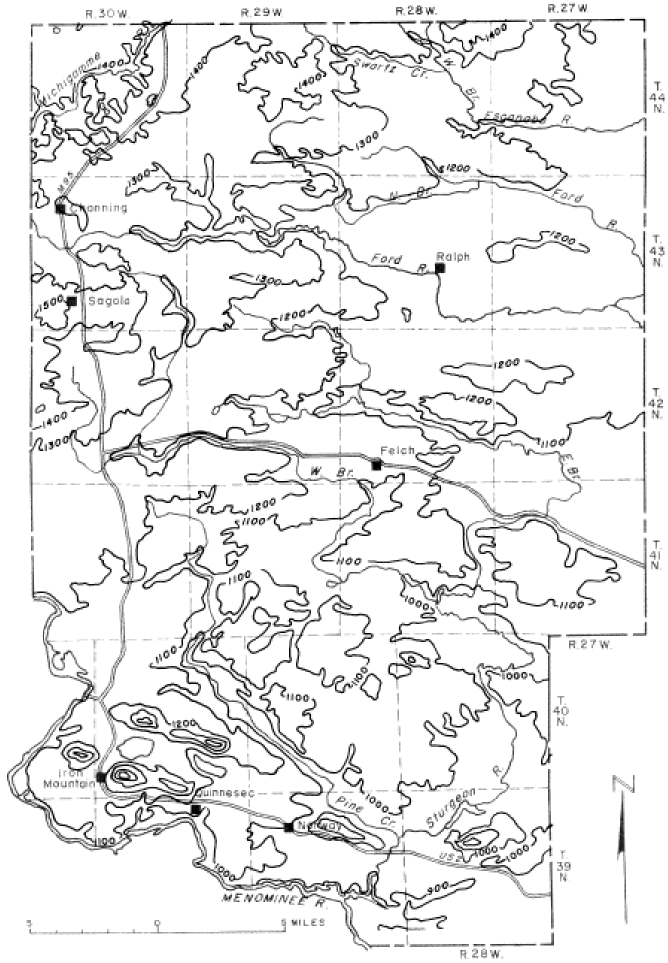
Surface Geology and Topography

Although glacial drift covers most of the surface of Dickinson County, bedrock is exposed in the central and south-central areas (maps 1 and 2 in pocket). Small outcrops are also exposed at Randville and Felch and in many small patches elsewhere.

The glacial drift is composed of mixtures of sand and gravel, silt, clay, cobbles, and boulders. Bedrock includes dense igneous, sedimentary, and metamorphic rocks of Precambrian age and sandstones and dolomites of Cambrian and Ordovician age.

The relief of the glacial drift generally is characterized by rolling hills and swampy lowlands; the bedrock surface commonly is more rugged, but smoothed by the polishing action of the glacial ice. Many of the hills in both glacial and bedrock areas are more than 1,400 feet above sea level, and a few rise above 1,500 feet. The lowest elevation in the county is about 900 feet along the Menominee River in the southeast.

The Menominee River borders the county on the south, with the tributary Sturgeon and Pine rivers draining most of the central and southern areas. The northern part of the county is drained chiefly by the Ford River and the West Branch of the Escanaba. The Michigamme River drains a small area in the northwest corner.



Map 3. Topography of Dickinson County, Michigan.

Ground-Water Recharge

Rain and snow are the source of all water. Annual rainfall averages about 28 inches. Part of this rain and melting snow runs off over the surface of the ground and is carried off by streams or is stored in lakes. Another part is returned to the air by evaporation and transpiration of plants while the remainder, percolating down to ground-water reservoirs, is called ground-water recharge. Ground water moves slowly through the reservoirs to discharge into streams, lakes or swamps keeping them flowing during rainless periods.

The more rain and snowmelt entering the underground reservoirs, the greater the amount of ground water available for wells, and the greater the flow of streams during rainless periods. Sand and gravel occurring at the surface in places along the major streams of the county (map 1) are so permeable that as much as 10 inches of the rainfall and snowmelt is estimated to percolate down to the ground-water reservoir. By way of contrast, the steeply-sloping areas of Precambrian bedrock in the south-central part of the county are relatively impermeable. Probably not more than 1 inch of the rainfall and snowmelt recharges the ground-water reservoir in those areas. In addition, the openings between particles of sand and gravel can store and transmit much more water than the thin fracture-openings in the Precambrian rocks. Thus, wells drilled in the sand and gravel deposits generally yield much more water than wells in the Precambrian bedrock. In addition, streams flowing in the sand and gravel areas have higher flows during rainless periods than streams of comparable drainage area in Precambrian bedrock.

Not only the quantity but also the quality of water available is influenced by the character of earth materials. Rain or snow falling on the earth in inland areas is nearly pure, normally containing less than 10 ppm (parts per million) of dissolved solids. However, as soon as the water comes in contact with soils and rock, it begins to pick up soluble materials. Water passing quickly over the surface to lakes and streams has little time to dissolve mineral matter. On the other hand water percolating into the ground is able to pick up a greater amount of dissolved solids.

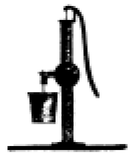
Economy and Water Development

Dickinson County, situated in the west central part of the Northern Peninsula of Michigan, has an area of 757 square miles and a population of 23,917 (1960). The county is served by five trunkline highways, three railroads and one airport. Most of the industry and 65 percent of the people are located in the cities of Iron Mountain, Kingsford, and Norway. Most of the land in the northern half of the county is taken up with state-owned acreage within the Sturgeon River State Forest and private hunting camps. Farms totalled 15 percent of the land area in 1954; by 1959 farmlands had declined to 10 percent. Of the 77 manufacturing establishments operating in 1962, 40 were making lumber or other wood products. A wide range of outdoor recreational activities attract tourists from a large area in the midwest. Furnishing services and accommodations during all seasons plays a major part in the economy.

