Chemical Quality of Michigan Streams

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DEFINITION OF TERMS

Dissolved solids. Consist mainly of the dissolved mineral constituents in water and are represented by the residue that remains after filtration, evaporation, and drying at a temperature of 180°C.

Hardness. A property of water which causes an increase in the amount of soap that is needed to produce foam or lather. Hardness is produced almost completely by the presence of calcium and magnesium salts in solution. Carbonate hardness is represented by the carbonate and bicarbonate salts of calcium and magnesium. Noncarbonate hardness is represented by all other salts of calcium and magnesium. Hardness is expressed conventionally in terms of an equivalent quantity of calcium carbonate. The following scale may assist the reader in appraising hardness:

<i>Degree of hardness</i>	<i>Hardness range (mg/l)</i>
Soft	0-60
Moderately hard	61-120
Hard	121-180
Very hard	>180

Milligrams per liter (mg/l). A unit for expressing the concentration of chemical constituents by weight per unit of volume. It is numerically equal to parts per million (ppm) in the analyses used in this publication.

pH. A measure of the hydrogen-ion concentration of a solution. A pH unit is expressed as the negative $\log_{10}$ of the hydrogen-ion concentration. The pH of pure water is 7; acid water has a smaller pH and alkaline water a larger pH.

Specific conductance. A measure of the ability of a water to conduct an electrical current. It is expressed in micromhos per centimeter at 25°C. Pure water has a very small electrical conductance, but the conductance increases with increasing concentration of dissolved minerals.

CHEMICAL QUALITY OF MICHIGAN STREAMS

By WARREN W. WOOD

ABSTRACT

Concentrations of chemical constituents of Michigan streams exhibit regional patterns that are primarily a function of geology and evapotranspiration. However, in some areas waste disposal by municipal and industrial organizations has altered the natural distribution and concentrations of dissolved material. Concentration and areal distribution of chemical constituents were found to change very little from high spring to low summer flow conditions.

INTRODUCTION

Chemical quality of streams in Michigan is becoming a matter of increasing public interest and concern. With this public awareness, there is an increase in demand for water quality information by representatives of industry, recreation, and local units of government. This report is intended to provide a source of chemical quality information for these groups and also to present information for statewide comparison and water management planning.

Chemical analyses of samples collected from streams have been published by the U.S. Geological Survey (1943-65) in a series of water-supply papers. These analyses were made from samples collected for specific areal projects as well as those collected from miscellaneous sites throughout the State. Detailed investigations conducted by the Michigan Water Resources Commission also are a source of water quality information on selected areas. (See "Selected references.") However, for this report it was deemed desirable to gather data over the entire State from all types of streams under conditions which are likely to indicate the normal range in chemical quality.

To aid in defining the chemical quality of

stream water, samples were collected at approximately 200 gaging stations (fig. 1). One series of samples was collected in late March and early April 1967 when streamflow was high. The second set was collected in late August and early September 1967 under conditions of low streamflow.

It is recognized that the hydrologic distribution of gaging stations is not ideal for this type of sampling because many tributaries and several major rivers are not represented. However, the advantages of having instantaneous discharge in addition to long periods of discharge records covering a relatively large number of areally well-distributed sample sites is considered to compensate for the lack of a complete sample coverage.

It was intended that analysis of these samples would (1) give comparable values over the entire area of the State under conditions which produce extremes in natural water quality, (2) give regional variation patterns in chemical quality so that reasonable estimates of water quality could be made in the absence of specific analyses, (3) give values to which future measurements may be compared for evaluating changes in water quality, and (4) give a framework on which future and detailed water-quality studies can be conducted.

ACKNOWLEDGMENTS

This project was conducted in cooperation with the Michigan Department of Natural Resources, formerly Department of Conservation, R. A. MacMullan, Director, and under an overall agreement for water resources investigations in Michigan with the State Water Resources

FIGURE 1.—Locations and identification numbers of sampling sites.

Commission, Loring F. Oeming, Executive Secretary, succeeded by Ralph W. Purdy.

STREAM QUALITY OBSERVATIONS

FIELD METHODS OF ANALYSIS

Samples of water from the stream were collected by personnel of the Michigan District of the U.S. Geological Survey during their regular visits to the gaging stations. The samples were collected in disposable plastic bottles and returned to the district office where chemical analyses were performed using field methods. The time between collection and analysis averaged about 2 weeks. To verify the stability of the parameters during transportation and storage, multiple samples were collected at several sites and analyzed at time intervals up to 1 month in length. There were no changes in the measured constituents greater than those expected from analytical error.

Field methods of analysis consisted of using mercuric nitrate for chloride determination (American Public Health Association, 1965) turbidimetric method for sulfate, colorimetric EDTA (ethylenediaminetetraacetic acid) for hardness, colorimetric and potentiometric titration for bicarbonate, and a conductivity meter (accuracy within 2 percent) for specific conductance. A glass electrode and pH meter were used to determine pH. Dissolved solids were determined by multiplying specific conductance by 0.65. Results obtained from field methods were within 5 percent of the values obtained from laboratory analyses of 40 duplicate samples.

BASIC QUALITY OF STREAMS

Figures 2 and 3 illustrate the distribution of the concentration of dissolved solids during periods of low and high flow, respectively. During high-flow conditions streams generally exhibit more dilute water due to the additions of large quantities of rain and snowmelt water. However, the change in concentration between extreme flow conditions is relatively small.

Hardness of stream water (figs. 4, 5) follows the same general pattern as the dissolved solids because the stream water is of the calcium magnesium bicarbonate type. Chloride (figs. 6, 7) and sulfate concentrations (figs. 8, 9) also follow the same distribution pattern. The chlo-

ride content in most streams is generally lower than sulfate by a factor of about four. The sulfate ion is usually associated with calcium and magnesium which contribute to the hardness of the water. Chloride results from the presence of dissolved salts of calcium and sodium chloride.

It is apparent from figures 2 through 9 that the mapped chemical constituents increase in concentration from north to south in Michigan streams. Stream water in the western half of the northern peninsula contains the lowest concentrations of dissolved solids, whereas the southeastern section of the southern peninsula contains the highest concentrations. A sampling bias does however exist, because some stream gaging stations are located downstream from significant or unusual waste-water discharges. This bias is particularly noticeable in the Saginaw River system where industrial discharge, rather than natural controls, increased the chloride concentration of the stream. This condition is also apparent in the Grand, Kalamazoo, and Rouge River systems.

The distribution patterns of major concentrations are controlled by differences in bedrock geology, thickness and composition of glacial drift, runoff, and evapotranspiration. Rocks of Precambrian age near the surface in the western half of the northern peninsula (Martin, 1936) are generally very siliceous in composition and would yield small amounts of soluble material to the streams. Because the lithology of the overlying glacial drift is influenced by the underlying bedrock lithology, the drift also yields small amounts of dissolved solids in this area. In the remainder of the State glacial erosion of the Paleozoic and Mesozoic age carbonaceous and argillaceous sediments has contributed fresh unweathered material to the glacial drift. This material is readily soluble and consequently yields significant amounts of dissolved solids to the streams.

Paleozoic age rocks locally contain highly mineralized water (Feth, 1965). Where these rocks are near the surface, they can contribute relatively large amounts of dissolved solids to the stream. This condition is illustrated in the southeastern section of the southern peninsula.

Another factor contributing to the concentration distribution is the greater runoff in the northern part of the State (fig. 10). The difference in runoff is chiefly the result of smaller

FIGURE 2.—Concentration of dissolved solids in streams under low-flow conditions.

FIGURE 3.— Concentration of dissolved solids in streams under high-flow conditions.

