



Long Term Resource Monitoring Program

## Program Report

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# Annual Status Report, 1996: Macroinvertebrate Sampling



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# **Annual Status Report, 1996: Macroinvertebrate Sampling**

by

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April 1997

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## Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This document is an annual summary for 1996, containing a synthesis of target macroinvertebrate populations in the UMRS. This report satisfies, for 1996, Task 2.2.7.4, *Evaluate and Summarize Annual Results* under Goal 2, *Monitor Resource Change*, as specified in the Operating Plan for the Long Term Resource Monitoring Program (USFWS 1993). This report was developed with funding provided by the Long Term Resource Monitoring Program.

# Annual Status Report, 1996: Macroinvertebrate Sampling

by

Jennifer S. Sauer

## Abstract

In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, and the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program. Long-term monitoring is needed to detect population trends and local changes in aquatic ecosystems. Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic *Corbicula* species were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) were added in 1995. Mayflies, fingernail clams, and midges, members of the soft-substrate community, were chosen because they play an important ecological role in the Upper Mississippi River System. Sampling was based on a stratified random design and was conducted at approximately 125 sites per study area. Mean densities of organisms were weighted by strata for extrapolation purposes. Pool 13 had the highest mean number of mayflies and fingernail clams (146.6 and 231.4 m<sup>-2</sup>, respectively). La Grange Pool reported the highest densities of midges (149.9 m<sup>-2</sup>). Overall, the impounded areas, including Lake Pepin, and the contiguous backwaters tended to support the highest densities of mayflies, fingernail clams, and midges. Substrates with predominantly a silt clay constituent supported the highest mean densities of mayflies, fingernail clams, and midges.

## Introduction

In 1986, Congress designated the Upper Mississippi River System (UMRS), which consists of the Upper Mississippi and Illinois Rivers and several important tributaries, as a nationally significant ecosystem and a nationally significant navigation system. In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, the Open Reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program (LTRMP). Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic *Corbicula* species were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) in 1995. These organisms, found in the soft-sediment substrate, were chosen because they play an important ecological role in the UMRS. The exotic *Corbicula* species and zebra mussels were chosen for sampling because of possible detrimental effects they may have on the economy and biology of the UMRS. Further background information can be found in Sauer (1996).

The objective of the LTRMP macroinvertebrate component is to annually monitor and report trends in the status and distribution of select macroinvertebrate populations. The publically available data and annual status reports are the most basic LTRMP products. These annual status reports provide more detailed summaries of macroinvertebrate data than are included in trend reports (Sauer 1997). This status report and the trend reports are best used as information sources for assessment of background variation (Lubinski 1993), identification of management problems, and formulation of hypotheses. The ultimate goal of the LTRMP is not simply to report status and trends, but to improve the understanding and management of the UMRS. That goal can best be achieved by integration of routine monitoring with experimental research directed at identifying the causes of and solutions to specific problems. Future LTRMP efforts will integrate more narrowly focused analyses of data from all LTRMP monitoring components (limnology, bathymetry, sediments, aquatic plants, and fisheries) with results of experimental studies to identify causes of problems and opportunities for improved management. The resulting syntheses will be the ultimate products of the LTRMP.



## Methods

### *Sampling Procedures*

The sampling of mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), midges (Chironomidae), *Corbicula* sp., and zebra mussels (*Dreissena polymorpha*) was conducted during 1996 in Pools 4, 8, 13, 26, the Open Reach of the Mississippi River, and La Grange Pool of the Illinois River (Figure 1).

Sampling was conducted at about 125 sites per study reach per year (Table 1; Figures 2–7). Sample allocation was based on several criteria: surface area of the aquatic area in each study reach, field station input on accessibility, and productivity of organisms in each aquatic area. All sites were sampled in spring 1996 (Table 2).

Sites included locations where benthic samples were collected historically and randomly selected sites distributed among key aquatic areas, which are based on enduring geomorphic features (Wilcox 1993): contiguous backwaters (BWC), areas that have apparent surface water connection with the rest of the river; main channel borders (MCB), the area between the navigational buoys and the riverbank—not including revetments and channel-training structures; impounded areas (IMP), areas that are large, mostly open-water areas located in the downstream portion of the navigational pools; and side channels (SC), channels that carry less flow than the navigational channel. In the case of Pool 4, the "impounded" area is in the form of Lake Pepin, a tributary delta lake (TDL) formed by the Chippewa River. For this report, only randomly selected sites will be discussed.

The LTRMP developed a spatial database of aquatic areas (Owens and Ruhser 1996) based on aerial photography made in 1989; this database is used for randomized selection of sampling sites and the quantification of sampling strata reported herein. Ongoing change detection requires that this database be updated at appropriate intervals. The LTRMP Operating Plan (USFWS 1993) prescribes future repetition of aerial photography. Additionally, the LTRMP updates sampling maps, as needed, from direct observations made by the sampling crews.

Macroinvertebrate sampling procedures are described in detail in the LTRMP Procedures Manual (Thiel and Sauer 1995). Benthic samples were collected with a winch-mounted 23- × 23-cm (0.052-m<sup>2</sup>) standard Ponar grab sampler (Ponar Grab Dredge, Wildlife Supply Company, Saginaw, Michigan). The sieve size of the Ponar wash frame was a U.S. Standard No. 16 (1.18 mm). Thus, inferences in macroinvertebrate numbers made from this data for this report are restricted to the larger organisms of the population whole (i.e., adults). Mayflies, fingernail clams, midges (greater than 1 cm), *Corbicula* sp., and zebra mussels were counted and picked in the field.

### *Site Information*

Substrate composition was noted according to subjective characterization. Six categories of substrate composition were used: hard clay, silt clay, silt clay with sand, sand with silt clay, sand, and gravel rock.

The percentage of submersed and floating-leaved aquatic vegetation in the column of water and sediment that the Ponar dredge fell through was recorded. Also, the type and percentage of vegetation and open water in a 15-m radius from the boat were characterized. Water depth was also measured at each site.

## Statistical Analyses

Total catch is recorded for each target organism from individual Ponar samples. Whenever a species is not caught in a sample, the catch for that species in that sample is zero.

Analyses of densities (*DS*) in the present report are based on estimates of mean densities obtained by pooling data over all strata selected for macroinvertebrate sampling (Sauer 1997). In this way, the analyses track the broadest possible spatial scale in relative densities. The pooling probably presents a truer image of reachwide trends in true densities because it does not rely only on particularly favorable habitats. If the quantity of preferred habitat declines through time while densities in those preferred habitats remains constant, then these pooled mean *DS* statistics should also reflect that decline, whereas mean *DS* statistics from only the preferred habitats would not. The LTRMP monitors both the composition of aquatic areas and macroinvertebrates. Therefore, if the quantity of that aquatic area class preferred by a particular species declines through time while the abundances within each aquatic area remain constant, then the pooled mean *DS* statistics should also reflect the resulting decline in reachwide abundance, whereas mean *DS* statistics from only the preferred aquatic area would not.

