ERDC/EL TR-02-34

US Army Corps
of Engineers®
Engineer Research and
Development Center

# Effects of Channel Modification and Flow Augmentation on Freshwater Mussels in the Bayou Meto Area, Arkansas

Andrew C. Miller and Barry S. Payne

September 2002

Environmental Laboratory

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

PRINTED ON RECYCLED PAPER

ERDC/EL TR-02-34
September 2002

# Effects of Channel Modification and Flow Augmentation on Freshwater Mussels in the Bayou Meto Area, Arkansas

by Andrew C. Miller, Barry S. Payne

Environmental Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report



Prepared for U.S. Army Engineer District, Memphis
167 North Main St., Memphis, TN 38103-1894

# Contents

## List of Figures

## List of Tables

# Preface

The U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, conducted these studies in 2001 for the U.S. Army Engineer District, Memphis. The purpose of these studies was to assess impacts to the mussel fauna of dredging, clearing, snagging, channel enlargement, and flow augmentation in the Bayou Meto area (including Bayou Meto, Bayou Two Prairie, Crooked Creek, Indian Bayou, Salt Bayou Ditch, Wabbaseka Bayou, and associated miscellaneous ditches) near Stuttgart, AR. The field crew from ERDC consisted of Dr. Andrew C. Miller, Dr. Barry S. Payne, Mr. Will Green, and Ms. Kathryn Barko. A four-person crew from Mainstream Commercial Divers, Paducah, KY, collected mussels at some of the sites. Mr. Mark R. Smith, Memphis District, supplied maps and background information on the project area. Authors of this report were Drs. Miller and Payne.

During the conduct of this study, Dr. Edwin A. Theriot was Director, Environmental Laboratory (EL), ERDC; Dr. David J. Tazik was Chief, Ecosystem Evaluation and Engineering Division, EL, ERDC; and Dr. Al Cofrancesco was Chief of the Aquatic Ecology and Invasive Species Branch, EL.

Commander and Executive Director of ERDC during publication of this report was COL John W. Morris III, EN. Director was Dr. James R. Houston.

This report should be cited as follows:

> Miller, A. C., and Payne, B. S. (2002). "Effects of channel modification and flow augmentation on freshwater mussels in the Bayou Meto Area, Arkansas," ERDC/EL TR-02-34, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

# 1 Introduction

## Background

Bayou Meto and its tributaries encompass over 700,000 acres (283,280 ha) in Arkansas, Jefferson, Lonoke, and Prairie Counties, central Arkansas. Within the basin, there are over 640 miles (1,030 km) of streams and bayous adjacent to agricultural land and bottomland hardwood forests. The U.S. Army Engineer Districts, Vicksburg, and Memphis, are evaluating water supply, ecosystem restoration, and flood control in the Bayou Meto Basin.

There is a need to increase the quantity of water in streams and bayous in the watershed. Water supply could be augmented with flow from the Arkansas River, immediately upstream of David D. Terry Lock and Dam. Water could then be carried via a system of streams, canals, and pipelines to the surrounding delta. Maximum diversion from the Arkansas River would range from 2,000 to 2,500 cfs (57 to 71 cms). Water would be used for agricultural irrigation, commercial withdrawal, and waterfowl management.

In addition, a flood-control project is proposed for the lower reaches of Bayou Meto. Flood-control alternatives will be developed for the outlet of Bayou Meto that currently has a gravity structure that empties into the Arkansas River. To reduce the sump area, an alternative gravity outlet and pumping station will be considered. In addition, channel modifications (selective clearing and snagging and channel excavation) are being evaluated to reduce flood duration in the lower reaches of Bayou Meto, Little Bayou Meto, Wabbaseka Bayou, Indian Bayou, Salt Bayou, and Crooked Creek.

As required by the National Environmental Policy Act and the Endangered Species Act of 1972, as amended, the U.S. Army Corps of Engineers must evaluate the environmental effects of these actions on freshwater mussels (Family: Unionidae). Freshwater mussels are an important component of the ecosystem; they stabilize benthic substrates, filter organic matter out of the water column, and provide food for certain species of fishes, mammals, and waterfowl. While their shells were once used to make buttons, now certain thick-shelled species are used for culturing pearls.

With respect to the native freshwater mussels, there are several environmental concerns associated with this project. First, District personnel

want to ensure that proposed channel modifications do not damage mussels or their habitat. Second, there is concern that the nonindigenous zebra mussel (*Dreissena polymorpha*) could be accidentally introduced into the project area and, therefore, negatively affect the native mussels.

Currently, there are no zebra mussels in the project area, although there are high-density populations in the Arkansas River. There are commercial shelling operations for the cultured pearl business near the project area. In addition, the project area is within the range of two endangered species of mussels, the pink pearly mucket (*Lampsilis abrupta*) and the fat pocketbook (*Potamilus capax*).

## Study Area

The Bayou Meto Drainage is in central Arkansas, southeast of Little Rock. Mussel collections were made at the site of the pumping plant on the Arkansas River (Figure 1), at a series of streams associated with Bayou Meto proper west of Stuttgart (Figure 2), in Indian Bayou east of England (Figure 3), in Salt Bayou Ditch west of Wabbaseka (Figure 4), and in Wabbaseka Bayou (Figure 5).

## Methods

Two to four individuals working simultaneously collected mussels by hand via timed searches. Since visibility was low, this had to be done principally by feel. Collectors were instructed to search the top few centimeters of substratum and retrieve all live mussels that were encountered. Dead mussels and live *Corbicula fluminea* were excluded. Qualitative sampling is useful for obtaining species composition, including presence/absence of endangered or very uncommon species. Typically it can be biased toward the larger, easier-to-find species, although every effort is made to avoid this. However, it should be noted this bias will be reduced in fine-grained sediments that characterize the study area. The amount of time expended searching was recorded and results are expressed as mussels collected per minute, or catch per unit effort (CPUE). More information on sampling methods can be found in Miller et al. (1993).

Quantitative samples were taken at Waypoint 6 (the Prison Farm site) on Indian Bayou using a 0.25-sq-m quadrat (50 cm on a side), constructed of 0.6- by 100-mm aluminum stock. Quantitative samples were taken specifically to provide estimates of density as well as unbiased estimates of recent recruitment. Quadrats were placed haphazardly on the substratum and then all sand, silt, mud, gravel, live mussels, and shells was removed and placed into a 20-L bucket. Sediments were screened, live mussels were identified, and total shell length was measured. Bivalve nomenclature followed Williams et al. (1993).

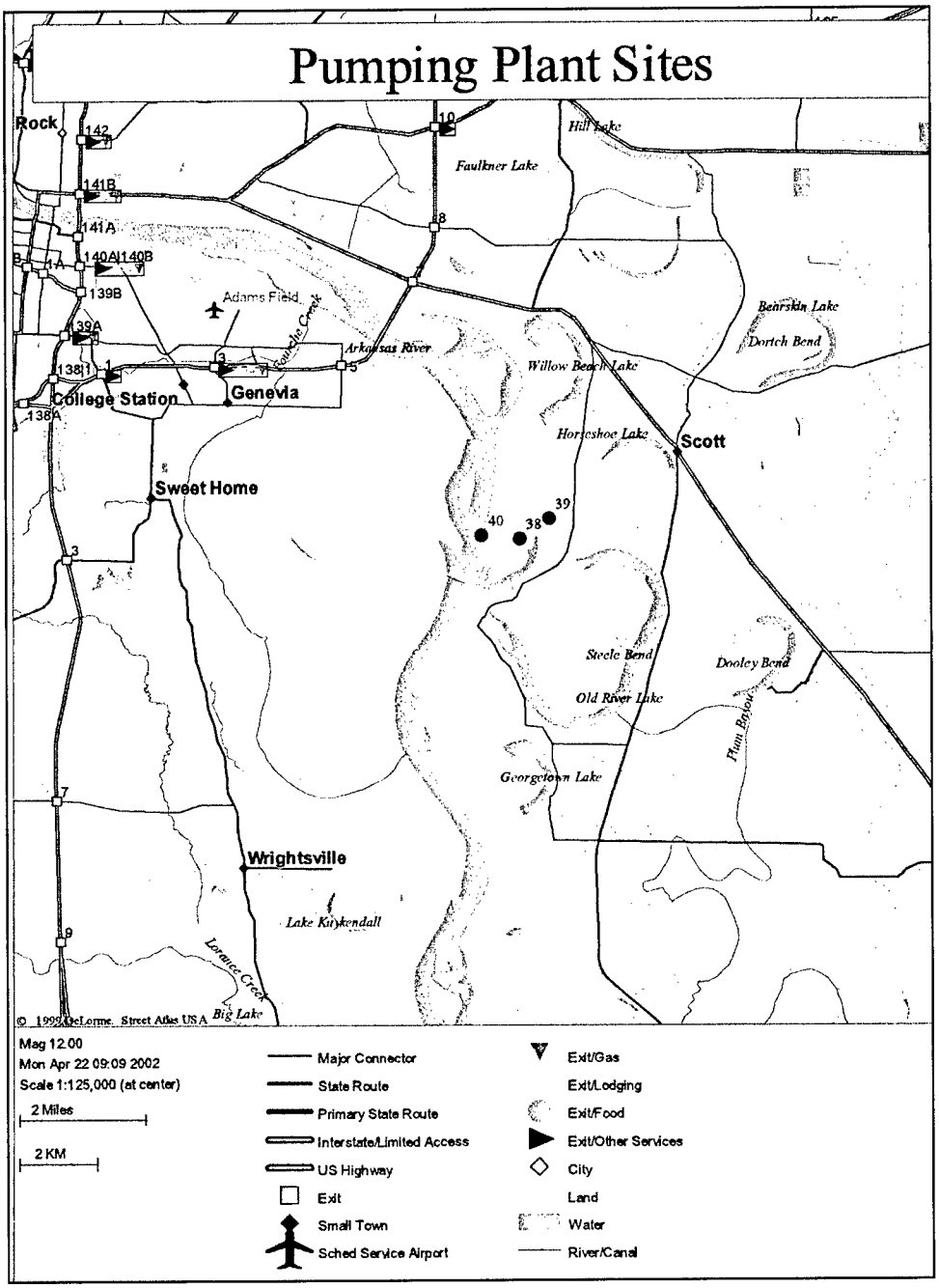


Figure 1. Study sites (38, 39, 40) near the proposed intake plant on the Arkansas River

