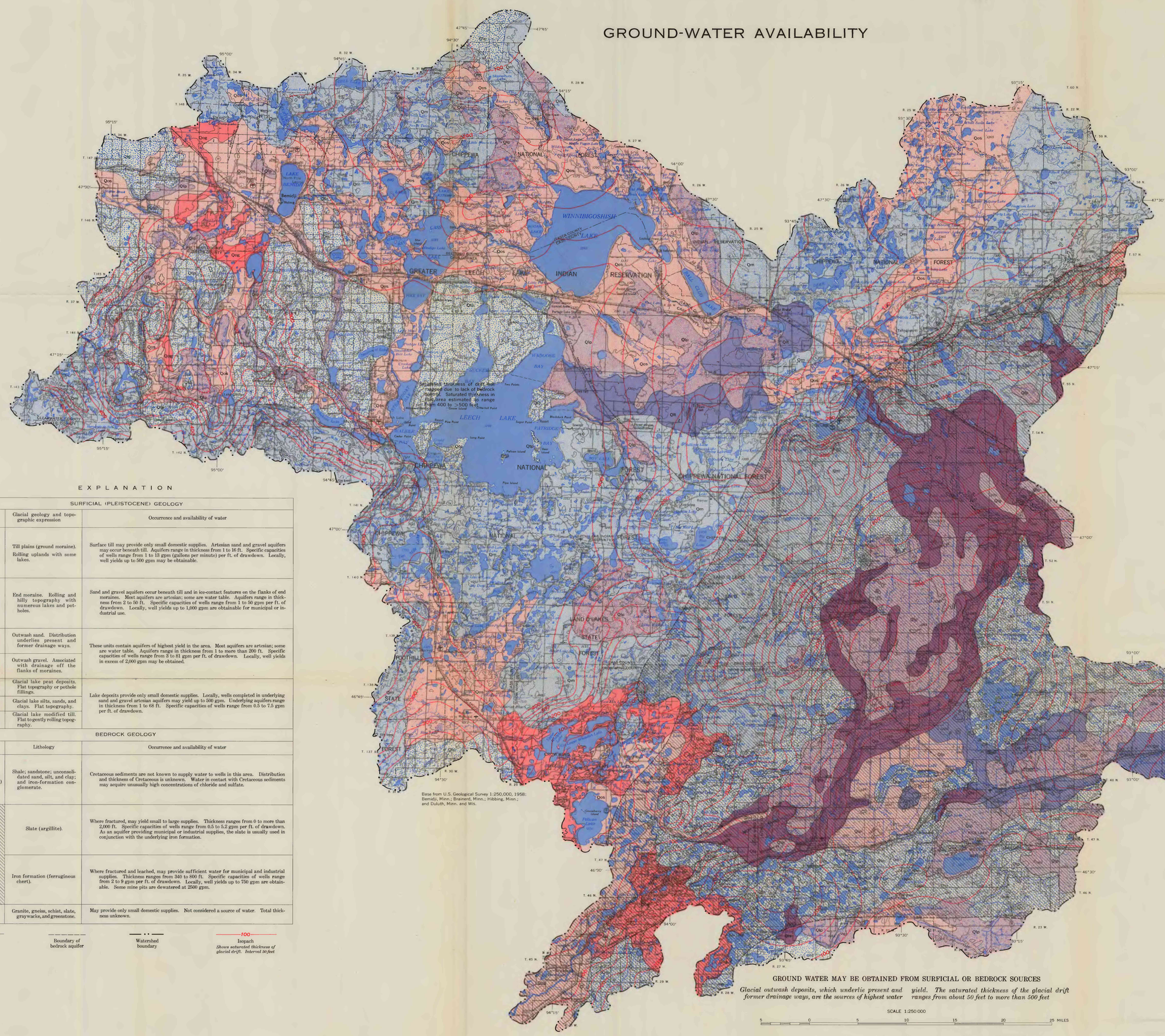
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
THE MINNESOTA DEPARTMENT OF CONSERVATION
DIVISION OF WATERS, SOIL, AND MINERALS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-278 (SHEET 2 OF 4)

