SEDIMENT, NUTRIENTS, AND OXYGEN-DEMANDING SUBSTANCES IN THE MINNESOTA RIVER: SELECTED WATER-QUALITY DATA, 1989-90

by Gregory A. Payne

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MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
702 Post Office Building
St. Paul, MN 55101

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CONVERSION FACTORS

Multiply	By	To obtain
square mile (mi^2)	2.590	square kilometer
cubic feet per second (ft^3/s)	0.02832	cubic meter per second
mile (mi)	1.609	kilometer
ton	0.9072	megagram

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ABSTRACT

This report presents selected physical and chemical data collected by the U.S. Geological Survey for the Minnesota River Assessment Project, a four-year interagency study coordinated by the Minnesota Pollution Control Agency. Water samples were collected at 12 sites on the Minnesota River and at the mouths of 10 major tributary streams located from the outlet of Lac qui Parle Reservoir to Henderson, Minnesota. Sampling from August 1989 through September 1990 resulted in collection of 171 stream-water samples. This report includes data on streamflow, total suspended solids, nitrite plus nitrate nitrogen, total phosphorus, biochemical oxygen demand, and chlorophyll *a*.

INTRODUCTION

The Minnesota River drains nearly 17,000 square miles in southwestern Minnesota and portions of eastern South Dakota and northern Iowa (fig. 1). A study by the Minnesota Pollution Control Agency (MPCA) demonstrated that the Minnesota River and its tributaries are significantly impacted by non-point source pollution (MPCA, 1982). High concentrations of suspended solids, nitrate, phosphorus, and fecal coliform bacteria impair industrial, domestic, and recreational uses of the river. A waste-load allocation study in the lower Minnesota River basin (MPCA, 1985) identified a need for a basin-wide program to control surface-runoff-related sources of nonpoint pollutants.

MPCA currently is coordinating an interagency effort to study the Minnesota River and its tributaries. The four-year study, entitled the Minnesota River Assessment Project (MRAP), will attempt to identify sources of non-point source pollution and the effect on water quality. The U.S. Geological Survey (USGS), in cooperation with the MPCA and the Legislative Commission on Minnesota Resources (LCMR), is monitoring selected physical characteristics and chemical constituents in the river as part of the MRAP. The physical and chemical monitoring has focused on four primary objectives:

1. Determine concentration and loads of suspended sediment, major nutrients, biochemical oxygen demand (BOD), and organic carbon to identify their sources and to isolate the effects of specific sources on water quality.

2. Determine the relation of suspended sediment to major nutrients, BOD, algal productivity, and organic carbon, to gain an understanding of the interactions of these constituents in the Minnesota River.

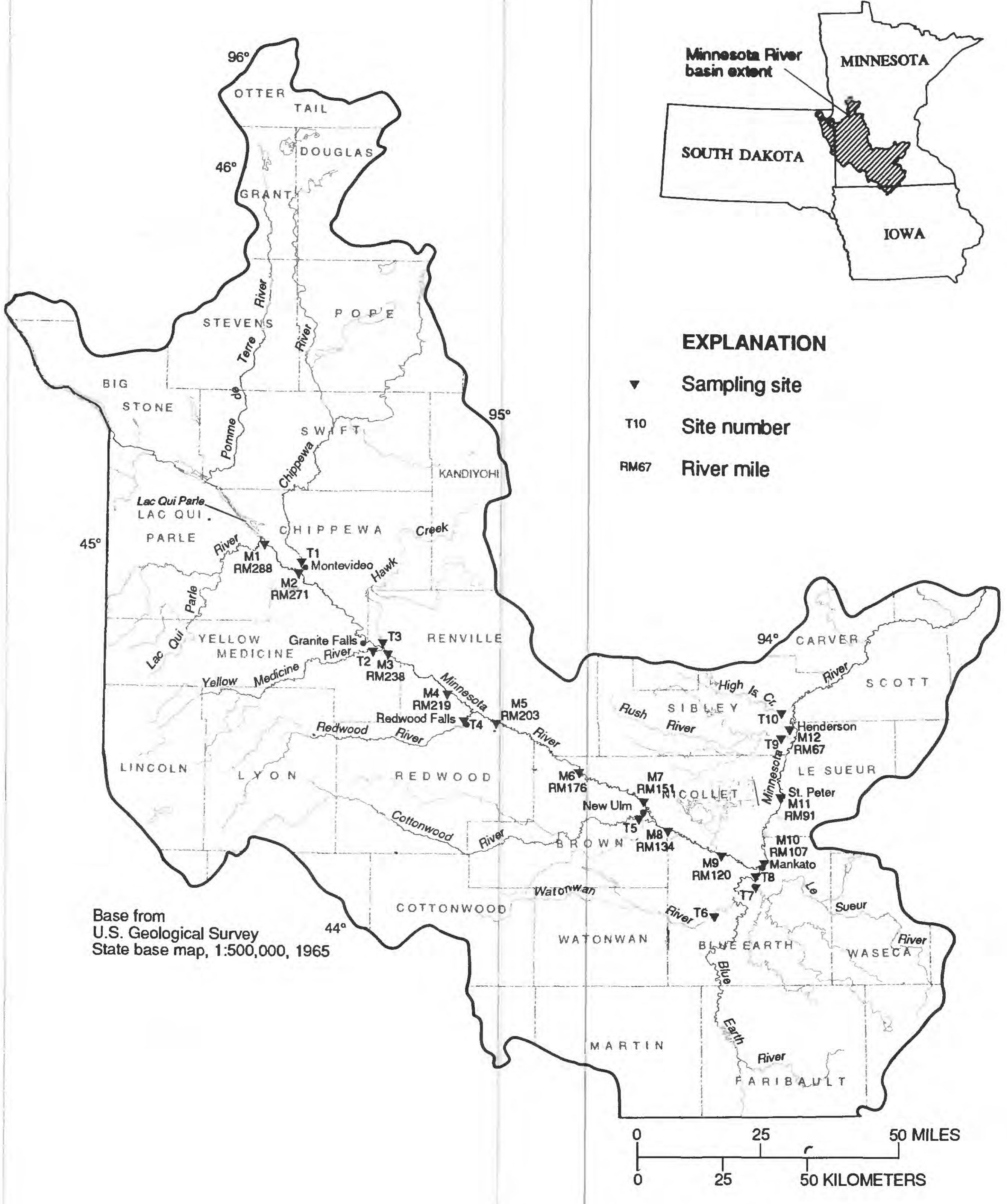

Figure 1.--Location of the Minnesota River basin and water-quality sampling sites.

3. Quantify the transport of sediment and associated pollutants between river reaches.

4. Identify areas of bank erosion and sediment deposition to determine the relative significance of instream sediment loading as compared to non-point source loading from the watershed.

This report contains selected data collected during the first two years of the four-year investigation.

APPROACH AND METHODS

A two-fold sampling approach is being used to identify areas of the Minnesota River basin that are contributing non-point source substances. The first approach consists of water-quality sampling at the mouths of 10 major tributaries. Sampling includes measuring chemical concentrations and determining loads so that each tributary can be ranked by the magnitude of its contribution to the Minnesota River. The second approach consists of sampling the mainstem of the Minnesota River at 12 locations to determine the accumulated effects of all non-point sources and instream processes.

Tributary sites were established near the mouths of 10 major tributaries: Chippewa River, Hawk Creek, Yellow Medicine River, Redwood River, Cottonwood River, Watonwan River, Le Sueur River, Blue Earth River, Rush River, and High Island Creek (fig. 1). Mainstem sites were established at intervals ranging from 13 to 33 miles, beginning at the outlet of Lac qui Parle Reservoir and extending downstream to Henderson, Minnesota (fig. 1).

Samples were collected across a range of conditions to characterize the change in water quality as the streams responded to both dry and wet conditions. Accordingly, samples were collected at all sites during low flow in late summer 1989, in winter 1990, and in late summer 1990. Samples were collected during a short time period (2-3 weeks), progressing from upstream to downstream to obtain a synoptic appraisal of water quality during low streamflow. Samples were collected at selected sites during snowmelt (March-April 1990) and during runoff from summer rainfall (May-July 1990). The Minnesota River at Montevideo and the Blue Earth River at Mankato were sampled frequently throughout 1989-90 (weekly from March through July and monthly from August through February) to more precisely determine short-term changes in water quality. Suspended-sediment samples were collected daily from March through November 1990 at the Blue Earth River at Mankato site and at the Minnesota River at Mankato site. Fifteen springs and seeps that discharge to the Minnesota River and to its tributaries were sampled during August 1989 and August 1990 to determine the quality of ground water entering the rivers. Data collection activities from August 1989 through September 1990 resulted in the collection of 171 samples from streams and 30 samples from springs and seeps.

The approach during 1989-1990 was designed to provide information about both areal and temporal variability in water quality, thereby addressing part of objectives one and three. The approach during 1991-92 will be adjusted on the basis of findings during 1989-90. Sampling efforts will be redirected to fully address all four study objectives as more data are collected.

Samples were collected and analyzed according to methods adopted by the USGS that are described in Buchanan and Somers (1969), Fishman and Friedman (1989), Wershaw and others (1983), Edwards and Glysson (1988), Ward and Harr (1990), and Britton and Greeson (1989). Streams were sampled using depth-integrating samplers at multiple intervals across the stream to obtain samples that were representative of total stream discharge. Streamflow discharge was determined for each sample to enable calculation of chemical constituent loads. Streamflow was determined by current-meter measurements or obtained from USGS streamflow gaging-station records.

Water samples and bottom-material samples were analyzed for chemical constituents at the USGS Central Laboratory at Arvada, Colorado. Samples for suspended-sediment concentrations and particle-size determinations for suspended sediment and bottom material were analyzed by the USGS Sediment Laboratory at Iowa City, Iowa.

Specific conductance, pH, temperature, and dissolved-oxygen concentration were determined in the field using portable meters that were calibrated at the beginning and end of each sampling day. Five-day BOD and bacteria counts were determined in field laboratories. BOD analyses were performed on natural (unseeded) water samples; some samples required dilution with deionized water. The physical, chemical, and biological determinations and analyses for stream, spring, and bottom-material samples are listed in table 1, at the back of the report.

MINNESOTA RIVER SYNOPTIC SAMPLING

Selected data for three periods of intensive sampling at sites on the Minnesota River mainstem are shown in figures 2-12, at the back of the report. The mainstem sampling sites and river-mile locations are listed in table 2. Instantaneous discharge at the time of sample collection is shown in figure 2 and concentrations and loads of total suspended solids, nitrite plus nitrate nitrogen, total phosphorus, BOD, and chlorophyll *a* are shown in figures 3-12.

WATER-QUALITY DATA FROM WEEKLY AND MONTHLY MONITORING

Selected data for the Minnesota River at Montevideo and the Blue Earth River at Mankato are shown in figures 13-30. The figures show instantaneous discharge, total suspended solids, and concentrations and loads of nitrite plus nitrate nitrogen, total phosphorus, and BOD.

TRIBUTARY WATER-QUALITY DURING RUNOFF PERIODS

Tributary streams were sampled during periods of runoff following rainstorms. Streamflow and selected water-quality data for tributary streams are presented in table 3, at the back of the report.

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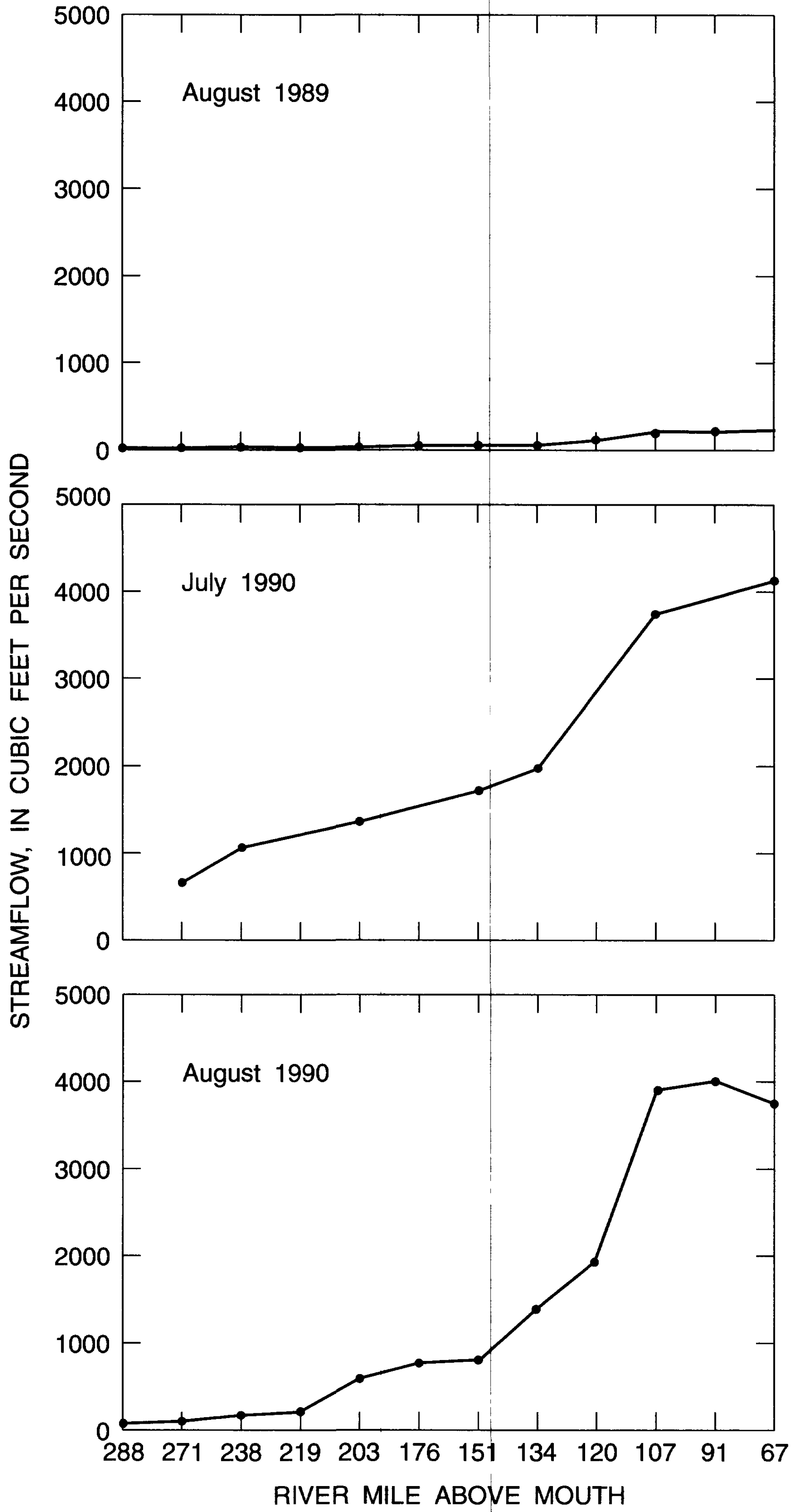

