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A Reconnaissance for Selected Herbicides, Metabolites, and Nutrients in Streams of Nine Midwestern States, 1994–95

By ELISABETH A. SCRIBNER, DONALD A. GOOLSBY, E. MICHAEL THURMAN, and WILLIAM A. BATTAGLIN

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CONVERSION FACTORS, MISCELLANEOUS ABBREVIATIONS, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
mile (mi)	1.609	kilometer
pound (lb)	453.6	gram
pound per acre (lb/acre)	1.121	kilogram per hectare
square mile (mi^2)	2.590	square kilometer

Temperataure can be converted to degrees Celsius (°C) or degrees Fahrenheit (°F) by the equations:

$$°C = 5/9\ (°F-32)$$

$$°F = 9/5\ (°C) + 32.$$

Miscellaneous Abbreviations

inside diameter (i.d.)
mass to charge (m/z)
meter (m)
milliseconds per ion (ms/ion)

Abbreviated Water-Quality Units

kilopascal (kPa)
microgram per liter (µg/L)
microliter (µL)
micrometer (µm)
microsiemens per centimeter at 25 degrees Celsius (µS/cm)
milligram per liter (mg/L)
milliliter (mL)
milliliter per minute (mL/min)
millimeter (mm)
nanogram (ng)
nanogram per microliter (ng/µL)

A Reconnaissance For Selected Herbicides, Metabolites, and Nutrients in Streams of Nine Midwestern States, 1994–95

By Elisabeth A. Scribner, Donald A. Goolsby, E. Michael Thurman, *and* William A. Battaglin

Abstract

Water-quality data were collected from 53 Midwestern streams during 1994–95 as part of a study to determine if changes in herbicide use resulted in an overall decrease in herbicide concentrations since a previous reconnaissance study in 1989–90. This report includes a description of sampling-site selection, sample-collection and processing methods, laboratory methods, quality-assurance procedures, and a compilation of data on herbicide and nutrient concentrations. Sites were sampled in 1994 prior to application of herbicides in March or early April and during the first runoff period after application of herbicides. In 1995, sites were sampled during the first runoff period after the application of herbicides. Samples were analyzed for 13 herbicides, two atrazine metabolites, three cyanazine metabolites, and one alachlor metabolite. Samples also were analyzed for dissolved nutrients. These data have been useful in determining trends in herbicide concentrations in Midwestern streams and in determining the geographic distribution of alachlor, atrazine, and cyanazine metabolites.

INTRODUCTION

This is the sixth in a series of water-quality reports intended to present the analytical results from studies of herbicides and nutrients in water resources of the Midwestern United States. This report presents the analytical results from a study of 13 preemergent herbicides, two atrazine metabolites, three cyanazine metabolites, one alachlor metabolite, and dissolved nutrients in surface water of nine Midwestern States—Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin (fig. 1) during 1994–95. Previous reports have presented analytical results from regional studies of selected herbicides and dissolved nutrients in ground water (Kolpin and others, 1993), surface water (Scribner and others, 1993), storm runoff (Scribner and others, 1994), precipitation (Goolsby and others, 1995), and reservoirs (Scribner and others, 1996). This study was conducted by the U.S. Geological Survey (USGS) as part of the Toxic Substances Hydrology Program and in cooperation with the U.S. Environmental Protection Agency (USEPA).

Previous Studies

During 1989, the U.S. Geological Survey (USGS) conducted a reconnaissance study of 147 streams in 10 Midwestern States (those shown in fig. 1 plus South Dakota) to determine the geographic and seasonal distribution of herbicides and nutrients (Scribner and others, 1993). The streams were sampled before application of herbicides, during the first major runoff period after application of herbicides, and during a low-flow period in the fall when most of the streamflow was derived from ground water. Results from the 1989 study showed that large amounts of alachlor, atrazine, cyanazine, and metolachlor were flushed into streams during the first post-application runoff (Thurman and others, 1991, 1992; Battaglin and others, 1993;

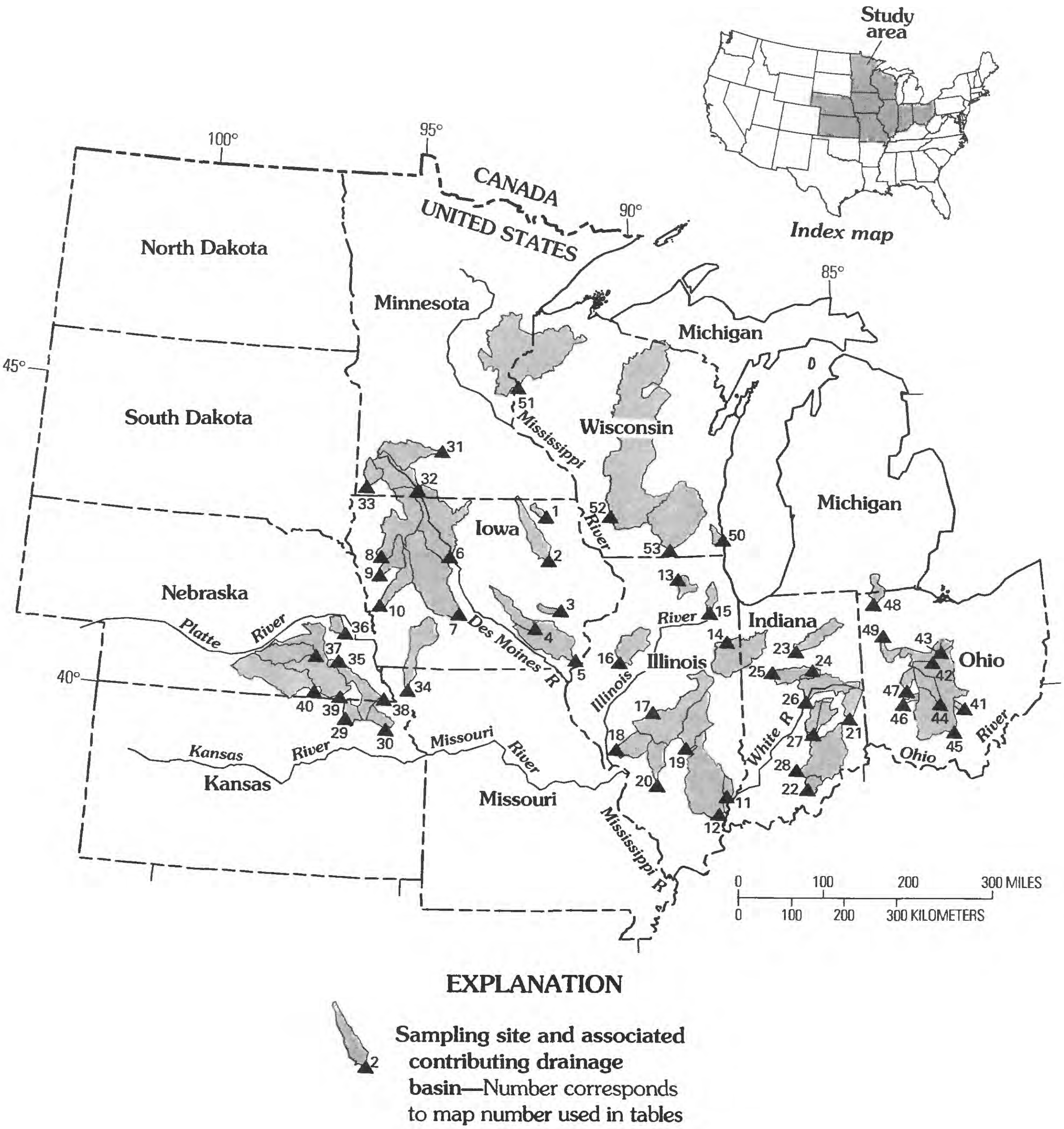

Figure 1. Location of study area, stream sites, and associated contributing drainage areas sampled during 1994–95 in Midwestern United States.

Goolsby and Battaglin, 1993; Goolsby and others, 1993). The maximum concentrations of alachlor, atrazine, and cyanazine exceeded 50 µg/L, and the maximum concentration of metolachlor exceeded 39 µg/L during the post-application period. Maximum herbicide concentrations were less than 5 µg/L, and most concentrations were less than 1 µg/L during the pre-application and fall low-flow sampling periods; however, more than one-half of the streams had detectable concentrations during all three sampling periods. Both atrazine and cyanazine concentrations temporarily exceeded drinking-water regulations in about one-half of the streams (Thurman and others, 1991, 1992; Goolsby and others, 1994). The atrazine Maximum Contaminant Level (MCL) for drinking water established by USEPA is 3 µg/L, and the cyanazine health advisory (HA) is 1 µg/L (U.S. Environmental Protection Agency, 1992). It should be noted, however, that there is no violation of the Safe Drinking Water Act unless the annual average concentration exceeds the MCL, or unless an individual concentration exceeds four times the MCL.

The 1989 reconnaissance study documented the geographic and seasonal distribution of herbicides in streams at a regional scale. A follow-up study was conducted by USGS in 1990 because of increased concern about the findings of high post-application concentrations of herbicides. The distributions of the concentrations of the major herbicides detected in 50 streams were essentially the same for both years for the pre- and post-application periods (Goolsby and others, 1991). These results and those of other studies (Wauchope, 1978; Frank and others, 1982; Leonard, 1988; Snow and Spalding, 1988; Baker and Richards, 1989) further indicated that the flush of herbicides following application is an annual occurrence. Additional studies by USGS in 1990 and 1991 using automatic samplers (Thurman and others, 1992; Goolsby and Battaglin, 1993; Scribner and others, 1994) showed that the herbicide flush lasts for several weeks to several months following application. By late summer, herbicide concentrations generally decrease to low concentrations (less than 0.50 µg/L) and remain low until the process is repeated the following year.

Changes in Herbicide Use Since 1989–90

Since the 1989–90 regional-scale studies were conducted, two decreases have occurred in the maximum application rate of atrazine recommended on the manufacturers' labels. In 1990, the manufacturers of atrazine voluntarily reduced the maximum recommended application rate for atrazine to 3 lb active ingredient per acre per year for corn and sorghum (USEPA, written commun., Jan. 23, 1990). Prior to this, the recommended maximum application rate was 4 lb active ingredient per acre per year. The 1990 label change also restricted noncropland uses of atrazine to a maximum of 10 lb active ingredient per acre per year. This label change occurred because of concern about ground-water contamination and applied to all products released for shipment after September 1, 1990.

In 1992, the manufacturers of atrazine further voluntarily reduced the maximum recommended application rate of atrazine on corn and sorghum to a range of 1.6 to 2.5 lb active ingredient per acre per year depending on soil organic residue and erosion potential. As much as 0.50 lb active ingredient per acre per year can be used in subsequent applications (USEPA, written commun., March 8, 1993). The total of all applications cannot exceed 2.5 lb active ingredient per acre per year. A maximum of 1.6 lb active ingredient per acre per year is recommended on soil with less than 30-percent plant residue remaining on the surface. Most noncropland uses of atrazine are no longer recommended on manufacturers' labels. This label change applied to all products shipped for use after August 1, 1992.

As a result of the two voluntary label changes, the maximum recommended application rate for atrazine on corn and sorghum essentially has been reduced by 50 percent since the 1989–90 studies were conducted. However, atrazine typically has not been applied at the maximum recommended rate. The actual application rate for atrazine decreased about 10 percent from an average of 1.22 lb/acre in 1990 to 1.07 to 1.1 lb/acre in 1994–95 (U.S. Department of Agriculture, 1991, 1994, 1995). The total use of atrazine decreased about 10 percent between 1989–90 and 1994–95.

The long-term use history, from 1963 through 1995, of atrazine and four other major herbicides is shown in figure 2. The use of alachlor decreased from about 50 million lb in 1989–90 to 27 million lb in 1994 and to 12.6 million lb in 1995. A new herbicide, acetochlor, was introduced in 1994. About 7 million lb of acetochlor were used in 1994. In 1995, acetochlor use had increased to about 23 million lb. The overall use of cyanazine increased slightly between 1989–90 and 1994–95. The use of metolachlor changed very little between 1989–90 and 1994–95 (fig. 2).

Objectives of 1994–95 Study

The principal objective of the 1994–95 study was to determine if changes in the application rate recommended by the manufacturers of atrazine have resulted in an overall decrease in atrazine concentrations in Midwestern streams since 1989–90. Other objectives were to determine the geographic distribution of selected herbicide and metabolite concentrations in these streams.

Purpose and Scope of Report

The purpose of this report is to present results of analyses of 13 herbicides (acetochlor, alachlor, ametryn, atrazine, cyanazine, metolachlor, metribuzin, prometon, prometryn, propachlor, propazine, simazine,

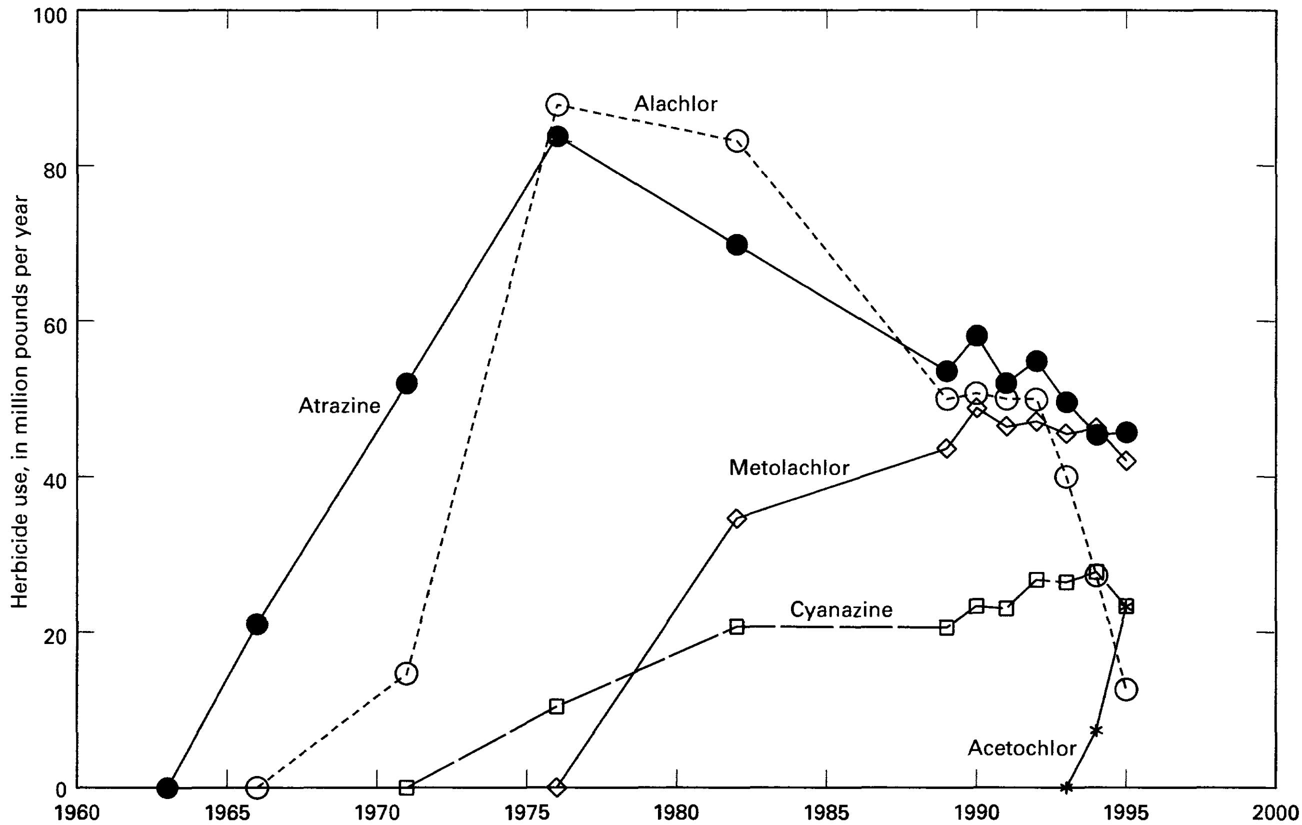

Figure 2. Herbicide use in Midwestern United States, 1963–95 (sources of data: 1964, Lin and others, 1995; 1966–89, Gianessi, 1992; 1990–95, U.S. Department of Agriculture, 1991, 1992, 1993, 1994, 1995).

and terbutryn), two atrazine metabolites (deethylatrazine and deisopropylatrazine), three cyanazine metabolites (cyanazine amide, deethylcyanazine, and deethylcyanazine amide), one alachlor metabolite (ethane sulfonic acid), and nutrients (nitrite as nitrogen, nitrite plus nitrate as nitrogen, ammonia as nitrogen, and orthophosphate as phosphorus) in water samples from 53 streams in nine Midwestern States during 1994–95. The study area includes all or parts of the following Midwestern States: Iowa, Illinois, Indiana, Kansas, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin. This report also describes the selection of sampling sites, sample-collection and processing methods, laboratory methods, quality-assurance procedures, and gives a brief comparison of 1994–95 study results with 1989–90 results.