FIGURE 4.—Concentration of hardness of stream water under low-flow conditions.

FIGURE 5.—Concentration of hardness of stream water under high-flow conditions.

FIGURE 6.—Concentration of chloride in streams under low-flow conditions.

FIGURE 7.—Concentration of chloride in streams under high-flow conditions.

FIGURE 8.—Concentration of sulfate in streams under low-flow conditions.

FIGURE 9.—Concentration of sulfate in streams under high-flow conditions.

FIGURE 10.—Average annual runoff, in inches, 1951-60.

FIGURE 12.—Mean annual precipitation, in inches 1931-55.

FIGURE 11.—Average annual lake evaporation, in inches, 1946-55.

amount of evapotranspiration in the north (fig. 11) (Kohler and others, 1959) rather than greater precipitation (fig. 12) (Strommen, 1967).

In areas of urbanization the concentration of dissolved constituents varies as much as three orders of magnitude within a small stream segment. The dissolved materials come from combination sewers, septic tank effluents, waste treatment from municipal and industrial sources, and the use of soluble components for ice and dust control. Thus, the regional patterns of distribution and concentration are disrupted and the prediction of chemical quality is difficult. Records for the Clinton River basin, station 4-1608 to 4-1655 (table 1), illustrate the large variation in chemical quality occurring in an urbanized environment.

CONCLUSIONS

All measured parameters illustrate distinct regional patterns of distribution that shift only slightly under conditions of high and low flow. Water in the streams is of the calcium magnesium bicarbonate type and remains this type

under high- and low-flow conditions. Concentrations of dissolved substances are generally lower during periods of high flow than during periods of low flow. The higher concentrations that occasionally occur at spring high flows are attributed to inflow of water from combination of effluent from sewers, fertilizers, and possibly road salt. Considering all parameters, there is a distinct tendency for the most dilute water to appear in the northern peninsula.

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TABLE 1

TABLE 1.—Chemical analyses of samples collected from Michigan streams under low- and high-flow conditions, 1967

[Chemical analyses of field-measured samples, in milligrams per liter]

Station No.	Station Name	Location	Drainage area (sq mi)	Date sampled	Time	Discharge (cfs)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Hardness as CaCO ₃		Specific conductance (micro-mhos at 25°C)	pH	Water temperature	
											Ca, Mg.	Non-carbonate			F°	C°
STREAMS TRIBUTARY TO LAKE SUPERIOR																
4-0310.....	Black River near Bessemer.	SE¼sec. 32, T. 48 N., R.46 W.	200	Apr. 1	1030	3000	20	0	3.0	2.0	20	4	55	7.4	33	0.5
				Sept. 6	0950											
0315.....	Presque Isle River at Marenisco.	NW¼sec. 21, T. 46 N., R.43 W.	171	Apr. 11	1150	50.7	56	0	2.0	5.0	54	8	105	7.4	60	15.5
				Sept. 8	1220	855	28	0	2.0	1.0	25	2	60	7.3	35	1.5
0320.....	Presque Isle River near Tulsa.	NW¼sec. 23, T. 48 N., R.44 W.	261	Apr. 10*	1400	82.0	54	0	2.2	2.0	48	4	80	7.1	65	18.5
				Sept. 7	1015	1730	15	0	10	2.0	18	6	38	7.0	28	3.5
0330.....	Middle Branch Ontonagon near Paulding.	NE¼sec. 29 T. 46 N., R.38 W.	164	Apr. 2	0930	117	56	0	1.0	2.0	50	4	100	7.3	62	17.0
				Sept. 8	1110	590	38	0	4.0	2.0	32	1	75	7.6	33	.5
0345.....	Middle Branch Ontonagon River near Trout Creek.	SW¼sec. 8, T. 47 N., R.38 W.	203	Sept. 7	2015	116	88	0	8.0	2.0	74	2	150	7.3	61	16.0
						43.5	76	0	7.0	2.0	63	1	125	7.3	60	15.5
0350.....	East Branch Ontonagon River near Mass.	NW¼sec. 33, T. 50 N., R.38 W.	272	Mar. 31	1630	2920	83	0	2.0	2.0	68	0	135	7.6	32	0.0
				Sept. 7	1800	123	80	0	4.5	2.0	66	0	135	7.7	62	16.5
0355.....	Middle Branch Ontonagon River near Rockland.	SE¼sec. 27, T. 50 N., R.39 W.	671	Mar. 31	1535	9190	104	0	11	2.0	83	0	160	7.8	32	0.0
0360.....	West Branch Ontonagon River near Bergland.	NE¼sec. 3, T. 48 N., R.42 W.	162	Apr. 10	1545	530	26	0	5.0	2.0	25	4	60	7.4	36	2.0
				Sept. 7	1110	199	27	0	17	4.0	28	4	60	7.0	67	19.5
0375.....	Cisco Branch Ontonagon River at Cisco Lake Outlet.	E½sec. 32, T. 45 N., R.41 W.	50.7	Apr. 11	1315	150	62	0	5.0	2.0	46	0	100	7.7	40	4.5
				Aug. 2	0955	12.2	51	0	6.5	2.0	42	0	85	7.4	71	21.5
				Apr. 1	1730		15	0	1.0	2.0	18	6	45	7.5	33	0.5
0395.....	South Branch Ontonagon River at Ewen.	NW¼sec. 26, T., 48 N., R.40 W.	348	Apr. 1	1300	35.0	68	0	7.0	4.0	60	4	120	7.3	62	16.5
				Sept. 7	1800	16900	88	0	29	.5	84	12	172	8.0	32	0.0
0400.....	Ontonagon River near Rockland.	NE¼sec. 20, T. 50 N., R.39 W.	1340	Mar. 31*												
				Sept. 29	1430	560	80	0	5.0	3.0	66	0	140	7.2	52	11.0
0415.....	Sturgeon River near Aston.	SE¼sec. 15, T. 50 N., R.35 W.	346	Aug. 21	1515	600	51	0	3.0	3.0	46	4	90	7.3	62	16.5
0425.....	Otter River near Elo.	NE¼sec. 8, T. 50 N., R.34 W.	162	Apr. 4	1000	499	39	0	5.0	2.0	36	4	85	7.4	34	1.0
				Aug. 21	1600	84.2	112	0	6.0	4.0	88	0	180	7.8	57	14.0
0430.....	Sturgeon River near Arnheim.	SE¼sec. 1, T. 52 N., R.34 W.	705	Apr. 4*		3790	33	0	9.6	2.0	32	5	73	7.0	32	0.0
				Aug. 23	1030	401	76	0	2.0	3.0	64	2	125	7.4	63	17.0
0444.....	Carp River near Negaunee.	SE¼sec. 29, T. 48 N., R.26 W.	51.4	Aug. 16	1625	35.7	98	0	13	9.0	92	12	190	7.4	73	23.0
0445.83.	Cherry Creek near Harvey.	SE¼sec. 13, T. 47 N., R.25 W.	4.53	Aug. 16	1900	18.2	107	0	6.0	4.0	92	4	180	7.7	49	9.5
0455.....	Tahquamenon River near Tahquamenon Paradise.	NE¼sec. 11, T. 48 N., R.8 W.	790	Sept. 7	1300	293	105	0	14	3.0	98	12	190	7.3	67	19.5
STREAMS TRIBUTARY TO LAKE MICHIGAN																
4-0460.....	Black River near Garnet.	SE¼sec. 13, T. 43 N., R.9 W.	28.0	Aug. 16	1645	9.74	161	0	4.0	2.0	134	2	245	8.2	66	15.5
0495.....	Manistique River at Germfask.	SE¼sec. 4, T. 44N., R.13 W.	341	Apr. 3		753	33	0	12	1.0	34	7	75	7.5	35	0.5
				Aug. 17	1030	207	71	0	9.0	1.0	66	8	130	7.1	66	19.0
0550.....	Manistique River near Blaney.	SE¼sec. 28, T. 43 N., R.14 W.	704	Apr. 5	1300	4150	29	0	6.0	2.0	29	5	60	7.5	33	0.5
				Aug. 16	1400	319	78	0	8.5	2.0	70	6	140	7.5	70	21.0
0565.....	Manistique River near Manistique.	SE¼sec. 15, T. 42 N., R.15 W.	1100	Apr. 5*	1500	7500	28	0	11	2.0	30	7	66	7.4	32	0.0
				Aug. 16	1100	434	85	0	8.0	2.0	77	7	150	7.6	69	20.5
0570.....	Indian River near Manistique.	NE¼sec. 34, T. 42 N., R.16 W.	302	Apr. 22	1030	847	79	0	19	2.0	82	17	170	7.8	36	2.0
				Aug. 16	1810	256	107	0	48	2.0	132	44	255	7.8	76	24.5
0575.1.....	Sturgeon River near Nahma Junction.	SE¼sec. 17 T. 41 N., R.19 W.	183	Aug. 18	1245	87.7	107	0	9.9	2.0	97	9	185	8.2	66	19.0
0578.....	Middle Branch Escanaba River at Humboldt.	SW¼sec. 1, T. 47 N., R.29 W.	46	Apr. 2	1430	346	20	0	5.0	1.0	15	0	<50	7.4	34	1.0
				Aug. 18	1030	14.8	41	0	8.0	4.0	40	6	85	7.2	58	14.5
0579.....	Black River near Republic.	NE¼sec. 2, T. 46 N., R.29 W.	34.4	Apr. 4	1000	156	15	0	6.0	4.0	20	8	55	7.1	34	1.0
				Aug. 17	1310	8.18	51	0	16	6.0	58	16	130	7.0	69	20.5
0580.....	Middle Branch Escanaba River near Ishpeming.	SW¼sec. 12, T. 46 N., R.28 W.	128	Apr. 4	1430	824	12	0	11	3.0	17	7	50	7.6	34	1.0
				Aug. 16	1365	41.2	42	0	7.0	4.0	40	6	80	7.3	67	19.5
0581.....	Middle Branch Escanabe River near Princeton.	NW¼sec. 12, T. 43 N., R.26 W	210	Apr. 4	1500	930	23	0	8.0	2.0	18	0	50	7.6	33	0.5
				Aug. 14	1750	370	42	0	1.0	4.0	40	6	85	7.1	68	20.0
0592.....	Schweitzer Creek near Palmer.	SW¼sec. 1, T. 46 N., R.27 W.	23.6	Apr. 3	1615	133	61	0	7.0	3.0	60	10	135	7.6	34	1.0
				Aug. 16	0915	5.71	83	0	4.0	.0	470	2	140	7.4	54	12.0