GROUND-WATER AVAILABILITY



EXPLANATION

SURFICIAL (PLEISTOCENE) GEOLOGY

	Map unit	Glacial geology and topographic expression	Occurrence and availability of water
QUATERNARY	Qtp	Till plains (ground moraine). Rolling uplands with some lakes.	Surface till may provide only small domestic supplies. Artesian sand and gravel aquifers may occur beneath till. Aquifers range in thickness from 1 to 16 ft. Specific capacities of wells range from 1 to 13 gpm (gallons per minute) per ft. of drawdown. Locally, well yields up to 500 gpm may be obtainable.
	Qm	End moraine. Rolling and hilly topography with numerous lakes and potholes.	Sand and gravel aquifers occur beneath till and in ice-contact features on the flanks of end moraines. Most aquifers are artesian; some are water table. Aquifers range in thickness from 2 to 50 ft. Specific capacities of wells range from 1 to 50 gpm per ft. of drawdown. Locally, well yields up to 1,000 gpm are obtainable for municipal or industrial use.
	Qos	Outwash sand. Distribution underlies present and former drainage ways.	These units contain aquifers of highest yield in the area. Most aquifers are artesian; some are water table. Aquifers range in thickness from 1 to more than 200 ft. Specific capacities of wells range from 3 to 81 gpm per ft. of drawdown. Locally, well yields in excess of 2,000 gpm may be obtained.
	Qog	Outwash gravel. Associated with drainage off the flanks of moraines.	
	Qlp	Glacial lake peat deposits. Flat topography or pothole fillings.	Lake deposits provide only small domestic supplies. Locally, wells completed in underlying sand and gravel artesian aquifers may yield up to 500 gpm. Underlying aquifers range in thickness from 1 to 68 ft. Specific capacities of wells range from 0.5 to 7.5 gpm per ft. of drawdown.
	Qls	Glacial lake silts, sands, and clays. Flat topography.	
	Qlt	Glacial lake modified till. Flat to gently rolling topography.	

BEDROCK GEOLOGY

	System	Lithology	Occurrence and availability of water
MESOZOIC	Cretaceous (not mapped)	Shale; sandstone; unconsolidated sand, silt, and clay; and iron-formation conglomerate.	Cretaceous sediments are not known to supply water to wells in this area. Distribution and thickness of Cretaceous is unknown. Water in contact with Cretaceous sediments may acquire unusually high concentrations of chloride and sulfate.
PRECAMBRIAN	Middle	Slate (argillite).	Where fractured, may yield small to large supplies. Thickness ranges from 0 to more than 2,000 ft. Specific capacities of wells range from 0.5 to 5.2 gpm per ft. of drawdown. As an aquifer providing municipal or industrial supplies, the slate is usually used in conjunction with the underlying iron formation.
		Iron formation (ferruginous chert).	Where fractured and leached, may provide sufficient water for municipal and industrial supplies. Thickness ranges from 340 to 800 ft. Specific capacities of wells range from 2 to 9 gpm per ft. of drawdown. Locally, well yields up to 750 gpm are obtainable. Some mine pits are dewatered at 2500 gpm.
	Middle and lower	Granite, gneiss, schist, slate, graywacke, and greenstone.	May provide only small domestic supplies. Not considered a source of water. Total thickness unknown.

