U.S. Department of the Interior
U.S. Geological Survey

Hydrogeology and Ground-Water Quality of the Bay Mills Indian Community Study Area, near Brimley, Michigan

Introduction

Problem

Bay Mills Indian Community (BMIC) near Brimley, Mich. (fig. 1), with a population of about 1,000, needs hydrogeologic and ground-water-quality information to help assure a reliable ground-water supply for future economic development. Currently (1995), three wells supply water to a housing development adjacent to Mission Hill, but the remainder of BMIC is dependent on private low-capacity wells. Currently (1995), motel and gaming facilities are being constructed at the former Fisherman's Wharf site. These facilities will require large-capacity wells for public supply and fire protection. In addition, a proposed fish hatchery would require a water supply that would meet stringent water-quality requirements and be capable of producing about 500 to 600 gallons per minute (gal/min). This report summarizes hydrogeologic and ground-water-quality information needed to effectively plan for water-supply development at BMIC and is the result of a cooperative effort between BMIC and the U.S. Geological Survey (USGS).

Physical Setting

The BMIC is at Bay Mills in Chippewa County in the Upper Peninsula of Michigan. Bay Mills is about 2 miles northwest of Brimley, and on Sugar Island, which is in the Saint Marys River east of Sault Ste. Marie. The study area described in this report only covers the Bay Mills part of the BMIC, which has an area of about 1,600 acres (fig. 1).

The study area is in the Saint Marys River drainage basin. In the northern part of the drainage basin, surface water flows directly to the Saint Marys River; in the southern part, surface water runs off to small streams draining into the Saint Marys River. About one-half of the total area (770 acres) is wetland (Wieting, 1994).

Land-surface altitudes range from 601 feet (ft) above sea level at the shore of the Saint Marys River to 840 ft above sea level near Mission Hill. Land-surface altitudes for most of the study area are less than 700 ft above sea level. Soil types vary, but primarily are sandy. Veatch and others (1932) and the U.S. Department of Agriculture (1991) published a comprehensive discussion of the soils of Chippewa County, and Wieting (1994) discusses soil types specific to the study area. Vegetation types range from mature conifer and deciduous forests in dry areas to bushes and other plants in wetland areas.

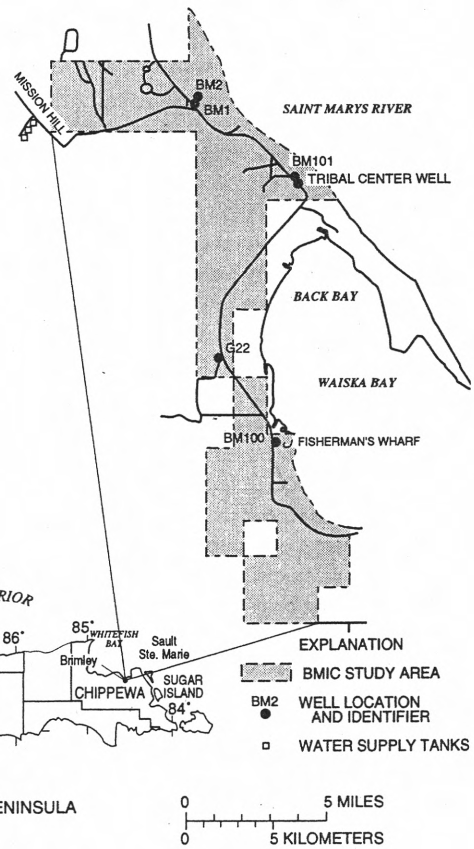
Climate at BMIC is moderated by the Great Lakes. The nearest climatological data-collection site is in Sault Ste. Marie, Mich., where average annual precipitation is 33.5 inches. February is the driest month with a mean of 1.7 inches of precipitation; September is the wettest month with a mean of 3.9 inches. Annual mean temperature is 39.8°F and monthly mean temperatures range from 16.6°F in January to 60.4°F in August (Eichenlaub and others, 1990).