0583.....	Warner Creek near Palmer.	NW¼sec. 10, T. 46 N., R.26 W.	14.2	Apr. 3	1405	119	29	0	15	6.0	32	8	80	7.5	34	1.0
0584.....	Goose Lake Outlet near Sands Station.	SE¼sec. 12, T. 46 N., R.26 W.	37.5	Aug. 15	1815	4.48	112	0	13	12	102	10	230	7.4	67	19.5
0585.....	East Branch Escanaba River at Gwinn.	NE¼sec. 21, T. 45 N., R.25 W.	124	Apr. 11	1555	203	65	0	75	9.0	134	81	310	7.4	38	3.5
0590.....	Escanaba River at Cornell.	NW¼sec. 32, T. 41 N., R.23 W.	870	Aug. 15	1435	10.5	73	0	42	7.0	98	38	220	8.0	60	15.5
0595.....	Ford River near Hyde.	SW¼sec. 19, T. 39 N., R.23 W.	450	Apr. 3	1120	722	37	0	33	5.0	55	25	140	7.6	34	1.0
0605.....	Iron River at Caspian.	SW¼sec. 1, T. 42 N., R.35 W.	92.1	Aug. 14	1420	42.0	71	0	17	6.0	72	14	160	7.5	63	17.0
0610.....	Brule River near Florence, Wis.	SE¼sec. 11, T. 41 N., R.32 W.	389	Apr. 13*	1200	3780	74	0	19	1.5	78	18	158	7.5	37	3.0
0615.....	Paint River at Crystal Falls.	SE¼sec. 20, T. 43 N., R.32 W.	597	Aug. 24	1135	247	105	0	9.5	4.0	92	6	180	7.6	68	20.0
0620.....	Paint River near Alpha.	NW¼sec. 25, T. 42 N., R.32 W.	631	Apr. 13*	1030	2340	90	0	18	1.5	96	22	175	7.6	37	3.0
0621.....	Peshekee River near Michigamme.	SE¼sec. 1, T. 48 N., R.30 W.	66.5	Aug. 24	1425	49.9	207	4	10	3.0	180	6	320	8.5	70	21.0
0622.....	Peshekee River near Champion.	NW¼sec. 13, T. 48 N., R.30 W.	133	Apr. 1*	1300	552	13	0	69	5.0	78	68	195	6.6	37	3.0
0622.7.....	Michigamme River near Champion.	NW¼sec. 27, T. 47 N., R.30 W.	231	Sept. 8	1515	61.6	137	0	210	15	316	204	580	7.3	60	15.5
0623.....	Michigamme River at Republic.	SE¼sec. 18, T. 46 N., R.29 W.	240	Apr. 2	1510	1620	48	0	22	1.0	60	21	140	7.4	33	0.5
0624.....	Michigamme River near Witch Lake.	NW¼sec. 1, T. 44 N., R.30 W.	316	Aug. 30	1345	327	120	0	42	4.0	138	40	265	7.5	60	15.5
0625.....	Michigamme River near Crystal Falls.	NW¼sec. 20, T. 43 N., R.31 W.	656	Apr. 11	1200	4270	26	0	5.0	1.0	22	1	55	7.5	36	2.0
0630.....	Menominee River near Florence, Wis.	NE¼sec. 16, T. 41 N., R.31 W.	1780	Aug. 31	1540	447	73	0	8.0	5.0	66	6	130	7.4	61	16.0
0653.....	West Branch Sturgeon River near Randville.	NE¼sec. 30, T. 42 N., R.29 W.	56.1	Apr. 11*	1315	1770	20	0	21	2.0	23	6	54	7.4	36	2.0
0655.....	Sturgeon River near Foster City.	NW¼sec. 36, T. 41 N., R.28 W.	237	Aug. 30	1540	82.4	80	0	8.5	4.0	72	6	145	7.4	65	18.5
0964.....	St. Joseph River near Burlington.	SW¼sec. 20, T. 4 S., R.6 W.	201	Apr. 10	1515	764	9	0	4.0	2.0	11	4	<50	7.4	33	0.5
0966.....	Coldwater River near Hodunk.	N¼sec. 22, T. 5 S., R.7 W.	293	Aug. 17	1635	27.0	29	0	4.0	2.0	26	2	<50	6.9	70	21.0
0969.....	Nottawa Creek near Athens.	NW¼sec. 12, T. 5 S., R.9 W.	162	Apr. 10	1530	1330	10	0	4.0	1.0	10	2	<50	7.2	34	1.0
0970.6.....	Little Portage Creek near Fulton.	SW¼sec. 29, T. 4 S., R.9 W.	27.0	Aug. 18	1450	44.9	22	0	1.5	2.0	22	4	<50	7.3	65	18.5
0971.7.....	Portage River near Vicksburg.	SW¼sec. 16, T. 4 S., R.10 W.	68.2	Apr. 18	1115	2680	16	0	11	1.0	17	4	<50	7.4	37	3.0
0972.....	Gourdneck Creek near Schoolcraft.	NE¼sec. 5, T. 4 S., R.11 W.	7.29	Aug. 18	1655	135	17	0	8.0	4.0	20	6	<50	6.8	66	19.0
0975.....	St. Joseph River at Three Rivers.	S¼sec. 18, T. 6 S., R.11 W.	1350	Aug. 18	1730	146	17	0	7.0	3.0	23	9	50	7.0	68	20.0
0975.4.....	Prairie River near Nottawa.	SW¼sec. 6, T. 7 S., R.9 W.	106	Apr. 18	1300	2960	30	0	12	2.0	20	4	50	7.7	40	4.5
0985.....	Fawn River near White Pigeon.	SW¼sec. 10, T. 8 S., R.11 W.	192	Aug. 18	1800	180	49	0	8.0	4.0	46	6	95	7.5	66	19.0
0990.....	St. Joseph River at Mottville.	SW¼sec. 6, T. 8 S., R.12 W.	1686	Apr. 19	1050	4330	32	0	5.0	2.0	30	4	70	7.5	.....	.....
1015.....	St. Joseph River at Niles.	SW¼sec. 26, T. 7 S., R.17 W.	3666	Aug. 31	1830	616	51	0	8.0	2.0	49	7	100	7.2	65	18.5
1018.....	Dowagiac River at Summerville.	SE¼sec. 30, T. 6 S., R.16 W.	255	Apr. 18	1400	11200	26	0	10	2.0	38	17	85	7.5	43	6.0
1025.....	Paw Paw River at Riverside.	NE¼sec. 26, T. 3 S., R.18 W.	390	Aug. 31	0820	545	117	0	36	6.0	128	32	250	8.2	61	16.0
1027.....	Black River near Bangor.	NW¼sec. 28, T. 1 S., R.16 W.	83.6	Apr. 2	1400	291	70	0	18	3.0	68	11	140	7.8	34	1.0
1055.....	Kalamazoo River near Battle Creek.	SW¼sec. 1, T. 2 S., R.8 W.	824	Aug. 25	1350	13.4	217	0	8.5	4.0	186	8	325	8.0	64	18.0
1057.....	Augusta Creek near Augusta.	SW¼sec. 27, T. 1 S., R.9 W.	38.9	Apr. 2*	1645	1180	88	0	20	1.0	98	26	175	7.5	32	0.5
1058.....	Gull Creek near Galesburg.	NE¼sec. 7, T. 2 S., R.9 W.	38.1	Aug. 25	1900	46.5	229	0	8.5	3.0	194	6	246	7.8	70	21.0
1060.....	Kalamazoo River at Comstock.	NE¼sec. 19, T. 2 S., R.10 W.	1010	Apr. 7	1700	668	212	3	65	13	247	70	460	8.4	.....	.....
1061.9.....	Portage Creek near Portage.	NW¼sec. 15, T. 3 S., R.11 W.	18.6	Aug. 14	1025	35.5	271	0	52	18	272	50	530	8.0	63	17.0
1063.....	Portage Creek near Kalamazoo.	SE¼sec. 34, T. 2 S., R.11 W.	22.4	Mar. 27	1450	934	208	3	69	10	246	72	450	8.4	.....	.....
				Aug. 14	1210	43.9	207	0	70	16	238	68	465	7.5	68	20.0
				Aug. 14	1145	294	202	0	68	6.0	246	80	440	8.2	52	11.0
				Mar. 27	1345	42.1	273	0	54	10	278	54	515	8.2	69	20.5
				Aug. 14	0840	6.59	278	0	38	7.0	260	32	480	7.8	56	13.5
				Aug. 16	1120	93	124	0	92	7.0	200	98	395	8.0	36	2.0
				Mar. 14	0945	19.6	196	3	58	8.0	210	46	405	8.4	69	20.5
				Aug. 16	1345	10.8	213	3	19	8.0	197	19	370	8.4	.....	.....
				Apr. 12	1545	4.54	220	0	318	10	198	18	355	7.8	74	23.5
				Aug. 15	1260	3500	223	0	35	5.0	220	34	390	8.4	.....	.....
				Apr. 8	1325	642	217	0	35	8.0	212	34	405	7.8	72	22.0
				Aug. 15	1705	182	205	4	90	13	276	104	520	8.5	.....	.....
				Apr. 10	1535	21.4	232	0	78	10	258	68	475	8.1	74	23.5
				Aug. 14	0940	508	232	0	54	13	246	56	480	8.2	.....	.....
				Apr. 8	1130	65.4	268	0	40	16	265	45	510	7.8	69	20.5
				Aug. 15	1220	4510	207	4	55	9.0	236	62	445	8.5	.....	.....
				Apr. 8	0905	539	227	0	39	10	223	37	425	7.8	73	23.0
				Aug. 15	1545	7310	216	0	67	12	354	76	482	7.9	.....	.....
				Apr. 8*	1800	1460	239	0	56	18	244	48	470	7.8	.....	.....
				Aug. 16	1355	138	268	0	38	8.0	202	16	465	7.9	65	18.5
				Aug. 11	1000	201	238	4	33	14	230	30	450	8.5	.....	.....
				Aug. 17	1215	28.1	268	0	23	32	238	18	520	8.2	68	20
				May 13	1205	742	272	0	55	18	287	64	580	8.1	.....	.....
				Mar. 14	1400	64.0	183	2	3.0	22	208	56	380	8.3	36	2.0
				Mar. 14	1345	42	219	3	21	4.0	196	14	370	8.4	37	3.0
				Apr. 8	1440	1930	212	0	74	12	249	75	460	8.0	.....	.....
				Mar. 27	1400	40	164	3	31	7.0	163	26	320	3.5	.....	.....
				Mar. 28	1245	54	220	0	37	28	224	44	480	8.1	43	6.0

