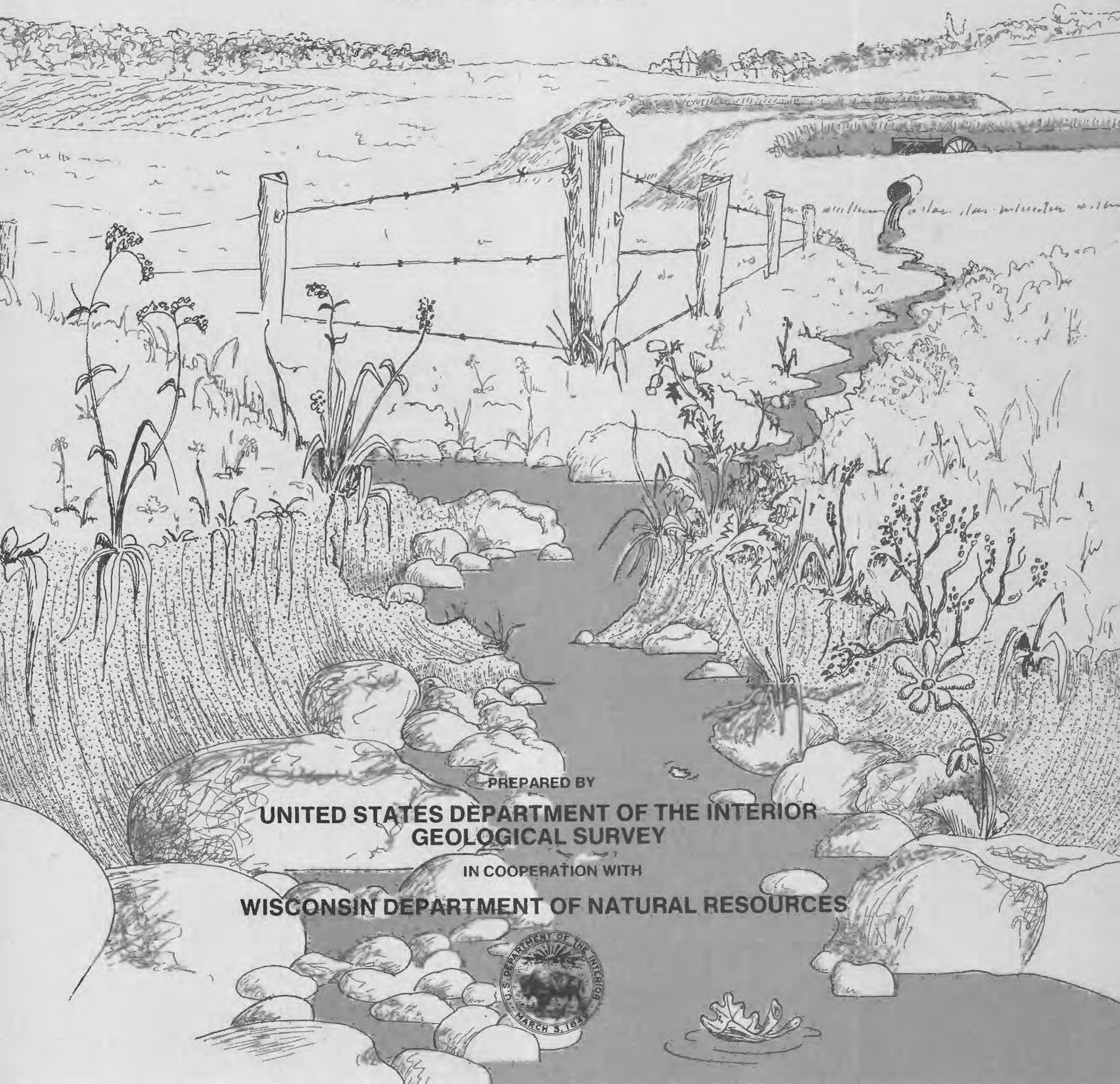
WATER RESOURCES INVESTIGATIONS
78-49

Ten-Year Low Mean Monthly Discharge Determinations for Ungaged Streams near Waste-Stabilization Ponds in Wisconsin