In most areas private wells supply water for commercial and household uses. Industrial development is concentrated within the areas served by municipal water systems. Very few private wells provide ground water for industrial or commercial cooling processes. A private industrial well in Iron Mountain, however, pumps almost continuously from glacial drift at a rate of 20 to 25 gpm (gallons per minute) with no apparent effect on the reservoir.

At the present time, ground water is not being used to process iron ore, but is used for domestic purposes at the mines. As open pit mines deepen, dewatering may become necessary, possibly lowering ground-water levels in the area to some extent.

GROUND-WATER RESOURCES



The aquifers (water-bearing formations) of Dickinson County are in both glacial and bedrock deposits. Most of the ground-water is obtained from wells.

Wells range in diameter from 1¼ inches to 60 inches and in depth from 12 feet to more than 350 feet (table 1 in Appendix). Most of the wells are 5 to 6 inches in diameter and 25 to 100 feet deep. Some are driven and a few are dug, but most of the wells are constructed by drilling. Drilled and driven wells in glacial drift generally are equipped with steel casing and a screen or sand point, although a few drilled wells are not screened but left with the open end of the casing in the sand and gravel. Wells drilled into rock are cased through the glacial drift and a few feet into the underlying rock, with the remainder left open. Dug wells usually are cribbed with precase concrete or tile. For driller's logs of wells, see table 2 in Appendix.

Prospects of developing a successful well at any given location depend mostly on the earth materials underlying and surrounding the site, and the local topography.

Well Number	Aquifer Pc = Precambrian Pa = Paleozoic Gd = Glacial drift	Yield (gal/min)	Drawdown (feet)	Duration of test (Hours)	Specific Capacity (gal/min/ft/drawdown)
39N 28W 7-1	Pc	5	--	--	--
14-1	Gd	5	--	--	--
14-2	?	8	60	1	0.1
19-1	Pc	17	4	2	4.3
19-2	Pc	9	40	1½	0.2
19-3	Pc	12	--	--	--
20-1	Gd	30	--	--	--
20-2	Gd	20	15	2	1.3
24-1	Pa	240	--	--	--
30-1	Gd	5	6	½	0.8
30-2	Gd	40	10	2	4.0
30-3	Gd	5	--	--	2.5
30-4	Gd	10	4	½	--
39N 29W 8-1	Gd	20	1½	2	13.3
22-1	Gd	15	4	8	3.8
25-1	Gd	30	10	2	3.0
36-1	Pc	20	10	2	2.0
39N 30W 3-2	Gd	125	12	8	10.4
4-1	Pc	20	10	--	2.0
40N 28W 12-1	Gd	4	90	½	0.04
26-1	Gd	3	40	1	0.8
35-1	Gd	3	5	2	0.6
40N 29W 28-1	Gd	3	8	1	0.4
40N 30W 8-1	Gd	15	4	4	3.8
17-1	Gd	3	8	1	0.4
18-2	Gd	30	5	8	6.0
18-4	Gd	12½	10	1	1.3
18-5	Gd	25	12	2	2.0
18-7	Gd	5	18	--	0.3
19-3	Gd	350?	--	6	--
21-1	Gd	15	4	3	3.8
23-1	Pc	6	56	2	0.1
28-1	Gd	30	20	6	1.5
41N 30W 4-1	Pc	15	20	2	0.8
32-1	Pc	10	100	2	0.1
42N 29W 22-3	Gd (sand)	15	4	2	3.8
26-1	Pc	3	35	1	0.08
31-1	Pa	300	26	96	11.5
34-1	Pc	12	10	2	1.2
42N 30W 4-1	Pc	5	0	3	5.0
7-1	Pc	10	4	2	2.5
18-1	Gd	3	6	1	0.5
32-1	Gd	15	0	2	15.0
43N 27W 28-1	Pa	4	18	2	0.2
43N 28W 23-2	Pa	20	5	2	4.0
23-4	Pa	9	6	1	1.5
43N 30W 29-2	Pc	14	15	5	0.9
34-1	Gd	12	10	4	1.2
44N 28W 10-1	Gd	25	3	2	8.3
44N 30W 23-3	Pc	15	20	2	0.8
33-1	Gd	30	6	1	5.0

Table 3. Pump Test Results

Maps 1 and 2, (in pocket) showing availability of ground water, were prepared from records of existing wells, from information on the soils and the surface and bedrock geology, and from topographic information. Because of the scarcity of wells in many areas, they were prepared largely on geologic information. These maps show only areas generally favorable or unfavorable for obtaining a given amount of water. For example, an indication that an area will yield enough water for a domestic supply means the probability of a successful well is better than a fifty-fifty chance. It does not mean every well drilled will be successful. Conversely, an indication that an area will not yield enough water for domestic supplies does not mean every well drilled in the area will be a failure. Map 4 (in pocket) shows the locations of wells mentioned.

In this report water supplies are classified as follows:

	gal/min
Domestic	at least 1
Small	1 to 9
Moderate	10 to 100
Large	over 100

Glacial Aquifers

Glacial aquifers are the major source of ground water in the county (map 1). Most wells obtain water from sand and gravel, although some obtain small amounts of water from till. Capacities of drift wells range from less than 1 to more than 300 gpm per foot of drawdown (table 3). Thickness of glacial materials varies from a few inches to more than 150 feet. The surface of the bedrock beneath the drift is irregular, especially where the bedrock is of Precambrian age. In some instances a well may penetrate more than 100 feet of glacial materials, while nearby, another well may encounter bedrock at a depth of only a few feet.

Sand and Gravel

Sand and Gravel includes outwash and kames associated with end moraines.