The estimates of pooled reachwide mean *DS* were obtained from the conventional design-based estimator for stratified random samples (Cochran 1977). For an arbitrary random variable denoted *y* (for this report *y* is *DS*), the pooled mean, denoted  $\bar{y}_{st}$  (*st* for stratified) is given by

$$\bar{y}_{st} = \frac{1}{N} \sum_{h=1}^L N_h \bar{y}_h \quad (1)$$

where  $N_h$  is the number of sampling sites within stratum *h*,  $N = \sum_{h=1}^L N_h$ , and  $\bar{y}_h$  denotes the estimator of the sample mean of *y* for stratum *h*. The estimator of the variance of  $\bar{y}_{st}$  is

$$s^2(\bar{y}_{st}) = \frac{1}{N^2} \sum_{h=1}^L N_h (N_h - n_h) \left( \frac{s_h^2}{n_h} \right) \quad (2)$$

where

$$s_h^2 = \frac{\sum_{i=1}^{n_h} (y_{hi} - \bar{y}_h)^2}{n_h - 1}$$

is the usual estimator of the variance of  $y_h$  and  $n_h$  is the number of samples taken in stratum *h* (Cochran 1977). The standard error of  $\bar{y}_{st}$  is therefore  $s(\bar{y}_{st})$ . For LTRMP macroinvertebrate monitoring, the sampling units are the 50-m<sup>2</sup> sampling grids.

Equation (1) is used to obtain estimates of overall mean densities 1992–96 random sampling. In random samples, equation (1) yields unbiased estimates of the pooled means regardless of the probability distribution of *y* (Cochran 1977).

## Summary

- Measured depths at sampling sites ranged from 0.2 to 15.1 m with a mean of 3.1 m.
- In all study reaches, more than 79% of the Ponar grabs contained no submersed or floating-leaved vegetation (Table 3).
- The majority of samples taken in all reaches were in open water surrounded by little vegetation (Tables 4–7).
- Macroinvertebrate samples ( $N = 665$ ) in 1996 produced a total of 1,936 mayflies, 1,558 fingernail clams, 1,542 midges, 17 *Corbicula* sp., and 484 zebra mussels.
- Mean densities of target organisms were weighted by strata selected for macroinvertebrate sampling (Sauer 1997) to estimate pool or reachwide means (Table 8). Pool 13 had the highest densities of mayflies and fingernail clams. La Grange Pool had the highest estimated mean numbers of midges. Low numbers of *Corbicula* species were reported for all study reaches. Zebra mussel densities were highest in Pool 4 with the majority found in Lake Pepin.
- Visual classification of sediments indicated that sample sites in Pools 4, 8, 13, 26, and La Grange Pool were dominated by silt clay. The Open River reach had a predominance of sand (Table 9).
- The IMP aquatic area in Pool 8 and Lake Pepin in Pool 4 supported the highest numbers of mayflies. Mayfly densities in Pools 13 and 26 were highest in the SC aquatic areas.
- Mean densities of fingernail clams were highest in Lake Pepin (Pool 4) and the IMP area of Pools 8 and 13 (Tables 10–12). No fingernail clams were found in the Open River Study Reach.
- The BWC areas had the highest densities of midges in Pools 4, 13, and 26. La Grange Pool reported the highest densities in MCB aquatic areas.
- The silt clay substrate supported the highest mean numbers of mayflies in most study reaches, except in Pool 26 and La Grange Pool where silt clay with sand supported the highest mean numbers (Table 13). The silt clay substrate also supported the highest mean number of fingernail clams in all study reaches (Table 14). Higher densities of midges tended to be found in a wider variety of substrates (Table 15). The silt clay substrate seems to be well suited for burrowing organisms. The silt clay substrates apparently make it easier for burrowing yet, they still maintain their shape to allow for water movement and food uptake.

## Acknowledgments

The LTRMP is a cooperative effort by the Biological Resources Division of the U.S. Geological Survey, the U.S. Army Corps of Engineers, the Illinois Department of Conservation, the Illinois Natural History Survey, the Iowa Department of Natural Resources, the Minnesota Department of Natural Resources, the Missouri Department of Conservation, and the Wisconsin Department of Natural Resources. Monitoring is conducted by the participating state resource management and research agencies. Thanks go to these agencies and field station staff, especially K. Douglas Blodgett, Troy Clemment, Lesly Conaway, Fred Cronin, Steve DeLain, Terry Dukerschein, Russ Gent, Robert Hrabik, Matt O'Hara, Walter Popp, and Dirk Soergel. Special thanks to Pamella Thiel for the initiation of the LTRMP macroinvertebrate component.

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**Table 1.** Macroinvertebrate random sample sites by study reach and aquatic area. Numbers in parenthesis are historical (fixed) sites.

Study reach	Contiguous backwater	Impounded	Side channel	Main channel border
Pool 4	60 (3)	46 (1)	10	10
Pool 8	32 (3)	49 (11)	19 (2)	10
Pool 13	48 (4)	47 (1)	15 (2)	15
Pool 26	40	27	38 (3)	19 (4)
Open River	—	—	49 (18)	35 (2)
La Grange Pool	42 (18)	—	42 (7)	42 (1)

\*Pool 4 Impounded = Lake Pepin, Tributary Delta Lake

**Table 2.** Sampling dates for 1996 macroinvertebrate sampling.

Study reach	Beginning date	Ending date
Pool 4	May 7	May 16
Pool 8	May 20	May 30
Pool 13	May 31	June 13
Pool 26	May 6	May 17
Open River	March 26	April 5
La Grange Pool	May 6	May 17

**Table 3.** Number of sites, reported as percentages, with submersed and floating-leaved vegetation in the column of water and sediment that the Ponar fell through. *N* = number of samples.

Study reach ( <i>N</i> )	Vegetation present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (121)	91.7	6.6	0.8	0.8	—
Pool 8 (109)	92.7	0	—	—	—
Pool 13 (118)	79.7	19.5	0.8	—	—
Pool 26 (112)	100	—	—	—	—
Open River (107)	98.1	1.9	—	—	—
La Grange (98)	100	—	—	—	—

**Table 4.** Number of sites, reported as percentages, with submersed vegetation within a 15-m radius from the boat. *N* = number of samples.

Study reach ( <i>N</i> )	Vegetation present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (121)	100	—	—	—	—
Pool 8 (109)	90.8	9.2	—	—	—
Pool 13 (118)	77.1	18.6	4.2	—	—
Pool 26 (112)	100	—	—	—	—
Open River (107)	100	—	—	—	—
La Grange (98)	100	—	—	—	—

**Table 5.** Number of sites, reported as percentages, with floating-leaved vegetation within a 15-m radius from the boat. *N* = number of samples.