METHODS

Selection of Sampling Sites

Fifty-three stream sites were sampled during this study. Sampling-site names and locations are given in table 1, and the corresponding map locations are shown in figure 1. Also, included in table 1 is the contributing drainage area for each sampling site.

Fifty of the 53 sites were sampled in both 1989 and 1990. These 50 sites were selected by a statistical process from the 147 sites sampled during the post-planting period in 1989. This process included ranking the 147 sites from highest to lowest on the basis of total herbicide concentrations and dividing them into three equal strata. From the strata containing the highest concentrations, 25 sites were randomly selected. Similarly, 13 sites were randomly selected from the middle-concentration strata, and 12 sites were randomly selected from the low-concentration strata. This selection process ensured both geographic distribution of sampling sites and ensured that sites with low and high herbicide concentrations would be selected on the basis

Table 1. Sampling-site names, locations, and contributing drainage areas

Map no. (fig. 1)	Site identification no.	Site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Contributing drainage area (square miles)
		Iowa			
1	05411600	Turkey River at Spillville	43°12'28"	91°56'56"	177
2	05421000	Wapsipinicon River at Independence	42°27'49"	91°53'42"	1,048
3	05455100	Old Mans Creek near Iowa City	41°36'25"	91°36'40"	201
4	05472500	North Skunk River near Sigourney	41°18'03"	92°12'16"	730
5	05474000	Skunk River at Augusta	40°45'13"	91°16'40"	4,303
6	05480500	Des Moines River at Fort Dodge	42°30'22"	94°12'04"	4,190
7	05484500	Raccoon River at Van Meter	41°32'02"	93°56'59"	3,441
8	06606600	Little Sioux River at Correctionville	42°28'20"	95°47'49"	2,500
9	06607200	Maple River at Mapleton	42°09'28"	95°48'27"	669
10	06609500	Boyer River at Logan	41°38'33"	95°46'57"	871
		Illinois			
11	03378000	Bonpas Creek at Browns	38°23'11"	87°58'32"	228
12	03381495	Little Wabash River at Carmi	38°05'32"	88°09'22"	3,088
13	05439500	South Branch Kishwaukee River at Fairdale	42°06'40"	88°54'00"	387
14	05526000	Iroquois River near Chebanese	41°00'32"	87°49'27"	2,091
15	05540500	Dupage River near Shorwood	41°31'20"	88°11'35"	324
16	05569500	Spoon River at London Mills	40°42'32"	90°16'53"	1,072
17	05576500	Sangamon River at Riverton	39°50'34"	89°32'52"	2,618
18	05587000	Macoupin Creek near Kane	39°14'03"	90°23'40"	868
19	05592100	Kaskaskia River near Cowden	39°13'50"	88°50'33"	1,330
20	05594000	Shoal Creek near Breese	38°36'35"	89°29'40"	735
		Indiana			
21	03275000	Whitewater River near Alpine	39°34'46"	85°09'29"	522
22	03302800	Blue River at Fredricksburg	38°26'02"	85°11'31"	283
23	03328500	Eel River near Logansport	40°46'55"	86°15'50"	789
24	03333450	Wildcat Creek near Jerome	40°26'29"	85°55'08"	146
25	03335000	Wildcat Creek near Lafayette	40°26'26"	86°49'45"	794
26	03351000	White River near Nora	39°54'35"	86°06'20"	1,219
27	03362500	Sugar Creek near Edinburgh	39°21'39"	85°59'51"	474
28	03371500	East Fork White River near Bedford	38°46'10"	86°24'30"	3,861

Table 1. Sampling-site names, locations, and contributing drainage areas—Continued

Map no. (fig. 1)	Site identification no.	Site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Contributing drainage area (square miles)
		Kansas			
29	06885500	Black Vermillion River near Frankfort	39°41'03"	96°26'15"	410
30	06890100	Delaware River near Muscotah	39°31'17"	95°31'57"	431
		Minnesota			
31	05317000	Cottonwood River near New Ulm	44°17'29"	94°26'24"	1,280
32	05476000	Des Moines River at Jackson	43°37'10"	94°59'10"	1,220
33	06483000	Rock River at Luverne	43°39'15"	96°12'03"	425
		Missouri			
34	06817700	Nodaway River near Graham	40°12'08"	95°04'07"	1,320
		Nebraska			
35	06803000	Salt Creek at Roca	40°39'29"	96°39'55"	167
36	06804000	Wahoo Creek at Itica	41°08'40"	96°32'10"	271
37	06880800	West Fork Big Blue River near Dorchester	40°43'52"	97°10'38"	1,206
38	06815000	Big Nemaha River at Fall City	40°02'08"	95°35'45"	1,340
39	06882000	Big Blue River at Barneston	40°02'40"	“96°35'12"	4,447
40	06884000	Little Blue River near Fairbury	40°06'54"	“97°10'13"	2,350
		Ohio			
41	03157000	Clear Creek near Rockbridge	39°35'18"	“82°34'43"	89
42	03219500	Scioto River near Prospect	40°25'10"	“83°11'50"	567
43	03223000	Olentangy River at Claridon	40°34'58"	“82°59'20"	157
44	03230500	Big Darby Creek at Darbyville	39°42'02"	“83°06'37"	534
45	03234500	Scioto River at Higby	39°12'44"	“82°51'50"	5,131
46	03240000	Little Miami River near Oldtown	39°44'54"	“83°55'53"	129
47	03267900	Mad River at Eagle City	39°57'51"	“83°49'54"	310
48	04185000	Tiffin River at Stryker	41°30'16"	“84°25'47"	410
49	04186500	Auglaize River near Fort Jennings	40°56'55"	“84°15'58"	332
		Wisconsin			
50	04087240	Root River at Racine	42°45'05"	“87°49'25"	190
51	05340500	St. Croix River at St. Croix Falls	45°24'25"	“92°38'49"	6,240
52	05407000	Wisconsin River at Muscoda	43°11'54"	“90°26'26"	10,400
53	05430500	Rock River at Afton	42°36'33"	“89°04'14"	3,340

of past data. Three additional sites were sampled where automatic samplers were operated in 1990 to determine the temporal distribution of herbicides in several Midwestern streams (Scribner and others, 1994). These sites were also sampled in 1989. Thus, the 53 sites selected for this study had previously been sampled during pre- and post-application periods in both 1989 and 1990.

Sample Collection

All 53 sites were sampled twice in 1994. In 1995, 51 sites were sampled once. Two sites were not sampled because runoff did not occur. In 1994, the first sample was collected prior to the application of herbicides in March or early April. A second sample was collected after herbicides had been applied and following the first precipitation that produced overland flow (runoff). Attempts were made to collect the sample near the peak discharge during this runoff. Results and hydrographs from the 1989 sampling and studies using autosamplers in 1990 showed this was when the largest herbicide and nutrient concentrations occurred (Thurman and others, 1992).

Only one sample was collected at each site in 1995. This sample was collected after herbicides had been applied and following the first precipitation that produced overland flow. Attempts were made to collect the sample near the peak discharge during the runoff. At two sites, Old Mans Creek in Iowa (map no. 3, fig. 1) and Salt Creek in Nebraska (map no. 35, fig. 1), samples were collected several times throughout the spring and summer of 1995 to determine the temporal distribution of herbicides.

Water samples were collected with a depth-integrating technique at three or more locations across each stream (Ward and Harr, 1990). The water samples from each site were composited in a single glass container or Teflon bottle. Stream discharge was determined at each site by direct measurement (current meter), from a rating curve, or estimated from data collected at a nearby USGS streamflow-gaging station.

Sample Processing

Herbicide samples were withdrawn from the compositing container and filtered through a 0.70-µm glass-fiber filter using a peristaltic pump. Nutrient samples were withdrawn and filtered through 0.45-µm membrane filters. Filters were leached with about 200 mL of sample prior to filtration of herbicide or nutrient sample.

The filtrate for herbicide analysis was collected in four heat-cleaned 125-mL amber glass bottles. The filtrate for nutrient analysis was collected in a 125-mL amber polyethylene bottle. The remainder of the water in the compositing container was used for onsite measurements of specific conductance, pH, and water temperature. All samples were chilled immediately and shipped to the appropriate laboratory within 3 days of collection. Herbicide samples were sent to the USGS laboratory in Lawrence, Kansas, for gas chromatography/mass spectrometry (GC/MS) and enzyme-linked immunosorbent assay (ELISA) analyses. Herbicide sample bottles received at the USGS laboratory in Lawrence, Kansas, were logged in, assigned identification numbers, and refrigerated at 4 °C until analyzed. Nutrient samples were shipped to the USGS laboratory in Arvada, Colorado, for analysis.

Laboratory Methods

Samples were analyzed for 13 herbicides, two atrazine metabolites, and three cyanazine metabolites by GC/MS according to procedures described by Thurman and others (1990), Meyer and others (1993), and Meyer (1994). Alachlor ESA was analyzed by the method of Aga and others (1994). Nutrient compounds were analyzed using the method described by Fishman and Friedman (1989). The methods of analysis and reporting limits for physical properties and chemical compounds are listed in table 2.

Solid-Phase Extraction

Analytes for GC/MS analysis were extracted and concentrated using solid-phase extraction. An automated procedure (Meyer and others, 1993) using a Waters Millilab workstation and C18 Sep-Pak-Plus cartridges was used. Cartridges were preconditioned on the workstation sequentially with 2 mL distilled water, 6 mL ethyl acetate, 2 mL methanol, and 3 mL distilled water. Each 123-mL water sample was spiked with 100 µL of a surrogate standard, terbuthylazine (1.23 ng/µL), and pumped through the cartridge at a rate of 20 mL/min by the robotic system. Analytes were eluted from the cartridge with 3.5 mL ethyl acetate and spiked robotically with 100 ng of phenanthrene-d_{10}. Samples with concentrations above the

Table 2. Method of determination or analysis and reporting limits for physical properties and chemical compounds in water samples from 53 streams in nine Midwestern States, 1994–95

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius, °C, degrees Celsius, µg/L, micrograms per liter; mg/L, milligrams per liter; SPE, solid-phase extraction; GC/MS, gas chromatography/mass spectrometry; ELISA, enzyme-linked immunosorbent assay; N, nitrogen; P, phosphorus]

Property or compound	Method of determination or analysis	Reporting limit
	Property	
Streamflow	Current meter or rating curve	0.01 ft^3/s
Specific conductance	Conductance meter	1 µS/cm
pH	pH meter	.10 standard unit
Temperature, water	Thermometer or thermister	.10 °C
	Herbicides	
acetochlor	SPE–GC/MS	.05 µg/L
alachlor	do.	do.
ametryn	do.	do.
atrazine	do.	do.
cyanazine	do.	do.
metolachlor	do.	do.
metribuzin	do.	do.
prometon	do.	do.
prometryn	do.	do.
propachlor	do.	do.
propazine	do.	do.
simazine	do.	do.
terbutryn	do.	do.
	Herbicide metabolites	
alachlor ethane sulfonic acid (ESA)	SPE–ELISA	.10 µg/L
cyanazine amide	SPE–GC/MS	.05 µg/L
deethylatrazine	do.	do.
deethylcyanazine	do.	do.
deethylcyanazine amide	do.	.50 µg/L
deisopropylatrazine	do.	.05 µg/L
	Nutrients	
nitrite as N	colorimetric	.01 mg/L
nitrite plus nitrate as N	do.	.05 mg/L
ammonia as N	do.	.01 mg/L
orthophosphate as P	do.	do.

linear range, 10 µg/L, were diluted, reextracted, and reanalyzed. The ethyl acetate layer was transferred by probe to a clean test tube. The robotic probe was washed between samples by immersing in ethyl acetate and bubbling air through the probe to prevent sample cross contamination of herbicide samples and standards. Finally, the extract was evaporated to a volume of 100 µL with a Turbovap evaporator at 45 °C under a nitrogen stream. This was pipetted into a 100-µL glass autosampler vial.

Gas Chromatography/Mass Spectrometry

Analyses were made for the 13 herbicides listed in table 2 as well as two atrazine metabolites, deethylatrazine and deisopropylatrazine. Automated GC/MS analyses of the sample extracts were performed on a Hewlett-Packard Model 5890 GC and a 5970A mass selective detector (MSD) in selected ion mode. Operating conditions were as follows: ionization voltage, 70 electronvolts; ion-source temperature, 280 °C; electron multiplier, 400 volts over the autotune voltage; direct capillary interface at 280 °C, initial GC oven temperature, 60 °C, tuned daily with perfluorotributylamine; dwell time, 25 to 50 ms/ion. Separation of the herbicides was carried out using a Hewlett Packard fused-silica, Ultra-1, 12 m x 0.2 mm i.d., GC capillary column of methyl silicone film with a thickness of 0.33 µm. Helium was used as the carrier gas at a flow rate of 1 mL/min and a head pressure of 35 kPa. The column temperature was held at 60 °C for 1 minute and then ramped at 6 °C per minute to 250 °C. Injector temperature was 280 °C.

Quantification was based on the area ratio of the base peaks relative to the response of the 188 ion of phenanthrene-d_{10}, the internal standard. Confirmation of the compound was based on the presence of the molecular ion and two confirming ions with a retention-time match of ±0.2 percent relative to phenanthrene-d_{10}. The quantitation limit for the compounds was 0.05 µg/L. Concentrations were based on a standard curve developed from known standards in distilled water. Samples with concentrations above the linear range, 10 µg/L, were diluted, reextracted, and finally reanalyzed. The preceding procedure is described in detail by Thurman and others (1990) and Meyer and others (1993).

For the separation of the cyanazine metabolites, cyanazine amide, deethylcyanazine, and deethylcyanazine amide, a Hewlett Packard Ultra-2, 12 m x 0.2 mm, GC capillary column of methyl silicone with 5-percent phenyl film was used. The GC/MS conditions for these analysis were the same as described previously except for the following: direct capillary interface at 210 °C, initial GC oven temperature, 140 °C; ramp rate, 15 °C per minute to 250 °C. The quantitation limit for cyanazine amide and deethylcyanazine was 0.05 µg/L and for deethylcyanazine amide, 0.50 µg/L. A dilution of the sample was used when necessary. This procedure is described in more detail by Meyer (1994).