Outwash consists of sediments deposited by braided streams and sheet runoff of meltwater issuing from the glacier front and is composed chiefly of stratified sand and gravel with some silt and clay. They are generally extensive, flat or gently sloping areas, referred to as "outwash plains". They may be pitted and irregular, however, where isolated blocks of ice were buried by outwash. Subsequent melting caused depressions which form many of today's "pit lakes".

Kames were laid down by meltwaters in contact with the glacier front, therefore, are closely associated with moraines. Like outwash, they are composed chiefly of stratified sand, gravel, silt, and clay, but they may also contain large pockets of unsorted till and boulders. Unlike outwash, beds of sand and gravel pinch out in short distances. Kame deposits are characterized by rounded or conical hills which merge with the rolling hills underlain by till.

Large-diameter wells (more than 12 inches) along major streams may yield more than 100 gpm. Most small-diameter wells will yield enough water for a modern domestic supply (at least 1 gpm). Some wells will fail to yield even 1 gpm because of relatively impermeable or thin drift. Most favorable sites are on low terraces, in valleys and along streams as far removed as possible from exposures of bedrock.

Till

Till includes both end moraines and till-plain deposits. End moraines are ridgelike accumulations of drift built up along the margin of the ice sheet. Till plains are flat or gently rolling deposits formed under the ice or where it did not form well-defined end moraines. Till is composed chiefly of unsorted, unstratified mixtures of sand, silt, clay, and stones. Small pockets of stratified sand and gravel are often present, but are minor in extent. Till was dumped directly from the melting ice with little or no transpiration by meltwater.

Only a few wells will yield more than 10 gpm. About half of the small-diameter wells will yield enough water for a modern domestic supply. Because of larger infiltration area and storage capacity, dug wells may be more successful in these deposits than drilled or driven wells. Many wells will fail to yield enough for a domestic supply because of relatively impermeable or thin drift.

Sandy Till (with pockets of sand and gravel)

Sandy Till (with pockets of sand and gravel) includes sand and gravel deposits associated with end moraines. Till consisting of a high content of sand is the predominant material in these areas, but pockets of sand and gravel are important locally. The topography is characterized by rolling hills.

Large-diameter wells located in valleys along streams or near lakes may yield as much as 100 gpm. Because the beds of sand and gravel generally are of small areal extent, water levels may decline more rapidly than would be expected in the more extensive outwash aquifers. Most small-diameter drilled and driven wells will yield enough water for a modern domestic supply. Some wells will fail to yield enough for a domestic supply because of relatively impermeable drift or bedrock at shallow depth.

Swamp Deposits

Swamp Deposits include peat and muck generally confined to flat lowland areas bordering streams and lakes and former lakes, originating subsequent to glaciation.

Large-diameter wells penetrating thick deposits of sand and gravel beneath the swamp deposits may yield more than 100 gpm. Most small-diameter wells will yield enough water for a modern domestic supply. Some wells may fail to yield enough for a domestic supply because of relatively impermeable or thin drift.

Bedrock Areas

Bedrock is either at the surface or encountered within a few feet of the surface. Some wells located in valleys along streams may obtain enough water from the drift for domestic purposes, but most will fail to obtain enough for even a hunting camp. If a well in the drift fails to yield water, possibly a small supply may be obtained by deepening the well a few feet into the underlying bedrock.

Bedrock Aquifers

The bedrock aquifers of Dickinson County include igneous, metamorphic, and sedimentary rocks (map 2). Bedrock is an important source of water in the eastern part and in isolated areas in the central part, but generally yields only small amounts elsewhere.

Precambrian rock formations occur, either at the surface or beneath the drift, throughout most of the county west of the eastern tier of townships (Range 27 West). Granite, schist, and gneiss predominate from the north-central to south-central parts. The remainder of the Precambrian area consists mostly of slates, quartzites, and volcanics.

Paleozoic sandstones and dolomites underlie the glacial drift in almost all of the eastern tier of townships (Range 27 West), parts of Range 28 West, and crop out or underlie the drift in small isolated patches in the central part.

Precambrian Aquifers

In many areas small quantities of water for domestic supplies are obtained at shallow depth from fractured and weathered Precambrian rocks. Capacities as high as 5 gpm per foot of drawdown have been reported, but most are less than 1 gpm per foot (table 3). Chances of obtaining water decrease with depth, and it is usually considered hopeless to drill more than 100 feet into these rocks. In faulted areas sandstone, apparently filling cracks and fissures at depths of several hundred feet (James and others, 1961), may produce enough water for a domestic supply, but the chances of encountering them are extremely small. Furthermore, any water obtained might be highly mineralized.

Other things being equal, there is a better chance of obtaining ground water from Precambrian rocks in valleys than on the highlands because weathered and fractured rock is more likely to occur below the water table in the valleys. Highland areas where Precambrian rocks crop out or are covered by a few feet of soil are the least favorable for obtaining ground water.

In upland areas where Precambrian bedrock is at or near the surface most wells in bedrock will fail to obtain enough water for a modern domestic supply. In valleys or along streams where bedrock is covered by more than 20 feet of permeable drift, wells drilled a few feet into the bedrock may yield enough water for a modern domestic supply, and a few may yield more than 10 gpm. Drilling over 100 feet into Precambrian formations is usually futile.

Paleozoic Aquifers

Small to moderate supplies of water are obtained from wells in sandstones and dolomites of Cambrian and Ordovician age in the eastern part of the county and in isolated areas in the central part. The reported yields of most wells in the Paleozoic aquifers are 20 gpm or less, but these yields generally represent the capacities of the pumps, not the potential of the wells. Probably most large-diameter wells drilled more than 50 feet into the Paleozoic bedrock would be capable of yielding as much as 50 gpm. A twelve-inch diameter well in section 31, T. 42N., R. 29W. yielded 320 gpm from sandstone. This well was pumped at a rate of 300 gpm for four days with a drawdown of about 26 feet (table 3). Reported capacities of other wells ranged from 0.2 to 5 gpm per foot of drawdown.

