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Evaluation of Water-Quality and Habitat Assessment Data to Determine Ranges in Stream Conditions in the Mississippi River Alluvial Plain of Northwestern Mississippi and Eastern Arkansas

Water-Resources Investigations Report 03-4251

U.S. Department of the Interior
U.S. Geological Survey

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By Richard A. Rebich, Heather L. Welch, and Richard H. Coupe

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U.S. Department of the Interior
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CONVERSION FACTORS, ABBREVIATIONS, AND ACRONYMS

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

µm	**micron, or micrometer**
mg/L	**milligrams per liter**
µg/L	**micrograms per liter**
µS/cm	**microsiemens per centimeter**
ANOVA	**Analysis of variance**
CWA	**Clean Water Act**
EA	**Eastern Arkansas**
EPA	**U.S. Environmental Protection Agency**
ERDC	**Engineer Research and Development Center**
GIS	**Geographical information system**
IBI	**Index of Biological Integrity**
MDEQ	**Mississippi Department of Environmental Quality**
MDMSEA	**Mississippi Delta Management Systems Evaluation Areas**
MISE	**Mississippi Embayment**
MRAP	**Mississippi River Alluvial Plain**
NAWQA	**National Water-Quality Assesment**
NFQA	**National Field Quality Assurance**
NTU	**Nephelometric Turbidity Unit**
NWM	**Northwestern Mississippi**
QAPP	**Quality Assurance Project Plan**
RPD	**Relative percent difference**
USACE	**U.S. Army Corps of Engineers**
USGS	**U.S. Geological Survey**

EVALUATION OF WATER-QUALITY AND HABITAT ASSESSMENT DATA TO DETERMINE RANGES IN STREAM CONDITIONS IN THE MISSISSIPPI RIVER ALLUVIAL PLAIN OF NORTHWESTERN MISSISSIPPI AND EASTERN ARKANSAS

By Richard A. Rebich, Heather L. Welch, and Richard H. Coupe

ABSTRACT

In January 2002, the U.S. Geological Survey began a study to collect water-quality and habitat-assessment data at 50 sites located in the Mississippi River Alluvial Plain. Forty-three sites in northwestern Mississippi and seven sites in eastern Arkansas were sampled during winter and summer 2002. Water-quality analyses included physical-property measurements, nitrogen and phosphorus species, chlorophyll-a, and chloride. Water-quality data collected during this study compared well to data collected for ongoing studies located in the study area and collected by similar sampling techniques.

Statistical analyses were performed to determine whether the water-quality and/or habitat-assessment data could be used to detect ranges in stream conditions for the sampled sites. These analyses compared the data sets based on sample index period, site location, drainage-area size, and subjectively evaluated stream conditions (sites that were considered to have good or poor water quality and habitat). Of the water-quality data analyzed, turbidity was the most practical in indicating ranges in stream conditions among the sites sampled. Habitat-assessment total scores were similarly practical.

The statistical results were also evaluated to determine the value of data analysis by category. Sample index period and site location categories provided the strongest results. For example, the mean turbidity value for northwestern Mississippi sites sampled during the winter index period (213 NTU) was about three times the mean turbidity value for the summer index period (68 NTU). The median turbidity value for the eastern Arkansas sites (17 NTU) was about one-fifth the median value for the northwestern Mississippi sites (89 NTU). Drainage-area size and subjectively evaluated stream conditions were the weakest categories with respect to statistical results. None of the comparisons were statistically significant for water-quality or habitat-assessment data from northwestern Mississippi sites categorized as good to data from sites categorized as poor.

INTRODUCTION

The U.S. Environmental Protection Agency (USEPA) outlines in section 303(d) of the Clean Water Act (CWA) a requirement for each State to design restoration and remediation strategies for impaired water bodies within that State (Mississippi Department of Environmental Quality, 2000). As part of their statewide stream water-quality assessments, the Mississippi Department of Environmental Quality (MDEQ) uses the Index of Biological Integrity (IBI) method to determine impairment for most stream watersheds in Mississippi (Mississippi Department of Environmental Quality, 2000); however, the IBI method could not be used for streams located in northwestern Mississippi (Matt Hicks, Mississippi Department of Environmental Quality, written commun., 2002). As a result, MDEQ identified the need for a suitable monitoring and assessment method to evaluate water bodies for this particular region. In response, a workgroup was created to evaluate current methods to monitor and assess stream conditions for northwestern Mississippi streams and to define target conditions to serve as endpoints for ecological integrity (Randy Reed, Mississippi Department of Environmental Quality, written commun., 2001).

The workgroup, which included representatives from several State and Federal agencies, suggested a pilot study to: (1) collect four types of data – fish, macroinvertebrate, water quality, and habitat; and (2) determine whether a particular data type could be used to indicate a range of stream conditions, and ultimately impairment, in northwestern Mississippi streams. For each data-collection effort, sampling protocols were evaluated for their effectiveness to indicate ranges of stream conditions. In some cases, more than one sampling protocol was evaluated.

Purpose and Scope

The U.S. Geological Survey (USGS), in cooperation with MDEQ, collected water samples and assessed stream habitat at 43 sites in northwestern Mississippi and at 7 sites in eastern Arkansas (fig. 1) during two index periods (winter, January-April 2002, and summer, July-September 2002). This report: (1) documents methods of site selection and categorization, data collection, quality assurance and quality control, and statistical analysis used in this study; (2) presents summaries of the data collected for this study and comparisons to data collected in other studies located in the same study area; and (3) presents results of statistical analyses to determine whether any of the collected data could indicate a range of stream conditions for northwestern Mississippi streams.

Description of the Study Area

The study area is located in the Mississippi River Alluvial Plain (MRAP), specifically the part of the MRAP that lies in northwestern Mississippi and eastern Arkansas (fig. 1). The study focused primarily on the portion of the MRAP in northwestern Mississippi, an area described briefly in the following paragraphs.

The entire MRAP in Mississippi is drained by the Yazoo River, which is formed by the confluence of the Tallahatchie and Yalobusha Rivers. The Yazoo River flows southward from Greenwood along the eastern edge of the alluvial valley until it reaches the Mississippi River at Vicksburg. Four flood-control reservoirs (Arkabutla, Sardis, Enid, and Grenada Lakes) are located in the northeastern part of the basin. These reservoirs control the discharge from more than 4,400 mi^2 of drainage area within the Yazoo River Basin (Coupe, 2000).

Tributary inflow to the Yazoo River downstream of Yazoo City is diverted by a levee located along the right bank of the river channel from Yazoo City to the split of the old channel and the Yazoo River Diversion Channel. In the mid-1960's, the U.S. Army Corps of Engineers (USACE) constructed a diversion canal that connected Steele Bayou, Deer Creek, the Little Sunflower River, and the Big Sunflower River. Runoff from these four basins is controlled by two flood-control structures on the Steele Bayou and Little Sunflower River. The flood-control structures at Steele Bayou and Little Sunflower River are closed when water elevation of the Yazoo River approaches the pool elevation at each structure, thus preventing extensive alluvial flooding by backwater from the Mississippi River. The flood-control structures are opened when the stage in the Yazoo River drops below the pool elevation, allowing water to flow into the Yazoo River (Coupe, 2000).

The study area is sparsely populated and contains no major metropolitan areas. Agriculture is the dominant land use with cotton, soybean, catfish, rice, and corn being the most economically important crops. Farmers in the MRAP irrigate row crops and flood rice fields with ground water and some surface water, using as much as 7 billion gallons of water per day during the summer months (Kleiss and others, 2000).

Acknowledgments

The following people contributed to the data-collection efforts: Jeannie Bryson, David Burt, Laura Fauver, Russ Howell, Mike Manning, Barbara Tippens, and Darrell Wilson from the USGS in Jackson, Miss.; Billy Justus from the USGS in Little Rock, Ark.; Brian Caskey from the USGS in Montgomery, Ala.; and Chip Bray and Will Green from MDEQ in Jackson, Miss.

METHODS

The methods used in this study for data collection and analysis were as important to the workgroup as the actual data collected. The following sections document the methods used for site selection and categorization, data collection, quality assurance and quality control, and statistical analysis.

Site Selection and Categorization

In order to evaluate stream conditions in diverse water bodies, 50 MRAP sites (fig.1) of varying stream sizes were recommended for study by the workgroup. Alternate sites (discussed later) were treated as one site. Forty-three of the 50 sites are located in the eastern part of the MRAP region in the Yazoo River Basin, hereafter referred to as northwestern Mississippi (NWM) sites. Seven of the 50 sites are located in the western part of the MRAP region in eastern Arkansas, hereafter referred to as eastern Arkansas (EA) sites.

All 43 NWM sites were categorized according to drainage-area size, presence of flood-control structures, and whether the sites were perennial or intermittent based on information from the USACE Engineer Research and Development Center (ERDC). The site categories were as follows: (1) large, regulated; (2) large, unregulated; (3) medium; (4) small, perennial; and (5) small, intermittent. Fifteen of the 43 NWM sites were further categorized according to subjectively evaluated ("good" or "poor") stream conditions. These 15 NWM sites were considered by ERDC to have good or poor stream conditions based on existing fisheries data, which included total number of species, total number of fish, and species diversity (Jan Hoover and Jack Kilgore, Engineer Research and Development Center, oral commun., 2001). Eighteen of the 43 NWM sites were randomly selected as sites having small drainage areas. These 18 randomly selected sites were identified by Tetra Tech, Inc., using Geographical Information System (GIS) software (James Stribling, Tetra Tech, Inc., oral commun., 2003). The random sites were categorized as either small-perennial or small-intermittent, but because of insufficient data, were not categorized as having good or poor stream

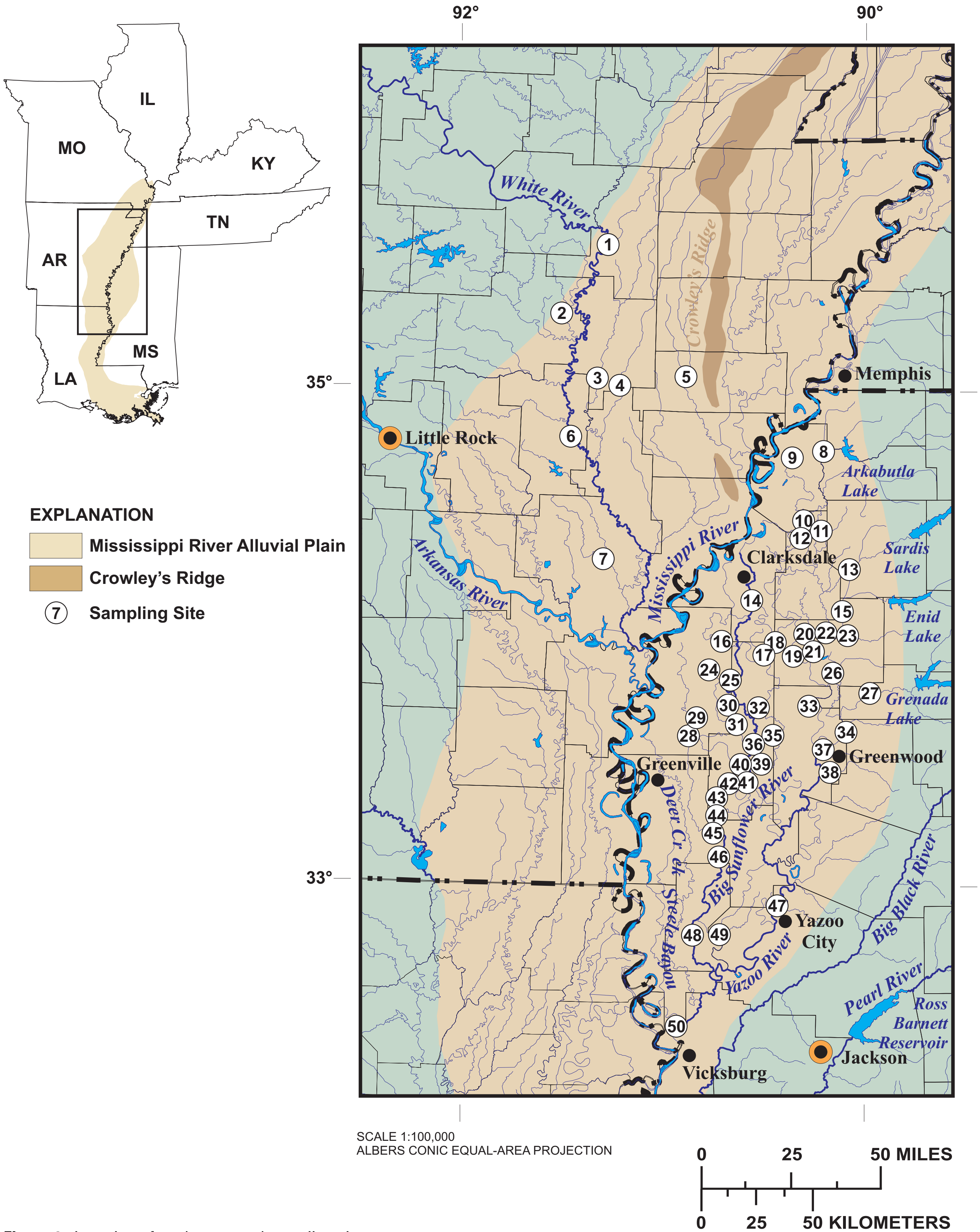


Figure 1. Location of study area and sampling sites.

conditions. EA sites were located on streams sampled as part of the USGS National Water-Quality Assessment (NAWQA) Program (Billy Justus, U.S. Geological Survey, written commun., 2003) and were included to expand the range of available data. These seven sites were chosen to represent good stream conditions. Sites that were sampled and their associated categories are listed in table 1.

About 30 alternate small NWM sites were chosen by using the same GIS software that was used to select the random sites. A list of these sites, in order of sampling preferences, was used when a site was dry, could not be accessed, or did not fit the proper size classification description. If the primary sites could not be sampled, then the first alternate in that size category (perennial or intermittent) was chosen from the alternate list, regardless of location of the primary site.

Data Collection

Data were collected during two index periods: winter (January – April 2002) and summer (July – September 2002). In 2002, the study area received approximately 6 in. above normal precipitation causing above-average streamflow conditions during the winter index period. [For example, see the relation between mean daily streamflow from January to September 2002 and the 5-year mean daily streamflow (1997-2001) for the Big Sunflower River near Merigold gaging station shown in figure 2. Note that the 5-year mean also included several months of drought during 2000.] During the study period, the USACE closed some of the flood-control structures in the Yazoo River Basin, which created backwater conditions for several of the NWM sites. The backwater conditions created access problems (sampling was unsafe, and conditions were unsuitable) during the winter sampling period; consequently, habitat assessments were conducted for only 28 of the 50 sites through mid-March 2002. Water samples were collected for the remaining sites as late as April 2002 (fig. 3). For sites 3, 20, 27, 37, 40, and 48, surface-water samples were collected from bridges during the winter index period due to high water conditions (habitat was not assessed).

During the summer index period, both surface-water samples and habitat assessments were collected within stream reaches located upstream or downstream of the bridges at sites 3, 20, 27, 37, 40, and 48. For statistical analysis, sampling locations for these sites were assumed to be the same. The sites sampled during the summer index period are shown in figure 4.

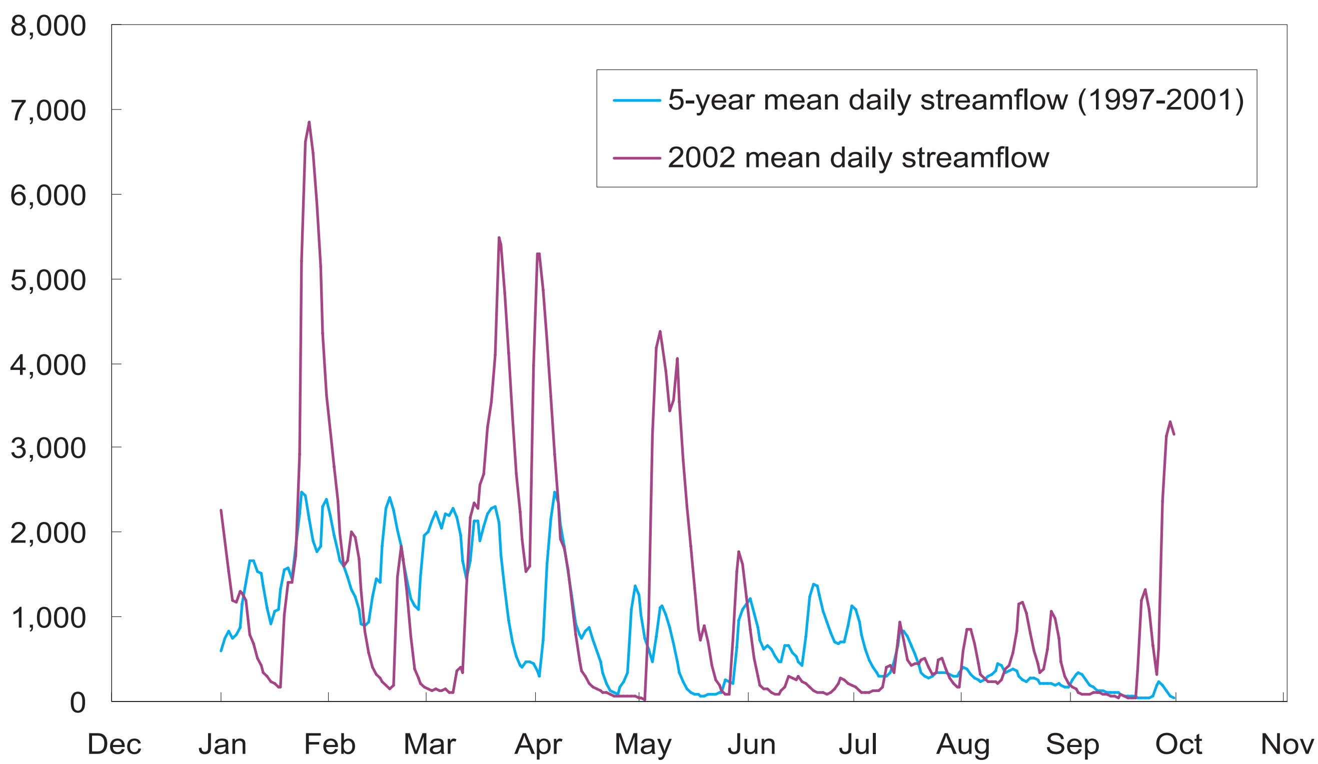


Figure 2. Relation of the 5-year mean daily streamflow (1997-2001) to the mean daily streamflow from January to September 2002 at the Big Sunflower River near Merigold, MS, gaging station.