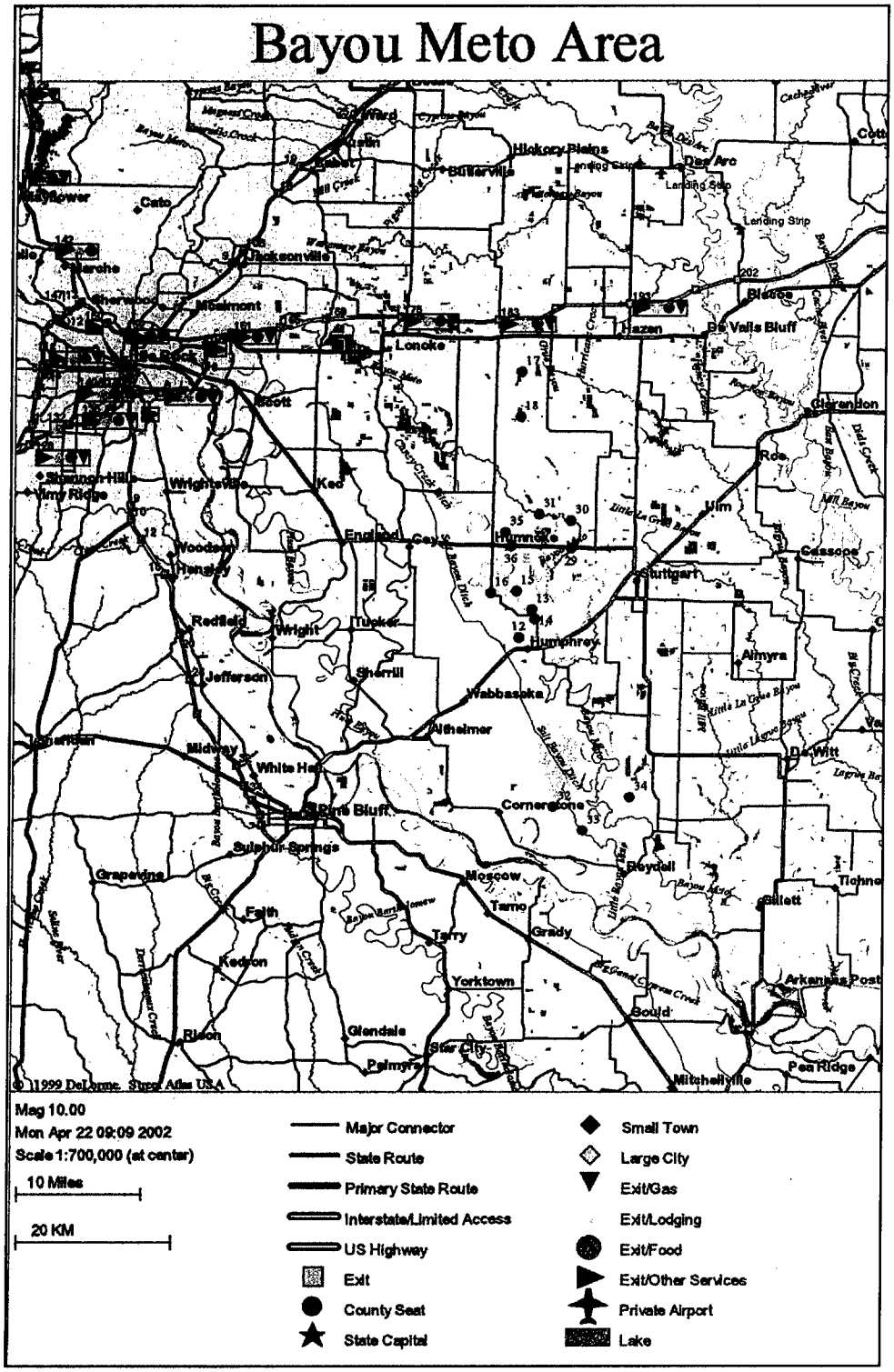


Figure 2. Study sites in the Bayou Meto area, including Bayou Two Prairie, Bayou Meto, Crooked Creek, and other adjacent streams