Solid-Phase Extraction and Enzyme-Linked Immunosorbent Assay for Alachlor Ethane Sulfonic Acid

Alachlor ESA was analyzed by solid-phase extraction (SPE) and ELISA by the method described in Aga and others (1994). The SPE procedure was automated with a Waters Millilab workstation for extraction of the analyte. The C_{18} Sep-Pak cartridges were preconditioned sequentially with 2 mL methanol, 6 mL ethyl acetate, 2 mL methanol, and 2 mL distilled water. Each 100-mL water sample was passed through a cartridge at a flow rate of 20 mL/min. The cartridge was eluted first with 3.5 mL ethyl acetate to remove the parent compound alachlor. A second elution with 3.5 mL methanol to remove alachlor ESA was collected in a separate test tube. The methanol extracts were evaporated to dryness under nitrogen at 45 °C using a Turbovap evaporator. The samples then were reconstituted with 10 mL of distilled water and analyzed using an alachlor immunoassay kit. The concentrations of alachlor ESA were calculated by the following equation (Brady, 1995):

$$\mathrm{logit}\,(y) = \ln\,(y/1\text{-}y), \qquad (1)$$

where y = absorbance reading, which transformed data using alachlor ESA standards of 0, 1.0, 5.0, and 20 µg/L divided by the concentration factor from the SPE procedure. All samples were analyzed in duplicate. The reporting limit was 10 µg/L.

Automated Colorimetric Procedure

Dissolved nitrite as nitrogen, nitrite plus nitrate as nitrogen, ammonia as nitrogen, and orthophosphate as phosphorus were determined by automated colorimetric procedures at the USGS laboratory in Arvada, Colorado, using methods described by Fishman and Friedman (1989).

Quality-Assurance Procedures

Quality-assurance procedures for this study were carried out by USGS personnel in accordance with a written work plan for the study (Goolsby and others, 1994). Sample collection, processing, and analytical procedures used in this study were identical to those used in the 1989–90 reconnaissance.

Decontamination

Onsite quality-assurance procedures required all sampling equipment to be cleaned by washing glass containers, filter units, and tubing with a nonphosphate detergent; rinsing sequentially with tap water, organic-free, deionized, or distilled water, and then methanol; and rinsing again with organic-free water to remove traces of methanol. Herbicide sample containers (125-mL glass bottles) were cleaned by heating overnight to about 350 °C.

Sample Collection and Analysis

Quality-control samples consisted of blind replicates, blind spikes, field-equipment blanks, and laboratory duplicates. About 5 percent of the samples were blind replicates, and an additional 5 percent of the samples consisted of blind spikes and field-equipment blanks. In addition, about 10 percent of all herbicide samples were analyzed in duplicate at the laboratory in Lawrence, Kansas. Blind replicate samples for herbicide analysis were obtained during each sampling period. Replicates of regular samples were labeled with ficticious site information and submitted to the laboratory in Lawrence, Kansas, along with the regular samples for herbicide analysis. Results for the blind replicate analyses are included in table 6 at the end of this report.

Blind spikes for herbicide analysis were independently prepared by the USGS National Water-Quality Laboratory in Arvada, Colorado, and submitted with the regular samples. These samples consisted of 125-mL bottles filled with solutions of known herbicide concentrations. They were labeled as stream samples and sent to the laboratory in Lawrence, Kansas. Results for spike samples analyzed during the sampling rounds are shown in table 3. There were no significant differences between the recoveries of the herbicides from the field spikes from 1989–90 to 1994–95.

Field-equipment blanks for herbicides were obtained on the first sample processed and about every 20th sample thereafter. Organic-free water was filtered into four 125-mL baked amber glass bottles labeled as a field-equipment blank and shipped overnight to the laboratory in Lawrence, Kansas, along with the regular herbicide samples. There were no detections of any herbicide compounds in the 16 field-equipment blanks analyzed.

Gas Chromatography/Mass Spectrometry

For the GC/MS method, each water sample to be analyzed for herbicides and metabolites was spiked with a surrogate standard and terbuthylazine. An internal standard, phenanthrene-d_{10}, was added to the sample after it was extracted by SPE. The ratio of the terbuthylazine to the phenanthrene-d_{10} in the final extract was used to calculate the percent recovery of the sample. Additional quality-assurance protocols consisted of 10 percent blank samples and 10 percent standard solutions for the sampling period. Results of the laboratory duplicate analyses are included in table 6 at the end of this report.

Solid-Phase Extraction and Enzyme-Linked Immunosorbent Assay for Alachlor Ethane Sulfonic Acid

For the alachlor ESA method, results were quantified with a new calibration curve prepared from standards run with each assay. Every ninth sample was extracted in duplicate, and all extracts were analyzed in duplicate and averaged.

ANALYTICAL RESULTS

A statistical summary of the concentrations of herbicide compounds measured in water samples from 53 streams for the 1994 post-application season is given in table 4. A summary of the 1995 results for samples from these same streams is given in table 5. Two compounds, alachlor ESA and atrazine, were detected in all post-planting samples.

In 1994, 35 percent of the stream samples had alachlor concentrations exceeding the MCL for drinking water of 2 µg/L (U.S. Environmental Protection Agency, 1992) and 4 percent exceeded four times the MCL. Samples with herbicide concentrations more than four times the MCL may violate the Safe Drinking Water Act. In 1995, alachlor concentrations were considerably lower, with 8 percent of the stream samples exceeding the alachlor MCL of 2 µg/L, and 2 percent exceeding four times the MCL. Both acetochlor and alachlor were detected in 82 percent of the stream samples in 1995, but the median acetochlor concentration (0.42 µg/L) was three times higher than the median alachlor concentration of 0.13 µg/L.

Atrazine, with a median concentration of 4.2 µg/L in 1994, exceeded the MCL of 3 µg/L (U.S. Environmental Protection Agency, 1992) in 65 percent of the stream samples and four times the MCL in 20 percent of the samples. The median concentration for atrazine was 5.5 µg/L in 1995, and concentrations exceeded the MCL of 3 µg/L in 60 percent of the stream samples and four times the MCL in 32 percent of the samples.

In 1994, cyanazine had a median concentration of 1.2 µg/L, and 20 percent of the stream samples had concentrations exceeding four times the HA of 1.0 µg/L (U.S. Environmental Protection Agency,

Table 3. Concentrations of selected herbicides and three metabolites in quality-assurance samples from 53 streams in nine Midwestern States, 1994–95

[DEA, deethylatrazine; DIA, deisopropylatrazine, Acetochlor, cyanazine amide, deethylcyanazine, and deethylcyanazine amide were not detected. --, no data; <, less than; NA, not available; one-half detection limit was used in calculation of mean values; NWQL, U.S. Geological Survey National Water-Quality Laboratory, Arvada, Colorado]

Laboratory identification no.	Quality-assurance identification no.	Date of collection (month/day/year)	Concentrations, in micrograms per liter												
			Alachlor	Ametryn	Atrazine	DEA	DIA	Cyanazine	Metolachlor	Metribuzin	Prometon	Prometryn	Propachlor	Propazine	Simazine
MT-22240A	Spike 1	03/23/94	0.22	0.23	0.31	0.22	0.20	0.23	0.25	0.19	0.24	0.26	--	0.23	0.07
MT-22237A	Spike 1	03/24/94	.27	.26	.33	.23	.20	.29	.29	.25	.26	.28	--	.25	<.05
MT-22274A	Spike 1	03/25/94	.26	.26	.29	.23	.20	.28	.27	.23	.23	.28	--	.27	.07
MT-22277B	Spike 1	03/25/94	.19	.19	.20	.20	.21	.22	.18	.11	.20	.20	--	.19	.08
MT-22297A	Spike 1	03/29/94	.20	.20	.22	.18	.19	.22	.20	.08	.18	.22	--	.20	.09
MT-22303A	Spike 1	03/30/94	.27	.25	.32	.22	.21	.32	.29	.21	.27	.28	--	.31	.09
MT-22306A	Spike 1	03/30/94	.20	.19	.25	.21	.23	.28	.20	.18	.20	.21	--	.23	.07
MT-22299A	Spike 1	03/31/94	.30	.29	.34	.21	.24	.32	.33	.24	.24	.31	--	.31	<.05
MT-22299B	Spike 1	03/31/94	.26	.25	.32	.24	.22	.24	.27	.23	.27	.26	--	.30	.08
Mean			**.24**	**.24**	**.29**	**.22**	**.21**	**.27**	**.25**	**.19**	**.23**	**.26**	**--**	**.25**	**.07**
Theoretical			.20	NA	.20	.20	NA	.20	.20	NA	NA	NA	NA	NA	.10
NWQL			.23	.22	.20	.13	<.05	.21	.22	.28	.20	.23	--	.22	.08
MT-22290A	Spike 2	03/21/94	1.1	.81	1.2	1.1	1.1	.98	1.3	.93	.82	.68	--	1.0	.39
MT-22288A	Spike 2	03/22/94	1.1	.85	1.3	1.2	1.2	1.0	1.3	.82	.90	.77	--	1.1	.39
MT-22283A	Spike 2	03/24/94	.99	.99	.97	.81	.86	1.2	1.0	.79	.82	1.0	--	.95	.32
MT-22284A	Spike 2	03/24/94	.90	1.2	1.2	1.1	1.2	.88	1.1	.55	1.0	1.2	--	1.2	.44
MT-22307A	Spike 2	04/01/94	.90	.96	1.2	1.0	.93	1.2	1.0	1.0	1.0	.97	--	1.1	.40
MT-22337A	Spike 2	04/06/94	.89	1.1	1.1	.90	.92	1.0	1.1	.83	.97	1.1	--	1.1	.34
MT-22335A	Spike 2	04/06/94	.97	1.1	1.1	.88	.84	.92	1.0	.87	.93	1.1	--	1.0	.32
MT-22338A	Spike 2	04/06/94	1.0	1.1	1.2	.97	1.0	1.1	1.1	.95	1.0	1.2	--	1.1	.36
Mean			**.98**	**1.0**	**1.2**	**1.0**	**1.0**	**1.0**	**1.1**	**.84**	**.93**	**1.0**	**--**	**1.1**	**.37**
Theoretical			.80	NA	.80	.80	NA	.80	.80	NA	NA	NA	NA	NA	.40
NWQL			.99	.83	.79	.62	.31	.87	.88	1.5	.83	.86	--	.81	.28

Table 3. Concentrations of selected herbicides and three metabolites in quality-assurance samples from 53 streams in nine Midwestern States, 1994–95—Continued

Laboratory identification no.	Quality-assurance identification no.	Date of collection (month/day/year)	Concentrations, in micrograms per liter												
			Alachlor	Ametryn	Atrazine	DEA	DIA	Cyanazine	Metolachlor	Metribuzin	Prometon	Prometryn	Propachlor	Propazine	Simazine
MT-22841A	Spike 3	05/24/94	0.86	0.79	1.0	1.0	1.1	1.2	0.88	0.95	0.87	0.84	--	0.96	0.56
MT-22858A	Spike 3	05/24/94	1.2	.98	1.2	1.0	1.1	2.7	1.1	1.3	1.0	1.0	--	1.1	.67
MT-23004A	Spike 3	05/24/94	1.3	1.1	1.3	1.1	1.1	1.7	1.2	1.5	1.2	1.2	--	1.2	.72
MT-22842A	Spike 3	05/25/94	.53	.52	.63	.44	1.0	.53	.72	.36	.51	5.3	--	.59	.35
MT-23267B	Spike 3	06/08/94	1.2	1.2	1.2	.99	1.0	1.4	1.1	1.1	1.1	1.2	--	1.2	.62
MT-23463A	Spike 3	06/14/94	1.2	1.1	1.2	.99	.96	1.3	1.0	.95	1.1	1.1	--	1.2	.62
MT-23267A	Spike 3	08/14/94	1.1	1.0	1.2	.95	.98	1.1	1.0	.95	1.1	1.1	--	.97	.60
Mean			**1.1**	**.96**	**1.1**	**.92**	**1.0**	**1.4**	**1.0**	**1.0**	**.98**	**1.7**	**--**	**1.0**	**.59**
Theoretical			1.0	NA	1.0	1.0	NA	1.0	1.0	NA	NA	NA	NA	NA	.50
NWQL			1.1	1.1	.93	.81	.27	1.0	1.1	.83	1.2	1.1	--	.98	.50
MT-23591A	Spike 4	06/14/94	7.2	8.5	8.6	6.9	6.2	9.6	7.8	7.1	7.4	9.4	--	7.9	5.2
MT-23592A	Spike 4	06/15/94	7.0	7.1	8.4	6.9	5.9	9.0	7.2	7.6	7.0	7.5	--	7.9	4.9
MT-23592C	Spike 4	06/15/94	9.1	9.3	11	9.6	10	10	8.5	9.5	10	9.4	--	10	5.9
MT-23871A	Spike 4	06/28/94	7.1	7.3	8.0	7.2	5.2	9.6	7.3	8.6	8.1	7.5	--	6.6	5.3
MT-23872A	Spike 4	06/29/94	7.8	8.0	9.2	8.2	6.0	11	7.0	9.7	8.9	8.2	--	8.2	5.8
MT-24011D	Spike 4	07/07/94	9.5	9.6	11	9.9	10	10	8.9	9.7	11	9.7	--	11	6.1
Mean			**8.0**	**8.3**	**9.4**	**8.1**	**7.2**	**9.9**	**7.8**	**8.7**	**8.7**	**8.6**	**--**	**8.6**	**5.5**
Theoretical			8.0	NA	8.0	8.0	NA	8.0	8.0	NA	NA	NA	NA	NA	4.0
NWQL			6.0	6.2	6.1	5.5	3.2	5.4	5.8	--	6.1	6.5	--	6.1	5.6

Table 3. Concentrations of selected herbicides and three metabolites in quality-assurance samples from 53 streams in nine Midwestern States, 1994–95—Continued

Laboratory identification no.	Quality-assurance identification no.	Date of collection (month/day/year)	Concentrations, in micrograms per liter												
			Alachlor	Ametryn	Atrazine	DEA	DIA	Cyanazine	Metolachlor	Metribuzin	Prometon	Prometryn	Propachlor	Propazine	Simazine
MT-26646A	Spike 5	05/26/95	.90	.93	1.2	1.0	1.0	1.2	1.2	.81	.95	1.1	.80	1.1	.29
MT-26640B	Spike 5	05/30/95	.90	1.0	1.1	.73	.73	1.4	1.1	.75	.92	1.1	.80	1.0	.33
MT-26774A	Spike 5	06/12/95	.91	.88	1.2	.97	.89	1.2	1.1	.85	.97	1.1	.90	1.1	.30
MT-26856A	Spike 5	06/26/95	.96	1.0	1.2	.97	1.2	1.0	1.1	.82	1.1	1.1	1.0	1.1	.31
MT-26921A	Spike 5	06/30/95	.94	.98	1.1	.94	1.0	1.2	1.1	1.1	1.0	1.0	1.1	1.1	.30
Mean			**.92**	**.96**	**1.2**	**.92**	**.96**	**1.2**	**1.1**	**.87**	**.99**	**1.1**	**.92**	**1.1**	**.31**
Theoretical			1.0	NA	1.0	1.0	1.0	1.0	1.0	1.0	1.0	NA	NA	1.0	.50
MT-26638B	Spike 6	05/29/95	8.0	8.4	9.4	7.7	7.0	12	9.9	7.0	7.9	9.1	6.9	8.9	2.9
MT-26648A	Spike 6	05/31/95	7.1	6.9	9.0	7.5	7.1	9.9	8.1	6.9	7.7	7.6	8.8	8.5	2.5
MT-26776A	Spike 6	06/12/95	7.1	7.3	9.5	7.7	7.4	9.1	7.5	7.4	8.0	8.4	7.1	9.0	2.8
MT-26855A	Spike 6	06/26/95	5.5	5.8	6.9	5.9	4.3	6.6	6.3	5.4	6.3	6.2	7.7	6.6	2.1
MT-26919A	Spike 6	06/30/95	7.8	9.7	12	7.8	7.5	9.2	9.7	7.4	11	10	7.4	11	3.1
MT-26919B	Spike 6	06/30/95	6.0	6.2	7.2	5.8	6.2	6.3	6.8	5.5	6.2	6.7	6.2	7.0	2.3
Mean			**6.9**	**7.4**	**9.0**	**7.1**	**6.6**	**8.9**	**8.1**	**6.6**	**7.9**	**8.0**	**7.4**	**8.5**	**2.6**
Theoretical			8.0	NA	8.0	8.0	8.0	8.0	8.0	8.0	8.0	NA	NA	8.0	4.0

