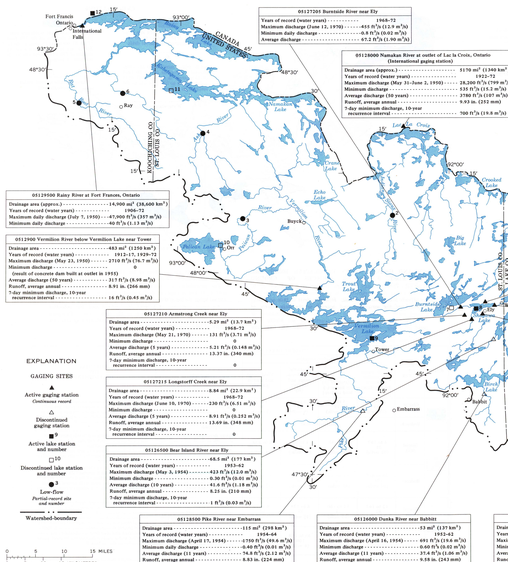
PREPARED IN COOPERATION WITH THE
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS, SOILS, AND MINERALS

SURFACE WATER



EXPLANATION

GAGING STATIONS

Active gaging station — Continuous record

Discontinued gaging station

Active lake station and number

Discontinued lake station and number

Low-flow — Partial-record site and number

Watershed boundary

05120901 Burntside River near Ely
Years of record (water year) 1948–72
Maximum discharge (June 12, 1970) ..... 455 ft³/s (12.9 m³/s)
Minimum daily discharge ..... 0.8 ft³/s (0.02 m³/s)
Average discharge ..... 87.2 ft³/s (1.90 m³/s)

05120000 Namakan River at outlet of Lac la Croix, Ontario (International gaging station)
Drainage area (approx.) ..... 5170 mi² (13400 km²)
Years of record (water year) 1921–72
Maximum discharge (May 31–June 2, 1950) ..... 18,200 ft³/s (*709 m³/s*)
Minimum discharge ..... 535 ft³/s (15.1 m³/s)
Average discharge (50 years) ..... 2780 ft³/s (187 m³/s)
Runoff, average annual ..... 9.93 in. (252 mm)
7-day minimum discharge, 10-year recurrence interval ..... 700 ft³/s (19.8 m³/s)

05120500 Rainy River at Fort Frances, Ontario
Drainage area (approx.) ..... 14,900 mi² (38,600 km²)
Years of record (water year) 1908–72
Maximum daily discharge (July 7, 1950) ..... 47,900 ft³/s (*357 m³/s*)
Minimum daily discharge ..... 40 ft³/s (1.13 m³/s)

05120900 Vermilion River below Vermilion Lake near Tower
Drainage area ..... 483 mi² (1250 km²)
Years of record (water year) 1912–17, 1929–72
Maximum discharge (May 23, 1950) ..... 3710 ft³/s (*105 m³/s*)
Minimum discharge (result of concrete dam built at outlet in 1915)
Average discharge (50 years) ..... 315 ft³/s (8.99 m³/s)
Runoff, average annual ..... 8.91 in. (266 mm)
7-day minimum discharge, 10-year recurrence interval ..... 18 ft³/s (0.45 m³/s)

05121010 Armstrong Creek near Ely
Drainage area ..... 5.29 mi² (13.7 km²)
Years of record (water year) 1966–72
Maximum discharge (May 21, 1970) ..... 131 ft³/s (3.71 m³/s)
Minimum discharge 0
Average discharge (5 years) ..... 5.21 ft³/s (0.148 m³/s)
Runoff, average annual ..... 13.37 in. (340 mm)
7-day minimum discharge, 10-year recurrence interval 0

05122115 Longsteroff Creek near Ely
Drainage area ..... 8.88 mi² (22.9 km²)
Years of record (water year) 1966–72
Maximum discharge (June 10, 1970) ..... 230 ft³/s (6.51 m³/s)
Minimum discharge 0
Average discharge (5 years) ..... 5.91 ft³/s (0.252 m³/s)
Runoff, average annual ..... 13.69 in. (348 mm)
7-day minimum discharge, 10-year recurrence interval 0

05116500 Bear Island River near Ely
Drainage area ..... 68.5 mi² (177 km²)
Years of record (water year) 1913–62
Maximum discharge (May 5, 1916) ..... 423 ft³/s (11.6 m³/s)
Minimum discharge ..... 0.36 ft³/s (0.01 m³/s)
Maximum daily mean (May 5, 1916) ..... 1,000 ft³/s (28.3 m³/s)
Runoff, average annual ..... 8.51 in. (216 mm)
7-day minimum discharge, 10-year recurrence interval ..... 0 ft³/s (0.00 m³/s)

