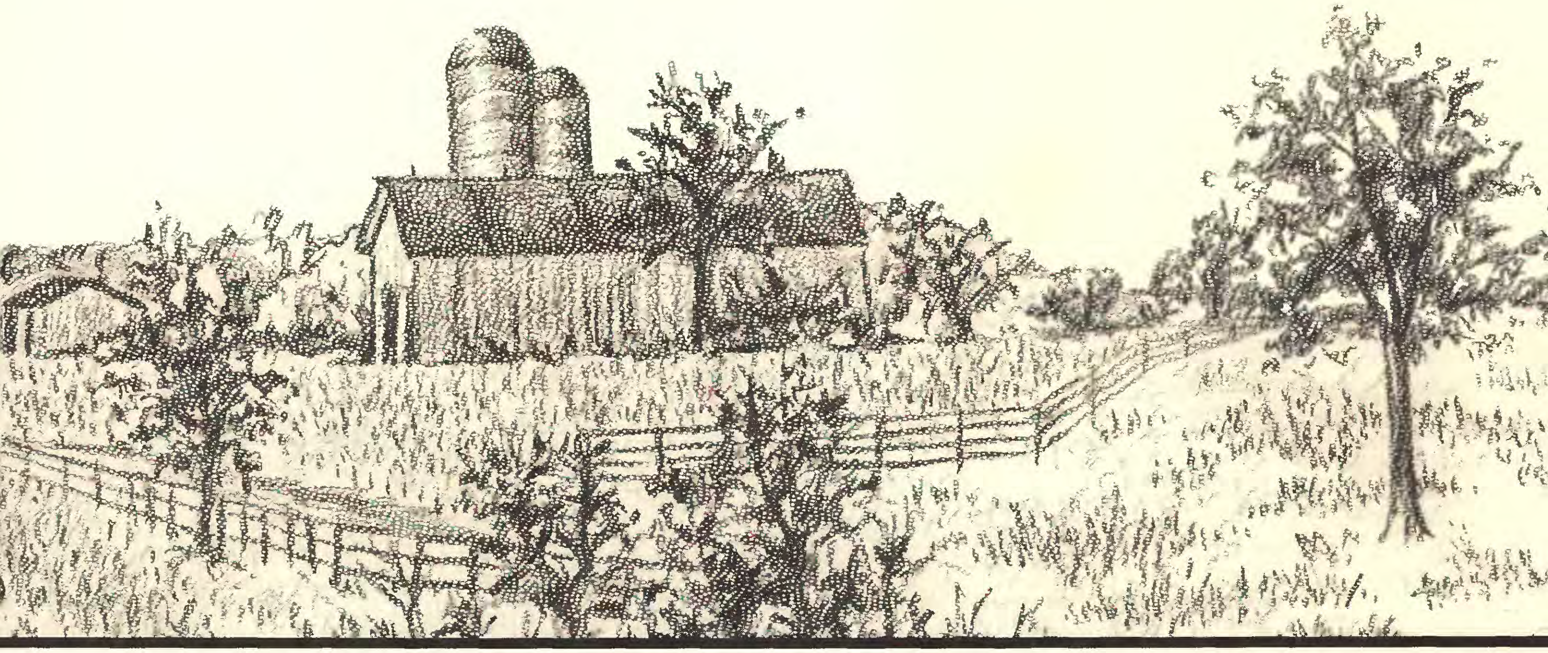
U.S. GEOLOGICAL SURVEY
Open-File Report 96-661A

EVALUATION OF NONPOINT-SOURCE CONTAMINATION, WISCONSIN: FOR WATER YEAR 1995



Prepared in cooperation with the
WISCONSIN DEPARTMENT OF NATURAL RESOURCES

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By D.W. Owens, S.R. Corsi, and K.F. Rappold

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1997

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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To Obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
acre	0.4048	hectare
square mile (mi^2)	2.590	square kilometer
million cubic feet (Mft^3)	0.02832	million cubic meters
pound (lb)	453.6	gram
pounds per square mile (lb/mi^2)	0.17573	kilograms per square kilometer (kg/km^2)
ton (short)	0.9072	megagram (mg)

Abbreviated water-quality units used in this report: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million. Other units of measurement used in this report are microsiemens per centimeter at 25°Celsius (µS/cm), micrometers (µm), and bacteria colonies per 100 milliliters of water sample (col./100 mL).

EVALUATION OF NONPOINT-SOURCE CONTAMINATION, WISCONSIN: SELECTED TOPICS FOR WATER YEAR 1995

By D.W. Owens, S.R. Corsi, *and* K.F. Rappold

Abstract

The objective of the watershed-management evaluation monitoring program in Wisconsin is to evaluate the effectiveness of best-management practices (BMP's) for controlling nonpoint-source contamination in eight rural and four urban watersheds. This report, the fourth in an annual series of reports, presents a summary of the data collected for the program by the U.S. Geological Survey and the results of several detailed analyses of the data.

To complement assessments of water quality, a land-use and BMP inventory is ongoing for 12 evaluation monitoring projects to track nonpoint sources of contamination in each watershed and to document implementation of BMP's that were designed to cause changes in the water quality of streams. Each year, updated information is gathered, mapped, and stored in a geographic-information-system data base. Summaries of land-use, BMP implementation, and water-quality data collected during water years 1989–95 are presented.

Storm loads, snowmelt-period loads, and annual loads of suspended sediment and total phosphorus are summarized for eight rural sites. Storm-load data for suspended solids, total phosphorus, total recoverable lead, copper, zinc, and cadmium are summarized for four urban sites.

Quality-assurance and quality-control (QA/QC) samples were collected at the eight rural sites to evaluate inorganic sample contamination and at one urban site to evaluate sample-collection and filtration techniques for polycyclic aromatic hydrocarbons (PAH's). Some suspended solids and fecal coliform contamination was detected at the rural sites. Corrective actions will be taken to address this contamination. Evaluation of PAH sample-collection techniques did not uncover any deficiencies, but the small amount of data collected was not sufficient to draw any definite conclusions. Evaluation of PAH filtration techniques indicate that water-sample filtration with 0.7-µm glass-fiber filters in an aluminum filter unit does not result in significant loss of PAH.

INTRODUCTION

In October 1989, the U.S. Geological Survey (USGS) began a watershed-management evaluation monitoring program in cooperation with the Wisconsin Department of Natural Resources (WDNR). The overall objective of the 12 individual projects in the program (4 in urban areas and 8 in rural areas) is to determine whether the quality of water in a receiving stream has improved as a result of the implementation of land-management practices in the watershed. This determination is made through monitoring of water chemistry and ancillary variables before best-management practices (BMP's) are implemented, during BMP implementation, and after BMP's have been completely implemented. In this report, the period before BMP implementation is termed "pre-BMP," the period during active implementation is termed "transitional," and the period after complete implementation is termed "post-BMP."

The county Land Conservation Departments (LCD's) and the WDNR have identified nonpoint sources of contamination in the eight rural watersheds. This information was used to select sites that are eligible for partial funding of BMP implementation. The LCD's are in the process of contacting landowners to request that they implement the appropriate BMP's for streamwater-quality improvement. This BMP implementation is voluntary and, therefore, may result in varied success, depending largely on the amount of land treated, and also on the effectiveness of implemented BMP's in improving water quality.

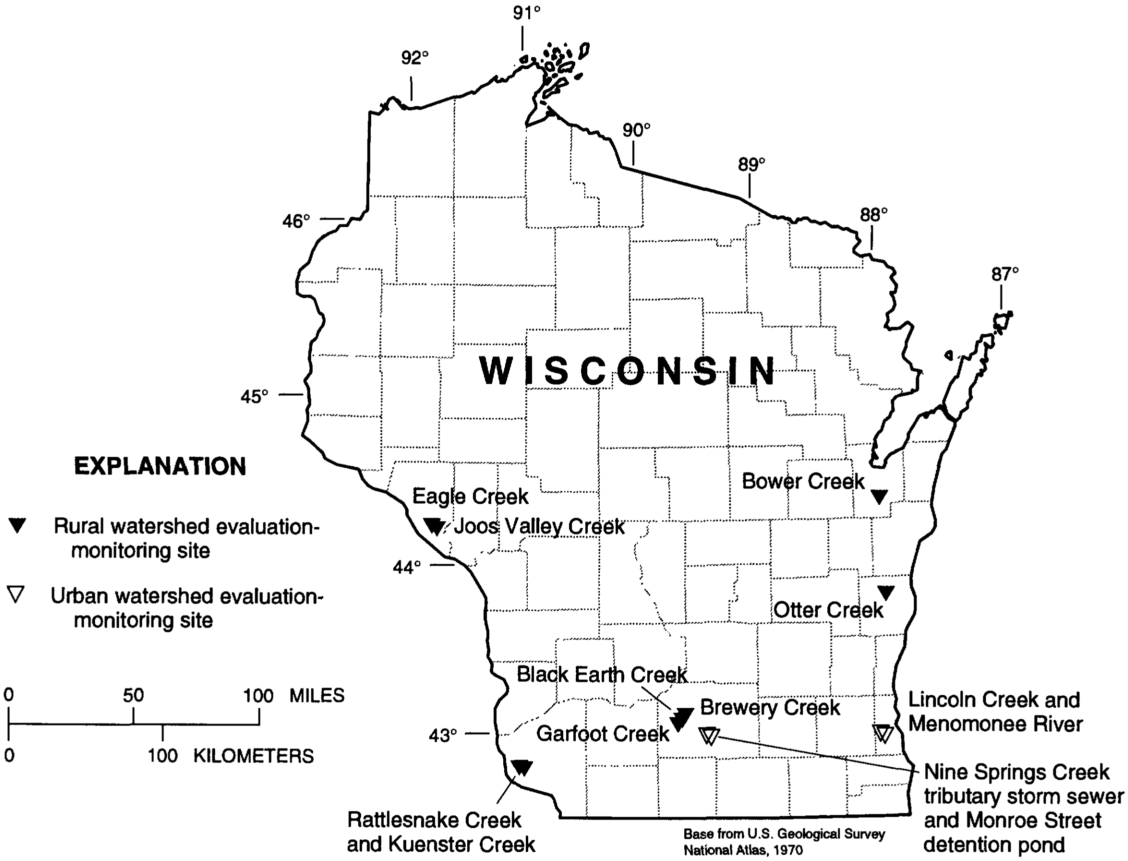

Figure 1. Locations of rural and urban sites in the Wisconsin watershed-management evaluation monitoring program, water year 1995.

The WDNR and each city have identified nonpoint sources of contamination for the four urban watersheds. Goals for reduction of nonpoint-source contamination have been set, but specific plans identifying the types and locations of BMP's needed to achieve these goals have not been defined.

Among the criteria for site selection were likelihood for extensive BMP implementation, relatively small watershed size (less than 50 mi^2), and feasibility of accurate measurement of streamflow in the watershed. An additional stream, a reach of Black Earth Creek, was selected for a detailed analysis of dissolved oxygen. Locations of the sites are shown in figure 1, and a brief summary of site characteristics is given in table 1.

EVALUATION OF NONPOINT-SOURCE CONTAMINATION

This report, the fourth in a series of annual progress reports (Graczyk and others, 1993; Corsi and others, 1994; Walker and others, 1995), is divided into three sections. The following topics are addressed: (1) land-use and best-management-practices inventory, including a discussion of data-collection efforts and the status of BMP implementation, (2) streamwater-quality data, including a discussion of rural annual snowmelt and rainfall loads, and (3) quality assurance and quality control practices, including an analysis of rural blank samples collected to examine for contamination of samples by inorganic constituents and an analysis of sampling and filtration methods for polycyclic aromatic hydrocarbons (PAH's) in urban areas. For sec-

Table 1. Characteristics of sites in the Wisconsin evaluation monitoring program

[Data-collection period in water years; mi^2, square miles]

Site name	U.S. Geological Survey station number	Data collection period	Surface-water divide contributing drainage area (mi^2)	Site type	Data collected
Black Earth Creek at County Trunk P	05406460	1985–86; 1990–95	12.8	Rural	Dissolved oxygen and water temperature
Black Earth Creek at Mills Street	05406476	1985–86; 1990–95	22.7	Rural	Dissolved oxygen and water temperature
Black Earth Creek at South Valley Road	05406497	1985–86; 1990–95	37.8	Rural	Dissolved oxygen and water temperature
Bower Creek	04085119	1991–95	14.8	Rural	Water chemistry[1]
Brewery Creek	05406470	1985–86; 1990–95	7.7	Rural	Water chemistry[2]
Eagle Creek	05378185	1990–95	14.3	Rural	Water chemistry[1]
Garfoot Creek	05406491	1985–86; 1990–95	5.39	Rural	Water chemistry[2] and dissolved oxygen
Joos Valley Creek	05378183	1990–95	5.89	Rural	Water chemistry[1]
Kuenster Creek	054134435	1993–95	9.59	Rural	Water chemistry[1] and dissolved oxygen
Lincoln Creek	040869415	1993–95	9.56	Urban	Water chemistry[1]
Menomonee River	04087120	1991–95	123	Urban	Water chemistry[1]
Monroe Street detention pond inlet	430309089260701	1991–95	.372	Urban	Water chemistry[1]
Nine Springs Creek tributary storm sewer	05429268	1991–95	.18	Urban	Water chemistry[1]
Otter Creek	040857005	1991–95	9.5	Rural	Water chemistry[1] and dissolved oxygen
Rattlesnake Creek	05413449	1992–95	42.4	Rural	Water chemistry[1] and dissolved oxygen

[1]Samples analyzed for suspended solids, total phosphorus, and ammonia nitrogen.

[2]Samples analyzed for suspended sediment, total phosphorus, and ammonia nitrogen.

tions describing ongoing data-collection efforts, data collected during water year 1995 are summarized and, if appropriate, implications for future data-collection efforts are discussed. (A water year is the period beginning October 1 and ending September 30; the water year is designated by the calendar year in which it ends.) Storm-load data summarized in appendixes 1 and 2 include data collected through water year 1994 for rural sites and water year 1995 for urban sites.

Land-Use and Best-Management-Practices Inventory

The land-use inventory program began in 1992 to provide information on the effects of land-use and land-treatment changes on water quality. A brief description of the program is given in Corsi and others (1994), and a comprehensive summary of the program is given in Wierl and others (1996). This section summarizes activities for water year 1995 and planned activities for water year 1996.

Activities in Water Year 1995

The land-use-inventory program has been tracking BMP implementation and changes in land use and land cover with a geographic information system (GIS) since 1992. A detailed description of the program is given in Wierl and others (1996). The GIS data base developed by the USGS in cooperation with the

WDNR is managed with ARC/INFO[1] software. GIS data layers were produced from 1:24,000-scale topographic maps and aerial photographs at an approximate scale of 1:600. These GIS layers include surface water drainage-basin boundaries, hydrography, hydrologic units, elevation, roads, stream and rain gages, BMP's, forests, and field boundaries. The GIS data base has been used to (1) track the implementation of BMP's; (2) display annual land cover or changes in land use; (3) depict the areas that are critical nonpoint sources of contaminants; (4) provide inputs for water-quality models; and (5) perform various queries and analyses.

A water-quality model (WINHUSLE[2]) has been used to estimate the quantity of sediment and phosphorus reaching Otter Creek from each field. Inputs for the model were imported from three GIS layers: field boundaries, elevation, and hydrologic units. The model results will be used to assess the need for specific BMP's within the Otter Creek watershed.

Updates on contracted or implemented BMP's were obtained from the local LCD's and from the WDNR, Water Resources Bureau. This information was entered into the GIS layer for BMP's. Ephemeral gullies were inventoried in spring 1995. The length, vertical depth, average width and the length of time it took for the gully to develop were used to estimate the sediment loading from a particular gully. Field inventories were conducted in summer and fall 1995 to identify the agricultural crops that were grown. This crop information was entered into the GIS layer for field boundaries.