Geology

Bedrock

Configuration and topography of the bedrock surface is poorly known at Bay Mills because few water wells are completed in bedrock. Four distinct lithic units are recognized in the Precambrian Jacobsville Sandstone that underlies Pleistocene glacial deposits (Hamblin, 1958). Lithologic units are listed in order of decreasing abundance: lenticular sandstone, massive sandstone, basal conglomerate, and thin-bedded shale. Average grain size of the Jacobsville Sandstone is 0.25-0.50 millimeter (Hamblin, 1958). Jacobsville Sandstone is red and reddish-brown in color mottled with white streaks, blotches, and circular spots, which represent reduction of iron.

Precambrian metamorphic and igneous rocks, which crop out in Ontario, Canada, north and east of Sault Ste. Marie, and in the western Upper Peninsula of Michigan underlie the Jacobsville Sandstone. The Jacobsville Sandstone crops out at Sault Ste. Marie to form the falls of the Saint Marys River, and along the shore of Lake Superior west of Munising, from Grand Island to Bete Grise Bay (Hamblin, 1958). The contact between the Jacobsville Sandstone and



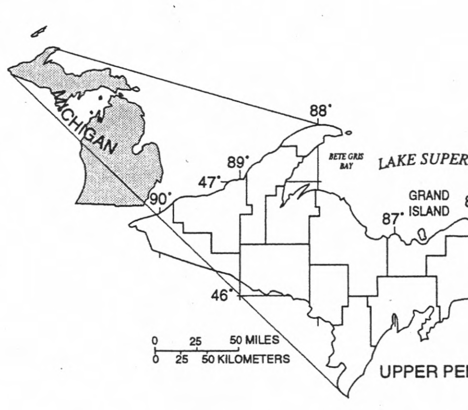


Figure 1. Location of the Bay Mills Indian Community study area, near Brimley, Michigan.

younger Cambrian and Ordovician units, including the Munising Formation (Cambrian age), is near the study area, and some investigators have suggested that these units overlie the Jacobsville Sandstone in parts of the study area (Martin, 1936; Wieting, 1994).

Glacial Deposits

Pleistocene glacial deposits are primarily sand and clay, with some gravel. Thickness of glacial deposits ranges from about 100 to at least 426 ft along Waiska Bay, near Brimley, Michigan (Vanlier and Deutsch, 1958).

Three types of glacial landforms are present in the study area. Land surface is relatively flat near the Saint Marys River. This area was defined as a lake plain by Vanlier and Deutsch (1958) and probably represents a terrace formed by post-glacial Lake Nipissing. Mission Hill is a steep ridge of sand that trends to the northwest along the west boundary of the study area. Mission Hill, which at its highest point is about 450 ft above the current surface of Lake Superior, is thought to be the wave-cut cliff of a post-glacial Lake Nipissing dune (Vanlier and Deutsch, 1958). The area southwest of Waiska Bay is defined as a moraine (Vanlier and Deutsch, 1958).

Geophysical Logs

Geophysical logs were completed in April 1995 in USGS observation well G22 and BM100 (fig. 1). Well G22 is 44 ft deep and completed in glacial deposits. Well BM100 is 205 ft deep and completed in the Jacobsville Sandstone.

Geophysical logs can be used to obtain hydrogeologic information about the subsurface geologic materials. Many types of geophysical measurements can be made. Each type measures a specific physical property of the material. Resistivity and gamma-ray logs can help delineate the extent of aquifer materials; however, resistivity logs must be run in fluid-filled, uncased boreholes and gamma-ray logs can be run in cased boreholes with or without fluids.

All wells in the study area are fully cased, with the exception of well BM100 at the new motel site, which was uncased in the bedrock part of the well. As a result, the only resistivity log completed for this study was for well BM100.

The electrodes of the resistivity probe used in this study were spaced 16 and 64 inches apart (the larger the electrode spacing, the further into the formation resistivity is measured). The resistance measured by the 64-inch spacing is about 270 to 280 ohm-meters at a depth of 176 to 195 ft below land surface. A reading of this magnitude is about mid-range for a formation comprised of sandstone and containing freshwater (Driscoll, 1986). The driller's log for well BM100 shows sandstone at a depth of 176 to 195 ft below land surface.