05118500 Pike River near Embarrass
Drainage area ..... 115 mi² (298 km²)
Years of record (water year) 1916–64
Maximum discharge (April 15, 1954) ..... 1700 ft³/s (48.1 m³/s)
Minimum daily discharge ..... 0.40 ft³/s (0.01 m³/s)
Average discharge (11 years) ..... 76.8 ft³/s (2.06 m³/s)
Runoff, average annual ..... 8.83 in. (224 mm)
7-day minimum discharge, 10-year recurrence interval ..... 2 ft³/s (0.06 m³/s)

05116000 Dunka River near Babbitt
Drainage area ..... 53 mi² (137 km²)
Years of record (water year) 1918–64
Maximum discharge (April 16, 1956) ..... 691 ft³/s (19.6 m³/s)
Minimum daily discharge ..... 0.60 ft³/s (0.02 m³/s)
Average discharge (11 years) ..... 37.6 ft³/s (1.06 m³/s)
Runoff, average annual ..... 9.58 in. (243 mm)
7-day minimum discharge, 10-year recurrence interval ..... < 1 ft³/s (< 0.03 m³/s)

05121500 Stoney River near Isabella
Drainage area ..... 180 mi² (466 km²)
Years of record (water year) 1913–64
Maximum discharge (April 21, 1957) ..... 2040 ft³/s (57.8 m³/s)
Minimum discharge ..... 5.6 ft³/s (0.16 m³/s)
Average discharge (12 years) ..... 127 ft³/s (3.60 m³/s)
Runoff, average annual ..... 9.58 in. (243 mm)
7-day minimum discharge, 10-year recurrence interval ..... 8 ft³/s (0.23 m³/s)

05122000 Baptisma River near Winton
Drainage area (approx.) ..... 1740 mi² (4510 km²)
Years of record (water year) 1923–27, 1930–72
Maximum discharge (May 24, 1950) ..... 15,600 ft³/s (442 m³/s)
Minimum discharge ..... 73 ft³/s (2.1 m³/s)
Average discharge (94 years) ..... 1383 ft³/s (39.2 m³/s)
Runoff, average annual ..... 10.79 in. (274 mm)
7-day minimum discharge, 10-year recurrence interval ..... 190 ft³/s (5.38 m³/s)

05122500 Isabella River near Lake Superior
Drainage area ..... 120 mi² (311 km²)
Years of record (water year) 1913–64
Maximum discharge (April 21, 1957) ..... 3050 ft³/s (86.4 m³/s)
Minimum discharge ..... 28 ft³/s (0.68 m³/s)
Average discharge (9 years) ..... 280 ft³/s (7.93 m³/s)
Runoff, average annual ..... 11.15 in. (283 mm)
7-day minimum discharge, 10-year recurrence interval ..... 28 ft³/s (0.72 m³/s)

05120500 South Kawishiwi River near Ely
Years of record (water year) 1952–61
Maximum discharge (May 4, 1954) ..... 3130 ft³/s (*88 m³/s*)
Minimum discharge ..... 25 ft³/s (0.71 m³/s)
Average discharge (10 years) ..... 437 ft³/s (12.4 m³/s)

LOW-FLOW PARTIAL-RECORD SITES

Key number	Station number	Station name	Period of record (water years)	Minimum discharge (cfs)	Range of specific conductance (micromhos per centimeter at 25° C)	7-day minimum discharge 10-year recurrence interval (ft³/s)
1	05124997	Little Isabella River near Isabella	1970–73	11.3	40–100	–
2	05129150	Little Indian Sioux River near Boyck	1970–73	6.86	all < 50	–
3	05129165	Pelican River near Ore	1970–73	12.7	40–90	–
4	05129260	Ash River near Ray	1970–73	1.57	230–340	0
5	05129300	Rat Root River near Littlefork	1970–73	0.37	180–340	0
6	05129390	East Fork Rat Root River near Ray	1970–73	0.08	170–290	0