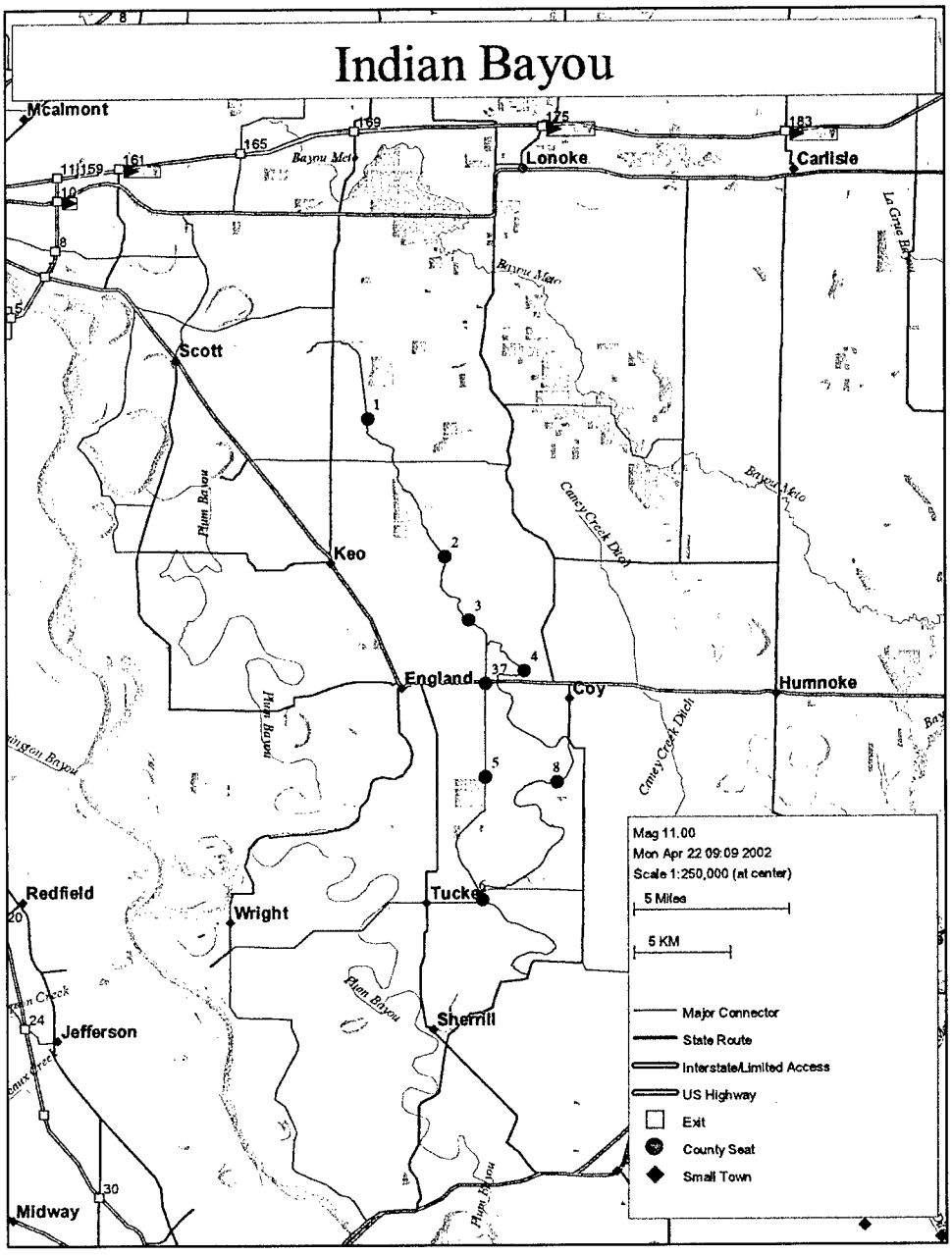


Figure 3. Sample sites on Indian Bayou and Indian Bayou Ditch

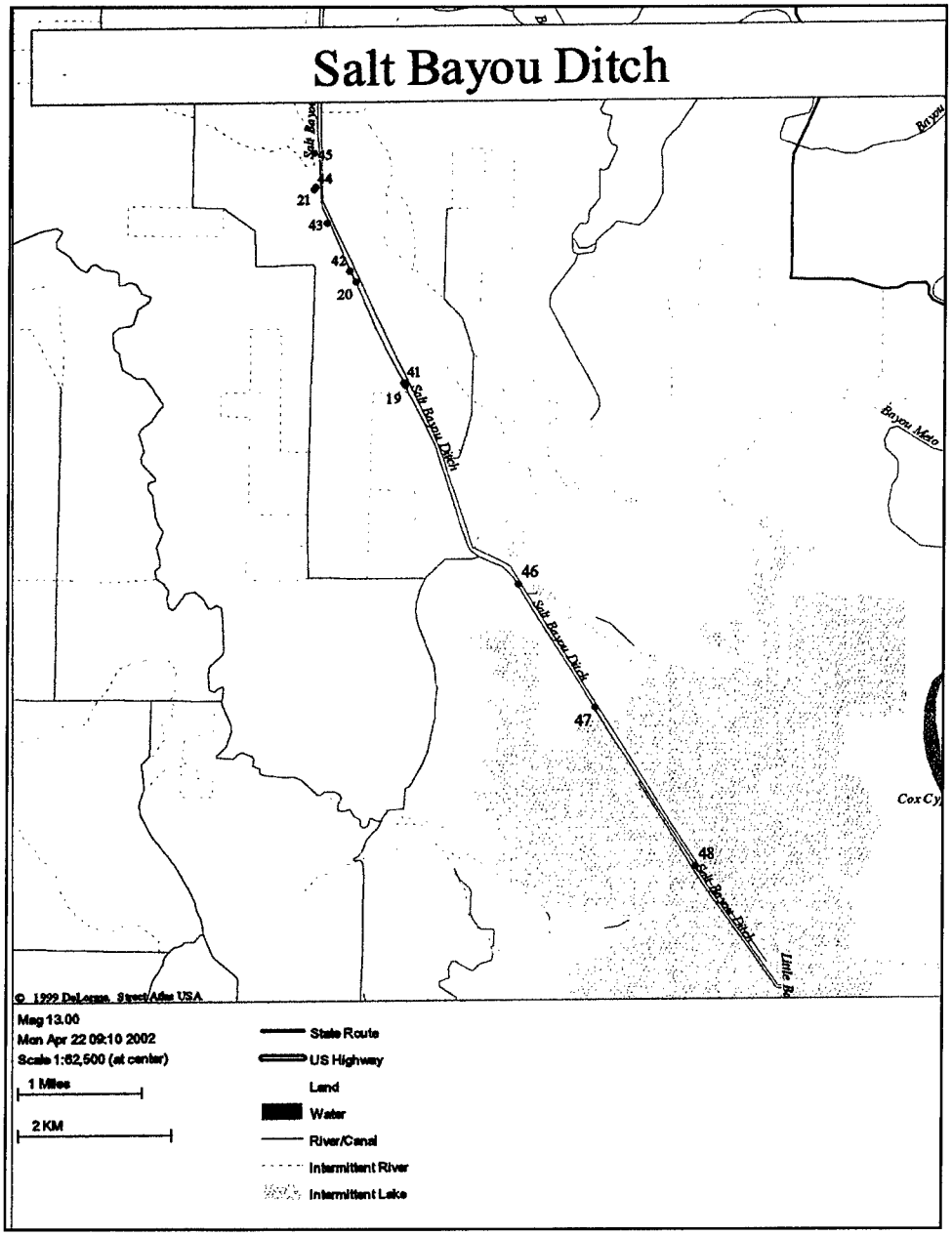


Figure 4. Sample sites along Salt Bayou Ditch

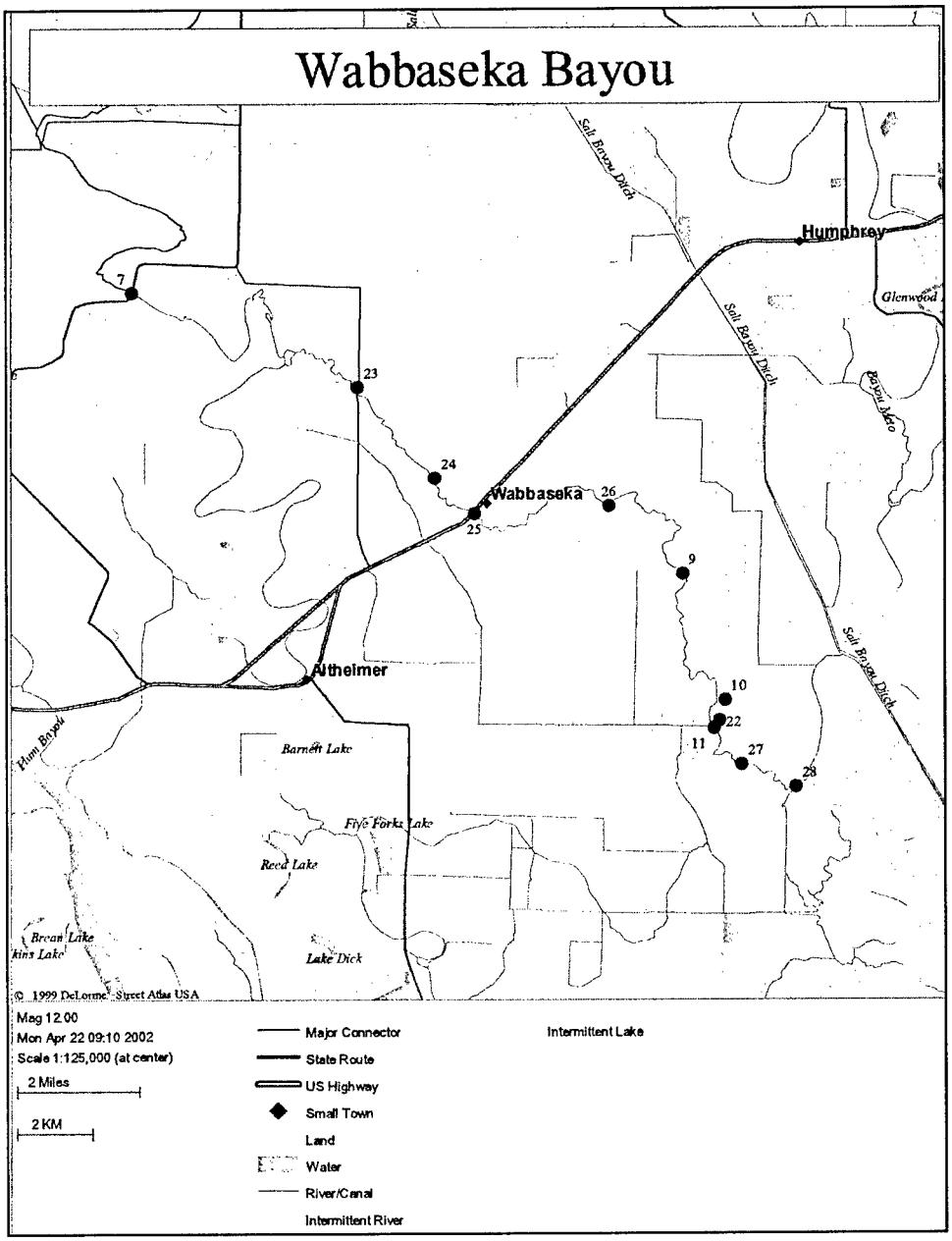


Figure 5. Sample sites along Wabbaseka Bayou

After collecting, live mussels were kept cool and moist. When work was completed, mussels were returned to the water unharmed, as close to the location where they were collected as possible. All quantitative and qualitative collections in Indian Bayou were obtained without diving since the water was less than 1 m deep.

A global positioning system (GPS) was used to mark each site where either qualitative or quantitative samples were obtained. All tables and figures are keyed to the waypoints collected with the GPS (Table 1).

