UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LOW-FLOW STUDY OF THE PIKE RIVER BASIN, RACINE AND KENOSHA COUNTIES, WISCONSIN

By Stephen J. Field

Open-File Report 75-653

Prepared in cooperation with the

Wisconsin Department of Natural Resources

Madison, Wisconsin

January 1976

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FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

Multiply English unit	By	To obtain SI units
feet (ft)	0.3048	metres (m)
miles (mi)	1.609	kilometres (km)
square miles (mi^2)	2.590	square kilometres (km^2)
cubic feet per second (ft^3/s)	.02832	cubic metres per second (m^3/s)

EXPLANATION OF TERMS

Cubic feet per second per square mile $\{(ft^3/s)/mi^2\}$ is the average number of cubic feet of water flowing per second from each square mile of area drained, assuming that the runoff is distributed uniformly in time and area.

Cubic foot per second (ft^3/s) is the rate of discharge representing 1 cubic foot passing a given point during 1 second and is equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute.

Discharge is the volume of fluid that passes a given point within a given period of time.

Drainage area of a stream at a specified location is that area, measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the stream above the specified point. Drainage-area figures include the entire basin, including noncontributing areas, unless otherwise noted.

Flow duration is the percentage of time that specified discharges are equalled or exceeded.

Gaging station is a site on a stream where systematic observations of gage height or discharge are obtained. When used with a discharge record, the term applies only to gaging stations having a continuous discharge record.

Milligrams per litre (mg/l) is a unit for expressing the concentration of chemical constituents in solution. Milligrams per litre represents the weights of solute per unit volume of water.

Partial-record station is a site where periodic streamflow or water-quality data are collected systematically over a period of years.

$Q_{7,2}$ is the annual minimum 7-day mean flow that occurs on the average of once in 2 years or has a 50-percent chance of occurring in any given year.

$Q_{7,10}$ is the annual minimum 7-day mean flow that occurs on the average of once in 10 years or has a 10-percent chance of occurring in any given year.

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ABSTRACT

The low-flow characteristics of the Pike River basin, Racine and Kenosha Counties were studied to determine the feasibility of Public Law 566 watershed-protection practices. Two seepage runs, one in October 1973, and the other in September 1974, showed that most of the low flow is combined treated-sewage and industrial cooling-water discharge. This effluent was 4.66 cubic feet per second (1.3 cubic metres per second) on September 19, 1974, and discharged into the headwaters of the Pike River; near the mouth the discharge was essentially the same. During drought this effluent could be lost gradually by evapotranspiration and by seepage to the ground-water reservoir. The $Q_{7,2}$ discharge estimate near the mouth is 0.0 cubic foot per second.

Water temperatures October 25-26, 1973, ranged from 9.5° to 16°Celsius, whereas those for September 19-20, 1974, ranged from 10° to 22°Celsius.

Dissolved oxygen October 25-26, 1973, ranged from 4 to 13.5 milligrams per litre; for September 19-20, 1974, the range was from 6.0 to 12.5 milligrams per litre.

Specific conductance October 25-26, 1973, ranged from 480 to 1,350 micromhos; for September 19-20, 1974, the range was from 380 to 1,400 micromhos.

INTRODUCTION

The purpose of this study was to determine the low-flow characteristics of the Pike River basin in order for the Wisconsin Department of Natural Resources to determine the feasibility of Public Law 566 watershed-protection practices. The study was made by the U.S. Geological Survey in cooperation with the Wisconsin Department of Natural Resources. Stream discharge, air temperature, water temperature, specific conductance, and dissolved oxygen were determined at various sites in the basin when streams were at low flow (tables 1 and 2).

Table 1.--Stream discharge and related water-quality measurements in the Pike River basin, Racine and Kenosha Counties, Wisconsin, October 25-26, 1973