Table 1. List of site names, locations, sizes, types, and sampling dates

[USGS, U.S. Geological Survey; MDEQ, Mississippi Department of Environmental Quality; AR, Arkansas; M, medium; N.A., not applicable; w, winter; s, summer, S-P, small-perennial; L-R, large-regulated; MS, Mississippi; S-I, small-intermittent; L-U, large-unregulated]

Site number (fig. 1)	USGS station number	USGS station name	MDEQ station number	Latitude	Longitude	Size	Station type[1]	Winter sample date[2]	Summer sample date[2]
1	07074700	Village Creek near Newport, AR	212	35º 35’ 33”	91º 14’ 31”	M	Good	4/9/02	7/30/02
2	07074883	Glaise Creek at Hwy 64 near Augusta, AR	213	35º 17’ 30”	91º 28’ 26”	M	Good	4/9/02	7/30/02
3w	07077555	Cache River at James Ferry near Howell, AR	210	35º 02’ 07”	91º 19’ 19”	M	Good	4/9/02	N.A.
3s	07077527	Cache River near Cotton Plant, AR	210	35º 05’ 07”	91º 17’ 54”	M	Good	N.A.	7/31/02
4	07077720	Bayou DeView at Hwy 38 near Cotton Plant, AR	211	35º 00’ 17”	91º 12’ 28”	M	Good	4/8/02	7/29/02
5	07047947	Second Creek near Palestine, AR	216	35º 02’ 21”	90º 54’ 40”	S-P	Good	4/8/02	7/31/02
6	07077000	White River at Devalls Bluff, AR	208	34º 47’ 25”	91º 26’ 45”	L-R	Good	1/22/02	N.A.
7	07078040	Lagrue Bayou near DeWitt, AR	209	34º 19’ 00”	91º 16’ 57”	M	Good	4/8/02	7/29/02
8	344529090115500	Unnamed Tributary to Coldwater River near Prichard, MS	317	34º 45’ 29”	90º 11’ 55”	S-I	Random	1/31/02	7/15/02
9	344402090230100	Unnamed Tributary to White Oak Bayou near Tunica, MS	316	34º 44’ 02”	90º 23’ 01”	S-I	Random	1/31/02	N.A.
10	342815090195500	Unnamed Tributary to Twelvemile Bayou near Tibbs, MS	315	34º 28’ 15”	90º 19’ 55”	S-I	Random	2/1/02	7/16/02
11	342630090142600	Yellow Lake Bayou at Sledge, MS	411	34º 26’ 30”	90º 14’ 26”	S-P	Random	3/5/02	7/16/02
12	342510090183500	Unnamed Tributary to White Oak Bayou near Sledge, MS	314	34º 25’ 09”	90º 18’ 36”	S-I	Random	2/5/02	7/16/02
13	341640090055100	Unnamed Tributary to Tallahatchie River near Locke Station, MS	306	34º 16’ 39”	90º 05’ 52”	S-P	Random	2/5/02	7/16/02
14	07288010	Big Sunflower River at Hopson Spur, MS	28	34º 09’ 23”	90º 32’ 59”	M	Poor	2/13/02	7/23/02
15	340657090080900	Unnamed Tributary to Tallahatchie River near Crowder, MS	313	34º 06’ 57”	90º 08’ 09”	S-I	Random	4/10/02	7/16/02
16	335915090423900	Hushpuckena River near Hushpuckena, MS	218	33º 59’ 15”	90º 42’ 39”	S-P	N.A.	2/13/02	7/23/02
17	335632090291000	Bear Bayou near Minot, MS	402	33º 56’ 32”	90º 29’ 10”	S-P	Random	3/5/02	7/17/02
18	335737090270100	Quiver River near Rome, MS	305	33º 57’ 39”	90º 26’ 54”	S-P	Random	2/25/02	7/17/02
19	07280900	Cassidy Bayou at Webb, MS	217	33º 57’ 01”	90º 20’ 27”	S-P	Poor	4/10/02	8/13/02
20w	340030090155300	Opposum Bayou near Brazil, MS	33	34º 00’ 30”	90º 15’ 53”	S-P	Good	4/11/02	N.A.
20s	335919090133600	Opposum Bayou near Webb, MS	33	33º 59’ 19”	90º 13’ 36”	S-P	Good	N.A.	8/12/02
21	335946090121100	Tallahatchie River near Webb, MS	201	33º 59’ 46”	90º 12’ 11”	L-R	N.A.	4/10/02	8/12/02
22	340120090113300	Tallahatchie River near Charleston, MS	200	34º 01’ 20”	90º 11’ 33”	L-R	N.A.	4/10/02	8/13/02
23	340203090073000	Panola Quitman Floodway near Charleston, MS	202	34º 02’ 03”	90º 07’ 30”	L-R	N.A.	4/10/02	8/13/02
24	335250090454700	Unnamed Tributary to Jones Bayou near Mound Bayou, MS	511	33º 52’ 50”	90º 45’ 47”	S-I	Random	3/5/02	7/23/02
25	07288280	Big Sunflower River near Merigold, MS	54	33º 49’ 57”	90º 40’ 12”	M	Poor	2/14/02	7/23/02

Table 1. List of site names, locations, sizes, types, and sampling dates--Continued

Site number (fig. 1)	USGS station number	USGS station name	MDEQ station number	Latitude	Longitude	Size	Station type[1]	Winter sample date[2]	Summer sample data[2]
26	335200090094500	South Lake Bayou near Tippo, MS	303	33º 52’ 00”	90º 09’ 45”	S-P	Random	4/10/02	7/17/02
27w	07285730	Yalobusha River near Holcomb, MS	203	33º 46’ 38”	90º 00’ 04”	L-R	N.A.	4/11/02	N.A.
27s	334303090060100	Yalobusha River near Leflore, MS	203	33º 43’ 03”	90º 06’ 01”	L-R	N.A.	N.A.	8/14/02
28	07288643	Bogue Phalia near Shaw, MS	59	33º 36’ 10”	90º 51’ 10”	M	Poor	2/14/02	7/23/02
29	334030090482200	East Bogue Hasty near Skene, MS	513	33º 40’ 30”	90º 48’ 22”	S-I	Random	2/25/02	7/23/02
30	334402090395400	Unnamed Tributary to Darr Bayou near Cleveland, MS	311	33º 44’ 06”	90º 39’ 57”	S-I	Random	2/12/02	7/24/02
31	333940090370900	Jones Bayou at Linn, MS	58	33º 39’ 34”	90º 37’ 07”	S-P	Poor	2/26/02	7/24/02
32	334248090311000	Quiver River Southeast of Ruleville, MS	215	33º 42’ 48”	90º 31’ 10”	M	Poor	4/9/02	7/24/02
33	334251090181900	Unnamed Tributary to Tallahatchie River near Minter City, MS	310	33º 42’ 51”	90º 18’ 19”	S-I	Random	2/20/02	7/17/02
34	07286200	Yalobusha River at Whaley, MS	204	33º 37’ 54”	90º 06’ 38”	L-R	N.A.	4/11/02	8/14/02
35	333600090281000	McGregory Bayou near Blaine, MS	415	33º 36’ 00”	90º 28’ 10”	S-P	Random	2/12/02	7/24/02
36	07288500	Big Sunflower River at Sunflower, MS	214	33º 32’ 50”	90º 32’ 35”	M	Poor	2/27/02	8/6/02
37w	07287000	Yazoo River at Greenwood, MS	205	33º 31’ 28”	90º 10’ 54”	L-R	N.A.	4/11/02	N.A.
37s	07281610	Tallahatchie River above Pemberton Cut near Greenwood, MS	205	33º 31’ 58”	90º 14’ 17”	L-R	N.A.	N.A.	8/14/02
38	332749090103400	Pelucia Creek near Rising Sun, MS	301	33º 27’ 51”	90º 10’ 25”	S-P	Random	2/19/02	7/17/02
39	07288600	Quiver River near Moorhead, MS	69	33º 29’ 16”	90º 31’ 06”	M	Good	4/9/02	8/7/02
40w	07288530	Big Sunflower River above Quiver River near Indianola, MS	67	33º 28’ 23”	90º 34’ 30”	L-U	Poor	2/28/02	N.A.
40s	07288610	Big Sunflower River near Moorehead, MS	67	33º 27’ 44”	90º 33’ 45”	L-U	Poor	N.A.	8/6/02
41	07288620	Big Sunflower River at Baird, MS	66	33º 25’ 38”	90º 35’ 30”	L-U	Good	3/7/02	8/6/02
42	07288621	Big Sunflower River at Indianola, MS	71	33º 25’ 06”	90º 38’ 01”	L-U	Poor	3/7/02	8/6/02
43	332501090405800	Sheperds Bayou near Indianola, MS	300	33º 25’ 01”	90º 40’ 57”	S-P	Random	2/15/02	8/6/02
44	07288624	Big Sunflower River at Kinlock, MS	85	33º 18’ 34”	90º 42’ 23”	L-U	Good	3/8/02	8/7/02
45	331432090435300	Big Sunflower River below Bogue Phalia near Darlove, MS	87	33º 14’ 15”	90º 43’ 55”	L-U	Good	3/8/02	8/7/02
46	330730090431300	Murphy Bayou at Murphy, MS	506	33º 07’ 30”	90º 43’ 13”	S-I	Random	2/28/02	8/7/02
47	07287500	Yazoo River at Yazoo City, MS	206	32º 55’ 41”	90º 24’ 46”	L-R	N.A.	4/16/02	8/28/02
48w	07288955	Yazoo River below Steele Bayou near Long Lake, MS	207	32º 26’ 35”	90º 54’ 51”	L-R	N.A.	4/12/02	N.A.
48s	07288800	Yazoo River at Redwood, MS	207	32º 29’ 14”	90º 49’ 02”	L-R	N.A.	N.A.	8/27/02
49	07288720	Big Sunflower River at Holly Bluff, MS	106	32º 48’ 49”	90º 43’ 08”	L-U	Poor	4/16/02	8/28/02
50	322804090533900	Steele Bayou above Little Sunflower Connect Channel, MS	110	32º 28’ 04”	90º 53’ 39”	L-U	N.A.	4/16/02	8/27/02

[1] “Good” and “poor” refer to subjectively evaluated water quality (see text). “N.A.” in this column refers to sites “not categorized as having good or poor water quality.” Also, sites listed as “random” were not categorized as having good or poor water quality.

[2] “N.A.” refers to sites sampled for only one index period. In most cases, these were sites in close proximity to each other and were considered to be the same location for statistical analyses.

Physical Property Measurement

Physical properties (temperature, dissolved oxygen, pH, and specific conductance) were measured from the center point of flow at approximately 1 ft of depth by using a multi-parameter water-quality meter, hereafter referred to as a multi-probe. Calibration of the multi-probe followed guidelines outlined in Wilde and Radtke (1998). The multi-probe was inspected nightly for any tears in the dissolved oxygen membrane and was recharged for the next day. A Hach 2100P portable turbidimeter was used to measure turbidity, and was calibrated according to the guidelines in the user's manual (Hach Company, 1999). The water sample taken from a churn splitter was placed into the turbidimeter vial and measured five times. The average of the five turbidity measurements was recorded. Between each measurement, the vial was shaken vigorously and wiped down with silicone oil and a wiping cloth to lessen the likelihood of error in the reading. All instruments were calibrated each morning, and calibration was checked at the end of each sampling day. The final calibration for each constituent had to meet measurement performance criteria, which were based on manufacturer's guidelines and MDEQ protocols (table 2). Transparency depths were measured, in inches, by using a Secchi disk connected to a rope lowered into the water.

Table 2. Day-end calibration measurement criteria

[mg/L, milligrams per liter, °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; all criteria are dependent upon range of measurement for a specific multi-probe]

Measurement property	Calibration accuracy
Dissolved oxygen	The greater value of ±2 percent of reading or ±0.2 mg/L for 0-20 mg/L
pH	±0.2 standard units
Temperature	±0.10 °C
Specific conductance	The greater value of ±1 percent of reading or ±1 µS/cm
Turbidity	±2 percent

Water-Quality Sample Collection

Prior to sample collection, all equipment that came into contact with the water sample was cleaned with a 0.2 percent non-phosphate detergent, rinsed with deionized water, air dried, and stored in a dust-free environment. All equipment (churn splitter, tubing, and bottles) was placed in plastic bags to prevent contamination. Teflon nozzles were covered with Nitrile gloves to keep the sampling chamber free from contamination.

Water samples were collected from bridges, boats, or by wading sites using established velocity-weighted, depth- and width-integrating techniques (Shelton, 1994). Sample collection and processing followed protocols outlined in the National Field Manual for the Collection of Water-Quality Data (Wilde and Radtke, 1998). Approximately 1.5 L of water was collected for each sample. A churn splitter was used to subdivide each sample. Whole water samples – analyzed for turbidity, total ammonia plus organic nitrogen, and total phosphorus – were distributed into individual 125-mL bottles. One milliliter of 4.5 N H2SO4 was added to the whole water sample for preservation. Some of the water from the remaining sample was filtered into a 125-mL bottle by using a 0.45 µm filter. The filtered sample – analyzed for dissolved chloride, ortho-phosphorus, and nitrite plus nitrate – was chilled for preservation. In addition, a 25-mL (or 50 mL later) aliquot was measured by using a graduated cylinder for chlorophyll-a analysis. The 25- or 50-mL aliquot was filtered by using a 0.65-µm, 47-mm-diameter glass fiber filter. The filter was folded, placed in a Petri dish, wrapped in aluminum foil, and placed on dry ice. All samples were double bagged in zipper-sealed plastic storage bags, packed on ice, and shipped overnight to the USGS Ocala Water Quality and Research Laboratory in Ocala, Fla. (hereafter referred to as the USGS Ocala Laboratory). After each sampling, the churn splitters and tubing were cleaned thoroughly by using the non-phosphate solution followed by a series of washes, alternating between tap water and deionized water.

Habitat Assessment

A habitat-assessment form (fig. 5) was used to document habitat characteristics in a stream reach. The assessment form was modified by MDEQ from an earlier assessment of streams in other States to adapt to the low-gradient streams in the MRAP region (Barbour and Stribling, 1994; Florida Department of Environmental Protection, 1996). Stream reaches were selected and measured: 300 ft for small streams or 1,500 ft for medium or large streams. The upstream and downstream limits of the reach were marked on or near the stream bank with orange or pink flagging labeled with the stream name, upstream or downstream end, date, and samplers' initials. Each assessment included a visual inspection of 150 ft on each side of the marked reach.

The habitat-assessment form included a general characteristics section: water appearance, water odor, water temperature, stream depth, stream width, and high-water mark. Subsequent sections of the assessment were scored on a scale from 1 to 20 (some were scored on a scale from 1 to 10, fig. 5), according to the Habitat Parameter Assessment Guidelines for Glide Pool Streams (Barbour and Stribling, 1994; Florida Department of Environmental Protection, 1996) with 1 representing the most degraded and 20 representing the most stable habitat. The scored information included: epifaunal substrate/available cover, pool substrate characterization, pool variability, degree and type(s) of channel alteration, sediment deposition, channel sinuosity, channel flow status, bank vegetative protection, bank stability, and riparian vegetation zone width. Upon completion of the assessment form, photographs were

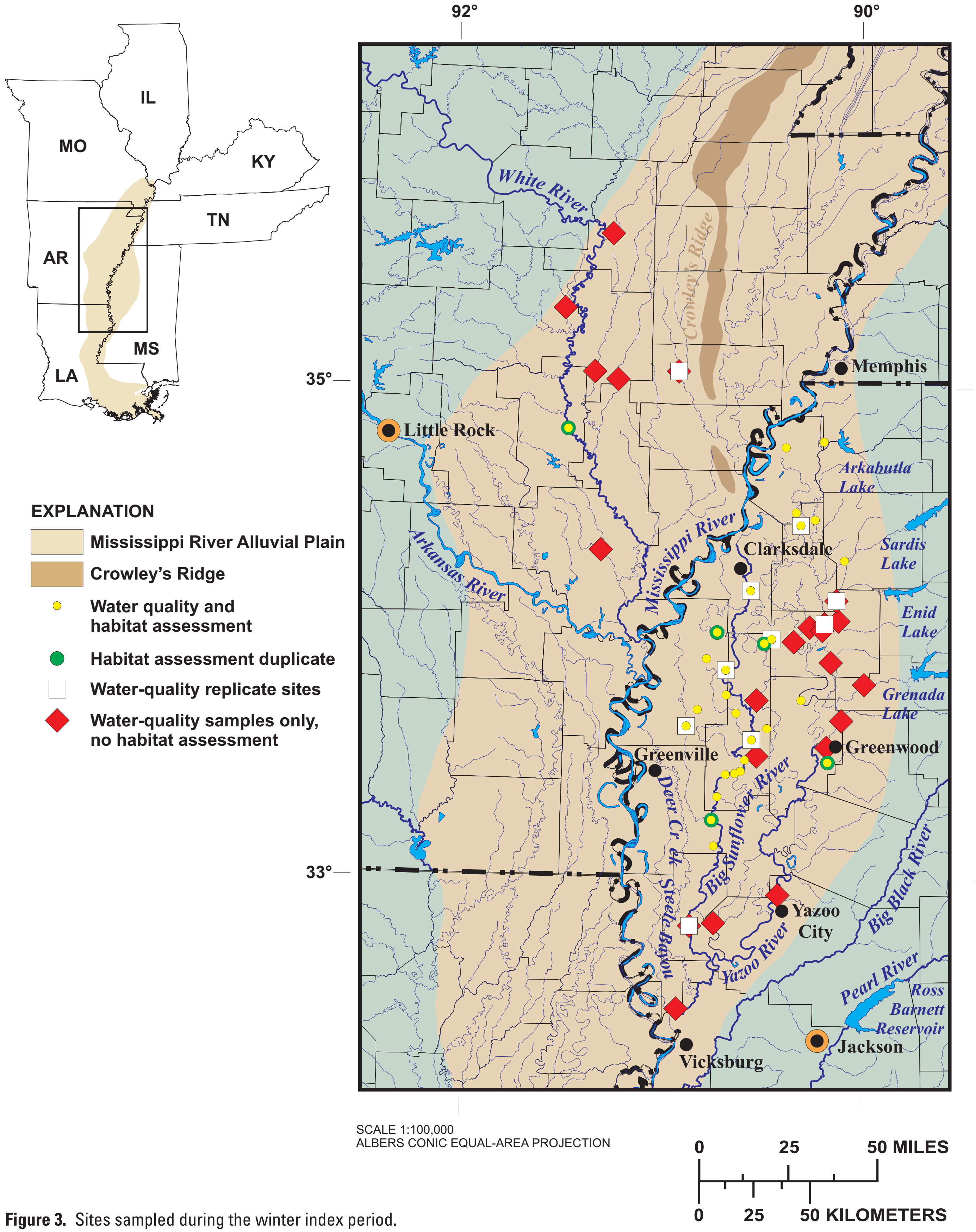


Figure 3. Sites sampled during the winter index period.

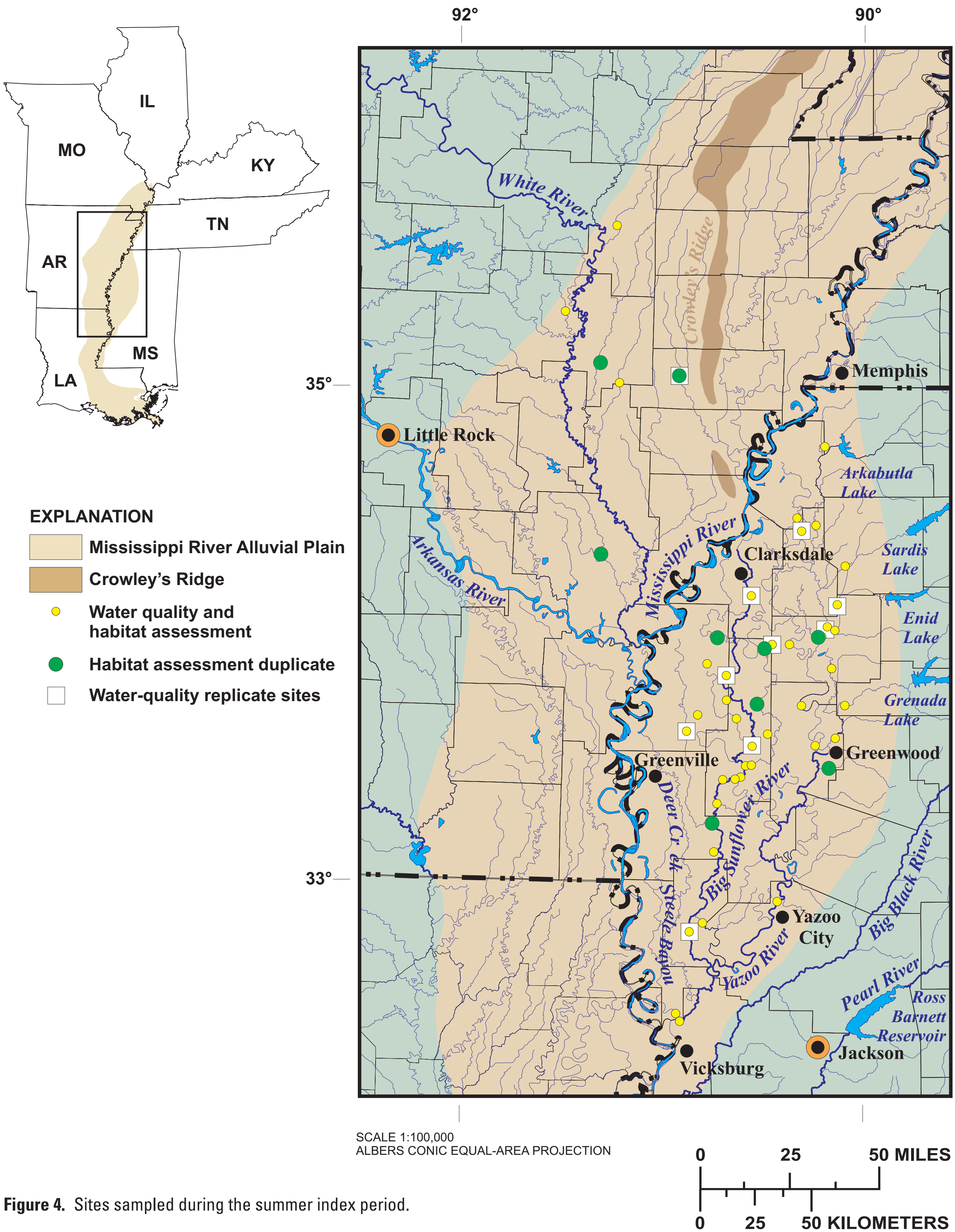


Figure 4. Sites sampled during the summer index period.