**Table 1**
**Sample Sites in the Bayou Meto Drainage, 2001**

| Waypoint | Longitude (E) | Latitude (N) | Location |
|---|---|---|---|
| 38 | 92.140006 | 34.677084 | Arkansas River Pump Point |
| 39 | 92.131927 | 34.681596 | Arkansas River Pump Point |
| 40 | 92.150638 | 34.677824 | Arkansas River Pump Point |
| 17 | 91.717311 | 34.740164 | Bayou Two Prairie |
| 18 | 91.718390 | 34.688156 | Bayou Two Prairie |
| 29 | 91.646292 | 34.538022 | Bayou Meto |
| 30 | 91.647043 | 34.569018 | Bayou Meto |
| 31 | 91.691991 | 34.576646 | Bayou Meto |
| 32 | 91.669407 | 34.237593 | Long Pond Access |
| 33 | 91.627613 | 34.209414 | Bayou Meto Control Structure |
| 34 | 91.561545 | 34.248843 | Pond |
| 35 | 91.739016 | 34.556036 | Bayou Meto |
| 36 | 91.730325 | 34.540270 | Bayou Meto |
| 12 | 91.718781 | 34.435728 | Crooked Creek |
| 13 | 91.700547 | 34.467378 | Crooked Creek |
| 14 | 91.697168 | 34.456902 | Crooked Creek |
| 15 | 91.722863 | 34.488621 | Crooked Creek |
| 16 | 91.758751 | 34.486604 | Crooked Creek |
| 1 | 91.987705 | 34.669059 | Indian Bayou Ditch |
| 2 | 91.944248 | 34.605458 | Indian Bayou Ditch |
| 3 | 91.930751 | 34.576083 | Indian Bayou Ditch |
| 4 | 91.899642 | 34.552013 | Indian Bayou |
| 5 | 91.921572 | 34.502633 | Indian Bayou Ditch |
| 6 | 91.923568 | 34.445867 | Indian Bayou Ditch |
| 8 | 91.881108 | 34.500348 | Indian Bayou |
| 37 | 91.921386 | 34.546162 | Indian Bayou Ditch |
| 19 | 91.704211 | 34.344597 | Salt Bayou Ditch: Boat Ramp |
| 20 | 91.711233 | 34.356850 | Salt Bayou Ditch |
| 21 | 91.716882 | 34.368061 | Salt Bayou Ditch |
| 41 | 91.704442 | 34.344935 | Salt Bayou Ditch |
| 42 | 91.712097 | 34.358073 | Salt Bayou Ditch |
| 43 | 91.715300 | 34.363791 | Salt Bayou Ditch |
| 44 | 91.717134 | 34.367782 | Salt Bayou Ditch |
| 45 | 91.717091 | 34.372026 | Salt Bayou Ditch |
| 46 | 91.688238 | 34.321621 | Salt Bayou Ditch |
| 47 | 91.677439 | 34.307168 | Salt Bayou Ditch |
| 48 | 91.663252 | 34.288352 | Salt Bayou Ditch |
| 7 | 91.897733 | 34.410617 | Wabbaseka Bayou |
| 9 | 91.739772 | 34.344260 | Wabbaseka Bayou |
| 10 | 91.729703 | 34.314026 | Wabbaseka Bayou |
| 11 | 91.730830 | 34.307840 | Wabbaseka Bayou |
| 22 | 91.729204 | 34.309648 | Wabbaseka Bayou |
| 23 | 91.833027 | 34.388258 | Wabbaseka Bayou |
| 24 | 91.810915 | 34.366854 | Wabbaseka Bayou |
| 25 | 91.799478 | 34.358481 | Wabbaseka Bayou |
| 26 | 91.760978 | 34.360326 | Wabbaseka Bayou |
| 27 | 91.722890 | 34.299268 | Wabbaseka Bayou |
| 28 | 91.707387 | 34.293909 | Wabbaseka Bayou |

# 2 Results

## Pumping Plant Sites

Water for the Bayou Meto project will be taken from the Arkansas River southwest of Scott, AR (Figure 1). Divers searched the intake area in the Arkansas River for 30 min and found no live native mussels. However, there were zebra mussels attached to rocks, shells, and submersed woody vegetation. Zebra mussel densities at the point of the intake structure were estimated at 150 individuals/$m^2$.

A total of 15 min were also expended searching for mussels at sites about 1 to 2 km from the river that will be modified to handle increased discharge (Waypoints 38 and 39, Figure 1). Water will be taken from the river and then sent through a man-made canal system to streams in the area. Two *Pyganodon grandis* were collected at Waypoint 38, and no live mussels were found at Waypoint 39.

## Bayou Meto Area

The Bayou Meto Area included Bayou Two Prairie, Crooked Creek, and portions of Bayou Meto proper (Figure 2). A total of 170 min were expended searching for mussels at 15 sites (Tables 1 and 2), and no live mussels were found. None of these sites had firm substratum or adequate flow necessary to support freshwater mussel assemblages. The following paragraphs provide a detailed description of the study sites.

### Bayou Two Prairie, Waypoint 17

The channel at this site was approximately 10 m wide and in a naturally meandering reach. Depth was approximately 0.7 m. The mud bottom was firmer than in most sites in the bayous and creeks of the project area. Large woody debris was abundant – both immersed and submersed. Canopy cover was approximately 60 percent. Although there was no flow, the nature of the substratum suggested occasional flushing flows. A single large *P. grandis* shell

**Table 2**
**Percent Abundance of Mussel Species Collected in Different Sections of the Bayou Meto Drainage, 2001**

| Species | Indian Bayou | Bayou Meto Area | Wabbaseka Bayou | Salt Bayou Ditch | Total |
|---|---|---|---|---|---|
| *A. plicata* | 59.19 | 0.00 | 8.33 | 77.04 | 60.89 |
| *Q. quadrula* | 24.97 | 0.00 | 8.33 | 10.37 | 22.92 |
| *Q. pustulosa* | 3.41 | 0.00 | 8.33 | 0.74 | 3.13 |
| *U. declivus* | 3.30 | 0.00 | 16.67 | 0.00 | 3.03 |
| *L. teres* | 2.64 | 0.00 | 0.00 | 0.00 | 2.27 |
| *A. confragosus* | 1.65 | 0.00 | 8.33 | 2.22 | 1.80 |
| *T. parvus* | 1.21 | 0.00 | 0.00 | 0.00 | 1.04 |
| *P. purpuratus* | 0.66 | 0.00 | 8.33 | 2.22 | 0.95 |
| *Q. apiculata* | 0.77 | 0.00 | 0.00 | 0.74 | 0.76 |
| *L. fragilis* | 0.55 | 0.00 | 16.67 | 0.00 | 0.66 |
| *M. nervosa* | 0.11 | 0.00 | 0.00 | 3.70 | 0.57 |
| *L. recta* | 0.55 | 0.00 | 0.00 | 0.00 | 0.47 |
| *F. flava* | 0.44 | 0.00 | 0.00 | 0.00 | 0.38 |
| *P. grandis* | 0.11 | 0.00 | 16.67 | 0.00 | 0.28 |
| *T. verrucosa* | 0.00 | 0.00 | 0.00 | 2.22 | 0.28 |
| *L. subrostrata* | 0.22 | 0.00 | 0.00 | 0.00 | 0.19 |
| *P. ohiensis* | 0.00 | 0.00 | 0.00 | 0.74 | 0.09 |
| *A. suborbiculata* | 0.00 | 0.00 | 8.33 | 0.00 | 0.09 |
| Total individuals | 909 | 0 | 12 | 135 | 1056 |
| Total species | 15 | 0 | 9 | 9 | 18 |
| Total time | 566 | 170 | 207 | 188.5 | 1131.5 |
| CPUE | 1.61 | 0.00 | 0.06 | 0.72 | 0.93 |
| No. of sites | 8 | 15 | 11 | 11 | 45 |

was found on the shore, but a 20-min search yielded no mussels and no other shells.

### Bayou Two Prairie, Waypoint 18

This site was just south of a catfish farm complex of ponds. Channel dimensions were similar to site Waypoint 17, but the bottom substratum was softer. Large woody debris and other debris (many old tires and other trash) clogged the channel. No shells were evident along the shore, and a 10-min search yielded no mussels or shells.

### Bayou Meto, Waypoint 31

This site was located north of the 165 Bridge (Figure 2). Water was shallow and less than 25 cm deep in most places. Canopy coverage was less than 15 percent. There was no flow, and the majority of the 30- to 50-m-wide channel was choked with sediment, aquatic plants, and woody vegetation. A total of 10 min of searching yielded no live mussels.

### Bayou Meto, Waypoint 30

This site was located off a wooden bridge located 1 to 2 miles (1.6 to 3.2 km) north of Highway 165 (Figure 2). At this site the water was 1 to 2 m deep with little or no flow. There were a few logs and woody debris in the water. No live mussels were found, although shells of *Toxolasma parva, Ligumia subrostrata,* and *Uniomerus tetralasma* were collected. These three species are all tolerant of organic debris, low flow, and sand/silt substratum. A total of 10 min was expended searching at this site.

### Bayou Meto, Waypoint 29

This site was located just off the Highway 165 bridge west of Stuttgart, AR (Figure 2). A total of 10 min of searching yielded no live mussels and only a single dead *A. plicata* shell. Canopy coverage was 10 to 15 percent at this location, and flow was at or near zero. Considerable organic matter, consisting of twigs and leaves, covered the mud and silt substratum. A total of 10 min was spent searching at this site.

### Crooked Creek Ditch, Waypoint 35

The ditch at this site was 1 to 2 m wide, had approximately 0 to 10 cm of water, and was choked with emergent vegetation. This was not suitably aquatic for mussels. A total of 30 min was spent searching at this site.