Figure 2.--Instantaneous discharge for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

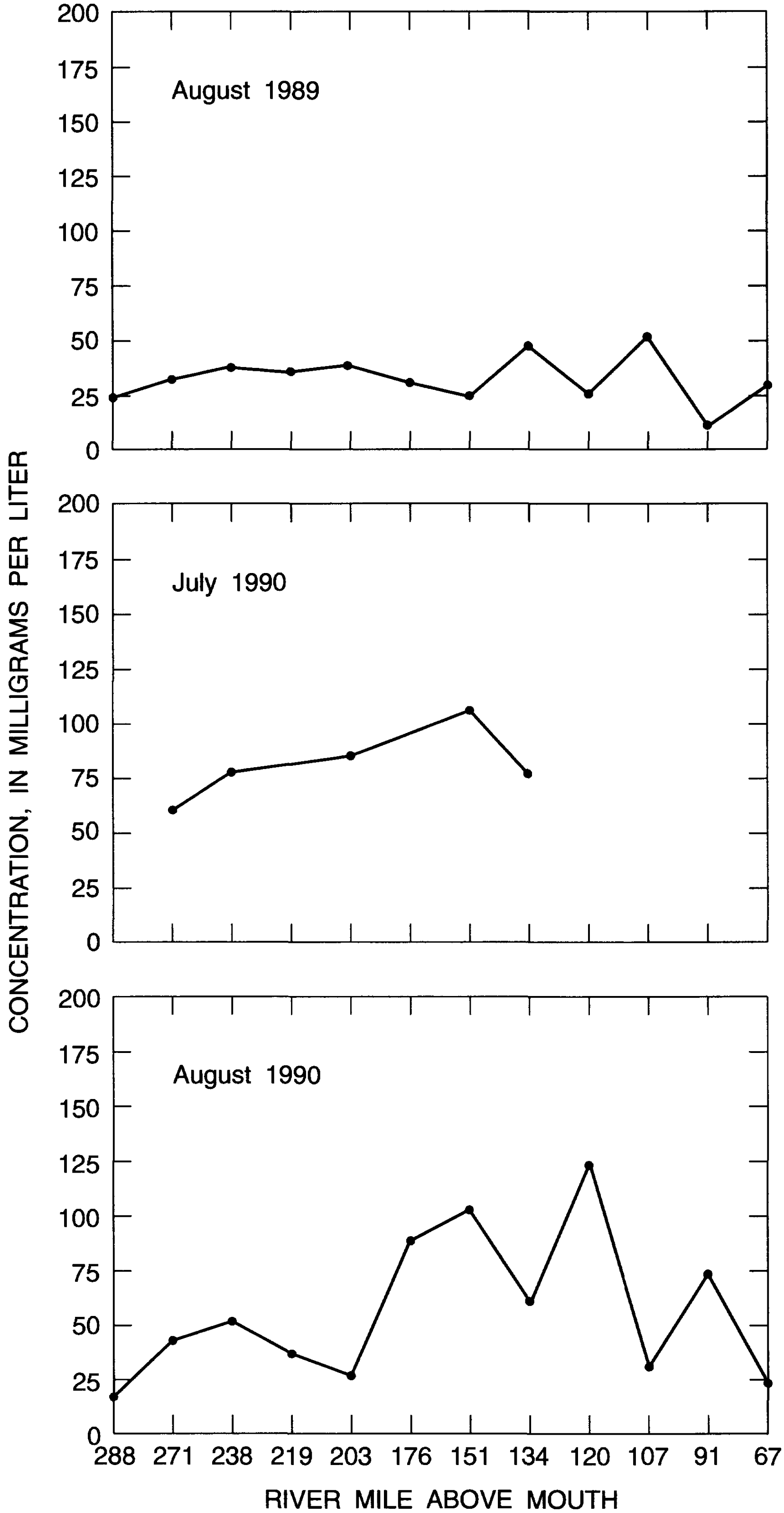

Figure 3.--Total suspended solids concentrations for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

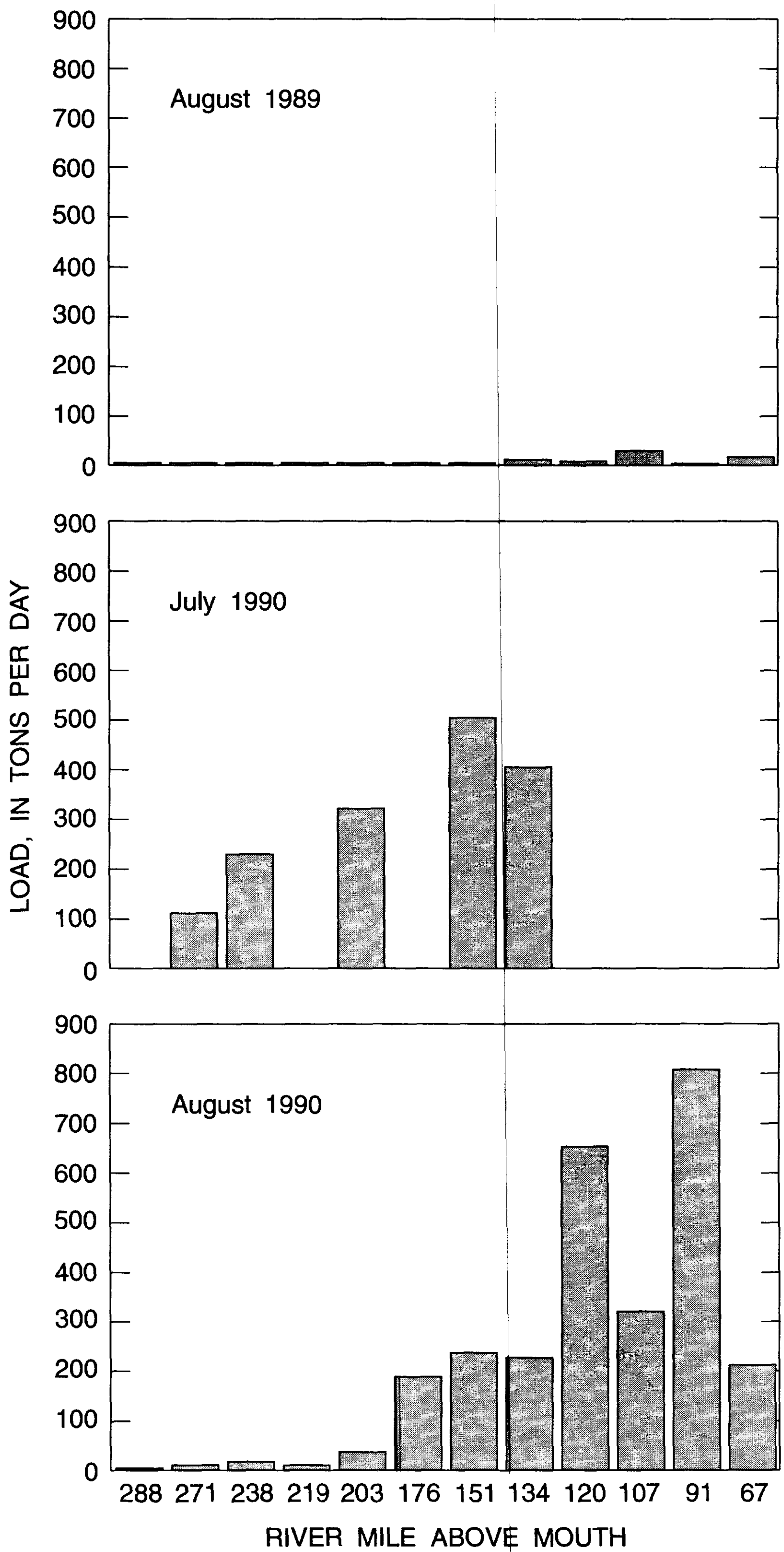

Figure 4.--Total suspended solids loads for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

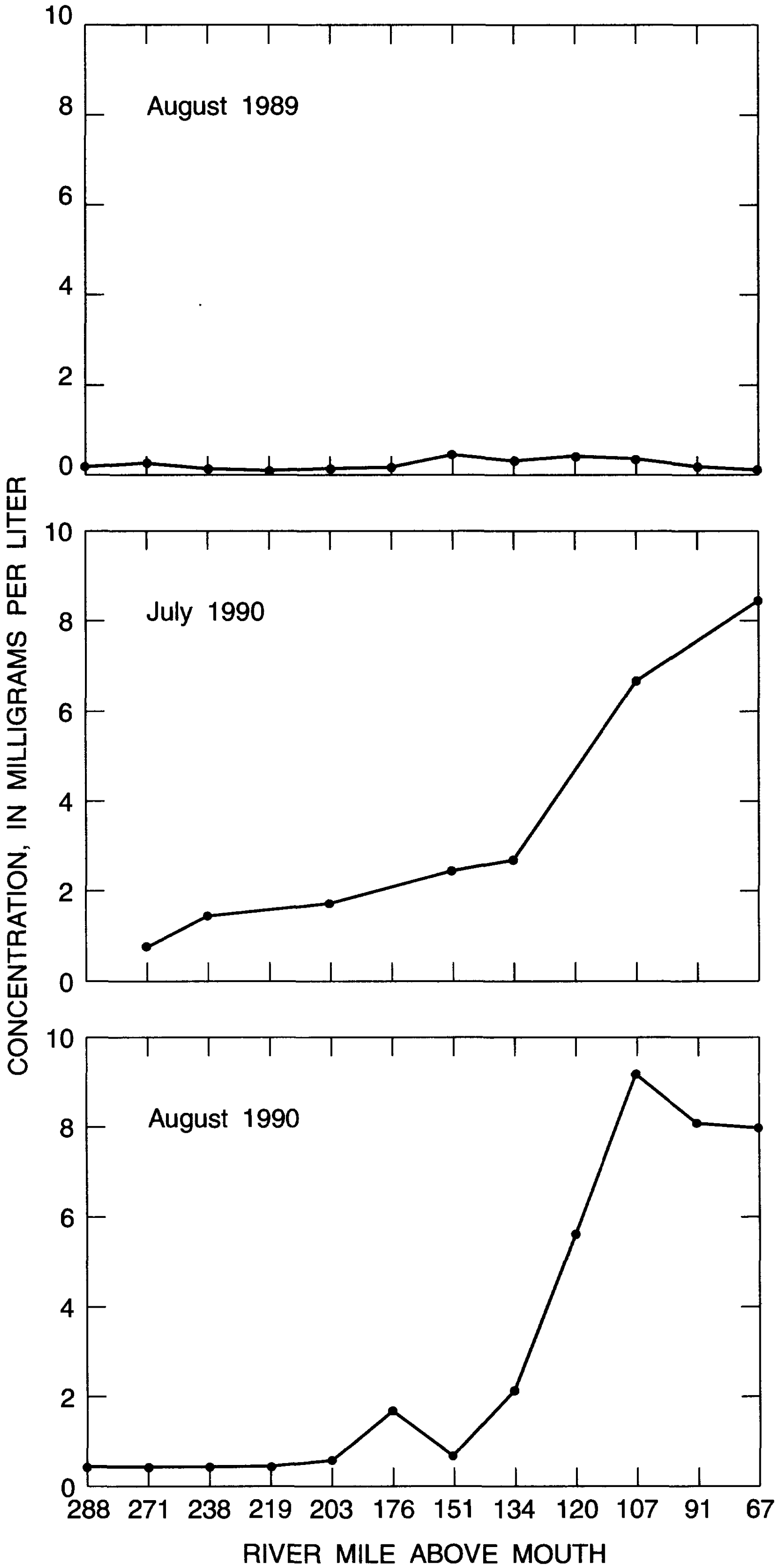

Figure 5.--Nitrite plus nitrate nitrogen concentrations for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

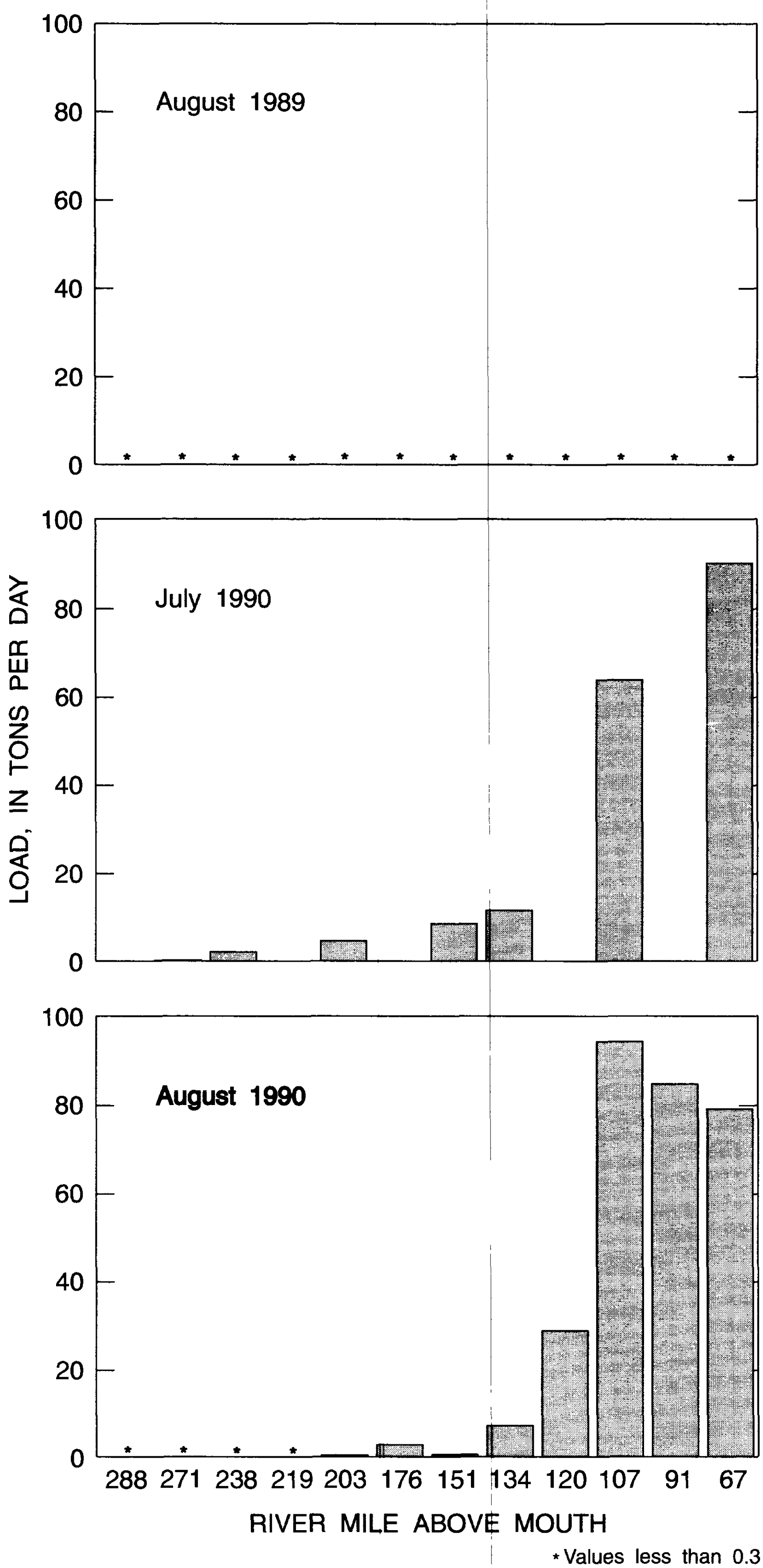

Figure 6.--Nitrite plus nitrate nitrogen loads for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