The base of the Paleozoic is in contact with the top of the Precambrian. The Paleozoic formations range in thickness from a feather-edge along their western margin to perhaps 100 feet or more in places along the eastern county line. Isolated outliers, as near Randville and Felch, have the same range of thickness.

Most wells drilled into the dolomitic formations will yield enough water for a modern domestic supply. Large-diameter wells drilled more than 50 feet into the dolomite rocks may yield as much as 50 gpm. Wells penetrating the underlying sandstones may yield over 100 gpm.

Most wells drilled into the sandstone will yield enough water for a modern domestic supply. Large-diameter wells drilled more than 50 feet into sandstone beds may yield more than 100 gpm. Some wells in bedrock will fail because impermeable shale or Precambrian rocks are encountered at shallow depth.

Ground-Water Storage

Ground water is stored in intergranular openings in glacial aquifers and in fracture openings in Precambrian formations. In sandstones water may be stored in both intergranular and fracture openings. The amount of water in storage in an aquifer varies. Fluctuations in storage are reflected in fluctuations in water levels in wells -- the water levels being high when storage is high and low when storage is low. Figure 1 shows fluctuations in water levels in a well in glacial drift.

Water levels rise in early spring with snowmelt. Later, growing vegetation uses much water that would otherwise pass down to the water table, and water levels decline. A secondary rise may occur in the fall after the vegetation dies, but before the ground is frozen. As winter advances most of the precipitation accumulates on the ground as snow, and water levels again decline until the spring thaws.

Unusually heavy rains may cause a rise in water table at any time -- especially where the water table is at shallow depth. In areas where the water table is more than 50 feet below land surface the effect of heavy rains are noticeably delayed. High water levels generally are associated with wet years and low water levels with dry years. However, the intensity of rainfall and the seasonal distribution and rate of snowmelt also affect the rate of recharge and, consequently, the elevation of the water table. There is no evidence of a long-term rise or fall in ground-water levels in unpumped areas of Dickinson County.

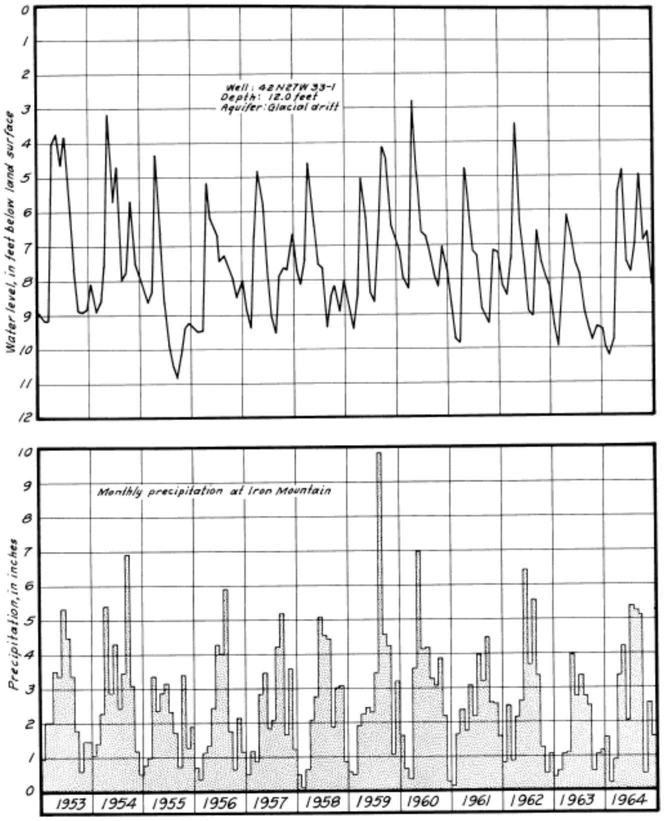
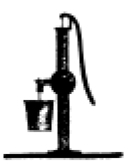


Figure 1. Relationship of precipitation to water levels in a well drilled in glacial drift.

QUALITY OF WATER



Water obtained from most wells in Dickinson County is suitable for household use and for most other uses (tables 4 and 5). Although the water is generally hard to very hard and, in some places, contains undesirable amounts of iron, household water-treatment systems can usually improve the quality to satisfactory standards. Water from most wells ranges in hardness from 150 to 250 ppm. A few wells and springs yield water with a hardness greater than 300 ppm. The iron content of water from wells in both drift and bedrock is quite variable, ranging from less than 0.1 to more than 4.0 ppm.

During periods of low flow, stream water is similar to water obtained from shallow drift wells except stream water generally is somewhat softer and has less iron content (table 6). The quality of water in lakes ranges widely. In most lakes having surface outlets, the quality is similar to stream water. Lakes without outlets generally have very soft water with hardness less than 20 ppm. Also the pH of such lakes usually is less than 7.0, indicating that the water is slightly acid.