The gamma-ray response in well BM100 from 178 to 192 ft below land surface is typical of a shale, but the driller's log and resistivity log indicate that the formation at these depths is a sandstone. The gamma-ray response indicates that this interval has a higher rate of radioactivity than is common for sandstone. The Jacobsville Sandstone in the Upper Peninsula has a potassium anomaly, primarily because the formation contains large amounts of microcline feldspar (J. Kalliokoski, Michigan Technological University, oral commun., 1995). The potassium anomaly probably is the reason for the anomalous gamma-ray response in well BM100.

Hydrology

Ground-Water Flow

Regionally, ground water flows toward the Saint Marys River, Waiska Bay, and Back Bay (Gillespie and Dumouchelle, 1988). A large number of flowing wells are present in the study area, which indicates that a substantial part of ground-water flow is upward. The ground-water level measured in well BM100 was about 612.7 ft above sea level, which is about 7.5 ft above land surface prior to motel construction. The difference between ground-water levels near Mission Hill and those near Saint Marys River (a distance of about 1 mile), probably accounts for the large number of flowing wells throughout the southeastern part of the study area. The water table is at or near land surface near wetlands, lakes, and the Saint Marys River.

Hydraulic Characteristics

Previous aquifer tests done by the USGS near the study area indicate that wells less than 6 inches in diameter completed in the Jacobsville Sandstone are likely to yield less than 10 gal/min, although larger diameter wells could potentially yield several tens of gallons per minute (Twenter, 1966a; Rheaume, 1991). The Jacobsville Sandstone is well cemented and primary permeability is low. Most water moves along fractures or separations in bedding planes (Vanlier, 1963). Locally, the Jacobsville Sandstone is a source of saline water.

Wells completed in the sand and gravel aquifer near BMIC yield from 10 to 100 gal/min (Twenter, 1966b; Rheaume, 1991), however, larger diameter wells (6 inch or larger) completed in the sand and gravel aquifer can potentially yield several hundred gallons per minute. An aquifer test in 6-inch diameter public-supply wells BM1 and BM2 (fig. 1) completed in the sand and gravel aquifer was done May 16-17, 1995. The depth of well BM1 is 192 ft below land surface and the depth of well BM2 is 190 ft below land surface; both wells are screened at the bottom 10 ft. Well BM1 is about 160 ft from well BM2. Pumps in wells BM1 and BM2 were shut-off 19 hours prior to the beginning of the test to allow water levels to stabilize. Well BM2 was then pumped at an average rate of 34 gal/min for just more than 5 hours, while water levels were measured in well BM1. The aquifer test was stopped because of community water needs.

The time-drawdown log-log plot was matched with the Theis curve (Theis, 1935). Several conditions are assumed in the application of the Theis method; the aquifer is confined, homogeneous, isotropic and infinite in extent, the well(s) fully penetrate the aquifer, and the aquifer is screened over the entire thickness of the aquifer, which is constant. The transmissivity of the aquifer, which is defined as the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient, is about 4,300 feet squared per day. The storage coefficient, which is defined as the volume of water released from storage in a unit volume of an aquifer when head is lowered a unit distance, is about 0.0005. The specific capacity, which is defined as yield divided by drawdown, of well BM2 is about 3 gallons per minute per foot.

Results of the aquifer test are compatible with information from driller's logs. The aquifer material at wells BM1 and BM2 is overlain by a confining layer described by the drillers as hardpan or sandy clay, which could possibly protect the aquifer from potential sources of contamination.

Ground-Water Quality

Ground water in the study area is good for human consumption, with few exceptions. As part of this study, chemical constituents of water from wells BM100, G22, and BM101 were sampled to determine water quality (fig. 1). The results of the chemical analyses are shown in table 1.

Constituent concentrations in water from each of the three samples analyzed are less than the U.S. Environmental Protection Agency (USEPA) primary and secondary contaminant levels (1991, 1994). In 1986, observation well G22 was sampled for volatile organic compounds and trace metals, and concentrations were less than USEPA drinking-water standards (Gillespie and Dumouchelle, 1988).