Nonpoint sources of contamination have been identified and quantified for most of the monitored watersheds. These sources include runoff from barnyards and erosion from streambanks, uplands and gullies. Nonpoint-contaminant-source data were obtained from the priority watershed plans, local LCD's, pollutant loadings estimated from water-quality models, and completed watershed inventories (for example, gully and streambank erosion inventories).

Eligible, contracted, and installed BMP's for the evaluation monitoring watersheds are summarized in table 2. The GIS layers for BMP implementation are updated twice a year if BMP's are either contracted or implemented. Two of the rural evaluation monitoring watersheds will complete their BMP funding periods for implementing BMP's by the end of 1997 (table 3), four of the rural watersheds will complete their BMP funding periods by the end of 1999, and the remaining two rural watersheds will complete their BMP funding periods by the end of 2000.

[1]Use of trade names in the report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

[2]WINHUSLE is an empirical water-quality model that estimates the sediment yield from each field to the receiving water, and the in-stream sediment deposition rate (Wisconsin Department of Natural Resources, 1994).

Activities Planned for Water Year 1996

The following land-use and BMP monitoring activities are planned for water year 1996:

1. Update all pertinent land-use data in the GIS data base. The data base will provide the information necessary to create GIS maps.
2. Publish a USGS Open-File report that includes descriptions of the evaluation monitoring watersheds.
3. Complete an inventory of agricultural crops being grown in each watershed.
4. Complete an inventory of BMP's implemented in each watershed.
5. Complete an inventory of ephemeral gully erosion in each watershed.
6. Complete water-quality model runs for some of the remaining monitored watersheds.

Selected Streamwater-Quality Data

Streamwater-quality data are summarized in two parts. The first part discusses the availability of water-quality data, including loads for stormflow periods. The second part discusses specific data compiled at rural sites, and includes (1) a graph of the number of storms and estimated constituent loads, (2) annual constituent loads for the specific period of record at each site, and (3) a breakdown of annual rural loads into snowmelt and stormflow sources of runoff.

Availability of Water-Quality Data

Precipitation, streamflow volume, and storm loads for several water-quality constituents have been computed for all monitored storm periods and summarized for rural sites (appendix 1) and urban sites (appendix 2). The rural data are summarized through water year 1994. Data collection was suspended in

Table 2. Summary of eligible, contracted, and implemented rural best-management practices in nonpoint-source evaluation monitoring watersheds, Wisconsin

[ft, feet; BMP's, best-management practices; table contains revisions to a BMP table previously published in Walker and others, 1995, which are the result of changes in practices eligible, contracted, or implemented]

Practice	Evaluation monitoring watershed					
	Brewery Creek	Garfoot Creek	Eagle Creek and Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek and Kuenster Creek
			Animal-waste management			
Eligible manure storage	0	0	7	5	2	60[1]
Contracted manure storage	0	0	3	5	2	2
Implemented manure storage	0	0	1	3 17 others from previous farm programs	2	1
Eligible barnyard-control systems	16	7	16[2]	26	8	103
Contracted barnyard-control systems	11[3]	6	9	10	8	11 (not including 3 practices no longer contracted)
Implemented barnyard-control systems	9 5 barns no longer have livestock	6	1	5	7	6
			Streambank protection			
Eligible streambank protection[4]	22,000 ft	16,800 ft	28,100 ft	2,320 ft	7,000 ft	255,000 ft[1]
Contracted streambank protection[4]	22,000 ft	16,800 ft	8,273 ft	0	0 ft	1,730 ft
Implemented streambank protection[4]	19,100 ft	16,700 ft	323 ft	0	0 ft	1,605 ft
Contracted fencing	1,200 ft	5,475 ft	25,165 ft	625 ft	9,200 ft	0
Implemented fencing	Site no longer with livestock	5,475 ft	3,127 ft	625 ft	9,200 ft	0
Contracted stream crossing	1	4	11	1	3	2
Implemented stream crossing	1	4	1	1	3	2
Contracted grade stabilization	2	0	8	0	3	0
Implemented grade stabilization	Sites no longer with livestock	0	5	0	3	0
			Upland management			
Eligible nutrient management	2,440 acres	592 acres	990 acres	4,020 acres	1,130 acres	2,980 acres[1]
Contracted nutrient management	903 acres	156 acres	554 acres	1,080 acres	1,282 acres	274 acres[1]
Implemented nutrient management	775 acres	156 acres	0	387 acres	1,152 acres	274 acres[1]
Eligible upland BMP's[5]	5,170 acres[1]	1,520 acres[1]	2,140 acres[1]	4,480 acres	851 acres	17,400 acres[1]
Contracted upland BMP's	1,143 acres	221 acres	7	99 acres	2 acres	701 acres
Implemented upland BMP's	1,143 acres	221 acres	0	77 acres	1 acre	49 acres

[1]An estimate derived from the nonpoint source control plan.

[2]Does include one eligible yard that was sold.

[3]Total includes a barnyard-control system to be installed by a landowner without cost-share funding.

[4]The contracts for length of streambank protection reflects the total length of each practice. One eroded site can include several practices such as riprap, shoreline and streambank stabilization, and shoreline buffers. Both banks may have been eroded, contracted, or implemented with BMP's.

[5]Includes an individual practice or series of practices, other than nutrient management, that result in a reduced pollutant source, such as contour farming, contour strip cropping, field strip cropping, grassed waterways, and reduced tillage.

Table 3. Milestone dates for project selection, watershed assessment, plan approval, signup period, end of BMP funding, pre-BMP period, transitional period, and post-BMP period for nonpoint-source evaluation monitoring watersheds, Wisconsin

[BMP, best-management practice; WDNR, Wisconsin Department of Natural Resources; LCD, Land Conservation Department]

	Evaluation monitoring watersheds							
Milestone	Brewery Creek	Garfoot Creek	Eagle Creek	Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek	Kuenster Creek
Project selected[1]	1985	1985	1985	1985	1986	1985	1986	1986
Watershed assessment[1]	1986–87	1986–87	1987–88	1987–88	1988–90	1987–88	1989–90	1989–90
Plan approved[1]	1989	1989	1990	1990	1991	1991	1991	1991
Signup period[2]	March 1989–February 1994	March 1989–February 1994	March 1990–December 2000	March 1990–December 2000	September 1991–December 1996	June, 1991–May 1997	October 1991–October 1997	October 1991 - October 1997
End of BMP funding[2]	February 1997	February 1997	December 2000	December 2000	December 1999	December 1999	October 1999	October 1999
Pre-BMP period[3]	Prior to October 1989	Prior to September 1989	Prior to September 1993	Prior to September 1992	Prior to November 1992	Prior to September 1993	Prior to May 1993	Prior to June 1994
Transitional period[3]	November 1989–1997	October 1989–1995	October 1993–2000	October 1992–2000	December 1992–1999	October 1993–1996	June 1993–1996	July 1994–1998
Post-BMP period[3]	After 1997	After 1995	After 2000	After 2000	After 1999	After 1996	After 1996	After 1998

[1]All years listed correspond with Priority Watershed plans.

[2]All years listed were obtained from the WDNR and the local LCD's.

[3]All years listed were designated by the evaluation monitoring team with information obtained from the WDNR and the local LCD's. The post-BMP and transitional periods may be changed, if all the BMP's are implemented prior to the date listed.

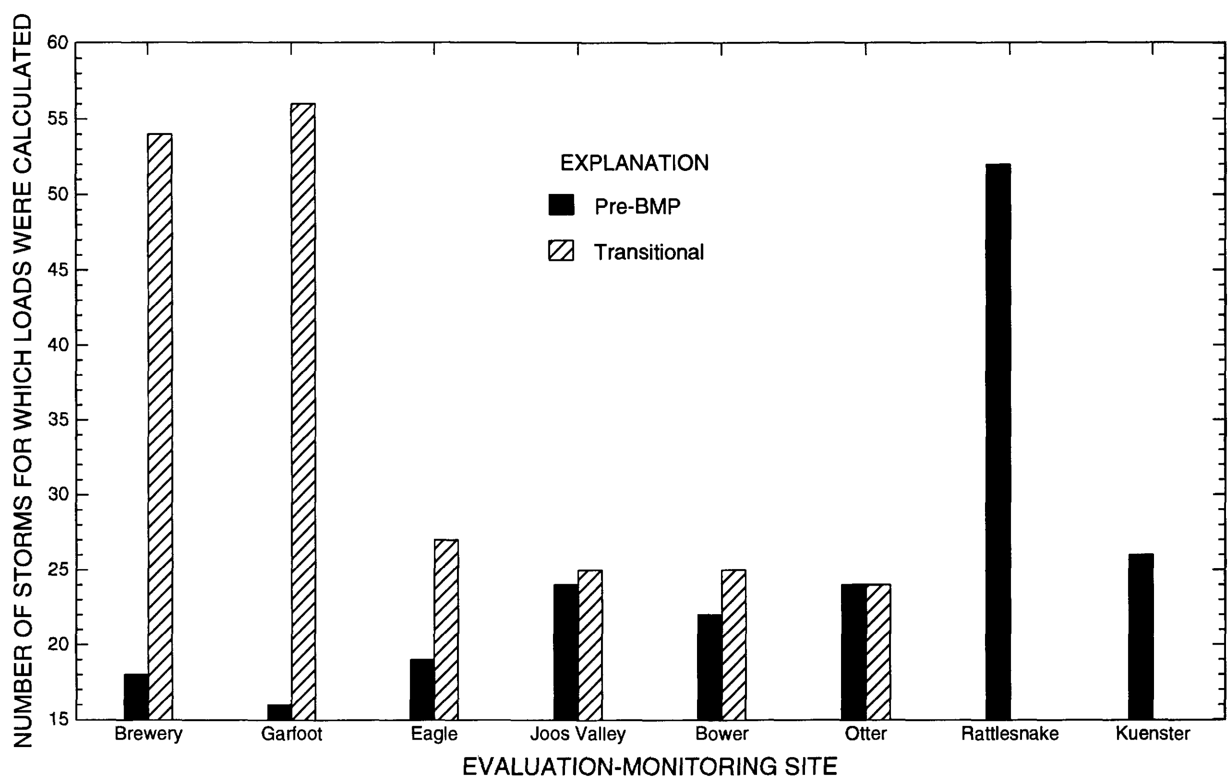

Figure 2. Number of storms through water year 1995 for which loads were calculated at the Wisconsin evaluation monitoring sites before implementation of best-management practices (BMP's) and during transitional periods.

1994 for three of the urban sites and in 1995 for the remaining urban site pending approved watershed plans. Accordingly, data in appendix 2 are through the end of the appropriate data-collection period. Daily loads for selected constituents and discrete concentration data for the samples used to calculate these loads are published in the USGS annual water-data reports for Wisconsin (Holmstrom and others, 1986–87; Holmstrom and Erickson, 1989; Holmstrom and others, 1990–95). Maximum, minimum, and mean dissolved-oxygen concentrations and water temperatures also are published in these annual reports. Data for water year 1995 are published in the annual report for 1995. Constituent loads for stormflow periods for water year 1995 are to be published in the 1996 annual progress report on the evaluation monitoring program. Data are available by request from the USGS office in Madison, Wis.

Summary of Loads at Rural Sites

Water-quality monitoring at the eight rural evaluation monitoring sites (fig. 1) continued in water year 1995 with sampling during base-flow and stormflow periods. Instantaneous water-quality data were used in conjunction with continuous streamflow data to estimate total constituent loads for stormflow periods. Suspended-sediment or suspended-solids, total-phosphorus, and ammonia-nitrogen loads were computed at the eight rural evaluation monitoring sites. For Brewery and Garfoot Creeks, suspended-sediment loads were computed to be consistent with pre-BMP data collected in a previous study; for all other sites, suspended-solids loads were computed. Ammonia-nitrogen loads were not computed for sites on Otter and Bower Creeks. The rural storm-load data will be used to evaluate the effect of BMP's on streamwater quality. Previous research using the rural regression analysis (Walker and Graczyk, 1993; Walker, 1994) has shown theoretically that the minimum detectable change at rural sites becomes distinguishable at roughly 40 total storms; this corresponds to 20 pre-BMP and 20 post-BMP storms for a balanced data collection. The number of pre-BMP and post-BMP storms for which loads were calculated at rural evaluation monitoring sites is shown in figure 2. Loads for a sufficient number of storms are probably available for the pre-BMP implementation period at five of the sites; at the other three sites, BMP implementation has begun, so collection of additional pre-BMP data is not possible.

Annual loads of suspended sediment or suspended solids and total phosphorus were determined at each of the eight rural evaluation monitoring sites (fig. 1) for the entire period of data collection. The annual loads are summarized in table 4.

A significant part of the annual rural load may be transported during snowmelt runoff periods which are frequent in Wisconsin during the winter and early spring. A determination of the percentage of annual load contributed by snowmelt-period runoff will indicate the importance of snowmelt periods for the rural regression analyses. Snowmelt periods were defined as periods when snow was either falling or already on the ground. Climatological data from the closest station collecting snow and snow-on-ground data were used for the snowmelt-period determination.

For each water year, daily mean loads were summed for snowmelt periods. These load data are summarized in table 4.

Monitoring Activities Planned for Water Year 1996

The following water-quality-monitoring activities are planned for water year 1996:

1. Continue collection of rural stormflow samples for determination of suspended-solids or suspended-sediment, total-phosphorus and ammonia-nitrogen loads. Data collection may be scaled back at some sites if implementation of BMP's in the watersheds has not begun. Intensive data collection can begin again once a sufficient number of BMP's have been implemented.

2. Continue dissolved-oxygen monitoring at the four sites (Kuenster, Rattlesnake and Garfoot Creeks and Black Earth Creek at South Valley Road). Analyze data for the coldwater sites where most of the BMP's have been installed. Available data may be sufficient at the end of water year 1996 to determine whether dissolved-oxygen concentrations have changed as a result of the BMP implementation.

Quality Assurance and Quality Control

In this section, two components of quality-assurance/quality-control (QA/QC) for evaluation monitoring sites are summarized and evaluated. First, rural field-blank and splitter-blank samples collected in water years 1994–95 are considered; second, some components of the urban sampling protocol for polycyclic aromatic hydrocarbons (PAH's) are investigated.

Blank Samples for Inorganic Constituents at Rural Sites

One part of the QA/QC plan for rural evaluation monitoring sites includes regular collection of blank samples from the automatic samplers and the sample splitter. Runoff samples are collected by use of an automatic refrigerated sampler. Plastic sample tubing connects the stream to a peristaltic pump, which pumps water into one of twenty-four 1-L plastic bottles that are stored in the refrigerator until retrieved by field personnel. The samples are then capped and transported to a field office, where they are split by use of a 10-port, plastic, small-volume sample splitter and sent to the Wisconsin State Laboratory of Hygiene (WSLH) for analysis. Field-blank samples are collected by attaching one end of a short section of tubing onto the stream end of the plastic sample tubing and placing the other end in a bottle of Milli-Q water. Milli-Q water is then pumped through the automatic sampler into a 1-L plastic bottle in the refrigerator. The bottle is capped and transported to a field office, where its contents are split and sent to the WSLH for analysis. Splitter-blank samples are collected by pouring Milli-Q water through the sample splitter and sending the resulting sample to the WSLH for analysis. A more detailed description of blank- sample collection is given in Graczyk and others (1993).