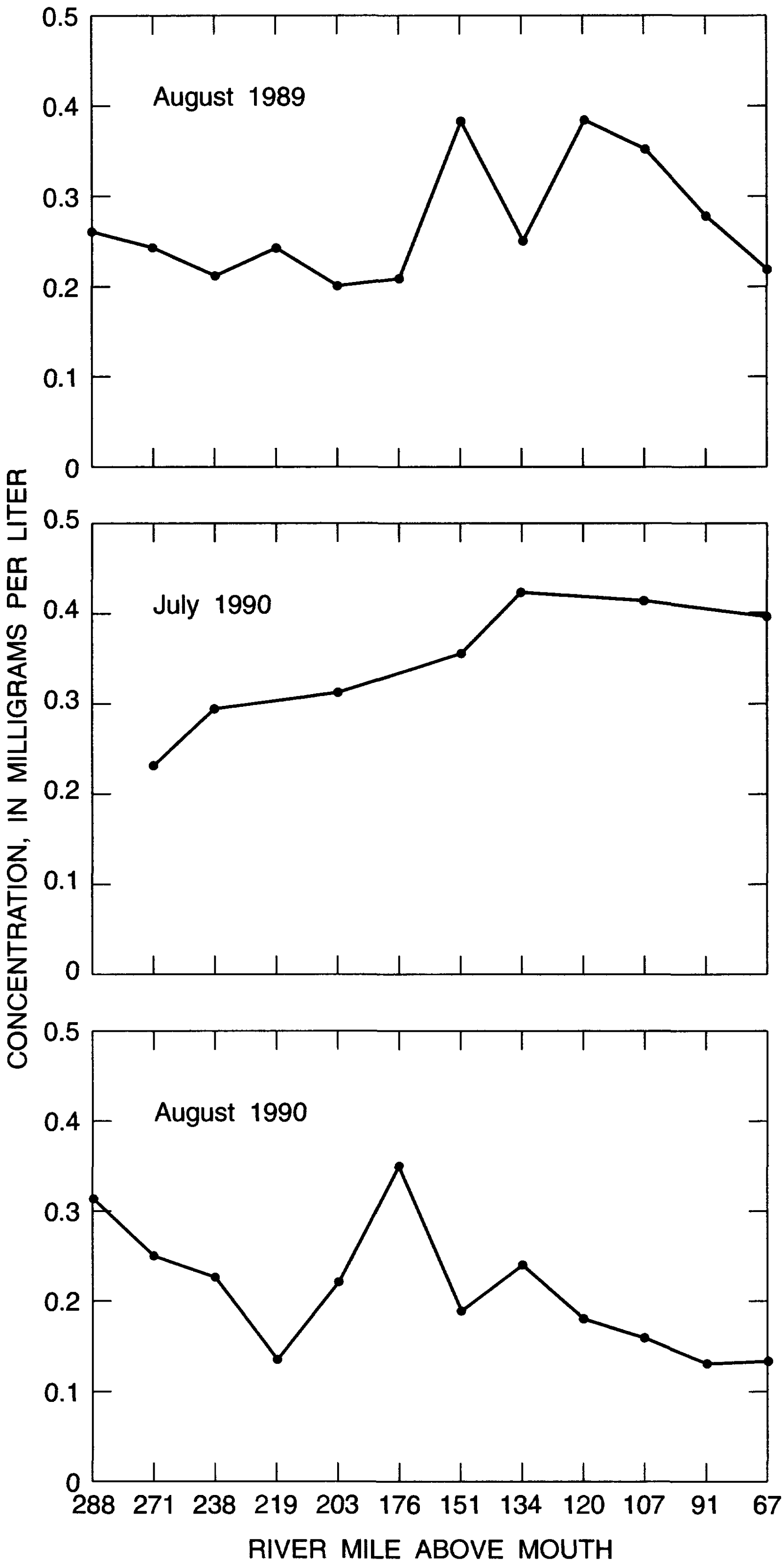

Figure 7.--Total phosphorus concentrations for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

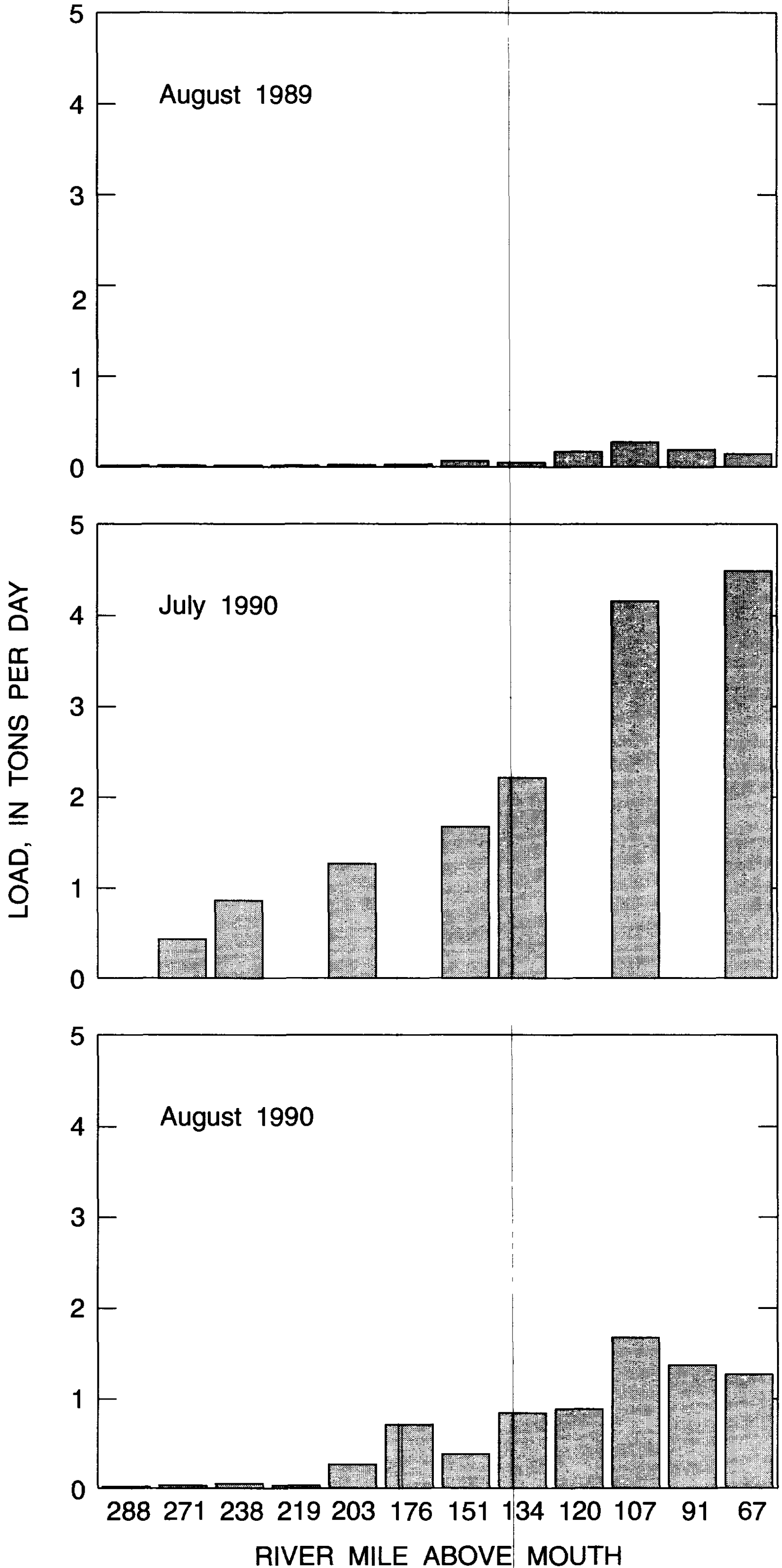

Figure 8.-- Total phosphorus loads for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

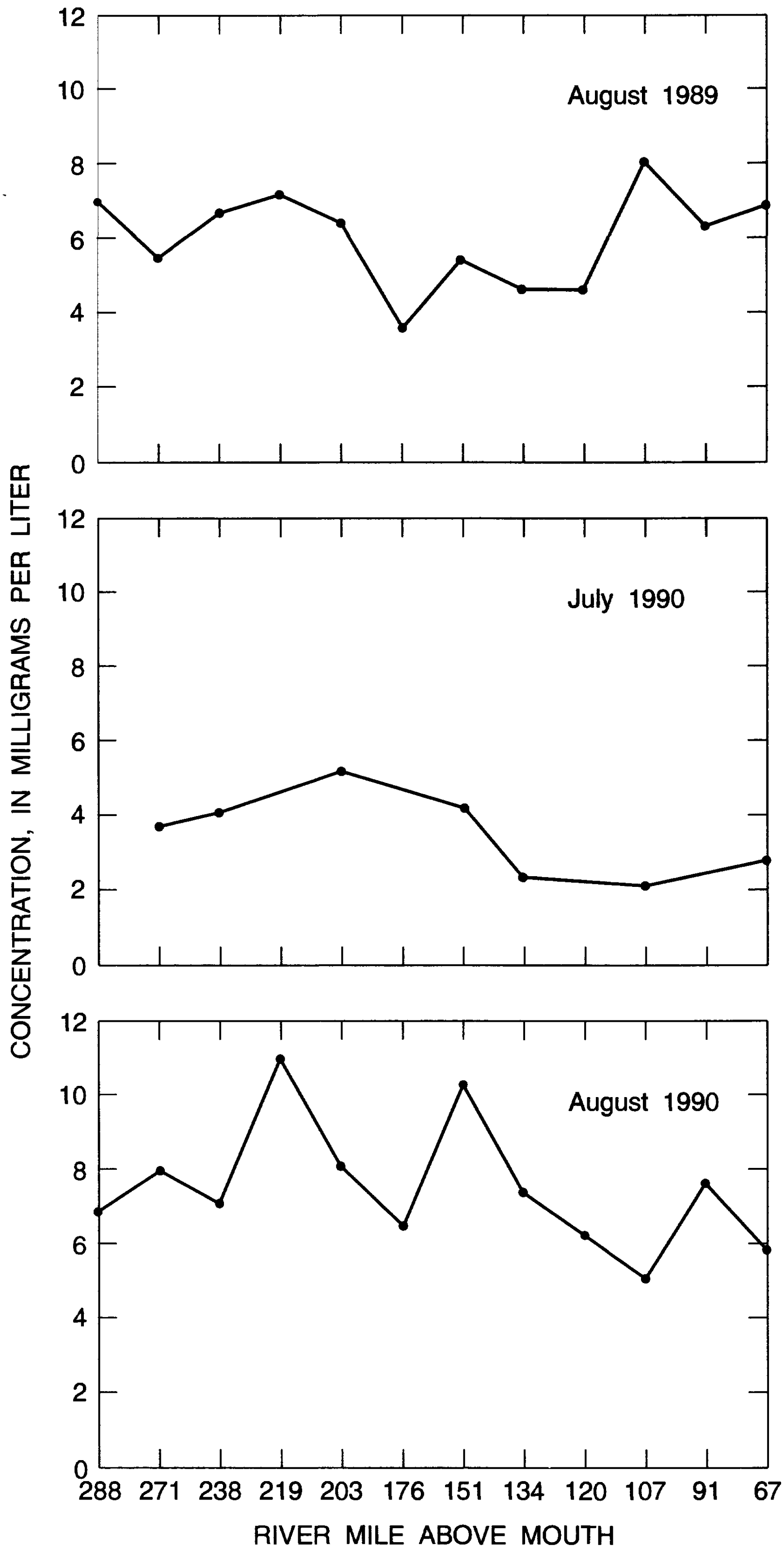

Figure 9.--Biochemical oxygen demand concentrations for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