Study reach ( <i>N</i> )	Vegetation present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (121)	100	—	—	—	—
Pool 8 (109)	95.4	4.6	—	—	—
Pool 13 (118)	93.2	6.8	—	—	—
Pool 26 (112)	96.4	3.6	—	—	—
Open River (107)	100	—	—	—	—
La Grange (98)	100	—	—	—	—

**Table 6.** Number of sites, reported as percentages, with emergent vegetation within a 15-m radius from the boat. *N* = number of samples.

Study reach ( <i>N</i> )	Vegetation present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (121)	88.4	6.6	2.5	2.5	—
Pool 8 (109)	97.2	2.8	—	—	—
Pool 13 (118)	98.3	0.8	0.8	—	—
Pool 26 (112)	100	—	—	—	—
Open River (107)	100	—	—	—	—
La Grange (98)	100	—	—	—	—

**Table 7.** Number of sites, reported as percentages, with open water within a 15-m radius from the boat. *N* = number of samples.

Study reach ( <i>N</i> )	Open water present				
	0%	1%–20%	21%–50%	51%–90%	91%–100%
Pool 4 (121)	—	—	0.8	19.8	79.3
Pool 8 (109)	—	—	—	0.9	99.1
Pool 13 (118)	0.8	—	0.8	7.6	90.7
Pool 26 (112)	—	—	—	—	100
Open River (107)	0.9	—	1.9	35.5	61.7
La Grange (98)	—	—	—	—	100

**Table 8.** Estimated mean number of mayflies, fingernail clams, midges, *Corbicula* sp., and zebra mussels per square meter by study reach. Estimated means are weighted by areas of strata. *N* = number of samples.

Study reach ( <i>N</i> )	Mayflies ( $\pm 1$ SE)	Fingernail clams ( $\pm 1$ SE)	Midges ( $\pm 1$ SE)	<i>Corbicula</i> sp. ( $\pm 1$ SE)	Zebra mussels ( $\pm 1$ SE)
Pool 4 (121)	131.9 ( $\pm 33.9$ )	39.4 ( $\pm 7.3$ )	37.7 ( $\pm 11.5$ )	0.0 ( $\pm 0.0$ )	115.8 ( $\pm 113.3$ )
Pool 8 (109)	38.3 ( $\pm 11.2$ )	2.2 ( $\pm 0.9$ )	15.0 ( $\pm 4.1$ )	0.0 ( $\pm 0.0$ )	0.6 ( $\pm 0.4$ )
Pool 13 (118)	146.6 ( $\pm 37.5$ )	231.4 ( $\pm 58.2$ )	21.1 ( $\pm 7.0$ )	0.0 ( $\pm 0.0$ )	13.9 ( $\pm 8.2$ )
Pool 26 (112)	12.9 ( $\pm 10.4$ )	0.2 ( $\pm 0.1$ )	18.1 ( $\pm 8.5$ )	0.0 ( $\pm 0.0$ )	0.3 ( $\pm 0.3$ )
Open River (107)	10.9 ( $\pm 6.1$ )	0.0 ( $\pm 0.0$ )	5.0 ( $\pm 2.4$ )	1.2 ( $\pm 0.8$ )	0.3 ( $\pm 0.2$ )
La Grange (98)	3.6 ( $\pm 1.5$ )	4.7 ( $\pm 2.7$ )	149.9 ( $\pm 49.7$ )	1.2 ( $\pm 0.7$ )	0.4 ( $\pm 0.4$ )

**Table 9.** Percentage of predominant substrate type found in Ponar grab samples by study reach. *N* = number of samples

Study reach ( <i>N</i> )	Predominant Substrate (%)						Total (%)
	Hard clay	Silt clay	Silt clay with sand	Sand with silt clay	Sand	Gravel rock	
Pool 4 (121)	1.7	62.8	5.0	8.3	18.2	4.1	100
Pool 8 (109)	0.9	37.6	11.9	26.6	22.9	—	100
Pool 13 (118)	4.2	51.7	12.7	5.9	22.0	3.4	100
Pool 26 (112)	4.5	45.5	10.7	6.3	25.0	8.0	100
Open River (107)	3.7	22.4	11.2	2.8	34.6	25.2	100
La Grange (98)	3.1	49.0	21.4	11.2	14.3	1.0	100

**Table 10.** Mean number of mayflies per square meter by study reach and aquatic area. *N* = number of samples.

Study reach ( <i>N</i> )	Aquatic area			
	BWC (±1 SE)	MCB (±1 SE)	IMP (±1 SE)	SC (±1 SE)
Pool 4 (121)	75.8 (±22.6)	1.9 (±1.9)	163.5 (±41.1) <sup>a</sup>	2.3 (±1.5)
Pool 8 (109)	22.3 (±10.6)	0.0 (±0.0)	63.9 (±15.5)	11.1 (±6.5)
Pool 13 (118)	185.6 (±33.7)	3.8 (±2.8)	94.9 (±20.9)	406.8 (±156.3)
Pool 26 (112)	36.1 (±14.2)	48.1 (±48.1)	66.2 (±16.4)	192.3 (±77.7)
Open River (107)	—	10.1 (±6.0)	—	17.0 (±7.1)
La Grange (98)	4.7 (±2.1)	1.2 (±0.8)	—	29.1 (±6.8)

BWC = contiguous backwater

MCB = main channel border

IMP = impounded

SC = side channel

<sup>a</sup>Pool 4 IMP = Lake Pepin, Tributary Delta Lake

**Table 11.** Mean number of fingernail clams per square meter by study reach and aquatic area. *N* = number of samples.

Study reach ( <i>N</i> )	Aquatic area			
	BWC (±1 SE)	MCB (±1 SE)	IMP (±1 SE)	SC (±1 SE)
Pool 4 (121)	12.7 (±4.7)	0.0 (±0.0)	51.1 (±8.8) <sup>a</sup>	3.4 (±2.5)
Pool 8 (109)	1.9 (±1.0)	0.0 (±0.0)	3.1 (±1.0)	1.0 (±1.0)
Pool 13 (118)	98.4 (±20.6)	88.5 (±73.3)	413.3 (±89.9)	91.7 (±27.5)
Pool 26 (112)	28.8 (±9.6)	0.0 (±0.0)	15.4 (±3.8)	—
Open River (107)	—	0.0 (±0.0)	—	0.0 (±0.0)
La Grange (98)	8.7 (±5.0)	3.0 (±1.8)	—	2.9 (±1.2)