TABLE 1.—Chemical analyses of samples collected from Michigan streams under low- and high-flow conditions, 1967—Continued

Station No.	Station Name	Location	Drainage area (sq mi)	Date sampled	Time	Discharge (cfs)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Hardness as CaCO ₃		Specific conductance (micro-mhos at 25°C)	pH	Water temperature	
											Ca, Mg	Non-carbonate			°F	°C
STREAMS TRIBUTARY TO LAKE MICHIGAN—Continued																
4-1064	West Fork Portage Creek at Kalamazoo.	NE¼sec. 5, T. 3 S., R.11 W.	18.7	Mar. 14	1235	13	227	0	22	8.0	207	21	400	8.2	38	3.5
1085	Kalamazoo River near Fennville.	NE¼sec. 5, T. 2 N., R.14 W.	1600	Apr. 12	1755	3030	223	0	68	16	252	69	495	8.2	—	—
1086	Rabbit River near Hopkins.	SE¼sec. 16, T. 3 N., R.12 W.	71.4	Mar. 28	1550	155	165	2	40	12	184	46	360	8.3	47	8.5
1088	Black River near Zeeland.	NW¼sec. 31, T. 5 N., R.14 W.	65.8	Apr. 13*	1425	14.1	241	4	46	10	242	40	455	8.5	74	23.5
1090	Grand River at Jackson.	Sec. 22, T. 2 S., R.1 W.	174	Apr. 6	1005	30.5	184	0	65	42	242	91	543	8.1	—	—
1110	Grand River near Eaton Rapids.	NE¼sec. 26, T. 2 N., R.3 W.	661	Apr. 6	0840	3.94	196	5	38	66	228	62	580	8.6	69	20.5
1115	Deer Creek near Dansville.	E½sec. 33, T. 3 N., R.1 E.	16.3	Apr. 5	1540	325	241	3	126	72	347	146	800	8.4	—	—
1120	Sloan Creek near Williamston.	E½sec. 1, T. 3 N., R.1 W.	9.34	Apr. 5	1800	1400	201	3	94	19	278	111	530	8.4	—	—
1130	Grand River at Lansing.	NW¼sec. 9, T. 4 N., R.2 W.	1230	Apr. 5	1450	23	242	0	76	14	297	99	540	8.2	—	—
1140	Grand River at Portland.	NW¼sec. 4, T. 5 N., R.5 W.	1385	Mar. 31	1035	2850	208	3	83	20	280	107	530	8.4	—	—
1145	Lookingglass River near Eagle.	Sec. 10, T. 5 N., R.4 W.	281	Mar. 31	1600	2360	211	0	104	22	298	125	575	8.1	54	12.0
1150	Maple River at Maple Rapids.	Sec. 5, T. 8 N., R.3 W.	434	Apr. 15	1530	673	187	0	87	12	252	99	465	8.0	—	—
1160	Grand River at Ionia.	NW¼sec. 30, T. 7 N., R.6 W.	2840	Apr. 15	1050	629	176	0	45	12	212	68	400	7.9	—	—
1185	Rouge River near Rockford.	NE¼sec. 15, T. 8 N., R.11 W.	234	Apr. 13	1453	1350	229	4	96	21	270	98	545	8.4	—	—
1190	Grand River at Grand Rapids.	NE¼sec. 25, T. 7 N., R.12 W.	4900	Aug. 18	1305	169	217	0	59	24	234	56	500	7.8	71	21.5
1210	Muskegon River near Merritt.	NW¼sec. 2, T. 22 N., R.5 W.	309	Apr. 4	1055	1100	234	0	54	30	244	52	510	7.8	74	23.5
1215	Muskegon River at Ewart.	NE¼sec. 3 T. 17 N., R.8 W.	1450	Mar. 29	1020	892	60	0	14	4.0	58	9	130	7.9	36	2.0
1219	Little Muskegon River near Morley.	SW¼sec. 24, T. 13 N., R.9 W.	138	Mar. 27	1155	3550	94	0	13	7.0	87	10	200	8.1	35	1.5
1220	Muskegon River at Newago.	NE¼sec. 24, T. 12 N., R.13 W.	2350	Aug. 2	1600	521	94	0	13	2.0	84	7	185	7.9	34	1.0
1221	Bear Creek near Muskegon.	NW¼sec. 4, T. 10 N., R.16 W.	14.8	Mar. 30*	1600	59.9	202	0	12	6.0	176	10	320	7.7	75	24.0
1222	White River near Whitehall.	NW¼sec. 4, T. 12 N., R.16 W.	380	Aug. 3	0810	5800	144	2	27	18	152	30	333	8.3	40	4.5
1230	Big Sable River near Freesoil.	NE¼sec. 24, T. 20 N., R.17 W.	127	Aug. 2	0900	1890	166	0	15	16	152	16	290	7.7	70	21.0
1235	Manistee River near Grayling.	NW¼sec. 31, T. 27 N., R.4 W.	159	Aug. 2	0825	4.58	110	0	17	26	112	22	275	7.6	63	17.0
1240	Manistee River near Sherman.	NE¼sec. 36, T. 24 N., R.12 W.	900	Apr. 18	1130	3360	84	0	10	4.0	74	5	165	7.9	50	10.0
1255	Pine River near Hoxeyville.	NE¼sec. 24, T. 20 N., R.17 W.	127	Mar. 29*	1320	278	183	0	22	25	174	34	360	7.8	69	20.5
1261	Manistee River near Manistee.	NW¼sec. 31, T. 27 N., R.4 W.	159	Aug. 1	1445	446	84	0	21	7.0	90	21	192	7.8	38	3.5
1262	Little Manistee near Freesoil.	NE¼sec. 36, T. 24 N., R.12 W.	900	Mar. 31	1415	113	168	0	16	17	154	16	320	8.2	67	19.5
1270	Boardman River near Mayfield.	NE¼sec. 21, T. 26 N., R.10 W.	223	Aug. 4	0915	281	157	0	8.0	2.0	128	0	260	7.9	45	7.0
1278	Jordan River near East Jordan.	NW¼sec. 7, T. 31 N., R.6 W.	67.6	Apr. 4	1200	184	180	0	6.0	5.0	142	0	270	8.2	60	15.5
				Aug. 1	1435	2200	117	0	12	2.0	106	10	215	8.1	40	4.5
				Apr. 6	0950	827	183	0	12	5.0	154	4	295	7.8	64	18.0
				Aug. 1	1430	553	142	0	12	4.0	122	6	260	8.2	44	6.5
				Apr. 6*	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	21.5
				Aug. 1	1225	236	190	0	13	4.0	154	0	300	8.0	59	15.0
				Aug. 3	1250	4550	136	2	15	4.0	130	15	251	8.3	—	—
				Mar. 29	1600	1330	183	0	12	8.0	156	6	305	8.2	71	