The field- and splitter-blank samples for rural evaluation monitoring sites were analyzed for biochemical oxygen demand (BOD), total phosphorus (TP), ammonia nitrogen (NH_3-N), suspended solids (SS), and fecal coliform bacteria. Four splitter-blank samples were collected and analyzed for BOD, seven for TP, NH_3-N, and SS, and eight for fecal coliform. One sample each of BOD, TP, NH3-N, and SS had concentrations slightly above the limit of quantification (LOQ) (table 5). All fecal coliform concentrations were below the LOQ.

A total of 71 field-blank samples were collected during water years 1994 and 1995. Concentrations were above the LOQ in at least 19 samples for all constituents. For all constituents except NH_3-N concentrations were measurable in more than 50 percent of the samples (table 5).

There appears to be some source of BOD, TP, NH_3-N, and SS contamination in the field blanks. Because concentrations of BOD and TP in the field-blank samples are all relatively low compared to those in most runoff samples collected by the automatic samplers, contamination by these constituents is not a serious concern. Concentrations of SS and fecal coliform in field-blank samples were generally low compared to those in most rural runoff samples. In a few field-blank samples, however, SS and fecal coliform concentrations were greater than those in some runoff samples. In 14 of 67 field-blank samples, suspended solids concentrations were greater than 20 mg/L; and in 12 of 55 fecal coliform samples concentrations were greater than 500 (col.)/100 mL. Both of these concentrations are considered to be low but not uncommon for rural runoff samples. This contamination is a problem that warrants further investigation and appropriate corrective action.

The source of BOD, TP, NH_3-N, and SS contamination in the field blanks must lie with the automatic-sampling process or the bottle-handling procedure because splitter blanks have not been contaminated. Contamination is most likely due to residue particulate matter and streamwater in the sample tubing. If this is the case, the problem would probably be solved by cleaning the sample tubing with a tubing brush and rinsing the sample tubing periodically (once every 2 weeks would probably be sufficient). This possibility will be investigated during water year 1996.

Polycyclic Aromatic Hydrocarbon Sampling at Urban Sites

Some components of the current sampling and sample-processing methods for PAH's at the urban watershed-management evaluation monitoring sites were investigated in 1995. Runoff samples are collected by use of refrigerated automatic peristaltic pump samplers. Teflon-lined 3/8-in. sample tubing connects the stream or storm sewer to a peristaltic pump, which pumps water through approximately 3 ft of polyethylene tubing into one of four 10-L open wide-mouth glass bottles stored in the refrigerator. Field personnel visit the site within 24 hours of the end of each runoff period. Samples are then capped and transported in an iced cooler to the USGS office in Madison at a temperature of approximately 4°C. The samples are split by use of a Teflon-lined churn splitter and filtered by use of a 0.7-µm glass fiber filter. Three components of this procedure were investigated: (1) the peristaltic pump system, (2) the waiting period from when the samples are pumped into the 10-L glass bottles to when they are retrieved and capped by field personnel, and (3) the filtration system. The components were tested with urban stormwater runoff from a storm sewer that drains the West Towne Mall parking lot in Madison, Wis.

Peristaltic Pump System

To evaluate the peristaltic pump system, three sets of two samples each were collected. Each set of samples contained a grab sample from the stormwater runoff from the storm sewer and a simultaneous sample collected by placing a bottle directly under the outlet from the peristaltic pump system. Concentrations of PAH's from the peristaltic pump sample were greater than those of the grab samples for the first two sets of samples but were slightly less for the third set of samples (fig. 3). Eleven of sixteen PAH's were detected in all samples. The five PAH's not detected were acenaphthene, acenaphtylene, dibenzo[A,H]anthracene, fluorene, and naphthalene. In the first two sets of samples differences between the pump samples and the grab samples are more apparent.

Waiting Period

To evaluate the effect of the waiting period on PAH's for the time the samples are pumped into the 10-L glass bottles to when they are retrieved and capped by field personnel, a grab sample was collected directly from the storm sewer. The Teflon-lined churn splitter was used to split this sample into three amber 1-L glass bottles filled completely (ambient samples 1, 2, and 3) and one clear 10-L glass bottle filled half full. The 1-L bottles were capped and shipped for analysis. The 10-L bottle was left uncovered and refrigerated for 24 hours to simulate a runoff event where samples may be left in the automatic sampler for as long as 24 hours before field personnel retrieve them. The sample was then split into three amber 1-L glass bottles (uncovered sample 1, 2, and 3) that were capped and shipped for analysis. Ten of fifteen PAH's were detected in all samples. Non-detected target PAH compounds include

Table 4. Summary of annual and snowmelt-period suspended-sediment or suspended-solids loads, total-phosphorus loads, and streamflow at Wisconsin evaluation monitoring sites, water years 1985–86 and 1990–94

[--, not computed; lb, pound; mi^2, square miles; Mft^3, million cubic feet]

Water year	Suspended sediment or suspended solids			Total phosphorus			Total streamflow		
	Annual load (tons)	Snowmelt load (tons)	Percent snowmelt	Annual load (lb)	Snowmelt load (lb)	Percent snowmelt	Water year (Mft^3)	Snowmelt period (Mft^3)	Percent snowmelt
Brewery Creek - 05406470 (surface-water divide contributing area 7.7 mi^2)									
1985	894	198	22	4,840	1,860	38	86.0	28.7	33
[1]1986	[1]279	[1]181	[1]65	[1]1,590	[1]896	[1]56	[1]75.0	[1]35.6	[1]47
1990	521	46.9	9	3,850	1,180	31	36.5	14.0	38
1991	45.3	11.9	26	700	200	28	18.4	7.93	43
1992	180	57.5	32	1,960	888	45	28.4	13.1	46
1993	2,640	457	17	10,700	2,990	28	135	40.3	30
1994	792	445	56	3,420	1,780	52	125	47.7	38
[2]Mean	845	203	--	4,250	1,480	--	71.6	25.3	--
Garfoot Creek - 05406491 (surface-water divide contributing area 5.39 mi^2)									
1985	462	174	38	3,060	894	29	166	50.7	31
[1]1986	[1]441	[1]232	[1]53	[1]2,450	[1]1,350	[1]55	[1]156	[1]77.6	[1]50
1990	337	40.3	12	2,850	474	17	100	30.5	30
1991	290	137	47	2,100	999	47	103	35.7	35
1992	200	90.0	45	2,230	983	44	127	52.6	41
1993	1,160	410	35	7,080	2,870	40	243	87.4	36
1994	238	134	56	1,720	1,090	63	155	68.2	44
[2]Mean	448	164	--	3,175	1,220	--	130	47.5	--
Eagle Creek - 05378185 (surface-water divide contributing area 14.3 mi^2)									
[3]1990	[3]4,340	--	--	[3]9,460	--	--	[3]84.5	--	--
1991	6,580	21.5	0	11,600	132	1	244	51.1	21
1992	3,920	367	9	8,900	1,060	12	287	93.7	33
1993	7,960	543	7	17,900	1,350	8	425	103	24
1994	5,687	2,120	37	11,600	4,480	39	370	104	28
[2]Mean	6,040	762	--	12,500	1,760	--	331	87.9	--

Table 4. Summary of annual and snowmelt-period suspended-sediment or suspended-solids loads, total-phosphorus loads, and streamflow at Wisconsin evaluation monitoring sites, water years 1985–86 and 1990–94—Continued

Water year	Suspended sediment or suspended solids			Total phosphorus			Total streamflow		
	Annual load (tons)	Snowmelt load (tons)	Percent snowmelt	Annual load (lb)	Snowmelt load (lb)	Percent snowmelt	Water year (Mft^3)	Snowmelt period (Mft^3)	Percent snowmelt
Joos Valley Creek - 05378183 (surface-water divide contributing area 5.09 mi^2)									
[3]1990	1,150	--	--	3,080	--	--	28.3	--	--
1991	1,470	30.9	2	3,160	67.6	2	95.6	20.8	22
1992	1,390	71.9	5	3,880	266	7	127	44.3	35
1993	2,900	79.1	3	6,440	409	6	183	46.4	25
1994	2,100	952	45	4,990	2,220	44	162	47.4	29
[2]Mean	1,970	284	--	4,620	740	--	142	39.7	--
Bower Creek - 04085119 (surface-water divide contributing area 14.8 mi^2)									
1991	718	338	47	9480	6,330	67	217	142	66
1992	1,450	288	20	10,800	3,710	34	200	88.3	44
1993	11,100	785	7	26,600	8,980	34	584	205	35
1994	2,420	104	4	9,143	1,940	21	144	49.8	35
Mean	3,920	378	--	14,000	5,240	--	286	121	--
Otter Creek - 040857005 (surface-water divide contributing area 9.5 mi^2)									
1991	308	113	37	2,490	937	38	181	55.3	31
1992	285	99.5	35	2,180	839	38	202	69.6	34
1993	867	138	16	5,580	1,320	24	343	75.3	22
1994	216	58.7	27	3,060	1,340	44	193	61.6	32
Mean	419	102	--	3,330	1,110	--	230	65.4	--
Rattlesnake Creek - 05413449 (surface-water divide contributing area 42.4 mi^2)									
1992	5,870	5,260	90	30,600	18,400	60	675	213	32
1993	35,500	7,130	20	156,000	49,900	32	1,690	427	25
1994	8,480	6,460	76	34,800	22,100	64	972	245	25
Mean	16,600	6,280	--	73,700	30,100	--	1,110	295	--
Kuenster Creek - 054134435 (surface-water divide contributing area 9.59 mi^2)									
1993	9,690	2,960	31	38,000	12,900	34	385	93.0	24
1994	3,180	2,480	78	9,180	6,190	67	199	50.6	25
Mean	6,430	2,720	--	23,600	9,520	--	292	71.8	--

[1]Partial year of data collected (October through June).
[2]Mean does not include partial years.
[3]Partial year of data collected (July through September).

Table 5. Number of splitter-blank and field-blank samples with concentrations greater than the limit of quantification and number of splitter-blank and field-blank samples collected, Wisconsin evaluation monitoring program, water years 1994–95

[a/b, where a=number of blank samples with concentration exceeding the limits of quantification (LOQ), and b=number of blank samples collected; mg/L, milligrams per liter; mL, milliliter]

Site name	Biochemical oxygen demand	Total phosphorus (LOQ=.031 mg/L)	Ammonia nitrogen (LOQ=.085 mg/L)	Suspended solids (LOQ=19.8 mg/L)	Fecal coliform (LOQ=10 col./100 mL)
			Splitter blanks		
Splitters	1/4	1/7	1/7	1/7	0/8
			Field blanks		
Brewery Creek	5/5	4/11	2/10	7/10	4/5
Garfoot Creek	7/7	7/10	4/10	7/9	5/6
Eagle Creek	1/5	2/9	4/9	5/9	2/9
Joos Valley Creek	1/5	1/9	2/9	6/9	2/10
Bower Creek	1/2	0/2	0/2	0/2	1/3
Otter Creek	6/7	2/7	1/7	1/7	2/7
Rattlesnake Creek	6/8	8/8	3/8	7/8	7/7
Kuenster Creek	5/5	10/13	3/13	12/13	7/8

acenaphthene, acenaphtylene, dibenzo[A,H] anthracene, fluorene, and naphthalene. Concentrations of ambient samples 1, 2, and 3 were averaged and concentrations of uncovered samples 1, 2, and 3 were averaged. Concentrations of all constituents from the uncovered samples were within 12 percent of those from the ambient samples (fig. 4).

The above evaluation shows that the sampling methods for PAH's do not give results that are drastically different from grab sampling of stormwater, but the data set is too small to draw any definite conclusions. The small number of samples collected resulted in a small range of constituent concentrations and five of the target PAH's are not even detected in these samples. To fully evaluate the effect of the waiting period on the results for PAH's, samples would have to be collected at other sites and under other conditions so that all the target PAH's would be detected and a greater range of concentrations would be available for between-method comparisons.

Filtration

Water samples for PAH's for the urban evaluation monitoring sites are filtered by use of a positive displacement pump that pushes water through a 0.7-µm glass-fiber filter in an aluminum filter unit, as outlined in Sandstrom (1995). This method is commonly used in the USGS for filtration prior to analysis for pesticides and other organic compounds, but it has not been explicitly evaluated for PAH's. Because PAH's are hydrophobic compounds, a primary concern about filtering water samples is the loss of PAH's due to sorption onto the sampling apparatus or the filter. To evaluate the possibility of PAH sorption, six samples were collected and processed with a double filtration procedure. The samples were filtered, and a portion of the filtrate was analyzed (filtrate 1). The remaining filtrate was filtered again and then analyzed (filtrate 2). Concentrations of PAH's should be less in the second filtrate if PAH compounds are sorbing to the sampling apparatus or filtration unit. Of 16 target PAH compounds, 3 were detected in all but 1 sample.

Results from the first filtration and the second filtration are virtually identical (fig. 5). Concentrations from the second filtrate are not consistently less than those from the first. The observed differences may be simply a result of analytical variability. Concentrations from the second filtrate were within 12 percent of concentrations from the first filtrate for all samples but three. The concentration of pyrene in the first filtrate of sample 1 was 0.05 µg/L, whereas that in the second filtrate was less than the limit of quantification (0.04 µg/L); the concentration of pyrene in sample 6 is 20 percent greater than that in the first filtrate, and the concentration of fluoranthene in the second filtrate is 21 percent less than that of the first filtrate.

Results from this investigation do not indicate a problem with the PAH filtration method; however, the investigation probably would have been more conclu-

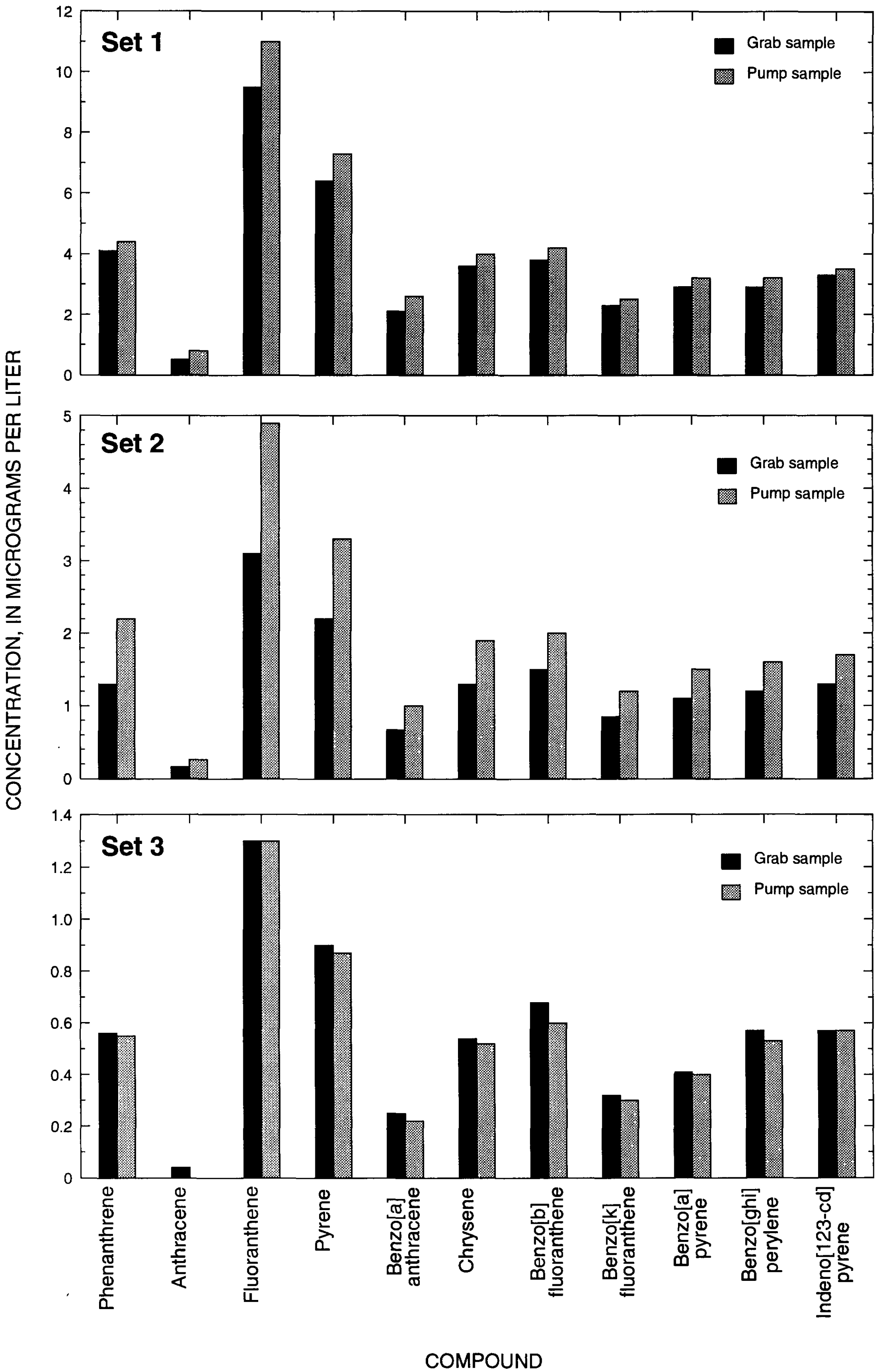

Figure 3. Comparison of grab samples and peristaltic-pump samples for polycyclic aromatic hydrocarbon compounds detected in each of three sets of urban stormwater samples, Madison, Wisconsin.