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Communities that use fill-and-draw waste-water treatment lagoons or waste-stabilization ponds are required to discharge during the spring and fall of the year at a rate that does not exceed the assimilative capacity of the receiving stream. The 10-year low mean monthly discharge (MMQ_{10}) for October, November, April, and May for the receiving stream has been used to establish the discharge rate for the treatment systems at the appropriate time of the year. To determine the MMQ_{10} for the receiving stream the monthly mean discharge first was estimated by using a technique developed by Riggs (1969). Once the monthly mean discharge was determined, the MMQ_{10} of the ungaged stream was estimated by using a graphical correlation between the monthly mean discharge and the MMQ_{10} of at least three gaging stations near the waste-stabilization pond. The MMQ_{10} for these gaging stations were determined by a log-Pearson Type III frequency analysis.

The MMQ_{10} was determined for five sites in Wisconsin.

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S. J. Field

ABSTRACT

Communities that use fill-and-draw waste-water treatment lagoons or waste-stabilization ponds are required to discharge during the spring and fall of the year at a rate that does not exceed the assimilative capacity of the receiving stream. The 10-year low mean monthly discharge (MMQ_{10}) for October, November, April, and May for the receiving stream has been used to establish the discharge rate for the treatment systems at the appropriate time of the year. To determine the MMQ_{10} for the receiving stream the monthly mean discharge first was estimated by using a technique developed by Riggs (1969). Once the monthly mean discharge was determined the MMQ_{10} of the ungaged stream was estimated by using a graphical correlation between the monthly mean discharge and the MMQ_{10} of at least three gaging stations near the waste-stabilization pond. The MMQ_{10} for these gaging stations were determined by a log-Pearson Type III frequency analysis.

The MMQ_{10} was determined for Maple Creek at Valmy, Allens Creek near Oakdale, North Branch Manitowoc River at Sherwood, East Fork Poplar River near Curtiss, and Yellow River at Barronette.

INTRODUCTION

Fill-and-draw waste-water treatment lagoons or waste-stabilization ponds are economically attractive to small communities or emerging population centers. The initial capital construction costs are not high and operating and maintenance costs are less than for mechanical treatment plants (Barsom, 1973, p. 26). Effluent from both mechanical treatment plants and waste-stabilization ponds must meet water-quality standards based on the flow in the receiving stream. For mechanical treatment plants the standards are based on the annual minimum 7-day mean flow below which the flow will fall on the average of once in 10 years ($Q_{7,10}$). However, the effluent from waste-stabilization ponds at most times cannot meet these standards when the $Q_{7,10}$ of the receiving stream is low. Therefore, the Wisconsin Department of Natural Resources has adopted standards for waste-stabilization-pond effluent which use the 10-year low mean monthly discharge (MMQ_{10}) of the receiving stream for April, May, October, and November.

The effluent from these ponds is discharged twice a year, during April or May and October or November. During these months the capacity of a stream to assimilate effluent is greatest because of generally high discharge and cool water.

The purpose of this report is to describe a technique used to determine the MMQ_{10} for the months of April, May, October, and November for the following streams near the waste-stabilization ponds shown in figure 1 and to present the results.

1. Maple Creek at Valmy
2. Allens Creek near Oakdale
3. North Branch Manitowoc River at Sherwood
4. East Fork Poplar River near Curtiss
5. Yellow River at Barronette

For the convenience of readers who prefer to use metric units, the U.S. customary units in this report may be converted by using the following factors.