LAKE STATIONS

Key number	Station number	Station name	Period of record (water years)	Minimum stage (ft above mean sea level)	Minimum stage (ft above mean sea level)
7	05127000	Burntside Lake near Ely	1926–35, 1948–69	1373.55	1370.39
8	05127221	Shagawa Lake at Ely	1963–72, 1948–64	1340.22	1336.91
9	05128300	Vermilion Lake near Soudan	1914, 1919–72	1310.72	1304.82
10	05129100	Pelican Lake at Ore	1960–67	1290.19	1287.31
11	05129400	Sabin-Lyons Lake near Ray	1956–67	1129.52	1126.77
12	05129400	Rainy Lake near Fort Francis, Ontario (International gaging station)	1911–17, 1923–72	1112.97	1101.26

05122200 Burgo Creek near Ely
Drainage area ..... 2.56 mi² (7.57 km²)
Years of record (water years) 1966–72
Maximum discharge (June 10, 1970) ..... 710 ft³/s (20.7 m³/s)
Minimum discharge 0
Average discharge (5 years) ..... 3.98 ft³/s (0.113 m³/s)
Runoff, average annual ..... 17.78 in. (452 mm)
7-day minimum discharge, 10-year recurrence interval 0

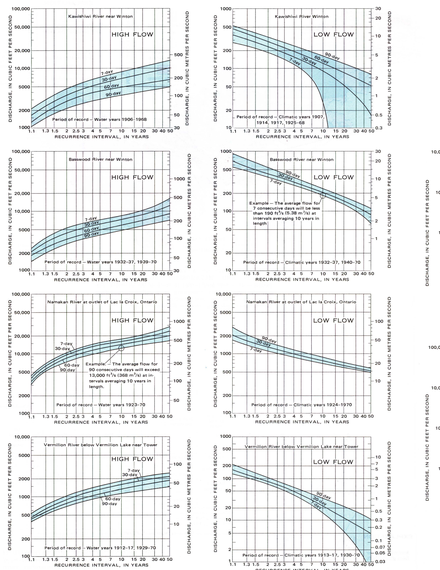
05127000 Kawishiwi River near Winton
Drainage area (approx.) ..... 1300 mi² (3110 km²)
Years of record (water years) 1905–06, 1915–19, 1923–71
Maximum daily discharge (May 18, 1950) ..... 16,600 ft³/s (*471 m³/s*)
Minimum discharge 0
Average discharge (73 years) ..... 1021 ft³/s (*289 m³/s*)
Runoff, average annual ..... 11.55 in. (293 mm)
7-day minimum discharge, 10-year recurrence interval ..... 27 ft³/s (0.76 m³/s)
Remarks — Flow regulated by powerplant and by nine lake reservoirs

05124400 Kawishiwi River near Ely (Benchmark station)
Drainage area ..... 253 mi² (655 km²)
Period of record (water years) 1967–72
Maximum discharge (April 29, 1969) ..... 1940 ft³/s (*54.9 m³/s*)
Minimum discharge ..... 24 ft³/s (0.68 m³/s)
Average discharge (6 years) ..... 255 ft³/s (7.22 m³/s)
Runoff, average annual ..... 13.68 in. (348 mm)

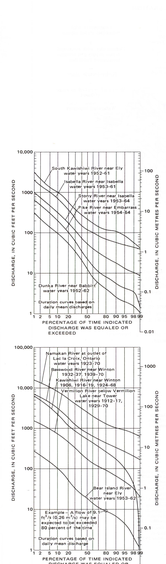
05127130 Shagawa River at Ely
Years of record (water years) 1968–72
Maximum discharge (June 12, 1970) ..... 62 ft³/s (1.76 m³/s)
Minimum discharge ..... 0.2 ft³/s (0.0 m³/s)
Average discharge (5 years) ..... 10.9 ft³/s (0.31 m³/s)

05127219 Shagawa Lake tributary at Ely
Drainage area ..... 0.71 mi² (1.84 km²)
Years of record (water year) 1972
Maximum discharge (June 17, 1972) ..... 48 ft³/s (1.4 m³/s)
Minimum discharge 0
7-day minimum discharge, 10-year recurrence interval 0