BWC = contiguous backwater

MCB = main channel border

IMP = impounded

SC = side channel

<sup>a</sup>Pool 4 IMP = Lake Pepin, Tributary Delta Lake



**Table 12.** Mean number of midges per square meter by study reach and aquatic area. *N* = number of samples.

Study reach ( <i>N</i> )	Aquatic area			
	BWC (±1 SE)	MCB (±1 SE)	IMP (±1 SE)	SC (±1 SE)
Pool 4 (121)	46.5 (±12.1)	25.0 (±12.5)	36.7 (±10.9)	32.8 (±16.6)
Pool 8 (109)	19.2 (±5.7)	3.8 (±2.6)	20.4 (±4.9)	1.0 (±1.0)
Pool 13 (118)	52.8 (±13.8)	3.8 (±3.8)	4.9 (±2.6)	11.8 (±8.0)
Pool 26 (112)	147.7 (±47.1)	32.1 (±19.0)	66.2 (±11.7)	86.5 (±28.8)
Open River (107)	—	3.0 (±2.1)	—	20.6 (±4.5)
La Grange (98)	97.3 (±20.9)	175.5 (±63.9)	—	135.8 (±38.3)

BWC = contiguous backwater

MCB = main channel border

IMP = impounded

SC = side channel

\*Pool 4 IMP = Lake Pepin, Tributary Delta Lake

**Table 13.** Mean number of mayflies per square meter by study reach and predominant substrate type. *N* = number of samples.

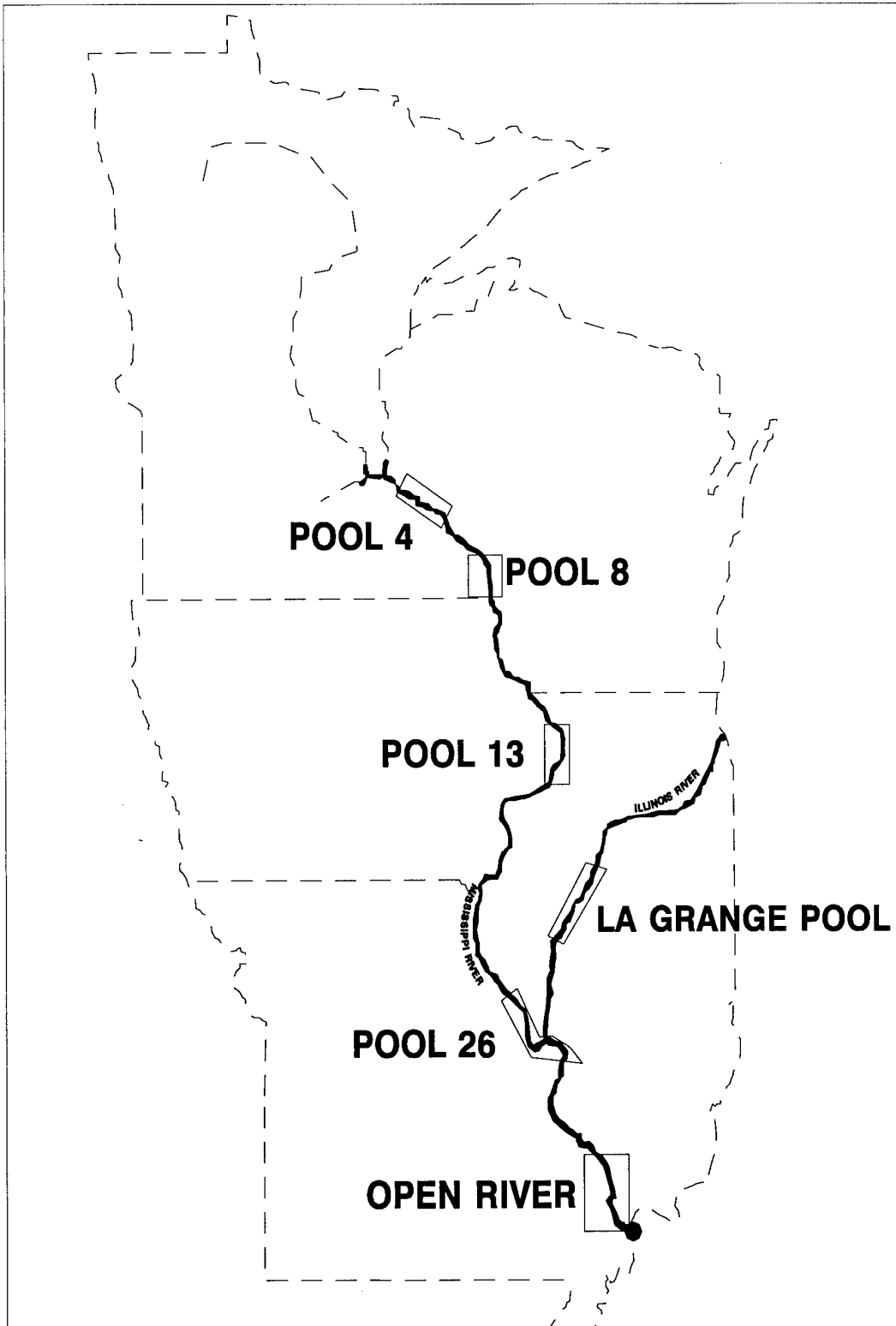
Study reach ( <i>N</i> )	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (121)	0.0 (±0.0)	143.9 (±27.6)	9.6 (±6.6)	0.0 (±0.0)	0.9 (±0.9)	3.8 (±3.8)
Pool 8 (109)	307.7	80.7 (±17.4)	32.5 (±13.1)	0.0 (±0.0)	0.0 (±0.0)	—
Pool 13 (118)	0.0 (±0.0)	279.9 (±40.6)	33.3 (±12.7)	19.2 (±16.3)	2.9 (±1.8)	0.0 (±0.0)
Pool 26 (112)	38.5	63.0 (±15.3)	240.4 (±48.1)	—	0.0	0.0 (±0.0)
Open River (107)	14.4 (±9.2)	55.3 (±20.4)	14.4 (±6.3)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)
La Grange (98)	0.0 (±0.0)	13.2 (±3.7)	23.8 (±8.6)	1.7 (±1.7)	0.0 (±0.0)	0.0

**Table 14.** Mean number of fingernail clams per square meter by study reach and predominant substrate type.  
*N* = number of samples.