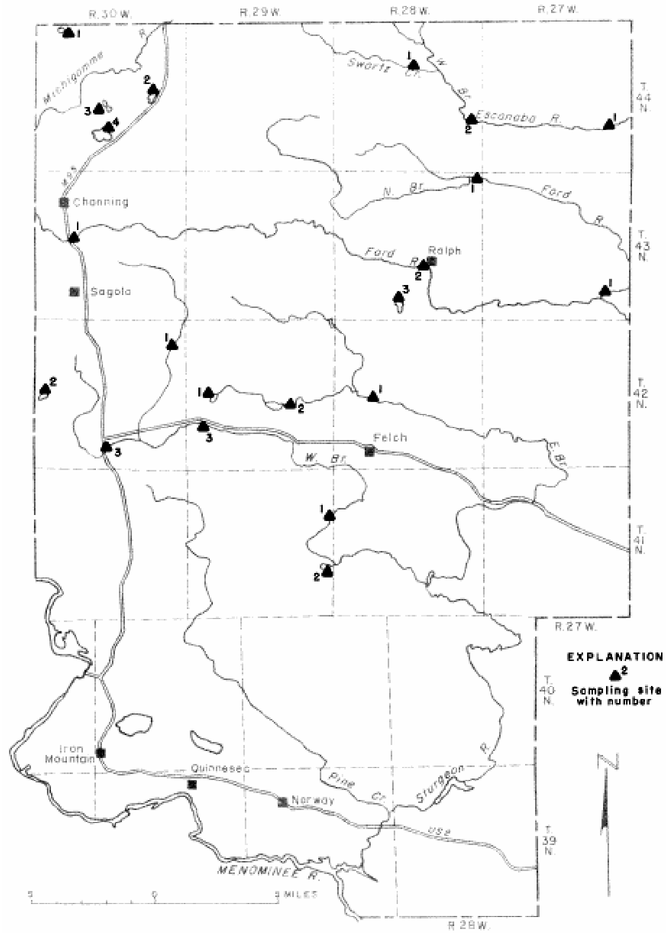


Figure 2. Sampling points from streams and lakes used for chemical analyses of water.

WATER MANAGEMENT

Maintaining and improving public water supplies and providing adequate streamflow to dilute sewage and other wastes are the chief activities relating to management of water in Dickinson County at present. Another problem is flooding of iron mines in the southern part. Expected growth and development will add other water management problems.

Public Water Supplies

Iron Mountain

The city of Iron Mountain maintains the largest public water supply system in the county, furnishing water to some 3,000 customers in Iron Mountain, Kingsford, East Kingsford and part of Breitung Township. During 1964, daily pumpage averaged nearly 1.5 million gallons (fig. 3) of both ground water and surface water. In summer, cooler water is obtained from an abandoned mine shaft, but during winter Lake Antoine supplies softer water. The mine shaft is 2,300 feet deep, with the pump set 90 feet below the surface. During August, 1964, temperature of the water from the shaft averaged 48°F., with a hardness of 310 ppm softened to about 85 ppm.

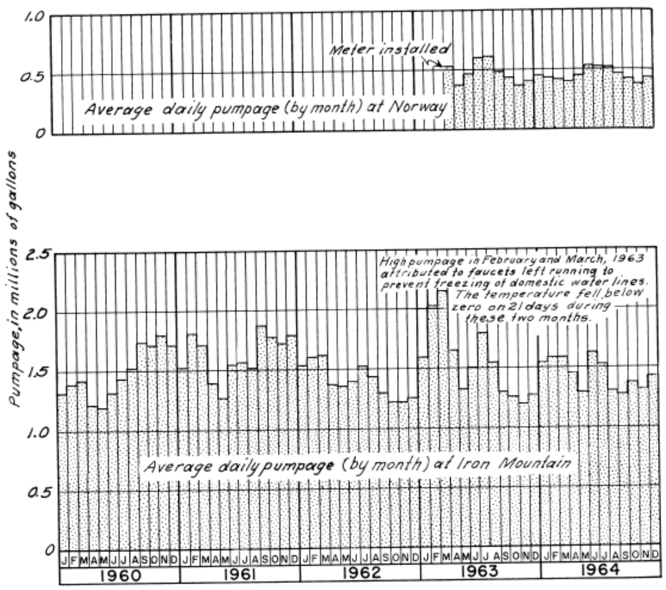


Figure 3. Average daily pumpage (by month) at Iron Mountain and Norway.

Analysis of Water at Iron Mountain
(by City of Iron Mountain)

	Hamilton Shaft August, 1964	Lake Antoine April, 1964
Temperature, °F	48.05	39
pH	7.4	7.3
Free CO_2, ppm	229	----
Calcium (Ca), ppm	52.8	36.8
Magnesium (Mg), ppm	43.4	27.2
Noncarbonate	23.8	9
Total hardness, ppm	310.3	206
Iron (Fe), ppm	0.0	0
Color	----	3
Turbidity	----	1
Odor	----	Musty smell @ 60°C
Alkalinity	----	197

Norway

The city of Norway furnished water to about 1,380 customers within the city and adjoining areas. Prior to 1959, water was obtained from both Lake Fumee and two wells near the lake. Water from the wells was harder than the lake water. The wells were abandoned in 1959.

Analysis of Municipal Water at Norway, July, 1952
(by Michigan Department of Health)

	parts per million	
	Wells	Lake
Total solids	240	196
Silica (SiO_2)	7.2	4
Iron (Fe)	.18	0
Sodium & potassium (Na + K)	2.3	3.8
Chloride (Cl)	Trace	Trace
Sulphate (SO_4)	19.2	15.1
Fluoride (F)	.15	.15
Hardness ($CaCO_3$)	228	178
Bicarbonate (HCO_3)	260	211
Calcium (Ca)	50	36.5
Magnesium (Mg)	25.2	21.6

During 1964, a little over 169 million gallons of water was metered at the municipal pumping station (fig. 3).

Breitung Township

Two 125- to 160-foot wells located in Quinnesec supply water for about 160 families in Breitung Township. The wells obtain water from the glacial drift.

Field Analysis of Water in Breitung Township,
February 8, 1965

Specific conductance, micromhos @ 25°C	590
Chloride (Cl), ppm	30
Hardness ($CaCO_3$), ppm	500
Iron (Fe), ppm	< 0.1
pH	7.5

Sagola Township

Sagola Township supplies water to approximately 50 customers in the town of Sagola. Water is from a 6-inch well 115 feet deep, probably tapping glacial gravels.