Stream	Site No.	Drainage area above site (mi^2)	Date	Discharge		Velocity (ft/sec)	Specific conductance (micromhos)	Temperature (°C)		Time CST	Dissolved oxygen	
				(ft^3/s)	[(ft^3/s)/mi^2]			Air	Water		(mg/l)	(percent saturation)
Pike River	10	4.42	26	0.15	0.034	0.34	1200	6.5	9.5	0700	7.5	65
Tributary	11	.65	26	0	0					0740		
Tributary	12	1.67	25	.005		.084	1350	18.5	14.0	0930	9.0	87
Tributary	12a	2.20	-	-	-							
Pike River	9	11	26	5.16	.469	1.32	480	11.0	16.0	0805	5.5	55
Tributary	8	1.10	25	[1] <.05								
Tributary	7	1.08	25	.43	.398	.46	1000	14.5	14.0	1045	9.5	91
Pike River	6	17.9	25	6.42	.359	.68	530	14.0	15.5	1550	6.0	59
Pike Creek	18	7.35	25	.11	.014	.32	925	16.0	15.0	1420	11.5	114
Tributary	13	2.04	25	.05	.025	.36	900	16.5	15.0	1350		
Pike Creek	14	13.2	25	.30	.023	.12		15.5		1400	4.5	
Tributary	15	.83	26	[1] <.01								
Tributary	16	2.71	25	.11	.041	.57	1250	15.5	14.0	1200	8.0	77
Tributary	17	2.48	25	.04	.016	1.08	1100	14.5	13.0	1100	4.0	38
Pike River	5	38.6	25	6.37	.165	.47	620		14.0	1425	7.0	67
Pike River	4	39.9	25	[2] 5.60	.140	.57	680	16.0	14.0	1230	13.5	130
Pike River	3	40.4	26	6.68	.165	.56	690	16.5	11.0	1100	11.5	104
Pike River	2	41.7	25	6.36	.153	.48	670	15.0	14.0	1105	13.0	125
Tributary	1	3.69	26	.44	.119	.44	1000	16.5	12.0	1015	9.0	83
Pike River(mouth)	19	51.8										

[1] Estimate
[2] Accuracy of discharge is questionable, due to poor measuring conditions

Table 2.--Stream discharge and related water-quality measurements in the Pike River basin, Racine and Kenosha Counties, Wisconsin, September 19-20, 1974

Stream	Site No.	Drainage area above site (mi^2)	Date	Discharge		Velocity (ft/sec)	Specific conductance (micromhos)	Temperature (°C)		Time CST	Dissolved oxygen	
				(ft^3/s)	[(ft^3/s)/mi^2]			Air	Water		(mg/l)	(percent saturation)
Pike River	10	4.42	19	0.03	0.007	0.17	940		15.5	1200	[1]12.5	125
Tributary	11	.65	19	0	0							
Tributary	12	1.67	19	0	0							
Tributary	12a	2.20	19	4.66	2.12	.90	380	30.0	21.5	1240	6.5	73
Pike River	9	11	19	4.95	.450	.80	400	23.0	22.0	1345	7.5	85
Tributary	8	1.10	19	0	0					1000		
Tributary	7	1.08	19	0	0					1010		
Pike River	6	17.9	19	4.97	.278	.62	380	21.5	19.5	1455	9.0	97
Pike Creek	18	7.35	19	0	0					1030		
Tributary	13	2.04	19	0	0							
Pike Creek	14	13.2	19	.04	.003	.52	900	27.5	16.0	1040	6.0	61
Tributary	15	.83	19	[1]<.01								
Tributary	16	2.71	19	.02	.007	.47	1400		20.0	1130	6.5	71
Tributary	17	2.48	19	0						1250		
Pike River	5	38.6	19	[1]4.6	.119							
Pike River	4	39.9	20	4.73	.119	.54	420		16.0	940	10.5	106
Pike River	3	40.4	20	5.24	.130	1.51	420	15.5	10.0	745	9.5	84
Pike River	2	41.7	20	4.64	.111	.39	435		16.0	815	10.0	100
Tributary	1	3.69	20	.02	.005	.40			13.5	915	10.5	100
Pike River(mouth)	19	51.8										

[1] Sample taken September 20, 1974
[2] Estimate
[3] Discharge determined from rating table
[4] Measured once, discharge of 2.99 ft^3/s, Oct. 1, 1968

PHYSICAL SETTING

The Pike River basin (pl. 1) is in the southeast part of Racine County and the northeast part of Kenosha County. It has a drainage area of 51.8 mi^2 (134 km^2). The land surface of the basin is an undulating plain with low, irregular, north-south ridges of glacial moraines as prominent features. The total relief of the basin is approximately 200 ft (60 m); the highest point is about 780 ft (240 m) altitude at the northwest edge of the basin divide near Sturtevant, and the lowest point is approximately 580 ft (180 m) altitude at the mouth of the Pike River at Lake Michigan.