1295.....	Pigeon River at Afton.	NE¼sec. 2, T. 34 N., R.2 W.	159	Mar. 31	1400	61.5	143	2	12	5.0	128	9	255	8.3	41	5.0
1300.....	Cheboygan River near Cheboygan.	SW¼sec. 19, T. 37 N., R.1 W.	865	Apr. 18	0915	1440	166	2	13	2.0	143	5	280	8.3	38	3.5
1305.....	Black River near Tower.	NE¼sec. 29, T. 35 N., R.1 E.	313	Mar. 31	1530	1270	150	0	13	2.0	128	5	255	8.1	38	3.5
				Aug. 14	1455	278	206	3	7.0	3.0	172	0	310	8.4	67	19.5
1315.....	Rainy River near Ocuqueoc.	NW¼sec. 22, T. 35 N., R.2 E.	85.0	Mar. 31	1330	493	129	0	15	2.0	118	12	235	8.1	33	0.5
				Aug. 16	1450	8.36	241	0	3.0	2.0	202	4	340	8.0	63	17.0
1325.....	Thunder Bay River near Hillman.	SE¼sec. 8, T. 30 N., R.4 E.	232	Mar. 31	1030	767	159	2	12	3.0	142	9	280	8.4	36	2.0
1335.....	Thunder Bay River near Bolton.	NE¼sec. 36, T. 32 N., R.6 E.	588	Mar. 31	1140	2860	143	0	19	4.0	132	15	260	8.1	33	0.5
				Aug. 4	0920	60.6	183	0	7.5	5.0	152	2	280	7.8	66	19.0
1340.....	North Branch Thunder Bay near Bolton.	Sec. 29, T. 32 N., R.7 E.	184	Apr. 3*	1505	2240	92	0	24	2.0	98	22	188	7.5	32	0.0
1355.....	Au Sable River at Grayling.	SE¼sec. 7, T. 26 N., R.3 W.	110	Apr. 3*	1530	175	108	0	14	1.0	102	14	199	8.1	40	4.5
1365.....	Au Sable River at Mio.	SE¼sec. 7, T. 26 N., R.3 E.	1100	Apr. 6	1340	2440	122	0	11	9.0	104	4	230	8.2	38	3.5
				Aug. 3	1020	830	171	2	8.0	5.0	140	0	265	8.4	69	20.5
1380.....	East Branch Au Gres River at Melvor.	NW¼sec. 10, T. 21 N., R.6 E.	84.0	Mar. 28*	1615	400	92	0	20	1.0	96	20	198	7.8	39	4.0
				Aug. 2	0720	37.4	178	0	24	5.0	158	12	300	7.9	61	16.0
1385.....	Au Gres River near National City.	NW¼sec. 32, T. 21 N., R.6 E.	169	Mar. 27*	1140	1600	112	0	33	3.0	128	36	267	8.0	33	0.5
				Aug. 2	0850	19.8	198	0	89	8.0	230	68	440	8.0	68	20.0
1390.....	Houghton Creek near Lupton.	SE¼sec. 10, T. 23 N., R.3 E.	27.0	Apr. 17*	1015	169	169	2	24	4.0	150	24	289	8.3	47	8.5
				Aug. 3	0720	36.2	212	0	17	6.0	184	10	345	8.0	56	13.5
1395.....	Rifle River at "The Ranch" near Lupton.	SW¼sec. 11, T. 23 N., R.3 E.	54.0	Apr. 17*	1045	282	158	0	32	2.0	162	32	308	7.7	47	8.5
				Aug. 3	0820	61.1	193	0	22	4.0	162	4	320	8.2	57	14.0
1400.....	Prior Creek near Selkirk.	SE¼sec. 33, T. 23 N., R.3 E.	19.0	Mar. 29*	1215	169	106	0	32	4.0	118	31	248	7.6	33	0.5
				Aug. 2	1205	6.96	198	0	10	4.0	162	0	305	8.2	62	16.5
1405.....	Rifle River at Selkirk.	NE¼sec. 9, T. 22 N., R.3 E.	110	Mar. 29	1230	773	140	0	29	5.0	141	26	285	8.0	36	2.0
				Aug. 2	1345	79.8	200	0	23	5.6	180	16	340	8.0	64	18.0
1410.....	South Branch Shepard Creek near Selkirk.	SE¼sec. 8, T. 22 N., R.3 E.	1.20	Apr. 6*	0645	17.5	98	0	30	5.0	114	34	240	8.0	38	3.5
				Aug. 2	1450	.033	238	3	42	4.0	231	33	410	8.3	70	21.0
1420.....	Rifle River near Sterling.	SW¼sec. 5, T. 19 N., R.4 E.	320	Aug. 1	1500	166	195	0	28	23	184	24	380	8.2	71	21.5
1435.....	North Branch Kawka- lin near Kawkawlin.	SE¼sec. 27, T. 15 N., R.4 E.	101	Mar. 28*	1250	897	90	0	31	12	118	44	254	7.9	34	1.0
				Aug. 9	1245	2.15	239	0	11	35	228	32	445	7.6	76	24.5
1440.....	Shiawassee River at Byron.	NE¼sec. 23, T. 5 N., R.4 E.	368	Mar. 27*	1155	809	175	5	74	18	240	88	469	8.4	.....	.....
				Aug. 10	0815	57.4	272	8	35	34	267	35	570	8.7	69	20.5
1445.....	Shiawassee River at Owosso.	SW¼sec. 12, T. 7 N., R.2 E.	538	Mar. 29*	1155	1280	173	4	79	16	246	98	481	8.3	44	6.5
				Aug. 7	1050	76.4	280	7	56	38	286	50	600	8.6	.....	.....