Analysis of Water in Sagola Township, August, 1959

	parts per million
Total solids	335
Silica (SiO_2)	13
Iron (Fe)	0.75
Calcium (Ca)	66
Magnesium (Mg)	33
Sodium & potassium (Na + K)	7.2
Chloride (Cl)	13
Sulphate (SO_4)	30
Bicarbonate (HCO_3)	322
Total hardness ($CaCO_3$)	300
Fluoride (F)	0

Channing 4-H Club

In 1951 the Channing 4-H Club tried to develop a ground-water supply at their camp on Sawyer Lake. A 6-inch well encountered some water in the drift at a depth of about 65 feet. The quantity was insufficient so drilling continued until bedrock was reached at about 185 feet. The zone of fine sand, just above the rock, appeared capable of supplying an adequate amount of water; however, the sand was mixed with fine silt, and the water would not clear up. Even after extensive pumping, silt continued to cause malfunctioning of the system. Therefore, the well was abandoned and a chlorinator installed to make use of Sawyer Lake.

Industrial Water Supplies

In 1951 the Hanna Mining Company drilled a well at their Groveland Mine to test whether sufficient water was available to supply part of the needs of an iron ore beneficiation plant. Several more wells were drilled during 1957 and 1958, none of which indicated quantities sufficient to meet their needs. One of these wells was test pumped at slightly more than 300 gpm and is now used as the domestic supply in the mine buildings. On September 28, 1960, the Michigan Water Resources Commission issued a permit to divert not more than 4,500 gpm from the West Branch of the Sturgeon River. After the water is used in the mill, it passes into two large settling ponds; part is returned to the mill for re-use, while part flows into Pine Creek which joins the Sturgeon River several miles downstream from the point of the original diversion.

Mine Flooding

The southern part of Dickinson County contains many abandoned iron mine shafts and pits. When the mines were operating, a system of sumps and pumps was maintained to remove water seeping into working areas. After the mines were abandoned, water began to rise in the shafts to the extent that it now poses problems in some areas.

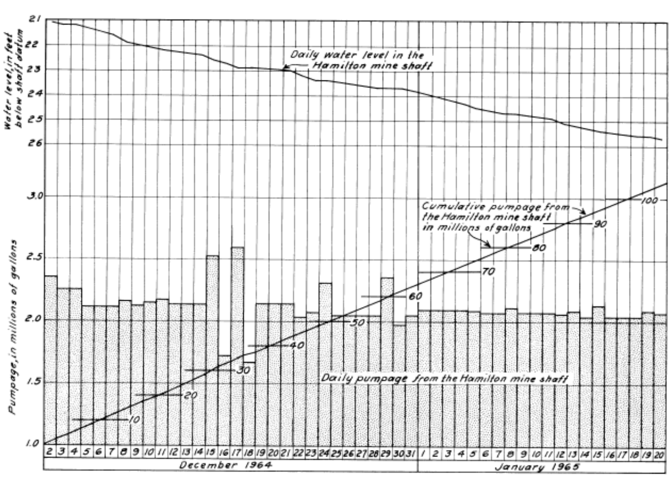


Figure 4. Daily pumpage and water levels in the Hamilton shaft.

Iron Mountain

Water in the 2,300-foot deep Hamilton Shaft of the Chapin Mine has risen high enough to raise the water table and cause flooding of basements and storm drains in the northeast part of town. To relieve this situation and improve the water supply, the city pumps over a million gallons a day from the shaft into its water plant during the summer. In the winter, about two million gallons a day are pumped from the shaft into Lake Antoine. This procedure maintains the water at a safe level in the shaft and replaces water drawn from Lake Antoine into the city system (fig. 4).

Norway

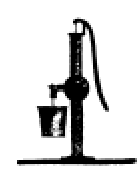
The mines at Norway were abandoned in 1945. Waters rose in the shafts and overflowed into the glacial drift, flooding low areas on the southwest side of the city. During December of 1949, as much as two feet of water entered basements not equipped with sump pumps. To relieve this flooding, the city installed a pump at 75 feet in the Aragon mine shaft. Present withdrawal is about 2,000 gpm. East of this shaft are other shafts and pits having water levels responding to pumping in the Aragon. One of these open-pit depressions, dry until 1948, had an estimated water depth of one hundred feet in 1951. However, pumping from the Aragon shaft has no visible effect on the water levels in shafts and pits farther east toward Vulcan, nor does it appear to affect the level of Hanbury Lake about a mile and a half southeast. By maintaining a 2,000 gpm rate of pumping, flooding can be held to a minimum. The water from the mine is extremely hard, but otherwise of fair quality. It is pumped into a small creek upstream from the city sewer outlet, thus diluting the sewage in the stream.

Field Analysis of Water from Norway Mine Shaft, February 8, 1965

Specific conductance, micromhos @ 25°C	725
Chloride (Cl), ppm	25
Hardness ($CaCO_3$), ppm	450
Iron (Fe), ppm	0.1
pH	7.0

FUTURE NEEDS

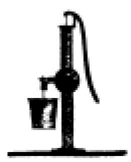
Although the county has ample water for current needs, local problems may arise as a result of uneven distribution of supplies and possible conflicting demands. Additional development of water supplies will surely be needed to accommodate any large expansion of population and industrial development.



All sources of water in the county -- lakes, streams, and ground water -- are related to each other. Development of one source may influence the availability from another source. For example, development of new well fields along a stream may reduce the flow of the stream so that it is no longer adequate for waste disposal or for recreational use. Or, diversion of water from a lake may lower the water table so that the yield of nearby wells is decreased. Development of any source of water in the county should be guided by knowledge of the probable consequences of the development on that source as well as on all other sources.