Mississippi Department of Environmental Quality

SURFACE WATER HABITAT ASSESSMENT FIELD DATA SHEET

Benthos Survey ☐
Fish Survey ☐

Station Name:________ Station Location:________
Station Number:________ Station Type:________ Project Name:________
Date/Time:________ Lattitude:________ Longitude:________
County:________ Basin:________ Ecoregion:________
Investigator(s):________ Completed by:________ Photo ID:________
Weather Conditions:________
Comments/Observations (Directions to station/describe important features):________

SECTION I – PHYSICAL CHARATERIZATION

RIPARIAN ZONE/INSTREAM FEATURES

Surrounding Land Use Percent (%): Forest_____ Field/Pasture_____ Agricultural_____ Residential_____ Commercial_____ Industrial_____ Other________

Local Watershed Erosion: None___ Moderate___ Heavy___ Dam Present: Yes___ No___ Channelized: Yes___ No___

Local Watershed NPS Pollution: No Evidence___ Some Potential Sources___ Obvious Sources___ Describe________

Estimated Stream Width (m):_____ Bank Width (m):_____ High Water Mark (m):_____ Average Stream Depth (m):_____

Canopy Cover: Open (0-25%)_____ Partly Open (25-50%)_____ Partly Shaded (50-75%)_____ Shaded (75-100%)_____

SEDIMENT SUBSTRATE

Sediment Odors: Normal___ Sewage___ Petroleum___ Chemical___ Anaerobic___ Other________

Sediment Oils: Absent___ Slight___ Moderate___ Profuse___

Sediment Deposits: Sludge___ Sawdust___ Paper Fiber___ Sand___ Relict Shells___ Silt___ Other________

Are the undersides of stones which are not deeply embedded black? Yes___ No___

Inorganic Substrate Type	Diameter	Percent Composition	Organic Substrate Type	Characteristics	Percent Composition
Cobble	64-256 mm (2.5-10”)		Detritus	Sticks, wood, coarse plant materials (CPOM)	
Gravel	2-64 mm (0.1-2.5”)				
Sand	0.06-2 mm (gritty)		Muck/Mud	Black, very fine organic (FPOM)	
Silt	0.004-0.06 mm				
Clay	<0.004 mm (slick)		Marl	Gray shell fragments	
Hard-Pan Clay			Other:		

SECTION II – WATER QUALITY

Air Temp:______°C pH:_____ Water Temp:______°C Dissolved Oxygen:______mg/L Conductivity:______µmhos/cm

Salinity:_____ppt TDS:_____mg/L Dissolved Oxygen (% Sat):_____ Other________ Instruments________

Water Odors: Normal___ Sewage___ Petroleum___ Chemical___ Other________ % of Reach Affected:______

Water Surface Oils: None___ Flecks___ Globs___ Sheen___ Slick___ Photograph ID:______ % of Reach Affected:______

Turbidity: Clear___ Slightly Turbid___ Turbid___ Opaque___ NTU:________ Water Color:________

SECTION III – HABITAT TYPES SAMPLED

Indicate number of jabs allocated / habitat type (allocate jabs in proportion to their frequency within reach - EXCEPTION: standard 5 jabs in sand/silt for *all* stations)

COBBLE/GRAVEL - HARD SUBSTRATES IN FAST-FLOWING RIFFLE/RUN WATERS	
SNAGS - DEBRIS ACCUMULATIONS OF LEAVES AND STICKS	
VEGETATED BANKS - UNDERCUT BANKS / ROOT MATS	
SUBMERGED MACROPHYTES - AQUATIC PLANTS THAT ARE ROOTED ON THE STREAM BOTTOM	
SAND/SILT - SOFT, BOTTOM SUBSTRATES	5
TOTAL NUMBER OF JABS *MUST* EQUAL 20	

Figure 5. Example of surface-water habitat-assessment field-data sheet.

SECTION IV – HABITAT ASSESSMENT

	HABITAT PARAMETER		HABITAT SCORE
1.	Bottom Substrate/Available Cover _____ Fallen trees/large woody debris _____ Deep pools _____ Shallow pools _____ Overhanging shrubbery in water _____ Large rocks	 _____ Undercut banks _____ Thick root mats _____ Dense macrophyte beds _____ Deep riffles/runs with turbulence	
2.	Pool Substrate Characterization		
3.	Pool Variability		
4.	Channel Alteration		
5.	Sediment Disposition		
6.	Channel Sinuosity		
7.	Channel Flow Status		
8.	Bank Vegetative Protection	--Left Bank*	
		--Right Bank*	
9.	Bank Stability	--Left Bank*	
		--Right Bank*	
10.	Riparian Vegetation Zone Width	--Left Bank*	
		--Right Bank*	
		Total Score:	

Figure 5. Example of surface-water habitat-assessment field-data sheet -- Continued.

taken from the upstream and downstream ends of the reach (Mississippi Department of Environmental Quality, 2002b).

Quality Assurance and Quality Control

All field and laboratory methods for this study were outlined in the MDEQ Quality Assurance Project Plan (QAPP) (Mississippi Department of Environmental Quality, 2002a). Any modifications to the plan were approved by the MDEQ and the USGS. In addition, MDEQ conducted three quality-assurance field audits during the study. The audits included a review of all sample collection, processing, and shipping procedures and documentation. Any problems or protocol changes were immediately reported, and modifications were made to the QAPP and conveyed to the field personnel.

The USGS Ocala Laboratory adheres to a Comprehensive Quality-Assurance Plan (U.S. Geological Survey, 1999), which outlines protocols for sample handling, calibration and analytical procedures, and data review. In addition, all data received from the laboratory were reviewed by USGS study personnel. Data also were rechecked for proper entry into the USGS water-quality database. All data review procedures followed those outlined in the USGS Mississippi District quality-assurance plan (Slack, 1991).

Five field blanks were collected from 2000 to 2002 as part of the Mississippi Embayment (MISE) – NAWQA study (Appendix I). Equipment, personnel, cleaning procedures, and sampling techniques of the MISE-NAWQA study were the same as those used in this study. Results of the analyses of the blank samples indicated that the amount and frequency of detections in the blanks were not of environmental significance.

Duplicate samples are collected to assess variability in the data set due to random errors and to evaluate analytical precision. Nineteen duplicate water samples (or 12 percent of the total samples) were collected during this study. Nearly all of the duplicate samples were split samples, which are produced by splitting one sample into two. One set of sequential duplicates (duplicate samples collected one after the other by the same personnel) was collected at Big Sunflower River near Hopson Spur, Miss., on February 13, 2002. Relative percent difference (RPD) was calculated for each duplicate pair for each constituent, and both types of duplicates were considered collectively. RPDs were calculated by subtracting the value of a duplicate sample from the value of its paired sample, then dividing by their average and multiplying by 100.

Distributions of the RPDs for each constituent are shown graphically as boxplots in figure 6. Median RPDs for all constituents were less than 10 percent; all of the 75th percentile RPDs for each constituent were less than 15 percent. Therefore, variability associated with random errors in the data set was minimal for this study. The two extreme values of 115 percent for chloride and 182 percent for dissolved nitrite plus nitrate in figure 6 were associated with one set of split duplicates taken at Second Creek near Palestine, Ark., on July 31, 2002. There was no obvious explanation for the large discrepancy in the duplicate values for this sample. Another duplicate sample was taken at the same site on April 8, 2002, with no discrepancy in the data. Therefore, the discrepancy associated with the July 31st duplicate sample was likely an aberration, and the variances should not affect assessment of chloride and dissolved nitrite plus nitrate data at this site.

There are at least three potential sources of error associated with habitat-assessment scores: basin/stream heterogeneity, sample variance, and field-personnel error. Fifteen duplicate habitat-assessment samples (or 20 percent) were collected on adjacent reaches by two different field personnel at each site to determine variability in stream heterogeneity. Habitat-assessment total scores for these duplicates were identical for 13 of the 15 samples (RPDs for these 13 samples were 0 percent). RPDs were 1.2 and 3.5 percent, respectively, for duplicate habitat-assessment total scores determined at White River at Devalls Bluff, Ark., and at Big Sunflower River below Bogue Phalia near Darlove, Miss.. Habitat-assessment duplicates were not collected to assess sample variance and field-personnel error.

Statistical Analysis

Traditional statistical analyses require data sets to be random and independent. The water-quality and habitat data collected for this study did not follow these basic rules for two reasons: (1) only 18 sites were randomly selected — the remaining sites were selected as was previously discussed; and (2) many of the sites were located on the same river, and

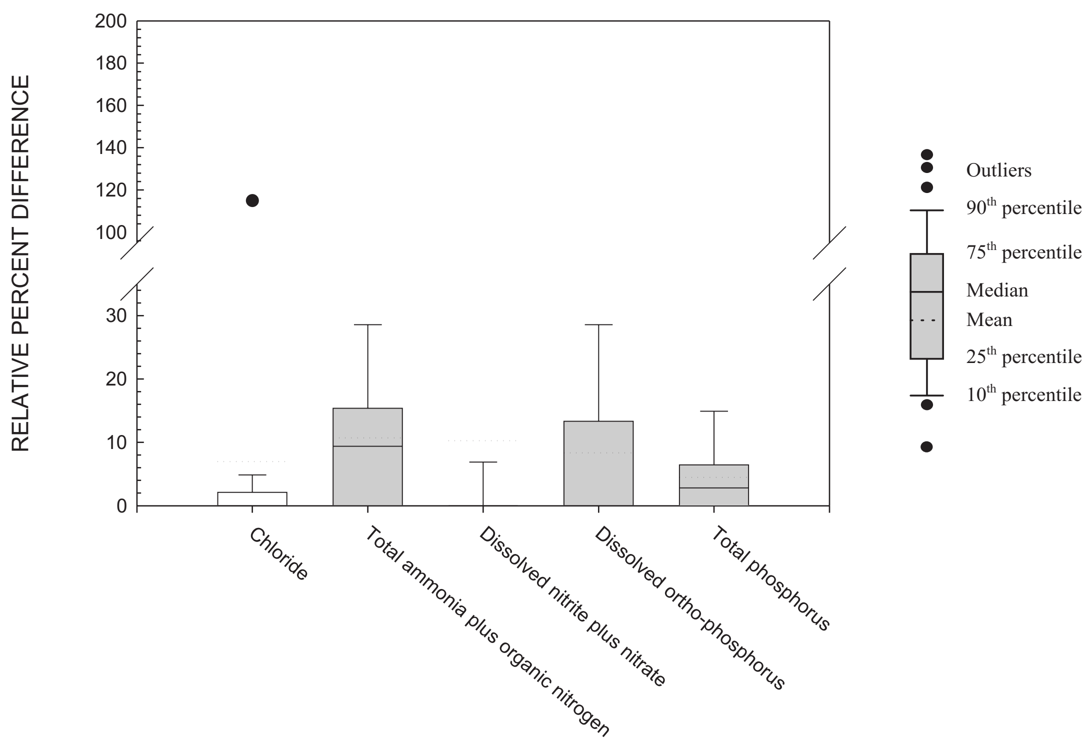


Figure 6. Relative percent difference for duplicate samples of selected constituents for the study data set.

therefore, are not independent. Although the data sets for this study do not comply with these basic rules, statistical analyses were completed, and the results were interpreted for exploratory purposes.

The software package, SigmaStat (SPSS, Inc., 1997a), was used to perform the statistical analyses. SigmaStat uses the Kolmogorov-Smirnov test with Lilliefors' correction to determine whether a data set is normally distributed and to select the most appropriate statistical analyses (SPSS, Inc., 1997b, p. 6-29). The test statistic for all parametric tests was the mean of the data set being tested. Non-parametric tests were used for analysis when data were not normally distributed. The test statistics for the non-parametric tests were based on the ranks of the data. A p-value, which is the probability of attaining a specified significance level (Helsel and Hirsch, 1992), was calculated for each test (parametric or non-parametric). P-values were compared to a significance level, of 0.05 (5 percent), which means there was less than a 5-percent chance that test results were incorrect.

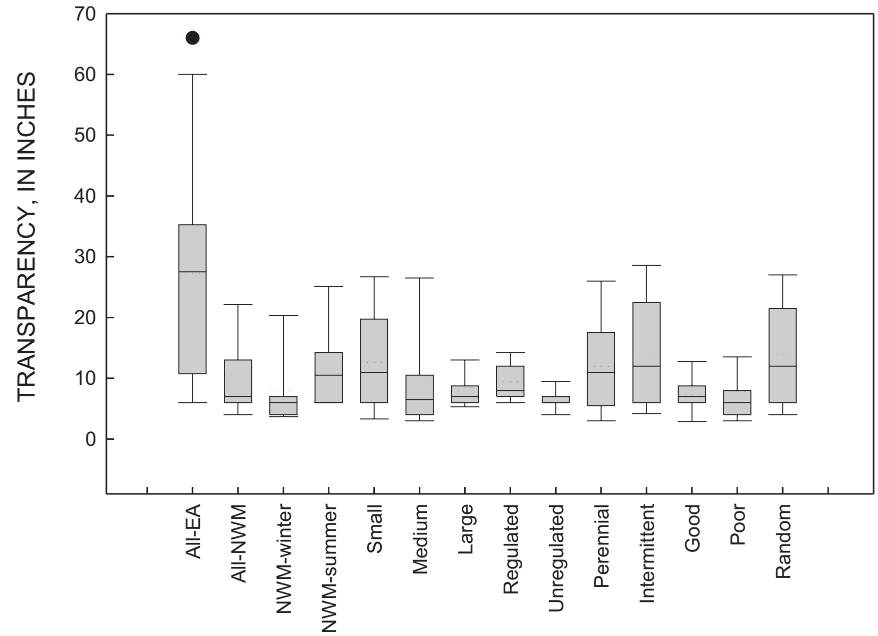
The primary purpose of the statistical analyses was to determine whether the water-quality or habitat-assessment data could indicate ranges in stream conditions among and along streams in the study area. To accomplish this purpose, the analyses were designed to determine statistically significant differences for the following comparisons (based on site categories presented in table 1):

1. Sample index period – Nearly every NWM site was sampled during the winter and summer index period, which created winter and summer data sets (or paired data sets) with an equal number of values for each constituent. The paired t-test or the Wilcoxon signed rank (non-parametric) test were the most appropriate tests to determine statistically significant differences in two data sets of equal sizes (Helsel and Hirsch, 1992): in this case, differences in the paired winter and summer data sets. If the associated p-value for a particular test was higher than 0.05, then the paired data were not statistically different. If the p-value was equal to or less than 0.05, then the tests indicated that the paired data were statistically different.
2. Site location – Because there were fewer EA sites sampled than NWM sites, statistical analyses would require comparing two data sets of unequal sizes. The most appropriate statistical tests for such data were the t-test or the Mann-Whitney rank sum (non-parametric) test (Helsel and Hirsch, 1992). These tests were selected to determine whether data collected from the two regions were statistically different.
3. Drainage-area size – Statistical analyses were used to compare water-quality data at the 43 NWM sites categorized as large, medium, or small (table 1). Statistical analyses would require comparing multiple data sets of unequal sizes; thus, analysis of variance (ANOVA) or the Kruskal-Wallis (non-parametric) tests were considered the most appropriate tests (Helsel and Hirsch, 1992). These tests determined whether data from the individual size categories were statistically different from data from all size categories combined. If statistically significant differences were detected, then all pair-wise comparisons were analyzed separately: for example, data from small sites compared to data from medium sites.
4. Subjectively evaluated stream conditions – Statistical tests were used to compare water-quality data from the 15 NWM sites categorized as good or poor (table 1). The statistical tests required comparing two data sets of unequal sizes, and the t-test (or the Mann-Whitney rank sum non-parametric test) was selected as the most appropriate test.
5. Habitat assessment – Statistical methods applied to the water-quality data for comparisons 1 to 4, listed above, were repeated using habitat-assessment total scores. Results of the tests for the habitat data were compared to results of the tests for the water-quality data.
6. Big Sunflower River – No hypotheses tests were run separately for the Big Sunflower River. Data for each constituent were plotted by river mile location from the mouth, and general conclusions were based on visual inspection of each graph.

WATER-QUALITY AND HABITAT-ASSESSMENT DATA SUMMARIES

All water-quality and habitat-assessment data collected during this study are presented in Appendixes II and III. Concentration distributions, by category, for these data are presented as boxplots in figures 7-13. These types of plots allow for a side-by-side comparison of data distributions (Helsel and Hirsch, 1992). For the purposes of this report, values that were recorded as less than the detection limit were plotted as one half the detection limit. The plots include: physical properties – transparency, turbidity, dissolved oxygen, pH, and specific conductance; nitrogen species – total ammonia plus organic nitrogen (detection limit, 0.2 mg/L), dissolved nitrite plus nitrate (detection limit, 0.02 mg/L), and total nitrogen (sum of total ammonia plus organic nitrogen and dissolved nitrite plus nitrate); phosphorus species – dissolved ortho-phosphorus (detection limit, 0.01 mg/L) and total phosphorus (detection limit, 0.02 mg/L); chloride (detection limit, 0.1 mg/L); chlorophyll-a (detection limit, 0.1 µg/L); and habitat-assessment total scores.

For perspective, data collected during this study were compared to data collected for other studies with similar site locations in the MRAP region and with similar sampling procedures. The 25th, 50th, and 75th percentiles for nutrient data collected at three sites in the MISE-NAWQA study (Coupe, 2002) and from one site in the Mississippi Delta Management Systems Evaluation Area (MDMSEA) project (Rebich, 2001) are presented in table 3. The MISE-NAWQA



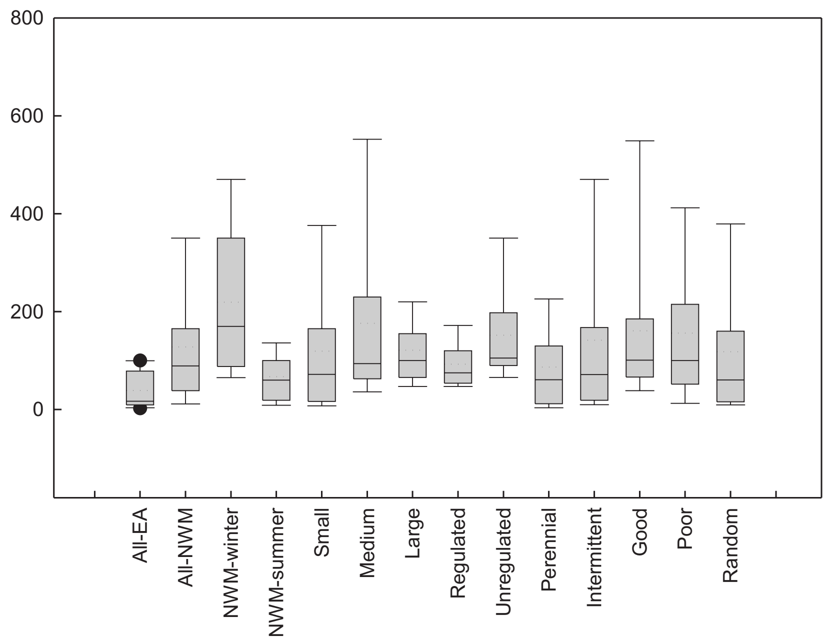
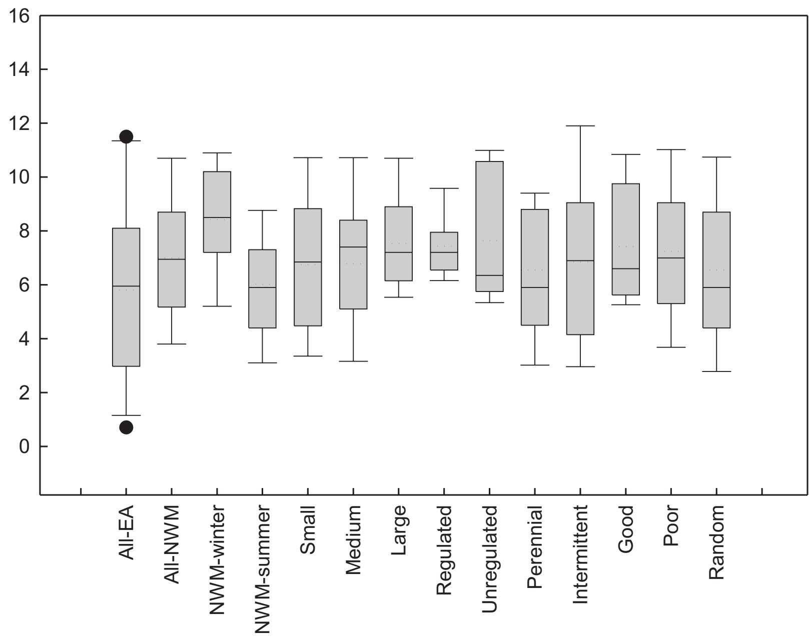


Figure 7. Distributions for transparency and turbidity data collected at northwestern Mississippi (NWM) and eastern Arkansas (EA) sites. [For an explanation of plots, see fig. 6.]