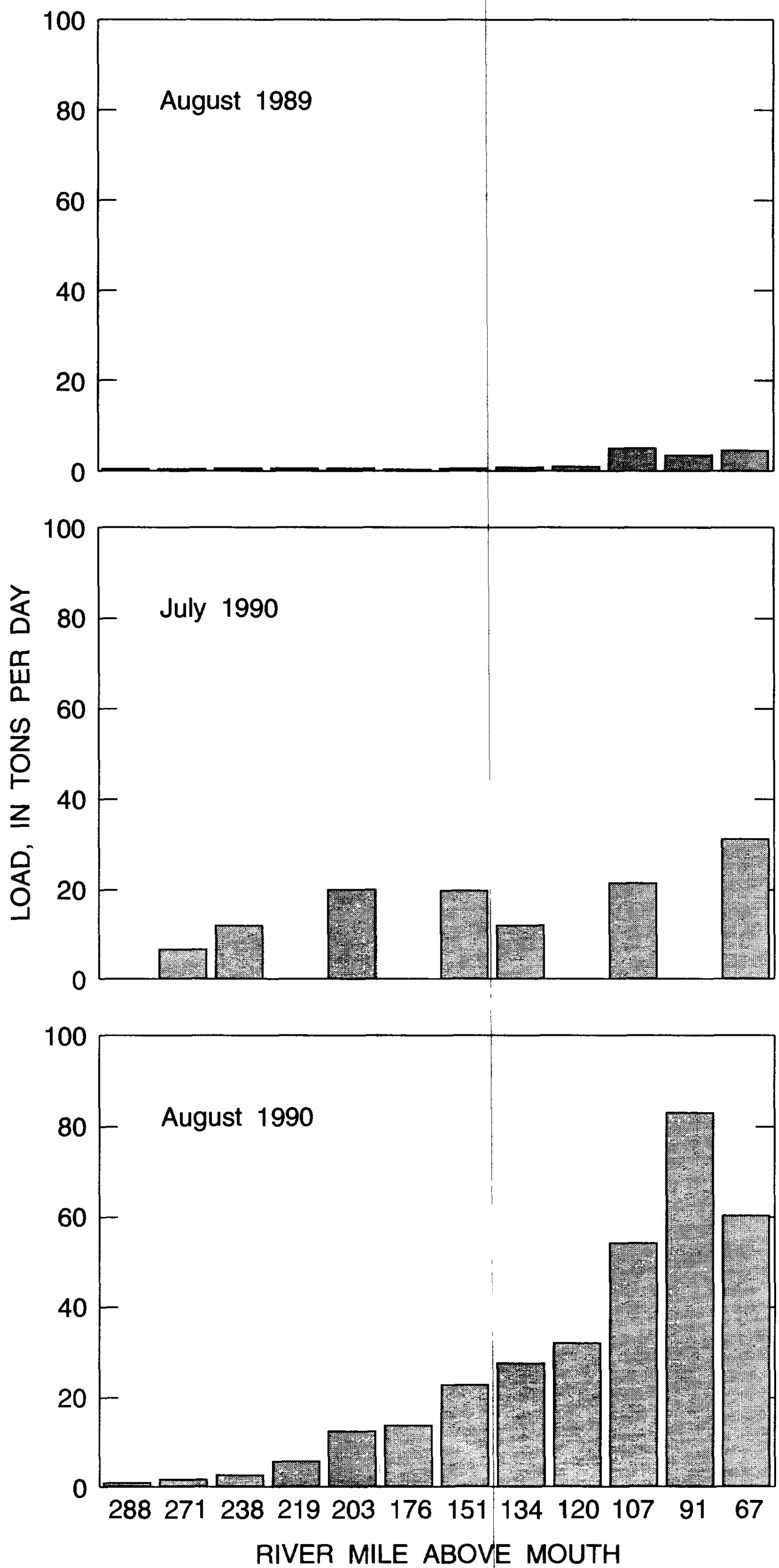

Figure 10.--Biochemical oxygen demand loads for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

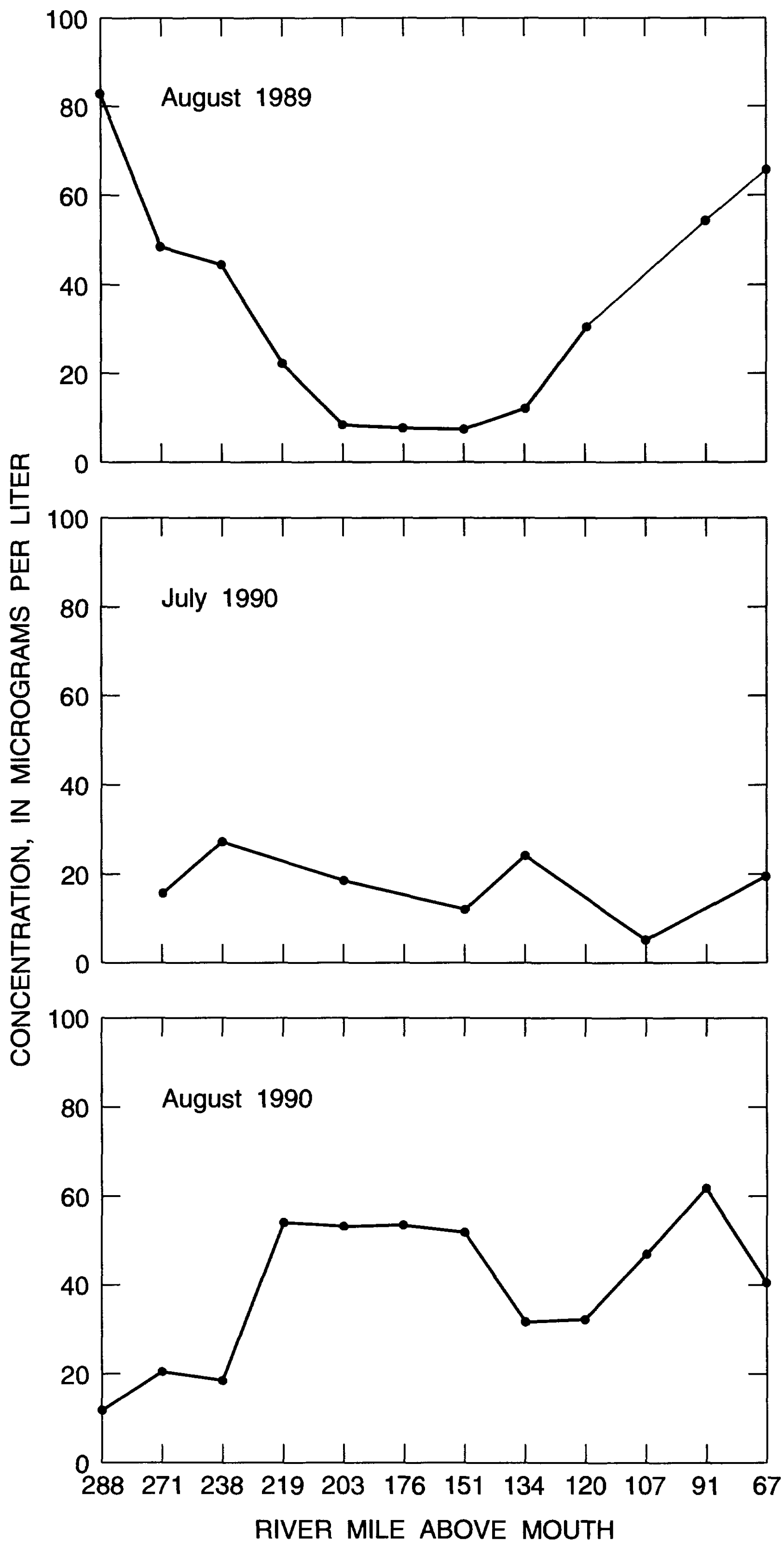

Figure 11.--Chlorophyll *a* concentrations for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

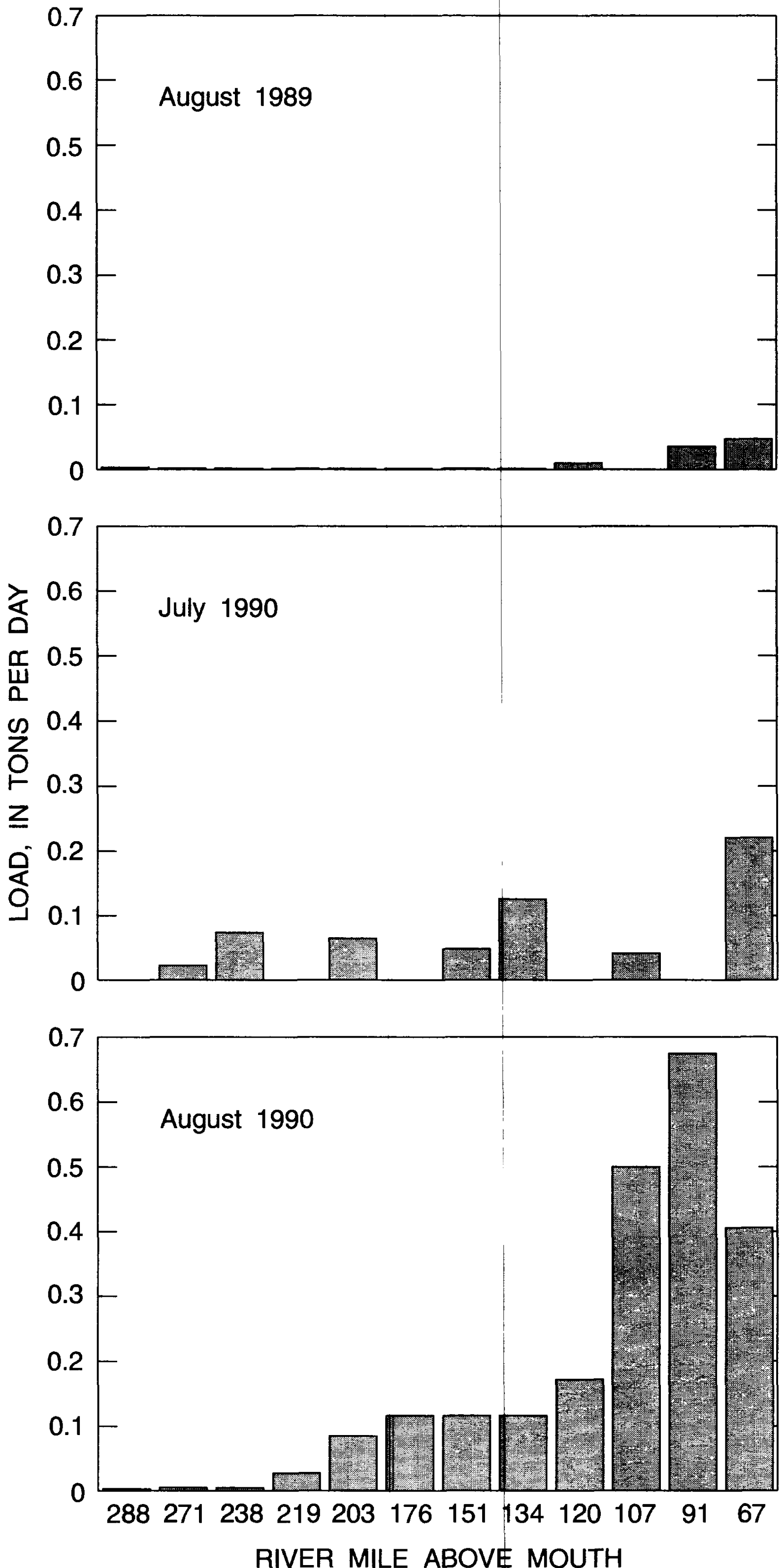

Figure 12.--Chlorophyll *a* loads for Minnesota River mainstem water-quality sampling sites, August 1989, July 1990, and August 1990.

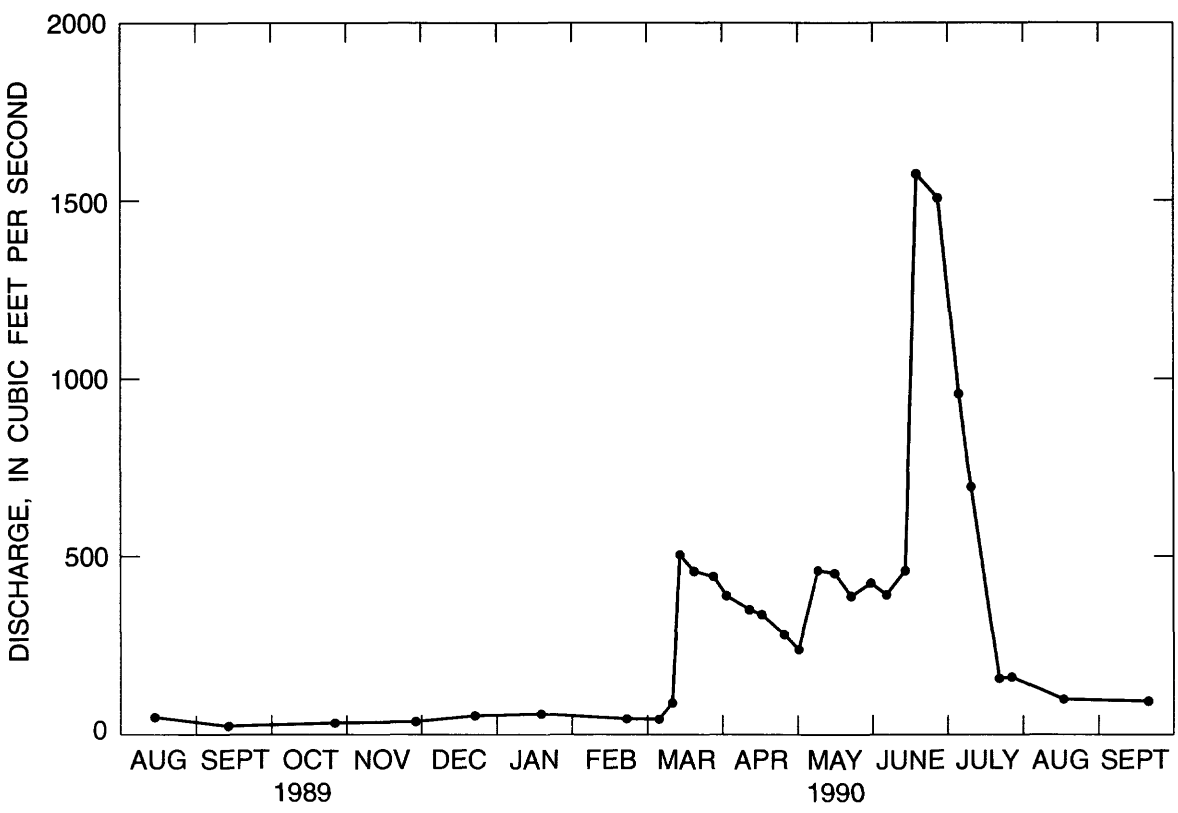

Figure 13.--Instantaneous discharge for Minnesota River at Montevideo, Minnesota.