Unconsolidated surficial glacial deposits of outwash and till overlie consolidated bedrock of dolomitic limestone (Hutchinson, 1970). The glacial deposits are at the land surface in the western three-fourths of the basin but are overlain by a thin layer of lake clay, peat, or beach sand-and-gravel deposits in the eastern one-fourth of the basin (fig. 1). The beach sand and gravel was deposited by earlier stages of Lake Michigan. Sandy areas occur just east of the principal abandoned beaches shown as hachured lines in figure 1.

STREAMFLOW

A continuous streamflow record of the Pike River near Racine, site 5, (04087257) (pl. 1) is available since October 1971. The minimum discharge for the period October 1971 to September 1973 is 0.53 ft^3/s (0.015 m^3/s) on November 11, 1971; the average discharge is 43.2 ft^3/s (1.22 m^3/s) (U.S. Geol. Survey, 1974, p. 79).

The discharge of the Pike River was greater than normal for 1971-73 because of greater-than-normal precipitation, as indicated by comparing it with the discharge recorded at a nearby gaging station, Root River at Racine. The average discharge of Root River at Racine for the October 1971 to September 1973 period is 212 ft^3/s (6.00 m^3/s) compared with a 10-year average discharge of 146 ft^3/s (4.13 m^3/s). The minimum discharge for the 2-year period is 3.8 ft^3/s (0.108 m^3/s) compared with a minimum recorded of 1.3 ft^3/s (0.037 m^3/s) during the 10 years of record.

Two seepage runs were made in the basin to determine streamflow gains or losses. The first was on October 25-26, 1973; the second was on September 19-20, 1974. Streamflow data from nearby basins indicate that natural flows for the basin were about the 40 and 55 percent flow-duration points, respectively, for the first and second seepage run. The discharges measured at various sites during the runs are shown in figure 2.

Both seepage runs indicate about the same flow at site 9 in the headwaters of the Pike River as at site 2 in its lower reach. The unusually high discharge at site 9 results from discharge of treated sewage from Sturtevant and the discharge of cooling-water effluent from Waxdale between

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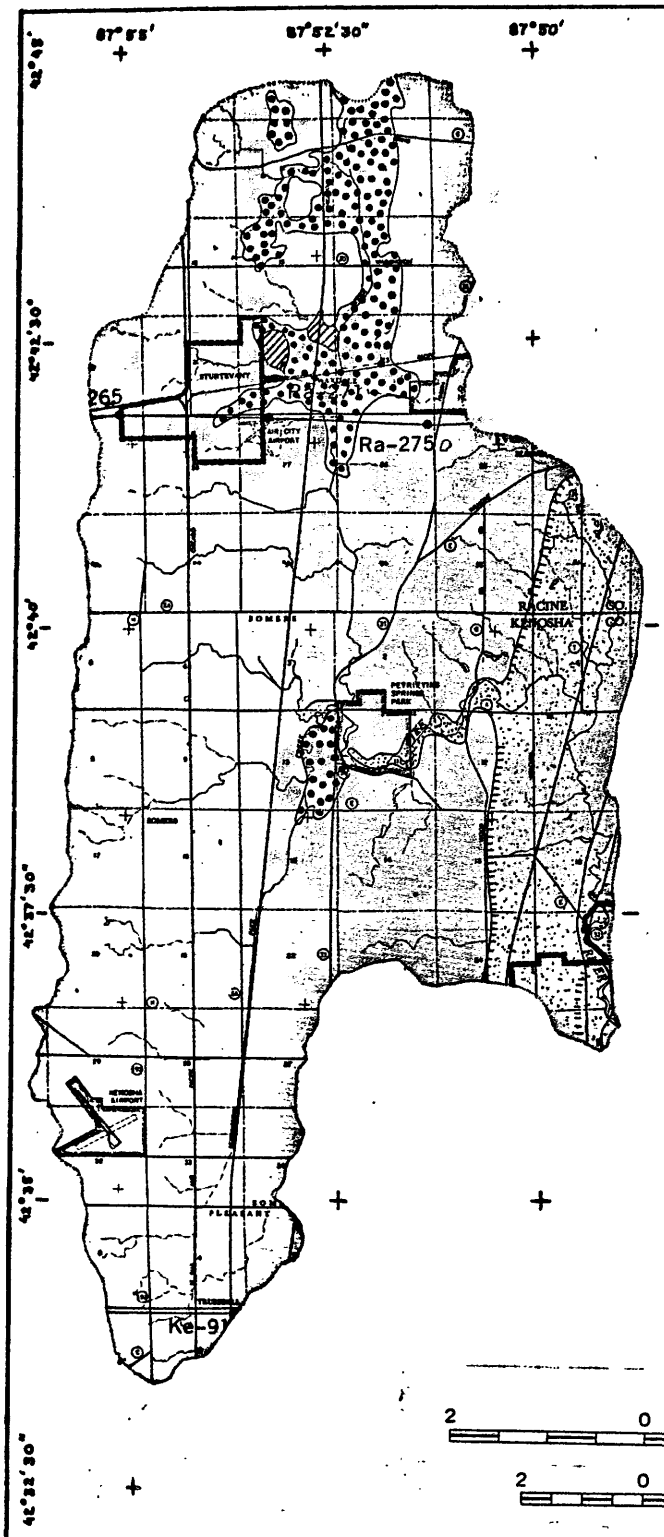