Management decisions must be based on a thorough knowledge of streamflow, ground-water levels, lake levels, and quality of water obtained from reliable records. Also needed are data on water use, ground-water pumpage, surface-water diversions, and waste disposal. When collected over a sufficient period, these records provide more reliable information on the effects of future development than any intensive short-term study.

SUMMARY AND CONCLUSIONS



Dickinson County has abundant, though unevenly distributed, ground-water resources in glacial and bedrock aquifers. In some areas, wells in glacial drift or in sandstones of Cambrian or Ordovician age will yield several hundred gpm, while in other areas obtaining the few gpm needed for a domestic supply is difficult or impossible.

The most favorable areas for obtaining large supplies of water from wells are the sand and gravel deposits along major streams. The least favorable areas are where Precambrian crystalline rocks crop out or are covered by only a few feet of glacial drift.

Most wells are 5 to 6 inches in diameter, 25 to 100 feet deep, and constructed by drilling.

Well water is mostly hard to very hard, locally containing undesirable amounts of iron, but otherwise suitable for domestic and other uses. Household water treatment methods generally improve quality to satisfactory standards.

Public water supplies are obtained from lakes, wells, and an abandoned mine shaft.

Future expansion of population and industry in Dickinson County may bring water problems caused by uneven distribution of supplies and conflicting demands. Long-term records of streamflow, ground-water levels, lake levels, and quality of water from streams, lakes and wells will be needed to cope with future needs.

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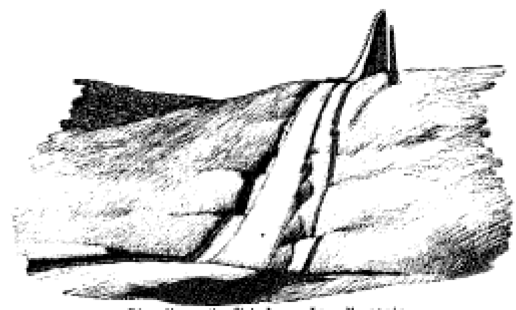

Pine Mountain Ski Jump, Iron Mountain

ABSTRACT

The abundant ground-water resources of Dickinson County are not evenly distributed. Wells yielding several hundred gallons per minute can be obtained in some parts of the county while in other parts obtaining the few gallons per minute needed for a single household is difficult or impossible. Water from wells generally is hard and locally contains objectionable amounts of iron, but is otherwise suitable in quality for most uses. Public water supplies in the county are obtained from wells, lakes, and an abandoned mine shaft. Maps showing the availability of ground water in drift and bedrock aquifers are included.

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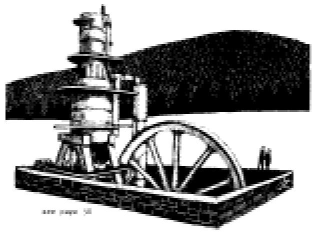

Cornish water pump at the site of the abandoned Chapin iron mine in Iron Mountain. This huge pump, installed in 1893, was the largest of its type ever built in the United States. It could lift about 4,000,000 gallons of water a day from a depth of 1,500 feet. The 40-foot flywheel weighs 160 tons.

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the MICHIGAN GEOLOGICAL SURVEY and
the UNITED STATES GEOLOGICAL SURVEY
have cooperated officially for many years
producing basic information on water resources

this report is a product of that continuing program

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Well Number	Aquifer	Date Collected	Analyst	Chemical constituents in parts per million											
				Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na + K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids	Hardness ($CaCO_3$)	Specific Conductance (Micromhos @ 25°C)	pH
44N 28W 10-1	Gd	7/31/64	USGS	----	--	--	----	184	19	1.5	0.1	---	189	314	8.1
43N 30W 29-3	Gd	1959	MDH	0.75	66	33	7.2	322	30	13	----	335	300	---	---
43N 30W 9-2	Pc	8/5/64	USGS	----	--	--	----	261	14	2.5	0.1	---	222	414	7.8
42N 28W 35-2 (Spring)	Gd	9/15/64	USGS	----	--	--	----	292	19	4.5	4.6	---	303	501	8.4
42N 28W 29-1	Pc	9/11/64	USGS	----	--	--	----	252	13	5.0	0.2	---	202	413	7.8
42N 27W 20-1	Pa	9/14/64	USGS	----	--	--	2.1	262	29	1.5	0.1	---	275	447	7.4
40N 30W 31-1	Gd	10/6/64	USGS	----	--	--	----	404	65	15	3.8	---	468	746	7.6
39N 30W 3-1	Gd	8/14/58	MDH	0.00	72	00	14.1	282	37	23	31	400	320	640	7.4
39N 28W 14-1	Gd	5/14/64	USGS	----	13	36	14.2	159	45	6	----	231	223	391	8.5
39N 28W 19-3	Pc	5/14/64	USGS	----	34	31	20.3	250	25	13	----	257	221	469	7.9
Pc = Precambrian Pa = Paleozoic Gd = Glacial drift															

Table 4. Laboratory analyses of well water (By U. S. Geological Survey and Michigan Dept. of Health)