Table 4. Statistical summary of 1994 post-application herbicide and metabolite concentrations in water samples from 53 streams in nine Midwestern States

[MCL, Maximum Contaminant Level; HA, health advisory; µg/L, micrograms per liter; --, not determined; <, less than; propachlor not detected]

Herbicide or metabolite	Reporting limit (µg/L)	Number of samples	Percent detections	Concentrations, in micrograms per liter: 25th percentile	Median	75th percentile	Maximum	MCL or HA	Percentage[1] greater than four times MCL or HA
Acetochlor	0.05	53	35	<0.05	<0.05	0.16	1.2	2	0
Alachlor	.05	53	78	.09	.84	2.9	10	2	4
Alachlor ethane sulfonic acid	.10	52	100	1.1	5.2	8	28	--	--
Ametryn	.05	53	2	<.05	<.05	<.05	.08	--	--
Atrazine	.05	53	100	1.3	4.2	10	28	3	20
Cyanazine	.05	53	96	.36	1.2	3.2	56	1	20
Cyanazine amide	.05	53	90	.16	.62	1.5	6.4	--	--
Deethylatrazine	.05	53	96	.26	.71	1.4	3.5	--	--
Deisopropylatrazine	.05	53	92	.15	.43	.73	1.8	--	--
Metolachlor	.05	53	94	.34	1.8	4	11	70	0
Metribuzin	.05	53	47	<.05	<.05	.24	1.9	200	0
Prometon	.05	53	6	<.05	<.05	<.05	.22	--	--
Prometryn	.05	53	2	<.05	<.05	<.05	.06	--	--
Propazine	.05	53	31	<.05	<.05	.06	.49	10	0
Simazine	.05	53	51	<.05	.06	.30	4.8	4	0
Terbutryn	.05	53	0	--	--	--	--	--	--

[1]Concentrations of individual samples exceeding MCLs do not necessarily represent violation of the Safe Drinking Water Act.

1992). In 1995, 28 percent of the cyanazine samples exceeded four times the HA. The remaining herbicide compounds measured in 1995 were similar to those measured in 1994 as shown in tables 4 and 5.

The distribution of the concentrations of all herbicide compounds detected during post-application periods in 1994 and 1995 is shown in figure 3. The compounds are arranged in order of decreasing median concentration.

Box plots showing the distribution of the concentrations of acetochlor, alachlor, atrazine, and cyanazine in water from the 53 sampling sites in 1994 and 1995 are shown in figures 4 and 5. For comparison, box plots of post-application results from 1989 and 1990 are also shown. The range of concentrations was similar for all compounds since 1989, but the medians showed a downward trend except for acetochlor. The decrease in alachlor from 1994 to 1995 is substantial and corresponds with increased use of acetochlor.

Analytical results for 12 herbicides, one alachlor metabolite, two atrazine metabolites, and three cyanazine metabolites in water-quality samples collected from 53 streams during 1994–95 are presented in table 6 at the end of this report. One additional herbicide, terbutryn, was analyzed but not detected.

Analytical results for dissolved nutrients in water samples from the 53 stream sites are given in table 7 at the end of this report. Nitrogen and phosphorus compounds in streams are derived from many human-related and natural sources, including chemical fertiliz-

Table 5. Statistical summary of 1995 post-application herbicide and metabolite concentrations in water samples from 51 streams in nine Midwestern States

[MCL, Maximum Contaminant Level; HA, health advisory; µg/L, micrograms per liter; --, not determined; <, less than]

Herbicide or metabolite	Reporting limit (µg/L)	Number of samples	Percent detections	Concentrations, in micrograms per liter: 25th percentile	Median	75th percentile	Maximum	MCL or HA	Percentage[1] greater than four times MCL or HA
Acetochlor	0.05	51	82	0.08	0.42	1.2	5.6	2	0
Alachlor	.05	51	82	.06	.13	.65	20	2	2
Alachlor ethane sulfonic acid	.10	51	100	.92	1.6	4.1	23	--	--
Ametryn	.05	51	2	<.05	<.05	<.05	.08	--	--
Atrazine	.05	51	100	1.4	5.5	13	50	3	32
Cyanazine	.05	51	90	.38	1.3	5.2	25	1	28
Cyanazine amide	.05	50	90	.12	.47	1.3	5.1	--	--
Deethylatrazine	.05	51	96	.17	.43	1.1	6	--	--
Deisopropylatrazine	.05	51	96	.17	.42	.75	3.9	--	--
Metolachlor	.05	51	100	.52	1.7	6.4	18	70	0
Metribuzin	.05	51	42	<.05	<.05	.18	1.4	200	0
Prometon	.05	51	38	<.05	<.05	.06	.21	--	--
Prometryn	.05	51	2	<.05	<.05	<.05	.06	--	--
Propachlor	.05	51	12	<.05	<.05	<.05	7.9	90	0
Propazine	.05	51	58	<.05	.05	.14	.47	10	0
Simazine	.05	51	68	<.05	.08	.23	7.2	4	0
Terbutryn	.05	51	0	--	--	--	--	--	--

[1]Concentrations of individual sample exceeding MCLs do not necessarily represent violation of the Safe Drinking Water Act.

ers, animal wastes, domestic sewages, legumes, mineralization of vegetation, and soil organic matter. Streamflow and flow percentile are also presented in table 7. The flow percentile was derived from a flow-duration table for each site and represents the percentage of time the streamflow was less than the measured value. For example, a flow percentile of 90 means that 90 percent of the time the streamflow was less than the measured value. Table 7 also includes data on the specific conductance and pH of all samples.

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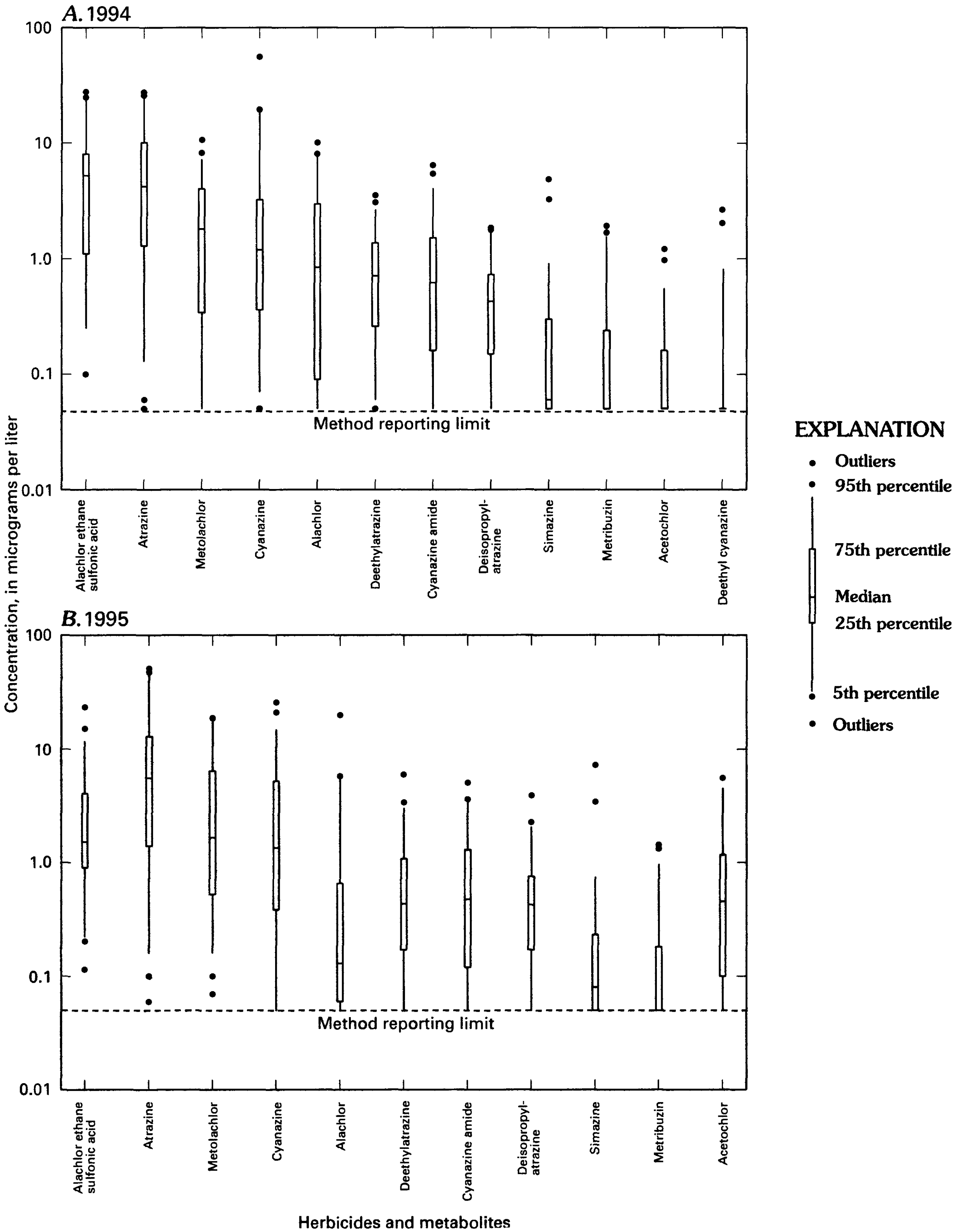

Figure 3. Distribution of concentrations of detected herbicides and metabolites in water from *(A)* 53 stream sites sampled during 1994 and *(B)* 51 stream sites sampled during 1995 post-application sampling periods (see tables 4 and 5).

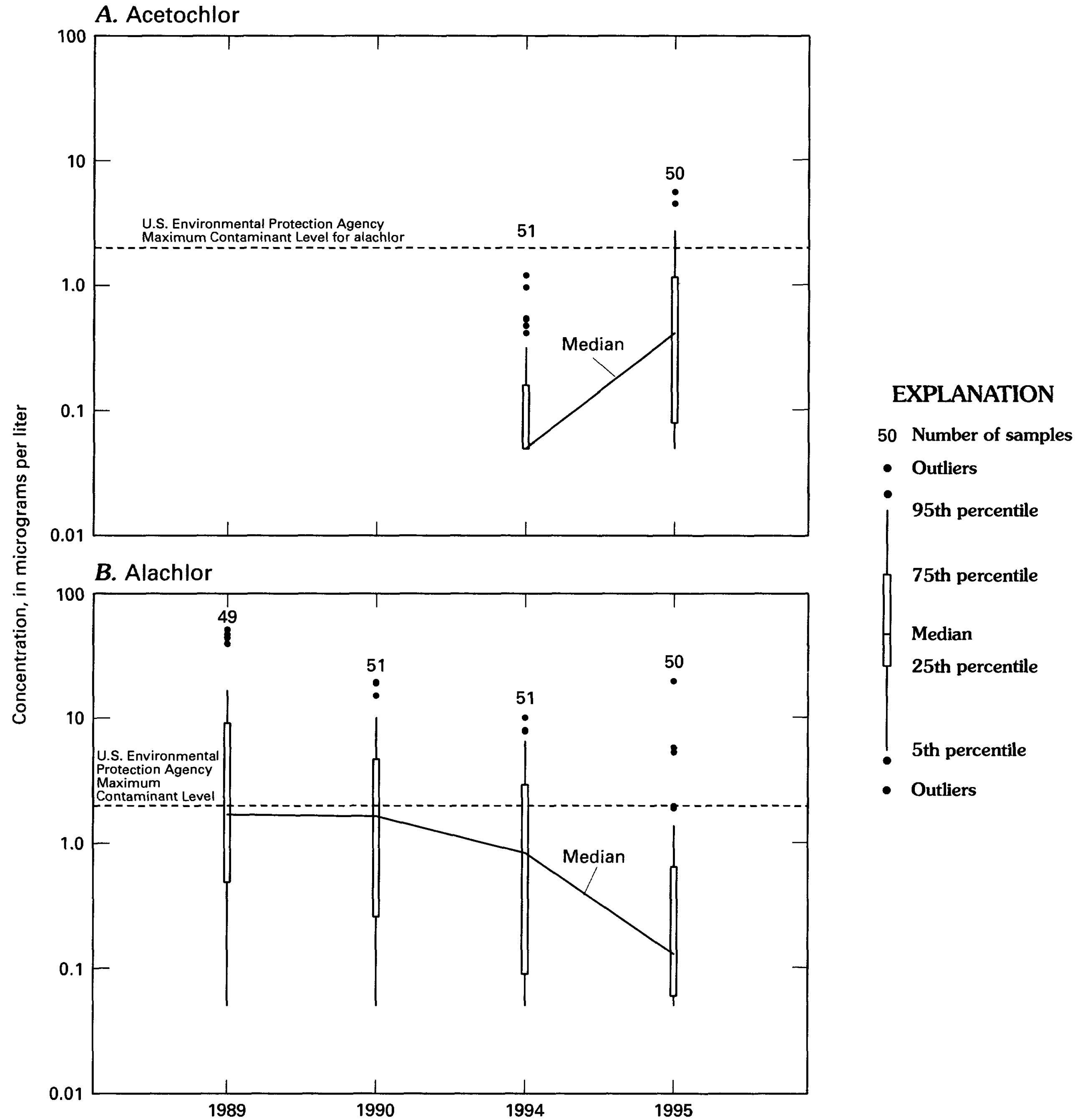

Figure 4. Post-application distributions of *(A)* acetochlor and *(B)* alachlor in samples from 53 Midwestern streams, 1989–90 and 1994–95.