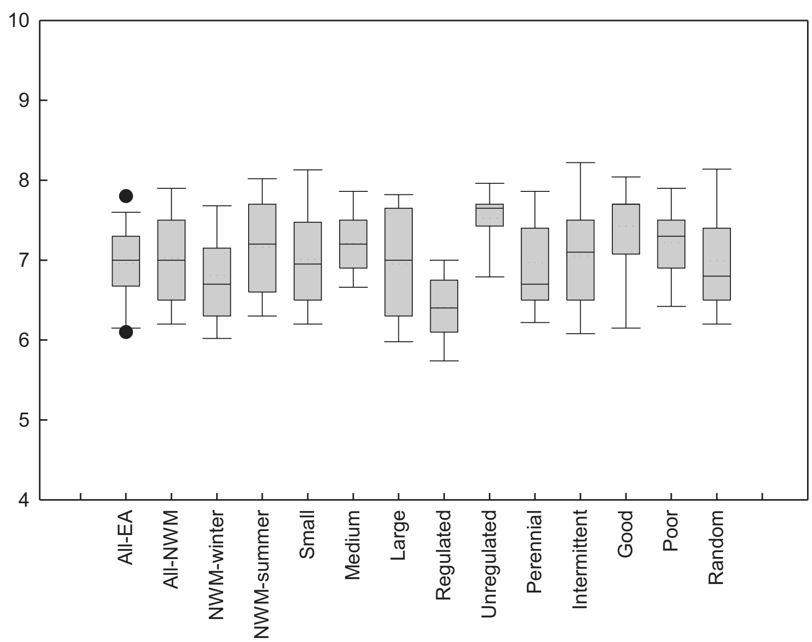
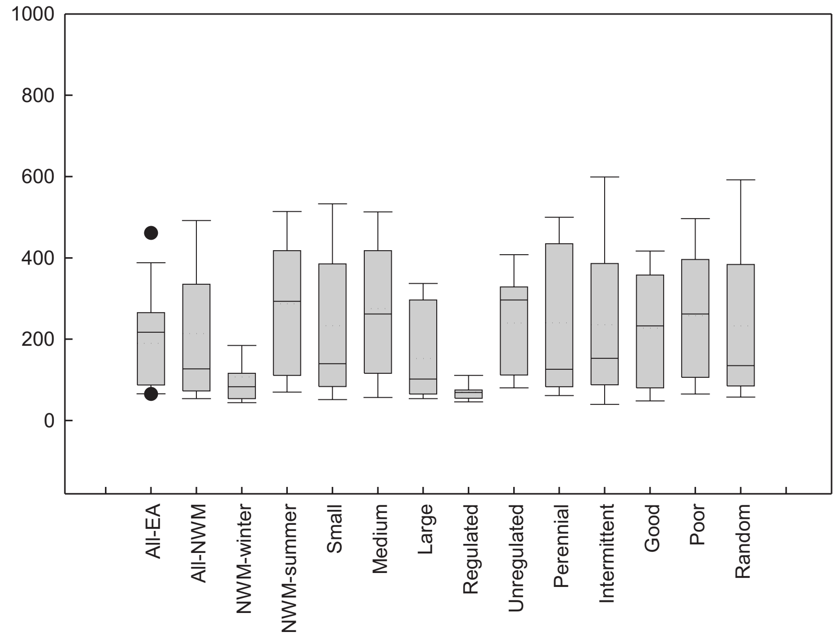


Figure 8. Distributions for dissolved oxygen and pH data collected at northwestern Mississippi (NWM) and eastern Arkansas (EA) sites. [For an explanation of plots, see fig. 6.]



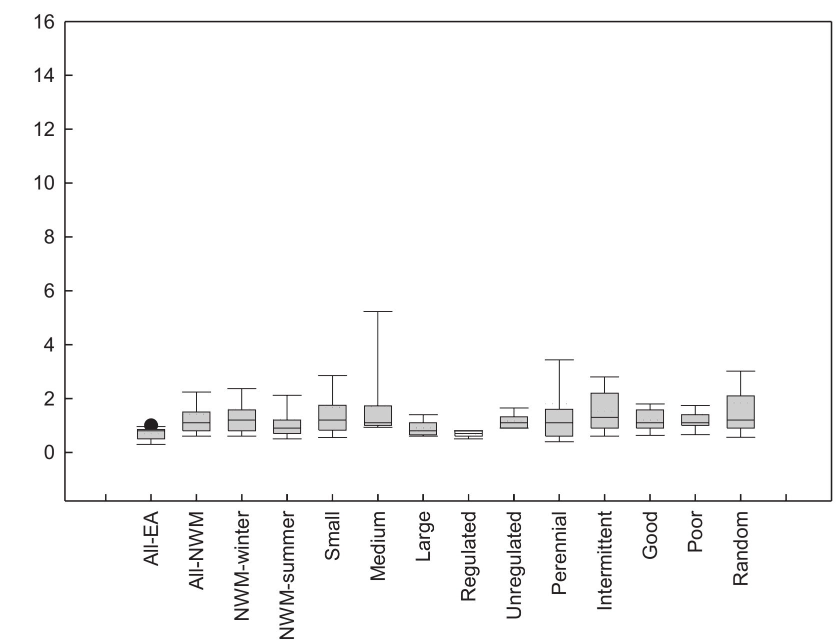


Figure 9. Distributions for specific conductance and total ammonia plus organic nitrogen data collected at northwestern Mississippi (NWM) and eastern Arkansas (EA) sites. [For an explanation of plots, see fig. 6.]

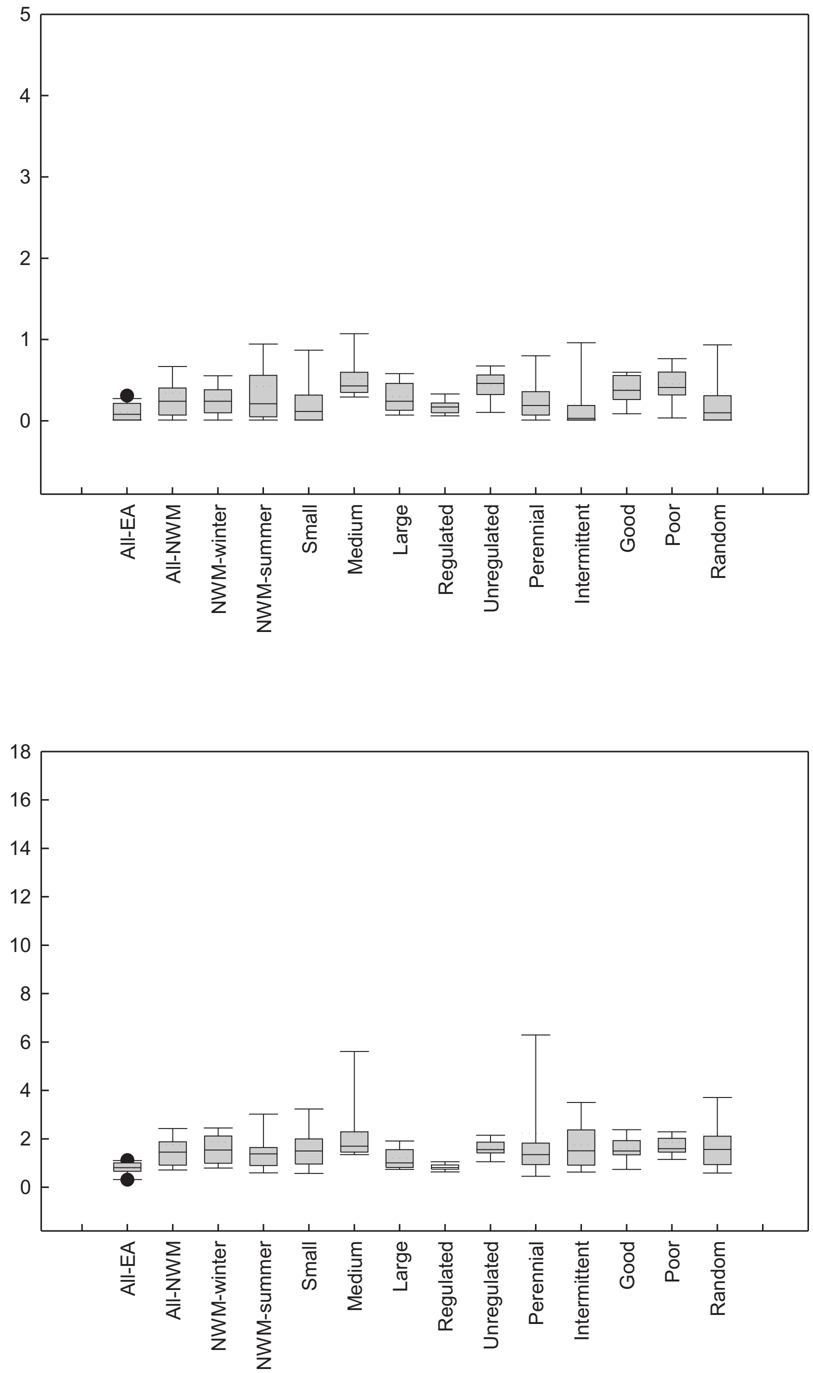
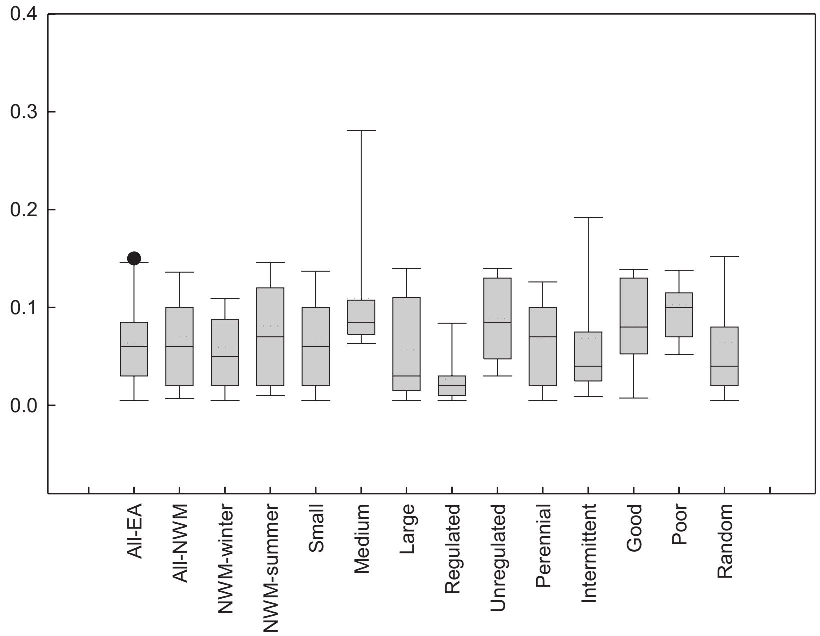


Figure 10. Distributions for dissolved nitrite plus nitrate and total nitrogen data collected at northwestern Mississippi (NWM) and eastern Arkansas (EA) sites. [For an explanation of plots, see fig. 6.]



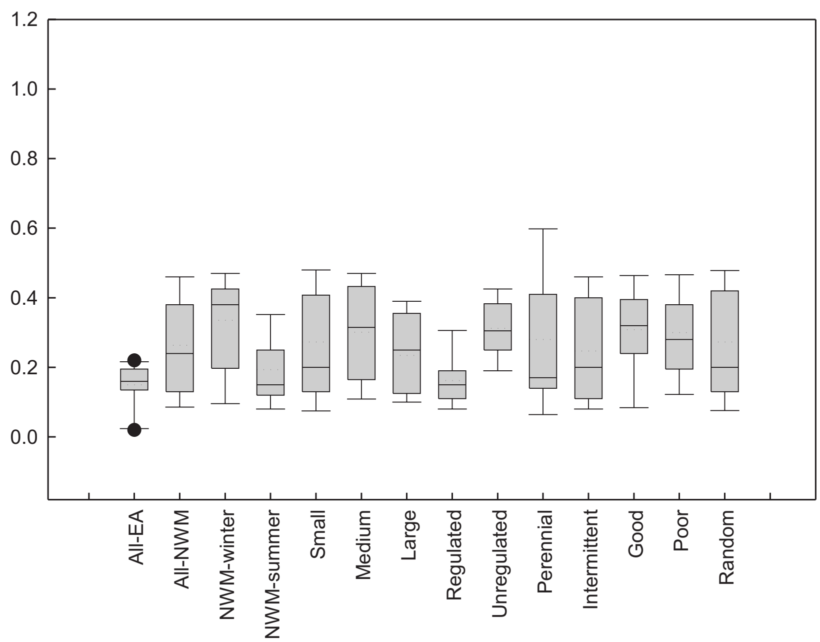
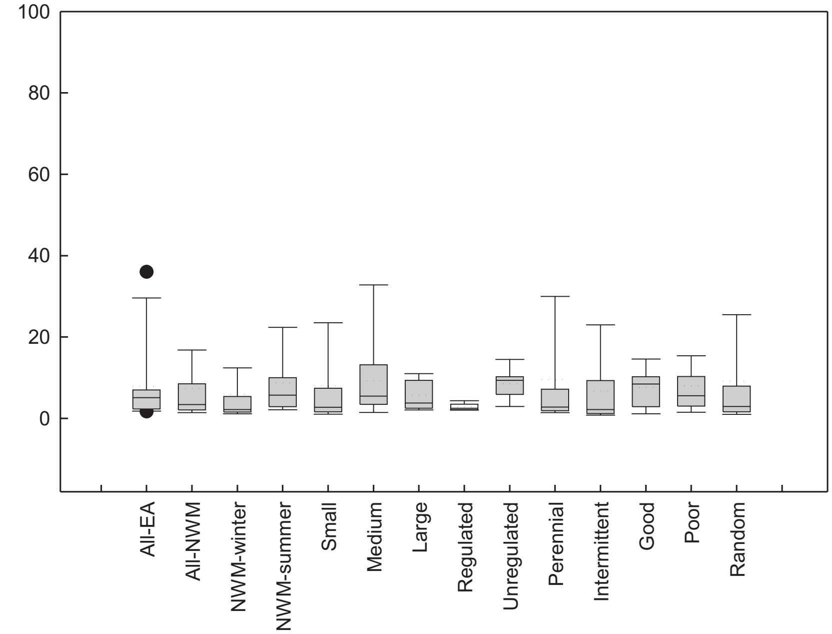


Figure 11. Distributions for dissolved ortho-phosphorus and total phosphorus data collected at northwestern Mississippi (NWM) and eastern Arkansas (EA) sites. [For an explanation of plots, see fig. 6.]



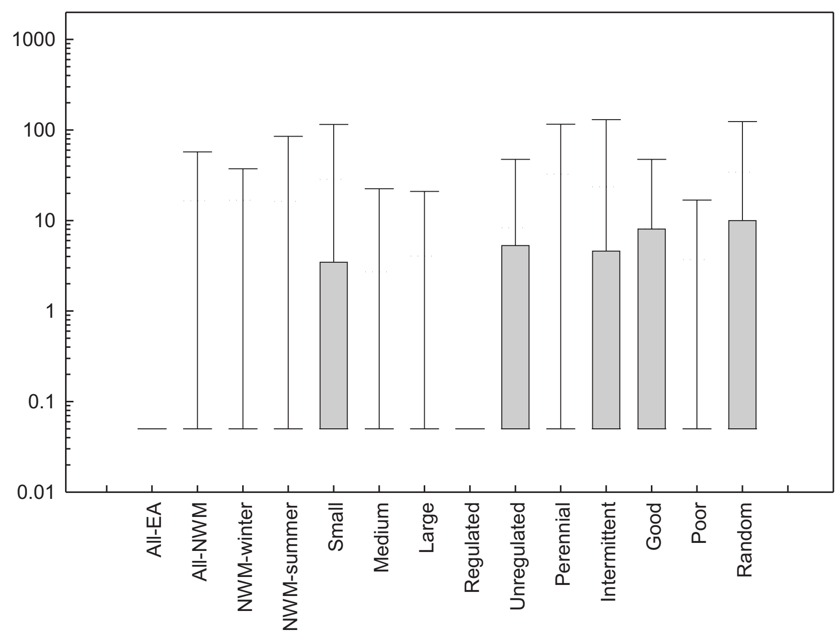


Figure 12. Distributions for chloride and chlorophyll-a data collected at northwestern Mississippi (NWM) and eastern Arkansas (EA) sites. [For an explanation of plots, see fig. 6.]

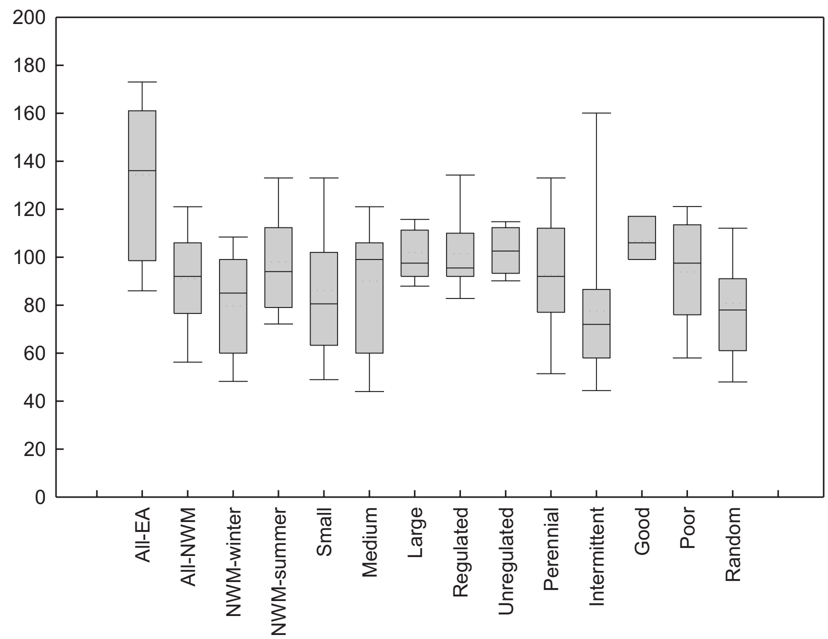


Figure 13. Distributions for habitat assessment total scores collected at northwestern Mississippi (NWM) and eastern Arkansas (EA) sites. [For an explanation of plots, see fig. 6.]

sites – Cache River near Cotton Plant, Ark., Bogue Phalia near Leland, Miss., and the Yazoo River below Steele Bayou, Miss. – were sampled during this study and were categorized as EA, medium, and regulated, respectively (table 1). Interquartile ranges (difference between the 75th and 25th percentiles) for nutrient data collected at the three MISE-NAWQA sites (table 3) were similar to interquartile ranges for data collected at sites categorized as EA, medium, and regulated during this study, respectively (figs. 9-11). The Browns Bayou near Inverness, Miss., site of the MDMSEA project, was hydrologically similar to sites categorized as intermittent in this study (table 1). Interquartile ranges for nutrient data from the MDMSEA site (table 3) were higher than interquartile ranges collected from sites categorized as intermittent for this study (figs. 9-11).

A synoptic study was conducted during summer 1997 as part of the MISE-NAWQA study; three to four samples were collected from May to September 1997 at numerous sites in the MRAP region (Coupe, 2002). Five sites sampled during the 1997 synoptic study also were sampled in this study – Second Creek near Palestine, Ark.; LaGrue Bayou near Dewitt, Ark.; Cassidy Bayou at Webb, Miss.; Big Sunflower River at Sunflower, Miss.; and Quiver River near Doddsville, Miss. The median values for nutrient data collected from the 1997 study were compared to values recorded during summer 2002 for these five sites (table 4). For the most part, nutrient data from the two studies were similar in magnitude (and, in a few cases, were identical). Dissolved nitrite plus nitrate differed the most with higher values recorded in 1997 at four of the five sites.

RESULTS OF STATISTICAL ANALYSIS

Statistical analyses were performed to determine whether any of the water-quality or habitat-assessment data could be used to detect ranges in stream conditions for sites sampled in this study. The water-quality and habitat-assessment data were categorized according to sample index period, site location, drainage-area size, and subjectively evaluated stream conditions. Statistical analyses were conducted to detect differences within these categories. In addition, the water-quality and habitat-assessment data were plotted with location for

Table 3. Selected summary statistics for nutrient data from three sites of the Mississippi Embayment National Water-Quality Assessment Program, February 1996 to January 1998, and from one site of the Mississippi Delta Management Systems Evaluation Areas project, 1996 to 1999

[Values are in milligrams per liter; AR, Arkansas; N, nitrogen; P, phosphorus; MS, Mississippi]

Constituent	Percentile		
	25	50	75
Cache River near Cotton Plant, AR*			
Total ammonia plus organic nitrogen as N	0.7	0.9	1.1
Dissolved nitrite plus nitrate as N	0.1	0.16	0.28
Total nitrogen as N	0.8	1.1	1.4
Dissolved ortho-phosphorus as P	0.01	0.03	0.05
Total phosphorus as P	0.15	0.19	0.25
Bogue Phalia near Leland, MS*			
Total ammonia plus organic nitrogen as N	0.9	1.3	1.7
Dissolved nitrite plus nitrate as N	0.21	0.51	1
Total nitrogen as N	1.2	1.8	2.8
Dissolved ortho-phosphorus as P	0.04	0.06	0.09
Total phosphorus as P	0.17	0.31	0.46
Yazoo River below Steele Bayou, MS*			
Total ammonia plus organic nitrogen as N	0.6	0.8	1.2
Dissolved nitrite plus nitrate as N	0.21	0.33	0.59
Total nitrogen as N	0.9	1.3	1.6
Dissolved ortho-phosphorus as P	0.03	0.04	0.05
Total phosphorus as P	0.17	0.22	0.34
Browns Bayou near Inverness, MS**			
Total ammonia plus organic nitrogen as N	1.8	2.0	3.6
Dissolved nitrite plus nitrate as N	0.35	1.05	3.5
Dissolved ortho-phosphorus as P	0.07	0.1	0.16
Total phosphorus as P	0.28	0.39	0.55

*Coupe, 2002, p. 48, 52-53.