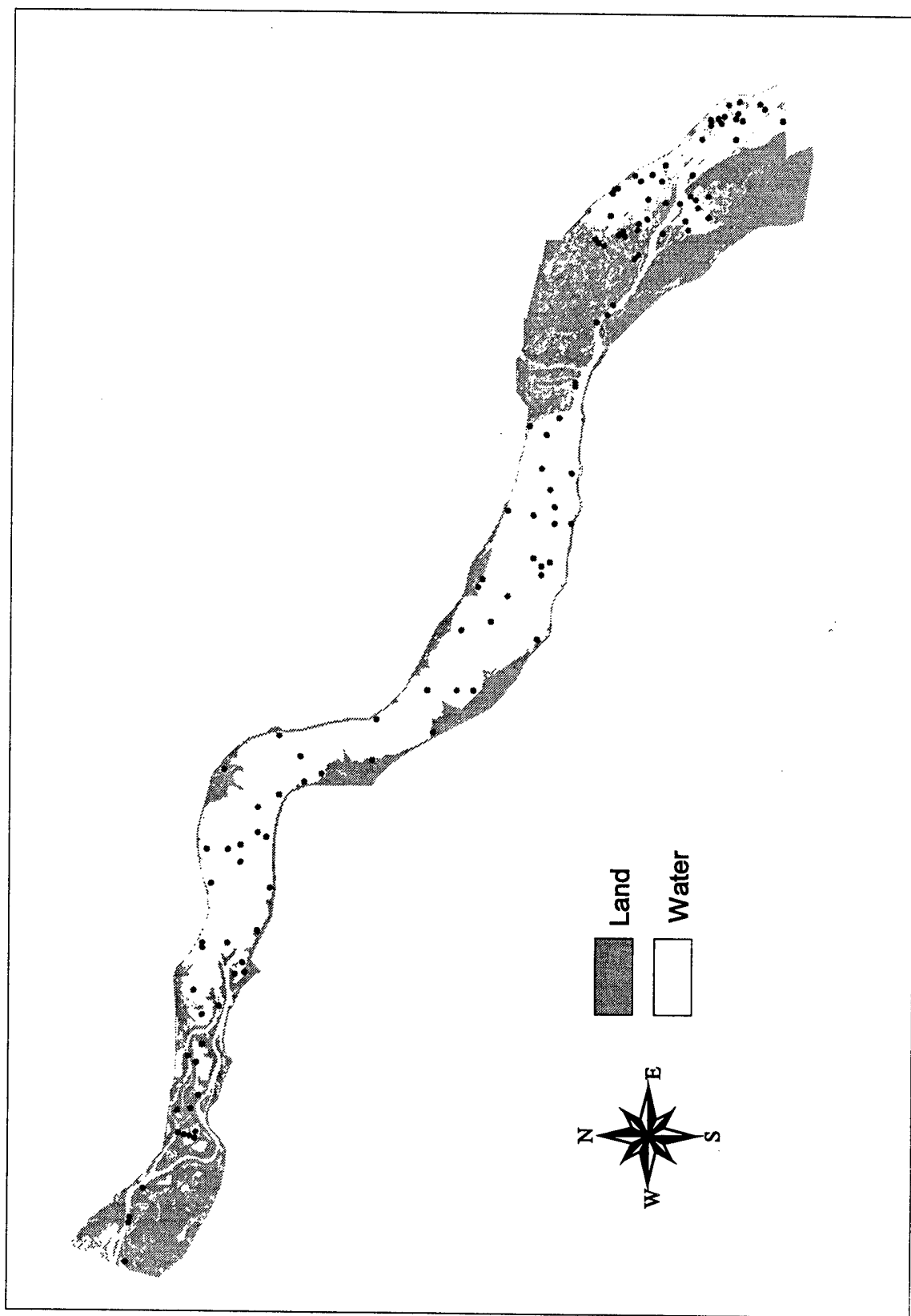
Study reach ( <i>N</i> )	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (121)	0.0 (±0.0)	36.9 (±6.2)	9.6 (±6.6)	3.8 (±3.8)	1.7 (±1.2)	0.0 (±0.0)
Pool 8 (109)	0.0	4.2 (±1.3)	1.5 (±1.5)	0.7 (±0.7)	0.8 (±0.8)	—
Pool 13 (118)	23.1 (±18.6)	314.9 (±67.0)	305.1 (±115.6)	93.4 (±59.4)	62.1 (±42.6)	0.0 (±0.0)
Pool 26 (112)	—	19.2 (±4.2)	0.0	—	0.0	0.0 (±0.0)
Open River (107)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)
La Grange (98)	0.0 (±0.0)	7.2 (±3.5)	4.6 (±2.3)	3.5 (±3.5)	0.0 (±0.0)	0.0 (±0.0)

**Table 15.** Mean number of midges per square meter by study reach and predominant substrate type.  
*N* = number of samples.

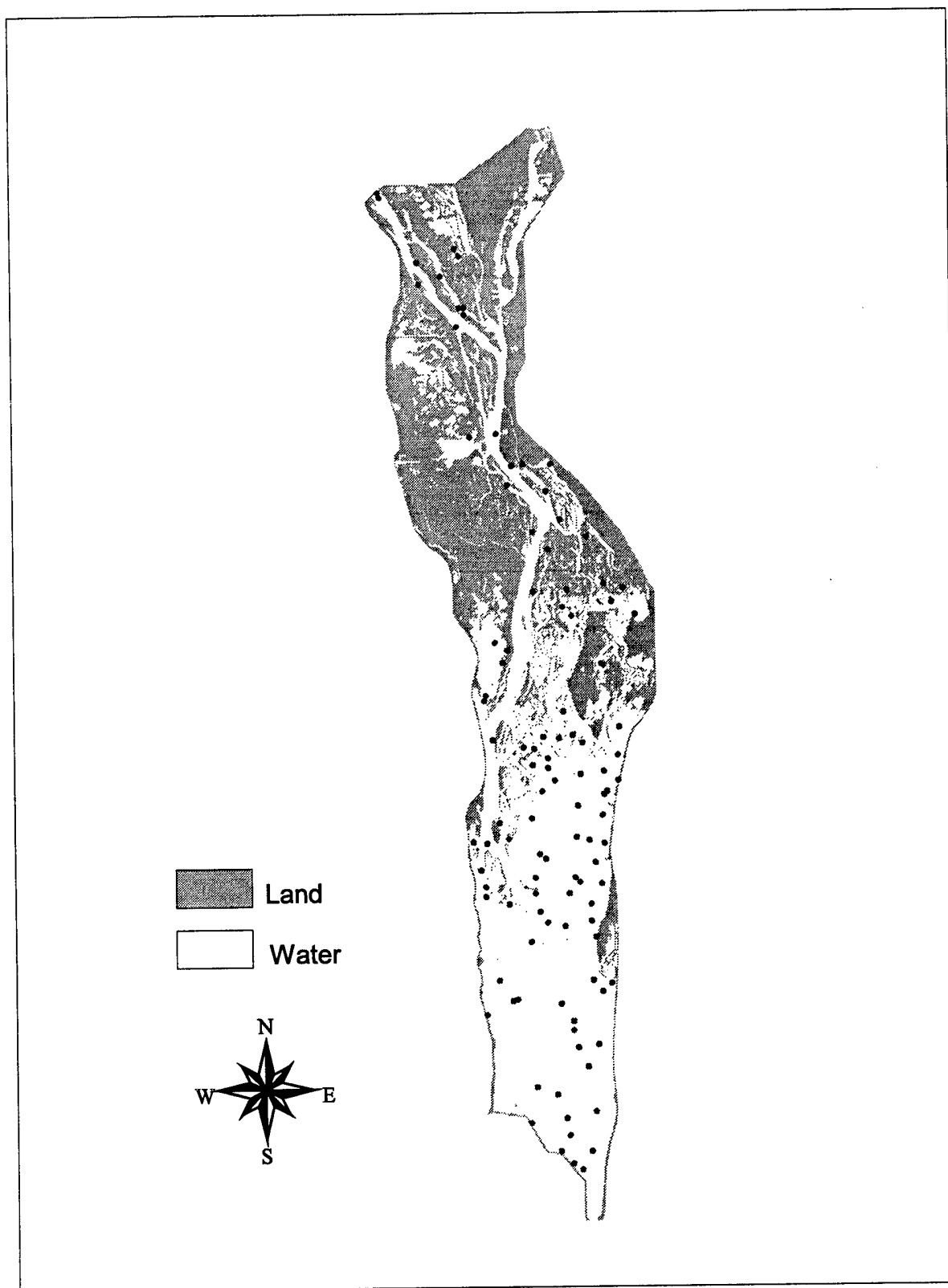
Study reach ( <i>N</i> )	Predominant substrate					
	Hard clay (±1 SE)	Silt clay (±1 SE)	Silt clay with sand (±1 SE)	Sand with silt clay (±1 SE)	Sand (±1 SE)	Gravel rock (±1 SE)
Pool 4 (121)	48.1 (±48.1)	45.3 (±9.8)	70.5 (±43.5)	21.2 (±10.5)	20.9 (±8.8)	23.1 (±18.6)
Pool 8 (109)	96.2	32.4 (±5.7)	2.9 (±2.9)	5.9 (±3.6)	0.8 (±0.8)	—
Pool 13 (118)	11.5 (±11.5)	42.2 (±10.2)	1.3 (±1.3)	2.7 (±2.7)	1.5 (±1.0)	0.0 (±0.0)
Pool 26 (112)	—	88.1 (±16.3)	96.2 (±64.7)	487.2 (±371.8)	28.8 (±28.8)	0.0 (±0.0)
Open River (107)	19.2 (±19.2)	20.0 (±5.8)	48.1 (±15.9)	25.6 (±16.9)	8.3 (±4.6)	0.7 (±0.7)
La Grange (98)	32.1 (±16.9)	86.1 (±15.2)	200.5 (±71.1)	110.1 (±65.5)	251.4 (±119.7)	134.6