HYDROGEOLOGIC EXPLANATION

Outwash

Sand and fine gravel, well-sorted; nearly horizontal bedding; may be locally covered by alluvium. Allows rapid infiltration and small surface runoff. Well drained except where water table is near the surface. Allows rapid percolation to aquifers

Silty-clay till

Intermixed clay, silt, sand, gravel, cobbles, and boulders; unsorted and massive. Very slow infiltration and moderate to large surface runoff. Drainage may be good to poor. Very slow percolation to aquifers

Lake deposits, dunes, and alluvium

Sand and gravel of high permeability developed during present and earlier stages of Lake Michigan. As mapped, includes areas of nearly impermeable lake silt. Sandy areas most commonly occur just east of principal abandoned beaches, which are shown by hachured lines. Infiltration may be rapid or very slow, depending on surface material. Surface runoff generally small due to flat land and sandy soil. Drainage may be fair to poor

Organic deposit

Organic matter that accumulated in marshes, swamps, and bogs. Permeability unknown, but probably high. Often underlain by nearly impermeable clay creating a perched or semiperched water table. May be interbedded with inorganic material, especially near streams. Surface runoff very small and commonly artificially drained. Only the largest and thickest deposits are shown

Base from Southeastern Wisconsin Regional Planning Commission
Kenosha County, Racine County, 1:62,500

Hydrogeology by R.D. Hutchinson, 1970

Figure 1.--Surficial Hydrogeologic Map of Pike River Basin

Sheet No. ____ of ____ Sheets. Prepared by ____ Date ____ Checked by ____ Date ____