A hydrogen sulfide odor has been noted in water from some wells in the study area. This is particularly notable in two 180-ft deep wells drilled in 1994 at newly constructed houses adjacent to the tribal center (BM101 is one of the two wells). Water from these wells contains 0.005 mg/L of sulfide (D. Sargent, Inter-Tribal Council of Michigan, written commun., 1995). Sulfide concentrations of more than 0.001 mg/L are objectionable to most people (Hem, 1985). Water from the tribal center well, which is about 110 ft deep, has no hydrogen sulfide odor.

Tritium is an unstable isotope of hydrogen that enters ground water during recharge. Manufacture and testing of nuclear weapons after 1953 increased the amount of tritium present in the atmosphere to two to three times previously recorded levels. As a result, tritium measured in ground water can be used to determine aquifer vulnerability to contamination at the land surface; concentrations less than 1.5 to 2.0 tritium units (TU) indicate that water from the aquifer has been in contact with the atmosphere since 1953 and the aquifer may be vulnerable to contamination; concentrations less than 1.5 TU indicate the aquifer is less vulnerable to contamination. Water from four wells was analyzed for tritium. Samples from wells BM2, BM100, and the tribal center well had concentrations less than 1.5 TU. A sample from observation well G22 had a concentration of about 38 TU.

J. Kalliokoski (Michigan Technological University, oral commun., 1995) investigated the Jacobsville Sandstone and other formations in the Upper Peninsula for the presence of uranium and its daughter products. Water passing through parts of the aquifers that contain uranium and its daughter products may contain these constituents. Data from a previous USGS study indicates that the median concentration of dissolved uranium in water from wells completed in the Jacobsville Sandstone throughout the Upper Peninsula was 2.2 µg/L, but water samples from wells in Chippewa County were not analyzed in that study (Cummings, 1989). In another USGS study, dissolved uranium was not detected in water from a Chippewa County well completed in the Jacobsville Sandstone (Huffman and Whited, 1988).

Table 1. Physical and chemical characteristics of water from wells at Bay Mills Indian Community study area, and water-quality standards for human consumption, fish habitat, and metal analysis, near Brimley, Michigan

[Concentrations are in milligrams per liter unless otherwise noted. Drinking-water standards are USEPA (U.S. Environmental Protection Agency) Primary or Secondary Standards. Analysis for tritium by University of Waterloo Environmental Isotope Laboratory; all other analyses by U.S. Geological Survey. Open intervals for wells BM101, G22, and BM100 are 175-180, 40-44, and 175-205 feet below land surface, respectively. µS/cm, microsiemen per centimeter at 25°C; °C, degrees Celsius; pCi/L, picocuries per liter; TU, tritium unit; --, not analyzed or no standard; <, actual value is less than value shown]