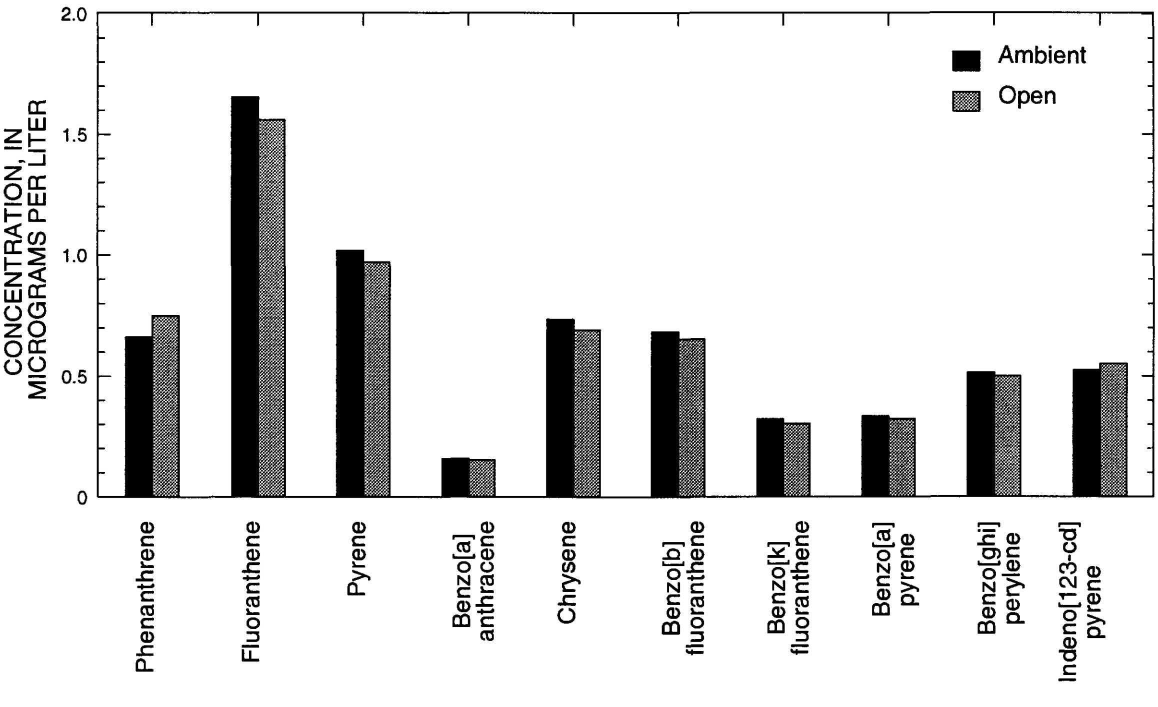

Figure 4. Comparison of average concentrations for capped samples (ambient) and samples left open for 24 hours (open) for polycyclic aromatic hydrocarbon compounds detected in urban stormwater samples, Madison, Wisconsin.

sive with additional data and a greater range of concentrations.

SUMMARY AND CONCLUSIONS

This report is an annual summary of the data collected for the Wisconsin watershed-management evaluation monitoring program and a presentation of the results from several specific analyses within this program.

A land use and best-management-practice inventory is ongoing for each evaluation monitoring project to track the nonpoint sources of contamination in each watershed. Information is being gathered from the county Land Conservation Districts (Wisconsin Department of Natural Resources, Water Resources Bureau, and other sources). This information is mapped and stored in a geographic-information-system data base. Each year, the information for each watershed is reviewed and updated.

Data on precipitation, streamflow volume, and storm loads of suspended solids and total phosphorus have been compiled for the eight rural sites through water year 1994 (appendix 1). Data on precipitation, streamflow volume, and storm loads for suspended solids, total phosphorus, and total recoverable lead, copper, zinc, and cadmium have been compiled for the four urban sites through water year 1995 (appendix 2). Annual and snowmelt-period loads for suspended sediment and total phosphorus were estimated for the eight rural sites.

Quality-assurance and quality-control (QA/QC) samples were collected at rural sites for inorganic constituents and at urban sites for polycyclic aromatic hydrocarbons (PAH's). Blank quality-control samples were collected at eight of the rural evaluation monitoring sites. The rural sampling protocol was designed to isolate contamination from the automatic sampler and the sample splitter. Low levels of contamination were found for biochemical oxygen demand, total phosphorus, and ammonia nitrogen. Levels of suspended solids and fecal coliform contamination in the automatic sampling equipment warrant investigations and corrective action. QA/QC sampling for PAH's at urban sites was inconclusive. QA/QC completed on the PAH filtration indicates that 0.7-µm glass-fiber filter in an aluminum filter unit can be used for sample filtration.

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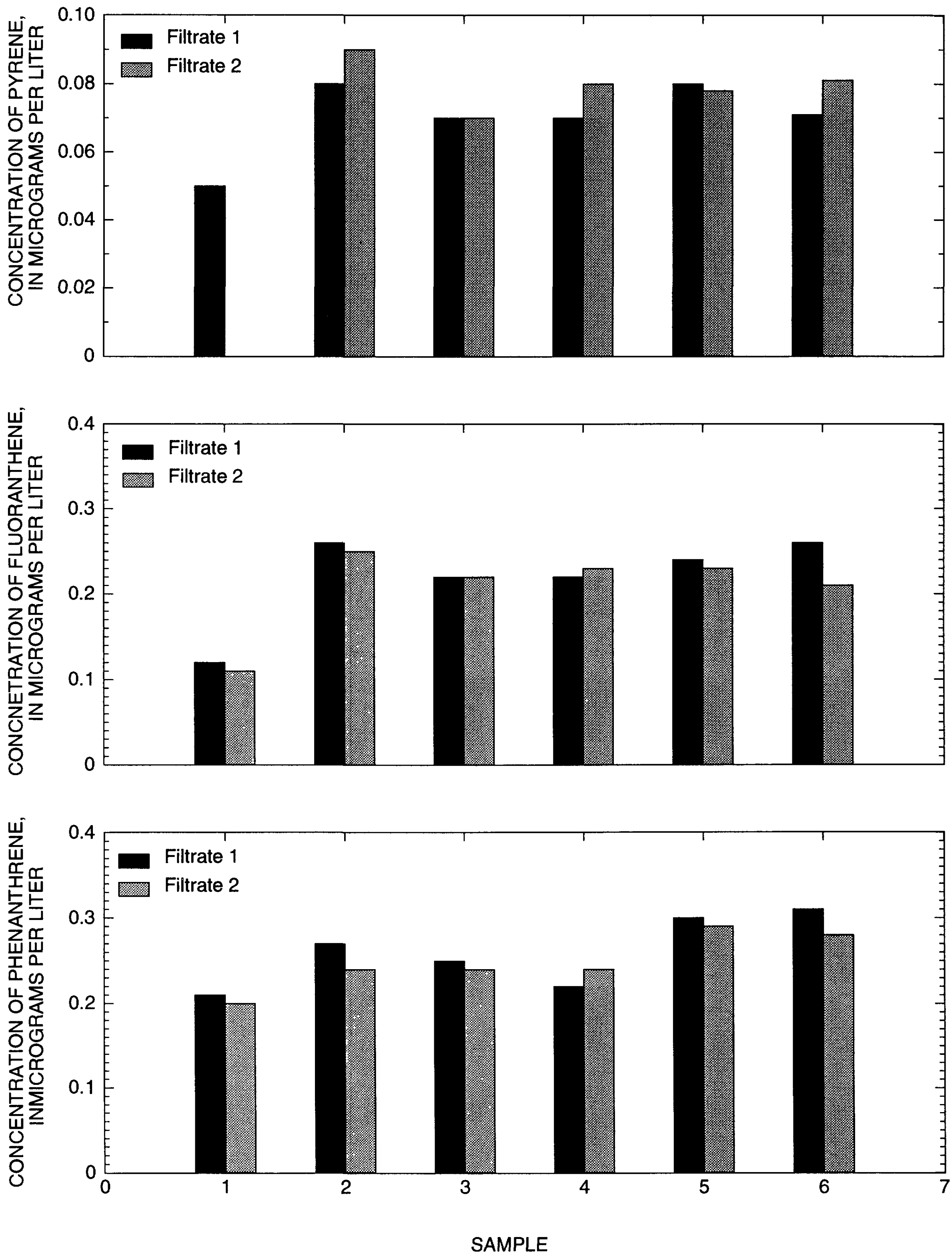

Figure 5. Comparison of polycyclic aromatic hydrocarbon samples filtered one time (filtrate 1) and two times (filtrate 2).

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APPENDIXES 1–2

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Brewery Creek							
84/10/18	1745	84/10/19	1700	2.78	1.5	35	140
84/11/01	0015	84/11/01	2245	.93	.48	7.4	28
84/12/28	0045	84/12/28	2145	s/m	1.3	22	180
85/02/21	0430	85/02/25	0700	s/m	9.6	120	1,500
85/07/24	1930	85/07/26	2230	6.85	14	500	2,000
85/08/12	2145	85/08/13	1800	.94	.25	1.2	13
85/08/25	0200	85/08/26	1000	1.70	.53	2.6	--
85/09/04	2330	85/09/05	2115	1.53	.56	2.3	38
85/09/09	0015	85/09/09	2345	1.40	1.3	25	130
85/10/12	0315	85/10/13	0200	.80	.76	3.3	--
85/10/23	1515	85/10/24	1400	.59	.39	2.3	20
85/10/31	1800	85/11/02	1100	2.77	2.4	20	190
85/11/17	2245	85/11/19	0800	.63	.85	3.5	55
86/03/09	2200	86/03/10	2300	s/m	.67	8.1	--
86/03/17	1200	86/03/20	0100	s/m	3.1	60	330
86/05/15	1500	86/05/16	0200	.58	.28	1.2	18
86/05/17	0100	86/05/18	0600	1.09	.96	8.1	78
86/06/22	0100	86/06/22	2300	1.16	.77	1.1	24
89/10/05	0745	89/10/05	1500	--	.020	.040	1.1
90/03/08	0930	90/03/09	0500	.67	1.8	590	750
90/03/11	0600	90/03/12	0200	.50	2.5	160	820
90/03/13	1815	90/03/14	0600	.84	.89	48	250
90/06/02	1315	90/06/03	1000	1.54	.59	35	140
90/06/28	2330	90/06/29	1900	2.14	4.1	250	1,100
91/04/12	1230	91/04/13	1230	1.17	.75	8.3	85
91/04/14	0600	91/04/14	2400	.80	.61	4.1	54
91/04/28	2045	91/04/29	1100	1.24	.29	7.1	47
91/05/05	0900	91/05/05	2400	1.08	.24	3.4	25
91/07/01	1415	91/07/02	1500	1.29	.34	1.7	27
91/07/07	1430	91/07/08	1315	1.11	.52	3.1	56
91/08/08	0130	91/08/08	0900	2.24	.14	.97	9.9
91/10/24	2000	91/10/26	0100	3.55	2.9	120	740
91/11/01	0030	91/11/02	1330	.81	.88	5.4	90
91/11/29	1900	91/11/30	1800	.61	.44	2.3	32
92/02/27	1030	92/02/28	0500	s/m	.87	6.7	130
92/02/28	0845	92/02/29	0300	s/m	.98	14	160
92/03/01	1200	92/03/02	0700	s/m	.66	20	120

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Brewery Creek—Continued							
92/07/13	1500	92/07/15	0300	1.49	.34	--	36
92/08/29	0330	92/08/29	1100	1.21	.037	.13	.78
92/09/16	1100	92/09/17	1800	1.19	.25	.51	27
92/09/18	0330	92/09/19	1700	.73	.33	.47	18
92/10/15	1800	92/10/15	2300	.45	.019	.020	.28
92/11/20	0300	92/11/22	0600	2.55	1.4	7.5	100
93/03/06	1000	93/03/07	0815	s/m	.60	13	440
93/03/07	1200	93/03/08	0800	s/m	1.2	9.3	490
93/03/08	1300	93/03/09	0400	s/m	.83	7.8	380
93/03/16	0700	93/03/17	0800	s/m	1.7	73	640
93/03/24	1000	93/03/25	0700	s/m	2.1	36	330
93/03/25	1000	93/03/26	0800	s/m	2.3	67	460
93/03/26	1200	93/03/27	0800	s/m	2.3	--	160
93/03/27	1200	93/03/28	0800	s/m	1.2	16	98
93/03/28	1100	93/03/29	0700	s/m	2.9	210	590
93/03/31	0300	93/04/01	0300	s/m	2.5	55	250
93/06/07	1035	93/06/08	1000	2.39	2.5	110	470
93/06/17	1000	93/06/18	1200	.43	.93	18	67
93/07/05	0430	93/07/07	0900	4.58	16	1,300	4,000
93/07/07	1800	93/07/08	0900	1.03	1.3	130	460
93/07/09	0100	93/07/10	0400	1.47	5.1	250	570
93/07/17	1100	93/07/18	0400	.86	.84	42	87
93/07/25	0100	93/07/26	0400	1.35	2.1	83	300
93/07/27	2200	93/07/28	1900	.88	1.4	25.8	120
93/08/15	0500	93/08/16	2000	2.48	4.7	88.6	470
93/09/13	0800	93/09/15	1500	2.12	2.9	12.1	130
94/02/18	1300	94/02/21	1200	--	4.9	220	780
94/03/05	1100	94/03/06	0800	--	2.8	72	510
94/03/06	0900	94/03/07	0700	--	1.7	30	110
94/06/23	1230	94/06/24	2100	--	1.2	4.2	62
94/06/25	2100	94/06/27	0100	--	.66	2.1	16
94/07/03	2345	94/07/05	2300	--	5.9	200	930
94/08/10	1530	94/08/12	0200	--	1.1	2.5	32
94/09/14	0400	94/09/15	0500	--	.65	4.1	36