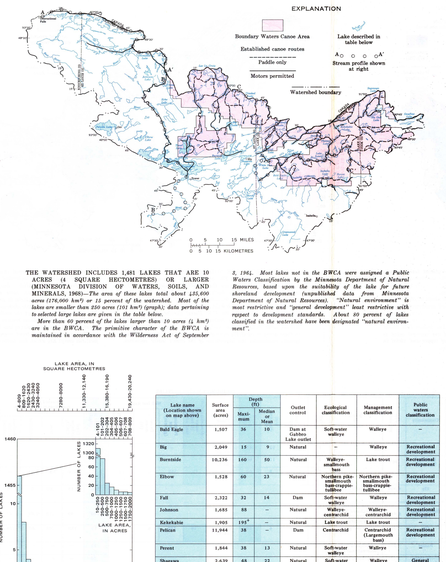
05124500 Isabella River near Isabella
Drainage area ..... 341 mi² (882 km²)
Years of record (water years) 1913–61
Maximum discharge (April 21, 1957) ..... 3550 ft³/s (101 m³/s)
Minimum discharge ..... 24 ft³/s (0.68 m³/s)
Average discharge (9 years) ..... 280 ft³/s (7.93 m³/s)
Runoff, average annual ..... 11.15 in. (283 mm)
7-day minimum discharge, 10-year recurrence interval ..... 28 ft³/s (0.72 m³/s)



STREAMFLOW IS SUSTAINED DURING HIGH AND LOW FLOWS BY DISCHARGE FROM LAKES AND, TO A LESSER DEGREE, FROM THE GROUND—WATER SYSTEM.—*High flow is most common in the spring following snowmelt but may occur at other times, from excessive rainfall. Low flows occur in winter, when precipitation is stored as snow and ice, and in late summer or fall, during extended dry periods.*



THE *relatively flat low-flow curves for Nemakan River indicate stable flow due to the many lakes in its drainage basin. Low flows in Kawishiwi River and, to a lesser degree, in Baptisma River decrease considerably for recurrence intervals greater than 5 and 20 years, respectively, because of upstream regulations. The decrease in flow of Vermilion River at recurrence intervals greater than 7 years reflects a natural decrease in the amount of water released from storage as the stage of Vermilion Lake declines.*

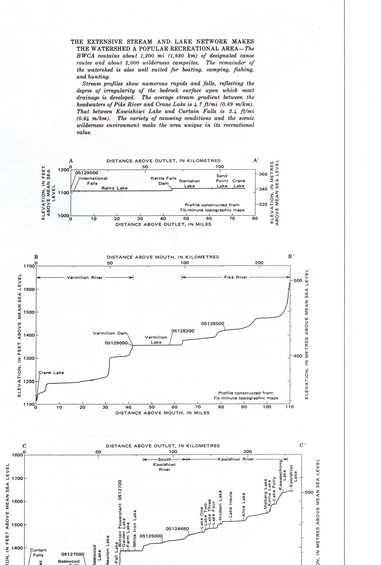


THE WATERSHED INCLUDES 1,481 LAKES THAT ARE 10 ACRES (4 SQUARE HECTOMETERS) OR LARGER (MINNESOTA DIVISION OF WATERS, SOILS, AND MINERALS, 1968).—*The area of these lakes total about 235,600 acres (176,000 km²) or 15 percent of the watershed. Most of the lakes are smaller than 250 acres (101 hm²) (graph); data pertaining to selected large lakes are given in the table below.*

More than 40 percent of the lakes larger than 10 acres (4 hm²) are in the BWCA. The primitive character of the BWCA is maintained in accordance with the Wilderness Act of September 3, 1964. Most lakes not in the BWCA were assigned a Public Waters Classification by the Minnesota Department of Natural Resources, based upon the suitability of the lake for future shoreland development (unpublished data from Minnesota Department of Natural Resources). "Natural environment" is most restrictive and "general development" least restrictive with respect to development standards. About 40 percent of lakes classified in the watershed have been designated "natural environment".