Contact

Boundary of bedrock aquifer

Watershed boundary

100 Isopach
Shows saturated thickness of glacial drift. Interval 50 feet

GROUND WATER MAY BE OBTAINED FROM SURFICIAL OR BEDROCK SOURCES

Glacial outwash deposits, which underlie present and former drainage ways, are the sources of highest water yield. The saturated thickness of the glacial drift ranges from about 50 feet to more than 500 feet

SUMMARY OF MUNICIPAL SUPPLIES AND DEVELOPMENT POTENTIAL

Municipality	Well no.	U.S.G.S. field number	Well depth (ft.)	Well diameter	Specific capacities of wells: Specific capacity equals: (gallons per minute per ft. of drawdown)	Specific capacities of wells: At a pumping rate of: (gallons per minute)	Specific capacities of wells: For a period of: (hours)	Quality: Milligrams per liter: Iron	Quality: Milligrams per liter: Magnesium	Quality: Milligrams per liter: Hardness as calcium carbonate	Quality: Milligrams per liter: Total dissolved solids	Quality: pH	Aquifer and depth below land surface	Remarks[1]	Average daily use (thousands of gallons per day)	Potential for additional development of ground-water supplies[2]
Village of Aitkin	2	47.27.26dda	229	8 in.	5.2	270	unknown	0.48	<0.02	140	——	7.6	Precambrian slate at 174 ft.	Not used.	224	Good additional supplies may be obtained from the presently used aquifer. Saturated thickness of glacial drift is about 250 ft.
	4	47.27.23ddd	216	12 in.	7.8	750	10.0	0.22	0.02	130	——	8.6	Glacial sand, 150–218 ft.	————		
	5	47.27.23cda	229	12 in.	11.5	1000	10.0	0.07	0.07	134	214	7.4	Glacial sand, 174–234 ft.			
City of Bemidji	7	146.33.15cbd	157	12 in.	11.8	280	1.5	1.40	0.07	250	——	7.5	Glacial sand, 133–155 ft.	High iron.	727	The sand and gravel deposits within the glacial drift underlying the city should be good to excellent sources of additional water.
	9	146.33.9 cbb	83	16 in.	12.8	300	1.0	0.04	0.06	242	——	8.4	Glacial sand, 56–87 ft.	————		
	10	146.33.4 cca 1	238	10 in.	22.2	400	24.0	0.80	<0.02	204	——	7.8	Glacial sand and gravel, 201–250 ft.	High iron.		
	11	146.33.4 cad	113	10 in.	18.0	330	1.25	0.69	0.12	211	239	7.9	Glacial sand and gravel, 85–133 ft.	High iron and manganese.		
	12	146.33.4 ccb	98	12 in.	24.0	440	2.0	0.06	0.04	210	——	8.4	Glacial sand and gravel, 66–98 ft.	————		
	14	146.33.4 cab	108	12 in.	——	——	——	0.12	0.09	200	——	8.3	Glacial sand and gravel, 56–108 ft.			
	15	146.33.4 cca 2	104	12 in.	34.5	678	12.0	0.18	0.08	220	——	7.3	Glacial sand, 32–103 ft.			
Village of Bovey[3]	——	56.24.32bda	88	16 in.	29.1	743	9.0	5.20	0.51	277	336	7.2	Glacial sand and gravel, 39–91 ft.	Excessive iron and manganese.	125	Good additional supplies may be obtained locally from glacial drift and from Precambrian iron formation.
City of Brainerd	3	45.31.36bbc 1	120.5	16 in.	——	——	——	1.10	0.63	380	——	7.3	All Brainerd wells are located in a glacial channel fill deposit of sand and gravel, 200+ ft. in thickness.	High iron and excessive manganese. Pumping capacities of all wells combined is greater than the capability of treatment or distribution system.	1646	An excellent source of additional water may be obtained by increased development of present well field.