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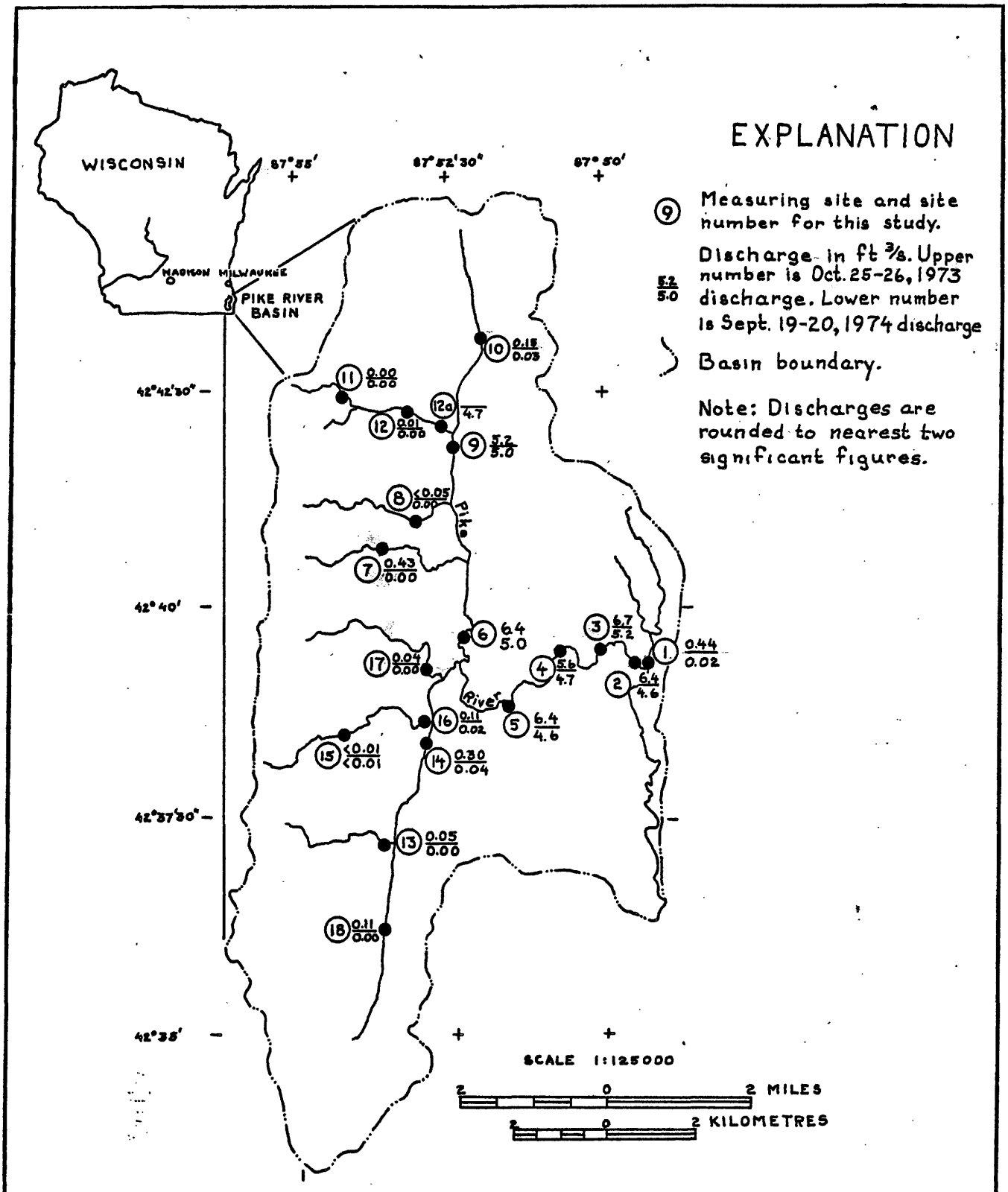

Figure 2.-- Location of Pike River basin in Wisconsin and map of basin showing discharge at various sites during seepage run.

Sheet No. ____ of ____ Sheets. Prepared by _____ Date _____ Checked by _____ Date _____

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sites 12 and 12a. Other streamflow gains or losses were insignificant. The discharge measured at site 4, October 25, 1973, indicates a losing reach from site 5, upstream, and a gaining reach downstream to site 3, but the measurement may be in error because of poor measuring conditions at site 4.

The discharge of 4.66 ft^3/s (1.3 m^3/s) at site 12a on September 19, 1974, is mostly the combined treated-sewage and industrial discharge. The tributary above the treated-sewage outfall was dry on this date.

The sewage-treatment plant at Sturtevant has an average hydraulic capacity of 0.47 ft^3/s (0.013 m^3/s) (Southeastern Wis. Regional Plan. Comm., 1974, p. 181) but since 1970 has experienced flows greater than the design capacity. An industrial plant at Waxdale discharges an average of 2.0 ft^3/s (0.57 m^3/s) with a maximum discharge of 2.7 ft^3/s (0.76 m^3/s) (Wisconsin Pollutant Discharge Elimination System Permit Number WI-0027758, Wis. Dept. of Nat. Resources).

During drought, the effluent discharged from the sewage-treatment plant at Sturtevant and from the Waxdale plant could be lost gradually by evapotranspiration and by seepage to the ground-water reservoir. Discharge measurements (shown below) made downstream (at site 3) indicate many flows lower than the probable combined total of the two plants.