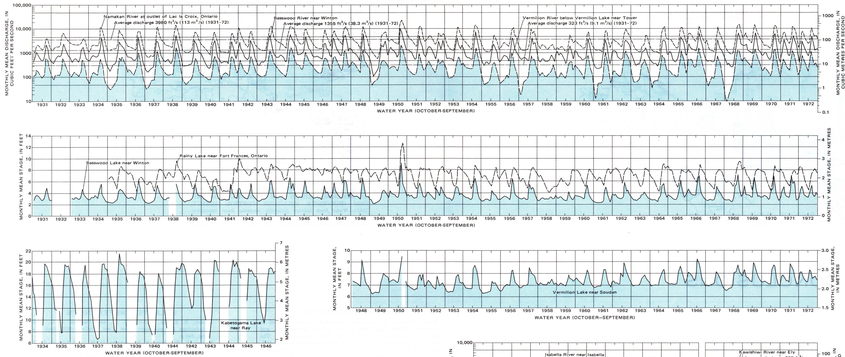
Lake name (Location shown on map above)	Surface area (acres)	Depth (ft) Maximum	Depth (ft) Median	Outlet control	Ecological classification	Management classification	Public waters classification
Bald Eagle	1,057	36	10	Dam at Gaches Lake outlet	Soft-water walleye	Walleye	–
Big	2,049	15	9	None	Walleye	Walleye	Recreational development
Burntside	10,236	160	80	Natural	Walleye-smallmouth bass	Lake trout	Recreational development
Elbow	1,518	60	23	Natural	Northern pike-smallmouth bass-walleye-tullibee	Northern pike-smallmouth bass-walleye-tullibee	Recreational development
Fall	2,312	32	14	Dam	Soft-water walleye	Walleye	Recreational development
Johnson	1,685	88	–	Natural	Walleye-cisco-whitefish	Walleye-cisco-whitefish	Recreational development
Kekekabic	1,905	195[1]	–	Natural	Lake trout	Lake trout	–
Pelican	11,944	38	13	Natural	Walleye-northern pike	Cisco-walleye (Largemouth bass)	Recreational development
Prescot	1,844	38	13	Natural	Soft-water walleye	Walleye	–
Shagawa	2,434	48	32	Natural	Soft-water walleye	Walleye	General development
Trout	9,237	98	40	Natural	Lake trout	Lake trout-walleye	–
Vermilion	49,110	68	25	Dam	Walleye	Walleye-pike	General development

(Data from Minnesota Department of Natural Resources)



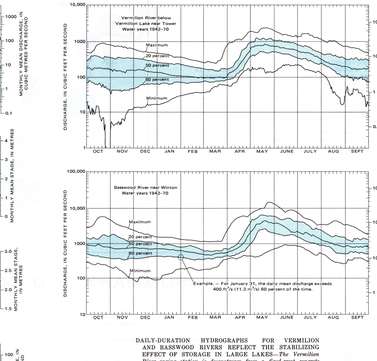
THE EXTENSIVE STREAM AND LAKE NETWORK MAKES THE WATERSHED A POPULAR RECREATIONAL AREA.—*The BWCA contains about 1,200 mi (1,930 km) of designated canoe routes and about 2,000 wilderness campsites. The remainder of the watershed is also well suited for boating, camping, fishing, and hunting.*

Stream profiles show numerous rapids and falls, reflecting the degree of irregularity of the bedrock surface upon which most drainage is developed. The average stream gradient between the headwaters of Pike River and Crane Lake is 4.7 ft/mi (0.89 m/km). That between Kawishiwi Lake and Curtain Falls is 2.4 ft/mi (0.45 m/km). The variety of canoeing conditions and the scenic wilderness environment make the area unique in its recreational value.



STREAMFLOW IN MUCH OF THE WATERSHED IS SUSTAINED BY WATER RELEASED FROM LAKES.—*Namakan, Basswood, and Vermilion Rivers have hydrographs highly similar in shape although they drain areas of 3,370, 2,740, and 483 mi² (12,200, 7,310, and 1,250 km²), respectively. The gaging station for each of these rivers is at the outlet of a large lake.*

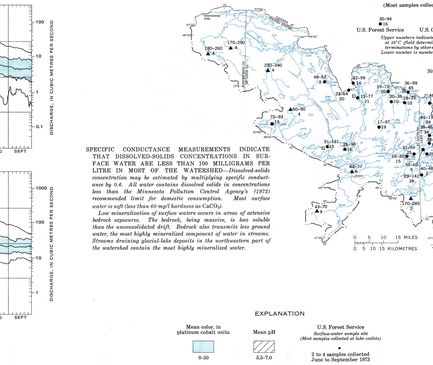
Stages for regulated lakes fluctuate widely, the amount of fluctuation being dependent on the purpose for which the lake is regulated. Kabetogama Lake stages are controlled by a dam at Kettle Falls at the outlet of Namakan Lake. The annual extremes in lake level often exceeded 10 ft (3 m) during the period of record. Kabetogama Lake is used to store excess runoff for release in Rainy Lake as needed. Rainy Lake is regulated by a dam at its outlet at International Falls where the water is used for power generation and thus, a relatively stable lake level is maintained. Basswood and Vermilion Lakes have natural outlets and normally fluctuate less than the regulated lakes. The stage of Vermilion Lake fluctuated 5.3 ft (1.1 m) during the period of record but the lake fluctuates less than 2 ft (0.6 m) in most years.