	4	45.31.36bbc 2	120	16 in.	50.5	1550	unknown	1.00	0.63	310	——	7.5				
	5	45.31.35aca 1	145	16 in.	46.5	2550	unknown	2.10	0.65	214	272	7.7				
	6	45.31.35aad	150	16 in.	47.5	2500	unknown	0.94	0.62	230	——	7.7				
	7	45.31.35aca 2	150	20 in.	81.0	2100	24.0	2.10	0.23	230	——	7.8				
Village of Calumet[3]	2	56.23.21bcd 1	495	8 in.	——	240	——	0.19	0.00	141	161	7.8	Precambrian slate, 200–311 ft., iron formation, 311–495 ft.	Standby use only.	30	Additional supplies available from Precambrian bedrock may be limited by diversion of ground-water recharge by mine dewatering.
	3	56.23.21bcd 2	500	10 in.	——	200	——	0.06	0.04	150	——	7.7	Precambrian slate, 119–300 ft., iron formation, 300–500 ft.	————		
Village of Cass Lake	1	145.31.15bab 1	110	10 in.	10.0	400	unknown	——	——	——	——	——	Glacial sand.	————	75	Good additional supplies may be obtained locally from glacial drift.
	2	145.31.15bab 2	105	6 in.	5.5	175	unknown	0.02	0.02	200	——	7.9	Glacial sand, 49–105 ft.			
	3	145.31.15bdb	110	12 in.	6.9	220	unknown	0.17	0.09	201	245	7.3	Glacial sand and gravel, 42–111 ft.			
Village of Coleraine[3]	1	56.24.32cab 1	107	24 in.	——	——	——	0.62	0.34	220	——	7.8	Glacial sand and gravel.	High iron and excessive manganese.	200	Good additional supplies may be obtained locally from glacial drift and from Precambrian iron formation.
	3	56.24.32cab 2	120	16 in.	53.8	1022	10.0	0.30	0.48	210	258	7.4	Glacial sand with gravel, 70–121 ft.			
Village of Cooley[4]	——	56.22.6 dcc	537	12 in.	3.9	330	unknown	0.05	0.00	139	152	7.3	Precambrian slate, 149–310 ft. iron formation 310–537 ft.	Also connected to Nashwauk.	65	Good additional supplies may be obtained locally from glacial drift. Probably much ground-water recharge to the bedrock aquifer is diverted by mine dewatering.
Village of Cromwell	——	49.20.33dcc	150	10 in.	0.55	30	5.5	0.08	0.16	204	246	7.5	Glacial sand, 80–83 ft. Precambrian slate, 83–150 ft.	Glacial aquifer is of limited value due to thinness of sand. Additional supplies of unknown *quantity* may be obtained by drilling deeper into slate.	8	
Village of Crosby	1	46.29.12dbc 1	91	12 in.	7.7	200	10.0	1.40	0.25	133	173	7.1	Glacial sand and gravel, 0–91+ ft.	High iron and manganese.	250	An excellent source of additional water may be obtained by increased development of present well site.
	2	46.29.12dbc 2	90	5 in.	——	——	——	——	——	——	——	——		Not used.		
	3	46.29.12dbc 3	——	6 in.	——	——	——	2.20	1.10	150	——	7.4		High iron and excessive manganese.		
Village of Cuyuna	——	47.28.31bbd	25	30 ft.	——	——	——	0.06	0.05	193	229	7.9	Probably alluvial sand, 0–25 ft.	Shallow dug well with 42,000 gallons stored at static water level.	18	Good additional supplies may be obtained locally from glacial drift. Saturated thickness of glacial drift is 75 ft.