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Garfoot Creek							
84/10/18	1200	84/10/19	2200	2.64	3.1	37	210
84/10/31	2400	84/11/01	1800	1.13	1.1	16	76
84/12/27	2200	84/12/29	0900	s/m	2.4	45	140
85/02/21	0200	85/02/25	0100	s/m	6.3	62	470
85/07/24	1915	85/07/26	0500	6.56	7.5	65	710
85/09/04	2400	85/09/05	1300	1.38	.49	1.7	22
85/09/09	0015	85/09/09	2100	1.63	2.2	17	130
85/09/23	0300	85/09/24	0300	1.20	.57	1.9	--
85/10/11	2345	85/10/12	2100	.85	1.1	14	--
85/10/23	1600	85/10/24	0700	.70	.62	9.8	46
85/10/31	1626	85/11/02	1400	2.79	5.3	34	370
85/11/18	0300	85/11/19	0900	.73	1.6	17	98
86/03/09	1600	86/03/11	0600	s/m	1.7	26	110
86/03/16	1200	86/03/20	0200	s/m	7.7	59	610
86/05/15	1400	86/05/16	0500	.72	.53	14	27
86/05/17	0100	86/05/18	0400	1.15	1.2	15	75
89/10/05	0930	89/10/06	0600	--	.21	.27	6.4
90/01/16	1845	90/01/17	2200	s/m	1.4	13	190
90/03/11	0600	90/03/12	0400	.48	2.9	53	330
90/03/13	0600	90/03/14	1300	.76	1.3	30	160
90/03/14	1600	90/03/15	1500	1.12	2.0	31	230
90/06/02	1300	90/06/03	0100	1.48	.42	23	100
90/06/28	2330	90/06/29	2300	2.45	3.0	77	530
90/08/19	1630	90/08/20	1200	--	.81	4.6	61
91/03/01	0945	91/03/02	2200	1.51	3.2	53	370
91/03/22	2130	91/03/23	0700	.74	.33	4.2	28
91/04/12	1500	91/04/13	1400	1.74	2.2	74	210
91/04/14	0600	91/04/14	2400	.99	1.9	58	200
91/08/08	0200	91/08/08	1500	2.34	.30	--	12
91/11/01	0900	91/11/02	0100	1.40	1.3	15	150
91/11/29	2000	91/11/30	1300	.87	.98	13	76
92/02/26	1400	92/02/27	0100	s/m	.30	--	11
92/02/27	1045	92/02/28	0100	s/m	.68	9.0	54
92/02/28	1130	92/02/28	2400	s/m	.44	1.5	21
92/09/16	1200	92/09/17	0330	1.34	.69	7.4	46
92/09/18	0330	92/09/18	1800	.89	.70	5.2	48
92/11/19	2000	92/11/21	2300	2.68	3.4	43	420

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
			Garfoot Creek—Continued				
92/12/15	1600	92/12/16	1200	1.30	1.2	7.4	400
93/03/24	1300	93/03/25	0830	s/m	2.1	24	240
93/03/25	1030	93/03/26	1000	s/m	3.4	41	300
93/03/26	1300	93/03/27	0500	s/m	1.7	14	130
93/03/27	1240	93/03/28	0400	s/m	1.3	9.1	100
93/03/28	1000	93/03/29	0300	s/m	2.7	44	290
93/03/31	0400	93/04/01	0400	s/m	3.7	28	210
93/04/07	2300	93/04/08	1700	.62	1.3	13	60
93/04/15	0100	93/04/16	1200	1.55	4.2	35	240
93/04/19	1300	93/04/20	2300	1.69	3.8	37	180
93/06/07	1045	93/06/08	2000	1.97	2.8	31	180
93/06/17	1800	93/06/18	1200	1.09	.99	13	54
93/07/05	0500	93/07/07	0200	3.98	7.7	130	730
93/07/08	1300	93/07/10	0400	1.81	5.9	110	490
93/07/10	1800	93/07/11	0500	.45	1.1	12	63
93/07/25	0300	93/07/25	2400	1.48	2.5	43	220
93/07/27	2200	93/07/28	1500	.44	.92	5.92	38
93/08/15	0500	93/08/16	1300	2.35	3.6	30.8	230
93/08/23	1600	93/08/24	0700	1.26	1.3	14.2	65
93/09/13	1000	93/09/15	0500	2.27	2.7	18.6	140
94/02/19	0100	94/02/21	0700	--	6.4	74	650
94/03/05	1200	94/03/06	0500	--	1.2	9	89
94/03/06	1100	94/03/07	0500	--	1.2	5.7	63
94/08/10	1200	94/08/11	1500	--	1.4	12	76
94/09/14	0500	94/09/14	2000	--	.59	5.2	22
			Eagle Creek				
91/04/29	0200	91/04/29	2200	1.81	5.1	2,100	3,800
91/05/05	0800	91/05/05	2230	1.29	1.7	61	210
91/05/15	2130	91/05/17	0200	.85	6.9	3,200	4,700
91/05/31	0900	91/05/31	2000	.50	1.2	250	280
91/07/21	1715	91/07/21	2400	1.99	1.6	220	430
91/08/07	1540	91/08/08	1500	1.88	1.6	62	140
91/10/23	2325	91/10/24	1200	1.21	.88	52	200
91/11/01	0050	91/11/01	2300	2.75	7.0	620	1,400
91/11/17	1900	91/11/18	1200	1.15	1.9	120	250
92/03/01	1100	92/03/02	0400	s/m	1.3	140	220

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Eagle Creek—Continued							
92/03/03	2000	92/03/04	0900	.41	.92	48	130
92/03/09	0100	92/03/09	1300	.82	1.1	72	170
92/04/20	1500	92/04/21	0900	1.24	1.8	210	300
92/05/16	1645	92/05/16	2400	1.54	.66	83.6	160
92/05/21	1730	92/05/21	2200	.51	.24	6.3	22
92/05/22	1815	92/05/23	0300	.44	.47	26	84
92/07/13	1400	92/07/13	2400	1.27	.73	43	80
92/08/01	1900	92/08/02	0200	1.03	.49	16	31
92/09/16	0200	92/09/16	2400	3.99	1.2	1,700	3,300
93/03/26	1200	93/03/27	0200	s/m	1.1	35	87
93/03/29	1100	93/03/29	2400	s/m	9.9	27	42
93/03/30	1300	93/03/31	2100	1.67	4.7	420	610
93/04/11	0200	93/04/12	0600	.79	2.4	50	100
93/04/18	2100	93/04/20	0600	2.22	7.0	450	960
93/04/27	0100	93/04/27	1400	1.02	1.4	74	180
93/06/08	1500	93/06/09	0400	1.47	4.4	950	2,000
93/07/02	0010	93/07/02	1100	1.47	5.5	420	1,100
93/07/03	1400	93/07/04	0600	1.06	6.1	1,500	3,000
93/07/27	1715	93/07/28	0400	.76	1.5	120	220
93/08/09	0600	93/08/09	2000	1.09	2.8	310	540
93/08/15	0400	93/08/15	1800	1.18	2.2	73	160
93/08/18	0900	93/08/18	2100	1.30	3.6	290	640
93/08/30	0400	93/08/30	2000	1.69	4.6	410	1,000
93/09/13	1000	93/09/14	1100	1.72	3.6	120	300
94/02/18	1300	94/02/20	0900	--	12	1,700	3,400
94/03/04	1100	94/03/05	0800	--	3.6	380	790
94/03/05	1100	94/03/06	1000	--	2.9	130	450
94/04/15	0140	94/04/16	0600	--	2.2	67	140
94/04/24	2000	94/04/25	1900	--	2.0	54	110
94/04/26	0010	94/04/27	0200	--	5.2	1,900	2,900
94/07/07	1300	94/07/08	1100	--	1.9	75	170
94/08/10	0110	94/08/11	1000	--	6.0	390	800
94/08/18	0315	94/08/18	2100	--	1.7	95	180
94/08/30	0835	94/08/31	0300	--	1.5	51	110
94/09/13	2035	94/09/15	0300	--	5.5	340	920
94/09/23	1615	94/09/24	1100	--	1.4	30	63

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft³, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
			Joos Valley Creek				
90/08/17	1850	90/08/18	0200	1.37	.96	170	420
90/08/26	0545	90/08/26	1500	1.75	2.8	750	1,600
91/04/29	0200	91/04/29	1600	2.11	1.7	840	1,500
91/05/05	0730	91/05/05	2000	1.25	.64	26	57
91/05/15	2000	91/05/17	0200	1.21	1.8	390	850
91/05/31	0850	91/05/31	1900	.57	.40	36	78
91/07/21	1710	91/07/22	1100	1.24	.68	27	70
91/08/07	1500	91/08/08	1100	2.27	.63	11	34
91/10/23	2250	91/10/24	1300	.83	.34	3.4	12
91/10/31	2200	91/11/01	2200	2.87	2.1	110	330
91/11/17	1800	91/11/18	1400	1.21	.96	14	62
92/03/01	1000	92/03/02	0400	s/m	.63	16	68
92/03/03	1400	92/03/04	0800	.37	.47	1.5	11
92/03/08	2400	92/03/09	1100	.86	.45	20	49
92/04/20	1300	92/04/21	0700	1.24	.77	56	120
92/05/16	1500	92/05/16	2200	1.62	.34	54	110
92/05/21	1700	92/05/21	2400	.74	.22	13	35
92/05/22	1800	92/05/23	0300	.49	.27	12	31
92/06/17	0400	92/06/17	1800	.57	.25	2.8	7.7
92/07/02	0500	92/07/02	1500	.72	.23	4.2	9.2
92/07/13	1300	92/07/14	0200	1.32	.40	7.1	21
92/07/22	1000	92/07/23	0300	1.19	.37	1.4	5.7
92/08/01	1800	92/08/02	1300	1.24	.57	24	73
92/09/16	0100	92/09/16	2200	4.19	5.4	910	1,700
93/03/24	1100	93/03/25	0500	s/m	.38	1.4	14
93/03/26	1300	93/03/27	0200	s/m	.47	8.3	56
93/03/30	1100	93/03/31	2000	1.50	2.1	86	25
93/04/11	0100	93/04/12	0200	.53	.87	4.0	15
93/04/16	1200	93/04/17	0100	.64	.60	4.2	16
93/04/18	2200	93/04/20	0300	2.07	2.7	130	320
93/04/27	0100	93/04/28	0200	1.07	1.5	22	63
93/06/08	1500	93/06/08	2310	1.50	1.8	630	900
93/07/01	2400	93/07/02	0940	1.33	1.2	180	410
93/07/03	1400	93/07/03	2100	.90	2.2	880	1,600
93/07/27	1700	93/07/27	2300	.75	.54	64	130
93/08/09	0600	93/08/09	1400	1.17	.92	110	220

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
			Joos Valley Creek—Continued				
93/08/15	0300	93/08/15	1500	1.19	.73	12	330
93/08/18	0900	93/08/18	0900	1.08	.87	53	140
93/08/30	0300	93/08/30	1300	1.78	1.4	130	290
94/02/18	1200	94/02/20	0800	--	5.7	740	1500
94/03/04	1000	94/03/05	0500	--	1.8	160	350
94/03/05	1100	94/03/06	0800	--	1.3	28	250
94/04/15	0110	94/04/16	0300	--	.84	16	35
94/04/24	2110	94/04/26	2100	--	2.8	670	1,200
94/07/07	1122	94/07/08	1000	--	.77	19	60
94/08/10	0425	94/08/11	1900	--	2.3	130	300
94/08/18	0325	94/08/18	2300	--	.68	22	70
94/08/13	0740	94/08/30	2100	--	.5	5.1	17
94/09/13	2035	94/09/14	2300	--	2.1	150	420
94/09/23	1550	94/09/23	2300	--	.31	4.2	9.5
			Bower Creek				
90/10/17	2040	90/10/20	0925	.38	3.6	12	280
91/03/01	1500	91/03/04	1100	1.05	100	100	--
91/03/05	1700	91/03/08	1500	s/m	12	13	520
91/03/18	1300	91/03/25	0900	s/m	160	160	1,800
91/04/09	1100	91/04/12	2000	s/m	48	48	460
91/04/12	2400	91/04/17	2400	.71	260	260	1,500
91/06/14	0500	91/06/15	1545	1.40	1.2	9.7	70
91/10/29	1000	91/10/31	1400	1.02	1.00	1.8	58
91/11/01	1325	91/11/04	0600	.35	.91	.55	77
91/11/18	0700	91/11/20	0905	.23	.90	.24	32
91/11/29	1805	91/12/02	1610	.78	10	64	590
91/12/12	0825	91/12/14	0700	.61	14	64	700
92/03/29	1500	92/03/31	0940	.28	3.9	5.9	120
92/03/31	1200	92/04/02	1100	.12	3.9	11	150
92/04/10	1700	92/04/13	1535	.43	12	75	440
92/04/15	1200	92/04/18	0935	2.07	34	710	2,900
92/04/19	1355	92/04/20	1815	.19	3.4	11	110
92/04/20	1945	92/04/22	0910	.36	7.2	72	430
92/07/13	1820	92/07/16	0500	.71	.48	.24	13
92/09/16	0725	92/09/17	0520	1.39	.95	2.9	110
92/09/18	0240	92/09/20	0800	1.48	13	97	950

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Bower Creek—Continued							
92/09/26	1000	92/09/30	0510	1.11	3.3	2.7	120
92/11/01	1900	92/11/03	2300	1.27	8.1	40	550
92/11/08	2300	92/11/12	0401	.34	4.1	3.7	130
92/11/12	1200	92/11/14	1001	.34	4.7	6.3	170
92/11/20	0005	92/11/22	0530	1.60	38	270	2,500
92/12/15	0715	92/12/17	2216	1.02	47	180	1,900
92/12/29	0600	92/12/31	2301	s/m	1.6	.77	58
93/03/02	1140	93/03/18	1801	s/m	29	30	1,600
93/03/24	0859	93/03/31	1501	s/m	22	26	1,100
93/04/04	1130	93/04/07	1101	s/m	9.5	22	350
93/04/07	1345	93/04/10	0101	.76	28	290	1,700
93/04/11	1459	93/04/14	0801	s/m	7.4	8.0	230
93/04/15	0559	93/04/19	0301	1.01	46	420	2,400
93/04/19	0900	93/04/23	0801	.49	32	140	1,300
93/04/27	1729	93/04/29	1401	.55	8.5	27	340
93/05/30	1245	93/06/03	0531	.92	4.0	2.5	110
93/06/08	0300	93/06/11	1201	2.51	38	1,100	3,600
93/06/14	0225	93/06/16	0021	.96	6.9	110	480
93/08/05	2300	93/08/08	1700	1.18	1.6	5.1	--
93/10/15	1730	93/10/19	0300	--	1.8	1.4	19
93/10/20	2200	93/10/23	2200	--	2.2	1.5	78
93/11/12	2200	93/11/18	0600	--	3.2	1.2	68
93/11/26	0700	93/11/29	0900	--	2.9	3.6	89
94/02/19	0700	94/02/25	0300	--	78	46	930
94/03/04	1200	94/03/09	2200	--	36	48	770
94/04/12	1500	94/04/14	1000	--	3.3	7.3	65
94/04/15	0245	94/04/17	0900	--	5.9	37	230
94/04/24	2000	94/04/27	0345	--	45	2,200	6,000
94/07/04	0100	94/07/09	2100	--	3.2	6.6	100
Otter Creek							
90/09/06	1940	90/09/08	1845	1.53	1.5	7.1	63
90/09/14	0540	90/09/18	2335	1.67	6.5	26	190
90/11/05	0610	90/11/06	1030	.79	1.2	1.2	20
91/02/03	0300	91/02/08	1400	s/m	10	11	180
91/03/01	1100	91/03/04	1600	s/m	5.3	27	--
91/06/14	1735	91/06/18	0300	2.24	5.2	35	230
91/10/24	1200	91/10/26	1245	1.85	2.0	8.3	57