**Rebich, 2001, p. 163-164.

Table 4. Nutrient data collected during summer 1997 and summer 2002

[Values are in milligrams per liter; MISE-NAWQA, Mississippi Embayment National Water-Quality Assessment Program; AR, Arkansas; N, nitrogen; P, phosphorus; <, less than; MS, Mississippi]

Constituent	Median of MISE-NAWQA 1997 summer synoptic study*	Value for summer 2002 study
	Second Creek near Palestine, AR	
Total ammonia plus organic nitrogen as N	0.8	0.8
Dissolved nitrite plus nitrate as N	0.06	0.21
Total nitrogen as N	0.8	1.01
Dissolved ortho-phosphorus as P	0.06	0.09
Total phosphorus as P	0.11	0.15
	LaGrue Bayou near Dewitt, AR	
Total ammonia plus organic nitrogen as N	0.59	0.3
Dissolved nitrite plus nitrate as N	0.17	<0.02
Total nitrogen as N	0.8	0.3
Dissolved ortho-phosphorus as P	0.03	0.03
Total phosphorus as P	0.1	0.16
	Cassidy Bayou at Webb, MS	
Total ammonia plus organic nitrogen as N	2.3	1.5
Dissolved nitrite plus nitrate as N	0.18	<0.02
Total nitrogen as N	2.5	1.5
Dissolved ortho-phosphorus as P	0.04	0.06
Total phosphorus as P	0.54	0.34
	Big Sunflower River at Sunflower, MS	
Total ammonia plus organic nitrogen as N	1.1	0.9
Dissolved nitrite plus nitrate as N	0.9	0.56
Total nitrogen as N	2.8	1.5
Dissolved ortho-phosphorus as P	0.09	0.12
Total phosphorus as P	0.23	0.24
	Quiver River near Doddsville, MS	
Total ammonia plus organic nitrogen as N	1.2	1.1
Dissolved nitrite plus nitrate as N	0.9	0.35
Total nitrogen as N	2.9	1.4
Dissolved ortho-phosphorus as P	0.06	0.06
Total phosphorus as P	0.23	0.13

* Coupe, 2002, p. 60-63.

sites sampled along the Big Sunflower River to determine whether trends within the river could be detected. Results of all the analyses are presented, and a discussion of the results is presented at the end of this section. Mean values are presented in parentheses in the text for statistically significant results determined by parametric tests (mean values are the test statistics for parametric tests). Median values are presented for statistically significant results determined by non-parametric tests. Although median values may not be the actual test statistics for the non-parametric tests, they are presented here to compare the data in original units.

Sample Index Period

Results of the paired t-tests (or Wilcoxon signed rank test) comparing water-quality data collected at the 43 NWM sites during the winter index period with data collected during the summer index period are presented in table 5. Statistically significant differences (p-values less than 0.05) were observed when comparing winter and summer values of transparency, turbidity, dissolved oxygen, pH, specific conductance, chloride, total ammonia plus organic nitrogen, and total phosphorus.

The median transparency value for the winter index period (6 in.) was lower than the median value for the summer index period (11 in.). The mean turbidity concentration for the winter index period (213 NTU) was three times higher than the mean turbidity concentration for the summer index period (68 NTU).

The mean dissolved oxygen concentration for the winter index period (8.4 mg/L) was higher than the mean for the summer index period (6.1 mg/L). This is an expected result as the saturation value of oxygen in water is inversely related to temperature (Hem, 1985). The mean temperatures associated with these dissolved oxygen concentrations were 13 ºC and 29 ºC for the winter and summer index periods, respectively.

Median values of pH were 6.7 and 7.2 for the winter and summer index periods, respectively; although this difference was considered statistically significant, this range in pH is considered typical for most surface waters (Hem, 1985). The mean specific conductance for the winter index period (108 µS/cm) was nearly one-third of the mean for the summer index period (283 µS/cm). Similarly, chloride concentrations were lower for the winter index period (median, 2.2 mg/L) than for the summer index period (median, 5.7 mg/L).

Although statistically different, the median values for total ammonia plus organic nitrogen were nearly identical:

Table 5. Results of statistical analyses comparing water-quality data collected at northwestern Mississippi sites in winter 2002 to data collected in summer 2002

[WSRT, Wilcoxon signed rank test; <, less than; --, no data; NTU, nephelometric turbidity units; PTT, paired t-test; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; µg/L, micrograms per liter]

Paired data set	Units	Test used[1]	P-value[2]	Winter mean[3]	Summer mean[3]	Winter median[4]	Summer median[4]
Transparency	Inches	WSRT	**<0.001**	--	--	6	11
Turbidity	NTU	PTT	**<0.001**	213	68	--	--
Dissolved oxygen	mg/L	PTT	**<0.001**	8.4	6.1	--	--
pH	pH units	WSRT	**<0.001**	--	--	6.7	7.2
Specific conductance	µS/cm	PTT	**<0.001**	108	283	--	--
Chloride	mg/L	WSRT	**<0.001**	--	--	2.2	5.7
Total ammonia plus organic nitrogen	mg/L	WSRT	*0.022*	--	--	1.2	1
Dissolved nitrite plus nitrate	mg/L	WSRT	0.738	--	--	0.24	0.28
Total nitrogen	mg/L	WSRT	0.244	--	--	1.51	1.45
Dissolved ortho-phosphorus	mg/L	PTT	0.069	0.06	0.08	--	--
Total phosphorus	mg/L	PTT	**<0.001**	0.33	0.19	--	--
Chlorophyll-a	µg/L	WSRT	0.339	--	--	<0.1	<0.1

[1]The paired t-test was used for data that were normally distributed. The Wilcoxon signed rank test was used for data that were not normally distributed.

[2]Values in **bold** were considered statistically significant. Values in *italics* had p-values less than the test statistic but were considered inconclusive.

[3]Winter and summer means are listed in columns 5 and 6 if the paired t-test was used for analyses (the means for the two groups are the test statistics for the paired t-test). If not, then no data (--) are listed.

[4]Winter and summer medians are listed in columns 7 and 8 if the Wilcoxon signed rank test was used for analyses. If not, then no data (--) are listed. Although the test statistics for the Wilcoxon signed rank test are not the medians of the two groups, the median values are listed to compare the data sets in original units.

1.2 and 1.0 mg/L for winter and summer sampling periods, respectively. The mean total phosphorus concentration for the winter index period (0.33 mg/L) was nearly double the mean concentration for the summer index period (0.19 mg/L). Test results for dissolved nitrite plus nitrate, total nitrogen, ortho-phosphorus, and chlorophyll-a indicated no statistically significant differences when comparing the data between the winter and summer index periods.

Site Location

Results of the t-tests (or Mann-Whitney rank sum test) comparing water-quality data collected at the EA sites with data collected at the NWM sites are presented in table 6. For each set of comparisons, data were not subdivided according to season because each site had a winter and summer sample. Statistically significant differences (p-values less than 0.05) were observed when comparing transparency, turbidity, total ammonia plus organic nitrogen, dissolved nitrite plus nitrate, total nitrogen, and total phosphorus data from EA sites with data from NWM sites.

The median transparency value for the EA sites (27.5 in.) was about four times higher than the median value for the NWM sites (7 in.). The median turbidity value for the EA sites (17 NTU) was about one-fifth the median value for the NWM sites (89 NTU). The median total ammonia plus organic nitrogen concentration at the EA sites (0.8 mg/L) was lower than the median concentration at the NWM sites (1.1 mg/L). The median concentration of dissolved nitrite plus nitrate at the EA sites (0.08 mg/L) was one-third the median concentration at the NWM sites (0.24 mg/L). The median total nitrogen concentration at the EA sites (0.81 mg/L) was about one-half of the median concentration at the NWM sites (1.45 mg/L). The mean total phosphorus concentration for the EA sites (0.15 mg/L) was almost one-half the mean concentration at the NWM sties (0.26 mg/L). Dissolved oxygen, pH, specific conductance, chloride, dissolved ortho-phosphorus, and chlorophyll-a data collected from EA sites were not statistically different from data collected from NWM sites.

Drainage-Area Size

Results of the ANOVA (or Kruskal-Wallis) tests comparing water-quality data collected at the 43 NWM sites categorized according to drainage-area size (small, medium, and large) are presented in table 7. For selected data sets, separate statistical analyses were run for each index period if there was a significant difference between index periods (table 5). Statistically significant differences (p-values less than 0.05) between drainage-area sizes were observed for transparency (winter), turbidity (summer), specific conductance (summer), chloride (winter), total ammonia plus organic nitrogen (summer), dissolved nitrite plus nitrate, total nitrogen, and dissolved ortho-phosphorus.

In the pair-wise comparisons for the winter transparency data, the median value for both the large and small site categories was 6 in.; the median value for the medium category was 4 in. Although the results of the statistical tests were considered significant, the overall interpretation of the results was inconclusive because the transparency data for all three categories for the winter index period were similar. For the summer index period, the median turbidity value for sites categorized as large (89 NTU) was more than four times the median value for sites categorized as small (20 NTU). For the summer index period, the median specific conductance value for sites categorized as medium (414 µS/cm) was nearly four times the median value for sites categorized as large (111 µS/cm). Although the overall test results were statistically significant when comparing chloride (winter) or total ammonia plus organic nitrogen (summer) data among the three size categories, none of the respective pair-wise comparisons were significant.

Separate statistical analyses by sampling period were unnecessary for the dissolved nitrite plus nitrate, total nitrogen, and dissolved ortho-phosphorus data based on results presented in table 5. The median dissolved nitrite plus nitrate concentration for sites categorized as medium (0.43 mg/L) was nearly four times the median concentration for sites categorized as small (0.12 mg/L). The median total nitrogen concentration for sites categorized as medium (1.7 mg/L) was nearly double the median concentration for sites categorized as large (1.0 mg/L). The median dissolved ortho-phosphorus concentration for sites categorized as medium (0.08 mg/L) was nearly three times the median concentration for sites categorized as large (0.03 mg/L). Statistically significant results were not detected when comparing dissolved oxygen, pH, total phosphorus, or chlorophyll-a data from NWM sites categorized as small, medium, and large.

Large sites were further subdivided as either regulated or unregulated, according to existence of flood-control structures within their drainage areas. Water quality appeared to be different at the regulated sites compared with the unregulated sites (figs. 7-13). Turbidity, nitrogen and phosphorus species, and chloride all were lower at the regulated sites than at the unregulated sites. Sites considered as regulated were primarily located on the Yazoo River, and sites considered as unregulated were primarily located on the Big Sunflower River. Statistical tests were not run for these subcategories because of the lack of independence of the samples.

Sites categorized as small were subdivided as either perennial or intermittent based on whether a stream becomes dry for any length of time during the year. When the intermittent sites were sampled during the summer index period, many had flowing water primarily due to irrigation. Therefore, statistical tests were not completed for these two subcategories.

Table 6. Results of statistical analyses comparing water-quality data collected at eastern Arkansas sites to data collected at northwestern Mississippi sites

[EA, eastern Arkansas; NWM, northwestern Mississippi; MWRST, Mann-Whitney rank sum test; <, less than; --, no data; NTU, nephelometric turbidity units; mg/L, milligrams per liter; TT, t-test; µS/cm, microsiemens per centimeter; µg/L, micrograms per liter]

Data set	Units	Test used[1]	P-value[2]	EA mean[3]	NWM mean[3]	EA median[4]	NWM median[4]
Transparency	Inches	MWRST	**<0.001**	--	--	27.5	7
Turbidity	NTU	MWRST	**0.002**	--	--	17	89
Dissolved oxygen	mg/L	TT	0.127	5.8	7	--	--
pH	pH units	MWRST	0.770	--	--	7	7
Specific conductance	µS/cm	MWRST	0.899	--	--	185	127
Chloride	mg/L	MWRST	0.544	--	--	5.1	3.4
Total ammonia plus organic nitrogen	mg/L	MWRST	**0.001**	--	--	0.8	1.1
Dissolved nitrite plus nitrate	mg/L	MWRST	**0.009**	--	--	0.08	0.24
Total nitrogen	mg/L	MWRST	**<0.001**	--	--	0.81	1.45
Dissolved ortho-phosphorus	mg/L	MWRST	0.953	--	--	0.06	0.06
Total phosphorus	mg/L	TT	**0.014**	0.15	0.26	--	--
Chlorophyll-a	µg/L	MWRST	0.308	--	--	<0.1	<0.1

[1]The t-test was used for data that were normally distributed. The Mann-Whitney rank sum test was used for data that were not normally distributed.

[2]Values in **bold** were considered statistically significant.

[3]Means are listed in columns 5 and 6 if the t-test was used for analyses (the means for the two groups are the test statistics for the t-test). If not, then no data (--) are listed.

[4]Medians are listed in columns 7 and 8 if the Mann-Whitney rank sum test was used for analyses. If not, then no data (--) are listed. Although the test statistics for the Mann-Whitney rank sum test are not the medians of the two groups, the median values are listed to compare the data sets in original units.

Subjectively Evaluated Stream Conditions

No results of the t-tests (or Mann-Whitney rank sum tests) comparing water-quality data from NWM sites categorized as good with data from NWM sites categorized as poor were statistically significant. Data from the 18 NWM sites that were randomly selected were added to the data from the 15 NWM sites categorized as good or poor, and statistical analyses were re-run (this time using the ANOVA or Kruskal-Wallis tests because there were now three data sets of unequal sizes for each water-quality constituent analyzed). Data from the 18 random sites were included in these analyses because little historical information was available for their locations, and the random sites possibly represented a range of good or poor stream conditions. Few results from the second round of statistical tests were statistically significant; for those results that were statistically significant (p-values less than 0.05), none of the pair-wise comparisons were considered conclusive (data not shown).

A third round of statistical tests were run with the inclusion of water-quality data from the seven EA sites (all of which were categorized as having good stream conditions). Results of the ANOVA (or Kruskal-Wallis) tests comparing water-quality data collected at the 15 NWM sites categorized as good or poor, the 18 randomly selected NWM sites, and the 7 EA sites are presented in table 8. For selected data sets, separate statistical analyses were run for each index period if there was a significant difference between index periods (table 5). Statistically significant differences (p-values less than 0.05) were observed for transparency (winter and summer), turbidity (winter and summer), dissolved oxygen (summer), pH (summer), total ammonia plus organic nitrogen (winter and summer), dissolved nitrite plus nitrate, total nitrogen, dissolved ortho-phosphorus, and total phosphorus (winter and summer).

The median transparency value for EA sites (16.5 in.) was more than four times the median value for NWM sites categorized as poor (4 in.) for the winter index period. The mean transparency value for EA sites (40 in.) was substantially higher than the mean values for all NWM sites categories (good, 9 in.; poor, 9 in.; and random, 15 in.) for the summer index period. The mean turbidity value for NWM sites categorized as poor (284 NTU) was more than five times the mean value for EA sites (53 NTU) for the winter index period. None of the pair-wise comparisons were considered significant (although overall test results were considered significant) for either the turbidity data during the summer index period or the dissolved oxygen concentrations during the summer index period. The median pH value for NWM sites categorized as good (7.7 pH units) was higher than the median value for EA sites (6.9 pH units) for the summer index period. Although the pH result was considered significant, this range in pH is considered typical for most surface waters (Hem, 1985).

The median total ammonia plus organic nitrogen concentrations for all three NWM categories (good, 1.5 mg/L; poor, 1.4 mg/L; and random, 1.4 mg/L) were nearly double the median concentration for EA sites (0.8 mg/L) for the winter

Table 7. Results of statistical analyses comparing water-quality data collected at northwestern Mississippi sites categorized as small, medium, and large

[KW, Kruskal-Wallis; --, no data; NTU, nephelometric turbidity units; ANOVA, analyses of variance; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; <, less than; µg/L, micrograms per liter]

Data	Units	Season[1]	Test used[2]	P-value[3]	Statistically significant group comparison[4]	Median[4]
Transparency	inches	winter	KW	**0.03**	Large vs. medium	6 vs. 4
					Small vs. medium	6 vs. 4
		summer	KW	0.166	--	--
Turbidity	NTU	winter	ANOVA	0.081	--	--
		summer	KW	**0.008**	Large vs. small	89 vs. 20
Dissolved oxygen	mg/L	winter	ANOVA	0.697	--	--
		summer	ANOVA	0.357	--	--
pH	pH units	winter	ANOVA	0.938	--	--
		summer	ANOVA	0.391	--	--
Specific conductance	µS/cm	winter	KW	0.589	--	--
		summer	KW	**0.014**	Medium vs. large	414 vs. 111
Chloride	mg/L	winter	KW	*0.042*	None	--
		summer	KW	0.379	--	--
Total ammonia	mg/L	winter	KW	0.084	--	--
plus organic nitrogen		summer	KW	*0.036*	None	--
Dissolved nitrite plus nitrate	mg/L	all data	KW	**<0.001**	Medium vs. small	0.43 vs. 0.12
Total nitrogen	mg/L	all data	KW	**0.008**	Medium vs. large	1.7 vs. 1.0
Dissolved ortho-phosphorus	mg/L	all data	KW	**0.039**	Medium vs. large	0.08 vs. 0.03
Total phosphorus	mg/L	winter	ANOVA	0.232	--	--
		summer	KW	0.571	--	--
Chlorophyll-a	µg/L	all data	KW	0.161	--	--

[1]Separate statistical tests were run for each index period based on results presented in table 5.

[2]The analyses of variance test was used for data that were normally distributed. The Kruskal-Wallis test was used for data that were not normally distributed.

[3]P-values presented in column 5 are results of the overall tests presented in column 4. Values in **bold** were considered statistically significant. Values in *italics* had p-values less than the test statistic, but no individual group comparisons were considered significant.

[4]Statistically significant results for individual group comparisons are listed in column 6 (p-values for group comparisons are not presented). Although the test statistics for the Kruskal-Wallis test are not the medians for each group, the medians of the groups specified in column 6 are listed in column 7 to compare the data in original units. No data are presented in columns 6 and 7 for results that were not considered statistically significant.

index period. The median total ammonia plus organic nitrogen concentration for randomly selected NWM sites (1.2 mg/L) was higher than the median concentration for EA sites (0.8 mg/L) for the summer index period. The mean total phosphorus concentrations for all three NWM categories (good, 0.41 mg/L; poor, 0.38 mg/L; and random, 0.35 mg/L) were triple or nearly triple the mean concentration for EA sites (0.13 mg/L).

Separate statistical analyses were unnecessary by index period for the dissolved nitrite plus nitrate, total nitrogen, and dissolved ortho-phosphorus data based on results presented in table 5. Median dissolved nitrite plus nitrate concentrations for good and poor NWM sites (0.38 mg/L and 0.41 mg/L, respectively) were substantially higher than the median concentration for EA sites (0.08 mg/L). The median dissolved nitrite plus nitrate concentration for NWM sites categorized as poor (0.41 mg/L) was four times the median concentration for randomly selected NWM sites (0.1 mg/L). The median total nitrogen concentrations for all three NWM categories (good, 1.5 mg/L; poor, 1.6 mg/L; and random, 1.6 mg/L) were double or nearly double the median concentration for EA sites (0.8 mg/L). The median dissolved ortho-phosphorus concentration for NWM sites categorized as poor (0.1 mg/L) was more than double the median concentration for randomly selected NWM sites (0.04 mg/L). Statistically significant differences were not observed for specific conductance, chloride, and chlorophyll-a.

Table 8. Results of statistical tests comparing water-quality data collected at eastern Arkansas sites and northwestern Mississippi sites categorized as good, poor, and random

[KW, Kruskal-Wallis test; EA, eastern Arkansas; --, no data; ANOVA, analyses of variance test; <, less than; NTU, nephelometric turbidity units; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; µg/L, micrograms per liter]

Data	Units	Season[1]	Test used[2]	P-value[3]	Statistically significant group comparison[4]	Mean[4]	Median[4]
Transparency	inches	winter	KW	**0.009**	EA vs. Poor	--	16.5 vs. 4
		summer	ANOVA	**<0.001**	EA vs. Good	40 vs. 9	--
					EA vs. Poor	40 vs. 9	--
					EA vs. Random	40 vs. 15	--
Turbidity	NTU	winter	ANOVA	**0.035**	Poor vs. EA	284 vs. 53	--
		summer	KW	*0.043*	none	--	--
Dissolved oxygen	mg/L	winter	ANOVA	0.91	--	--	--
		summer	ANOVA	*0.046*	none	--	--
pH	pH units	winter	KW	0.413	--	--	--
		summer	KW	**0.004**	Good vs. EA	--	7.7 vs. 6.9
Specific conductance	µS/cm	winter	ANOVA	0.946	--	--	--
		summer	ANOVA	0.552	--	--	--
Chloride	mg/L	winter	KW	0.445	--	--	--
		summer	KW	0.378	--	--	--
Total ammonia plus organic nitrogen	mg/L	winter	KW	**0.006**	Good vs. EA	--	1.5 vs. 0.8
					Random vs. EA	--	1.4 vs. 0.8
					Poor vs. EA	--	1.4 vs. 0.8
		summer	KW	**0.039**	Random vs. EA	--	1.2 vs. 0.8
Dissolved nitrite plus nitrate	mg/L	all data	KW	**<0.001**	Poor vs. EA	--	0.41 vs. 0.08
					Poor vs. Random	--	0.41 vs. 0.1
					Good vs. EA	--	0.38 vs. 0.08
Total nitrogen	mg/L	all data	KW	**<0.001**	Poor vs. EA	--	1.6 vs. 0.8
					Good vs. EA	--	1.5 vs. 0.8
					Random vs. EA	--	1.6 vs. 0.8
Dissolved ortho-phosphorus	mg/L	all data	KW	**0.009**	Poor vs. Random	--	0.1 vs. 0.04
Total phosphorus	mg/L	winter	ANOVA	**0.009**	Good vs. EA	0.41 vs. 0.13	--
					Poor vs. EA	0.38 vs. 0.13	--
					Random vs. EA	0.35 vs. 0.13	--
		summer	KW	0.402	--	--	--
Chlorophyll-a	µg/L	all data	KW	0.07	--	--	--

[1]Separate statistical tests were run for each index period based on results presented in table 5.