### Crooked Creek Ditch, Waypoint 36

This site was located immediately south of the Highway 165 crossing over the straight ditch through a buried culvert. The highway partially impounds the ditch, making it wider and deeper on the south than north side of the highway. The channel on the south side was approximately 12 m wide and 0.7 m deep. The substratum was muck with much moderate-to-small submersed woody debris. Canopy coverage was less than 5 percent. There was no perceivable flow. Hydrogen sulfide smell was moderately strong when the bottom was disturbed. A 20-min search yielded no mussels or shells. No shells were evident on the ditch banks.

### Crooked Creek Ditch, Waypoint 15

The channel was a wet ditch with only isolated, very shallow, and stagnant small pools choked with large woody debris. Habitat was not suitable for mussels and no collecting was done.

### Crooked Creek Ditch, Waypoint 16

This location was virtually identical to the Waypoint 15. No collecting was done at this site.

### Crooked Creek, Waypoint 12

This site was located slightly northwest of the town of Humphrey, AR. The creek in this reach is a meandering slough with cypress trees in and along its course. There was no perceptible flow. At this location, the channel was at least 60 m wide but less than 0.7 m deep. Substratum was mud with a large amount of detritus (mostly cypress needles, other leaves, and twiggy debris). The bottom smelled of hydrogen sulfide when disturbed. A total of 40 min was expended searching at this location.

### Crooked Creek, Waypoints 13 and 14

The creek at these locations was virtually identical in basic characteristics to those at Waypoint 12. This reach of the creek north of Humphrey is part of the same meandering reach as Waypoint 12. A 5-min search at each location by two waders (10 min total at each site) confirmed that the substratum was the same as at Waypoint 12; no mussels were found and no shells were observed.

### Miscellaneous sites south of Humphrey – Waypoints 32, 33, and 34

No mussels or suitable habitat for mussels were found at these sites (Figure 2). All sites had shallow water, much woody debris, and lacked suitable substratum and current velocity to support mussel assemblages. No sampling was done at these sites.

## Indian Bayou and Indian Bayou Ditch

Indian Bayou and Indian Bayou Ditch (Figure 3) flow due south between England and Coy, AR. These water bodies join Wabbaseka Bayou southeast of Altheimer, AR. Wabbaseka Creek joins Little Bayou Meto, which then enters the Arkansas River near Reydell, AR. The channel of the upper section of Indian Bayou has been dredged; hence, Waypoints 1, 2, and 3 are actually in Indian Bayou Ditch (Table 1). The unmodified section south of Coy is referred to as Indian Bayou (Waypoints 4 and 8). The straight reach that starts just north of

Highway 165 carries most of the flow of Indian Bayou (to the east) and is referred to as Indian Bayou Ditch (Waypoints 37, 5, and 6). Live mussels were found at five of the eight sites surveyed in this area.

### Indian Bayou Ditch, Waypoint 1

This site was in the upper reach of Indian Bayou Ditch. Access was at a bridge crossing along Chaney Road east of Highway 15. The survey was conducted within a reach approximately 150 m upstream of the bridge. At this location the channel was straight with old dredged material clearly forming the mounded left descending bank. Stream width was approximately 5 m; depth was less than 0.4 m and usually less than 0.25 m. Old *C. fluminea* and unionid shell material was abundant, suggesting that live mussels were also present.

Water velocity was approximately 10 to 15 cm/sec in the stream that flows in a southerly direction. Substratum was soft clay/mud with much filamentous green algae attached to old shell and small woody debris that littered the bottom. *Corbicula fluminea* were abundant here – both live individuals and empty shells. Dead *C. fluminea* shell comprised a substantial portion of the substratum, helping to armor the soft bottom. Live native mussels collected in a 25-min search by two individuals included *Amblema plicata* (n = 8), *Leptodea fragilis* (1), *Lampsilis teres* (2), *Quadrula quadrula* (a 30-mm-long recent recruit), *Ligumia subrostrata* (2), and *Ligumia recta* (1). Other species observed as dead shells included *Uniomerus tetralasmus*, *U. declivus*, and *Fusconaia flava*.

### Indian Bayou Ditch, Waypoint 2

Access to this site was from a bridge crossing along C. Jeans Road. The channel was approximately 20 m wide; water depth was approximately 0.7 m. The channel follows a slightly winding and more natural-looking course than in the very straight reach sampled at Waypoint 1. However, flow at Waypoint 2 was only barely perceivable. Substratum was very deep and soft mud that smelled strongly of hydrogen sulfide when disturbed. Submersed large woody debris was abundant. Some discarded debris was also present. The potential for this site to support unionids was very low.

Two waders each searched for 20 min. The only live mussel found was a large *Leptodea fragilis*. *Corbicula fluminea* were not present, perhaps indicating low dissolved oxygen conditions that presumably are common at this site. Only a few dead shells were found, including large *L. fragilis*, *A. plicata*, and *Pyganodon grandis*. All were old shells, deeply submersed in the mud, and stained black by reducing conditions.

### Indian Bayou Ditch, Waypoint 3

This site was slightly west of Jabb, AR, and had essentially the same characteristics as Waypoint 2 except for being more choked with discarded

debris and very abundant submersed and immersed large woody debris. A 5-min search by two waders yielded no mussels or shells; no shells were observed along the banks.

### Indian Bayou, Waypoint 4

This site was near the 135-deg bend that the bayou makes just north of Highway 165. Two waders conducted a 10-min search where the ditch turned west toward the town of England. The bayou at this location is a very stagnant cypress slough – a shallow pond without flow that supported many cypress trees in the water and along the shores. Indian Bayou Ditch diverts stream flow due south at a point not too far upstream of this location, and greatly reduces flushing of Indian Bayou in its natural course just east of Indian Bayou Ditch.

Substratum consisted of 15-cm-thick flocculent material covering hard mud. Hydrogen sulfide smell was strong when the mud was disturbed. No shells or live mussels were found.

### Indian Bayou Ditch, Waypoint 37

This site was at the Highway 165 crossing over the ditch, just east of the town of England, AR. A pooled area caused by a small logjam was located upstream of the highway bridge. There was a riffle just downstream of the logjam and under the bridge for a considerable distance farther downstream. The pool and riffle were searched for a total of 70 min. Substratum in the pool was a soft mud probably too flocculent to support many mussels. Depth of the pool was only 60 to 90 cm. The pool yielded few live mussels.

Water in the riffle was about 30 cm deep. Water velocities in the swifter braids in the riffle were approximately 20 cms. Substratum was soft mud, with sand, buckshot clay, and some gravel and cobble. The coarsest particles were probably associated with bridge construction and road maintenance. More than 100 mussels representing 10 species were obtained in 70 min in the pool and riffle. *Amblema plicata* and *Q. quadrula* shared dominance. Both populations showed ample evidence of occasional recruitment. *Corbicula fluminea* was also present in moderate abundance. Unionid density ranged from approximately 1 to 5 individuals/sq m.

### Indian Bayou Ditch, Waypoint 5

This site was in the perfectly straight portion that originates just north of Highway 165 east of England and continues south for several kilometers. The site at Waypoint 5 was at a bridge crossing along Tar Bottom Road. The area survey was slightly downstream of the bridge. Riparian trees were not present at this location.

The channel here was approximately 8 m wide. Substratum and flow were similar to that described for Waypoint 1. Namely, substratum was soft clay/mud with much filamentous green algae attached to old shell and small woody debris that littered the bottom. *Corbicula fluminea* were abundant here – both live individuals and empty shells. Dead *C. fluminea* shell comprised a substantial portion of the substratum, helping to armor the soft bottom. Uniformly large *A. plicata* comprised nearly all of the live mussel assemblage; the modal length was approximately 100 mm. *Amblema plicata* were moderately dense (approximately 5 to 10 individuals per square meter). A total of 28 *A. plicata* were recovered in an 18-min search by each of two waders. In addition, five *U. declivus* were obtained live as well as a single *Arcidens confragosus*.

### Indian Bayou, Waypoint 8

This site was in the long and winding portion of the bayou upriver of its confluence with Indian Bayou Ditch near the Tucker Prison Farm. The bayou throughout this reach (from just north of 165 to the Prison Farm area) was a stagnant shallow series of swamps and sloughs. There was no perceivable flow. A 10-min search by each of two waders yielded no live mussels or shells.

### Indian Bayou, Waypoint 6

This site was at the bridge crossing of the entry into Tucker State Prison Farm and was located slightly downstream of where Indian Bayou Ditch joins again with Indian Bayou. The most dense and species-rich mussel assemblage encountered in the project area was at this location.

The channel was approximately 15 m wide and very shallow (less than 30 cm deep at the deepest points and typically less than 0.1 m deep). An abundance of large dead shells of native mussels and *C. fluminea* suggested the presence of live mussels as well as the likelihood of mortality associated with stranding of mussels during extremely low water. Both banks were closely mowed all the way to the shoreline, and no trees were present for hundreds of meters in any direction (Figure 6). Despite the lack of any canopy, water was cool. Water velocity was approximately 35 cms. Substratum was shell material mixed with soft mud.