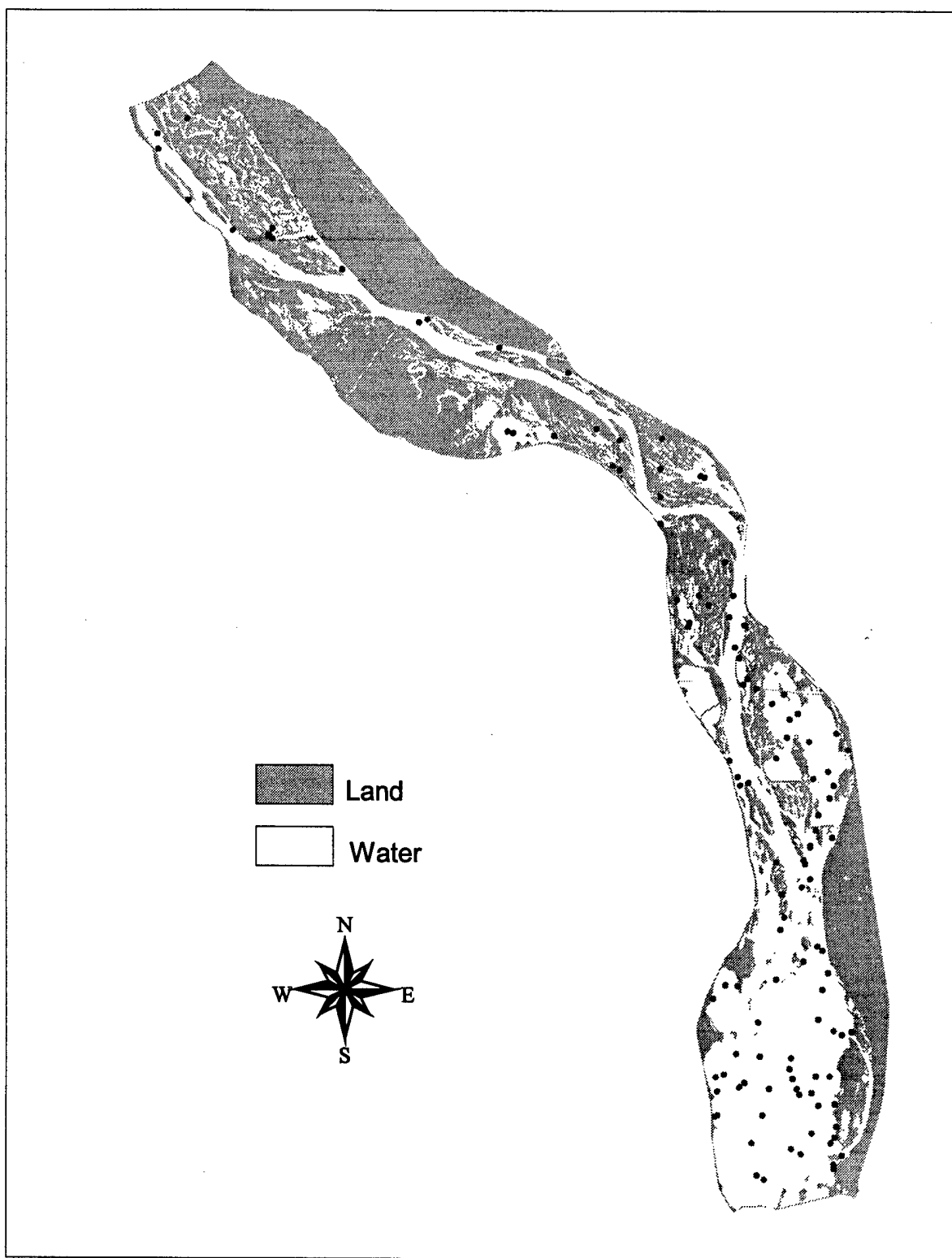
**Figure 1.** Long Term Resource Monitoring Program study reaches for macroinvertebrate sampling