Site 3

Date	Discharge (ft^3/s)	Date	Discharge (ft^3/s)
June 25, 1963	0.02	Oct. 13, 1964	0.24
July 11, 1963	.01	July 29, 1965	.68
Oct. 11, 1963	.60	June 2, 1966	12.2
July 1, 1964	1.03	Sept. 12, 1966	.92
Aug. 13, 1964	.09	Aug. 16, 1967	2.78

A loss of streamflow also was measured by the Southeastern Wisconsin Regional Planning Commission on September 22, 1964 (Southeastern Wis. Regional Plan. Comm., 1966, p. 237). A discharge of 2.3 ft^3/s (0.65 m^3/s) was measured at about site 6 and 1.2 ft^3/s (0.34 m^3/s) was measured 1.8 mi (2.9 km) above the mouth of the Pike River, which was about 2 mi (3 km) downstream from site 2--1.1 ft^3/s (0.31 m^3/s) was lost to the ground-water reservoir or evapotranspiration.

A loss in streamflow also was found in the Root River basin, which adjoins the Pike River basin and has similar flow characteristics. Hutchinson (1970, p. 32) found municipal and industrial effluent accounted for most gains in flow in the Root River canal and that streamflow decreased

in the lower part of the stream's reach because of seepage to the local ground-water reservoir.

Streamflow conditions preceding and during the time of the seepage runs are illustrated (fig. 3) by discharge hydrographs from the gaging station at site 5 (04087257) and a nearby gaging station, Fox River at Wilmot (05546500). The recorded precipitation at the U.S. Weather Bureau station in Kenosha, Wis., also is shown in figure 3. The Fox River gaging station and the recorded precipitation illustrate that streamflow should have been at low flow during the seepage run. However, discharge at the Pike River at Racine gaging station increased during the October 25-26, 1973, seepage run and showed a relatively low peak during the September 19-20, 1974, seepage run. The differences in the hydrographs during these periods are the result of effluent discharged into the Pike River upstream. The September 1974 hydrograph for the Pike River illustrates the streamflow augmentation. Upstream sources either reduce or discontinue effluent discharge to the tributary over the weekend causing streamflow to drop sharply on Saturdays (7, 14, 21, 28) and begin to recover on Mondays.

A comparison between the measured discharge at low-flow, partial-record stations and sewage-treatment-plant sites in the basin, at the time of the seepage runs, and the $Q_{7,2}$ and $Q_{7,10}$ discharge estimates is shown below. Most measurements indicate flows higher than the $Q_{7,2}$ estimate.

Site no.	Discharge (ft^3/s)					
	Oct. 25 1973	Oct. 26 1973	Sept. 19 1974	Sept. 20 1974	$Q_{7,2}$	$Q_{7,10}$
10		0.15	0.03		0.02	0.01
11		0	0		0	0
12	0.005		0		0	0
15		<0.01	<0.01		0	0
18	.11		0		0	0
3		6.68		5.24	0	0

WATER QUALITY

Water-temperature, dissolved-oxygen, and specific-conductance data collected at the time of the seepage run are only point samples of the streams' water quality. They may or may not indicate problem reaches in a stream. To interpret these parameters properly, continuous sampling or recording of water temperatures and dissolved oxygen, and chemical analyses