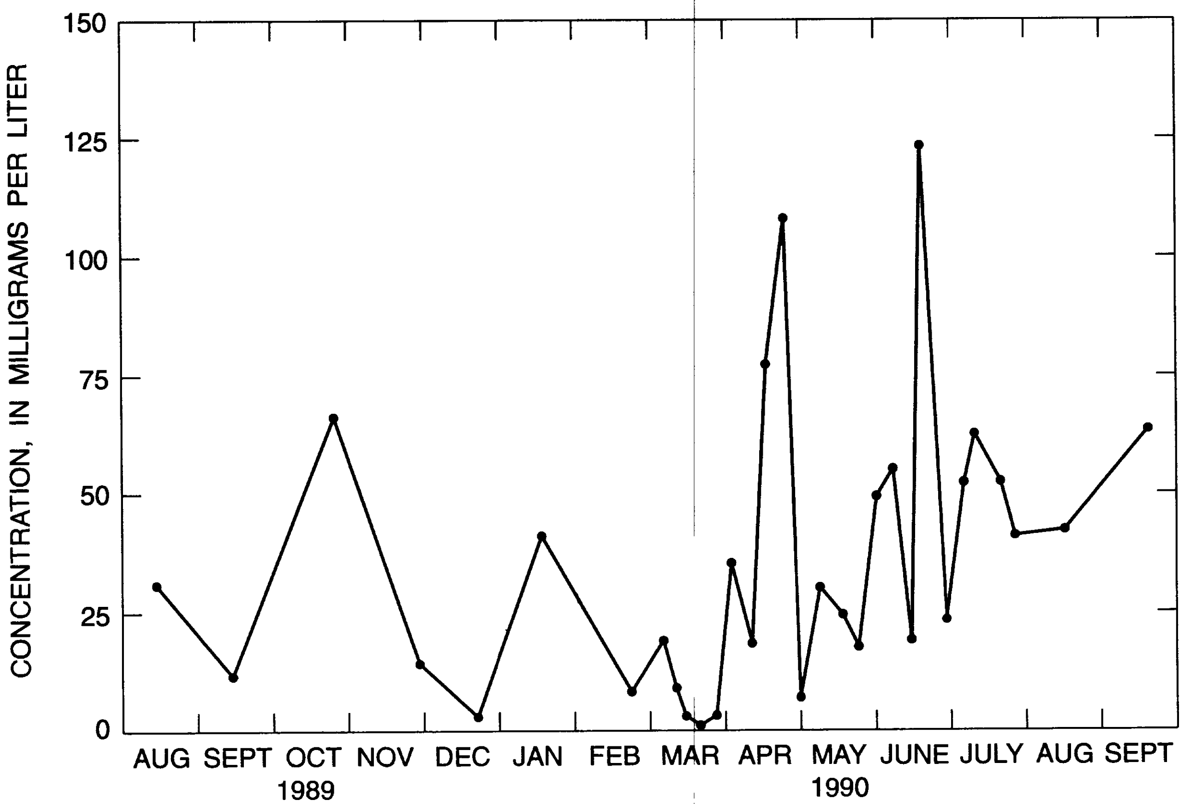

Figure 14.--Total suspended solids concentrations for Minnesota River at Montevideo, Minnesota.

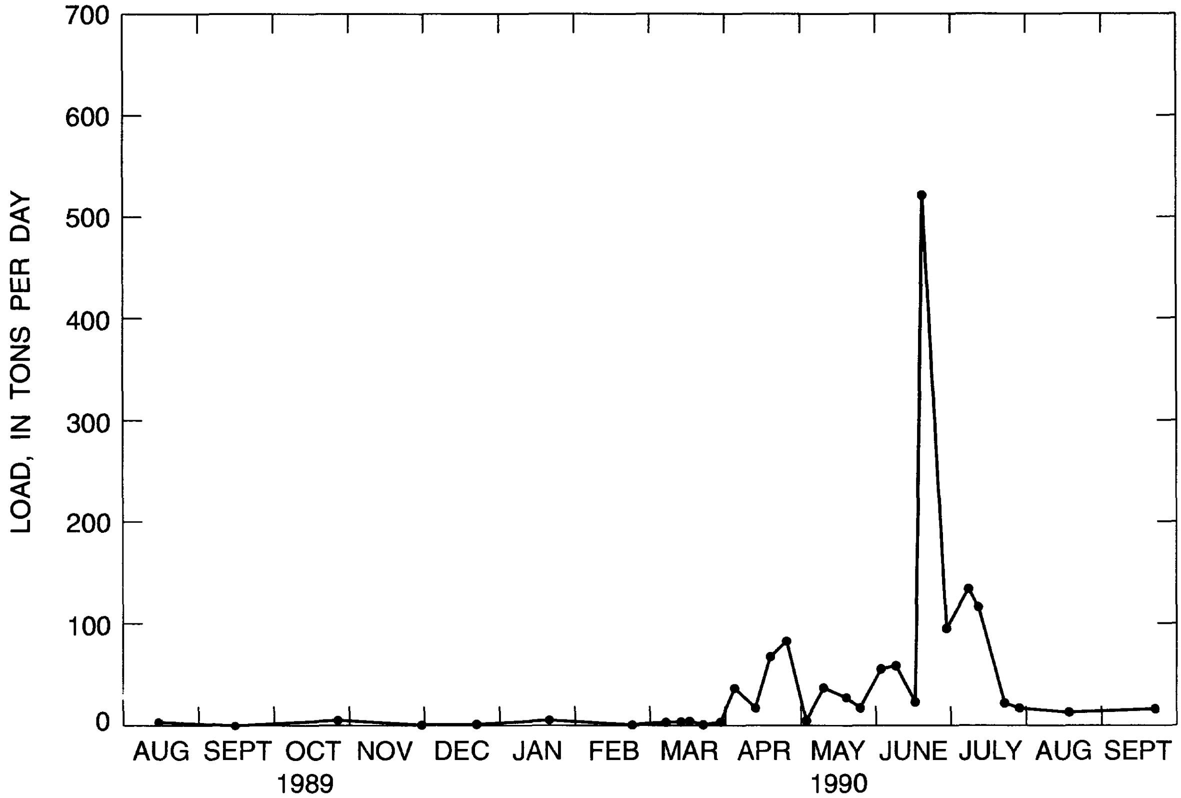

Figure 15.--Total suspended solids loads for Minnesota River at Montevideo, Minnesota.

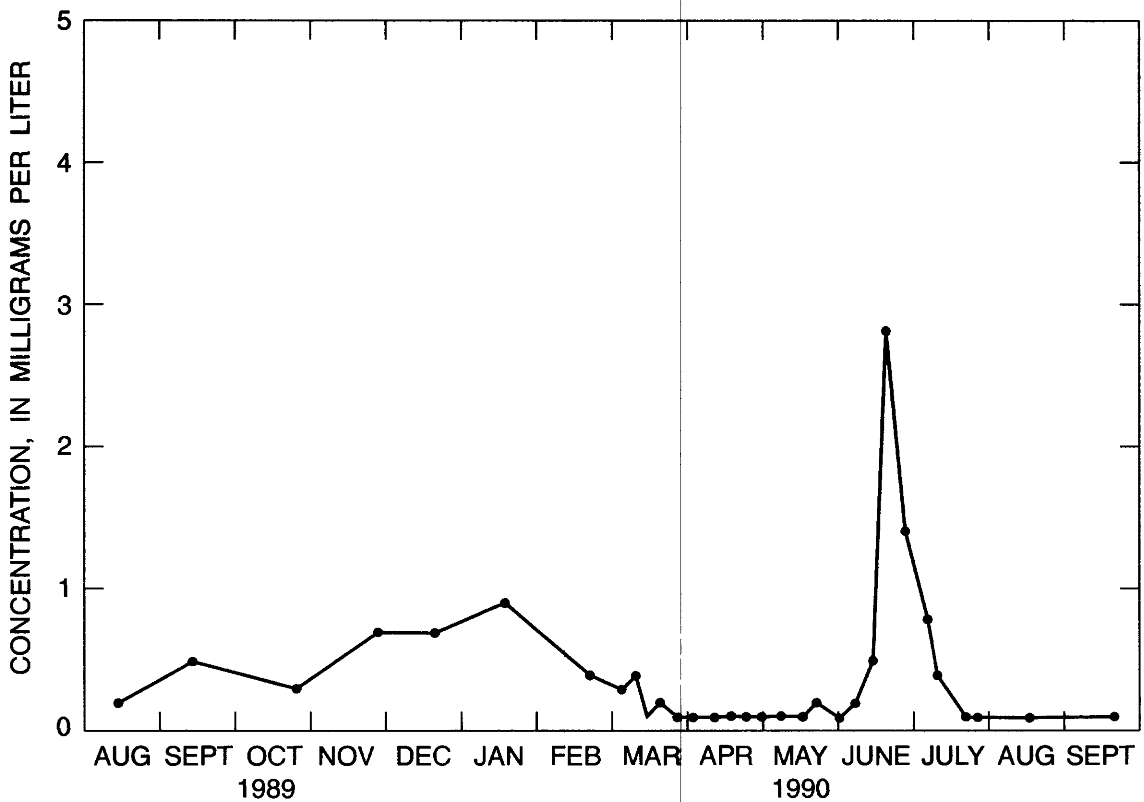

Figure 16.--Total nitrite plus nitrate nitrogen concentrations for Minnesota River at Montevideo, Minnesota.

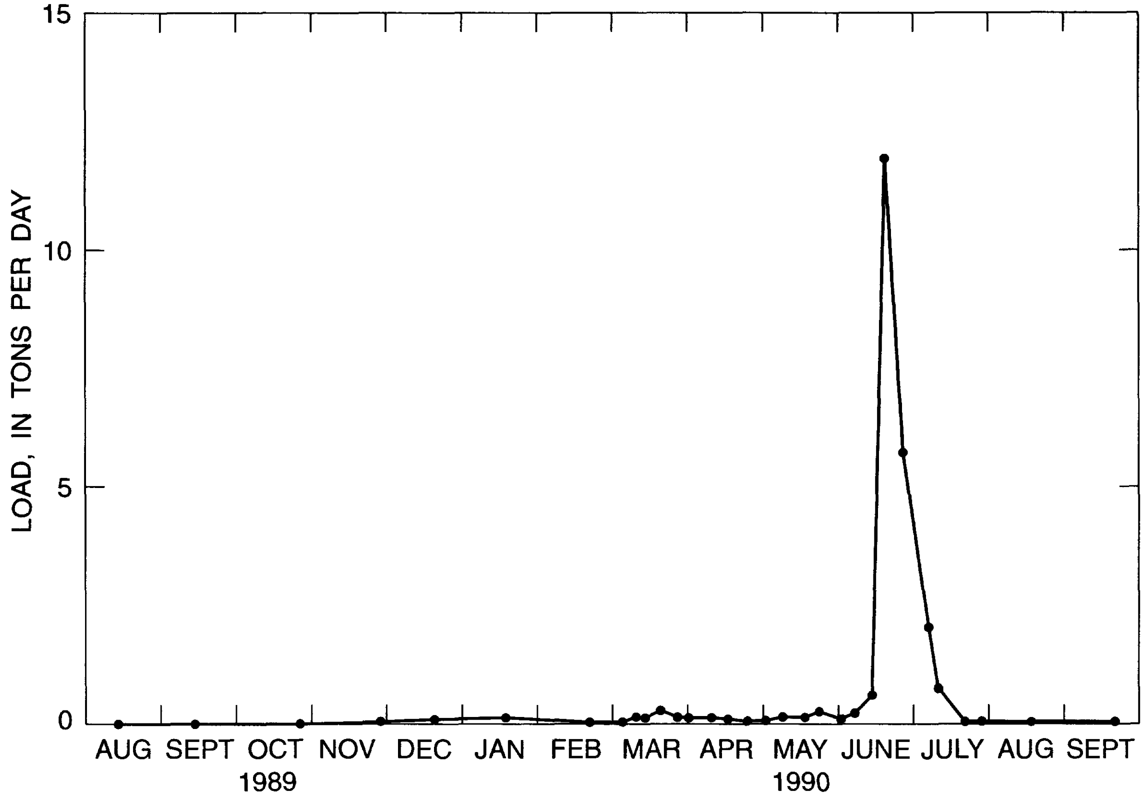

Figure 17.--Total nitrite plus nitrate nitrogen loads for Minnesota River at Montevideo, Minnesota.

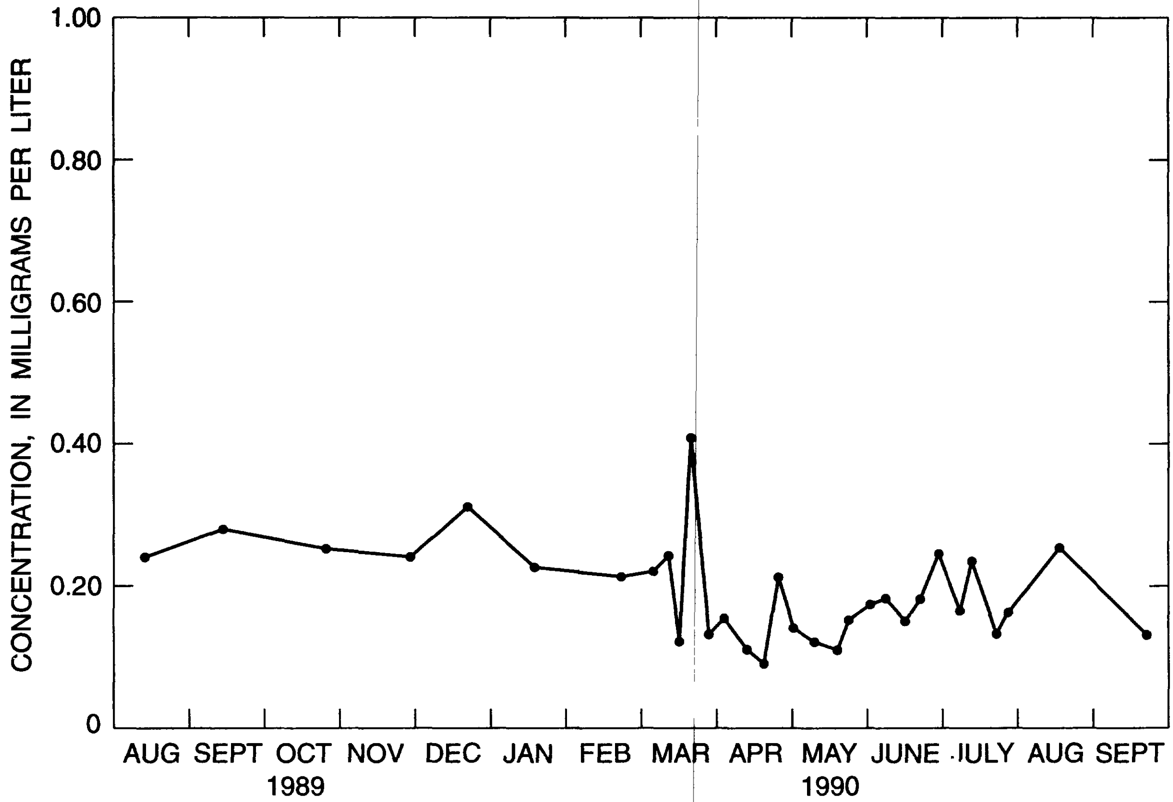

Figure 18.--Total phosphorus concentrations for Minnesota River at Montevideo, Minnesota.