Multiply	By	To obtain
cubic feet per second (ft^3/s)	0.0283	cubic meters per second (m^3/s)
square miles (mi^2)	2.59	square kilometers (km^2)

ESTIMATING MONTHLY MEAN FLOWS FROM DISCHARGE MEASUREMENTS

It is not reasonable to operate a gaging station at every potential site for 10 years to determine the MMQ_{10}. However, the MMQ_{10} can be estimated at an ungaged site after the monthly mean flow has been determined. Estimates of the monthly mean flow can be obtained by using a technique developed by Riggs (1969, p. 95-110). The technique requires that discharge at the ungaged site be measured and then correlated with the concurrent discharge at a nearby gaging station with similar hydrologic characteristics. The procedure "is based on the assumption that the ratio of concurrent daily mean flows of the two streams near the middle of the month equals the ratio of their means for that month." Riggs recommends that two discharge measurements, one near the first and another near the fifteenth of the month, be made for periods of high seasonal runoff. This was done for this study, with some slight modifications.

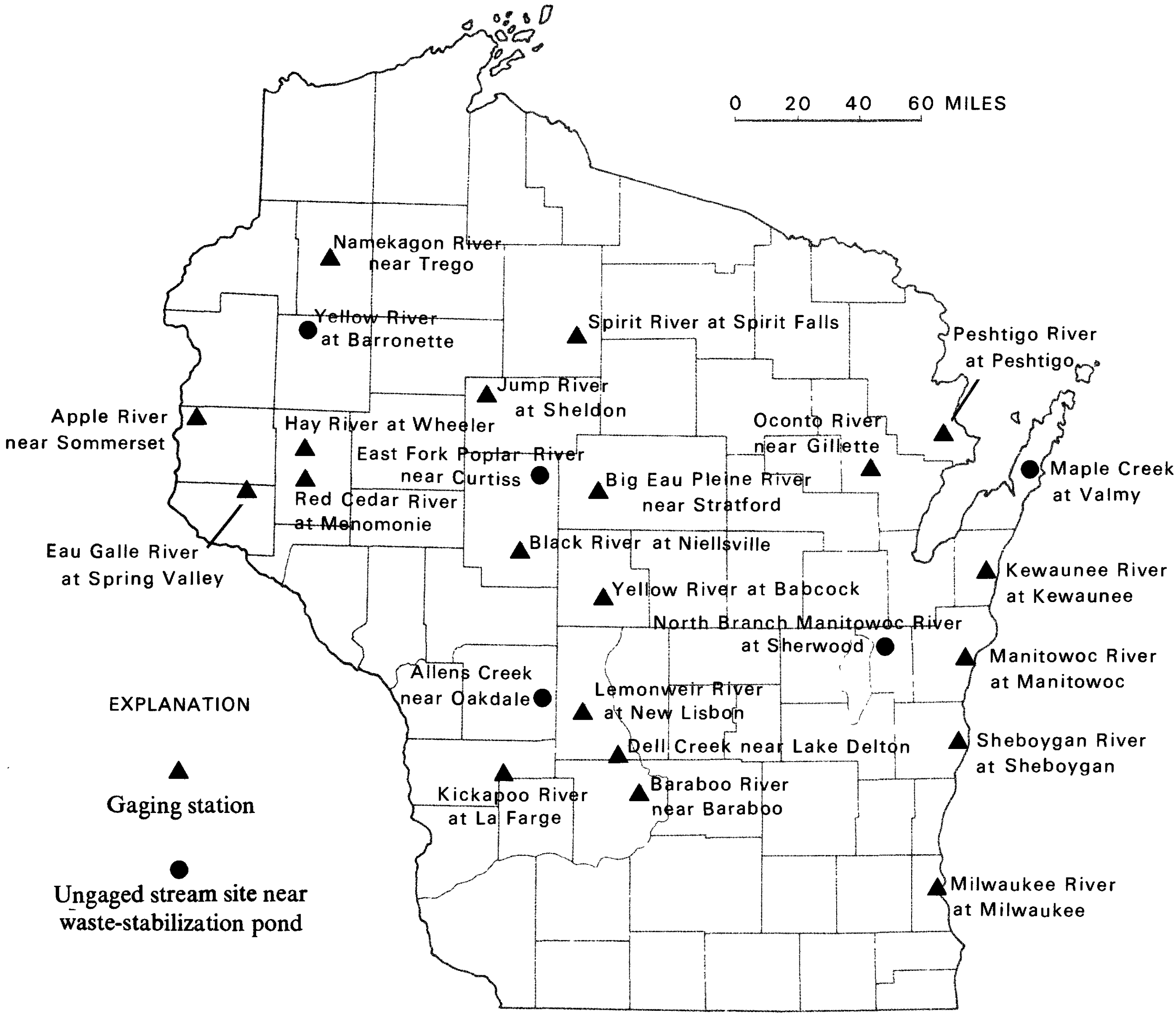

Figure 1. Location of ungaged stream sites and gaging stations near waste-stabilization ponds.

The technique is illustrated by showing the procedure used to determine the April and May 1977 monthly mean for Maple Creek at Valmy. The Kewaunee River near Kewaunee was chosen as the correlating gaging station with which to estimate the monthly mean discharge for Maple Creek because of its proximity to Valmy and its similar hydrologic characteristics. The discharge measured at Maple Creek and the concurrent discharge at the Kewaunee River gaging station for April and May are shown in table 1 and are plotted in figure 2.