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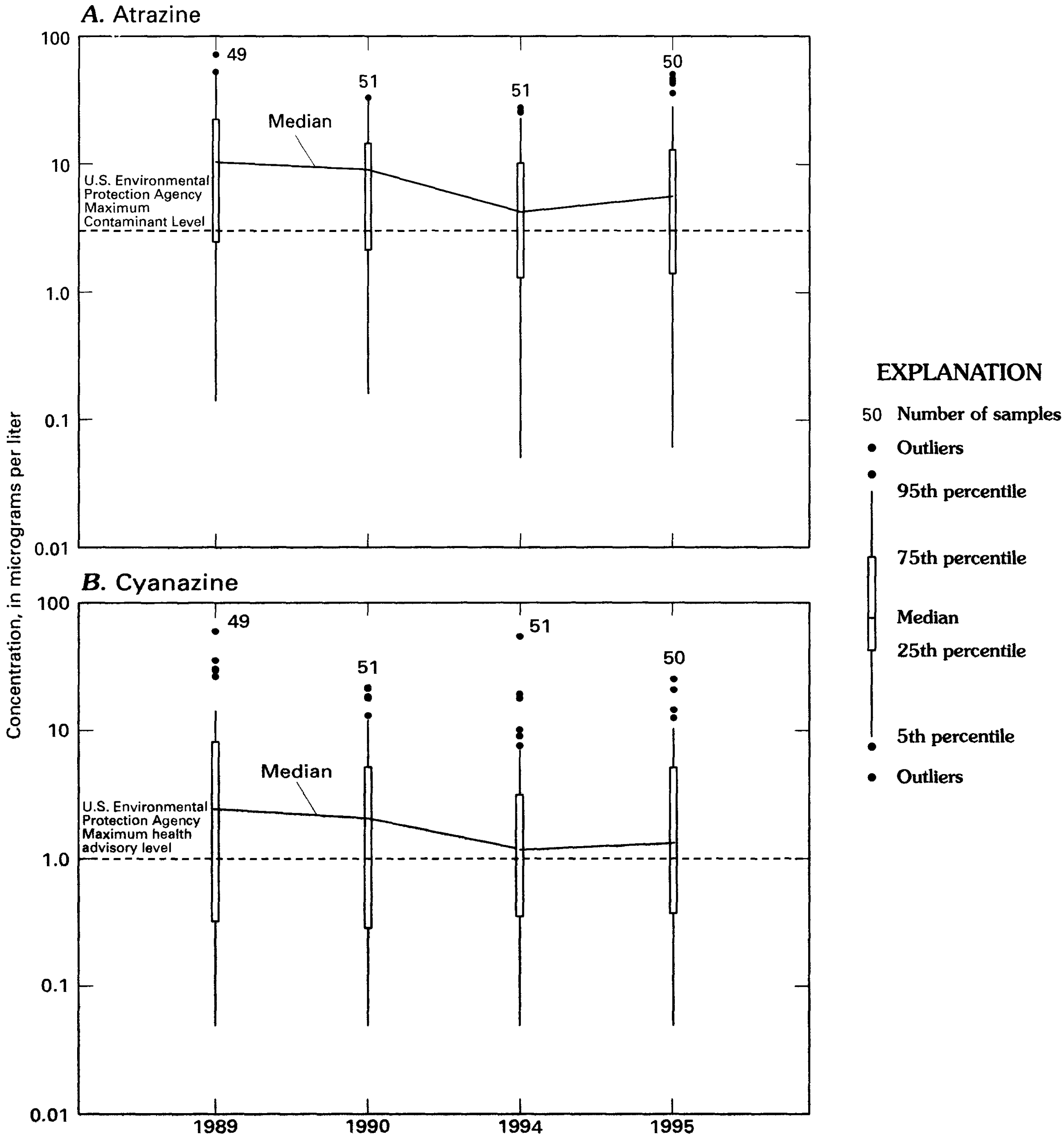

Figure 5. Post-application distributions of *(A)* atrazine and *(B)* cyanazine in samples from 53 Midwestern streams, 1989–90 and 1994–95.

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Table 6. Analytical results for selected herbicides and six metabolites in water

[--, no data; <, less than. Sample type: R, regular; T, temporal distribution; TD, temporad distribution duplicate

Map no. (fig. 1)	Site name	Date of collection (month/ day/ year)	Sample type	Concentration, in micrograms per liter: Acetochlor	Alachlor	Alachlor ethane sulfonic acid	Ametryn	Atrazine	Deethylatrazine	Deisopropylatrazine
										Iowa
1	Turkey River at Spillville	03/22/94	R	<0.05	0.08	5.2	<0.05	0.39	0.48	0.22
		05/24/94	R	<.05	.14	3.9	<.05	.31	.31	.06
		06/08/95	R	.62	1.9	11	<.05	17	1.1	.75
				<.05						
2	Wapsipinicon River at Independence	03/22/94	R	<.05	.09	5.0	<.05	.34	.37	.11
		05/24/94	R	<.05	.08	5.4	<.05	.37	.26	.08
		05/30/95	B	.34	.09	4.2	<.05	.66	.37	.21
		05/30/95	R	.36	.10	3.3	<.05	.67	.29	.14
3	Old Mans Creek near Iowa City	03/21/94	R	<.05	<.05	1.2	<.05	.14	.11	.11
		05/24/94	R	<.05	<.05	1.1	<.05	.39	.13	.25
		06/02/95	R	1.5	.54	7.1	<.05	13	.14	1.3
		06/14/95	T	.10	.07	2.2	.15	.77	.32	.27
		07/05/95	TD	.12	.05	1.0	<.05	3.4	1.1	.72
		07/05/95	T	.10	<.05	1.4	<.05	1.9	.55	.44
		07/06/95	T	.17	.55	2.1	<.05	3.0	.74	.53
		07/19/95	T	<.05	<.05	4.4	<.05	.38	.24	.19
		08/09/95	T	<.05	<.05	3.1	<.05	.24	.14	.12
		08/09/95	T	<.05	<.05	3.1	<.05	.26	.15	.15
		08/09/95	TD	<.05	<.05	2.8	<.05	.25	.14	.14
		08/09/95	T	<.05	<.05	4.1	<.05	.27	.15	.14
		08/14/95	T	<.05	<.05	3.0	<.05	.21	.12	.10
4	North Skunk River near Sigourney	03/24/94	R	<.05	<.05	1.5	<.05	.14	.11	.09
		05/25/94	R	<.05	<.05	1.5	<.05	.61	.12	.11
		06/06/95	R	2.7	<.05	1.3	<.05	17	.91	1.1
		06/06/95	L	3.1	.05	1.2	<.05	19	1.0	1.1
		03/24/94	B	<.05	<.05	1.7	<.05	.17	.10	.09
		03/24/94	B	<.05	<.05	2.1	<.05	.21	.13	.16

samples from 53 streams in nine Midwestern States, 1994–95

B, blind duplicate; L, laboratory duplicate; X, extra; XD, extra duplicate. Terbutryn was not detected]

Map no. (fig. 1)	Concentration, in micrograms per liter										
	Cyanazine	Cyanazine amide	De-ethylcyanazine	De-ethylcyanazine	Metolachlor	Metribuzin	Prometon	Prometryn	Propachlor	Propazine	Simazine
1	<0.05	0.11	<0.05	<0.50	0.11	<0.05	<0.05	<0.05	--	<0.05	<0.05
	.07	.05	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	10	3.0	--	--	.38	<.05	<.05	<.05	<0.05	.14	.05
2	<.05	.08	<.05	<.50	.15	<.05	<.05	<.05	--	<.05	<.05
	.09	.05	<.05	<.50	.11	<.05	<.05	<.05	--	<.05	<.05
	.57	.10	--	--	.48	<.05	<.05	<.05	<.05	<.05	<.05
	.54	.09	--	--	.50	<.05	<.05	<.05	<.05	<.05	<.05
3	<.05	.11	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.25	.16	<.05	<.50	.07	<.05	<.05	<.05	--	<.05	<.05
	21	5.1	--	--	2.9	.05	<.05	<.05	<.05	.14	.07
	.42	.19	--	--	.17	<.05	.11	.15	.06	.06	<.05
	2.7	<.05	--	--	1.2	.05	<.05	<.05	<.05	<.05	<.05
	1.3	<.05	--	--	.41	<.05	<.05	<.05	<.05	<.05	<.05
	1.1	<.05	--	--	.45	<.05	<.05	<.05	<.05	<.05	<.05
	.18	.20	--	--	.05	<.05	<.05	<.05	<.05	<.05	<.05
	.05	.09	--	--	.05	<.05	<.05	<.05	<.05	<.05	<.05
	.05	.09	--	--	.05	<.05	<.05	<.05	<.05	<.05	<.05
	<.05	.08	--	--	.05	<.05	<.05	<.05	<.05	<.05	<.05
	<.05	.09	--	--	.06	<.05	<.05	<.05	<.05	<.05	<.05
	<.05	.07	--	--	<.05	<.05	<.05	<.05	<.05	<.05	<.05
4	<.05	.09	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.29	.10	<.05	<.50	.12	<.05	<.05	<.05	--	<.05	<.05
	26	2.7	--	--	3.0	.07	<.05	<.05	<.05	.16	.08
	31	3.2	--	--	3.5	.08	<.05	<.05	<.05	.18	.09
	<.05	<.05	<.05	<.50	.06	<.05	<.05	<.05	--	<.05	<.05
	.06	<.05	<.05	<.50	.09	<.05	<.05	<.05	--	<.05	<.05

Table 6. Analytical results for selected herbicides and six metabolites in water

Map no. (fig. 1)	Site name	Date of collection (month/ day/ year)	Sample type	Acetochlor	Alachlor	Alachlor ethane sulfonic acid	Ametryn	Atrazine	Deethylatrazine	Deisopropylatrazine
				Concentration, in micrograms per liter						
	Iowa—Continued									
5	Skunk River at Augusta	03/24/94	R	<0.05	<0.05	0.89	<0.05	0.15	0.12	0.12
		06/03/94	R	<.05	.09	2.3	<.05	1.5	.28	.18
		06/08/95	R	1.7	.06	1.1	<.05	10	.64	.85
6	Des Moines River at Fort Dodge	03/23/94	R	<.05	.05	1.4	<.05	.17	.07	.05
		06/06/94	R	<.05	.12	2.4	<.05	.92	.13	.08
		05/29/95	R	1.4	.32	1.4	<.05	.39	.08	.07
		05/29/95	L	1.3	.30	--	<.05	.37	.08	.07
7	Raccoon River at Van Meter	03/23/94	R	<.05	<.05	.98	<.05	.12	.07	.05
		05/26/94	R	<.05	<.05	.81	<.05	.33	.09	.10
		05/29/95	R	4.5	.10	.72	<.05	5.9	.24	.31
8	Little Sioux River at Correctionville	03/24/94	R	<.05	<.05	1.0	<.05	.22	.10	.08
		06/06/94	R	<.05	<.05	.99	<.05	.34	.10	.10
		05/28/95	R	.88	.10	.79	<.05	1.4	.11	.15
9	Maple River at Mapleton	03/24/94	R	<.05	<.05	.33	<.05	.13	.10	.10
		06/05/94	R	.16	<.05	.25	<.05	1.4	.14	.09
		05/28/95	R	2.7	.06	.23	<.05	5.2	.25	.49
10	Boyer River at Logan	03/24/94	R	<.05	<.05	.36	<.05	.09	<.05	<.05
		06/02/94	X	<.05	.08	.41	<.05	1.8	.10	.09
		06/05/94	R	.20	.34	.73	<.05	4.7	.54	.50
		05/28/95	R	.89	.15	.34	<.05	2.0	.11	.19
	Illinois									
11	Bonpas Creek at Browns	03/23/94	R	<.05	<.05	.82	<.05	.14	.05	<.05
		06/24/94	R	<.05	3.7	10	<.05	15	3.1	1.8
		06/28/95	R	1.2	1.9	15	<.05	50	6.0	3.9
		06/29/95	X	.77	1.5	8.7	.28	29	5.2	3.4
12	Little Wabash River at Carmi	03/23/94	R	<.05	<.05	.97	<.05	.15	.05	<.05
		03/23/94	L	<.05	<.05	.96	<.05	.20	<.05	<.05
		06/28/94	R	.11	2.9	23	<.05	11	2.6	1.8
		06/29/95	R	.80	1.1	8.8	<.05	27	3.0	2.3
		06/29/95	B	.82	1.1	9.1	<.05	28	3.0	2.3

samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig. 1)	Concentration, in micrograms per liter										
	Cyana-zine	Cyana-zine amide	De-ethyl-cyana-zine	De-ethyl-cyana-zine	Meto-lachlor	Metri-buzin	Prome-ton	Prome-tryn	Propa-chlor	Propa-zine	Sima-zine
5	<0.05	0.09	<0.05	<0.50	0.05	<0.05	<0.05	<0.05	--	<0.05	<0.05
	1.1	.67	<.05	<.50	.40	<.05	<.05	<.05	--	<.05	<.05
	15	2.3	--	--	2.4	.08	.09	<.05	<0.05	.10	.07
6	<.05	.17	<.05	<.50	.19	<.05	<.05	<.05	--	<.05	<.05
	.84	.27	<.05	<.50	.26	<.05	<.05	<.05	--	<.05	.05
	.31	.09	--	--	2.6	<.05	<.05	<.05	.17	<.05	<.05
	.33	.07	--	--	2.4	<.05	<.05	<.05	.17	<.05	<.05
7	<.05	.08	<.05	<.50	.08	<.05	<.05	<.05	--	<.05	<.05
	.25	.06	<.05	<.50	.37	<.05	<.05	<.05	--	<.05	<.05
	7.0	.58	--	--	6.7	<.05	<.05	<.05	<.05	.05	<.05
8	<.05	.13	<.05	<.50	.09	<.05	<.05	<.05	--	<.05	<.05
	.09	.09	<.05	<.50	.10	<.05	<.05	<.05	--	<.05	<.05
	1.6	.17	--	--	3.3	<.05	<.05	<.05	<.05	<.05	<.05
9	<.05	.06	<.05	<.50	.08	<.05	<.05	<.05	--	<.05	<.05
	.80	.16	.05	<.50	.54	<.05	<.05	<.05	--	<.05	<.05
	13	1.1	--	1.0	.79	<.05	<.05	<.05	<.05	.06	.05
10	<.05	.07	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	3.6	.17	<.05	<.50	1.4	<.05	.34	<.05	--	<.05	.05
	7.8	2.0	.81	<.50	1.7	.15	<.05	<.05	--	<.05	.06
	6.1	.65	--	--	1.3	<.05	<.05	<.05	<.05	<.05	<.05
11	<.05	.05	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	.92	.29	<.05	<.50	11	.61	<.05	<.05	--	.23	4.8
	2.7	1.0	--	1.0	18	.39	.12	<.05	<.05	.38	7.2
	1.1	.50	--	1.0	15	.56	<.05	.25	.28	.46	4.2
12	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	<.05	<.05	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	3.1	1.3	<.05	<.50	2.8	<.05	.06	<.05	--	.18	3.3
	11	2.9	--	--	6.4	.54	<.05	<.05	<.05	.20	3.4
	10	2.9	--	--	6.6	.54	<.05	<.05	<.05	.20	3.5