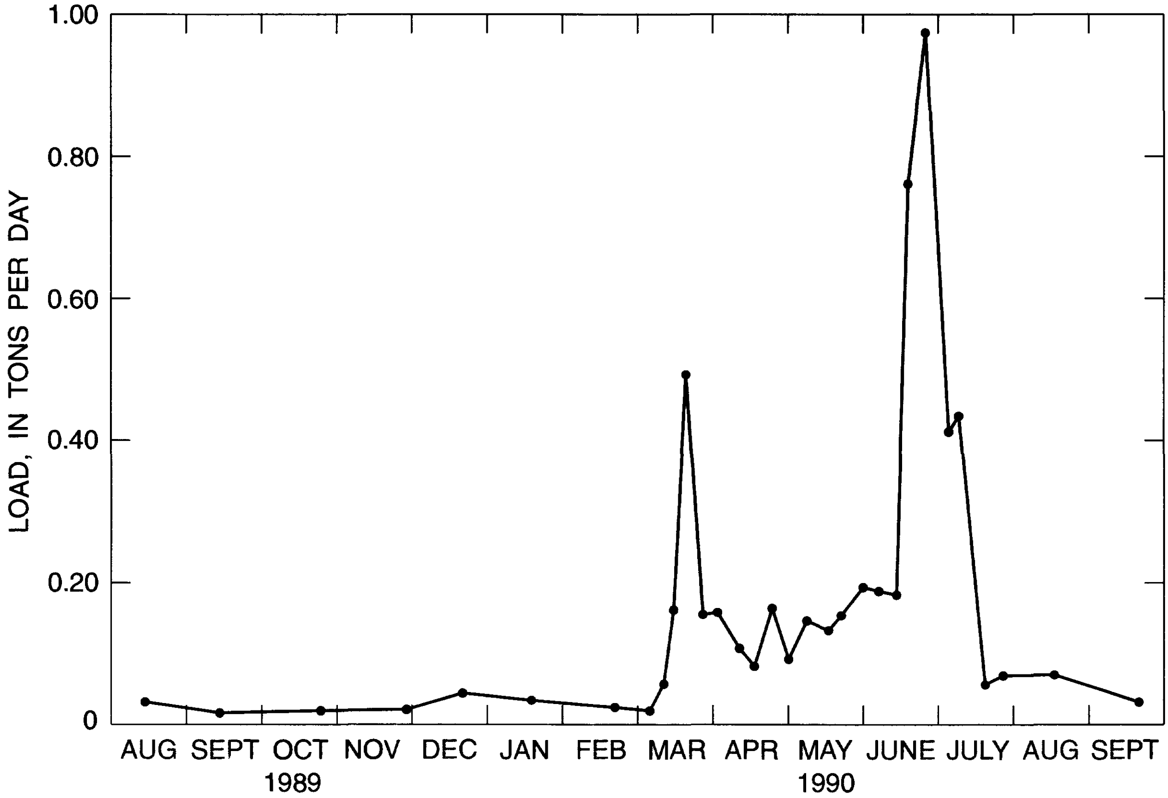

Figure 19.--Total phosphorus loads for Minnesota River at Montevideo, Minnesota.

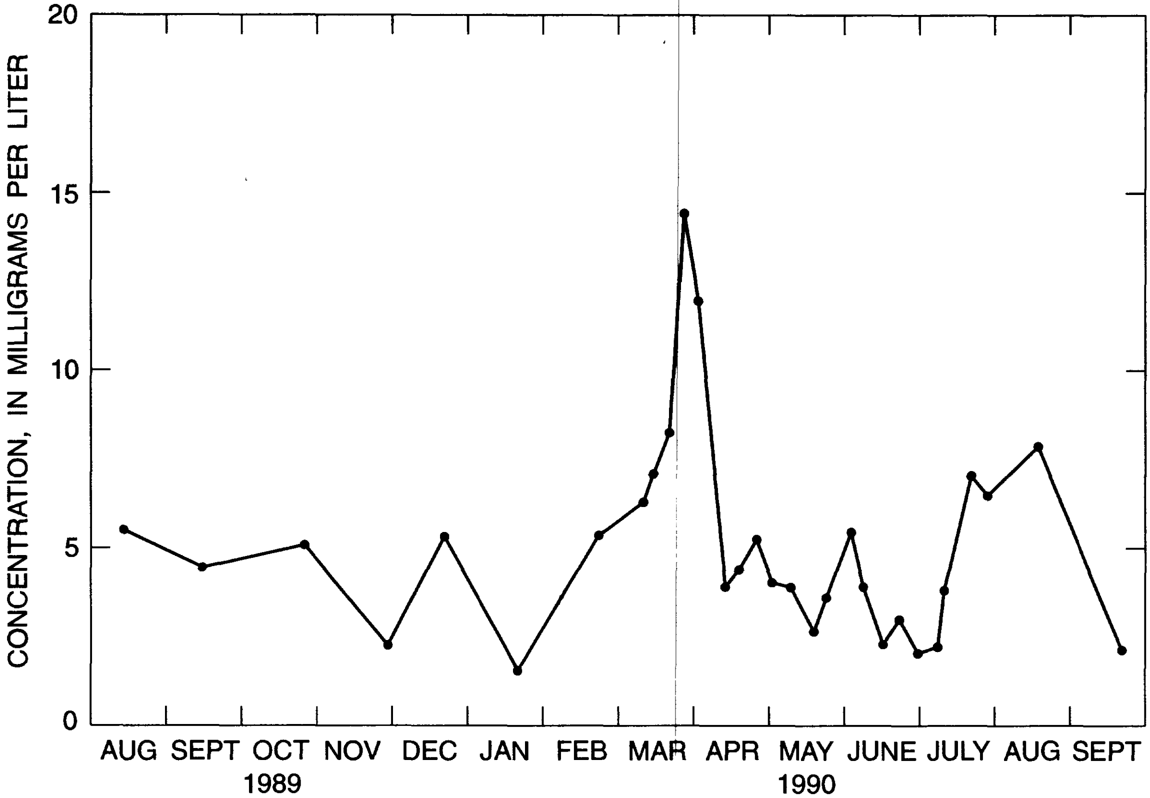

Figure 20.--Biochemical oxygen demand concentrations for Minnesota River at Montevideo, Minnesota.

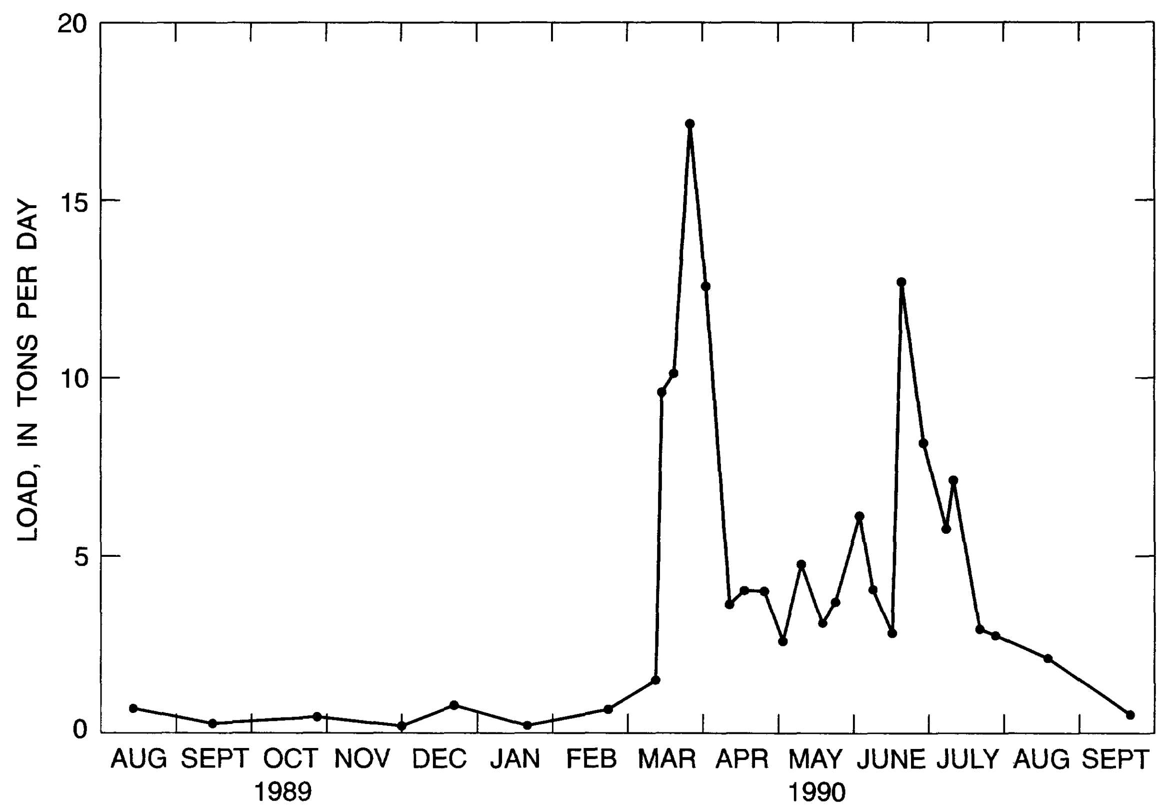

Figure 21.--Biochemical oxygen demand loads for Minnesota River at Montevideo, Minnesota.

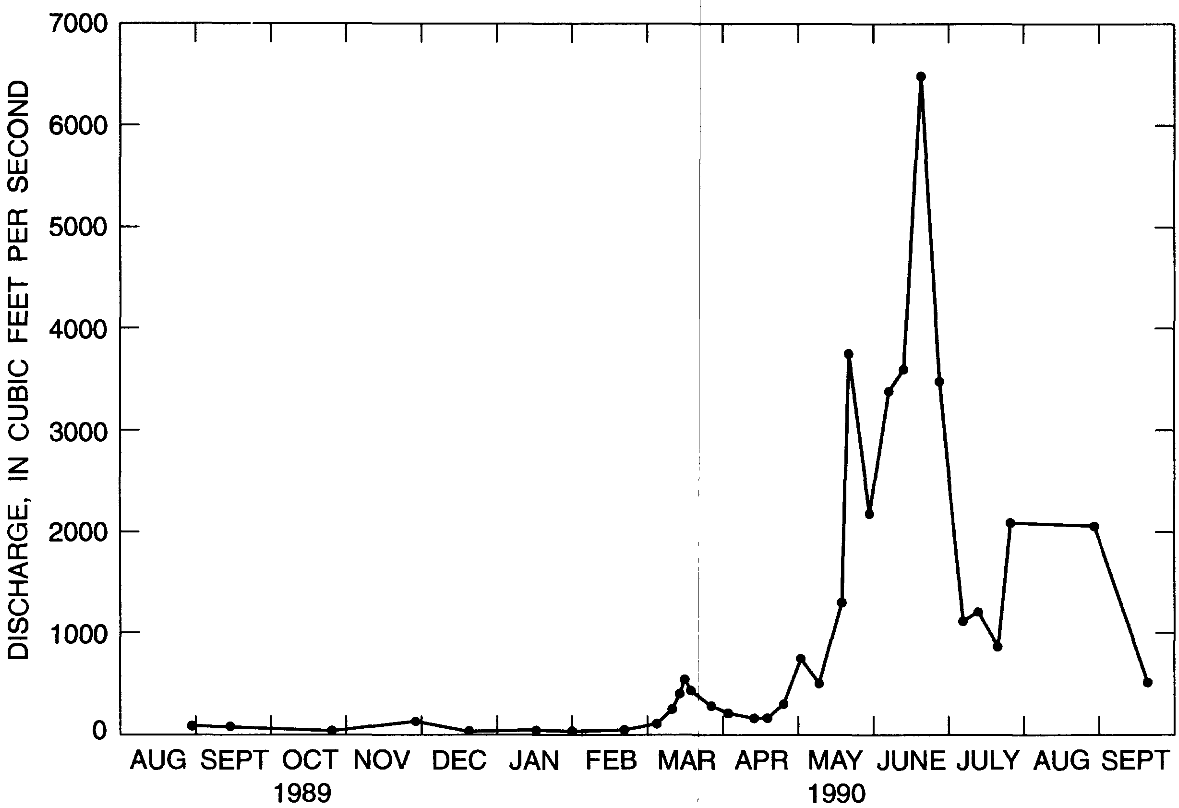

Figure 22.--Instantaneous discharge data for Blue Earth River at Mankato, Minnesota.