DAILY-DURATION HYDROGRAPHS FOR VERMILION AND BASSWOOD RIVERS REFLECT THE STABILIZING EFFECT OF STORAGE IN LARGE LAKES.—*The Vermilion River gaging station is downstream from a flood-crest concrete dam at the outlet of Vermilion Lake. The drainage area above the gaging station is 482 mi² (1,250 km²) and the surface area of Vermilion Lake is 76.7 mi² (199 km²). Zero discharge, on the minimum hydrograph, during October 25–29 was caused by temporary storage during construction of a new dam at the outlet of the lake in 1963.*

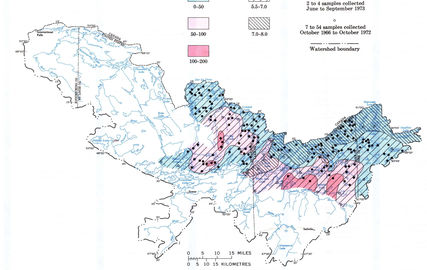
The drainage area above the Basswood River gaging station, located at the outlet of Basswood Lake, is approximately 1,710 mi² (4,430 km²). Basswood Lake has a surface area of 43.9 mi² (113 km²) of which 12 mi² (60 km²) are in Canada.

Hydrographs for both rivers are similar in shape, especially at the 50 percentile. Generally, flow in these rivers is stable in the fall, recedes slowly through the winter, and then rises slowly to a peak in May, 2 to 3 weeks later than peaks on nearby streams that drain areas containing only a few lakes. From the May peaks, flow normally recedes slowly through the summer, rousing only temporarily to heavy rainfall.



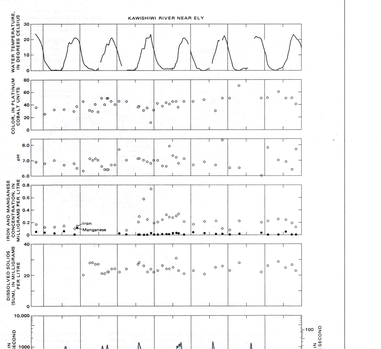
SPECIFIC CONDUCTANCE MEASUREMENTS INDICATE THAT DISSOLVED-SOLIDS CONCENTRATIONS IN SURFACE WATER ARE LESS THAN 100 MILLIGRAMS PER LITRE IN MOST OF THE WATERSHED.—*Dissolved-solids concentration may be estimated by multiplying specific conductance by 0.6. All water contains dissolved solids in concentrations less than the Minnesota Pollution Control Agency's (1972) recommended limit for domestic consumption. Most surface water is soft (less than 60 mg/l hardness as CaCO₃).*

Low mineralization of surface waters occurs in areas of extensive bedrock exposures. The bedrock, being massive, is less soluble than the unconsolidated drift. Bedrock also transmits less ground water, the most highly mineralized component of water in streams. Streams draining glacial-drift deposits in the northeastern part of the watershed contain the most highly mineralized water.



COLOR AND pH OF SURFACE WATERS VARY SYSTEMATICALLY OVER PART OF THE WATERSHED.—*Waters of low color and high pH occur in the northeastern part, an area of extensive bedrock exposures and relatively little soil cover. Larger amounts of soil cover elsewhere introduce more organic matter into the water, thereby increasing color and lowering pH. Both characteristics may vary considerably with time as shown at right by data for Kawishiwi River near Ely.*

THE MODERATE SLOPES OF THE DURATION CURVES INDICATE MOST STREAMS IN THE BASIN ARE NOT FLASHY.—*Curves for all stations except Kawishiwi River near Winton tend to flatten between the 60 and 80 percentiles. Discharge at the Kawishiwi River near Winton gaging station is regulated by a powerplant and eight controlled lake outlets which cause steepening of the curve at percentiles exceeding 10 percent.*



WILDERNESS WATERS ARE GENERALLY OF EXCELLENT QUALITY.—*Data from sample sites A–H (map at left and table below) indicate low concentrations of most chemical and bacteriological constituents. Most water-quality data are from the Superior National Forest.*

Much of the watershed is susceptible to contamination. Bedrock outcrops and thin soils immediately over bedrock permit direct or nearly direct introduction of contaminants into ground and surface waters.