Table 6. Analytical results for selected herbicides and six metabolites in water

Map no. (fig. 1)	Site name	Date of collection (month/day/year)	Sample type	Concentration, in micrograms per liter: Acetochlor	Alachlor	Alachlor ethane sulfonic acid	Ametryn	Atrazine	Deethylatrazine	Deisopropylatrazine
										Illinois—Continued
13	South Branch Kishwaukee	03/29/94	R	<0.05	<0.05	3.2	<0.05	0.33	0.25	0.09
	River at Fairdale	06/25/94	R	.42	1.9	11	<.05	6.2	1.1	.43
14	Iroquois River near	03/30/94	R	<.05	.05	2.7	<.05	.22	.07	.14
	Chebanese	06/16/94	R	<.05	1.1	5.3	<.05	4.2	.69	.55
		07/03/95	R	.42	.13	5.2	<.05	5.2	1.1	.86
15	Dupage River near	03/30/94	R	<.05	<.05	.34	<.05	<.05	<.05	<.05
	Shorwood	06/14/94	R	<.05	.52	1.5	<.05	2.7	.46	.21
		07/05/95	R	<.05	<.05	.27	<.05	.28	.07	.19
16	Spoon River at London Mills	03/29/94	R	<.05	<.05	.62	<.05	.17	.11	.08
		03/29/94	B	<.05	<.05	.57	<.05	.18	.11	.06
		05/07/94	B	.18	.16	1.0	<.05	3.5	.31	.46
		05/07/94	R	.15	.15	.90	<.05	3.6	.31	.43
		07/06/95	R	.48	.06	2.3	<.05	6.0	.85	.66
17	Sangamon River at Riverton	03/25/94	R	<.05	<.05	1.5	<.05	.22	.11	.12
		05/10/94	R	.54	.84	3.8	<.05	4.4	.35	.36
		06/23/95	R	.29	.27	2.0	<.05	6.0	.88	.71
18	Macoupin Creek near Kane	03/24/94	R	<.05	<.05	.81	<.05	.28	.11	.10
19	Kaskaskia River near	03/24/94	R	<.05	<.05	.91	<.05	.26	.16	.13
	Cowden	06/13/94	R	.22	2.1	7.0	<.05	10	1.9	1.1
		06/21/95	R	.30	<.05	.86	<.05	3.0	.35	.25
20	Shoal Creek near Breese	03/24/94	R	<.05	.24	.92	<.05	2.3	1.1	.56
		06/26/95	X	.63	1.2	5.3	<.05	13	1.7	1.2
		06/30/95	L	.41	.65	5.4	<.05	14	2.1	1.1
		06/30/95	R	.42	.65	5.2	<.05	15	2.2	1.2
										Indiana
21	Whitewater River near	03/29/94	R	<.05	.06	.48	<.05	.17	.07	<.05
	Alpine	06/24/94	X	<.05	.71	1.2	<.05	.74	.14	.08
		06/27/94	R	<.05	.70	5.7	<.05	3.6	.84	.40
		06/27/94	L	<.05	.72	5.4	<.05	3.4	.88	.37
		06/03/95	R	.79	.64	2.3	<.05	13	.94	.44

samples from 53 streams in nine Midwestern States, 1994–95—Continued

	Concentration, in micrograms per liter										
Map no. (fig. 1)	Cyana-zine	Cyana-zine amide	De-ethyl-cyana-zine	De-ethyl-cyana-zine	Meto-lachlor	Metri-buzin	Prome-ton	Prome-tryn	Propa-chlor	Propa-zine	Sima-zine
13	<0.05	0.11	<0.05	<0.50	0.05	<0.05	<0.05	<0.05	--	<0.05	<0.05
	3.2	1.9	<.05	<.50	3.5	<.05	<.05	<.05	--	<.05	<.05
14	.13	.11	<.05	<.50	.08	<.05	<.05	<.05	--	<.05	<.05
	3.2	1.8	<.05	<.50	1.1	<.05	<.05	<.05	--	<.05	<.05
	5.2	3.6	--	--	1.3	<.05	.05	<.05	<0.05	.06	.05
15	<.05	.06	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	4.0	1.5	.43	<.50	1.1	.08	<.05	<.05	--	<.05	.43
	.38	.12	--	--	.07	<.05	.05	<.05	<.05	<.05	.13
16	<.05	.07	<.05	<.50	.24	<.05	<.05	<.05	--	<.05	<.05
	<.05	.06	<.05	<.50	.23	<.05	<.05	<.05	--	<.05	<.05
	5.6	1.5	.14	<.50	1.3	<.05	<.05	<.05	--	<.05	.11
	5.7	1.5	.13	<.50	1.3	<.05	<.05	<.05	--	<.05	.11
	4.2	1.8	--	--	.74	<.05	.05	<.05	<.05	.06	.08
17	<.05	<.05	<.05	<.50	.22	<.05	<.05	<.05	--	<.05	<.05
	3.1	.78	.10	<.50	3.3	<.05	<.05	<.05	--	<.05	.08
	2.1	1.6	--	--	1.6	.07	.06	<.05	<.05	.06	.05
18	.23	.07	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
19	<.05	<.05	<.05	<.50	.09	<.05	<.05	<.05	--	<.05	<.05
	1.7	.83	<.05	<.50	5.6	.14	<.05	<.05	--	.22	.45
	.30	.09	--	--	.74	<.05	.06	<.05	<.05	<.05	.29
20	<.05	.06	<.05	<.50	.83	<.05	.07	<.05	--	<.05	.32
	5.3	3.6	--	--	3.7	.40	<.05	<.05	<.05	.15	.75
	3.9	1.9	--	--	6.0	.51	.07	<.05	<.05	.15	.18
	3.8	1.8	--	--	7.0	.51	.08	<.05	<.05	.15	.23
21	<.05	.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.13	--	--	--	.15	<.05	.33	<.05	--	<.05	.10
	.92	.57	<.05	<.50	1.2	.09	<.05	<.05	--	<.05	.30
	.90	.62	<.05	<.50	1.2	.09	<.05	<.05	--	<.05	.32
	3.6	.82	--	--	3.2	<.05	.05	<.05	<.05	.09	.25

Table 6. Analytical results for selected herbicides and six metabolites in water

Map no. (fig. 1)	Site name	Date of collection (month/ day/ year)	Sample type	Concentration, in micrograms per liter: Acetochlor	Alachlor	Alachlor ethane sulfonic acid	Ametryn	Atrazine	Deethylatrazine	Deisopropylatrazine
									Indiana—Continued	
22	Blue River at Fredricksburg	03/21/94	R	<0.05	<0.05	0.10	<0.05	0.09	0.15	<0.05
		05/16/94	R	<.05	.10	.66	<.05	6.8	1.6	.50
		06/21/95	R	<.05	.05	.37	<.05	2.0	.38	.20
23	Eel River near Logansport	03/23/94	R	<.05	<.05	1.4	<.05	.10	<.05	<.05
		06/08/94	X	<.05	.11	1.3	<.05	.33	.10	<.05
		06/14/94	R	.32	2.9	8.4	<.05	6.1	.90	.31
		06/14/94	L	.28	4.4	7.3	<.05	6.4	1.4	.86
		06/08/95	R	.11	.46	1.5	<.05	2.5	.24	.17
		06/08/95	B	.10	.42	1.5	<.05	2.3	.24	.14
		06/08/95	B	.08	.41	1.6	<.05	2.3	.24	.13
24	Wildcat Creek near Jerome	03/23/94	R	<.05	<.05	1.7	<.05	<.05	<.05	<.05
		05/25/94	R	.19	.66	3.3	<.05	3.8	.57	.71
		06/03/95	R	.06	.06	1.8	<.05	.94	.18	.74
25	Wildcat Creek near Lafayette	03/23/94	R	<.05	<.05	.62	<.05	.10	.05	<.05
		03/23/94	B	<.05	<.05	.92	<.05	.13	.07	<.05
		05/25/94	X	<.05	.24	1.5	<.05	3.4	.41	.39
		06/14/94	R	<.05	.98	3.9	<.05	4.8	1.3	.80
		06/23/95	R	<.05	<.05	1.1	<.05	1.5	.25	.18
26	White River near Nora	03/22/94	R	<.05	<.05	.88	<.05	.13	.06	<.05
		03/22/94	L	<.05	<.05	.79	<.05	.12	.06	<.05
		05/26/94	R	<.05	2.3	7.3	<.05	3.6	.64	.47
		05/26/94	L	<.05	2.5	6.1	<.05	4.3	.73	.46
		06/25/95	R	.07	.05	1.4	<.05	2.2	.38	.49
27	Sugar Creek near Edinburgh	03/21/94	R	<.05	<.05	.80	<.05	.09	.05	<.05
		05/16/94	R	<.05	2.0	6.0	<.05	10	1.1	.67
		05/16/94	B	<.05	2.2	6.8	<.05	11	1.1	.70
		06/04/95	R	.97	.23	2.8	<.05	7.2	.68	.30
28	East Fork White River near Bedford	03/22/94	R	<.05	<.05	.73	<.05	.08	.06	<.05
		05/16/94	R	.09	.91	3.4	<.05	5.7	.78	.37
		06/24/95	R	.57	.94	4.4	<.05	12	.74	.42

samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig. 1)	Cyana-zine	Cyana-zine amide	De-ethyl-cyana-zine	De-ethyl-cyana-zine	Meto-lachlor	Metri-buzin	Prome-ton	Prome-tryn	Propa-chlor	Propa-zine	Sima-zine
	Concentration, in micrograms per liter										
22	<0.05	<0.05	<0.05	<0.50	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.05
	2.0	.25	<.05	<.50	5.0	<.05	<.05	<.05	--	<.05	.59
	<.05	<.05	--	--	.50	<.05	<.05	<.05	0.06	<.05	.48
23	<.05	.06	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.49	.07	<.05	<.50	.15	<.05	<.05	<.05	--	<.05	.06
	.94	--	--	--	1.5	.09	<.05	<.05	--	.05	.91
	2.4	1.7	.43	<.50	1.9	.07	<.05	<.05	--	<.05	1.2
	.68	.20	--	--	.68	<.05	<.05	<.05	<.05	<.05	.18
	.58	.18	--	--	.61	.60	<.05	<.05	<.05	<.05	.19
	.53	.14	--	--	.64	<.05	<.05	<.05	<.05	<.05	.18
24	<.05	.10	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	6.2	2.7	.63	<.50	3.5	.28	<.05	<.05	--	<.05	<.05
	<.05	.67	--	--	.44	<.05	<.05	<.05	<0.05	<.05	<.05
25	<.05	.06	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	<.05	.07	<.05	<.50	.06	<.05	<.05	<.05	--	<.05	<.05
	3.4	.55	.17	<.50	1.4	<.05	<.05	<.05	--	<.05	.08
	1.7	.57	<.05	<.50	4.0	<.05	<.05	<.05	--	<.05	<.05
	.70	.37	--	--	.46	<.05	.05	<.05	<.05	<.05	.05
26	<.05	.08	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	<.05	.08	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	1.0	.49	<.05	<.50	2.0	.24	.22	<.05	--	<.05	.13
	2.7	.63	<.05	<.50	1.9	.29	.22	<.05	--	<.05	.15
	1.0	.49	--	--	.90	<.05	.21	<.05	<.05	<.05	.08
27	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	2.1	1.0	<.05	<.50	3.1	.05	<.05	<.05	--	.05	.85
	2.3	1.1	.10	<.50	3.4	<.05	<.05	<.05	--	.10	.90
	.98	.57	--	--	1.4	<.05	<.05	<.05	<.05	.06	.37
28	<.05	.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	1.2	.36	<.05	<.50	1.8	<.05	<.05	<.05	--	.06	.77
	<.05	.24	--	--	.84	<.05	<.05	<.05	<.05	.12	.21

Table 6. Analytical results for selected herbicides and six metabolites in water

Map no. (fig. 1)	Site name	Date of collection (month/day/year)	Sample type	Concentration, in micrograms per liter: Acetochlor	Alachlor	Alachlor ethane sulfonic acid	Ametryn	Atrazine	Deethylatrazine	Deisopropylatrazine
										Kansas
29	Black Vermillion River near Frankfort	03/22/94	R	<0.05	<0.05	0.72	<0.05	0.16	0.05	<0.05
		05/14/94	R	<.05	4.9	5.6	<.05	12	.71	.41
		05/14/94	L	<.05	5.6	7.3	<.05	12	.74	.38
		06/24/95	R	<.05	.72	1.2	<.05	36	1.1	.51
30	Delaware River near Muscotah	03/21/94	R	<.05	<.05	.49	<.05	.17	<.05	<.05
		05/15/94	R	.31	3.0	5.2	<.05	16	.85	.44
		06/25/95	R	.19	5.3	12	<.05	21	1.2	.49
										Minnesota
31	Cottonwood River near New Ulm	04/05/94	R	<.05	<.05	1.1	<.05	.05	<.05	<.05
		05/25/94	R	.48	4.5	6.8	<.05	3.7	.38	1.1
		05/28/95	R	.07	.06	1.1	<.05	.06	<.05	.14
32	Des Moines River at Jackson	04/05/94	R	<.05	<.05	1.5	<.05	.18	.06	<.05
		06/06/94	R	.10	.33	2.1	<.05	2.2	.31	.16
		05/28/95	R	.28	.05	1.6	<.05	.16	.08	.11
33	Rock River at Luverne	04/04/94	R	<.05	<.05	.69	<.05	.06	<.05	<.05
		04/04/94	L	<.05	<.05	.74	<.05	.07	<.05	<.05
		06/06/94	R	1.0	1.9	5.4	<.05	8.9	.81	.33
		05/28/95	R	6.0	.10	1.0	<.05	1.2	.17	.10
										Missouri
34	Nodaway River near Graham	03/29/94	R	<.05	<.05	.39	<.05	.06	<.05	<.05
		06/02/94	R	<.05	3.4	6.5	<.05	16	1.9	1.2
										Nebraska
35	Salt Creek at Roca	03/29/94	R	<.05	<.05	.69	<.05	.26	.10	<.05
		03/29/94	B	<.05	<.05	.72	<.05	.32	.12	.06
		05/15/94	R	1.0	6.5	18	<.05	26	1.7	.87
		05/15/94	L	2.0	7.2	14	<.05	26	2.1	1.0
		07/04/95	R	.08	1.4	1.6	<.05	28	2.2	1.5
		07/04/95	B	.09	1.4	1.7	<.05	30	2.5	1.8
		07/04/95	L	.10	1.6	--	<.05	31	2.8	1.6
		07/25/95	T	<.05	<.05	1.1	<.05	.91	.16	.10
		08/08/95	T	<.05	.54	4.5	<.05	3.3	.54	.32
		09/02/95	T	<.05	<.05	.69	<.05	.20	.06	<.05

samples from 53 streams in nine Midwestern States, 1994–95—Continued

	Concentration, in micrograms per liter										
Map no. (fig. 1)	**Cyanazine**	**Cyanazine amide**	**Deethylcyanazine**	**Deethylcyanazine**	**Metolachlor**	**Metribuzin**	**Prometon**	**Prometryn**	**Propachlor**	**Propazine**	**Simazine**
29	<0.05	<0.05	<0.05	<0.50	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.05
	<.05	<.05	<.05	<.50	4.8	1.2	<.05	<.05	--	<.05	<.05
	<.05	<.05	<.05	<.50	5.4	1.2	<.05	<.05	--	.14	<.05
	<.05	<.05	--	1.0	7.3	.30	<.05	<.05	6.3	.29	.05
30	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	3.3	.31	<.05	<.50	7.2	<.05	<.05	<.05	--	.10	<.05
	.20	.13	--	--	9.3	.96	<.05	<.05	7.9	.15	<.05
31	<.05	.11	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	56	4.0	2.0	.28	1.2	<.05	<.05	<.05	--	<.05	.10
	.17	.12	--	--	.28	<.05	<.05	<.05	<.05	<.05	<.05
32	<.05	.09	<.05	<.50	.08	<.05	<.05	<.05	--	<.05	<.05
	.93	.22	<.05	<.50	.12	<.05	<.05	<.05	--	<.05	<.05
	.38	.15	--	--	.22	<.05	<.05	<.05	<.05	<.05	<.05
33	<.05	<.05	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	<.05	<.05	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	3.2	.78	<.05	<.50	5.3	.20	<.05	<.05	--	.20	.07
	2.1	.17	--	1.0	11	<.05	<.05	<.05	<.05	<.05	<.05
34	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	18	6.4	<.05	<.50	3.1	.37	<.05	<.05	--	.23	.27
35	<.05	.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	11	2.3	<.05	<.50	6.3	1.7	<.05	<.05	--	.27	.08
	14	1.7	<.05	<.50	7.3	2.1	<.05	<.05	--	.36	<.05
	1.3	.45	--	1.0	19	1.4	<.05	<.05	5.3	.33	<.05
	1.3	.45	--	2.0	20	1.5	<.05	<.05	6.8	.36	.06
	1.4	.49	--	2.0	22	1.6	<.05	<.05	5.0	.35	<.05
	.25	.11	--	--	.22	<.05	<.05	<.05	<.05	<.05	<.05
	.36	.25	--	--	.52	<.05	<.05	<.05	<.05	<.05	<.05
	<.05	<.05	--	--	.07	<.05	.05	<.05	<.05	<.05	<.05