A 15-min search by each of two waders yielded at total of 57 native mussels. *Amblema plicata* (n = 26) and *Q. quadrula* (25) were both abundant. Three *Q. pustulosa* were obtained as were one each of *A. confragosus*, *Megalonaias nervosa* (a relatively young specimen although not a recent recruit), and *Potamilus purpuratus*. Considerable variation in size of individuals comprising the two dominant populations suggested moderately good recruitment. Eight *Q. quadrula* measured less than 60 mm long, with the smallest individuals

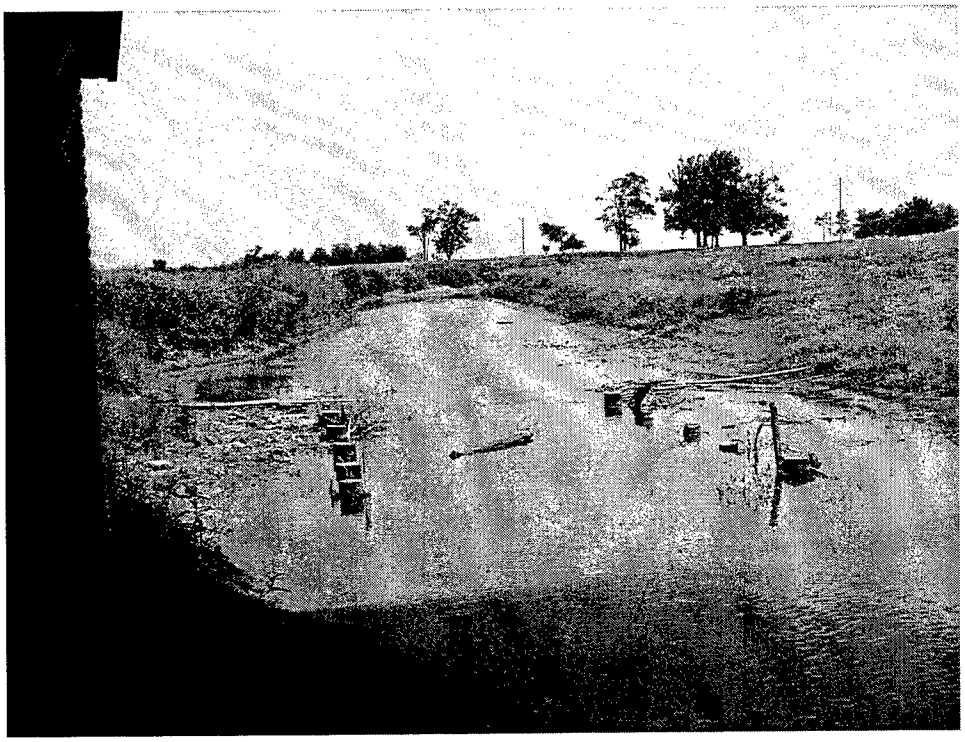

Figure 6. Indian Creek at Tucker (Waypoint 6)

measuring only 30 mm. Four *A. plicata* measured less than 70 mm long; the smallest of these was 61 mm.

Additional studies were done at this location because of the large number of mussels and species present (Tables 2 and 3). Ultimately, 300 min were spent searching for mussels at this site; 11 native species and over 700 live individuals were collected. The fauna was dominated by *Q. quadrula* and *A. plicata*; the remaining species each comprised less than approximately 4 percent of the assemblage. The CPUE was 2.5, which was greater than for any other site on Indian Bayou or Indian Bayou Ditch.

Mean density of native mussels was 14.7 individuals/$m^2$, and mean density of *C. fluminea* was more than 10 times greater, 168 individuals/$m^2$ (Table 4). Eight species were taken in the quantitative collections, more than 80 percent consisted of two common species, *Q. quadrula* and *A. plicata.*

## Summary of conditions in Indian Bayou and Indian Bayou Ditch

More than 500 min were spent searching Indian Bayou and Indian Bayou Ditch (Table 2). Slightly more than 900 mussels were collected, and 15 species were identified. No mussels were taken at Waypoints 2, 3, and 8, and comparatively few individuals were collected at Waypoints 1, 2, and 5 (Table 3). The best locations for mussels were at the Prison Farm near Tucker (Waypoint 6) and at Waypoint 37 located at Highway 165.

**Table 3**
**Percent Abundance of Mussel Species Collected in Indian Bayou and Indian Bayou Ditch, 2001**

| Species | Waypoint Number | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 37 | |
| *A. plicata* | 53.33 | 0.00 | 0.00 | 0.00 | 82.35 | 62.37 | 0.00 | 30.84 | 59.19 |
| *Q. quadrula* | 6.67 | 0.00 | 0.00 | 0.00 | 0.00 | 26.20 | 0.00 | 27.10 | 24.97 |
| *Q. pustulosa* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.12 | 0.00 | 0.00 | 3.41 |
| *U. declivus* | 0.00 | 0.00 | 0.00 | 0.00 | 14.71 | 0.80 | 0.00 | 17.76 | 3.30 |
| *L. teres* | 13.33 | 0.00 | 0.00 | 0.00 | 0.00 | 2.79 | 0.00 | 0.93 | 2.64 |
| *A. confragosus* | 0.00 | 0.00 | 0.00 | 0.00 | 2.94 | 1.86 | 0.00 | 0.00 | 1.65 |
| *T. parvus* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.28 | 1.21 |
| *Q. apiculata* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 5.61 | 0.77 |
| *P. purpuratus* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.80 | 0.00 | 0.00 | 0.66 |
| *L. fragilis* | 6.67 | 100.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.00 | 0.93 | 0.55 |
| *L. recta* | 6.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.74 | 0.55 |
| *F. flava* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.53 | 0.00 | 0.00 | 0.44 |
| *L. subrostrata* | 13.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 |
| *M. nervosa* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.11 |
| *P. grandis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.93 | 0.11 |
| *U. tetralasmus* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.87 | 0.22 |
| Total individuals | 15 | 1 | 0 | 0 | 34 | 752 | 0 | 107 | 909 |
| Total species | 6 | 1 | 0 | 0 | 3 | 11 | 0 | 10 | 16 |
| Total time | 50 | 40 | 30 | 20 | 36 | 300 | 20 | 70 | 566 |
| CPUE | 0.30 | 0.03 | 0.00 | 0.00 | 0.94 | 2.51 | 0.00 | 1.53 | 1.61 |

The mussel fauna was dominated by *A. plicata* and *Q. pustulosa*, which together comprised nearly 75 percent of all mussels collected (Tables 2 and 3).

Mean density of mussels was 14.7 individuals/$m^2$, which is low compared with mussel beds in the Ohio or upper Mississippi Rivers where density can exceed 75 individuals/$m^2$. There was evidence of recent recruitment at this location. Nearly 30 percent of the individuals were less than 30 mm in total shell length. Three species (*A. plicata, Q. quadrula,* and *Q. apiculata)* had at least one representative less than 30 mm in total shell length.

All of the mussels collected at this location are commonly collected in southern streams and are designated at "current stable" (Williams 1993) except for *Ligumia recta*, which is considered to be of "special concern" (although not listed as threatened or endangered). All the other species at this location were listed as "currently stable" by Williams (1993). This was one of the better

**Table 4**
**Results of Quantitative Sampling at Waypoint 6, the Tucker Prison Farm Site on Indian Bayou Ditch**

| Species | Quadrat Number | | | | | | | | | | | | Total | Percent Abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | |
| *Q. quadrula* | 1 | | 2 | 1 | | 4 | 5 | 3 | | 1 | 3 | 1 | 21 | 47.73 |
| *A. plicata* | | | 1 | 2 | 1 | 2 | | | 1 | 4 | 4 | | 15 | 34.09 |
| *Q. apiculata* | | 2 | | | | 1 | | | | | | | 3 | 6.82 |
| *A. confragosus* | | | | 1 | | | | | | | | | 1 | 2.27 |
| *F. flava* | | | | | | | | 1 | | | | | 1 | 2.27 |
| *L. fragilis* | | | | 1 | | | | | | | | | 1 | 2.27 |
| *Q. pustulosa* | 1 | | | | | | | | | | | | 1 | 2.27 |
| *T. parvus* | | | 1 | | | | | | | | | | 1 | 2.27 |
| Total species | 2 | 1 | 3 | 4 | 1 | 3 | 1 | 2 | 1 | 2 | 2 | 1 | 8 | |
| Total individuals | 2 | 2 | 4 | 5 | 1 | 7 | 5 | 4 | 1 | 5 | 7 | 1 | 44 | |

% Individuals < 30 mm total SL: 29.54

% Species < 30 mm total SL: 37.75

Density (individuals/sq m)

| Species / group | N | Mean | Standard Deviation |
|---|---|---|---|
| *C. fluminea* | 12 | 167.7 | 62.2 |
| Unionidae | 12 | 14.7 | 8.9 |

stream reaches for mussels in the Bayou Meto drainage because of the moderately high density and evidence of recent unionid recruitment.

### Size demography of dominant populations at Waypoint 6

The *A. plicata* population at Waypoint 6 (Indian Bayou Ditch at Tucker Prison Farm) ranged in size from recent recruits (<30 mm) to commercially valuable, very large adults (>100 mm) (Figure 7). Although large adults dominated the population, the presence of some individuals throughout much of the length range of 25 to 75 mm indicated that occasional recruitment occurs.