[1] U.S. Public Health Service recommended limits for iron and manganese are 0.30 mg. per liter and 0.05 mg. per liter, respectively. Amounts higher than this are noted. Where the concentration is greater by a factor of 10, it is arbitrarily termed excessive.

[2] The following arbitrary criteria are used to evaluate ground-water potential—in reference to water quantity only.
Excellent—The potential supply may be increased to greater than double present use.
Good—The potential supply may be increased to double present use.

[3] Additional detailed information in U.S. Geol. Survey Water-Supply Paper 1759-B.

[4] Additional detailed information in U.S. Geol. Survey Water-Supply Paper 1759-C.

Municipality	Well no.	U.S.G.S. field number	Well depth (ft.)	Well diameter	Specific capacities of wells: Specific capacity equals: (gallons per minute per ft. of drawdown)	Specific capacities of wells: At a pumping rate of: (gallons per minute)	Specific capacities of wells: For a period of: (hours)	Quality: Milligrams per liter: Iron	Quality: Milligrams per liter: Magnesium	Quality: Milligrams per liter: Hardness as calcium carbonate	Quality: Milligrams per liter: Total dissolved solids	Quality: pH	Aquifer and depth below land sufface	Remarks[1]	Average daily use (thousands of gallons per day)	Potential for additional development of ground-water supplies[2]
Village of Deer River	1	145.25.36bac 1	98	6 in.	——	——	——	1.40	0.20	360	——	7.9	Glacial sand.	High iron.	94	Good additional supplies may be obtained from the presently used aquifer. Saturated thickness of glacial drift is about 250 ft.
	2	145.25.36bac 2	98	6 in.	——	——	——	1.30	0.20	360	——	7.4	Glacial sand.	Not used.		
	3	145.25.36bac 3	104	10 in.	50.0	300	8.0	0.32	0.26	350	399	7.6	Glacial sand, 72–104 ft.	High manganese.		
Village of Deerwood	——	46.29.8 dca	181	12 in.	4.0	100	10.0	0.63	0.10	184	232	7.3	Glacial sand and gravel, 163–181 ft.	High iron and manganese.	45	Good additional supplies may be obtained from presently used aquifer.
Village of Grand Rapids[3]	1	55.25.17ddb 1	168	12 in.	17.9	1200	12.0	2.10	<0.02	200	——	7.6	Glacial sand and gravel, 80–176 ft.	Standby well. High iron.	640	Good additional supplies may be obtained from the presently used glacial drift and Precambrian bedrock aquifers. An excellent additional source may be obtained from glacial drift ½ mile north of present wells.
	2	55.25.17ddb 2	573	16 in.	2.8	500	24.0	0.65	0.00	213	224	7.8	Precambrian slate and iron formation, 214–573 ft.	High iron. High iron and manganese.		
	3	55.25.17ddb 3	176	12 in.	10.4	956	8.0	1.90	0.22	191	279	7.6	Glacial sand and gravel, 113–179 ft.			
Village of Hackensack	——	140.30.19acb	56	10 in.	——	——	——	1.10	0.15	190	231	7.3	————	High iron.	20	Good additional supplies may be obtained locally from glacial drift.
Village of Hill City	1	52.26.14ddd 1	198	10 in.	1.25	100	62.0	0.55	0.30	314	367	7.6	Glacial sand and gravel, 30–198 ft.	High iron and manganese.	30	Presently used aquifers may provide additional water of unknown quantity. Saturated thickness of glacial drift is about 250 ft. Deeper waters from possibly Cretaceous bedrock may be of undesirable quality.
	2	52.26.14ddd 2	111	6 in.	——	——	——	6.80	1.00	350	——	8.0	————	Not used, bad odor. Excessive iron and manganese.		
	3	52.26.14ddd 3	22	48 in.	——	——	——	2.30	0.31	270	——	8.0	————	Shallow dug standby well. High iron and manganese.		
Village of Ironton	1	46.29.14bba 1	38	16 in.	7.1	200	unknown	——	——	——	——	——	Glacial sand and gravel, 34.5–40 ft.	Standby well.	250	Additional supplies limited by thinness of presently used aquifer and by bedrock near the surface in the area of present wells.