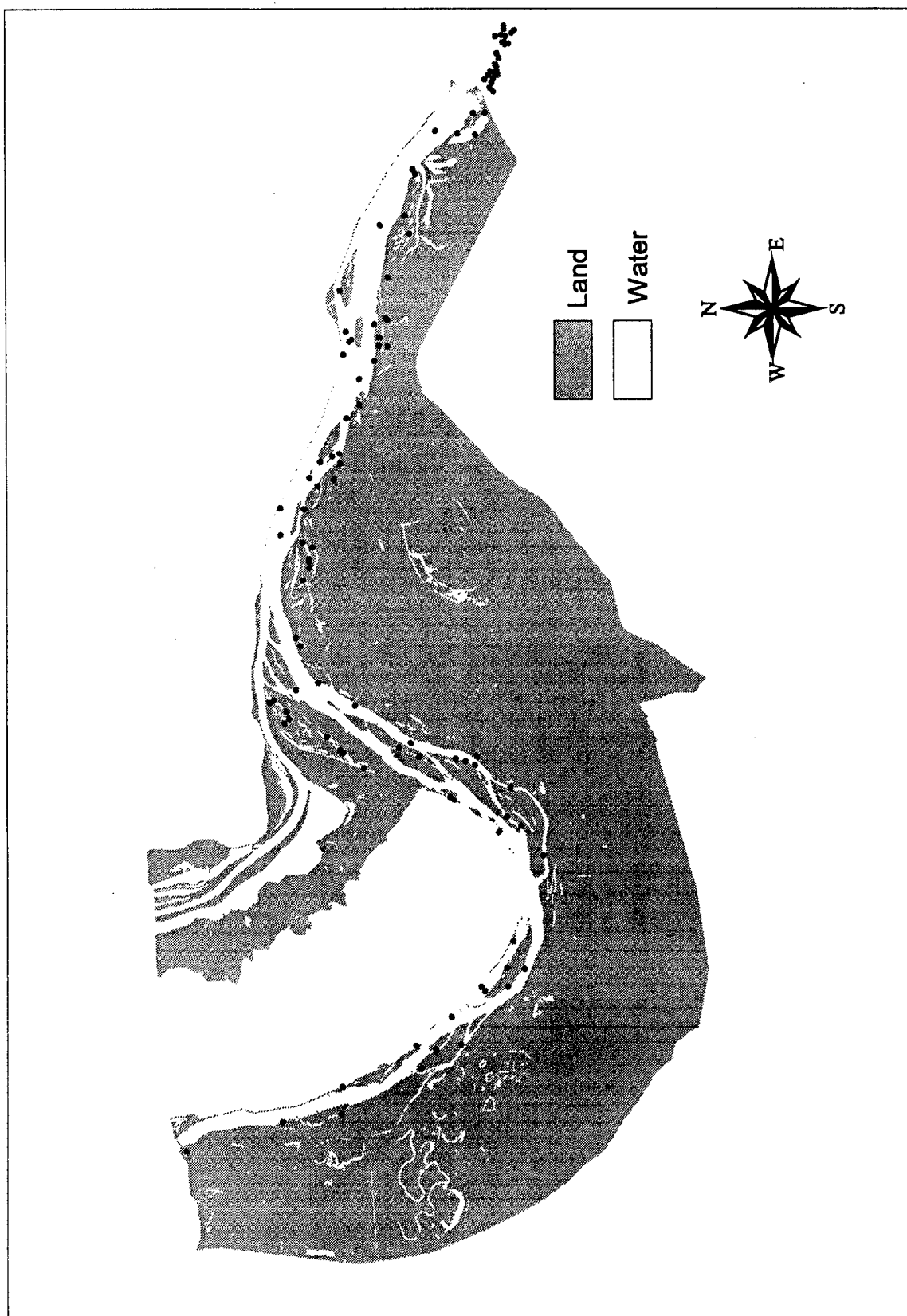
**Figure 2.** Pool 4 (river miles 753-797)—1996 Long Term Resource Monitoring Program macroinvertebrate random sample points.



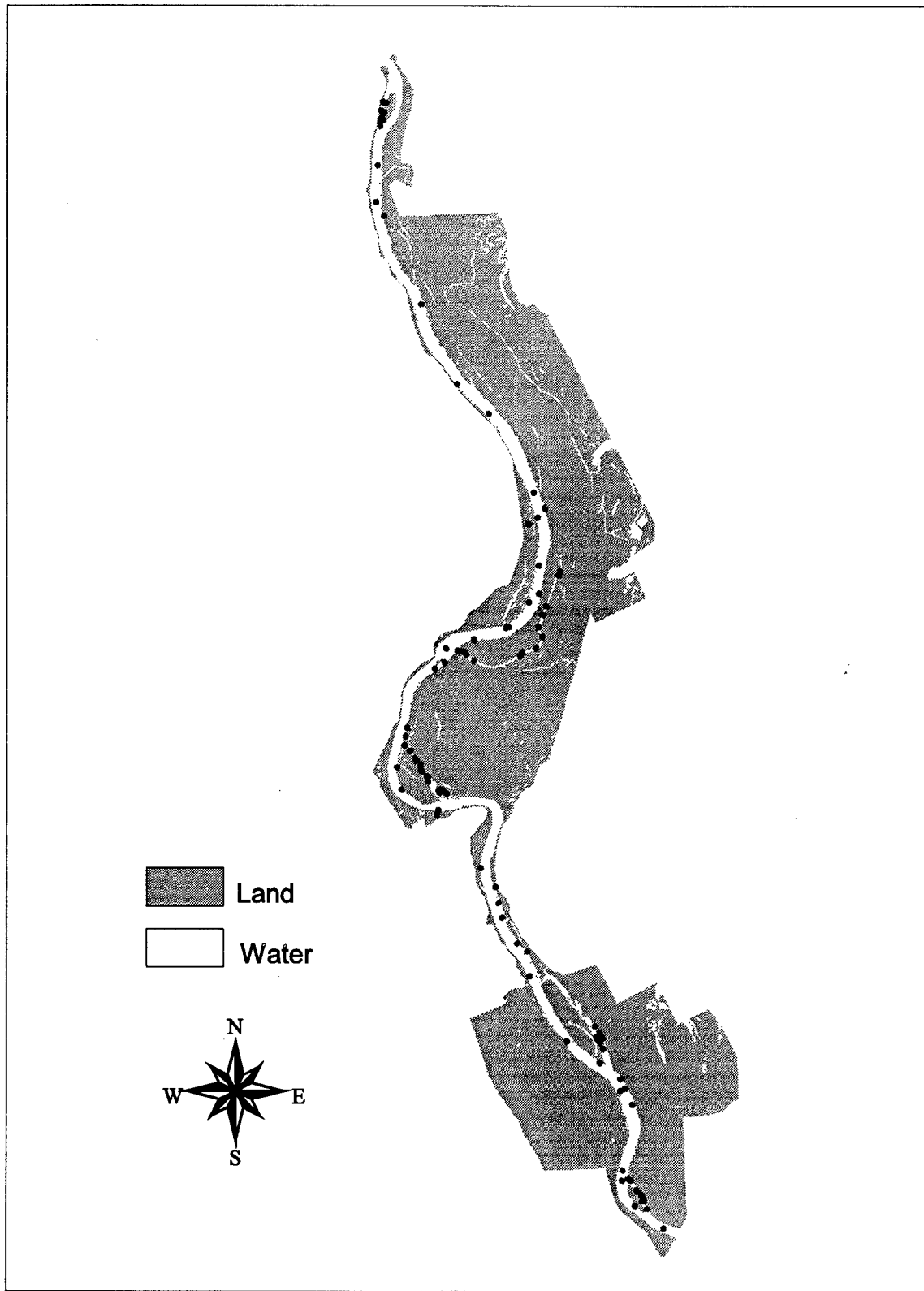
**Figure 3.** Pool 8 (river miles 679–703)—1996 Long Term Resource Monitoring Program macroinvertebrate random sample points.