To obtain the monthly mean discharge estimate for April 1977 a line was drawn between the plotted points of April 1 and April 6, April 6 and April 14, and April 14 and May 2. Then 45° lines (referenced to the x,y axis) were constructed midway between these points. Next the mean discharge for each period for the Kewaunee River was determined from this 45° line to obtain the estimate for the same time period for Maple Creek. Each period was weighted as shown below to obtain the monthly mean discharge.

	Average discharge for period (ft^3/s)		Water volume for period ($days \cdot ft^3/s$)
Period	Kewaunee River	Maple Creek	Maple Creek
April 1-6, 1977	318	4.5	6 days at 4.5 ft^3/s = 27
April 7-14, 1977	232	23	8 days at 23 ft^3/s = 184
April 15-30, 1977	64	9.5	16 days at 9.5 ft^3/s = 152

TOTAL 363 $days \cdot ft^3/s \div 30$ days = 12.1 ft^3/s April monthly mean

The estimated monthly mean discharge for April was 12.1 ft^3/s. The May monthly mean discharge of 2.22 ft^3/s was computed similarly.

As an independent check to determine the accuracy of Riggs' method, a staff gage was installed at Maple Creek at Valmy. The observed monthly mean discharges for April and May were 11.3 and 2.17 ft^3/s, respectively. The estimates by Riggs' method were 12.1 and 2.22 ft^3/s.

More discharge measurements were made during the runoff periods than Riggs recommended because of the necessity to develop a stage-discharge relation. These additional measurements improved the accuracy of the estimate for April. The estimates for April and May were within 7.1 percent and 2.3 percent, respectively, of the gaged discharge. However, if only the discharges on April 1, 14, and May 2 were used to estimate the monthly mean discharge for April, the estimate would have been in error 31 percent.