This situation was essentially the same as observed for this species at Site 37 (Indian Bayou Ditch at Highway 165). However, at Waypoint 5 (Indian Bayou Ditch at Tar Bottom Road), all individuals were of relatively uniform, large size. At Waypoint 1 (Chaney Road), the population size structure suggested less recruitment than at Waypoint 6 but was not nearly as uniform as at Waypoint 5. It should be noted that only at Waypoint 6 was quantitative sampling done that involved substratum removal (the best method of obtaining accurate, detailed information on size demography). At the other sites, notes concerning size distribution were based on individuals obtained by carefully searching the muddy bottom by feel.

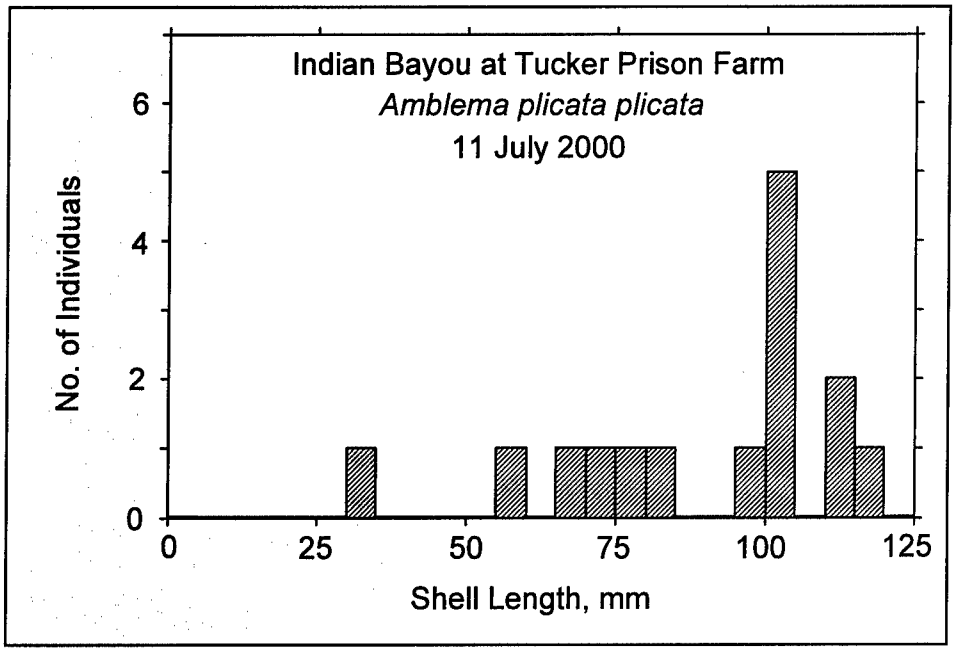


Figure 7. Length-frequency data for *A. plicata*

The size structure of *Q. quadrula* at Waypoint 6 suggested moderately strong recent recruitment (Figure 8). Nine of twenty mussels obtained by quantitative sampling measured less than 30 mm long, and ranged to as little as 15 to 20 mm. The remainder of the population ranged from 45 to 70 mm. Large adults of this species included individuals ranging from 55 to 70 mm.

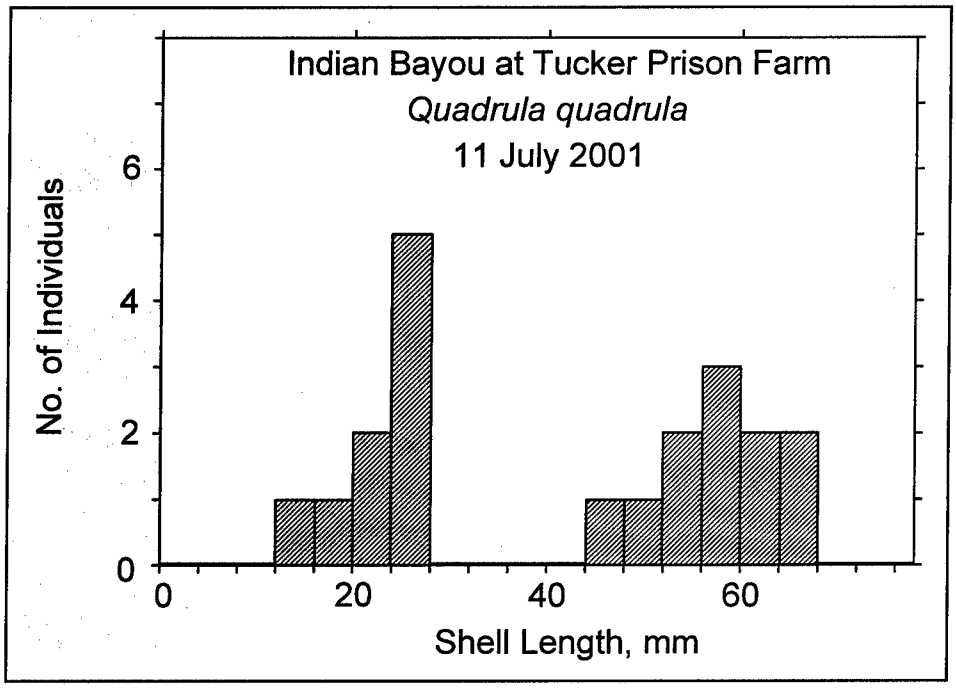


Figure 8. Length-frequency data for *Q. quadrula*

A single individual of this species was included among qualitative samples at Waypoint 1 (Chaney Road). This individual was <30 mm long and indicated that recruitment does occur at that location. The size distribution suggested by qualitative sampling at Waypoint 37 was similar to that at Site 6, except that even larger adults were obtained at the former location. No individuals of this species were taken in qualitative samples at Waypoint 5 (Tar Bottom Road).

The population of *C. fluminea* at Waypoint 6 was comprised of four distinct cohorts (Figure 9). The smallest was centered at 8.5 mm and ranged from 7 to 11 mm. The next and most abundant cohort was centered at 14.5 mm and ranged from 11 to 17 mm. A third cohort was centered at 20.5 mm and ranged from 17 to 23 mm. The final cohort was centered at 27.5 mm and ranged from 23 to 30 mm. It is likely that the smallest cohort represented spring 2001 recruitment. The two cohorts of intermediate-sized individuals probably represented periods of fall and spring recruitment in 2000. The cohort of the largest adults probably represented fall 1999 recruitment. Longevity of 1.5 to 2 years for this species is not uncommon; in warm habitats of the southern United States, reproduction typically ceases in summer (Aldridge and McMahon 1978). Because this species is not especially tolerant of low dissolved oxygen, the presence of dense populations with complex age structure suggests that water is usually present in Indian Bayou Ditch.

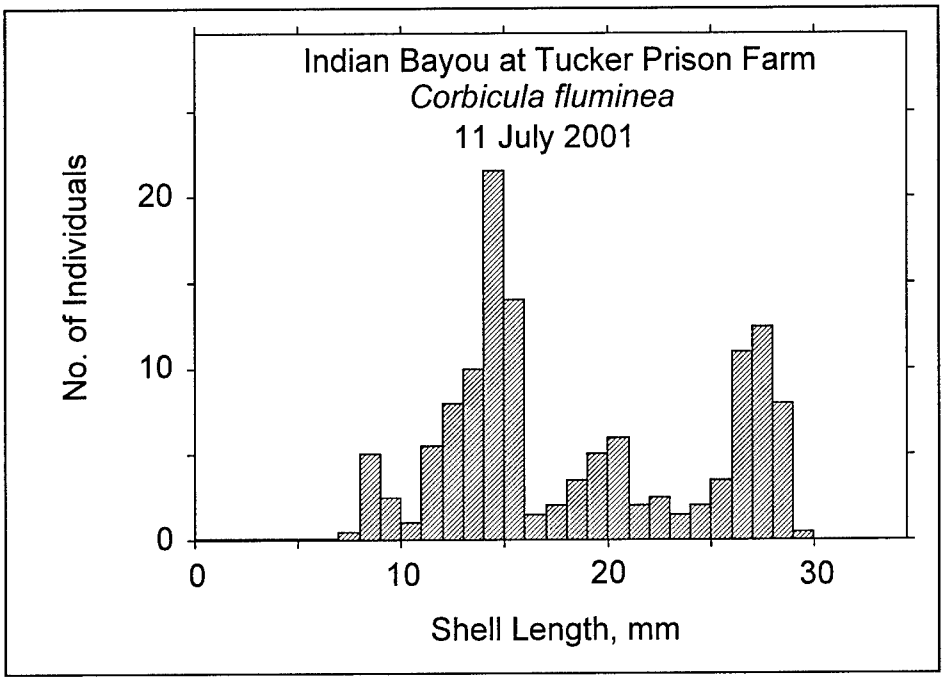


Figure 9. Length-frequency data for the nonindigenous bivalve, *C. flumina*

## Salt Bayou Ditch

Salt Bayou Ditch runs southeast and is located just west of Bayou Meto (Figure 4). For the most part, the ditch was straight with little or no woody vegetation or submersed vegetation present. Substratum consisted mainly of sand and silt. There was little or no perceptible current during the study period. Water depth was approximately 1 to 2 m deep in the center of the ditch between Waypoints 46 and 42 (Figure 4). Upriver and downriver of this reach, the water became gradually more and more shallow and in places was less than 1 m deep. Eleven sites were searched for mussels in Salt Bayou Ditch, and live mussels were found at eight of those sites. Waders and divers collected mussels at all sites in this water body.