1450.....	Shiawassee River near Fergus.	Sec. 22, T. 10 N., R.3 E.	637	Mar. 28	1245	2140	162	0	69	17	223	90	435	8.2	.....	.....
				Aug. 7	1350	86.6	295	0	57	40	290	48	640	7.8	.....	.....
1460.....	Farmers Creek near Lapeer.	Sec. 6, T. 7 N., R.10 E.	57.0	Mar. 27	1655	237	170	2	66	12	215	74	420	8.3	36	2.0
				Aug. 8	1030	9.7	329	0	39	18	300	30	575	8.0	.....	.....
1475.....	Flint River near Otisville.	SE¼sec. 9, T. 8 N., R.8 E.	547	Apr. 19	1400	1650	202	0	89	17	264	98	495	8.2	51	10.5
				Aug. 8	0720	76.9	267	4	62	20	288	64	540	8.4	.....	.....
1481.4.....	Kearsley Creek near Davison.	NE¼sec. 12, T. 7 N., R.7 E.	98.8	Mar. 27	1615	338	160	0	66	22	218	88	450	7.9	42	5.5
				Aug. 8	0835	17.7	273	4	43	30	272	42	540	8.4	.....	.....
1482.....	Swartz Creek near Holly.	SW¼sec. 15, T. 5 N., R.7 E.	11.9	Mar. 27	1355	37.4	178	2	37	13	187	39	350	8.4	40	4.5
				Aug. 10	1350	2.37	235	3	32	14	222	26	420	8.4	.....	.....
1485.....	Flint River near Flint.	SW¼sec. 4, T. 7 N., R.6 E.	927	Apr. 18	.....	.....	168	0	65	24	211	73	430	8.4	50	10.0
				Aug. 7	1800	126	183	0	93	94	254	104	810	7.7	.....	.....
1490.....	Flint River near Foster.	W¼sec. 6, T. 10 N., R.5 E.	1120	Mar. 28	1715	4090	173	0	79	30	244	102	500	7.9	.....	.....
				Aug. 7	1605	151	256	0	99	72	274	64	750	7.7	.....	.....
1500.....	South Branch Cass River near Cass City.	NW¼sec. 7, T. 13 N., R.12 E.	251	Mar. 28	0935	6200	83	0	28	7.0	106	38	235	7.8	35	1.0
1505.....	Cass River at Cass City.	NE¼sec. 4, T. 13 N., R.11 E.	370	Mar. 28	1315	8050	109	0	38	7.0	135	46	290	7.8	34	1.0
1510.....	Cass River at Vassar.	SW¼sec. 7, T. 11 N., R.8 E.	700	Apr. 11*	0840	1390	146	0	84	14	230	111	448	7.7	44	6.5
1515.....	Cass River at Frankenmuth.	SE¼sec. 27, T. 11 N., R.6 E.	848	Mar. 29	1040	10900	110	0	42	8.0	144	54	310	7.8	35	1.5
1525.....	Tobacco River at Beaverton.	Sec. 7, T. 17 N., R.1 W.	487	Aug. 10	0900	220	224	0	38	12	212	28	405	8.1	70	21.0
1535.....	Salt River near North Bradley.	SE¼sec. 7, T. 15 N., R.1 W.	138	Mar. 28*	0805	1650	98	0	36	16	135	54	316	8.0	36	2.0
				Aug. 10	0730	16.2	168	0	198	210	377	239	1120	8.0	66	19.0
1540.....	Chippewa River near Mount Pleasant.	W¼sec. 8, T. 14 N., R.3 W.	416	Mar. 27	1320	1320	148	0	33	15	158	37	340	8.0	39	4.0
				Aug. 9	1005	187	237	0	35	28	234	40	460	8.2	73	23.0
1545.....	Chippewa River near Midland.	NW¼sec. 24, T. 14 N., R.1 W.	597	Mar. 28*	1100	3050	118	0	37	18	152	56	336	8.2	38	3.5
				Aug. 8	0900	211	222	4	37	36	230	44	475	8.4	69	20.5
1550.....	Pine River at Alma.	SE¼sec. 34, T. 12 N., R.3 W.	288	Mar. 27	1355	1560	156	0	39	11	170	42	355	8.1	36	2.0
				Aug. 1	0940	173	256	0	41	33	262	52	510	7.6	73	23.0
1555.....	Pine River near Midland.	NW¼sec. 4, T. 13 N., R.1 E.	390	Mar. 28*	1045	1700	120	0	42	74	215	117	551	7.6	41	5.0
				Aug. 1	1115	193	180	0	55	801	920	772	2500	7.6	76	24.5
1560.....	Tittabawassee River at Midland.	NE¼sec. 29, T. 14 N., R.2 E.	2499	Mar. 29*	1210	14300	124	0	42	108	255	153	644	8.1	37	3.0
				Aug. 9	0810	382	202	0	40	208	356	190	950	8.1	86	30.0
1570.....	Saginaw River at Saginaw.	Sec. 24, T. 12 N., R.4 E.	6060	Mar. 31*	1330	29200	127	0	60	54	208	104	504	7.7	46	8.0
1585.....	Pigeon River near Owendale.	SE¼sec. 36, T. 16 N., R.10 E.	55.0	Mar. 27*	1535	1670	90	0	32	6.5	114	40	249	8.1	36	2.0
				Aug. 7	1035	5.75	200	0	115	14	266	102	490	8.2	67	19.5