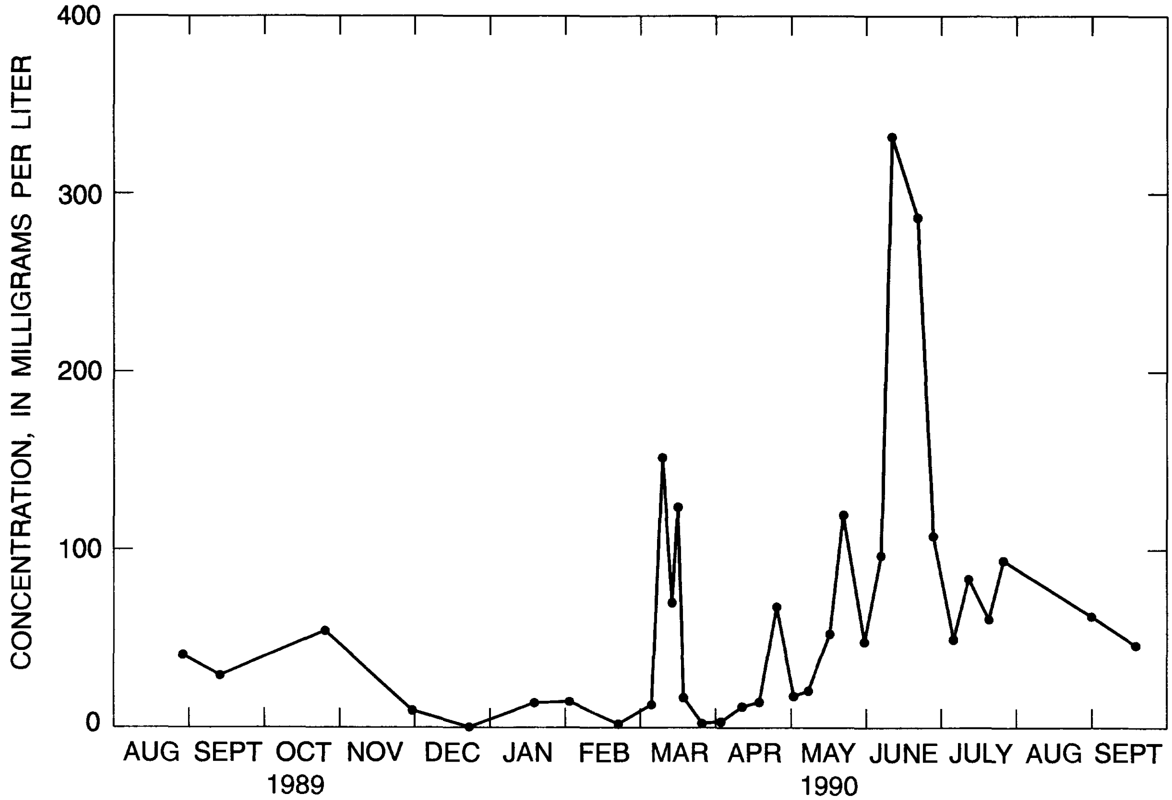

Figure 23.--Total suspended solids concentrations for Blue Earth River at Mankato, Minnesota.

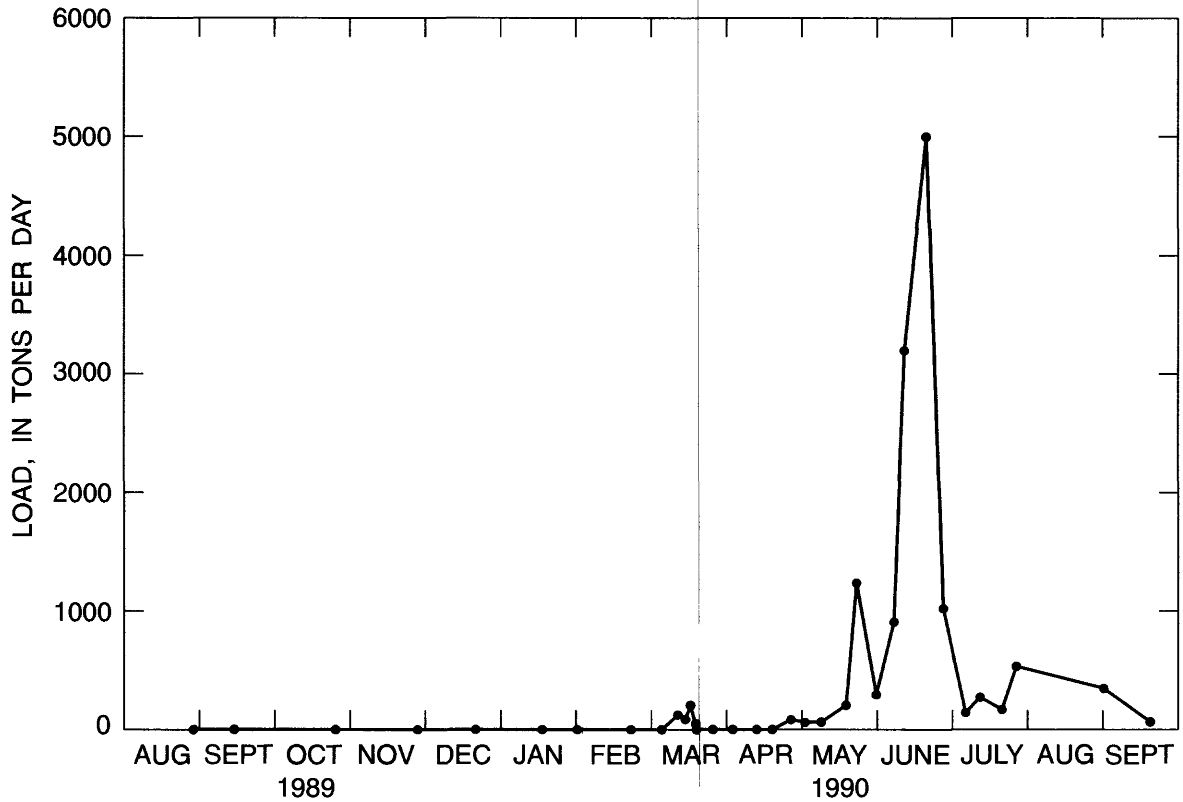

Figure 24.--Total suspended solids loads for Blue Earth River at Mankato, Minnesota.

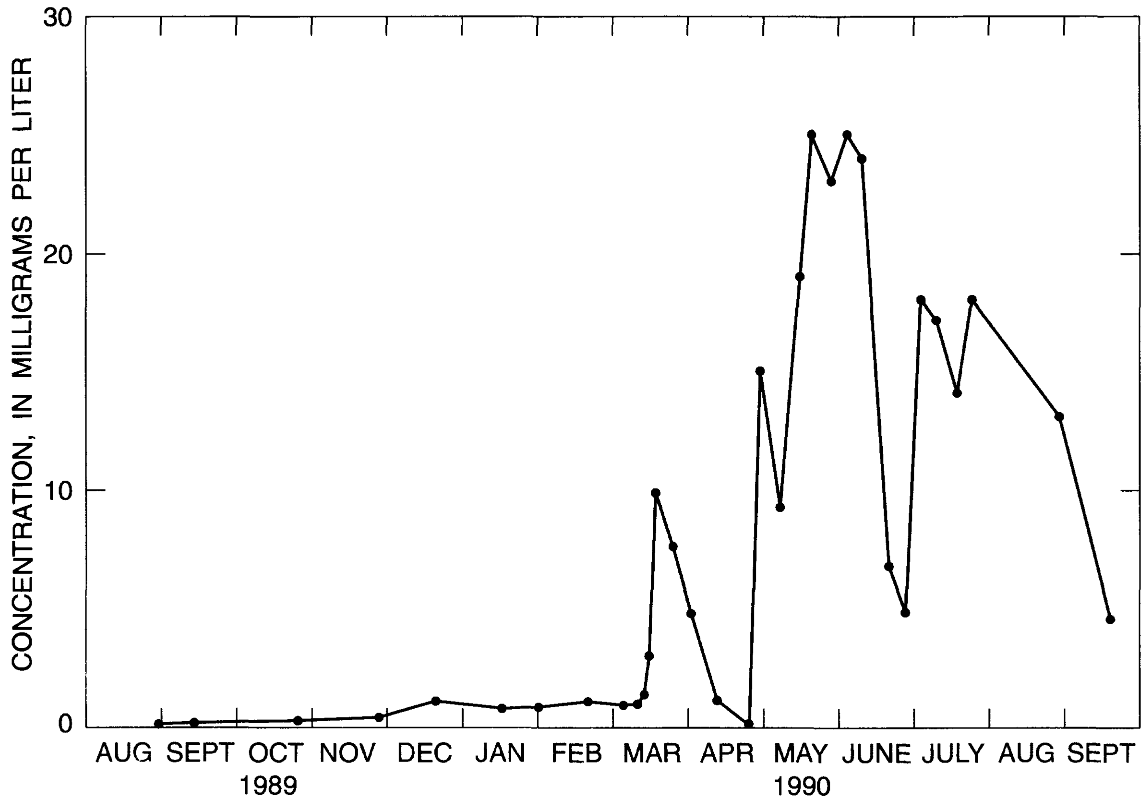

Figure 25.--Total nitrite plus nitrate nitrogen concentrations for Blue Earth River at Mankato, Minnesota.

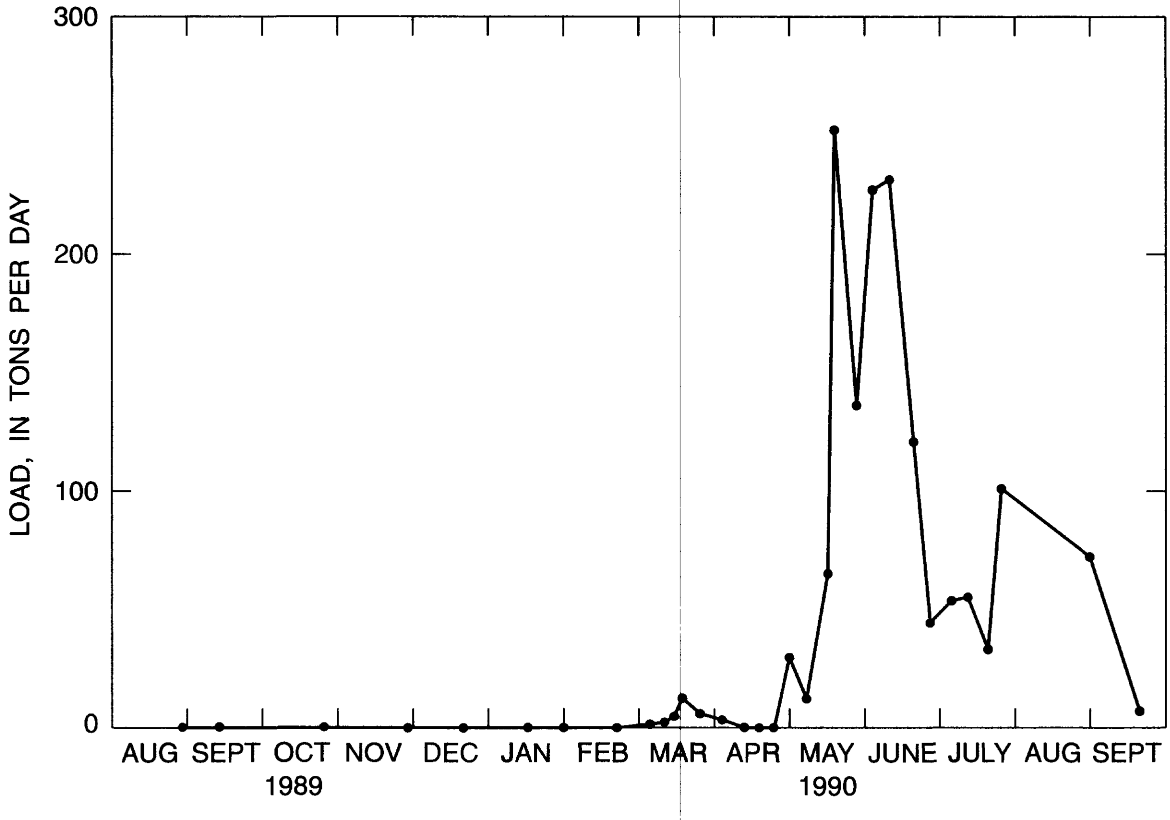

Figure 26.--Total nitrite plus nitrate nitrogen loads for Blue Earth River at Mankato, Minnesota.

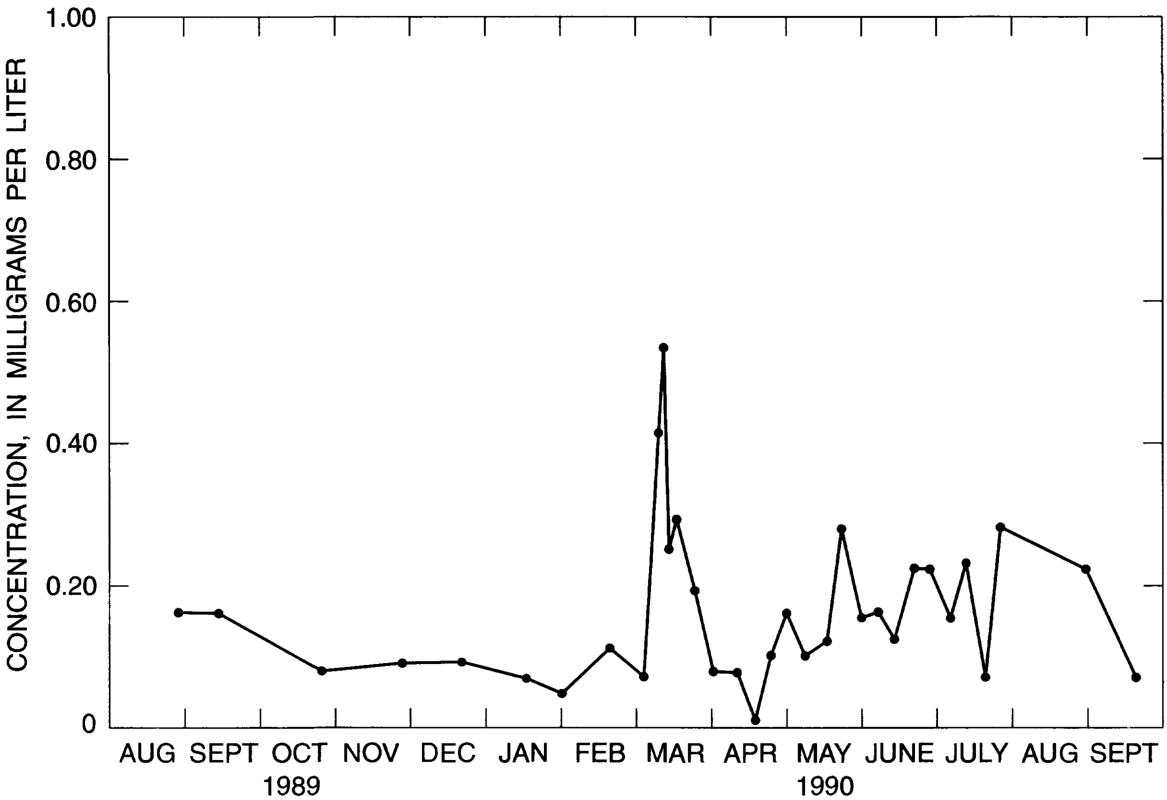

Figure 27.--Total phosphorus concentrations for Blue Earth River at Mankato, Minnesota.