[2]The analyses of variance test was used for data that were normally distributed. The Kruskal-Wallis test was used for data that were not normally distributed.

[3]P-values presented in column 5 are results of the overall tests presented in column 4. Values in **bold** were considered statistically significant. Values in *italics* had p-values less than the test statistic, but no individual group comparisons were considered significant.

[4]Statistically significant results for individual group comparisons are listed in column 6 (p-values for group comparisons are not presented). Means of the groups specified in column 6 are presented in column 7 for analyses of variance test results. Medians of the groups specified in column 6 are presented in column 8 for Kruskal-Wallis test results. Although the test statistics for the Kruskal-Wallis test are not the medians for each group, the medians are presented in column 8 to compare the data in original units. No data are presented in columns 6-8 for results that were not considered statistically significant

Habitat-Assessment Data

Statistical analyses that were performed for the water-quality data discussed previously were repeated using the habitat-assessment data total scores. Results of the statistical analyses are as follows:

- The result of a paired t-test indicated a statistically significant difference when comparing habitat-assessment total scores collected at NWM sites during the winter index period with total scores collected during the summer index period (the p-value of the test was 0.044). The mean habitat-assessment total score for the winter index period (78) was lower than the mean score for the summer index period (88). In evaluating the individual sections of the habitat assessments (Appendix III), it appears that scores likely were influenced by higher than average flows during the summer index period at some of the sites. For example, higher individual scores were obtained for bottom substrate, pool substrate, pool variability, sediment deposition, and channel flow status at Big Sunflower River at Hopson Spur and Quiver River near Rome for the summer index period than for the winter index period.

- Habitat assessments for EA sites were available only for the summer index period. The result of a t-test indicated a statistically significant difference when comparing habitat-assessment total scores for the summer period at EA sites to total scores at NWM sites (the p-value of the test was less than 0.001). The mean total score at EA sites (151) was nearly double the mean total score at NWM sites (81) for the summer index period.

- Statistical tests were run separately for the two index periods when habitat-assessment total scores collected at NWM sites were compared based on drainage-area size (small, medium, and large). Statistically significant differences were detected for both index periods (p-value = 0.009, winter; p-value= 0.03, summer). In evaluating all pair-wise comparisons for the winter index period, the mean total score for large sites (102) was higher the mean total score for medium sites (59) and for small sites (77). Although statistically significant differences were detected in the total scores for the summer period, none of the pair-wise comparisons were statistically significant.

- Similar to the water-quality results, statistically significant differences were not detected when habitat-assessment total scores were compared from the 15 NWM sites categorized as good or poor. (Similarly, statistically significant differences also were not detected when total scores from the 18 randomly selected NWM sites were considered in the analyses). Statistically significant differences were detected (p-value = 0.001, ANOVA test) when total scores from EA sites were considered in the analyses. Statistical tests were run only for the summer index period because habitat was assessed at EA sites for the summer index period only. In considering all pair-wise comparisons, the mean total score from EA sites (151) was higher than the mean total scores from all NWM site categories (good, 106; poor, 100; random, 81).

Big Sunflower River

Data collected at nine sampling sites on the Big Sunflower River were plotted for each water-quality constituent and for habitat-assessment total scores (figs. 14-17; temperature and chlorophyll-a data were not plotted). The data were plotted according to location of the nine sample sites upstream from the mouth of the Big Sunflower River: mile 18.7, at Choctaw Bayou (near Holly Bluff); mile 68.4, downstream from the mouth of Bogue Phalia; mile 74.9, at Brumfield Landing; mile 88.3, downstream of U.S. Highway 49W; mile 94.6, above U.S. Highway 49W (Jenkins Brake); mile 99.2, at U.S. Highway 82; mile 118.1, at Sunflower; mile 153.9, east of Merigold; and mile 194.1, at Hopson. Locations were based on published river miles at known locations or were interpolated between known locations as defined by the USACE for the Big Sunflower River (U.S. Army Corps of Engineers, 1995). Plots were separated by winter and summer seasons.

For the most part, little variation in physical-property measurements and water-quality data were observed within the Big Sunflower River, with the exceptions of turbidity, dissolved oxygen, and dissolved nitrite plus nitrate (especially in the winter index period). Chloride, total ammonia plus organic nitrogen, dissolved nitrite plus nitrate, total nitrogen, ortho-phosphorus, and total phosphorus all were fairly consistent with minimal variation between sites, except for values recorded at the Hopson site. Overall, water quality was similar throughout the Big Sunflower River Basin during both index periods, and few trends were observed. For the most part, habitat-assessment total scores during the summer sampling period were similar throughout the stream reach. During the winter sampling period, habitat-assessment total scores decreased in the reach from U.S. Highway 82 to Hopson.

Discussion

Considering all of the water-quality data analyzed, transparency, turbidity, total nitrogen, and total phosphorus had the most statistically significant differences for the four comparisons (sample index period, site location, drainage-area size, and subjectively evaluated stream conditions). Statistically significant differences were detected in the transparency and turbidity data for all four comparisons. Statistically significant differences were detected in total nitrogen and total phosphorus data for three of four comparisons.

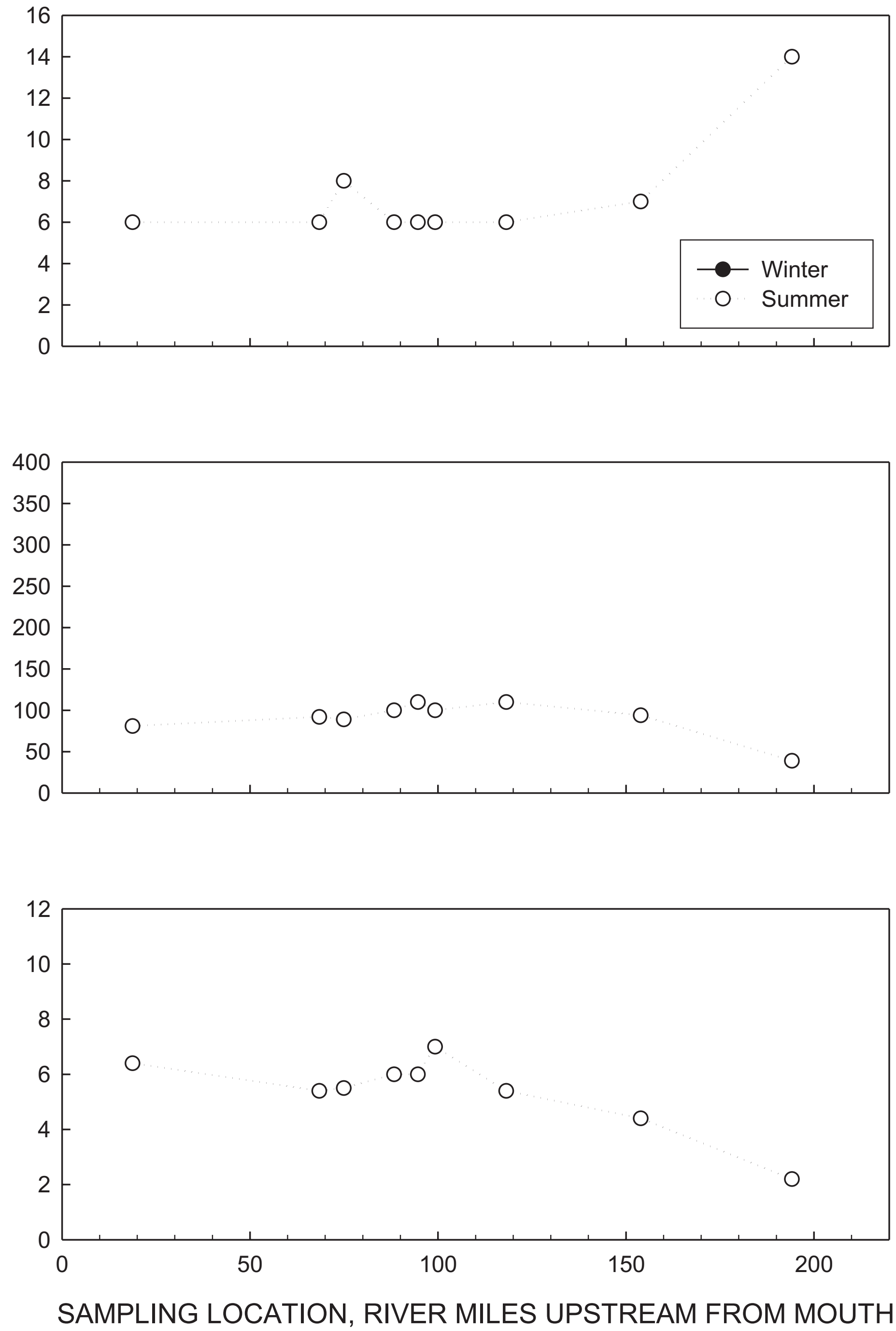


Figure 14. Transparency, turbidity, and dissolved oxygen versus river miles at nine sites in the Big Sunflower River.

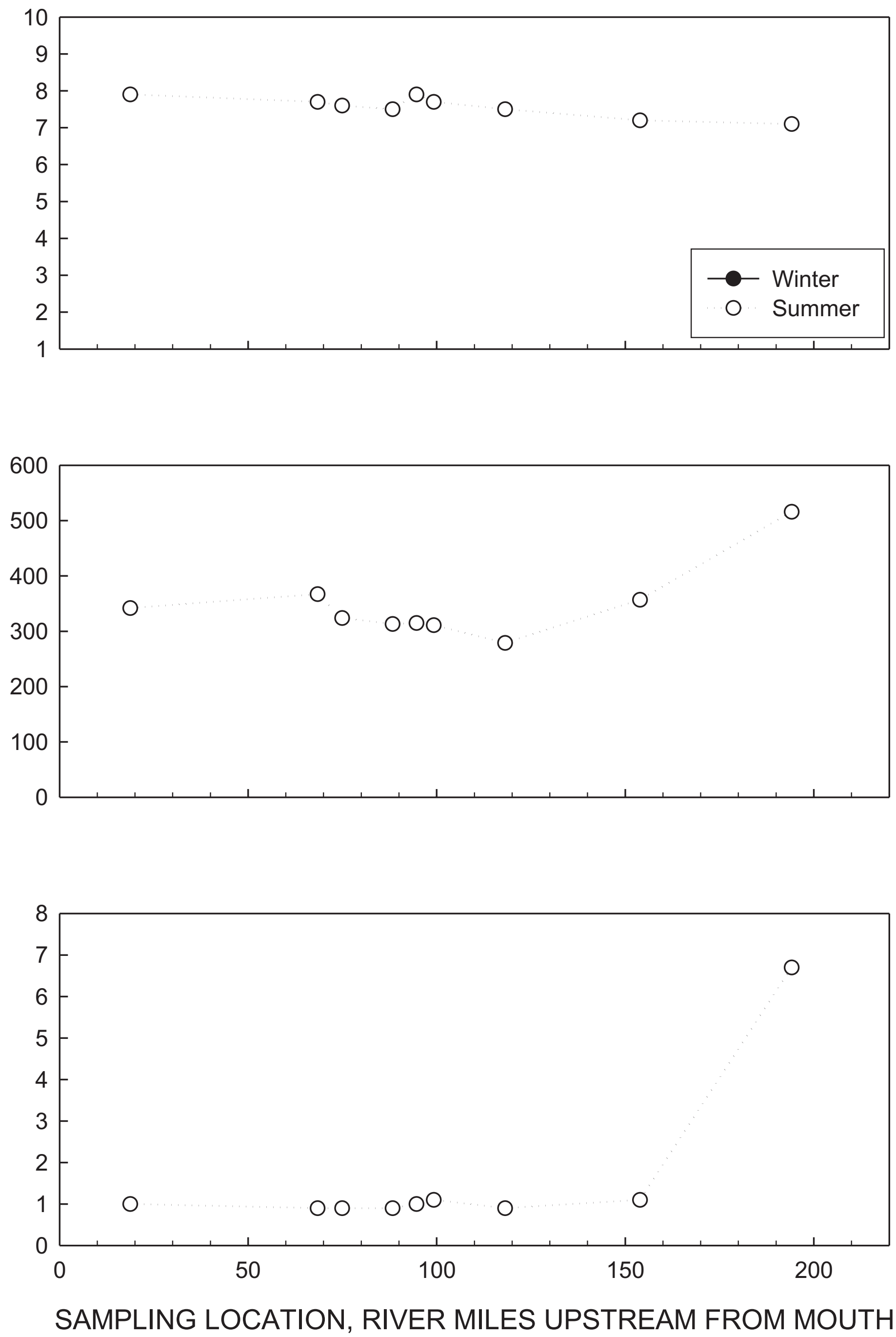


Figure 15. pH, specific conductance, and total ammonia plus organic nitrogen versus river miles at nine sites in the Big Sunflower River.

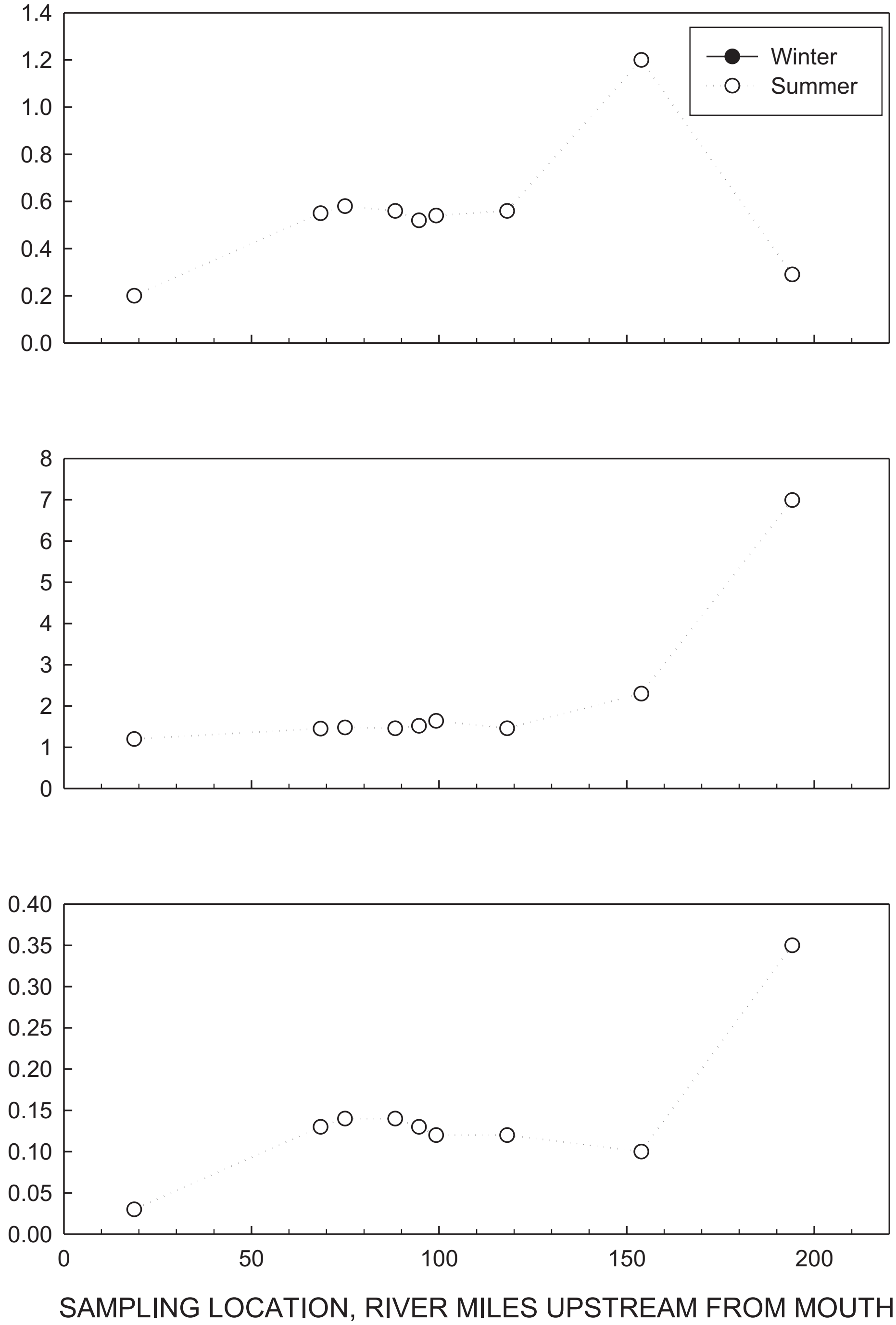


Figure 16. Dissolved nitrite plus nitrate, total nitrogen, and dissolved ortho-phosphorus versus river miles at nine sites in the Big Sunflower River.

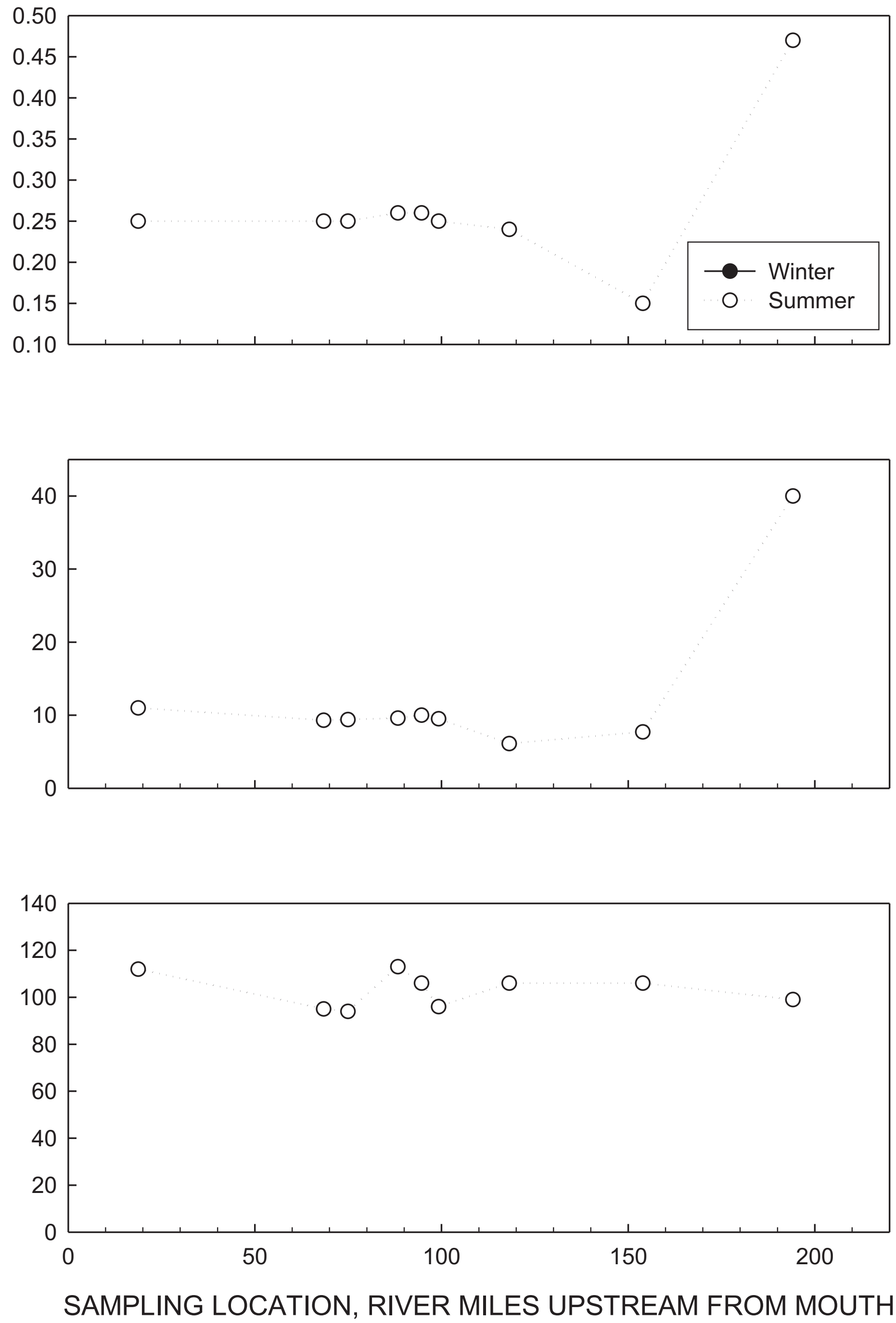


Figure 17. Total phosphorus, dissolved chloride, and habitat assessment total scores versus river miles at nine sites in the Big Sunflower River.

Transparency is a subjective, direct measurement of visible light penetration using a Secchi disk lowered into the stream. Transparency measurements were limited by stream depth during the summer months because the water was not deep enough at some sites to obtain an accurate reading. Field personnel could see the stream bottom; therefore, the transparency measurement was equal to stream depth. Turbidity is an analytical measure of light interference caused by insoluble particles in the water. Turbidity is measured from a composited sample of the stream water; therefore, turbidity is not limited by stream depth and, for these streams, probably is a better (though inverse) measure of light penetration. Total nitrogen and total phosphorus concentrations reflect the amount of nitrogen and phosphorus attached to sediment or other particulate matter, and likely, somewhat proportional to turbidity. Of these four water-quality constituents, turbidity was the measurement that was the most practical in indicating ranges in stream conditions among the sites sampled.