TABLE 1.—Chemical analyses of samples collected from Michigan streams under low- and high-flow conditions, 1967—Continued

Station No.	Station Name	Location	Drainage area (sq mi)	Date sampled	Time	Discharge (cfs)	Bicarbonate (HCO ₃)	Carbonate (CO ₃)	Sulfate (SO ₄)	Chloride (Cl)	Hardness as CaCO ₃		Specific conductance (micro-mhos at 25° C)	pH	Water temperature	
											Ca, Mg	Non-carbonate			°F	°C
STREAMS TRIBUTARY TO ST. CLAIR RIVER																
4-1595	Black River near Fargo.	NW¼sec. 32, T. 8 N., R.16 E.	480	Mar. 28	1215	7030	137	0	26	15	140	28	300	8.2	----	-----
				Aug. 9	0955	80.8	276	0	110	64	329	103	780	8.0	----	-----
1599	Mill Creek near Avoca.	NW¼sec. 8, T. 7 N., R.15 E.	169	Mar. 28	0930	1880	85	0	67	12	152	82	330	8.0	38	3.5
				Aug. 9	0810	13.8	256	0	210	60	382	172	850	7.8	----	-----
1605	North Branch Belle River at Imlay City.	NW¼sec. 16, T. 7 N., R.12 E.	18.0	Mar. 28	1445	92.0	62	0	136	25	228	177	480	8.0	41	5.0
				Aug. 8	1235	1.42	317	0	150	300	354	94	1600	7.9	----	-----
1606	Belle River at Memphis.	SE¼sec. 35, T. 6 N., R.14 E.	151	Apr. 20	1300	587	157	0	128	23	282	153	530	8.2	50	10.0
				Aug. 9	1255	15.2	317	0	140	92	390	130	940	7.6	----	-----
1608	Sashabaw Creek near Drayton Plains.	SE¼sec. 26, T. 4 N., R.9 E.	21.0	Apr. 18	1120	55.9	187	0	48	13	205	52	385	8.2	49	9.5
				Aug. 16	1830	2.96	196	5	42	18	220	54	420	8.6	72	22.0
1609	Clinton River near Drayton Plains.	NE¼sec. 21, T. 3 N., R.9 E.	79.5	Apr. 11	1150	116	212	3	39	25	227	51	465	8.4	45	7.0
				Aug. 31	1835	15.6	220	0	33	40	212	32	495	7.8	68	20.0
1610	Clinton River at Auburn Heights.	NW¼sec. 36, T. 3 N., R.10 E.	123	Apr. 19	1005	209	210	0	66	74	256	84	680	8.2	----	-----
				Aug. 16	1745	55.1	168	2	93	114	282	142	850	8.3	79	26.0
1611	Galloway Creek near Auburn Heights.	SE¼sec. 18, T. 3 N., R.11 E.	17.8	Apr. 11	0900	20.6	256	4	97	104	370	158	865	8.3	----	-----
				Aug. 31	1635	.86	334	0	125	64	326	52	820	7.6	----	-----
1615	Paint Creek near Lake Orion.	NE¼sec. 13, T. 4 N., R.10 E.	38.9	Apr. 11	1350	68.5	213	4	62	18	246	68	480	8.5	48	9.0
				Aug. 31	1455	11.7	222	0	45	24	228	46	478	7.7	----	-----
1615.4	Paint Creek at Rochester.	SE¼sec. 10, T. 3 N., R.11 E.	71.3	Apr. 19	0920	223	220	0	58	18	240	60	470	8.0	----	-----
				Aug. 16	1605	22.1	260	5	38	28	258	42	530	8.5	70	21.0
1615.8	Stony Creek near Romeo.	SW¼sec. 31, T. 5 N., R.12 E.	25.6	Apr. 11	1620	45.5	205	4	40	13	215	44	400	8.5	----	-----
				Aug. 31	1155	3.52	334	0	39	16	306	32	580	8.0	----	-----
1616	West Branch Stony Creek near Lakeville.	SE¼sec. 5, T. 4 N., R.11 E.	14.8	Apr. 11	1545	12.1	196	2	27	8.0	188	25	350	8.3	----	-----
1618	Stony Creek near Washington.	SW¼sec. 31, T. 4 N., R.12 E.	68.0	Apr. 10	1640	137	200	2	40	14	215	49	400	8.3	----	-----
				Aug. 31	1000	58.8	244	0	35	18	235	35	455	7.9	----	-----
1620	Red Run near Royal Oak.	NE¼sec. 12, T. 1 N., R.11 E.	36.5	Apr. 13	1600	.48	470	0	290	406	790	405	2500	8.0	----	-----
1629	Big Beaver Creek near Warren.	SW¼sec. 33, T. 2 N., R.12 E.	23.5	Apr. 13	1420	12.7	204	5	94	112	308	136	900	8.4	----	-----
				Aug. 24	1555	87	270	5	58	190	333	107	1220	8.4	69	20.5
1634	Plum Brook at Utica.	NE¼sec. 7, T. 2 N., R.12 E.	16.1	Apr. 13	1325	10.7	192	2	94	120	307	147	900	8.3	----	-----
				Aug. 25	1150	.27	256	0	88	156	366	156	1090	7.8	67	19.5
1640	Clinton River near Fraser.	NW¼sec. 20, T. 2 N., R.13 E.	445	Apr. 20	1135	811	219	3	60	51	266	81	610	8.3	----	-----
				Aug. 16	1058	152	215	0	67	64	244	68	690	7.9	----	-----
1640.1	North Branch Clinton River at Almont.	NE¼sec. 28, T. 6 N., R.12 E.	9.56	Apr. 21	0750	16.5	231	3	64	16	267	75	530	8.3	47	8.5
				Aug. 8	1410	1.70	220	0	48	18	214	34	620	8.0	----	-----
1640.5	North Branch Clinton River near Romeo.	NW¼sec. 31, T. 5 N., R.13 E.	49.7	Apr. 21	1225	92	247	3	92	26	317	112	640	8.3	51	10.5
				Aug. 8	1530	9.45	306	4	78	34	330	76	665	8.3	----	-----
1641	East Pond Creek at Romeo.	SE¼sec. 27, T. 5 N., R.12 E.	21.8	Apr. 21	1150	71.8	204	2	42	22	216	47	430	8.3	51	10.5
				Aug. 8	1450	5.46	295	4	23	32	250	4	540	8.3	----	-----
1642	Coon Creek near Armada.	SW¼sec. 1, T. 4 N., R.13 E.	10.0	Apr. 12	1105	7.40	186	2	86	28	270	115	610	8.3	----	-----
				Aug. 30	1625	1.01	310	0	84	26	332	78	640	8.0	----	-----
1642.5	Tupper Brook at Ray Center.	NW¼sec. 23, T. 4 N., R.13 E.	8.62	Apr. 12	.....	10.6	205	0	89	28	282	114	600	8.2	----	-----
				Aug. 30	.....	.05	1151	0	115	294	518	0	2400	7.1	----	-----
1643	East Branch Coon Creek at Armada.	NE¼sec. 23, T. 5 N., R.13 E.	13.0	Apr. 21	0950	10.3	251	0	120	33	358	152	670	8.2	50	10.0
				Aug. 8	1623	.36	354	0	113	34	384	94	755	8.1	----	-----
1643.5	Highbank Creek near Armada.	NW¼sec. 6, T. 4 N., R.14 E.	14.9	Apr. 12	0950	4.36	193	0	93	56	288	130	650	8.2	----	-----
				Aug. 30	1720	.37	224	0	148	62	340	156	750	7.8	81	27.0
1645	North Branch Clinton River near Mount Clemons.	NW¼sec. 2, T. 2 N., R.13 E.	199	Apr. 12	1625	180	184	0	91	38	272	121	570	8.2	----	-----
				Aug. 29	0110	26.2	261	0	76	48	284	70	620	7.6	----	-----
1646	Middle Branch Clinton River near Macomb.	SE¼sec. 2, T. 3 N., R.12 E.	22.2	Apr. 20	0920	26	213	0	66	44	274	99	640	8.2	44	6.5
				Aug. 16	1420	2.91	266	0	55	42	268	50	630	7.9	----	-----
1648	Middle Branch Clinton River at Macomb.	SW¼sec. 5, T. 3 N., R.13 E.	41.0	Apr. 12	1500	26.9	165	2	80	46	258	120	700	8.3	----	-----
				Aug. 30	1345	13.7	217	0	55	42	248	70	560	7.8	----	-----
1655	Clinton River at Mount Clemons at Moravian Drive.	T. 2 N., R.13 E.	734	Aug. 29	1240	309	246	0	57	58	248	46	645	7.6	----	-----