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft³, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
			Otter Creek—Continued				
91/10/26	1245	91/10/27	2300	.46	1.4	1.6	23
91/10/29	0225	91/10/30	1910	--	2.6	11	83
91/11/01	1200	91/11/03	0005	.53	2.2	8.1	70
91/11/14	1535	91/11/17	0155	.46	2.0	3.0	24
91/11/18	0140	91/11/20	1810	.39	2.7	7.6	45
91/11/29	2015	91/12/02	2235	1.38	6.7	19	150
92/02/27	1200	92/03/01	0900	s/m	4.1	12	110
92/03/01	0900	92/03/03	0900	s/m	4.1	14	130
92/03/05	2100	92/03/08	1100	.37	5.8	15	100
92/03/09	0335	92/03/10	1930	.55	4.8	24	98
92/03/24	1200	92/03/28	0700	s/m	6.0	8.3	82
92/04/10	1800	92/04/13	0500	.81	4.1	19	82
92/04/16	0500	92/04/18	0540	.80	4.5	25	110
92/09/14	1230	92/09/15	0600	1.01	.24	.27	2.8
92/09/16	0950	92/09/17	0640	1.00	.41	1.1	13
92/09/18	0440	92/09/19	0735	1.09	.82	3.1	25
92/09/26	2110	92/09/28	1700	.74	.63	.52	5.2
92/11/01	1600	92/11/03	1600	1.55	2.4	6.5	57
92/11/12	0800	92/11/13	1901	.39	.92	.62	9.3
92/11/19	2300	92/11/22	1701	.84	4.2	16	120
92/11/25	1900	92/11/27	1901	.35	2.7	3.0	53
92/12/15	0520	92/12/17	1301	.97	7.6	32	220
92/12/29	0744	92/12/30	0731	.30	.83	.44	7.8
93/03/24	1050	93/04/01	1201	s/m	29	39	450
93/04/03	1400	93/04/06	0900	s/m	5.7	4.8	58
93/04/08	0035	93/04/09	1833	1.10	12	45	270
93/04/11	1100	93/04/13	1001	.45	6.4	5.3	69
93/04/15	0335	93/04/17	0713	1.43	18	74	420
93/04/19	1505	93/04/21	2152	1.50	20	67	440
93/06/07	1230	93/06/09	2045	2.39	14	140	510
93/07/05	1700	93/07/07	2100	2.04	12	160	580
93/07/09	0300	93/07/10	2200	1.42	8.0	120	410
93/09/13	1045	93/09/16	0700	2.34	2.3	3.7	37
93/09/20	1435	93/09/22	0900	1.49	2.6	12	78
93/12/24	2100	94/01/04	0500	--	18	.0034	.039
94/03/20	1200	94/03/25	0800	--	10	9	85
94/04/24	2200	94/04/27	0800	--	4.1	9.9	70

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft³, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
			Otter Creek—Continued				
94/05/25	1900	94/05/27	2200	--	2.2	34	130
94/08/01	0200	94/08/02	2100	--	.82	.52	8.2
			Kuenster Creek				
92/11/01	1900	92/11/04	0100	1.38	1.0	1.8	36
92/11/19	1600	92/11/22	0100	2.73	2.4	19	300
92/12/15	0200	92/12/17	0400	s/m	1.7	8.2	220
93/03/05	1100	93/03/06	0400	s/m	1.7	85	440
93/03/07	1400	93/03/08	0700	s/m	4.2	2.70	1,200
93/03/08	1400	93/03/09	0800	s/m	3.4	83	560
93/03/15	2300	93/03/17	0900	s/m	6.5	290	920
93/03/25	1200	93/03/26	0900	s/m	9.7	1,100	3,600
93/03/26	1200	93/03/27	0700	s/m	7.8	430	1,400
93/03/27	1200	93/03/28	0500	s/m	6.6	210	1,190
93/03/28	1300	93/03/29	0600	s/m	4.1	91	540
93/03/30	1200	93/03/31	1900	1.78	14	3,000	6,700
93/05/02	1900	93/05/03	1000	1.63	3.8	340	1,400
93/06/17	1800	93/06/18	2000	.72	3.4	100	730
93/06/28	1600	93/06/29	0600	--	1.4	20	80
93/06/29	2300	93/06/30	2200	1.42	5.8	470	1,600
93/07/17	1000	93/07/17	1900	1.07	2.2	170	470
93/08/14	1715	93/08/16	0500	1.00	4.4	120	455
93/08/18	1100	93/08/19	1100	.88	2.4	36	190
94/03/04	1200	94/03/05	0800	--	6	790	2,000
94/03/05	1200	94/03/06	1100	--	3	85	330
94/06/20	0200	94/06/20	1300	--	.47	6.6	49
94/06/23	0600	94/06/24	2200	--	4.9	130	490
94/07/04	0800	94/07/05	1900	--	2.4	95	390
94/07/14	0100	94/07/15	0300	--	2.9	190	140
94/07/20	0000	94/07/21	0200	--	2.1	55	230
			Rattlesnake Creek				
90/01/16	1700	90/01/18	0800	s/m	9.4	150	1,600
90/03/08	0600	90/03/08	1200	s/m	16	1,300	3,600
90/03/11	0500	90/03/12	0200	s/m	4.1	57	480
90/05/09	0115	90/05/10	0100	--	3.2	170	360
90/05/19	0500	90/05/20	2100	--	5.8	83	530
90/06/22	0315	90/06/22	1800	--	3.3	55	180

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Rattlesnake Creek—Continued							
90/08/24	2000	90/08/25	2300	--	7.9	230	1,600
90/08/26	0900	90/08/27	0400	--	5.6	190	940
91/04/12	1100	91/04/13	1900	1.64	14	98	1,000
91/08/07	2000	91/08/08	2300	2.50	8.3	200	4,600
91/11/01	0045	91/11/02	0330	1.55	5.9	59	650
91/11/29	1100	91/11/30	1700	.80	6.2	29	230
92/02/03	1300	92/02/04	0900	s/m	3.7	69	290
92/02/20	1445	92/02/21	0800	s/m	19	2,800	7,600
92/02/22	1400	92/02/23	1635	s/m	14	1,600	4,400
92/02/24	1500	92/02/25	0900	.24	8.6	420	1,700
92/04/20	1300	92/04/21	0900	.91	4.4	34	520
92/06/16	1000	92/06/17	0300	.66	1.3	.44	14
92/09/07	2230	92/09/08	1800	.90	2.3	4.1	180
92/09/14	1400	92/09/15	1800	.84	2.3	2.9	130
92/11/01	1600	92/11/03	1000	1.25	3.7	3.3	64
92/11/19	2000	92/11/21	2200	2.68	10	68	1,300
92/12/15	0100	92/12/17	0400	.91	7.6	27	510
93/03/03	0300	93/03/05	0600	.27	16	2,100	4,000
93/03/05	1400	93/03/06	0800	s/m	7.7	330	1,700
93/03/06	1500	93/03/07	0800	s/m	4.8	120	1,500
93/03/07	1400	93/03/08	1000	s/m	19	610	4,700
93/03/08	1300	93/03/09	0900	s/m	18	380	3,600
93/03/16	0030	93/03/17	0600	s/m	31	1,400	4,200
93/03/24	1600	93/03/26	1100	s/m	63	4,300	14,000
93/03/26	1101	93/03/27	1000	s/m	31	420	3,000
93/03/27	1200	93/03/28	0800	s/m	26	840	4,300
93/03/28	1300	93/03/29	0900	s/m	15	240	1,700
93/03/30	1300	93/03/31	2000	1.67	43	4,400	14,000
93/05/02	2100	93/05/03	1500	1.64	17	500	2,600
93/06/07	1000	93/06/08	1900	1.53	13	260	1,100
93/06/13	2100	93/06/14	2100	1.01	5.0	29	170
93/06/17	1900	93/06/18	1500	1.25	13	690	2,700
93/06/28	0600	93/06/28	1500	.71	4.7	160	570
93/06/29	2300	93/06/30	1800	1.36	19	1,300	4,400
93/07/05	1200	93/07/06	1500	1.69	19	470	3,000
93/07/08	2330	93/07/09	2000	2.35	71	8,700	25,000
93/07/10	1600	93/07/12	0400	2.39	78	8,500	24,000

Appendix 1. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–93—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Rattlesnake Creek—Continued							
93/07/17	0900	93/07/18	0200	0.97	12	480	1,700
93/08/14	1700	93/08/15	0545	.97	6.5	130	590
93/08/15	0900	93/08/16	0100	.74	10	150	810
93/08/18	1300	93/08/19	0600	1.00	11	220	1,200
94/02/18	1600	94/02/21	0800	--	160	4200	15000
94/03/04	1300	94/03/05	0900	--	27	1900	6300
94/03/05	1100	94/03/06	0900	--	13	290	1600
94/06/20	0100	94/06/20	1900	--	2.7	20	83
94/06/23	0700	94/06/24	2300	--	16	520	2200
94/07/04	0700	94/07/05	1800	--	7.8	170	870
94/07/14	0200	94/07/14	2000	--	6.4	320	280
94/07/20	0015	94/07/20	1700	--	5.5	140	730

[1]Water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year starting October 1, 1992, and ending September 30, 1993, is called "water year 1993."

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94

[yr, year; mo, month; d, day; h, hour; in., inches; Mft³, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm				Loads					
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Lincoln Creek											
93/03/22	2235	93/03/24	0800	s/m	14.0	120	350	0.62	22	42	140
93/03/24	1030	93/03/26	1800	s/m	4.5	1.7	25	<.056	2.2	1.1	13
93/03/31	0800	93/04/02	0700	s/m	15.0	71	200	.58	20	29	120
93/04/02	0844	93/04/05	0730	s/m	6.5	3.6	20	.12	3.2	2.8	18
93/04/19	1220	93/04/21	0400	1.94	36.0	400	880	1.8	47	180	360
93/04/29	0300	93/04/29	1645	.55	3.7	12	56	.12	4	6.1	23
93/05/22	2200	93/05/24	0845	.35	3.1	21	57	.078	3.7	4.7	17
93/05/30	0800	93/05/31	0745	.53	3.4	12	44	<.042	3.3	4.2	17
93/06/04	1910	93/06/05	1500	.26	1.6	1.7	12	.04	.9	.9	4.3
93/06/07	1215	93/06/08	0215	1.98	19.0	12	190	.35	16	9.3	52
93/06/08	0215	93/06/08	0615	.32	3.2	11	.018	.03	1.3	1.9	6.6
93/06/14	0150	93/06/14	1930	.69	5.2	24	72	.13	4.6	5.9	28
93/06/17	1950	93/06/18	1245	.73	5.6	38	100	.21	7.3	15	45
93/06/19	1755	93/06/20	1040	.05	7.9	40	130	.15	6.9	14	46
93/06/30	0250	93/06/30	1745	.38	2.0	4.4	22	.025	1.2	1.5	7.8
93/07/03	2035	93/07/04	0330	.52	4.1	54	110	.20	7.9	18	61
93/07/05	2125	93/07/06	1145	.55	3.9	18	51	.12	3.6	6.8	23
93/07/08	1440	93/07/09	2400	1.06	8.5	25	96	.16	5.9	9.1	41
93/07/13	1900	93/07/14	1030	.51	3.5	9	41	--	2.8	3.7	18
93/07/25	0110	93/07/25	1245	.41	2.7	20	57	.12	4.5	7.2	25
93/08/09	1140	93/08/09	2000	.23	1.1	2.5	16	.021	1.1	1.3	5.9
93/08/15	0825	93/08/16	0400	.58	3.4	22	86	.13	5.6	8.4	32
93/08/30	1600	93/08/31	0215	1.88	17.0	8.5	64	<.21	11	4.3	30
93/09/13	0900	93/09/15	0655	1.79	13.0	58	180	.21	12	20	84
93/09/20	0900	93/09/21	1045	.72	5.6	28	81	.14	5.6	8.8	35
93/11/12	2020	93/11/13	0800	.40	2.0	12.0	91	0.063	3.4	4.3	19
93/11/14	1945	93/11/15	0445	.22	1.1	3.0	24	.021	1.1	1.0	6.1
93/11/25	1505	93/11/26	1745	.66	4.0	7.4	44	<.049	3.0	2.5	16
93/12/01	2100	93/12/02	0630	.16	1.5	2.5	18	.055	1.7	2.0	10

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft³, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm				Loads					
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Lincoln Creek—Continued											
94/03/20	1800	94/03/21	0930	.52	4.5	57	150	.45	18	34	99
94/04/30	1415	94/05/01	1900	.13	2.4	5.1	20	.056	2.3	2.7	12
94/05/11	0445	94/05/11	1030	.48	2.8	2.1	19	.044	1.6	1.5	7.7
94/06/20	0130	94/06/20	0745	.38	2.8	55	180	.38	14	21	68
94/06/23	1215	94/06/24	1700	1.40	8.8	83	190	.31	14	19	71
94/06/25	2300	94/06/26	1430	.46	3.0	24	110	.22	8.8	8.3	40
94/06/28	0500	94/06/28	0945	.12	.64	11	35	.074	2.6	3.7	14
94/07/07	1630	94/07/08	0545	1.13	10.0	1.8	8	.016	.52	.8	3.5
94/07/14	0345	94/07/14	1930	.63	4.1	110	220	.39	12	27	85
94/07/20	0220	94/07/20	0930	.41	2.1	14	46	.1	3.8	5.1	21
94/08/01	0230	94/08/01	0940	.30	1.9	8.8	36	.053	2.7	3.5	23
94/08/03	1530	94/08/04	0930	1.28	9.5	14	47	.058	3.0	3.7	19
94/08/10	1100	94/08/11	0500	.39	1.4	100	190	.35	14	27	83
94/08/12	2345	94/08/13	1715	.77	5.8	1.1	9.7	<.018	1.2	0.61	3.4
94/08/19	1345	94/08/19	2345	.45	2.5	42	120	.29	8.0	13	44
94/08/30	1215	94/08/30	2100	.47	2.2	13	37	.062	2.8	5.1	17
94/09/26	1400	94/09/27	0100	.63	3.7	13	40	.13	3.4	4.3	18
94/11/05	1555	94/11/06	1500	1.07	7.7	41	190	.2	9.6	14	58
94/11/27	0920	94/11/28	0210	.84	4.6	18	80	.12	5.1	6.8	31
95/01/13	2120	95/01/14	2230	.70	6.7	30	180	.29	12	16	76
Menomonee River											
91/06/14	**1500**	**91/06/18**	**1900**	**1.49**	**76**	**240**	**630**	**--**	**--**	**--**	**--**
91/06/22	0300	91/06/22	2250	--	6.3	13	62	--	--	--	--
91/07/01	**1600**	**91/07/03**	**0320**	**--**	**35**	**240**	**530**	**--**	**--**	**--**	**--**
91/07/07	**1615**	**91/07/08**	**0700**	**--**	**12**	**74**	**190**	**--**	**--**	**--**	**--**
91/07/12	**0730**	**91/07/13**	**1150**	**--**	**33**	**240**	**630**	**--**	**--**	**--**	**--**
91/07/18	1720	91/07/18	2120	--	2.1	9.4	45	--	--	--	--
91/07/21	**0520**	**91/07/22**	**1810**	**.56**	**26**	**100**	**310**	**--**	**--**	**--**	**--**
91/07/29	0500	91/07/29	1355	--	3.0	1.7	14	--	--	--	--