Similar to the turbidity data, statistically significant differences also were observed in the habitat-assessment total scores for all four comparisons. When comparing habitat-assessment total scores to turbidity values (figs. 7 and 13), total scores were high where turbidity values were low, indicating that sites that had good habitat were less turbid. Therefore, habitat-assessment total scores were similarly practical in indicating ranges in stream conditions among the sites sampled.

The statistical results also were evaluated to determine the value of data analysis by category. Sample index period and site location categories provided the strongest results. For example, the mean turbidity value for NWM sites sampled during the winter index period (213 NTU) was about three times the mean turbidity value for the summer index period (68 NTU). The median turbidity value for EA sites (17 NTU) was about one-fifth the median value for NWM sites (89 NTU).

Drainage-area size and subjectively evaluated stream conditions were the weakest categories with respect to statistical results. Evaluating the data based on drainage-area size produced mixed results. Only seven pair-wise comparisons were considered statistically significant (table 7). For example, the median turbidity value for large sites (89 NTU) was more than four times the median value for small sites (20 NTU) during the summer index period.

When comparing the data based on subjectively evaluated stream conditions, none of the comparisons were statistically significant for water-quality or habitat-assessment data from NWM sites categorized as good to data from sites categorized as poor. The strongest results were observed when data from EA sites were included in the analyses. For example, the mean turbidity value for NWM sites categorized as poor (284 NTU) was more than five times the mean value for EA sites (53 NTU) for the winter index period.

SUMMARY

A total of 50 Mississippi River Allivial Plain (MRAP) sites were sampled by the USGS and MDEQ during the winter and summer of 2002. Of the 50 sites, 43 were located in northwestern Mississippi; and 7 sites were located in eastern Arkansas. The seven eastern Arkansas sites were subjectively chosen for this study because they were representative of good stream conditions for the study area.

Water-quality analyses included measurements of physical properties, nitrogen and phosphorus species, chlorophyll-a, and chloride. USGS standard protocols were followed for physical-property measurements and water-sample collection.

Results from five water-quality blank samples collected as part of ongoing USGS studies being conducted in the study area indicated that the amount and frequency of detections in blank samples were not of environmental significance. Analyses of 19 duplicate water-quality samples (or 12 percent) collected from 10 sample sites during this study indicated very low variability in the data set – all median Relative Percent Difference (RPD's) between environmental and duplicate samples were less than 10 percent. Therefore, variability associated with random errors in the data set from this study is minimal.

MDEQ protocols were followed for habitat assessments. There are at least three potential sources of error associated with habitat assessment: basin/stream heterogeneity, sample variance, and observer error. Fifteen duplicate habitat-assessment samples (or 20 percent) were collected (on adjacent reaches) from 10 sites to determine variability in stream heterogeneity. Habitat-assessment total scores for these replicates were identical for 13 of the 15 samples (RPDs for these 13 samples were 0 percent), and RPDs were less than 4 percent for the other two replicates. Habitat-assessment replicates were not collected to assess sample variance and observer error.

Water-quality data collected during this study compared well with data collected at some of the same sites or similar sites in other studies. Statistical analyses were performed to determine whether the water-quality and/or habitat-assessment data could be used to detect ranges in stream conditions for sites sampled in the MRAP region. Both data sets were categorized according to sample-index period, site location, drainage-area size, and subjectively evaluated stream conditions (sites that were categorized as good or poor). Statistical analyses were completed to compare the data based on these categories.

Considering all of the water-quality data analyzed, turbidity, transparency, total nitrogen, and total phosphorus had the most statistically significant differences for the four comparisons. Statistically significant differences were detected in transparency and turbidity data for all four comparisons. Statistically significant differences were detected in total nitrogen and total phosphorus data for three of four comparisons. Transparency measurements are limited by stream depth.

Turbidity measurement is not limited by stream depth and, for these sites, probably is a better (though inverse) measure of light penetration. Total nitrogen and total phosphorus concentrations reflect the amount of nitrogen and phosphorus attached to sediment or other particulate matter, and likely are directly proportional to turbidity. Considering these four water-quality constituents, turbidity was the most practical in indicating ranges in stream conditions among the sampled sites.

Similar to the turbidity data, statistically significant results also were observed in the habitat-assessment total scores for all four comparisons. When comparing habitat-assessment total scores to the turbidity values, scores were high where turbidity values were low, indicating that sites that had good habitat were less turbid. Therefore, habitat-assessment total scores were similarly practical in indicating ranges in stream conditions among the sampled sites.

The statistical results also were evaluated to determine the value of data analysis by category. Sample index period and site location categories provided the strongest results. For example, the mean turbidity value for NWM sites sampled during the winter index period (213 NTU) was about three times the mean turbidity value for the summer index period (68 NTU). The median turbidity value for EA sites (17 NTU) was about one-fifth the median value for NWM sites (89 NTU).

Drainage-area size and subjectively evaluated stream conditions were the weakest categories with respect to statistical results. Evaluating the data based on drainage-area size produced mixed results. Only seven pair-wise comparisons were considered statistically significant. For example, the median turbidity value for large sites (89 NTU) was more than four times the median value for small sites (20 NTU) during the summer index period.

When comparing the data based on subjectively evaluated stream conditions, none of the comparisons were statistically significant for water-quality or habitat-assessment data from NWM sites categorized as good to data from sites categorized as poor. The strongest results were based on comparing data from EA sites with data from any NWM site categories (good, poor, and randomly selected). For example, the mean turbidity value for NWM sites categorized as poor (284 NTU) was more than five times the mean value for EA sites (53 NTU) for the winter index period.

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Appendixes

Appendix I. Summary of surface-water quality analytical results for the winter and summer index periods

[in, inches; NTU; nephelometric turbidity units; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; Cl, chloride; N, nitrgen; P, phosphorus; µg/L, micrograms per liter; --, no data; >, greater than; <, less than; E, estimated]

Site number (fig. 1)	Station number	Date	Transparency (in)	Turbidity (NTU)	Dissolved oxygen (mg/L)	pH, field (standard units)	pH, lab (standard units)	Specific conductance, field (µS/cm)	Specific conductance, lab (µS/cm)	Water temperature (Degrees Celsius)	Dissolved chloride (mg/L as Cl)	Total ammonia plus organic nitrogen (mg/L as N)	Dissolved nitrite plus nitrate (mg/L as N)	Dissolved ortho-phosphorus (mg/L as P)	Total phosph-orus (mg/L as P)	Chloro-phyll-a (µg/L)
								Winter Index Period								
1	07074700	4/9/02	6.00	99	7.1	6.1	7.4	86	90	15.4	1.9	1.0	.08	0.08	0.22	<.1
2	07074883	4/9/02	26.0	11	7.9	7.3	7.6	--	152	--	3.2	.30	.03	<.01	0.02	<.1
3	07077555	4/9/02	6.00	100	6.4	6.7	7.0	65	68	15.3	1.7	.80	.12	0.06	0.19	<.1
4	07077720	4/8/02	11.0	56	8.7	7.2	7.3	89	90	16.3	2.5	.80	<.02	0.06	0.18	<.1
5	07047947	4/8/02	22.0	28	4.4	7.1	7.3	107	113	16.7	4.8	.60	<.02	0.07	0.13	<.1
6	07077000	1/22/02	30.0	17	11.5	7.8	8.0	266	176	6.5	5.60	.40	.31	<.01	0.03	<.1
7	07078040	4/8/02	10.0	62	7.1	6.9	7.0	67	70	16.2	2.1	.90	.22	0.03	0.16	<.1
8	344529090115500	1/31/02	6.00	470	8.6	7.1	7.6	107	110	19.0	.9	2.1	<.02	--	0.39	<.1
9	344402090230100	1/31/02	--	470	7.8	7.3	7.4	135	136	21.5	1.2	2.3	.07	--	0.46	4.6
10	342815090195500	2/1/02	--	610	5.3	--	7.1	35	40	8.0	1.1	2.4	.07	0.02	0.42	<.1
11	342630090142600	3/5/02	4.00	240	8.9	6.4	7.3	87	99	5.0	2.2	1.3	.28	0.02	0.28	<.1
12	342510090183500	2/5/02	5.00	370	7.0	6.6	7.2	85	93	8.0	3.0	1.5	.32	.05	0.42	<.1
13	341640090055100	2/5/02	20.0	210	8.5	6.3	6.6	117	119	8.0	7.2	2.9	.07	0.04	1.00	10.0
14	07288010	2/13/02	--	120	7.5	7.0	7.4	210	240	10.0	16.0	1.8	.35	0.11	0.36	<.1
15	340657090080900	4/10/02	29.0	17	4.9	6.9	7.2	155	161	17.1	2.2	.80	<.02	0.03	0.2	<.1
16	335915090423900	2/13/02	5.00	170	9.4	7.1	7.4	89	105	10.5	1.4	.90	.27	E.08	0.41	<.1
17	335632090291000	2/25/02	--	400	4.5	6.7	7.0	59	65	11.5	1.5	1.8	.24	E.04	0.46	59.0
18	335737090270100	2/25/02	5.00	120	5.8	6.6	7.3	83	91	10.5	1.9	1.2	.36	0.09	0.3	<.1
19	07280900	4/10/02	3.00	510	6.8	6.2	6.9	46	48	15.9	1.5	1.4	.41	0.11	0.53	<.1
20	340030090155300	4/11/02	7.00	170	5.2	6.0	6.8	42	44	17.4	1.0	1.2	.15	E.10	0.39	<.1
21	335946090121100	4/10/02	6.00	80	8.7	6.7	7.0	46	53	14.9	1.9	.70	.24	0.02	0.15	<.1
22	340120090113300	4/10/02	8.00	150	7.9	6.7	7.0	61	64	15.9	2.1	.80	.33	0.04	0.24	<.1
23	340203090073000	4/10/02	--	75	9.9	6.7	7.0	45	48	13.8	2.1	.60	.22	<.01	0.08	<.1
24	335250090454700	3/5/02	3.00	290	13.4	9.1	8.0	204	229	12.5	23.0	2.8	<.02	0.03	0.47	130
25	07288280	2/14/02	5.00	180	10.2	6.6	7.3	131	140	8.5	5.6	1.1	.38	0.08	0.38	<.1
26	335200090094500	4/10/02	7.00	87	7.8	6.2	6.9	52	54	17.3	1.8	.60	.19	0.02	0.16	<.1
27	07285730	4/11/02	8.00	65	9.5	6.1	6.7	56	58	16.0	3.4	.60	.17	<.01	0.11	<.1
28	07288643	2/14/02	4.00	230	11.5	7.4	7.2	80	89	9.0	1.6	1.0	.45	0.07	0.27	<.1
29	334030090482200	2/25/02	5.00	160	9.4	8.3	8.2	104	117	16.5	1.6	1.5	<.02	0.03	0.23	<.1
30	334402090395400	2/12/02	7.00	83	10.9	5.7	7.4	91	97	10.5	1.3	1.1	<.02	<.01	0.08	<.1

Appendix I. Summary of surface-water quality analytical results for the winter and summer index periods -- Continued

[in, inches; NTU; nephelometric turbidity units; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; Cl, chloride; N, nitrgen; P, phosphorus; µg/L, micrograms per liter; --, no data; >, greater than; <, less than; E, estimated]

Site number (fig. 1)	Station number	Date	Transpar-ency (in)	Turbidity (NTU)	Dissolved oxygen (mg/L)	pH, field (standard units)	pH, lab (standard units)	Specific conduct-ance, field (µS/cm)	Specific conduct-ance, lab (µS/cm)	Water tem-perature (Degrees Celsius)	Dissolved chloride (mg/L as Cl)	Total am-monia plus organic nitrogen (mg/L as N)	Dissolved nitrite plus nitrate (mg/L as N)	Dissolved ortho-phosphorus (mg/L as P)	Total phosph-orus (mg/L as P)	Chloro-phyll-a (µg/L)
31	333940090370900	2/26/02	11.0	72	9.0	6.5	7.5	84	93	11.0	2.1	1.0	.14	0.09	0.28	<.1
32	334248090311000	4/9/02	4.00	460	7.7	6.8	7.0	47	50	16.1	1.4	1.4	.41	.09	0.45	<.1
33	334251090181900	2/20/02	--	88	7.6	6.3	6.4	26	29	14.0	.8	.90	.11	0.32	0.4	<.1
34	07286200	4/11/02	11.0	66	8.0	6.1	6.8	54	56	17.0	2.6	.60	.14	E.01	0.15	<.1
35	333600090281000	2/12/02	4.00	160	11.5	6.3	7.5	714	710	11.5	85.0	15.00	.39	<.01	0.49	450
36	07288500	2/27/02	4.00	380	8.5	6.7	7.3	116	124	9.5	5.3	1.5	.77	0.1	0.38	<.1
37	07287000	4/11/02	7.00	110	7.7	5.9	7.2	54	56	6.8	2.3	.60	.19	E.03	0.19	<.1
38	332749090103400	2/19/02	21.0	30	9.0	7.5	7.3	65	78	16.0	3.1	.40	.12	<.01	0.05	<.1
39	07288600	4/9/02	2.00	690	74.6	6.9	6.9	63	65	15.9	3.0	1.8	.60	0.08	0.47	<.1
40	07288530	2/28/02	4.00	350	9.1	7.0	7.4	111	120	9.0	5.0	1.4	.74	0.05	0.37	<.1
41	07288620	3/7/02	5.00	220	10.9	7.7	7.1	151	159	9.0	11.0	1.8	.35	0.03	0.39	49.0
42	07288621	3/7/02	6.00	190	10.7	7.5	7.0	102	110	8.5	6.2	1.2	.39	.07	0.38	<.1
43	332501090405800	2/15/02	6.00	130	4.9	6.7	6.9	67	78	7.0	1.6	1.1	.04	0.07	0.45	<.1
44	07288624	3/8/02	6.00	190	10.7	7.6	7.3	114	126	10.5	7.6	1.5	.35	E.06	0.41	<.1
45	331432090435300	3/8/02	7.00	140	10.4	7.7	7.4	120	127	9.5	6.8	1.3	.40	E.07	0.38	<.1
46	330730090431300	2/28/02	>36.0	10	10.5	7.2	7.8	333	352	7.0	13.0	.80	<.02	0.01	0.09	<.1
47	07287500	4/16/02	6.00	100	7.2	5.8	7.0	59	62	19.9	2.2	.70	.22	.03	0.18	<.1
48	07288955	4/12/02	--	--	6.5	7.0	7.2	67	72	17.5	2.52	.85	.29	.05	.26	<.1
49	07288720	4/16/02	4.00	350	5.2	6.3	6.9	77	80	19.8	3.1	1.3	.61	.10	0.44	<.1
50	322804090533900	4/16/02	7.00	200	5.7	7.1	6.9	82	88	21.9	2.8	1.1	.24	.13	0.35	<.1

Appendix I. Summary of surface-water quality analytical results for the winter and summer index periods -- Continued

[in, inches; NTU; nephelometric turbidity units; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; Cl, chloride; N, nitrgen; P, phosphorus; µg/L, micrograms per liter; --, no data; >, greater than; <, less than; E, estimated]

Site number (fig. 1)	Station number	Date	Transpar-ency (in)	Turbidity (NTU)	Dissolved oxygen (mg/L)	pH, field (standard units)	pH, lab (standard units)	Specific conduct-ance, field (µS/cm)	Specific conduct-ance, lab (µS/cm)	Water tem-perature (Degrees Celsius)	Dissolved chloride (mg/L as Cl)	Total am-monia plus organic nitrogen (mg/L as N)	Dissolved nitrite plus nitrate (mg/L as N)	Dissolved ortho-phosphorus (mg/L as P)	Total phosph-orus (mg/L as P)	Chloro-phyll-a (µg/L)
								Summer Index Period								
1	07074700	7/30/02	39.0	8.0	3.3	6.8	7.5	255	247	27.6	5.1	.90	.11	0.15	0.21	<.1
2	07074883	7/30/02	34.0	10	.7	6.2	6.8	90	87	26.6	6.4	.80	<.02	0.03	0.14	<.1
3	07077527	7/31/02	32.0	11	2.9	6.6	7.3	217	276	27.4	20.0	.70	<.02	0.08	0.16	<.1
4	07077720	7/29/02	54.0	5.5	5.5	7.0	7.6	223	220	27.7	7.6	.70	.22	0.14	0.2	<.1
5	07047947	7/31/02	66.0	2.0	1.4	6.8	7.3	280	209	27.7	5.4	.80	.21	0.09	0.15	<.1
7	07078040	7/29/02	16.5	95	3.6	7.0	7.6	464	448	28.9	36.0	.30	<.02	0.03	0.16	<.1
8	344529090115500	7/15/02	27.0	5.0	8.7	7.5	7.6	330	325	26.5	1.9	.50	<.02	0.02	0.07	<.1
10	342815090195500	7/16/02	19.0	19	1.5	6.4	7.2	170	169	24.8	1.9	2.2	1.30	0.04	0.12	<.1
11	342630090142600	7/16/02	12.0	38	2.9	6.7	7.2	169	165	27.5	2.7	.80	.14	0.08	0.2	<.1
12	342510090183500	7/16/02	7.00	130	4.0	6.0	6.8	59	60	29.3	.7	1.2	.10	0.07	0.19	<.1
13	341640090055100	7/16/02	15.0	18	8.8	6.5	7.1	107	105	30.6	6.5	1.5	.31	<.01	0.15	120
14	07288010	7/23/02	14.0	39	2.2	7.1	7.7	516	503	27.5	40.0	6.7	.29	0.35	0.47	<.1
15	340657090080900	7/16/02	6.00	140	4.3	6.6	7.3	132	129	33.1	6.2	1.3	.19	0.06	0.36	<.1
16	335915090423900	7/23/02	11.0	100	5.4	7.3	7.8	378	368	28.7	2.8	1.6	.36	0.1	0.16	<.1
17	335632090291000	7/17/02	7.00	82	4.8	7.1	7.3	261	248	28.2	5.7	1.1	<.02	0.02	0.06	<.1
18	335737090270100	7/17/02	>39.0	3.0	4.5	7.3	7.8	293	285	27.4	2.1	1.1	.28	0.11	0.15	<.1
19	07280900	8/13/02	8.00	200	10.1	8.2	7.5	149	153	31.8	3.0	1.5	<.02	0.06	0.34	56.0
20	335919090133600	8/12/02	14.0	34	6.9	6.5	7.2	69	71	27.5	2.5	.60	.08	<.01	0.07	<.1
21	335946090121100	8/12/02	13.0	60	7.3	6.9	7.2	69	71	27.8	2.5	.50	.07	<.01	0.1	<.1
22	340120090113300	8/13/02	8.00	48	6.5	7.0	7.5	111	116	29.9	3.5	.70	.11	0.03	0.12	<.1
23	340203090073000	8/13/02	13.0	63	7.2	6.3	6.9	57	60	26.2	2.2	.70	.05	0.01	0.08	<.1
24	335250090454700	7/23/02	12.0	40	15.0	8.1	8.2	629	617	32.5	27.0	3.2	.82	0.03	0.16	99.0
25	07288280	7/23/02	7.00	94	4.4	7.2	7.8	357	376	28.5	7.7	1.1	1.20	0.1	0.15	<.1
26	335200090094500	7/17/02	22.0	11	1.4	6.5	7.0	150	146	25.2	2.9	1.6	<.02	0.01	0.13	110
27	334303090060100	8/14/02	17.0	54	7.5	6.2	7.1	72	74	27.2	4.4	.60	.08	0.01	0.11	<.1
28	07288643	7/23/02	>39.0	37	7.7	7.4	8.1	461	444	31.4	5.4	1.0	.59	0.07	0.1	<.1
29	334030090482200	7/23/02	23.0	15	5.0	7.2	7.8	620	601	29.7	7.5	.60	.03	0.07	0.08	<.1
30	334402090395400	7/24/02	11.0	60	3.7	6.8	7.6	388	388	25.4	9.3	1.0	.96	0.08	0.11	<.1

Appendix I. Summary of surface-water quality analytical results for the winter and summer index periods -- Continued

[in, inches; NTU; nephelometric turbidity units; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter; Cl, chloride; N, nitrgen; P, phosphorus; µg/L, micrograms per liter; --, no data; >, greater than; <, less than; E, estimated]