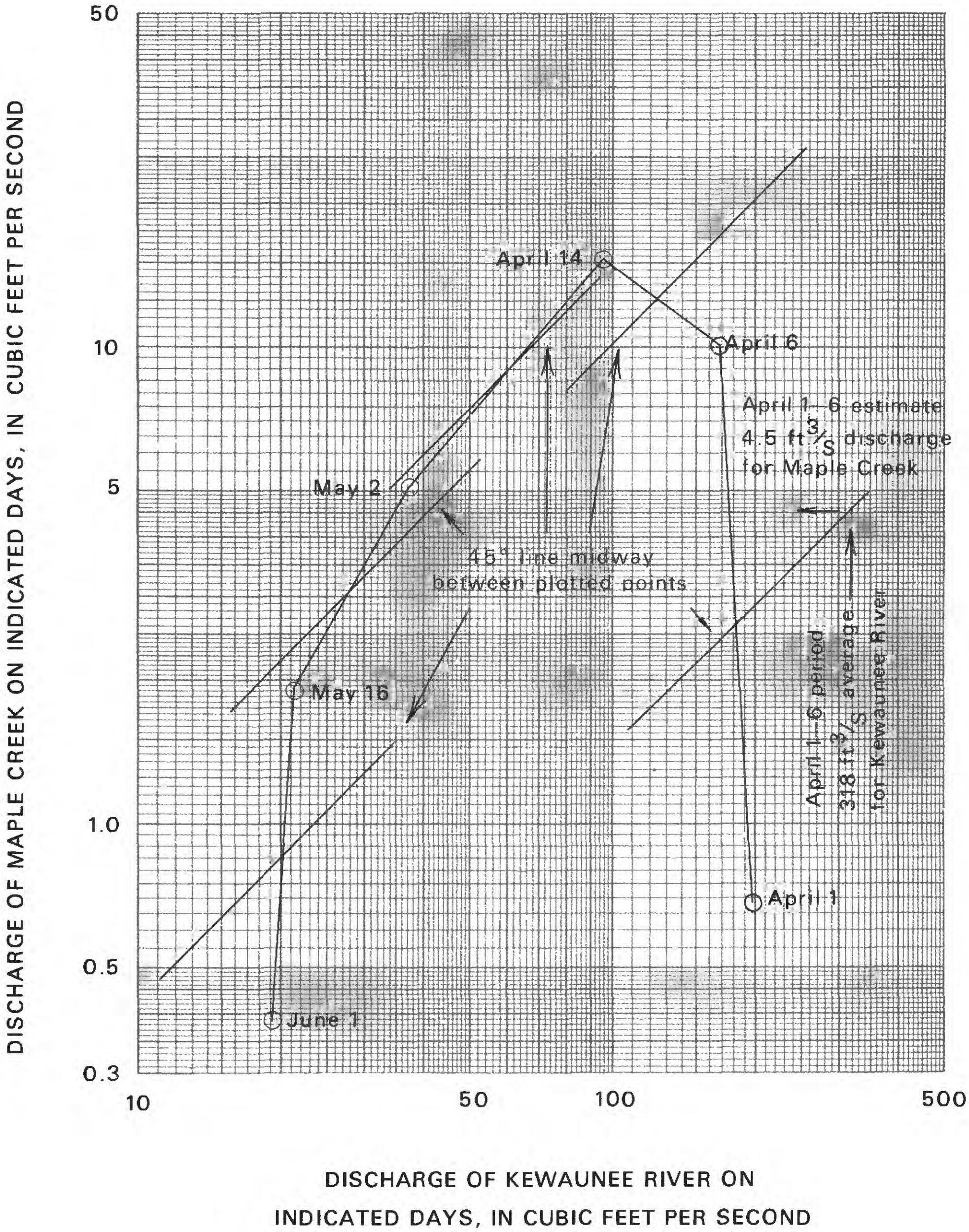

Figure 2. Method of estimating monthly mean discharge from concurrent discharges (from Table 1).

The discharge measurements for the streams near the waste-stabilization ponds and the concurrent discharge at the gaging stations used for correlation are shown in tables 1-5. The estimated monthly mean discharge for the streams near the waste-stabilization ponds and at the gaging stations used for correlation are shown in table 6. Three of the five streams had zero flows for October and November, and Riggs' method was not applicable for determining their monthly mean discharge.

Monthly mean flows at the gaging stations were much below normal during the study period. Generally, the October monthly mean discharges were about at the MMQ_{10}, but those for November were lower. The November monthly mean discharge for Yellow River at Babcock was the lowest since 1944. The April monthly mean discharges were slightly greater than the MMQ_{10}, and those for May were significantly lower. The May monthly mean discharge for Lemonwier River at New Lisbon was the lowest since 1944.

DETERMINING THE 10-YEAR LOW MEAN MONTHLY DISCHARGE FOR STREAMS NEAR WASTE-STABILIZATION PONDS

Once the monthly mean discharges were estimated for the ungaged streams, the MMQ_{10} for April, May, October, and November were determined for three or more gaging stations in the same area. To determine the MMQ_{10} for the selected gaging stations, a log-Pearson Type III (Riggs, 1968, p. 4-6) frequency analysis of the monthly mean discharge for the period of record was done.