Table 6. Analytical results for selected herbicides and six metabolites in water

Map no. (fig. 1)	Site name	Date of collection (month/day/year)	Sample type	Concentration, in micrograms per liter						
				Acetochlor	Alachlor	Alachlor ethane sulfonic acid	Ametryn	Atrazine	Deethylatrazine	Deisopropylatrazine
										Nebraska—Continued
35	Salt Creek at Roca—Continued	09/02/95	T	<0.05	<0.05	0.43	<0.05	0.15	0.06	0.06
36	Wahoo Creek at Itica	03/29/94	R	<.05	<.05	.28	<.05	.07	<.05	<.05
		06/02/94	R	<.05	10	8.2	<.05	28	2.0	1.9
		07/04/95	R	<.05	.07	.21	<.05	.64	.08	.07
37	West Fork Big Blue River near Dorchester	03/29/94	R	<.05	<.05	.51	<.05	.16	.08	<.05
		06/27/94	R	<.05	3.1	15	<.05	15	2.4	1.5
		06/09/95	R	5.6	2.0	4.1	<.05	45	3.4	2.0
38	Big Nemaha at Fall City	03/30/94	R	<.05	<.05	.32	<.05	.14	<.05	<.05
		05/15/94	R	.97	8.1	9.7	<.05	23	1.2	.57
		05/15/94	B	.87	7.2	5.2	<.05	24	1.0	.51
		06/26/95	R	<.05	5.8	6.6	<.05	43	1.8	.62
		06/26/95	L	<.05	5.3	7.0	<.05	40	1.7	.71
39	Big Blue River at Barneston	03/30/94	R	<.05	<.05	.71	<.05	.16	.07	<.05
		05/15/94	R	.09	7.9	15	<.05	25	1.3	.73
		06/26/95	R	1.3	20	23	<.05	47	2.1	.77
40	Little Blue River near Fairbury	03/30/94	R	<.05	<.05	.28	<.05	.22	.08	<.05
		06/02/94	R	<.05	7.9	4.3	<.05	20	1.4	.58
		06/02/94	L	<.05	6.6	6.6	<.05	16	1.1	.41
		06/26/95	R	2.4	5.3	9.6	<.05	27	1.8	1.01
										Ohio
41	Clear Creek near Rockbridge	03/28/94	R	<.05	<.05	.44	<.05	.10	.06	.05
		06/21/94	R	<.05	<.05	.25	<.05	1.3	.17	.15
		05/25/95	R	.96	.06	.28	<.05	6.9	.26	.21
		06/01/95	XD	.07	<.05	.33	<.05	.90	.13	.10
		06/01/95	X	.07	<.05	.28	<.05	.88	.12	.10
42	Scioto River near Prospect	03/25/94	R	<.05	.05	2.5	<.05	.16	.06	<.05
		03/25/94	L	<.05	<.05	2.4	<.05	.14	.05	<.05
		06/15/94	R	<.05	3.8	5.6	<.05	21	3.5	1.3
		05/30/95	R	1.1	.25	2.0	<.05	12	.90	.60

samples from 53 streams in nine Midwestern States, 1994–95—Continued

	Concentration, in micrograms per liter										
Map no. (fig. 1)	Cyanazine	Cyanazine amide	Deethylcyanazine	Deethylcyanazine	Metolachlor	Metribuzin	Prometon	Prometryn	Propachlor	Propazine	Simazine
35	<0.05	<0.05	--	--	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
36	<.05	.06	<0.05	<0.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	20	5.4	2.6	.71	7.0	1.9	<.05	<.05	--	<.05	<.05
	.60	<.05	--	--	.24	<.05	<.05	<.05	.05	<.05	<.05
37	<.05	<.05	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	1.5	.77	<.05	<.50	3.1	.11	<.05	<.05	--	.22	.09
	1.2	.28	--	--	7.9	.13	.15	<.05	.13	.34	.19
38	<.05	<.05	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	7.1	.38	<.05	<.50	8.2	1.5	<.05	<.05	--	.11	<.05
	6.4	.30	<.05	<.50	11	1.4	<.05	<.05	--	.11	<.05
	2.1	.29	--	1.0	16	1.3	<.05	<.05	1.8	.30	<.05
	2.1	.29	--	1.0	17	1.2	<.05	<.05	2.0	.25	<.05
39	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	6.1	.85	<.05	<.50	4.6	1.3	<.05	<.05	--	.11	.14
	.66	.15	--	1.0	19	.43	.15	<.05	4.1	.47	.09
40	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.27	<.05	<.05	<.50	6.0	<.05	<.05	<.05	--	.30	<.05
	.17	<.05	<.05	<.50	5.1	<.05	<.05	<.05	--	.22	.11
	.21	.08	--	--	5.6	.25	<.05	<.05	.21	.21	.09
41	<.05	<.05	<.05	<.50	.20	<.05	<.05	<.05	--	<.05	.07
	.36	.16	<.05	<.50	.33	<.05	<.05	<.05	--	<.05	.16
	.58	.29	--	--	1.7	.08	.07	<.05	<.05	.05	.73
	.27	.24	--	--	.31	<.05	<.05	<.05	<.05	<.05	.23
	.26	.25	--	--	.29	<.05	<.05	<.05	<.05	<.05	.23
42	<.05	.06	<.05	<.50	.18	<.05	<.05	<.05	--	<.05	<.05
	<.05	.06	<.05	<.50	.16	<.05	<.05	<.05	--	<.05	<.05
	9.2	1.7	<.05	<.50	4.0	1.0	<.05	<.05	--	.49	<.05
	8.9	2.0	--	--	6.6	.18	.11	<.05	<.05	.10	.45

Table 6. Analytical results for selected herbicides and six metabolites in water

Map no. (fig. 1)	Site name	Date of collection (month/ day/ year)	Sample type	Concentration, in micrograms per liter: Acetochlor	Alachlor	Alachlor ethane sulfonic acid	Ametryn	Atrazine	Deethylatrazine	Deisopropylatrazine
									Ohio—Continued	
43	Olentangy River at Claridon	03/25/94	R	<0.05	0.05	3.1	<0.05	0.22	0.10	<0.05
		06/24/94	R	.27	2.0	25	<.05	5.8	1.5	.85
		05/30/95	R	1.7	.27	2.3	<.05	13	1.4	1.0
		05/30/95	L	1.8	.27	--	<.05	13	1.4	.85
44	Big Darby Creek at Darbyville	03/28/94	R	<.05	<.05	.67	<.05	.13	.07	.08
		03/28/94	L	<.05	<.05	.63	<.05	.12	.08	.07
		06/24/94	R	<.05	<.05	.79	<.05	.79	.18	.15
		05/25/95	R	.18	<.05	.81	<.05	4.1	.44	.30
		06/01/95	X	.10	<.05	.63	<.05	2.2	.28	.22
45	Scioto River at Higby	04/06/94	R	<.05	<.05	.71	<.05	.27	.06	<.05
		07/01/94	R	<.05	.35	6.2	<.05	3.7	.94	.53
		05/26/95	R	1.2	.37	1.2	<.05	8.5	.68	.54
46	Little Miami River near Oldtown	03/29/94	R	<.05	.07	1.3	<.05	.17	.11	.10
		06/29/94	R	<.05	.13	3.6	<.05	2.3	.47	.36
		05/30/95	B	.32	.12	2.4	<.05	3.3	.48	.35
		05/30/95	R	.33	.13	2.9	<.05	3.5	.49	.33
47	Mad River at Eagle City	03/29/94	R	<.05	<.05	.77	<.05	<.05	<.05	<.05
		06/29/94	R	<.05	.90	8.0	<.05	4.5	1.4	.61
		05/30/95	R	.09	<.05	.92	<.05	1.8	.18	.14
48	Tiffin River at Stryker	03/30/94	R	<.05	.05	2.7	<.05	.23	.12	.10
		06/28/94	R	<.05	.38	10	<.05	3.3	1.3	.72
		05/31/95	R	.84	.70	3.1	.08	6.0	.47	.42
49	Auglaize River near Fort Jennings	03/30/94	R	<.05	<.05	1.3	<.05	.11	<.05	.07
		03/30/94	B	<.05	<.05	1.4	<.05	.12	.05	.06
		06/28/94	B	<.05	1.4	19	<.05	4.9	1.5	.78
		06/28/94	R	<.05	1.3	28	<.05	4.8	1.5	.74
		05/31/95	R	.26	.60	4.4	<.05	4.0	.42	.33

samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig. 1)	Cyana-zine	Cyana-zine amide	De-ethyl-cyana-zine	De-ethyl-cyana-zine	Meto-lachlor	Metri-buzin	Prome-ton	Prome-tryn	Propa-chlor	Propa-zine	Sima-zine
	Concentration, in micrograms per liter										
43	<0.05	0.06	<0.05	<0.50	0.18	<0.05	<0.05	<0.05	--	<0.05	<0.05
	1.6	1.5	<.05	<.50	3.9	.30	<.05	<.05	--	.06	.45
	11	3.4	--	--	5.0	.25	.06	<.05	<0.05	.09	.72
	11	3.8	--	--	5.7	.26	.06	<.05	<.05	.10	.69
44	<.05	.06	<.05	<.50	.06	<.05	<.05	<.05	--	<.05	<.05
	<.05	.06	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	1.0	.56	<.05	<.50	.34	<.05	<.05	<.05	--	<.05	.05
	2.3	.91	--	--	1.1	<.05	<.05	<.05	<.05	<.05	.23
	1.5	.82	--	--	.67	<.05	<.05	<.05	<.05	<.05	.14
45	<.05	<.05	<.05	<.50	.22	<.05	<.05	<.05	--	<.05	<.05
	.97	1.0	<.05	<.50	2.7	.13	.07	<.05	--	<.05	.34
	6.2	1.3	--	--	3.4	.17	.09	<.05	<.05	.07	.74
46	<.05	.07	<.05	<.50	.31	.09	<.05	<.05	--	<.05	.16
	2.7	1.6	<.05	<.50	1.2	.16	<.05	<.05	--	<.05	.40
	3.0	.95	--	--	1.0	.06	<.05	<.05	<.05	<.05	.12
	3.2	1.2	--	--	1.0	.06	<.05	<.05	<.05	.05	.13
47	<.05	<.05	<.05	<.50	.05	<.05	<.05	<.05	--	<.05	<.05
	.75	.76	<.05	<.50	3.0	.32	<.05	<.05	--	<.05	.28
	1.4	.59	--	--	.64	<.05	<.05	<.05	<.05	<.05	.12
48	<.05	.10	<.05	.27	.07	<.05	<.05	<.05	--	<.05	<.05
	2.4	3.2	<.05	<.50	1.4	.22	<.05	<.05	--	<.05	.19
	6.6	1.8	--	--	1.7	.30	.12	.06	<.05	.06	.18
49	<.05	.05	<.05	<.50	.13	<.05	<.05	<.05	--	<.05	.06
	<.05	.05	<.05	<.50	.14	<.05	<.05	<.05	--	<.05	.06
	.68	--	--	--	3.7	.81	<.05	<.05	--	<.05	.41
	.83	.75	<.05	<.50	4.1	.85	<.05	<.05	--	<.05	.46
	3.1	1.3	--	--	2.5	.26	.14	<.05	<.05	.05	.43

Table 6. Analytical results for selected herbicides and six metabolites in water

Map no. (fig. 1)	Site name	Date of collection (month/ day/ year)	Sample type	Concentration, in micrograms per liter						
				Acetochlor	Alachlor	Alachlor ethane sulfonic acid	Ametryn	Atrazine	Deethylatrazine	Deisopropylatrazine
										Wisconsin
50	Root River at Racine	04/15/94	R	<0.05	<0.05	0.73	<0.05	<0.05	<0.05	<0.05
		06/24/94	R	<.05	<.05	.84	<.05	.26	.07	<.05
		05/25/95	R	<.05	<.05	1.3	<.05	.10	.05	.08
51	St. Croix River at St. Croix Falls	04/13/94	R	<.05	<.05	.11	<.05	<.05	<.05	<.05
		06/20/94	R	<.05	<.05	.10	<.05	.13	<.05	<.05
		06/12/95	R	<.05	<.05	.12	<.05	.24	<.05	<.05
52	Wisconsin River at Muscoda	03/21/94	R	<.05	<.05	.43	<.05	.10	<.05	<.05
		06/28/94	R	<.05	<.05	.48	<.05	.06	<.05	<.05
		05/30/95	R	.23	.06	.41	<.05	.24	.05	<.05
53	Rock River at Afton	04/06/94	R	<.05	<.05	1.6	<.05	.07	.07	<.05
		04/06/94	L	<.05	<.05	1.5	<.05	.09	.10	.08
		06/30/94	R	<.05	<.05	.97	<.05	.05	.06	<.05
		06/08/95	R	.05	<.05	1.2	<.05	.31	.13	.05

samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig. 1)	Concentration, in micrograms per liter										
	Cyana-zine	Cyana-zine amide	De-ethyl-cyana-zine	De-ethyl-cyana-zine	Meto-lachlor	Metri-buzin	Prome-ton	Prome-tryn	Propa-chlor	Propa-zine	Sima-zine
50	<0.05	0.06	<0.05	<0.50	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.05
	.27	.12	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.18	.07	--	--	.10	<.05	<.05	<.05	<0.05	<.05	.11
51	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	<.05	<.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	<.05	<.05	--	--	.16	<.05	<.05	<.05	<.05	<.05	<.05
52	<.05	.05	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.12	.18	<.05	<.50	.10	<.05	<.05	<.05	--	<.05	<.05
	.49	<.05	--	--	.52	<.05	<.05	<.05	<.05	<.05	<.05
53	<.05	.08	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.06	.08	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.14	.12	<.05	<.50	<.05	<.05	<.05	<.05	--	<.05	<.05
	.27	.09	--	--	.18	<.05	<.05	<.05	<.05	<.05	<.05

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95

[ft^3/s, cubic feet per second; %, percentage of time streamflow was less than measured value; µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; <, less than; --, no data]