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft³, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm				Loads					
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Menomonee River—Continued											
91/08/08	**0550**	**91/08/10**	**2115**	**1.61**	**63**	**210**	**560**	**--**	**--**	**--**	**--**
91/09/09	1830	91/09/10	0535	--	9.8	57	210	--	--	--	--
91/09/11	**2325**	**91/09/13**	**1215**	**1.29**	**37**	**130**	**390**	**.45**	**24**	**47**	**140**
91/09/14	**0100**	**91/09/17**	**0020**	**.56**	**48**	**110**	**330**	**.43**	**19**	**27**	**110**
91/10/04	0100	91/10/09	0545	2.60	110	290	1,400	1.2	81	92	450
91/10/13	**2130**	**91/10/15**	**0700**	**--**	**8.0**	**1.7**	**20**	**<.057**	**7.1**	**2.5**	**8.8**
91/10/28	1615	91/11/05	1730	.62	160	210	1,400	<2.1	74	84	360
92/03/16	1800	92/03/20	0330	s/m	65	66	310	<.88	31	35	140
92/03/23	1130	92/04/01	2200	s/m	170	32	320	<3.7	<58	43	450
92/04/15	0720	92/04/23	0800	s/m	190	400	1,200	3	<40	<120	<470
92/05/11	**2115**	**92/05/14**	**0730**	**--**	**20**	**16**	**100**	**<.18**	**9.1**	**9.1**	**30**
92/06/14	0200	92/06/14	2100	--	4.6	12	80	<.047	3.1	2.8	12
92/06/17	1030	92/06/19	0100	.74	28	270	810	1.6	43	86	250
92/07/08	0900	92/07/10	1400	--	21	140	540	.91	29	44	160
92/07/12	1130	92/07/16	0900	2.10	84	440	1,300	<2.2	71	110	410
92/08/12	0800	92/08/13	2100	.89	13	38	130	--	11	11	46
92/08/25	2200	92/08/29	1900	.71	46	150	680	--	39	51	190
92/09/09	0700	92/09/11	1100	.88	27	140	570	--	33	62	180
92/09/14	1320	92/09/16	1355	.56	23	140	470	--	22	52	150
92/09/16	**1355**	**92/09/20**	**1500**	**--**	**76**	**210**	**610**	**--**	**33**	**61**	**200**
92/11/01	0600	92/11/05	2100	2.59	150	440	2,300	--	110	100	480
92/11/19	1745	92/11/25	1520	1.05	160	170	1,000	--	60	<60	300
92/12/15	**0700**	**92/12/17**	**0330**	**.93**	**78**	**170**	**720**	**--**	**50**	**62**	**250**
93/03/01	1100	93/03/04	1225	s/m	33	33	210	--	24	17	98
93/03/05	1225	93/03/07	1400	s/m	34	46	310	--	17	13	73
93/03/16	0300	93/03/17	0500	s/m	25	44	250	--	22	19	97
93/03/22	1000	93/03/25	0700	s/m	150	640	2,200	--	130	170	740
93/03/25	0905	93/03/27	1550	s/m	100	66	880	--	44	<19	150
93/03/27	1550	93/03/29	1240	s/m	82	51	510	--	21	15	110

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm			Loads						
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Menomonee River—Continued											
93/03/29	1240	93/03/31	0650	s/m	73	46	410	--	18	<14	100
93/03/30	0830	93/04/01	0330	s/m	120	400	1,500	--	90	110	430
93/04/14	1500	93/04/19	0000	s/m	400	980	3,300	--	<170	260	810
93/04/19	1300	93/04/24	0300	4.13	590	2,400	7,000	--	320	620	1,600
93/04/29	0345	93/05/01	0700	.58	54	48	310	--	23	23	93
93/05/22	2150	93/05/24	1600	.26	22	35	170	--	10	12	32
93/05/30	0945	93/06/01	1900	.44	32	54	260	--	17	17	70
93/06/04	1900	93/06/07	1145	.62	25	26	180	--	9	12	39
93/06/07	1200	93/06/12	1700	1.87	310	1,200	6,200	--	<180	<310	960
93/06/19	1805	93/06/22	0200	1.82	120	420	1,500	--	67	94	380
93/06/30	0250	93/07/01	0700	.51	15	36	170	--	9.4	11	48
93/07/05	**2115**	**93/07/07**	**1245**	**.41**	**36**	**130**	**430**	**--**	**24**	**41**	**140**
93/07/08	1500	93/07/13	1930	2.36	240	1,000	4,000	--	160	250	980
93/08/30	**0300**	**93/09/03**	**0900**	**1.86**	**120**	**200**	**830**	**<1.3**	**42**	**69**	**260**
93/09/13	**1000**	**93/09/18**	**0525**	**1.28**	**93**	**250**	**770**	**1.2**	**49**	**71**	**1,000**
93/11/12	2020	93/11/14	0200	.44	12	34	250	.24	9.0	9.8	53
Monroe Street detention pond											
92/03/16	1755	92/03/17	0300	.31	.03	.77	1.8	.0041	.089	.2	.7
92/03/22	1300	92/03/23	1000	s/m	.017	.1	.31	.0011	.022	.04	.15
92/03/28	2200	92/03/29	1500	.26	.022	.065	.41	.00055	.025	.038	.15
92/04/08	**2000**	**92/04/09**	**0900**	**.32**	**.055**	**2.2**	**4.2**	**.0048**	**.17**	**.38**	**1.2**
92/04/15	**0500**	**92/04/15**	**0850**	**.43**	**.042**	**1.8**	**3.6**	**.005**	**.16**	**.42**	**1.1**
92/05/11	1645	92/05/11	1900	.21	.018	.65	2.9	.0018	<.0034	.15	.50
92/06/17	1158	92/06/17	1600	.56	.088	5.1	11	.0088	.24	.77	2.5
92/07/02	0809	92/07/02	1100	.23	.019	.19	.99	.00093	.03	.08	.28
92/07/02	**1356**	**92/07/02**	**1900**	**.86**	**.14**	**6.7**	**11**	**.0096**	**.25**	**.96**	**2.1**
92/07/08	0800	92/07/08	1200	1.11	.18	8.1	9.8	.012	.33	1.0	2.6
92/12/30	**0645**	**92/12/31**	**0400**	**s/m**	**.065**	**.15**	**1.7**	**--**	**--**	**--**	**.41**
93/03/03	1224	93/03/04	0730	s/m	.036	.16	.54	--	--	--	.27

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm			Loads						
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Monroe Street detention pond—Continued											
93/03/05	1327	93/03/05	2330	s/m	.016	.038	.61	--	--	--	.069
93/03/06	1100	93/03/07	0430	s/m	.041	.14	2.1	--	--	--	.20
93/03/07	1304	93/03/08	0300	s/m	.038	.076	2.6	--	--	--	.16
93/03/08	1333	93/03/08	2200	s/m	.021	.024	1.4	--	--	--	.097
93/03/22	2339	93/03/24	0030	s/m	.22	.9	3.9	--	--	--	1.8
93/04/14	1034	93/04/14	2115	s/m	.011	.044	.22	--	--	--	.075
93/04/14	2310	93/04/16	2130	2.33	.41	3.4	7.1	.013	.26	.77	2.2
93/05/01	2112	93/05/02	1300	.62	.061	.27	1.8	--	--	--	.35
93/05/22	1922	93/05/23	0015	.20	.014	.082	.63	--	--	--	.11
93/05/23	1344	93/05/24	1245	.35	.048	.44	1.5	--	--	--	.36
93/05/30	0408	93/05/30	1700	.90	.097	.51	2.9	--	--	--	.66
93/06/02	1226	93/06/03	1200	.46	.037	.065	.76	--	--	--	.18
93/06/07	1058	93/06/08	0000	2.63	.38	9.0	19	--	--	--	4.0
93/06/24	1949	93/06/25	1000	.87	.1	1.5	4.2	--	--	--	.75
93/06/30	0022	93/06/30	0400	.63	.073	.45	1.7	--	--	--	.50
93/07/05	0524	93/07/05	2345	3.61	.065	13.	23	--	--	--	5.7
93/07/09	0113	93/07/09	0900	1.71	.3	6.4	9.3	--	--	--	2.8
93/07/25	**0249**	**93/07/25**	**0930**	**1.59**	**.26**	**4.2**	**8.5**	**.0066**	**.16**	**.69**	**1.8**
93/08/15	0527	93/08/15	1415	2.15	.31	2.4	8.2	.0058	.077	.46	1.4
93/09/13	0920	93/09/14	1100	2.84	.30	3.3	7.3	.0065	.24	.53	2.1
93/10/20	**1845**	**93/10/20**	**2130**	**.18**	**.0084**	**.02**	**2.0**	**.00021**	**.0094**	**.0073**	**.068**
93/11/12	1934	93/11/12	2200	--	.034	.12	4.5	.0011	.034	.047	.30
94/03/20	2356	94/03/21	0630	--	.036	.61	2.0	.0038	.088	.22	.68
94/04/12	0918	94/04/12	1445	--	.074	1.1	4.1	.0055	.17	.31	1.2
94/04/25	0600	94/04/26	0730	--	.054	.93	5.1	.004	.12	.24	.78
94/04/30	1049	94/04/30	2315	s/m	.063	.09	.94	<.00078	.031	.051	.20
94/05/07	0520	94/05/07	1100	.24	.032	.11	.79	.00059	.024	.039	.16
94/05/14	1403	94/05/15	0445	.24	.029	.24	1.6	.0009	.034	.058	.27
94/05/23	1823	94/05/23	2200	.27	.042	.61	5.3	.0021	.075	.10	.65

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm				Loads					
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Monroe Street detention pond—Continued											
94/06/11	1514	94/06/11	1630	.21	.044	2.5	6.0	<.00054	.014	.014	1.2
94/06/13	0131	94/06/13	0545	.28	.038	.13	1.1	.00072	.029	.031	.16
94/06/18	1737	94/06/19	0300	.67	.14	2.5	6.8	.0053	.17	.38	1.5
94/06/23	0825	94/06/24	0600	1.69	.30	2.5	7.3	.0075	.19	.43	1.7
94/07/03	2323	94/07/04	2330	.75	.13	2.3	7.3	.0075	.18	.66	1.5
94/07/07	1434	94/07/08	0730	.48	.085	2.8	5.3	.0048	.11	.46	1.1
94/07/17	0446	94/07/17	0800	.18	.04	1.2	1.7	.002	.06	.12	.45
94/07/20	0047	94/07/20	0900	.46	.072	.38	2.0	.0018	.05	.11	1.3
94/08/03	1338	94/08/03	2345	1.46	.21	3.9	13.0	.012	.29	.91	2.8
94/08/18	0515	94/08/18	1315	.55	.11	2.6	6.7	.0049	.13	.46	1.2
94/09/14	0522	94/09/14	1330	.44	.11	.97	3.5	.0028	.083	.19	.9
94/11/05	1621	94/11/06	1145	.60	.11	.81	13.0	.0029	.10	.31	.94
94/11/13	1809	94/11/14	0800	.22	.032	.25	2.2	.0009	.036	.058	.30
94/11/20	2211	94/11/21	1545	.47	.062	.40	2.0	.001	.043	.066	.35
94/12/05	**0135**	**94/12/05**	**1445**	**.07**	**.005**	**.012**	**.12**	**.000066**	**.0054**	**.005**	**.022**
Nine Springs storm sewer											
90/11/21	0225	90/11/21	0417	.24	.0032	.011	.054	--	--	--	--
90/11/27	0515	90/11/27	0710	.28	.012	.21	.45	--	--	--	--
90/11/27	**1531**	**90/11/27**	**1755**	**.14**	**.0027**	**.014**	**.06**	**--**	**--**	**--**	**--**
90/12/12	1209	90/12/12	1512	s/m	.00028	.0011	.0059	--	--	--	--
91/02/04	1334	91/02/04	1622	s/m	.0013	.01	.047	--	--	--	--
91/03/01	0939	91/03/02	0918	1.56	.12	.57	3.5	--	--	--	--
91/03/17	1406	91/03/18	0334	.35	.045	.095	.7	--	--	--	--
91/03/22	**1837**	**91/03/23**	**0330**	**.52**	**.12**	**3.3**	**7.5**	**--**	**--**	**--**	**--**
91/03/26	0309	91/03/26	0738	.14	.016	.043	.19	--	--	--	--
91/03/26	2320	91/03/27	1539	.94	.19	2.0	5.2	--	--	--	--
91/04/08	1326	91/04/09	2344	1.22	.21	.51	2.3	--	--	--	--
91/04/12	0933	91/04/13	0019	1.27	.36	1.1	4.3	--	--	--	--
91/04/13	1840	91/04/14	1249	.89	.2	.31	.087	--	--	--	--

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm				Loads					
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Nine Springs storm sewer—Continued											
91/05/05	0717	91/05/05	1454	.73	.098	.15	.92	--	--	--	--
91/05/17	1908	91/05/17	2011	--	.0042	.016	.2	.00032	.014	.0058	.12
91/05/18	1051	91/05/18	1533	.71	.13	.48	1.9	.0033	.15	.12	.91
91/05/21	1608	91/05/21	1739	.15	.026	.25	.69	.002	.043	.053	.58
91/05/25	**1529**	**91/05/25**	**1614**	**--**	**.0024**	**.0059**	**.043**	**.00018**	**.0046**	**.0028**	**.04**
91/06/10	1541	91/06/10	1822	.34	.044	.39	1.5	.0031	.094	.10	1.1
91/06/12	0253	91/06/12	0549	.40	.059	.29	1.0	.003	.063	.082	.59
91/06/13	2257	91/06/14	0159	.28	.039	.16	.64	.0015	.037	.047	.47
91/07/01	1702	91/07/01	1821	.17	.018	.19	.53	.0021	.062	.053	.49
91/07/21	**0503**	**91/07/21**	**1259**	**2.16**	**.86**	**8.6**	**18.0**	**.048**	**1.2**	**1.9**	**14**
91/08/07	**0621**	**91/08/07**	**0744**	**--**	**.010**	**.12**	**.45**	**--**	**--**	**--**	**--**
91/08/16	2233	91/08/17	0056	.15	.017	.059	.39	--	--	--	--
91/09/03	0947	91/09/03	1125	.10	.013	.11	.53	--	--	--	--
91/09/09	2303	91/09/10	0041	.45	.025	.033	.43	.0029	.034	.019	.48
91/09/11	1853	91/09/12	0807	1.05	.25	.30	3.0	-.0022	.045	.078	.60
91/09/14	**0551**	**91/09/15**	**0921**	**1.69**	**.35**	**1.4**	**1.1**	**.011**	**.14**	**.21**	**1.3**
91/09/15	2340	91/09/16	0314	.25	.037	.023	.21	-.00046	.012	.0093	.11
91/09/17	2017	91/09/18	0424	.46	.077	.055	.48	.0014	.024	.024	.45
91/09/24	1214	91/09/24	1557	.15	.014	.051	.28	.001	.02	.021	.23
91/10/03	2241	91/10/04	0044	.14	.013	.081	.36	.00039	.014	.011	.16
91/10/04	0923	91/10/05	1016	.92	.19	.47	3.0	.0059	.21	.18	1.4
91/10/13	1935	91/10/13	2202	.16	.014	.022	.4	.00017	.016	.0095	.12
91/10/26	0902	91/10/26	1535	.52	.10	.088	.78	.002	.25	.072	<.065
91/10/28	1549	91/10/29	1449	.53	.11	.16	.95	.0034	.068	.075	.82
91/10/31	1335	91/11/01	1532	1.04	.27	.50	.56	.0048	.13	.19	1.4
91/11/14	1252	91/11/15	0648	.66	.11	.27	1.6	.007	.21	.19	1.3
91/11/17	1653	91/11/18	0515	.63	.11	.15	.93	.0036	.086	.16	.79
91/12/12	0235	91/12/12	1719	.58	.10	.42	2.0	.007	.22	.28	1.3
92/01/08	2131	92/01/09	0224	.20	.034	.23	.82	.0032	.084	.13	.61