Studies by the U.S. Forest Service in the Superior National Forest are providing baseline data on surface-water quality. The Forest Service is studying the sensitivity of lakes to pollution. Water quality in the Voyageurs National Park is being studied by the MPCA (Minnesota Pollution Control Agency). A report by the MPCA (1969) concerning pollution of waters in the northern part of the watershed summarizes the quality of these waters as follows: low biochemical oxygen demand; high dissolved oxygen; low particle concentration; low coliform count, except in the discharge of the Ely sewage treatment plant into Shagawa Lake; and low algae population except in Shagawa Lake. The report also concludes that some nutrients were carried downstream from Shagawa Lake. Eutrophication of Shagawa Lake is being studied by the EPA (Mulvey and others, 1973).

Site	Station and statistical parameter	Iron, total	Calcium, total	Magnesium, total	Sodium, total	Potassium, total	Sulfate, total	Chloride, total	Nitrite plus Nitrate as Nitrogen	Hardness as CaCO₃	Specific conductance (Micromhos per centimeter at 25° C)	pH	Color (Platinum cobalt units)	Total coliform (coliform per 100 ml)	Fecal coliform (coliform per 100 ml)
		Chemical constituents and hardness, in milligrams per litre													
A	Basswood Lake (Tuomtoro Bay) Number of determinations	50	47	45	47	38	47	45	47	39	45	36	38	42	
	Maximum	0.34	9.6	3.8	3.3	0.4	.15	1.7	0.13	33	93	7.8	110	47	7
	Mean	.09	5.8	2.5	1.8	.3	.03	.9	.04	23	70	7.4	45	5	.02
	Minimum	.01	2.9	1.4	1.0	.2	.0	0	0	19	38	6.1	10	0	0
B	Crooked Lake Number of determinations	51	47	45	47	44	51	45	44	51	45	50	44	44	41
	Maximum	0.25	7.1	2.3	2.5	0.8	.22	1.1	0.13	28	99	7.7	70	40	3
	Mean	.03	5.3	2.0	1.3	.4	.05	.4	.07	23	73	7.0	41	3	.4
	Minimum	.01	3.1	1.8	.7	.2	.1	.4	0	19	36	6.0	25	0	0
C	Gabbro Lake Number of determinations	24	22	9	22	22	22	22	8	20	25	23	25	16	9
	Maximum	1.0	8.5	3.7	2.7	0.4	9.9	1.0	0.13	28	90	7.4	156	10	13
	Mean	.15	6.8	3.7	1.0	.3	.47	.2	.03	19	56	6.8	45	2	.8
	Minimum	.03	1.4	1.7	1.0	.2	0	0	.02	10	31	6.2	10	0	0
D	Pauness Lake Number of determinations	20	19	11	19	18	19	19	10	19	21	19	21	17	10
	Maximum	0.81	3.5	1.2	1.8	0.7	8.6	1.0	0.12	20	77	6.9	130	21	110
	Mean	.11	2.4	1.0	1.1	.4	3.3	.2	.05	16	38	6.2	105	1	.8
	Minimum	.03	.9	.8	.7	.2	0	0	.04	11	11	5.2	60	0	0
E	Sagonaga Lake Number of determinations	18	16	13	16	15	16	17	10	16	18	15	18	13	10
	Maximum	0.23	6.2	1.8	1.3	1.9	1.3	1.2	0.09	25	83	7.7	57	7	9
	Mean	.04	4.9	1.5	1.0	.5	1.3	.3	.05	20	51	7.0	20	.3	0
	Minimum	.002	3.1	1.3	.7	.3	1.3	0	.01	18	26	6.0	7	0	0
F	Stoney River Number of determinations	23	22	9	22	22	22	22	9	21	24	19	24	13	7
	Maximum	1.6	12	6.3	3.1	0.8	11	1.2	1.8	60	208	7.4	210	23	21
	Mean	.19	5.6	6.7	1.8	.5	3.3	.3	.68	35	85	6.8	129	5	4
	Minimum	.03	2.2	22	.9	.3	0	0	.02	11	43	6.3	75	0	0
G	Vermilion Lake Number of determinations	15	14	4	14	13	14	14	10	14	15	12	15	12	11
	Maximum	0.23	9.0	2.0	1.8	1.0	28	1.3	0.06	31	131	7.7	47	31	31
	Mean	.04	5.4	1.8	1.5	.7	7.3	.5	.01	27	75	7.1	27	5	5
	Minimum	.003	5.1	1.7	1.3	.5	3.2	0	.02	24	51	6.1	16	0	0