Map no. (fig.1)	Site name	Date of collection (month/day/year)	Streamflow (ft^3/s)	Streamflow percentile (%)	Specific conductance (µS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophosphate as phosphorus (mg/L)
				Iowa						
1	Turkey River at Spillville	03/22/94	16	6.6	481	8.1	0.03	0.03	5.2	0.05
		05/24/94	30	17	530	8.4	.04	.01	4.1	.02
		06/08/95	482	95	345	8.0	.08	.08	11	.08
2	Wapsipinicon River at Independence	03/22/94	1,220	82	376	8.0	.03	.03	3.9	.03
		05/24/94	241	40	356	8.2	.02	.12	.40	.01
		05/30/95	1,060	79	454	8.0	.05	.03	8.6	.01
3	Old Mans Creek near Iowa City	03/21/94	101	63	476	8.0	.05	.23	5.0	.07
		05/24/94	42	35	474	7.5	.06	.06	2.5	.06
		06/02/95	553	94	412	7.8	.06	.21	10	.15
4	North Skunk River near Sigourney	03/24/94	314	60	489	8.3	.04	.12	3.4	.06
		05/25/94	139	38	540	7.8	.04	.06	2.2	.05
		06/06/95	2,280	95	385	8.0	.06	.10	7.1	.08
5	Skunk River at Augusta	03/24/94	2,680	66	598	8.0	.02	.03	3.8	.11
		06/03/94	1,250	45	571	7.8	.02	.05	1.7	.04
		06/08/95	7,850	90	459	7.8	.06	.02	8.0	.13
6	Des Moines River at Fort Dodge	03/23/94	3,860	85	625	8.3	.04	.20	4.1	.11
		06/06/94	2,030	71	675	8.3	.02	.02	2.9	.01
		05/29/95	10,300	97	682	8.2	.04	.09	10	.09

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig.1)	Site name	Date of collection (month/day/year)	Streamflow (ft^3/s)	Streamflow percentile (%)	Specific conductance (µS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophosphate as phosphorus (mg/L)
				Iowa—Continued						
7	Raccoon River at Van Meter	03/23/94	1,410	61	653	8.4	0.03	0.05	5.4	0.15
		05/26/94	1,330	59	572	8.6	.03	.01	6.1	.01
		05/29/95	11,000	97	476	8.1	.05	.09	16	.12
8	Little Sioux River at Correctionville	03/24/94	1,810	83	680	8.3	.02	.09	4.9	.11
		06/06/94	977	67	705	8.3	.02	.02	4.1	.18
		05/28/95	4,030	95	628	8.3	.04	.02	7.1	.04
9	Maple River at Mapleton	03/24/94	290	67	740	8.4	.02	.05	8.3	.12
		06/05/94	291	68	648	8.4	.05	.09	7.5	.13
		05/28/95	1,100	95	577	8.2	.09	.09	7.8	.04
10	Boyer River at Logan	03/24/94	178	44	790	8.4	.01	.05	6.4	.25
		06/05/94	360	68	585	8.6	.05	.44	5.2	.17
		05/28/95	1,000	91	639	8.4	.04	.02	6.8	.19
				Illinois						
11	Bonpas Creek at Browns	03/23/94	24	51	758	7.6	.02	.07	.54	.04
		06/24/94	183	76	894	8.1	.23	.69	5.8	.23
		06/28/95	140	73	355	6.8	.15	.27	4.1	.10
12	Little Wabash River at Carmi	03/23/94	1,570	62	800	8.2	<.01	.03	<.05	<.01
		06/28/94	4,930	78	371	7.1	.17	.43	3.9	.11
		06/29/95	3,976	74	290	6.9	.22	.15	2.0	.06

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig.1)	Site name	Date of collection (month/day/year)	Streamflow (ft^3/s)	Streamflow percentile (%)	Specific conductance (µS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophosphate as phosphorus (mg/L)
				Illinois—Continued						
13	South Branch Kishwaukee River	03/29/94	449	80	729	8.0	0.03	0.02	9.9	0.07
	at Fairdale	06/25/94	1,670	97	523	7.8	.11	.16	18	.17
14	Iroquois River near Chebanese	03/30/94	1,260	58	629	8.0	.02	.02	3.9	.02
		06/16/94	1,570	64	593	7.6	.07	.08	5.8	.07
		07/03/95	3,564	83	540	7.5	.12	.06	10	.04
15	Dupage River near Shorwood	03/30/94	250	60	1,290	8.3	.07	.02	5.0	.53
		06/14/94	940	94	602	7.5	.11	.39	5.1	.43
		07/05/95	585	86	786	7.5	.04	.02	4.2	.50
16	Spoon River at London Mills	03/29/94	769	72	716	7.9	.02	.02	7.1	.03
		05/07/94	4,160	97	633	7.0	.04	.06	6.5	.10
		07/06/95	4,733	97	502	7.6	.10	.02	8.2	.03
17	Sangamon River at Riverton	03/25/94	816	57	792	7.7	.03	.04	5.7	.12
		05/10/94	9,410	99	511	6.8	.08	.03	7.3	.18
		06/23/95	2,306	84	735	7.7	.09	.02	5.3	.31
18	Macoupin Creek near Kane	03/24/94	154	59	715	8.2	.02	.02	1.1	<.01
19	Kaskaskia River near Cowden	03/23/94	1,420	66	491	7.8	.04	.07	5.3	.16
		06/13/94	2,130	84	291	7.7	.11	.16	4.8	.08
		06/21/95	1,804	76	498	7.9	.06	.02	4.6	.01

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig.1)	Site name	Date of collection (month/day/year)	Stream-flow (ft^3/s)	Stream-flow percentile (%)	Specific conduc-tance (µS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophos-phate as phosphorus (mg/L)
				Illinois—Continued						
20	Shoal Creek near Breese	03/24/94	105	49	639	8.0	0.01	0.03	0.60	0.02
		06/30/95	1,006	86	317	7.5	.13	.03	2.7	.09
				Indiana						
21	Whitewater River near Alpine	03/29/94	404	58	591	8.4	.02	.06	2.6	.01
		06/27/94	748	80	536	7.7	.08	.13	4.7	.08
		06/03/95	1,550	93	563	8.0	.04	.11	4.3	.10
22	Blue River at Fredricksburg	03/21/94	192	60	387	8.4	.02	.02	2.6	<.01
		05/16/94	486	83	342	7.6	.03	.08	3.0	.06
		06/21/95	563	85	388	7.5	.03	.06	2.9	.03
23	Eel River near Logansport	03/23/94	559	60	635	8.2	.04	.02	2.4	.02
		06/14/94	1,050	80	605	7.6	.07	.28	5.4	.08
		06/08/95	705	69	640	8.1	.02	.02	2.9	<.01
24	Wildcat Creek near Jerome	03/23/94	59	54	589	8.0	.03	.02	4.0	<.01
		05/25/94	170	79	585	7.5	.10	.10	6.0	.05
		06/03/95	76	61	671	8.0	.08	.05	9.4	.01
25	Wildcat Creek near Lafayette	03/23/94	358	46	648	8.5	.05	.02	2.0	.01
		06/14/94	1,360	85	441	7.6	.04	.15	2.9	.12
		06/23/95	354	46	709	8.0	.03	.02	2.5	<.01
26	White River near Nora	03/22/94	705	53	678	8.6	.05	.02	2.0	.08
		05/26/94	1,800	81	670	7.7	.10	.18	5.8	.14
		06/25/95	996	65	792	8.0	.03	.03	3.3	.12

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig.1)	Site name	Date of collection (month/day/year)	Stream-flow (ft^3/s)	Stream-flow percentile (%)	Specific conductance (µS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophosphate as phosphorus (mg/L)
				Indiana—Continued						
27	Sugar Creek near Edinburgh	03/21/94	245	51	629	8.5	0.03	0.02	1.5	<0.01
		05/16/94	710	81	531	7.9	.06	.14	4.8	.07
		06/04/95	1,040	88	587	7.7	.04	.10	5.6	.07
28	East Fork White River near Bedford	03/22/94	2,960	54	505	7.9	.03	.02	1.9	.01
		05/16/94	8,670	85	398	7.4	.02	.09	2.1	.07
		06/24/95	3,100	56	479	7.7	.04	.03	2.1	.02
				Kansas						
29	Black Vermillion River near Frankfort	03/22/94	45	59	615	7.7	.02	.03	.82	.09
		05/14/94	2,050	98	254	7.4	.05	.36	1.8	.06
		06/24/95	250	90	458	7.3	.08	.10	2.1	--
30	Delaware River near Muscotah	03/21/94	60	55	570	8.0	.07	.15	3.0	.08
		05/15/94	1,450	96	321	7.4	.07	.15	3.0	.08
		06/25/95	370	89	313	7.2	.10	.13	2.5	--
				Minnesota						
31	Cottonwood River near New Ulm	04/05/94	631	85	1,050	7.9	.02	.03	5.2	.06
		05/25/94	1,750	95	672	7.9	<.01	<.01	<.05	<.01
		05/28/95	1,541	94	1,113	8.1	.02	.03	9.3	.04
32	Des Moines River at Jackson	04/05/94	870	87	643	8.2	.02	.02	2.3	<.01
		06/06/94	1,120	90	712	8.0	.04	.02	3.5	<.01
		05/28/95	2,174	96	763	8.0	.05	.07	5.9	<.01

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig.1)	Site name	Date of collection (month/day/year)	Streamflow (ft^3/s)	Streamflow percentile (%)	Specific conductance (µS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophosphate as phosphorus (mg/L)
				Minnesota—Continued						
33	Rock River at Luverne	04/04/94	168	--	759	8.1	0.02	0.03	5.3	0.03
		06/06/94	770	--	555	7.8	.18	.33	5.7	.09
		05/28/95	2,000	95	557	8.1	.09	.07	6.1	.08
				Missouri						
34	Nodaway River near Graham	03/29/94	300	39	440	8.2	<.01	.04	1.5	.08
		06/02/94	4,900	96	120	7.8	.09	.38	4.5	.04
				Nebraska						
35	Salt Creek at Roca	03/29/94	17	66	894	7.8	.02	.02	.74	.11
		05/15/94	135	93	575	7.0	.12	.54	3.6	.18
		07/04/95	323	97	395	7.4	.08	.17	3.9	.19
36	Wahoo Creek at Itica	03/29/94	65	72	817	7.6	.03	.14	2.2	.16
		06/02/94	1,420	99	204	6.8	.09	.77	3.9	.04
		07/04/95	90	83	758	7.5	.05	.10	3.5	.21
37	West Fork Big Blue River near Dorchester	03/29/94	118	72	608	7.8	.03	.03	2.2	.24
		06/27/94	252	88	280	7.9	.09	.10	6.7	.53
		06/09/95	517	94	--	--	.02	.04	2.7	.40
38	Big Nemaha River at Fall City	03/30/94	248	61	674	7.9	.02	.02	.78	.05
		05/15/94	2,570	96	2,570	7.2	.09	.23	3.0	.13
		06/26/95	934	89	492	7.2	.07	.02	3.3	.07
39	Big Blue River at Barneston	03/30/94	905	80	740	8.3	.02	.02	2.4	.35
		05/15/94	5,430	97	251	7.2	.12	.35	3.6	.21
		06/26/95	639	73	494	7.0	.07	.03	2.8	.21

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig.1)	Site name	Date of collection (month/day/year)	Streamflow (ft^3/s)	Streamflow percentile (%)	Specific conductance (μS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophosphate as phosphorus (mg/L)
				Nebraska—Continued						
40	Little Blue River near Fairbury	03/30/94	208	66	555	7.6	0.03	0.04	1.1	0.17
		06/02/94	699	91	360	7.2	.05	.29	1.4	.11
		06/26/95	267	75	421	8.1	.07	.09	3.0	.27
				Ohio						
41	Clear Creek near Rockbridge	03/28/94	254	93	315	8.1	.03	.12	2.4	.03
		06/21/94	22	16	323	7.4	.06	.15	1.4	.06
		05/25/95	184	88	335	7.9	.06	.02	3.3	.02
42	Scioto River near Prospect	03/25/94	386	72	713	7.9	.04	.20	4.9	.10
		06/15/94	138	47	430	7.3	.36	1.1	22	.39
		05/30/95	1,820	93	422	7.7	.06	.02	5.4	.06
43	Olentangy River at Claridon	03/25/94	137	73	510	7.9	.02	.03	4.4	.03
		06/24/94	491	91	407	7.7	.20	.82	17	.06
		05/30/95	494	91	364	7.7	.07	.02	6.0	.04
44	Big Darby Creek at Darbyville	03/28/94	782	82	645	8.1	.03	.02	2.7	.02
		06/24/94	368	64	674	8.2	.04	.08	1.6	.11
		05/25/95	1,120	88	668	8.1	.03	.02	7.3	.03
45	Scioto River at Higby	04/06/94	4,050	63	608	8.1	.03	.06	2.5	.06
		07/01/94	5,280	70	607	7.8	.11	.04	7.4	.09
		05/26/95	16,700	93	469	7.8	.06	.03	4.5	<.01

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig.1)	Site name	Date of collection (month/day/year)	Stream-flow (ft^3/s)	Stream-flow percentile (%)	Specific conductance (µS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophosphate as phosphorus (mg/L)
				Ohio—Continued						
46	Little Miami River near Oldtown	03/29/94	134	70	680	8.3	0.05	0.02	4.8	0.01
		06/29/94	136	71	620	8.1	.04	.09	4.2	.08
		05/30/95	205	83	696	8.1	.01	.02	4.5	.03
47	Mad River at Eagle City	03/29/94	348	72	705	8.1	.05	.06	3.7	.01
		06/29/94	545	88	600	7.9	.09	.12	8.1	.06
		05/30/95	636	91	697	8.0	.02	.02	5.0	.02
48	Tiffin River at Stryker	03/30/94	513	80	626	8.1	.04	.06	4.4	.02
		06/28/94	227	62	620	7.8	.20	.09	8.0	.06
		05/31/95	425	77	643	7.9	.08	.02	7.3	.01
49	Auglaize River near Fort Jennings	03/30/94	67	45	771	8.2	.05	.05	2.5	.01
		06/28/94	313	80	632	7.7	.36	.19	16	.08
		05/31/95	201	72	709	8.1	.49	.02	8.3	<.01
				Wisconsin						
50	Root River at Racine	04/15/94	129	71	1,020	8.2	.01	.02	.89	<.01
		06/24/94	26	31	1,000	8.0	.02	.24	.12	.09
		05/25/95	159	75	914	8.0	.06	<.01	3.5	<.01
51	St. Croix River at St. Croix Falls	04/13/94	9,400	88	120	7.8	<.01	.04	.14	<.01
		06/20/94	6,320	78	145	7.8	<.01	.03	.19	.01
		06/12/95	6,890	80	158	6.9	<.01	.02	.14	.01

Table 7. Streamflow, physical properties, and analytical results for dissolved nutrients in water samples from 53 streams in nine Midwestern States, 1994–95—Continued

Map no. (fig.1)	Site name	Date of collection (month/ day/year)	Stream-flow (ft^3/s)	Stream-flow percentile (%)	Specific conduc-tance (µS/cm)	pH (standard units)	Nitrite as nitrogen (mg/L)	Ammonia as nitrogen (mg/L)	Nitrite plus nitrate as nitrogen (mg/L)	Orthophos-phate as phosphorus (mg/L)
				Wisconsin—Continued						
52	Wisconsin River at Muscoda	03/21/94	10,400	74	256	8.1	0.03	0.16	1.2	0.05
		06/28/94	5,750	24	242	8.5	.02	<.01	.28	.02
		05/30/95	10,700	75	230	8.1	.02	<.01	.53	<.01
53	Rock River at Afton	04/06/94	4,300	87	472	8.9	.02	.02	.47	<.01
		06/30/94	1,490	40	628	8.4	.03	.02	1.2	.32
		06/08/95	2,180	59	673	7.6	.05	.21	1.0	.19

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