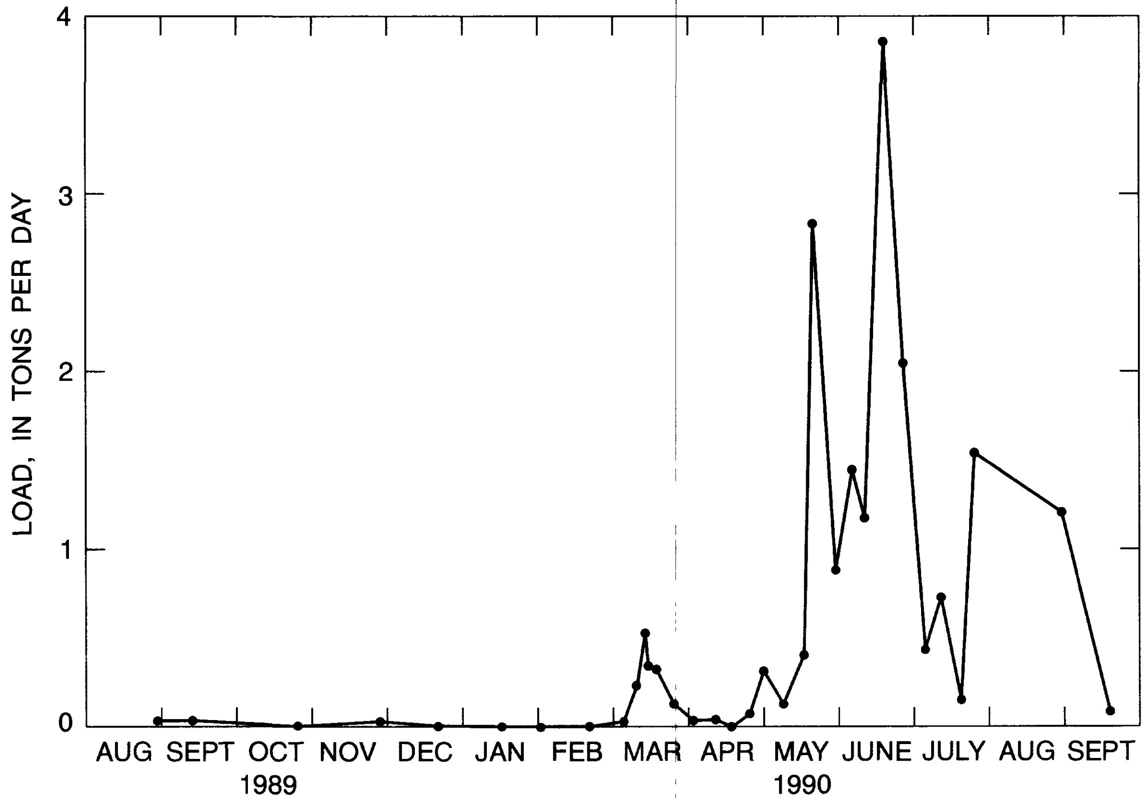

Figure 28.--Total phosphorus loads for Blue Earth River at Mankato, Minnesota.

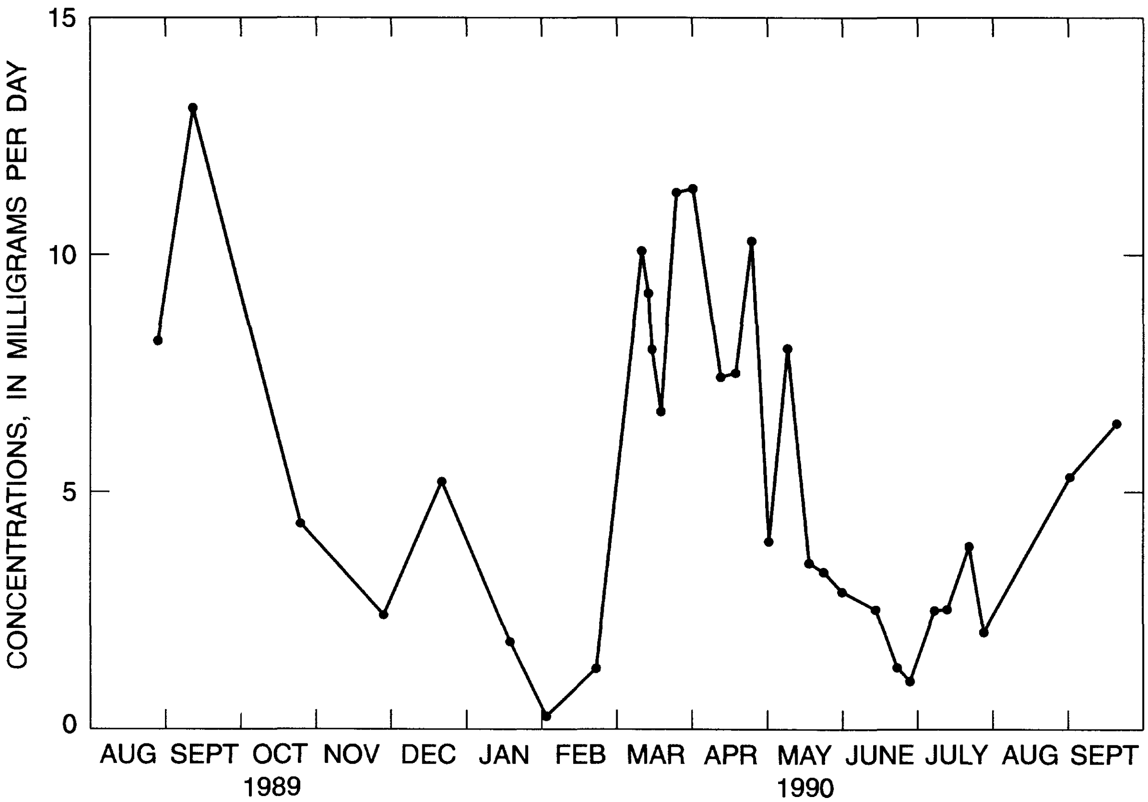

Figure 29.--Biochemical oxygen demand concentrations for Blue Earth River at Mankato, Minnesota.

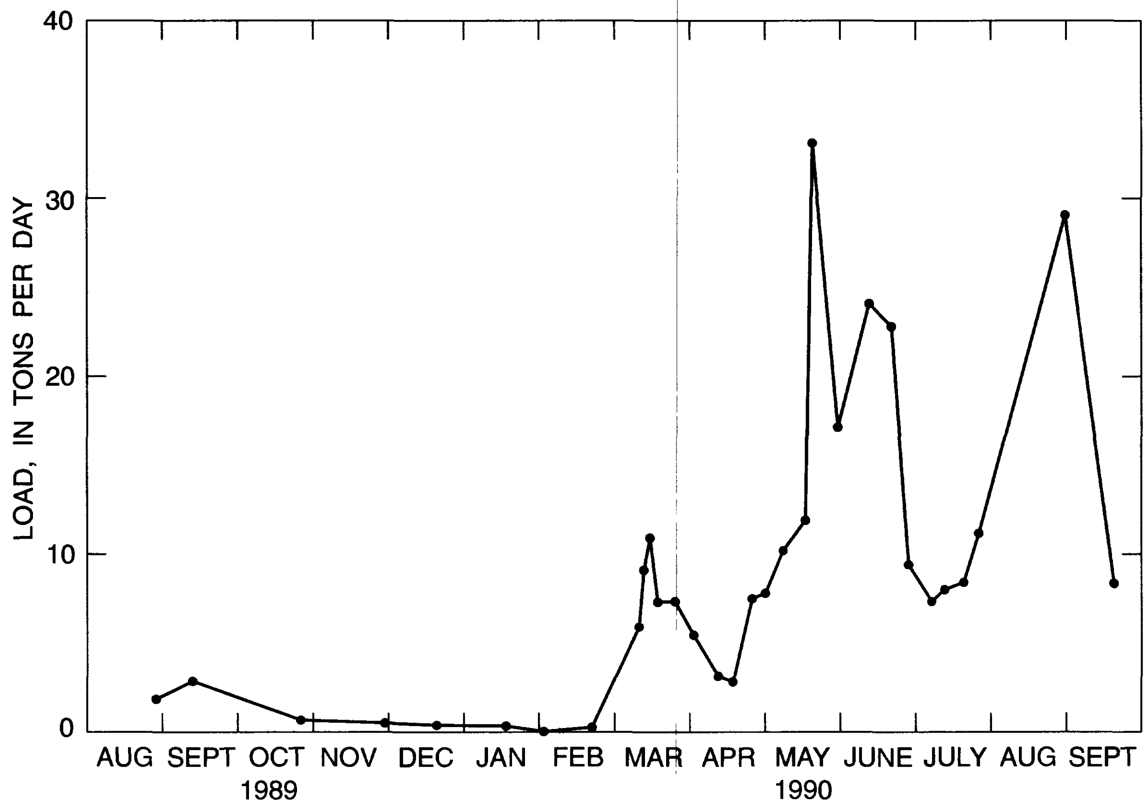

Figure 30.--Biochemical oxygen demand loads for Blue Earth River at Mankato, Minnesota.

Table 1.--*Physical characteristics, chemical constituents, and biological characteristics determined at sampling sites in the Minnesota River Assessment Project study area*

[x, sample collected; -, sample not collected]

	Streams	Springs	Bottom material
	Physical characteristics		
Streamflow	x	-	-
Specific conductance	x	x	-
pH	x	x	-
Water temperature	x	x	-
Dissolved oxygen	x	x	-
Biochemical oxygen demand	x	-	-
Suspended-sediment concentration	x	-	-
Suspended-sediment particle size	x	-	-
Bottom-material particle size	-	-	x
	Chemical constituents		
Total suspended solids	x	-	-
Volatile suspended solids	x	-	-
Nitrite plus nitrate nitrogen, total	x	-	x
Nitrite plus nitrate nitrogen, dissolved	x	x	-
Ammonia nitrogen, total	x	-	x
Ammonia nitrogen, dissolved	x	x	-
Ammonia plus organic nitrogen, total	x	-	x
Ammonia plus organic nitrogen, dissolved	x	x	-
Phosphorus, total	x	-	x
Phosphorus, dissolved	x	x	-
Orthophosphate, total	x	-	-
Orthophosphate, dissolved	x	x	-
Organic carbon, total	-	-	x
Organic carbon, dissolved	x	x	-
Organic carbon, suspended	x	-	-
Chemical oxygen demand	x	-	-
Triazine herbicides	x	x	-
Chlorophenoxy acid herbicides	x	x	-
Organophosphorus insecticides	x	x	x
Carbamate insecticides	x	x	-
Organochlorine compounds, PCB, and PCN	-	-	x
	Biological characteristics		
Fecal coliform bacteria	x	-	-
Fecal *Streptococcus* bacteria	x	-	-
Chlorophyll *a*	x	-	-

Table 2.--*Sampling sites on Minnesota River and Tributaries*

Site number	River mile	Site name
		<u>Sites on Minnesota River mainstem</u>
M-1	288	Minnesota River near Lac qui Parle
M-2	271	Minnesota River at Montevideo
M-3	238	Minnesota River near Sacred Heart
M-4	219	Minnesota River near Delhi
M-5	203	Minnesota River at Morton
M-6	176	Minnesota River near Fairfax
M-7	151	Minnesota River near New Ulm
M-8	134	Minnesota River near Courtland
M-9	120	Minnesota River at Judson
M-10	107	Minnesota River at Mankato
M-11	91	Minnesota River at St. Peter
M-12	67	Minnesota River at Henderson
		<u>Sites on tributary streams</u>
T-1		Chippewa River at Montevideo
T-2		Yellow Medicine River near Granite Falls
T-3		Hawk Creek near Sacred Heart
T-4		Redwood River at Redwood Falls
T-5		Cottonwood River at New Ulm
T-6		Watonwan River near Garden City
T-7		Le Sueur River near Rapidan
T-8		Blue Earth River at Mankato
T-9		Rush River near Henderson
T-10		High Island Creek near Henderson

Table 3.--*Streamflow and water-quality data for runoff periods on tributary streams*

[FLOW, instantaneous streamflow in cubic feet per second; TSS, total suspended solids concentration; TSSLD, total suspended solids load; TP, total phosphorus concentration; TPLD, total phosphorus load; NN, nitrite plus nitrate nitrogen concentration; NNLD, nitrite plus nitrate nitrogen load; BOD, biochemical oxygen demand concentration; BODLD, biochemical oxygen demand load; concentration values are in milligrams per liter, load values are in tons per day]

Stream	DATE	FLOW	TSS	TSSLD	TP	TPLD	NN	NNLD	BOD	BODLD
	1990									
Yellow Medicine River	6-19	1040	248	696	0.21	0.59	5.3	15	3.1	8.5
Hawk Creek	6-19	5050	295	4020	.37	5.0	4.3	59	2.2	30
Redwood River	6-20	1030	183	509	.18	.50	7.0	20	3.5	9.7
	7-26	605	201	328	.26	.42	3.2	5.2	5.0	8.2
Cottonwood River	6-05	316	27	23	.14	.12	5.9	5.0	2.5	2.1
	6-13	211	76	43	.15	.08	13	7.4	4.3	2.4
	6-21	1500	225	910	.14	.57	12	49	2.6	10
Watonwan River	5-31	279	1	<1	.16	.12	19	14	2.3	1.7
Le Sueur River	5-31	647	44	77	.17	.30	28	49	1.6	2.8
Rush River	6-13	180	1620	790	.72	.34	12	5.8	3.9	1.9
	6-14	234	72	46	.28	.18	28	18	2.6	1.6
High Island Creek	6-12	192	117	61	.17	.09	15	7.8	3.0	1.6
	6-13	229	395	244	.40	.25	14	8.7	3.1	1.9