STREAMS TRIBUTARY TO DETROIT RIVER

4-1660.....	River Rouge at Birmingham.	NW¼sec. 36, T. 2 N., R.10 E.	36.9	Apr. 10	1355	28.7	249	0	146	110	395	191	995	8.2	51	10.5
				Aug. 24	1500	5 0	268	4	115	107	376	152	945	8.3	69	20.5
1661.....	River Rouge at Southfield.	SW¼sec. 32, T. 1 N., R.10 E.	87.9	Apr. 10*	1140	80.7	240	0	102	100	338	141	846	7.9	50	10.0
				Aug. 24	1240	6.68	249	0	68	87	294	90	800	8.2	65	18.5
1662.....	Evans Ditch at Southfield.	SE¼sec. 28, T. 1 N., R.10 E.	9.49	Apr. 19	1510	4.12	295	2	122	151	440	196	1100	8.3	.....	.....
				Aug. 15	1525	.98	298	0	96	126	408	164	1020	7.9	.....	.....
1663.....	Upper River Rouge at Farmington.	NW¼sec. 27, T. 1 N., R.9 E.	17.5	Apr. 19	1245	11.5	296	0	77	50	342	99	650	8.0	.....	.....
				Aug. 15	1630	.96	198	2	65	32	238	74	610	8.3	72	22.0
1665.....	River Rouge at Detroit.	SW¼sec. 27, T. 1 S., R.10 E.	187	Apr. 3	1600	1210	178	0	64	67	233	87	600	8.2	55	13.0
				Aug. 15	1400	10.2	264	3	66	126	326	106	950	8.3	.....	.....
1670.....	Middle River Rouge near Garden City.	NW¼sec. 6, T. 2 S., R.10 E.	99.9	Apr. 14*	1105	142	236	0	91	98	332	138	823	8.2	.....	.....
				Aug. 23	1715	13.4	195	0	72	130	276	116	855	8.0	66	19.0
1680.....	Little River Rouge at Inkster.	SE¼sec. 19, T. 2 S., R.10 E.	82.2	Apr. 3*	1315	646	152	0	62	51	216	92	526	7.8	56	13.5
				Aug. 15	1145	1.55	239	0	64	88	202	6	800	8.0	.....	.....

STREAMS TRIBUTARY TO LAKE ERIE

4-1695.....	Huron River at Commerce.	SE¼sec. 10, T. 2 N., R.8 E.	49.6	Apr. 6	1515	86.3	216	3	24	17	207	27	410	8.4	.....	.....
				Aug. 16	0850	13.7	225	3	29	25	224	36	560	8.3	.....	.....
1700.....	Huron River at Milford.	SE¼sec. 9, T. 2 N., R.7 E.	125	Apr. 6	1420	173	229	3	38	26	232	41	470	8.3	.....	.....
				Aug. 17	1240	39.4	232	4	31	29	225	32	480	8.5	73	23.0
1705.....	Huron River near New Hudson.	NE¼sec. 1, T. 1 N., R.6 E.	143	Apr. 6	1220	46.8	223	4	33	26	222	36	465	8.4	.....	.....
				Aug. 17	1445	40.3	198	0	25	26	190	28	410	7.7	79	26.0
1715.....	Ore Creek near Brighton.	NW¼sec. 12, T. 1 N., R.5 E.	31.0	Mar. 31	1630	34.7	218	3	28	15	220	39	400	8.4	.....	.....
				Aug. 17	1710	4.38	249	0	17	20	222	18	450	7.7	.....	.....
1720.....	Huron River at Hamburg.	Sec. 24, T. 1 N., R.5 E.	299	Mar. 31	1555	382	214	3	52	27	240	62	500	8.4	.....	.....
1725.....	Portage River near Pinckney.	SW¼sec. 34, T. 1 N., R.4 E.	79.0	Mar. 31	1115	120	201	4	88	14	274	106	520	8.4	46	8.0
				Aug. 18	1010	2.13	185	0	72	15	228	76	485	8.2	.....	.....
1730.....	Huron River near Dexter.	SE¼sec. 13, T. 1 S., R.4 E.	506	Mar. 31	1235	854	202	0	62	24	242	76	488	8.2	41	5.0
				Aug. 18	1300	81.8	210	0	45	26	220	48	465	8.2	.....	.....
1735.....	Mill Creek near Dexter.	SE¼sec. 18, T. 2 S., R.5 E.	134	Apr. 26	1000	110	307	0	111	27	384	132	755	8.2	48	9.0
				Aug. 22	1530	17.4	243	5	66	34	270	66	700	8.5	68	20.0
1745.....	Huron River at Ann Arbor.	NW¼sec. 28, T. 2 S., R.6 E.	711	Apr. 21	0925	668	230	3	75	22	276	85	520	8.3	52	11.0
				Aug. 22	1700	81.4	220	0	51	28	236	56	520	8.2	72	22.0
1757.....	River Raisin near Tecumseh.	NE¼sec. 21, T. 6 S., R.4 E.	266	Apr. 17	1530	404	253	0	64	12	274	67	500	8.2	61	16.0
				Aug. 14	1210	14.2	212	4	52	17	238	56	545	8.5	.....	.....
1760.....	River Raisin near Adrian.	NW¼sec. 5, T. 7 S., R.4 E.	455	Apr. 17	1245	597	245	4	80	16	294	91	545	8.4	60	15.5
				Aug. 14	1200	47.9	273	0	73	28	302	78	640	8.0	.....	.....
1765.....	River Raisin near Monroe, on Ida May-bee Road.	On Ida May-bee Road	1034	Apr. 4*	1605	3110	178	4	86	28	280	127	561	8.4	.....	.....
				Aug. 15	0930	66.9	168	0	130	38	268	130	690	7.6	.....	.....

* Laboratory analysis.