	2	46.29.14bba 2	42	6 ft.	——	——	——	0.02	1.10	144	195	7.4	Glacial sand, 33–42.5 ft.	Well has radial collectors.		
Village of Keewatin[4]	——	57.22.24dcd	490	10 in.	——	500	24.0	0.19	0.17	166	177	7.3	Precambrian iron formation, 220–490 ft.	High manganese.	190	Additional supplies from the iron formation may be limited by diversion of ground-water recharge by mine dewatering. Good additional supplies may be obtained locally from glacial drift.
	——	57.22.25abd	600	13 in.	8.9	490	4.5	0.35	0.52	186	202	7.4	Precambrian iron formation, 220–600 ft.	Excessive manganese. Standby well.		
Village of Marble[3]	1	56.23.19aca 1	385	20 in.	4.1	300	unknown	——	——	——	——	——	Precambrian iron formation.	High iron and manganese.	132	Additional supplies from the iron formation may be limited by diversion of ground-water recharge by mine dewatering. Good additional supplies may be obtained locally from glacial drift.
	2	56.23.19aca 2	507	16 in.	6.5	385	6.0	0.80	0.11	169	200	7.5	Precambrian iron formation, 129–507 ft.			
Village of Nashwauk[4]	——	57.22.32cda	540	10 in.	——	650	24.0	0.89	0.42	148	161	7.0	Precambrian iron formation, 197–540 ft.	High iron and manganese.	142	Some ground-water recharge to the iron formation is diverted by mine dewatering. Supplies from glacial drift may be limited by deposits of low permeability.
Village of Pine River	1	138.29.31ccb	40	12 in.	19.1	105	2.5	0.06	0.00	200	——	——	Glacial sand.	————	112	Good additional supplies may be obtained from the presently used aquifer. Saturated thickness of glacial drift is about 300 ft.
	2	137.29.6 bbb	40	16 in.	12.5	125	4.0	0.01	0.01	180	230	7.6	Glacial sand.			
Village of Remer	2	141.26.1 caa 1	60	6 in.	——	45	——	3.90	0.68	280	——	7.3	Glacial sand and gravel, 0–60 ft.	Excessive iron and manganese.	50	Good additional supplies may be obtained from the presently used aquifer. Saturated thickness of glacial drift is about 175 ft.
	3	141.26.1 caa 2	52	6 in.	——	——	——	1.20	——	270	——	7.1	Glacial sand and gravel, 0–52 ft.	Standby use only.		
	5	141.26.1 caa 3	52	6 in.	7.1	85	8.0	1.30	0.41	274	317	7.4	Glacial sand and gravel, 0–52 ft.	High iron and manganese.		
Village of Riverton	——	46.29.18dcb	42	——	——	——	——	0.05	0.26	166	244	7.5	Probably sandy alluvium, 0–42 ft.	Shallow dug well of unknown diameter.	9	Good additional supplies may be obtained locally from glacial drift.
Village of Taconite[3]	——	56.24.27bcc	280	12 in.	2.0	100	unknown	0.30	0.05	268	296	7.8	Precambrian iron formation, 110–280 ft.	————	110	Additional supplies may be limited by thinness of glacial drift and by ground-water recharge to bedrock being diverted by mine dewatering.
Village of Tromnald	——	47.29.32ddb	77	8 in.	——	——	——	0.15	0.19	144	183	7.8	Glacial sand and gravel, 60–77 ft.	————	10	Good additional supplies may be obtained locally from glacial drift.
Village of Walker	1	142.31.22aca 1	95	12 in.	——	——	——	2.20	0.17	310	——	8.0	Glacial sand and gravel.	High iron.	120	Good additional supplies may be obtained from the presently used aquifer and from a 350 ft. saturated thickness of glacial drift.
	2	142.31.22aca 2	95	12 in.	26.6	800	24.0	2.50	0.09	301	350	7.8	Glacial sand and gravel, 62–95 ft.			
Village of Werba	2	54.23.28ddb 2	140	6 in.	——	——	——	0.07	0.09	146	300	7.8	Glacial sand, 124–136 ft.	A previous well finished in slate at a depth of 319 ft. produced water with a "salty" taste.	8	Additional supplies may be limited by low permeability of presently used glacial aquifers and by undesirable chemical quality of water from local bedrock aquifers.
	3	54.23.28cab	150	6 in.	7.2	65	6.0	0.38	0.12	190	——	8.3	Glacial sand and gravel, 128–150 ft.			

WATER RESOURCES OF THE MISSISSIPPI HEADWATERS WATERSHED, NORTH-CENTRAL MINNESOTA

By
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