The locations of the gaging stations for which the MMQ_{10} was determined are shown in figure 1, and the data are tabulated in table 6.

To estimate the MMQ_{10} for the ungaged streams near the waste-stabilization ponds, the monthly mean discharge for each gaging station was plotted against its MMQ_{10} and a line drawn averaging these plotted points. The estimated monthly mean discharge for the ungaged stream then was used to determine the MMQ_{10}. As illustrated in figure 3, the estimated April monthly mean of 12.1 ft^3/s for Maple Creek at Valmy was used to obtain a MMQ_{10} of 6.2 ft^3/s for this stream.

A few of the streams had zero flow during October and November in 1976, and the recurrence interval for a few of the correlating stations had monthly mean discharges that were less than the MMQ_{10}. Therefore, a value for the MMQ_{10} for these streams could not be determined.

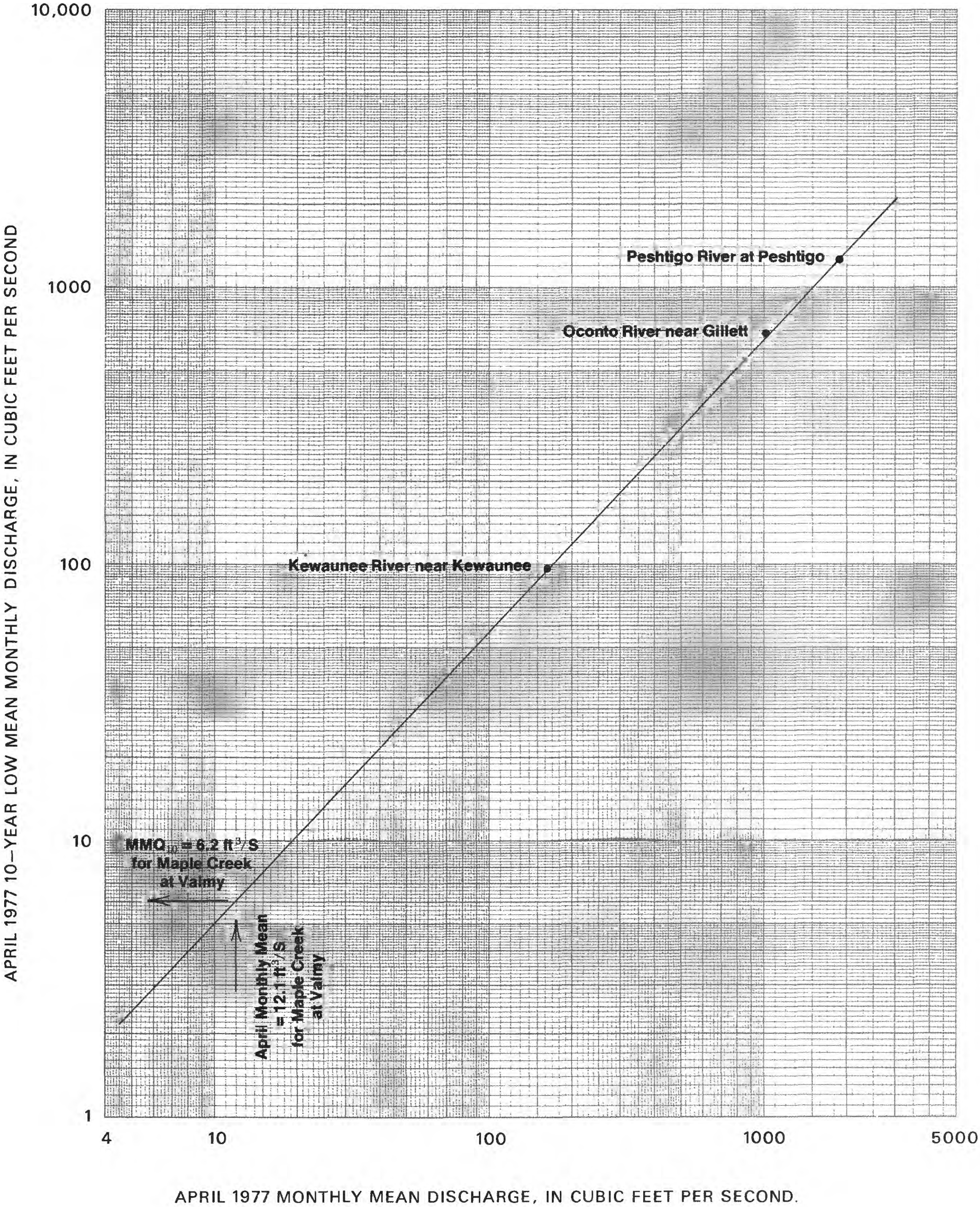

Figure 3. Method of estimating the MMQ_{10} for Maple Creek at Valmy from correlation of monthly-mean discharges to the MMQ_{10} at the gaging stations.

Table 1.--Date and discharge for Maple Creek at Valmy and Kewaunee River at Kewaunee

Date	Measured discharge of Maple Creek (ft^3/s)	Daily mean discharge of Kewaunee River (ft^3/s)
1976		
October 1	0.0	14
October 15	.0	13
November 1	.0	15
November 16	.0	13
November 30	.0	9
1977		
April 1	.69	197
April 6	10	168
April 14	15	95
May 2	5.0	37
May 16	1.9	21
June 1	.38	19

Table 2.--Date and discharge for Allens Creek near Oakdale and Lemonweir River at New Lisbon