Physical characteristic or water-quality constituent	USEPA drinking water standards	Maximum safe concentration for fishery	Well BM101	Well G22	Well BM100	Equipment blank (metals only)
Specific conductance (µS/cm at 25°C)	--	--	137	155	213	--
pH (standard units)	[1]6.5-8.5	--	8	8	8.1	--
Turbidity (NTU)	--	--	0.2	1.2	0.2	--
Hardness, total (as $CaCO_3$)	--	--	60	73	65	--
Calcium, dissolved	--	--	18	21	19	--
Magnesium, dissolved	--	--	3.6	4.9	4.3	--
Sodium, dissolved	--	--	3.5	2.6	12	--
Sodium, percent	--	--	12	8	27	--
Sodium adsorption ratio	--	--	0.2	0.1	0.6	--
Potassium, dissolved	--	--	1.4	0.8	4.8	--
Alkalinity (as $CaCO_3$)	--	--	65	70	60	--
Sulfate, dissolved	[1]250	--	4.3	7.5	8.5	--
Chloride, dissolved	[1]250	--	0.2	0.4	21	--
Fluoride, dissolved	[1]2.0	--	<0.1	<0.1	0.2	--
Silica, dissolved	--	--	13	19	14	--
Dissolved solids, residue at 180°C	--	--	83	97	118	--
Dissolved solids, residue at 105°C	--	--	96	122	128	--
Dissolved solids, sum of constituents	[1]500	--	83	99	120	--
Nitrogen, nitrite, dissolved (as N)	1	--	<0.01	<0.01	<0.01	--
Nitrogen, nitrite plus nitrate, dissolved (as N)	--	--	<0.05	0.13	<0.05	--
Phosphorus, total (as P)	--	--	0.02	0.03	0.04	--
Phosphorus, dissolved (as P)	--	--	<0.01	0.02	0.03	--
Phosphorus, ortho, dissolved (as PO_4)	--	--	0.02	0.02	0.03	--
Arsenic, total	[2]0.05	0.07	0.003	<0.001	0.004	<0.001
Chromium, dissolved	0.1	0.05	<0.005	<0.005	<0.005	<0.001
Copper, dissolved	[1]1	0.015	<0.001	<0.001	<0.001	<0.001
Iron, dissolved	[1]0.3	0.03	0.02	0.012	0.014	<0.01
Lead, dissolved	0.015	0.03	0.003	<0.001	<0.001	<0.001
Manganese, dissolved	[1]0.05	--	0.037	<0.001	0.019	<0.01
Mercury, dissolved	0.002	0.0005	<0.0001	<0.0001	<0.0001	<0.0001
Zinc, dissolved	[1]5	0.05	0.041	0.035	0.021	0.02
Radium 226 (pCi/L)	[3]20	--	--	--	<.02	--
Tritium, total (TU)	--	--	--	([4])	([5])	--

[1]Suggested USEPA Secondary Maximum Contaminant Level.
[2]Interim USEPA Maximum Contaminant Level.
[3]Proposed USEPA Maximum Contaminant Level.
[4]Tritium level at well BM101 ranged from 37.4-38.9 ± 2.6.
[5]Tritium level at well BM100 was 0.8 ± 0.4.

Radioactivity in drinking water is a major concern and health guidelines for radionuclides in water are published by the U.S. Environmental Protection Agency and the Michigan Department of Health. A water sample from well BM100 was analyzed for radium^{226}, a common daughter product of uranium. The level was lower than the detection limit of 0.02 Picocuries per liter. Further study of radioactivity in water from the Jacobsville Sandstone is needed before it can be used for public supply.

Summary

Hydrogeologic and ground-water-quality information contained in this report indicate that a reliable ground-water supply is available for the BMIC. The Jacobsville Sandstone in the BMIC study area is hydraulically connected to an overlying glacial aquifer. In some parts of the Upper Peninsula of Michigan, however, the Jacobsville Sandstone produces little water or produces water of poor quality. Although the Jacobsville Sandstone may be less subject to contamination than the glacial aquifer because it is deeper, the additional cost of drilling deeper wells along with the risk of high levels of radionuclides could negate the benefits of completing public-supply wells in the sandstone.

A supply of good-quality water is currently (1995) available from the glacial aquifer. Small-diameter wells yield from 10 to 100 gal/min and larger diameter wells can potentially yield several hundred gallons per minute. The productive parts of the sand and gravel aquifer appear to be overlain by clay and sandy clay. The clay and sandy clay could possibly protect the aquifer from potential sources of contamination. In places where the water table is near land surface, the shallow parts of the aquifer may be vulnerable to some sources of contamination, particularly individual septic systems and leaking underground storage tanks. However, the upward component of ground-water flow in the sand and gravel aquifer in the Bay Mills area lessens the chances of contamination.

Water quality of samples taken from wells tested at BMIC indicates that water is suitable for human consumption with the exception of possibly objectionable, but safe, levels of hydrogen sulfide in water from several wells completed in the sand and gravel aquifer. Concentrations of all chemical constituents measured are less than U.S. Environmental Protection Agency's maximum contaminant levels (1991, 1994). Large-capacity wells completed in the sand and gravel aquifer can potentially supply BMIC with quantities of fresh water necessary to meet increased economic development providing the aquifer is protected from contamination.

—T.L. Weaver

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