Well Number	Aquifer Pc=Precambrian Pa=Paleozoic Gd=Glacial drift	Date	Hardness ($CaCO_3$)	Iron (Fe)	Specific Conductance (Micromhos at 25°C)	pH	Temperature (°F)
44N 30W 23-1	Pc	10/21/64	140	0.7	260	8.0	--
33-1	Gd	10/19/64	240	0.2	375	7.5	--
44N 28W 27-1	Gd	9/9/64	190	---	240	---	--
43N 30W 11-1	Pc	8/5/64	170	<0.1	290	7.5	--
43N 29W 11-1 (Spring)	Gd	8/10/64	190	---	320	6.9	--
43N 28W 23-3	Gd	8/5/64	240	0.5	380	7.5	--
43N 27W 28-1	Pc	10/23/64	270	0.2	440	7.5	48
42N 30W 2-1	Pc	10/18/64	150	0.3	260	7.0	49
4-1	Pc	10/16/64	340	<0.1	590	7.0	48
18-2	Pc	10/15/64	210	0.2	325	8.0	--
24-1	Pc	10/16/64	130	4.0	215	7.5	46
33-1	Pc	10/15/64	320	<0.1	700	7.0	51
33-2	Pc	10/15/64	230	<0.1	410	7.5	47
42N 29W 19-1 (Spring)	Gd	10/21/64	270	<0.1	450	8.0	--
22-1	Gd	10/14/64	380	<0.1	700	6.5	54
22-2 (Flows)	Gd(?)	10/14/64	260	<0.1	510	7.5	42
31-1	Pa	11/18/64	220	<0.1	420	7.0	--
33-1	--	10/7/64	290	<0.1	410	7.0	53
42N 28W 5-5	Pa	10/23/64	220	0.7	320	7.5	45

32-1 (Spring)	Gd	9/17/64	640	---	1580	6.8	47
42N 27W 20-1	Pa	9/14/64	290	1.5	395	7.0	45
32-2	Pc	9/14/64	140	<0.1	300	7.5	--
41N 30W 16-1	Gd	11/18/64	150	0.2	300	8.0	--
25-3	--	11/19/64	240	<0.1	400	7.5	--
32-1	Pc	11/19/64	270	0.1	500	7.5	--
41N 28W 8-1	Pa	11/6/64	220	<0.1	360	7.5	48
8-2	Gd	11/6/64	260	<0.1	400	7.5	47
28-1 (Spring)	Gd	11/13/64	220	0.3	325	7.5	47
34-1	Gd	11/13/64	140	0.5	230	7.5	47
41N 27W 9-1	Pa	10/5/64	260	2.0	675	7.5	--
40N 30W 5-1	Gd(?)	12/10/64	150	---	275	8.0	51
6-1	Gd	1964	260	<0.1	---	7.5	56
14-1	Pc(?)	1964	290	0.1	580	7.5	49
14-2	--	12/14/64	240	1.5	420	7.5	48
20-1 (Flows)	--	1964	220	0.1	385	7.0	49
23-1	Pc	1964	300	0.2	500	7.5	--
40N 29W 6-2	Gd	9/11/64	240	0.2	---	8.0	--
40N 28W 10-1	Pc	12/9/64	270	<0.1	640	8.0	47
39N 29W 2-1	Gd	1964	---	---	480	---	50
14-2	Gd	12/15/64	170	0.1	340	7.5	--
15-1	Gd	12/15/64	260	1.5	420	7.5	--
20-1	Gd	1964	---	---	335	---	49
22-1	Gd	1964	250	0.2	460	---	53
26-1	Pc	1964	---	---	435	---	51
36-1	Pc	1964	---	---	525	---	53
36-2	--	1964	---	---	425	---	51
39N 28W 16-1	Pc	1964	---	---	380	---	50
24-1	Pa	9/16/64	---	---	540	---	51
30-8	Pc	12/15/64	310	<0.1	480	7.5	--
35-1	Pa	1964	---	---	660	---	53

(< = Less than)

Table 5. Field Analyses of Well Water.

Source	Date	Field number	Specific Conductance (Micromhos at 25°C)	Hardness ($CaCO_3$)	Dissolved Oxygen	pH	Temperature (°F)
Streams:							
Swartz Creek below dam	9/18/64	44N 28W-1	230	140	8.4	7.3	53
West Br. Escanaba River	9/17/64	44N 28W-2	---	150	10.0	8.0	46
West Br. Escanaba River	9/17/64	44N 27W-1	---	150	10.0	7.5	--
Ford River at M95 bridge	9/17/64	43N 30W-1	300	190	10.0	7.3	52
North Br. Ford River	9/17/64	43N 28W-1	---	190	9.5	8.0	46
Ford River at Ralph	9/17/64	43N 28W-2	287	190	9.6	7.5	47
Ford River at Alfred	9/16/64	43N 27W-1	---	200	10.8	8.0	49
N. Br. of W. Br. Sturgeon River	10/8/64	42N 30W-1	300	200	----	7.5	45
West Br. Sturgeon River	10/16/64	42N 30W-3	285	200	----	7.5	47
Six Mile Creek	10/7/64	42N 29W-2	275	150	----	7.5	46
West Br. Sturgeon River	10/16/64	42N 29W-3	300	210	----	7.5	48
West Br. Sturgeon River	10/14/64	42N 28W-1	285	170	----	8.0	54
West Br. Sturgeon River	11/6/64	41N 29W-2	250	150	----	7.5	--
Lakes with outlets:							
Pickerel Lake	10/23/64	43N 28W-3	320	190	----	8.0	--
Solberg Lake	10/16/64	42N 29W-1	320	220	----	8.0	--
Lyons Lake	11/6/64	41N 29W-2	250	150	----	7.5	--
Lakes with no outlets:							
Coy Lake	10/21/64	44N 30W-1	70	50	----	7.0	--
Silver Lake	10/19/64	44N 30W-2	<50	20	----	6.5	--
Edey Lake	10/19/64	44N 30W-3	<50	20	----	6.0	--
Sawyer Lake	10/19/64	44N 30W-4	<50	20	----	6.5	--
Brush Lake	10/15/64	42N 30W-2	<50	20	----	6.0	54

(< = Less than)

Table 6. Analyses of surface water.