Date	Measured discharge of Allens Creek (ft^3/s)	Daily mean discharge of Lemonweir River (ft^3/s)
1976		
September 29	2.2	54
October 14	.94	64
November 1	2.3	77
November 15	2.5	68
December 1	3.8	59
1977		
March 31	9.8	450
April 15	6.9	266
May 5	5.4	195
May 16	4.1	104
June 2	3.8	239

Table 3.--Date and discharge for North Branch Manitowoc River at Sherwood and Manitowoc River at Manitowoc

Date	Measured discharge of North Branch Manitowoc River (ft³/s)	Daily mean discharge of Manitowoc River (ft³/s)
1976		
October 1	0.04	20
October 15	.05	21
November 1	.07	31
December 1	.01	28
1977		
March 31	1.04	518
April 6	.98	604
April 15	.79	339
April 21	3.11[1]	217
May 17	.14	40
June 1	.48	36

[1]Average of two discharge measurements.

Table 4.--Date and discharge for East Fork Poplar River near Curtiss and Big Eau Pleine River near Stratford

Date	Measured discharge of East Fork Poplar River (ft³/s)	Daily mean discharge of Big Eau Pleine River (ft³/s)
1976		
September 30	0.0	2.5
October 18	.0	4.8
November 10	.0	4.3
December 1	.0	3.5
1977		
March 31	1.8	665
April 15	1.0	144
April 29	.78	30
May 16	.04	13
May 31	.02	6.6

Table 5.--Date and discharge for Yellow River at Barronette and Eau Galle River at Spring Valley

Date	Measured discharge of Yellow River (ft^3/s)	Daily mean discharge of Eau Galle River (ft^3/s)
1976		
September 30	0.0	12
October 14	.0	13
October 29	.0	5.8
November 15	.0	2.5
December 1	.0	12
1977		
February 11	.0	12
March 12	.0	127
March 29	.0	53
April 15	.80[1]	21
April 21	7.2[1]	147
May 2	.04	13
May 16	less than .01[2]	12
May 23	less than .01[2]	13
May 31	0	17

[1]Part of discharge estimated.

[2]Estimated.