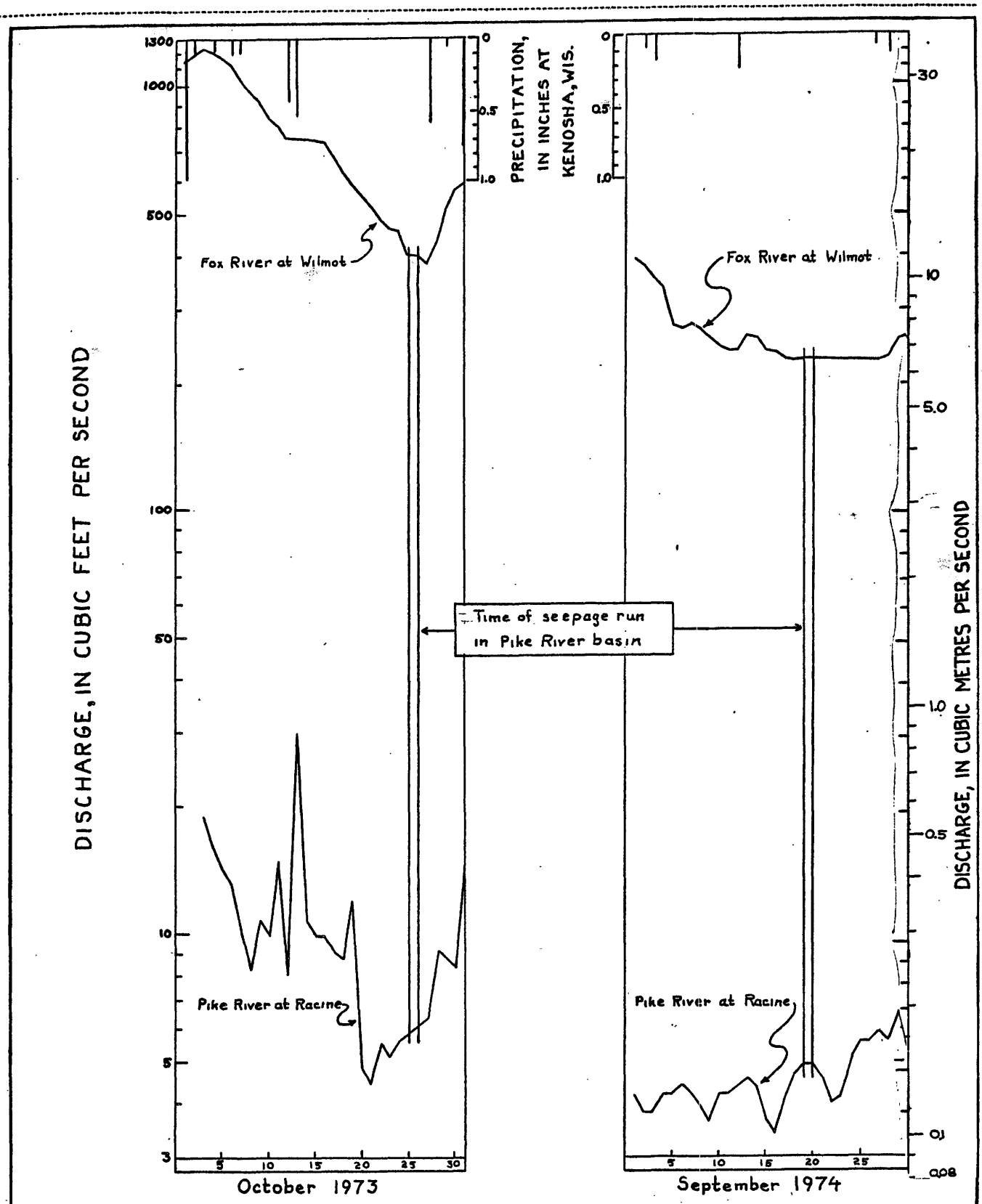

Figure 3.-- Discharge hydrographs of Pike River near Racine 5(04087257) and Fox River at Wilmot(05546500)

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of the water are required in conjunction with streamflow. Fairly extensive water-quality data have been collected by the Southeastern Wisconsin Regional Planning Commission in the Pike River basin from January 1964 to February 1965 and the data are available in "Water Quality and Flow of Streams in Southeastern Wisconsin".

Water temperatures observed during the October 25-26, 1973, seepage run ranged from 9.5° to 16°C (Celsius), whereas those for the September 19-20, 1974, seepage run ranged from 10° to 22°C. The highest temperature for both seepage runs is at site 9, below the tributary that carries the effluent from Waxdale and the sewage-treatment plant at Sturtevant.

Dissolved oxygen observed during the October 25-26, 1973, seepage run ranged from 4 to 13.5 mg/l (milligrams per litre); for September 19-20, 1974, the range was from 6.0 to 12.5 mg/l.

Specific conductance of water, in micromhos at 25°C, indicates the amount of dissolved minerals in the water. The dissolved-mineral concentration of the water in milligrams per litre is approximately 0.6 of the specific conductance. Specific conductance readings obtained October 25-26, 1973, ranged from 480 to 1,350 micromhos; for September 19-20, 1974, the range was from 380 to 1,400 micromhos.

REFERENCES

Hutchinson, R. D., 1970, Water resources of Racine and Kenosha Counties, Southeastern Wisconsin: U.S. Geol. Survey Water-Supply Paper 1878, 63 p.

U.S. Geological Survey, 1974, Water resources data for Wisconsin, 1973: Water Resources Div., 262 p.

Southeastern Wisconsin Regional Planning Commission, 1974, A regional sanitary sewage system plan for Southeastern Wisconsin, Rept. 16, 809 p.

_____1966, Water quality and flow of streams in Southeastern Wisconsin, Rept. 4, 342 p.