Site number (fig. 1)	Station number	Date	Transpar-ency (in)	Turbidity (NTU)	Dissolved oxygen (mg/L)	pH, field (standard units)	pH, lab (standard units)	Specific conduct-ance, field (µS/cm)	Specific conduct-ance, lab (µS/cm)	Water tem-perature (Degrees Celsius)	Dissolved chloride (mg/L as Cl)	Total am-monia plus organic nitrogen (mg/L as N)	Dissolved nitrite plus nitrate (mg/L as N)	Dissolved ortho-phosphorus (mg/L as P)	Total phosph-orus (mg/L as P)	Chloro-phyll-a (µg/L)
31	333940090370900	7/24/02	13.0	19	3.5	7.2	7.7	435	432	26.6	11.0	.60	.62	0.13	0.15	<.1
31	333940090370900	8/6/02	>2.90	2.0	8.2	7.7	8.0	487	484	28.3	13.0	.40	<.02	0.11	0.12	<.1
32	334248090311000	7/24/02	8.00	84	4.9	7.3	7.7	262	260	28.9	4.8	1.1	.35	0.06	0.13	<.1
33	334251090181900	7/17/02	15.0	24	5.8	7.7	7.5	385	380	31.3	4.7	.90	<.02	0.14	0.13	150
34	07286200	8/14/02	12.0	60	7.2	6.3	7.1	73	74	28.2	4.3	.80	.10	0.01	0.12	<.1
35	333600090281000	7/24/02	6.00	230	5.9	7.1	7.8	465	488	26.5	34.0	3.8	4.70	0.27	0.67	<.1
36	07288500	8/6/02	6.00	110	5.4	7.5	7.8	279	280	31.1	6.1	.90	.56	0.12	0.24	<.1
37	07281610	8/14/02	9.00	120	6.6	6.8	7.2	70	72	27.9	2.5	.80	.12	0.02	0.17	<.1
38	332749090103400	7/17/02	--	12	7.8	8.2	7.8	73	72	36.2	3.7	<.20	.03	0.02	0.14	<.1
39	07288600	8/7/02	9.00	63	6.1	7.7	8.0	418	431	30.4	15.0	1.0	.30	0.08	0.21	32.0
40	07288610	8/6/02	6.00	100	7.0	7.7	8.0	311	314	32.4	9.5	1.1	.54	0.12	0.25	21.0
41	07288620	8/6/02	6.00	110	6.0	7.9	7.9	315	318	30.8	10.0	1.0	.52	0.13	0.26	<.1
42	07288621	8/6/02	6.00	100	6.0	7.5	7.9	313	311	31.4	9.6	.90	.56	0.14	0.26	<.1
43	332501090405800	8/6/02	11.0	10	4.8	7.3	7.7	503	503	28.4	24.0	.90	.92	0.12	0.17	<.1
44	07288624	8/7/02	8.00	89	5.5	7.6	7.9	324	314	31.4	9.4	.90	.58	0.14	0.25	<.1
45	331432090435300	8/7/02	6.00	96	5.5	7.7	7.9	340	348	31.5	9.3	.90	.55	0.13	0.25	<.1
46	330730090431300	8/7/02	>24.0	19	7.7	7.5	7.7	524	513	29.2	20.0	2.0	<.02	0.16	0.31	64.0
47	07287500	8/28/02	6.00	160	6.3	6.6	7.2	77	81	28.5	3.4	.50	.33	0.15	0.27	<.1
48	07288800	8/27/02	7.00	220	5.6	5.5	7.4	102	103	29.2	3.8	.80	.21	0.03	0.36	<.1
49	07288720	8/28/02	6.00	81	6.4	7.9	7.8	342	341	30.5	11.0	1.0	.20	0.03	0.25	<.1
50	322804090533900	8/27/02	13.0	39	11.2	8.1	7.9	503	490	32.8	18.0	.90	<.02	0.04	0.13	46.0

Appendix II. Quality assurance data for the winter and summer 2002 index periods and blank data for the National Water-Quality Assessment Program, 2000 to 2002

[in, inches; NTU, nephelometric turbidity units; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; Cl, chloride; N, nitrogen; P, phosphorus; µg/L, micrograms per liter; --, no data; <, less than; NAWQA, National Water Quailty Assessment Program; E, estimated]

Site number (fig.1)	Station number	Date	Turbidity (NTU)	pH, lab (standard units)	Specific conductance, lab (µS/cm)	Dissolved chloride (mg/L as Cl)	Total ammonia plus organic nitrogen (mg/L as N)	Dissolved nitrite plus nitrate (mg/L as N)	Dissolved ortho-phosphorus (mg/L as P)	Total phosphorus (mg/L as P)	Chlorophyll-a (µg/L)
Winter quality assurance sampling period											
5	07047947	04-08-02	--	7.4	113	4.7	.70	<.02	.07	.13	<.1
12	342510090183500	02-05-02	360	7.1	93	3.0	1.6	.32	.05	.42	<.1
14	07288010	02-13-02	120	7.4	234	16.0	1.9	.35	.12	.37	<.1
15	340657090080900	04-10-02	--	7.2	161	2.2	.80	<.02	.04	.20	<.1
18	335737090270100	02-25-02	130	7.3	91	1.9	1.3	.36	.09	.35	<.1
22	340120090113300	04-10-02	--	7.1	63	2.0	.80	.33	.03	.24	<.1
25	07288280	02-14-02	180	7.3	134	5.6	1.1	.38	.08	.36	<.1
28	07288643	02-14-02	230	7.3	92	1.6	1.0	.45	.08	.26	<.1
36	07288500	02-27-02	380	7.3	117	5.3	1.7	.77	.09	.36	<.1
48	07288955	04-12-02	--	7.1	72	2.63	.85	.29	.04	.29	<.1
Summer quality assurance sampling period											
5	07047947	07-31-02	2.0	7.4	276	20.0	.60	<.02	.08	.16	<.1
12	342510090183500	07-16-02	140	6.7	60	.7	1.4	.10	.07	.20	<.1
14	07288010	07-23-02	41	7.6	510	41.0	6.1	.29	.35	.48	<.1
15	340657090080900	07-16-02	140	7.2	128	6.2	1.5	.19	.06	.35	<.1
18	335737090270100	07-17-02	3.0	7.7	285	2.0	1.1	.30	.11	.13	<.1
22	340120090113300	08-13-02	56	7.1	112	3.5	.90	.11	.04	.12	<.1
25	07288280	07-23-02	--	7.8	372	7.6	1.4	1.20	.10	.16	<.1
28	07288643	07-23-02	36	8.0	450	5.4	.90	.59	.07	.10	<.1
36	07288500	08-06-02	100	7.8	278	6.2	.90	.57	.12	.24	<.1
48	07288800	08-27-02	210	7.3	101	3.8	.60	.22	.04	.31	<.1

NAWQA field blanks

Site number (fig.1)	Station number	Date	Turbidity (NTU)	Turbidity, HACH (NTU)	pH, lab (standard units)	Specific conductance, lab (µS/cm)	Dissolved chloride (mg/L as Cl)	Total ammonia plus organic nitrogen (mg/L as N)	Dissolved nitrite plus nitrate (mg/L as N)	Dissolved ortho-phosphorus (mg/L as P)	Dissolved phosphorus (mg/L as P)
--	07288650	9/05/2001	--	0.6	6.8	3	<.08	<.08	<.05	<.02	<.06
48w	07288955	3/22/2000	0.4	--	8.6	E2	<.29	<.10	<.05	<.01	<.006
48w	07288955	9/07/2001	--	0.4	7.6	3	<.08	<.08	E.03	<.02	<.06
48w	07288955	7/09/2002	--	--	--	--	--	<.10	<.05	<.02	--

Appendix III. Summary of habitat-assessment data collected during the winter and summer 2002 index periods

[no., number; MDEQ, Mississippi Department of Environmental Quality; LB, left bank; RB, right bank; AR, Arkansas; BD, biological duplicate; s, summer; MS, Mississippi; w, winter. The 10 habitat parameters were scored on a scale of 1 to 20, with 1 representing the most degraded and 20 representing the most stable habitat.]

Site no. (fig. 1)	Station number	Station name	MDEQ no.	Date	Habitat-assessment scores: Bottom substrate / available cover	Pool substrate charac-ter-ization	Pool varia-bility	Channel altera-tion	Sedi-ment deposi-tion	Channel sinuosity	Channel flow status	Bank vegetative protection		Bank stability		Riparian vegetation width		Total
												LB	RB	LB	RB	LB	RB	
1	07074700	Village Creek near Newport, AR	212	7/30/02	18	13	10	20	14	15	20	10	10	10	9	10	5	164
2	07074883	Glaise Creek at Hwy 64 near Augusta, AR	213	7/30/02	5	6	6	15	3	12	11	8	8	9	9	10	7	109
			213-BD	7/30/02	5	6	6	15	3	12	11	8	8	9	9	10	7	109
3s	07077527	Cache River near Cotton Plant, AR	210	7/31/02	7	11	13	18	11	18	20	10	10	10	10	10	10	158
			210-BD	7/31/02	7	11	13	18	11	18	20	10	10	10	10	10	10	158
4	07077720	Bayou DeView at Hwy 38 near Cotton Plant, AR	211	7/29/02	18	13	18	15	14	16	20	10	10	10	10	9	10	173
5	07047947	Second Creek near Palestine, AR	216	7/31/02	13	17	11	15	14	18	20	10	10	10	10	10	10	168
			216-BD	7/31/02	13	17	11	15	14	18	20	10	10	10	10	10	10	168
6	07077000	White River at Devalls Bluff, AR	208	1/22/02	6	6	5	12	6	7	18	1	2	2	5	9	9	88
			208-BD	1/23/02	6	7	7	10	6	7	18	1	2	3	1	9	9	86
7	07078040	Lagrue Bayou near DeWitt, AR	209	7/29/02	18	11	6	15	9	18	10	5	8	8	8	10	10	136
			209-BD	7/29/02	18	11	6	15	9	18	10	5	8	8	8	10	10	136
8	344529090115500	Unnamed Tributary to Coldwater River near Prichard, MS	317	1/31/02	2	8	2	3	0	0	13	2	2	2	2	0	0	36
				7/15/02	4	6	0	1	0	0	18	1	8	3	3	0	0	44
9	344402090230100	Unnamed Tributary to White Oak Bayou near Tunica, MS	316	1/31/02	4	11	2	3	3	2	18	2	2	5	5	0	0	57
10	342815090195500	Unnamed Tributary to Twelvemile Bayou near Tibbs, MS	315	2/1/02	3	6	2	11	17	0	9	9	9	10	10	1	1	88
				7/15/02	6	8	3	1	18	0	11	9	9	9	9	2	2	87
11	342630090142600	Yellow Lake Bayou at Sledge, MS	411	3/5/02	0	6	0	5	1	6	16	4	4	5	5	4	4	60
				7/15/02	5	6	6	3	3	7	18	7	7	9	9	6	6	92
12	342510090183500	Unnamed Tributary to White Oak Bayou near Sledge, MS	314	2/5/02	3	6	0	3	6	0	20	9	9	4	4	0	0	64
				7/16/02	2	1	0	1	20	0	7	8	8	7	7	0	0	61
13	341640090055100	Unnamed Tributary to Tal-lahatchie River near Locke Station, MS	306	2/5/02	6	6	8	16	6	10	7	5	5	6	6	6	6	93
				7/16/02	6	11	8	11	6	6	5	6	6	8	8	5	5	91

Appendix III. Summary of habitat-assessment data collected during the winter and summer 2002 index periods -- Continued

[no., number; MDEQ, Mississippi Department of Environmental Quality; LB, left bank; RB, right bank; AR, Arkansas; BD, biological duplicate; s, summer; MS, Mississippi; w, winter. The 10 habitat parameters were scored on a scale of 1 to 20, with 1 representing the most degraded and 20 representing the most stable habitat.]

Site no. (fig. 1)	Station number	Station name	MDEQ no.	Date	Habitat-assessment scores: Bottom substrate / available cover	Pool substrate charac-ter-ization	Pool varia-bility	Channel altera-tion	Sedi-ment deposi-tion	Channel sinuosity	Channel flow status	Bank vegetative protection		Bank stability		Riparian vegetation width		Total
												LB	RB	LB	RB	LB	RB	
14	07288010	Big Sunflower River at Hopson Spur, MS	28	2/13/02	3	6	2	11	1	6	3	4	4	6	6	4	4	60
				7/22/02	6	6	8	15	6	13	5	5	5	6	6	9	9	99
15	340657090080900	Unnamed Tributary to Tallahatchie River near Crowder, MS	313	7/16/02	6	9	2	1	1	0	16	7	6	6	6	2	1	63
16	335915090423900	Hushpuckena River near Hushpuckena, MS	218	2/13/02	3	9	11	11	9	9	18	3	3	6	6	8	8	104
			218-BD	2/13/02	3	9	11	11	9	9	18	3	3	6	6	8	8	104
			218	7/22/02	12	8	12	14	9	10	18	9	9	7	7	9	9	133
			218-BD	7/22/02	12	8	12	14	9	10	18	9	9	7	7	9	9	133
17	335632090291000	Bear Bayou near Minot, MS	402	2/25/02	3	6	2	15	3	15	15	5	6	6	6	7	6	95
			402-BD	2/25/02	4	6	2	15	3	15	15	5	6	6	6	7	6	96
			402	7/17/02	6	11	3	3	3	4	11	7	7	9	9	2	2	77
			402-BD	7/17/02	6	11	3	3	3	4	11	7	7	9	9	2	2	77
18	335737090270100	Quiver River near Rome, MS	305	2/25/02	6	6	6	15	3	15	5	8	9	8	7	9	9	106
				7/17/02	19	13	10	15	9	16	20	9	9	9	9	9	9	156
19	07280900	Cassidy Bayou at Webb, MS	217	8/13/02	5	6	6	15	3	4	11	5	5	9	9	0	4	82
20s	335919090133600	Opposum Bayou near Webb, MS	33	8/12/02	6	11	7	11	9	7	16	9	9	6	6	10	10	117
			33-BD	8/12/02	6	11	7	11	9	7	16	9	9	6	6	10	10	117
21	335946090121100	Tallahatchie River near Webb, MS	201	8/12/02	6	8	7	3	11	4	18	2	6	2	5	2	7	81
22	340120090113300	Tallahatchie River near Charleston, MS	200	8/13/02	7	12	6	11	11	12	18	7	7	7	7	4	7	116
23	340203090073000	Panola Quitman Floodway near Charleston, MS	202	8/13/02	5	4	0	3	20	4	20	7	7	5	5	2	5	87
24	335250090454700	Unnamed Tributary to Jones Bayou near Mound Bayou, MS	511	3/5/02	3	4	0	3	11	4	18	5	5	5	5	0	0	63
25	07288280	Big Sunflower River near Merigold, MS	54	2/14/02	3	6	2	6	3	6	16	2	2	1	1	5	7	60
				7/23/02	7	8	6	11	14	7	18	6	6	6	6	7	4	106

Appendix III. Summary of habitat-assessment data collected during the winter and summer 2002 index periods -- Continued

[no., number; MDEQ, Mississippi Department of Environmental Quality; LB, left bank; RB, right bank; AR, Arkansas; BD, biological duplicate; s, summer; MS, Mississippi; w, winter. The 10 habitat parameters were scored on a scale of 1 to 20, with 1 representing the most degraded and 20 representing the most stable habitat.]

Site no. (fig. 1)	Station number	Station name	MDEQ no.	Date	Habitat-assessment scores: Bottom substrate / available cover	Pool substrate charac-ter-ization	Pool varia-bility	Channel altera-tion	Sedi-ment deposi-tion	Channel sinuosity	Channel flow status	Bank vegetative protection LB	Bank vegetative protection RB	Bank stability LB	Bank stability RB	Riparian vegetation width LB	Riparian vegetation width RB	Total
26	335200090094500	South Lake Bayou near Tippo, MS	303	7/16/02	11	11	6	16	11	6	9	9	9	7	7	5	5	112
27s	334303090060100	Yalobusha River near Leflore, MS	203	8/14/02	12	12	7	12	18	15	18	9	9	5	5	10	10	142
28	07288643	Bogue Phalia near Shaw, MS	59	2/14/02	3	7	3	3	1	2	16	1	1	1	1	1	0	40
				7/23/02	6	11	8	3	11	4	11	6	7	6	7	7	7	94
29	334030090482200	East Bogue Hasty near Skene, MS	513	2/25/02	2	6	3	3	2	2	15	2	3	3	5	1	1	48
				7/24/02	5	6	9	3	6	4	16	6	5	7	7	1	1	76
30	334402090395400	Unnamed Tributary to Darr Bayou near Cleveland, MS	311	2/12/02	5	9	5	3	6	2	10	6	6	6	6	2	2	68
				7/24/02	6	6	3	3	6	4	13	7	7	8	8	4	3	78
31	333940090370900	Jones Bayou at Linn, MS	58	2/26/02	7	9	5	15	6	12	15	8	10	9	9	7	10	122
				8/2/02	3	6	0	5	3	4	18	5	8	5	5	3	8	73
32	334248090311000	Quiver River Southeast of Ruleville, MS	215	7/23/02	6	6	6	13	14	13	13	9	9	8	8	8	8	121
			215-BD	7/24/02	6	6	6	13	14	13	13	9	9	8	8	8	8	121
33	334251090181900	Unnamed Tributary to Tallahatchie River near Minter City, MS	310	2/20/02	1	6	0	1	12	0	20	3	3	5	5	0	0	56
				7/17/02	5	5	3	4	2	4	20	7	6	8	9	2	2	77
34	07286200	Yalobusha River at Whaley, MS	204	8/14/02	6	12	3	10	14	8	18	7	7	4	4	9	9	111
35	333600090281000	McGregory Bayou near Blaine, MS	415	2/12/02	3	6	2	3	1	0	18	4	4	3	3	1	1	49
				7/25/02	2	6	0	3	0	0	5	4	4	7	7	1	2	41
36	07288500	Big Sunflower River at Sunflower, MS	214	2/27/02	5	6	6	3	9	9	15	3	3	3	3	7	5	77
				8/5/02	12	12	7	11	11	12	13	4	5	3	4	4	8	106
37s	07281610	Tallahatchie River above Pemberton Cut near Greenwood, MS	205	8/15/02	6	6	3	5	11	6	18	6	6	6	6	9	4	92
38	332749090103400	Pelucia Creek near Rising Sun, MS	301	2/19/02	5	8	6	6	6	4	16	6	6	6	6	5	5	85
			301-BD	2/19/02	5	8	6	6	6	4	16	6	6	6	6	5	5	85
			301	7/18/02	5	7	2	3	17	0	9	5	5	7	7	6	6	79
			301-BD	7/18/02	5	7	2	3	17	0	9	5	5	7	7	6	6	79

Appendix III. Summary of habitat-assessment data collected during the winter and summer 2002 index periods -- Continued

[no., number; MDEQ, Mississippi Department of Environmental Quality; LB, left bank; RB, right bank; AR, Arkansas; BD, biological duplicate; s, summer; MS, Mississippi; w, winter. The 10 habitat parameters were scored on a scale of 1 to 20, with 1 representing the most degraded and 20 representing the most stable habitat.]

Site no. (fig. 1)	Station number	Station name	MDEQ no.	Date	Bottom substrate / available cover	Pool substrate charac-ter-ization	Pool varia-bility	Channel altera-tion	Sedi-ment deposi-tion	Channel sinuosity	Channel flow status	Bank vegetative protection LB	Bank vegetative protection RB	Bank stability LB	Bank stability RB	Riparian vegetation width LB	Riparian vegetation width RB	Total
39	07288600	Quiver River near Moorhead, MS	69	8/6/02	5	6	6	16	11	13	13	5	5	6	6	7	7	106
40w	07288530	Big Sunflower River above Quiver River near Indianola, MS	67	2/28/02	5	6	6	15	12	9	16	2	2	2	2	7	7	91
40s	07288610	Big Sunflower River near Moore-head, MS		8/6/02	6	6	7	11	11	13	13	6	6	5	5	4	3	96
41	07288620	Big Sunflower River at Baird, MS	66	3/7/02	5	11	7	13	11	11	18	6	6	5	4	6	6	109
				8/6/02	5	6	7	16	3	10	15	9	9	7	7	6	6	106
42	07288621	Big Sunflower River at Indianola, MS	71	3/7/02	7	11	7	15	3	11	20	7	7	5	5	9	8	115
				8/6/02	7	9	3	16	6	10	15	7	8	7	7	9	9	113
43	332501090405800	Sheperds Bayou near Indianola, MS	300	2/15/02	3	8	8	3	3	0	10	3	3	4	4	1	2	52
				8/5/02	5	8	3	3	9	0	11	8	8	5	8	2	2	72
44	07288624	Big Sunflower River at Kinlock, MS	85	3/8/02	3	6	7	11	6	7	18	7	3	8	7	9	7	99
				8/7/02	6	6	6	3	3	11	15	9	9	6	6	7	7	94
45	331432090435300	Big Sunflower River below Bogue Phalia near Darlove, MS	87	3/8/02	3	11	7	11	11	7	18	3	4	4	3	7	7	96
			87-BD	3/8/02	3	6	7	11	6	7	19	7	7	7	7	10	6	103
			87	8/7/02	7	6	9	3	6	11	15	8	8	6	6	5	5	95
			87-BD	8/7/02	7	6	9	3	6	11	15	8	8	6	6	5	5	95
46	330730090431300	Murphy Bayou at Murphy, MS	506	2/28/02	6	11	8	10	11	2	15	4	4	6	6	2	2	87
				8/7/02	6	11	2	8	11	0	11	8	8	7	7	0	0	79
47	07287500	Yazoo River at Yazoo City, MS	206	8/28/02	5	8	7	11	14	11	7	7	7	7	7	9	7	107
48s	07288800	Yazoo River at Redwood, MS	207	8/27/02	5	6	8	6	3	7	13	6	6	7	7	9	9	92
49	07288720	Big Sunflower River at Holly Bluff, MS	106	8/28/02	6	6	7	16	6	12	11	9	9	6	6	9	9	112
50	322804090533900	Steele Bayou above Little Sun-flower Connect Channel, MS	110	8/27/02	7	6	3	6	3	4	13	8	8	7	7	9	9	90

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