Table 6.--Monthly mean discharge and 10-year low mean monthly discharge for ungaged streams and gaging stations near waste-stabilization ponds

Stream near waste-stabilization pond	Drainage area (mi^2)	Correlating stations	Drainage area (mi^2)
Maple Creek near Valmy	5.85		
		Kewaunee River near Kewaunee	129
		Peshtigo River at Peshtigo	1,124
		Oconto River near Gillette	678
Allens Creek near Oakdale	7.41		
		Baraboo River near Baraboo	609
		Dell Creek near Lake Delton	44.9
		Yellow River at Babcock	215
		Kickapoo River at LaFarge	266
		Lemonweir River at New Lisbon	507
East Fork Poplar River near Curtiss	1.16		
		Big Eau Pleine River near Stratford	224
		Jump River at Sheldon	574
		Black River at Neillsville	756
		Spirit River at Spirit Falls	81.6
		Yellow River at Babcock	215
		Dell Creek near Lake Delton	44.9
North Branch Manitowoc River at Sherwood	3.09		
		Manitowoc River at Manitowoc	530
		Kewaunee River near Kewaunee	129
		Sheboygan River at Sheboygan	432
		Milwaukee River at Milwaukee	679

Table 6.--Monthly mean discharge and 10-year low mean monthly discharge for ungaged streams and gaging stations near waste-stabilization ponds

Discharge (ft³/s)							
Monthly mean discharge				10-year low mean monthly discharge			
1976		1977					
Oct.	Nov.	Apr.	May	Oct.	Nov.	Apr.	May
0.0	0.0	[2]12	[2]2.2	0.0	[1]	6.2	3.8
14	13	162	22	12	15	97	36
348	332	1,900	538	398	467	1,260	802
252	258	1,030	400	273	324	699	524
[2]1.4	[2]2.9	[2]8.7	[2]4.0	1.5	4.2	8.0	5.6
179	184	405	194	127	151	316	205
22	20	35	28	16	18	28	20
4.5	4.7	134	24	6.8	11	149	48
97	123	144	100	85	91	141	110
66	70	361	132	72	87	388	243
.0	.0	[2]1.9	[2].10	[1]	[1]	1.3	.34
5.7	4.8	320	16	5.0	8.4	177	44
38	36	1,060	159	52	77	775	297
26	27	777	108	34	56	667	222
4.2	5.4	228	24	8.3	14	151	53
4.5	4.7	134	24	6.8	11	149	48
22	21	35	28	16	18	28	20
.05	.03	1.2	.31	.04	.03	.70	.45
24	30	374	55	[3]	[3]	[3]	[3]
14	13	162	22	12	15	97	36
48	49	310	69	31	41	259	100
104	112	610	139	65	95	369	140

Table 6.--Monthly mean discharge and 10-year low mean monthly discharge for ungaged streams and gaging stations near waste-stabilization ponds--Continued

Stream near waste-stabilization pond	Drainage area (mi^2)	Correlating stations	Drainage area (mi^2)
Yellow River at Barronette	3.13		
		Namekagon River near Trego	503
		Apple River near Sommerset	555
		Red Cedar River at Menomonie	1,760
		Hay River at Wheeler	426
		Eau Galle River at Spring Valley	64.8

[1]MMQ_{10} probably zero discharge but when monthly mean discharges at the gaging station are less than the MMQ_{10} a value cannot be determined.

[2]Monthly mean discharges estimated according to Riggs, 1969.

[3]Not enough record to determine MMQ_{10}.

Table 6.--Monthly mean discharge and 10-year low mean monthly discharge for ungaged streams and gaging stations near waste-stabilization ponds--Continued

Discharge (ft^3/s)							
Monthly mean discharge				10-year low mean monthly discharge			
1976		1977					
Oct.	Nov.	Apr.	May	Oct.	Nov.	Apr.	May
0.0	0.0	[2]0.46	[2]0.02	0	[1]	0.32	0.01
258	256	566	360	289	306	497	435
227	232	466	279	154	170	281	217
808	827	1,540	783	658	676	1,080	798
171	191	308	203	144	142	256	193
14	6.6	26	12	8.1	7.5	12.8	10.7

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