(Analyses by U.S. Forest Service; samples collected October 1966 to October 1972)

Site	Station and statistical parameter	Dissolved silica	Iron	Manganese	Calcium	Magnesium	Dissolved sodium	Dissolved potassium	Bicarbonate	Dissolved sulfate	Chloride	Fluoride	Nitrite plus Nitrate as Nitrogen	Boron	Dissolved solids (sum)	Hardness as $CaCO_3$	pH	Temperature (° Celsius)	Color (platinum cobalt units)
		Chemical constituents and hardness, in milligrams per litre																	
H	Kawishiwi River near Ely Number of determinations	41	41	33	34	41	41	41	41	41	41	41	41	10	40	39	41	41	41
	Maximum	1940	11	0.73	0.11	7.3	1.8	1.7	1.4	19	8.5	2.0	0.5	0.20	0.46	31	38	8.3	33.5	76
	Mean	321	6.1	.22	.02	3.4	1.4	1.1	.5	12	5.3	.8	.1	.06	.04	24	15	6.9	9.7	41
	Minimum	29	0	.07	0	2.4	.9	.6	0	10	3.5	0	0	0	0	20	12	6.0	0	11
Recommended limits for domestic consumption (Minnesota Pollution Control Agency, 1972)			.30	.05						250	250	1.5	10		500					15

(Analyses by U.S. Geological Survey; samples collected 1966–73)

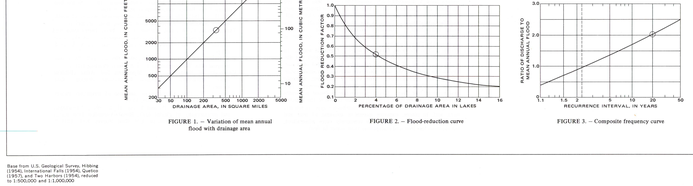


FIGURE 1. — Variation of mean annual flood with drainage area

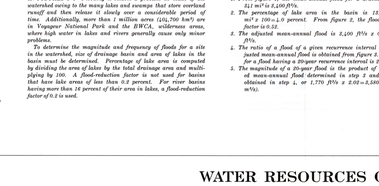


FIGURE 2. — Flood-reduction curve

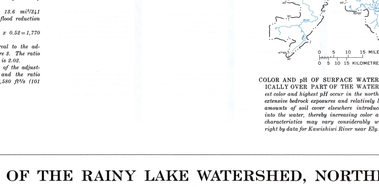


FIGURE 3. — Composite frequency curve

THE MAGNITUDE AND FREQUENCY OF FLOODS IN THE RAINY LAKE WATERSHED CAN BE DETERMINED BY THE REGIONAL FLOOD—FREQUENCY METHOD GIVEN IN FIGURES 1–3.—*Flooding is seldom a problem in much of the watershed owing to the many lakes and swamps that store overland runoff and then release it slowly over a considerable period of time. Additionally, more than 1 million acres (404,700 hm²) are in Voyageur National Park and the BWCA, wilderness areas, where high water in lakes and rivers generally cause only minor problems.*

To determine the magnitude and frequency of floods for a site in the watershed, size of drainage basin and area of lakes in the basin must be determined. Percentage of lake area is computed by dividing the area of lakes by the total drainage area and multiplying by 100. A flood-reduction factor is not used for basins that have lake areas of less than 0.2 percent. For river basins having more than 16 percent of their area in lakes, a flood-reduction factor of 0.1 is used.

Example.—Determine the magnitude of a flood having a 20-year recurrence for the Isabella River near Isabella, which has a drainage area of 341 mi² (883 km²) and a lake area of 12.6 mi² (32.6 km²).

1. From figure 1, the mean-annual flood for a drainage area of 341 mi² is 2,100 ft³/s.

2. The percentage of lake area in the basin is (12.6 mi²)/(341 mi²) × 100 = 4.0 percent. From figure 2, the flood reduction factor is 0.52.

3. The adjusted mean-annual flood is 2,100 ft³/s × 0.52 = 1,170 ft³/s.

4. The ratio of a flood of a given recurrence interval to the adjusted mean-annual flood is obtained from figure 3. The ratio for a flood having a 20-year recurrence interval is 2.02.

*5. The magnitude of a 20-year flood is the product of the adjusted mean-annual flood determined in step 3 and the ratio obtained in step 4, or 1,170 ft³/s ×