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm			Loads						
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Nine Springs storm sewer—Continued											
92/03/09	**0147**	**92/03/09**	**1533**	**.26**	**.046**	**.62**	**1.5**	**.008**	**.15**	**.23**	**1.2**
92/03/28	2217	92/03/29	0456	.28	.023	.049	.23	.00087	.02	.032	.20
92/04/08	1945	92/04/09	0208	.31	.032	.079	.34	.001	.036	.044	.32
92/04/15	0456	92/04/15	0737	.40	.046	.46	1.1	.0046	.12	.17	1.1
92/04/15	2046	92/04/15	2233	.13	.02	.25	.57	.0027	.044	.086	.52
92/04/16	0621	92/04/16	1139	.23	.038	.11	.50	.0017	.036	.05	.41
92/04/18	2317	92/04/19	0525	.60	.11	1.4	3.2	.0095	.20	.41	2.0
92/04/23	1216	92/04/23	1730	.24	.031	.11	.43	.0016	.039	.047	.37
92/05/11	1644	92/05/11	1815	.16	.017	.22	.88	.0032	.076	.07	.84
92/06/17	1200	92/06/17	1409	.36	.043	.70	1.7	.0045	.13	.21	1.1
92/06/24	0644	92/06/24	0758	--	.0097	.11	.3	.00085	.028	.04	.26
92/07/02	0810	92/07/02	1722	--	.084	.39	1.4	.0047	.11	.13	1.3
92/07/08	0758	92/07/08	1210	.97	.19	2.2	4.4	.012	.36	.51	2.4
92/07/13	0709	92/07/14	0001	1.26	.28	.57	2.5	.0052	.17	.21	1.4
92/07/16	0221	92/07/16	0449	.16	.017	.016	.18	.00022	.015	.014	.12
92/08/29	0400	92/08/29	0939	.98	.20	.49	2.2	--	.099	.16	1.2
92/09/06	0213	92/09/06	0838	.64	.10	.17	1.1	--	.045	.07	.77
92/09/09	0531	92/09/09	0955	.48	.076	.20	.86	--	.053	.067	.67
92/09/16	1221	92/09/16	1717	.94	.22	.37	6.6	--	.18	.33	1.7
92/09/17	0419	92/09/17	0937	.62	.17	.63	3.0	--	.22	.21	1.0
92/09/18	0332	92/09/18	0817	.44	.084	.19	1.2	--	.063	.063	.49
92/10/15	1756	92/10/16	0130	.47	.084	.16	1.0	--	.042	.057	.63
92/11/01	2225	92/11/02	0513	.16	.034	.019	.21	--	.015	.0084	.18
92/11/12	0600	92/11/12	1401	.20	.027	.13	.56	--	.04	.06	.53
92/11/19	1515	92/11/21	0711	2.45	.51	1.6	6.9	--	.34	.49	5.0
92/11/22	1412	92/11/22	2315	.53	.12	.17	1.0	--	.062	.07	.67
92/12/15	0259	92/12/16	0319	1.28	.25	.97	3.9	--	.50	.48	3.1
92/12/29	0126	92/12/29	0914	.36	.06	.09	.78	--	.075	.06	.67
92/12/30	0454	92/12/30	1233	.22	.033	.074	.74	--	.045	.045	.35

Appendix 2. Storm-load data for urban watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1991–94—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data; text in bold indicates storm coverage less than 80 percent]

Start of storm		End of storm				Loads					
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended solids (tons)	Phosphorus (lb)	Total cadmium (lb)	Total copper (lb)	Total lead (lb)	Total zinc (lb)
Nine Springs storm sewer—Continued											
93/01/23	1122	93/01/23	2313	s/m	.031	.04	.40	--	.054	.025	.29
93/03/02	**0805**	**93/03/02**	**2004**	**s/m**	**.018**	**.086**	**.53**	**--**	**.054**	**.049**	**.35**
93/03/03	1105	93/03/03	2358	s/m	.036	.12	.88	--	.07	.05	.41
93/03/05	1219	93/03/05	1948	s/m	.018	.039	.52	--	.022	.014	.14
93/03/06	1126	93/03/06	2001	s/m	.03	.047	.89	--	.028	.013	.15
93/03/07	1157	93/03/07	2215	s/m	.026	.02	.90	--	.023	.0066	.11
93/03/08	1122	93/03/08	1843	s/m	.016	.024	.49	--	.013	.0081	.078
93/03/16	0034	93/03/16	1900	s/m	.065	.23	1.5	--	.11	.089	.65
93/03/22	0948	93/03/22	1628	s/m	.016	.14	.5	--	.059	.075	.38
93/03/22	2254	93/03/25	0313	s/m	.30	1.1	5.1	--	.43	.64	3.7
93/03/31	0237	93/03/31	2236	1.55	.38	2.9	8.0	--	.76	.90	5.7
93/04/19	1035	93/04/20	1558	1.50	.33	1.1	3.5	--	.25	.38	2.5
93/05/01	1913	93/05/02	0716	.75	.13	.48	2.3	--	.13	.18	1.3
93/05/30	0315	93/05/30	2243	.96	.17	.25	1.6	--	.11	.095	1.2
93/06/02	1049	93/06/03	2051	.40	.079	.16	.79	--	.064	.074	.84
93/06/07	1007	93/06/07	2111	1.71	.55	5.0	20	--	.66	.97	5.5
93/06/24	1908	93/06/25	0458	.89	.14	.45	1.5	--	.09	.081	.89
93/06/29	2352	93/06/30	0723	.65	.12	.24	1.1	--	.061	.038	.76
93/10/20	1744	93/10/21	0046	.17	.02	.033	.66	--	.02	.011	.27

[1]Water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year starting October 1, 1992, and ending September 30, 1993, is called "water year 1993."

Appendix 2.1 Uncertainty in Urban Storm-Load Data

For each storm load listed in appendix 2, there is an associated uncertainty. Errors in measurement of discharge, sampling technique, sample processing and sample analysis all contribute to uncertainty in the final load. The following discussion addresses these errors and describes how their probable magnitude was used to estimate error in the final load.

The load is calculated as the product of event mean concentration and stormflow volume, so error in any particular load will include error from stormflow volume and error from event mean concentration. These errors are defined as follows:

$$\eta_c = \frac{\hat{C}}{C_t}$$

and

$$\eta_S = \frac{\hat{S}}{S_t},$$

where η_C is the error term for concentration, $\hat{C}$ is the estimated concentration, C_t is the true concentration, η_S is the error term for stormflow volume, $\hat{S}$ is the estimated stormflow volume, and S_t is the true stormflow volume. It follows that the error of the load is defined as

$$\eta_L = \eta_C \eta_S = \frac{\hat{C}\hat{S}}{C_t S_t}$$

For the purpose of this study, and because η_C and η_S have a lower limit of zero, η_C and η_S are assumed to be distributed lognormally, hence, η_L would also be lognormal. In general, the errors presented above have two components: a systematic component, termed bias, and a random component, termed precision. There was insufficient data collected to determine the bias of η_L; hence the errors were assumed to be unbiased. The precision was estimated as the variance of η_L, which is determined by adding the variances of η_C and η_S in log space.

The variance of η_S must be estimated separately for each site. The 95-percent confidence interval has been estimated by USGS personnel for error in discharge records (Holmstrom and others, 1993–95), and therefore for stormflow volume. For the lognormal distribution, the log-space standard deviation of the error in stormflow volume can be estimated by solving the following for β_{η_S}:

$$I_{95} = \exp(1.96\beta_{\eta_S}) - \exp(-1.96\beta_{\eta_S})$$

where β_{η_S} is the log-space standard deviation of η_S, and I_{95} is the 95-percent confidence interval for the stormflow error.

The variance of η_C must be estimated separately for each analyte. In determining the variance of η_C, sample-processing duplicates, field blank samples, laboratory blanks, and laboratory duplicates were considered. Data were insufficient to consider how well point samples collected during this study represent actual concentrations from the entire profile of the stream or storm sewer.

The variance of the error in concentration for each pair of sample-processing duplicates (Box and others, 1978) is

$$V[\eta_{PDi}] = \frac{2(C_{1i} - C_{2i})^2}{(C_{1i} + C_{2i})^2},$$

where $V[\eta_{PDi}]$ is the variance of the error in the *i*th pair of duplicates, C_{1i} and C_{2i} are the concentrations of the *i*th pair of duplicates. The estimate of variance in concentration error from sample processing duplicates, $V[\eta_{PD}]$, is the average of the variance of all pairs of duplicates (Box and others, 1978) or

$$V[\eta_{PD}] = 1/n \sum_{i=1}^{n} \frac{2(C_{1i} - C_{2i})^2}{(C_{1i} + C_{2i})^2},$$

where n is the number of duplicate pairs.

The variance for the constituents in field blank samples was calculated directly from constituent concentrations in the field blanks. Variance of laboratory blanks were obtained directly from the Wisconsin State Laboratory of Hygienė (WSLH). The laboratory duplicate tolerance, obtained from the WSLH, was considered to be a 99-percent confidence interval. As with stormflow volume, the log-space standard deviation of the error in laboratory duplicates η_{LD} can be estimated by solving the following for $\beta_{\eta LD}$:

$$I_{99} = \exp(2.58\beta_{\eta LD}) - \exp(-2.58\beta_{\eta LD}),$$

where $\beta_{\eta LD}$ is the log-space standard deviation of η_{LD} and I_{99} is the 99 percent confidence interval for the laboratory duplicate tolerance.

Because sample-processing duplicates include all sample-processing and laboratory procedures, variance in sample-processing duplicates should include variance inherent in field blanks, laboratory duplicates, and laboratory blanks; therefore, variance in sample processing duplicates should be greater than or equal to variance from field blanks, laboratory duplicates, and laboratory blanks. This was true for suspended solids, total phosphorus, cadmium, copper, and lead; however variance in laboratory duplicates was greater than variance from sample processing duplicates for zinc. Consequently, variance in sample-processing duplicates was used to estimate variance in error of concentration for all analytes except zinc, for which variance in laboratory duplicates was used. Final real space standard deviations are shown in table 1.

Table 1. Standard deviation of error for constituents used to estimate storm-load data from urban watershed-management evaluation monitoring sites, Wisconsin, water years 1991–95
[standard deviation (s.d.) in percent of true concentration]

Constituent	s.d.	Constituent	s.d.
Suspended solids	12	Total copper	7.1
Total phosphorus	6.8	Total lead	7.8
Total cadmium	17	Total zinc	3.9

The variance of the load of each analyte, $V[\eta_L]$, was determined by transforming $V[\eta_C]$ and $V[\eta_S]$ to log space and summing the two. $V[\eta_C]$ and $V[\eta_S]$ are transformed to log space using the following equation:

$$\beta^2 = \ln\left(1 + \frac{\sigma^2}{\mu^2}\right),$$

where β^2 is the variance in log-space, σ^2 is the variance in real space, and μ is the mean in real space. μ was calculated by trial and error assuming the mean in log space to be 0 (unbiased errors) and using the equation:

$$\mu^4 = \left(\sigma^2 + \mu^2\right)$$

The upper and lower limits of the 95-percent confidence interval in log space are 1.96β and -1.96β, expressed as a fraction of the true load. To transform back to real space and determine the 95-percent confidence limits of the estimated loads, the following equations were used:

$$L_{+95} = \exp(1.96\beta_{\eta L}) - 1$$

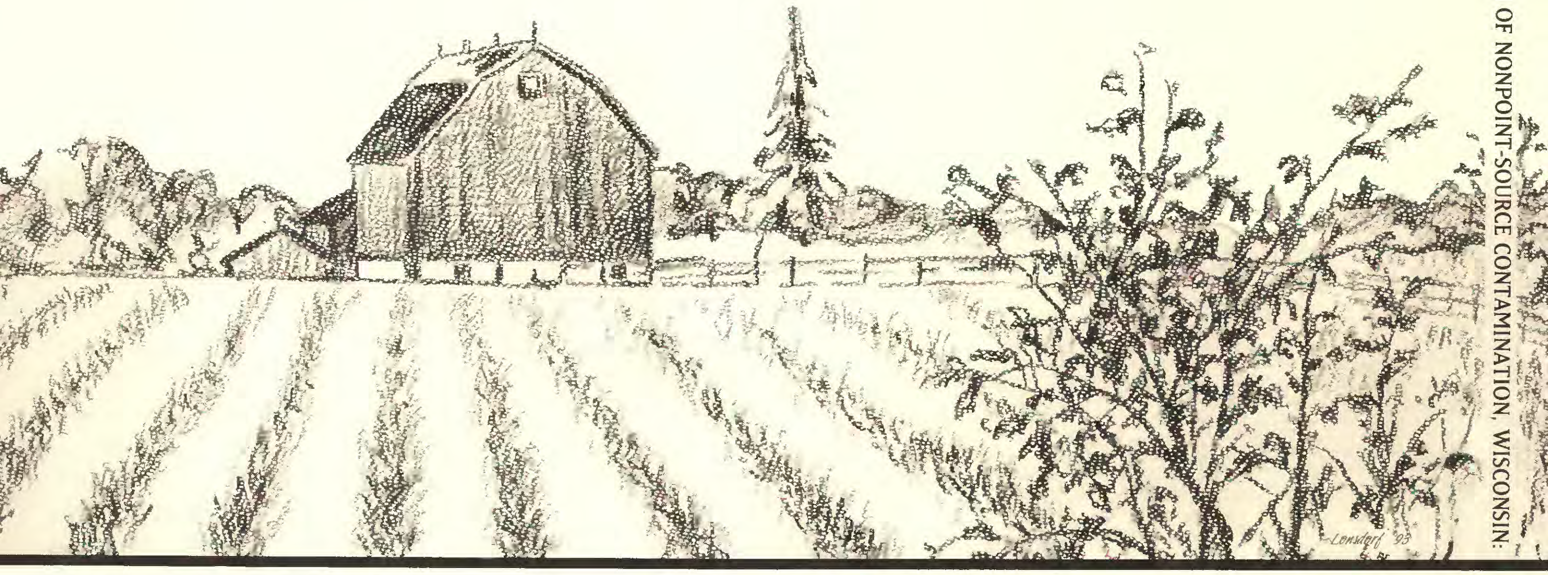
and

$$L_{-95} = \exp(-1.96\beta_{\eta L}) - 1$$

where $\beta_{\eta L}$ is the log space standard deviation of η_L, and L_{+95} and L_{-95} are the upper and lower limits of the 95-percent confidence intervals of the estimated loads in appendix 2. The values of L_{-95} and L_{+95}, expressed as a percentage of the estimated load for each analyte at each urban site, are given in table 2.

Table 2. Ninety-five percent confidence limits for storm-load data from urban watershed-management evaluation monitoring sites, Wisconsin, water years 1991–95
[values in percent of estimated load]

Constituent	Lincoln Creek		Menomonee River		Monroe Street detention pond		Nine Springs tributary storm sewer	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Suspended solids	-24	31	-22	28	-26	35	-22	28
Total phosphorus	-18	22	-15	18	-21	27	-15	18
Total cadmium	-19	23	-16	19	-22	28	-16	19
Total copper	-31	44	-30	42	-32	47	-30	42
Total lead	-19	24	-17	20	-22	28	-17	20
Total zinc	-16	19	-12	14	-19	24	-12	14



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