**Figure 4.** Pool 13 (river miles 522.5–557)—1996 Long Term Resource Monitoring Program macroinvertebrate random sample points.

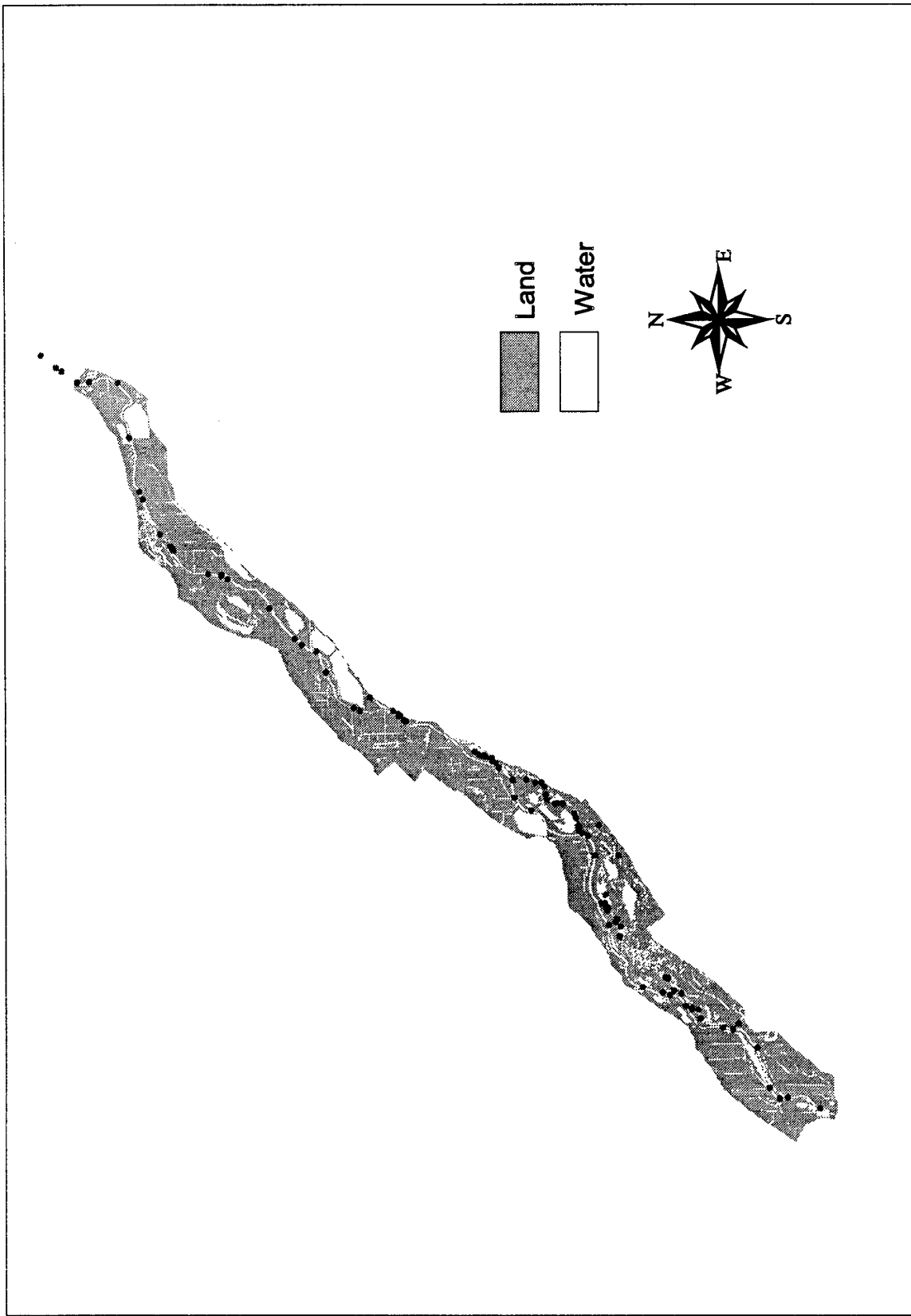


**Figure 5.** Pool 26 (river miles 203–241.5)—1996 Long Term Resource Monitoring Program macroinvertebrate random sample points.



**Figure 6.** Open River (river miles 0–80)—1996 Long Term Resource Monitoring Program macroinvertebrate random sample points.





**Figure 7.** La Grange Pool (Illinois river miles 80–158)—1996 Long Term Resource Monitoring Program macroinvertebrate random sample points.

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13. ABSTRACT (Maximum 200 words)  In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, and the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River, as part of the Long Term Resource Monitoring Program. Long-term monitoring is needed to detect population trends and detect local changes in aquatic ecosystems. Mayflies (Ephemeroptera), fingernail clams (Sphaeriidae), and the exotic <i>Corbicula</i> species were selected for monitoring. Midge (Chironomidae) were added to the sampling design in 1993 and zebra mussels ( <i>Dreissena polymorpha</i> ) were added in 1995. Mayflies, fingernail clams, and midges, members of the soft-substrate community; were chosen because they play an important ecological role in the Upper Mississippi River System. Sampling was based on a stratified random design and was conducted at approximately 125 sites per study area. Mean densities of organisms were weighted by strata for extrapolation purposes. Pool 13 had the highest mean number of mayflies and fingernail clams (146.6 and 231.4 m <sup>-2</sup> , respectively). La Grange Pool reported the highest densities of midges (149.9 m <sup>-2</sup> ). Overall, the impounded areas, including Lake Pepin, and the contiguous backwaters tended to support the highest densities of mayflies, fingernail clams, and midges. Substrates with predominantly a silt clay constituent supported the highest mean densities of mayflies, fingernail clams, and midges.			
14. SUBJECT TERMS  Benthic aquatic macroinvertebrates, <i>Corbicula</i> , fingernail clams (Sphaeriidae), mayflies (Ephemeroptera), midges (Chironomidae), Mississippi River, zebra mussels ( <i>Dreissena polymorpha</i> )			15. NUMBER OF PAGES  18 pp.
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