The mussel fauna in Salt Bayou Ditch consisted mainly of *A. plicata*, which comprised more than 75 percent of the assemblage (Table 5). *Quadrula quadrula* made up approximately 10 percent of the fauna, and the remaining nine species each comprised less than 5 percent of the assemblage. The fauna consisted of species tolerant of fine-grained substratum and low water velocity such as *Potamilus ohienis*, *Pyganodon suborbicula, Uniomerus* spp., and *Toxolasma parva.*

High-density assemblages were found at Waypoints 21, 42, 43, 44, and 45, where CPUE ranged from 0.53 to 1.47. Farther upriver of these waypoints the water in the ditch became shallow (less than 1 m deep) and the numbers declined. No mussels were found at Waypoints 46, 47, and 48. At these locations the water became more shallow, and the percentage of organic matter in the substratum increased.

## Wabbaseka Bayou

Wabbaseka Bayou flows southeast through the town of Wabbaseka, AR (Figure 5). A total of 11 sites were searched for mussels along this Bayou. More than 200 min were expended searching, and only 12 individuals (CPUE = 0.06 overall) were collected (Table 2). Mussels were found at only 2 of the 11 sites surveyed. The fauna in this water body consisted of species that were tolerant of fine-grained substratum and low water velocity. The following paragraphs provide more detailed information on study sites in this bayou.

### Wabbaseka Bayou, Waypoint 7

This site was at the Highway 31 Bridge. Only a few *C. fluminea* shells (old and darkened) were seen; no mussel shells were observed. The channel was 15 m wide, with trees along both banks and canopy coverage was approximately 75 percent. Abundant large woody and smaller debris littered the streambed. Substratum was a very soft muck with large and small woody debris. There was

**Table 5**
**Percent Abundance of Mussel Species Collected in Salt Bayou Ditch, 2001**

| Species | Waypoint Number | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 21 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | |
| *A. plicata* | 0.00 | 77.27 | 75.00 | 92.59 | 71.43 | 62.50 | 75.00 | 0.00 | 0.00 | 0.00 | 76.30 |
| *Q. quadrula* | 0.00 | 6.82 | 25.00 | 3.70 | 21.43 | 12.50 | 14.29 | 0.00 | 0.00 | 0.00 | 10.37 |
| *Q. pustulosa* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.57 | 0.00 | 0.00 | 0.00 | 0.74 |
| *U. declivus* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *L. teres* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *A. confragosus* | 0.00 | 2.27 | 0.00 | 3.70 | 0.00 | 0.00 | 3.57 | 0.00 | 0.00 | 0.00 | 2.22 |
| *T. parvus* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *P. purpuratus* | 0.00 | 4.55 | 0.00 | 0.00 | 0.00 | 6.25 | 0.00 | 0.00 | 0.00 | 0.00 | 2.22 |
| *Q. apiculata* | 0.00 | 0.00 | 0.00 | 0.00 | 7.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.74 |
| *L. fragilis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *M. nervosa* | 50.00 | 6.82 | 0.00 | 0.00 | 0.00 | 6.25 | 0.00 | 0.00 | 0.00 | 0.00 | 3.70 |
| *L. recta* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *F. flava* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *P. grandis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *T. verrucosa* | 0.00 | 2.27 | 0.00 | 0.00 | 0.00 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 2.22 |
| *L. subrostrata* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *P. ohiensis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.57 | 0.00 | 0.00 | 0.00 | 0.74 |
| *A. suborbiculata* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *U. tetralasma* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total individuals | 2 | 44 | 4 | 27 | 14 | 16 | 28 | 0 | 0 | 0 | 135 |
| Total species | 2 | 6 | 2 | 3 | 3 | 5 | 5 | 0 | 0 | 0 | 9 |
| Total time | 10 | 30 | 15 | 25 | 25 | 25 | 25 | 15 | 8.5 | 10 | 188.5 |
| CPUE | 0.20 | 1.47 | 0.27 | 1.08 | 0.56 | 0.64 | 1.12 | 0.00 | 0.00 | 0.00 | 0.72 |

no perceivable flow; substratum smelled strongly of hydrogen sulfide when disturbed. Depth was generally less than 60 cm. A total of 30 min of searching yielded no live mussels or shells.

### Wabbaseka Bayou, Waypoint 23

This site was accessed from a bridge on S. Gilliand Road. Water was shallow, less than 1 m deep, and substratum consisted of mud and organic material. Canopy coverage was less than 50 percent and banks were stable and well vegetated. A total of 20 min of searching yielded a single live *Potamilus purpuratus*. This was not a good site for live mussels.

### Wabbaseka Bayou, Waypoint 24

This site was accessed from a bridge crossing just east of the town of Wabbaseka, AR. Substratum consisted of mud and organic matter with considerable large woody debris. There was little or no flow at the time of the survey. A total of 10 min of searching at this location yielded no mussels. This was not a good site for live mussels.

### Wabbaseka Bayou, Waypoint 25

This site was accessed from Highway 79 at the town of Wabbaseka, AR (Figure 5). Conditions were similar to those at Waypoints 23 and 24. Substratum consisted of mud and organic matter, and there was little to no discharge at the time of the survey. Ten minutes of searching yielded no mussels. This river reach was not suitable for mussels.

### Wabbaseka Bayou, Waypoint 26

This site was east of Wabbaseka, AR, and located farther downstream of Waypoint 25 (Figures 5 and 10). Substratum consisted of organic matter, mud, woody debris, and trash. There was no flow at the time of the survey. Ten minutes of searching yielded no live mussels or shells.

Figure 10. Waypoint 26 on Wabbaseka Bayou

### Wabbaseka Bayou, Waypoint 9

This site is in the lower part of Wabbaseka Bayou approximately 4 km south of the town of Wabbaseka, AR. The channel was 20 m wide and 0.6 m deep. The substratum was deep soft mud overlain by at least a 0.3 m layer of fine and coarse detritus. A strong odor of hydrogen sulfide was associated with substratum disturbance. Water velocity was zero; this reach almost certainly exists as a series of intermittent pools during extremely low water. Canopy coverage was approximately 80 percent.

A few very old *A. plicata* shells were present on the shore, but a total of 30 min of searching by two waders yielded no shells or mussels from the channel.

### Wabbaseka Bayou, Waypoint 10

The site was accessed alongside the road that travels generally along the east side of the bayou below Waypoint 9. The channel here was less than 0.75 m deep. There was no water flow. Canopy coverage was approximately 50 percent. The substratum was soft mud overlain by very fine flocculent detritus. The flocculent layer was approximately 20 cm thick. The bottom smelled of hydrogen sulfide on disturbance. No mussels or shells were found in 20 min of searching.

### Wabbaseka Bayou, Waypoint 22

The site was located slightly south of Waypoint 10. There was no flow, and the substratum consisted almost entirely of organic matter (leaves and twigs) and fine detritus. Considerable woody debris was in the water at the time of the survey. No live mussels or shells were found, and the area did not provide appropriate habitat for freshwater mussels. A total of 17 min of searching was expended at this location.

### Wabbaseka Bayou, Waypoint 11

This site was similar to Waypoint 10 except that it occurred at a bridge crossing where canopy coverage was sparse (approximately 10 percent). A few mussel shells were evident along the shore. A total of 40 min of searching yielded a few live mussels. These included *Leptodea fragilis* (n = 2), *Pyganodon grandis* (n = 2), and one each of *A. confragosus*, *Q. pustulosa*, *Q. quadrula*, *U. declivus*, and *P. suborbiculata*. All were large adults except *L. fragilis*. These two individuals were only 24 and 30 mm long, representing recruitment than has occurred within the last 1 to 2 years.

### Wabbaseka Bayou, Waypoint 27

Ten minutes of searching at this location yielded no live mussels or shells. Flow was nonexistent, and the water was less than 50 cm deep at the time of the survey. There was considerable trash in the water, and it is extremely unlikely that any live mussels would be taken at this location (Figure 11).

Figure 11. Waypoint 27 on Wabbaseka Bayou

### Wabbaseka Bayou, Waypoint 28

A single *P. grandis* shell was found after 10 min of searching. No live mussels were found, and it is unlikely that live mussels would be found here. The water was shallow, flow was almost nonexistent, and considerable woody debris was in the water.

## Plum Bayou

On 18 September 2001, five sites along Plum Bayou, located northwest of Pine Bluff, AR, were evaluated for zebra mussels. The purpose was to look for zebra mussel habitat and evaluate a previous report made by Jim Petereson, U. S. Geological Survey, Little Rock, that there were live zebra mussels in the area. The five sites visited (PB-1 through PB-5) are discussed below and depicted in Figure 12. Search times for Plum Bayou were not included in tabular material for this report.

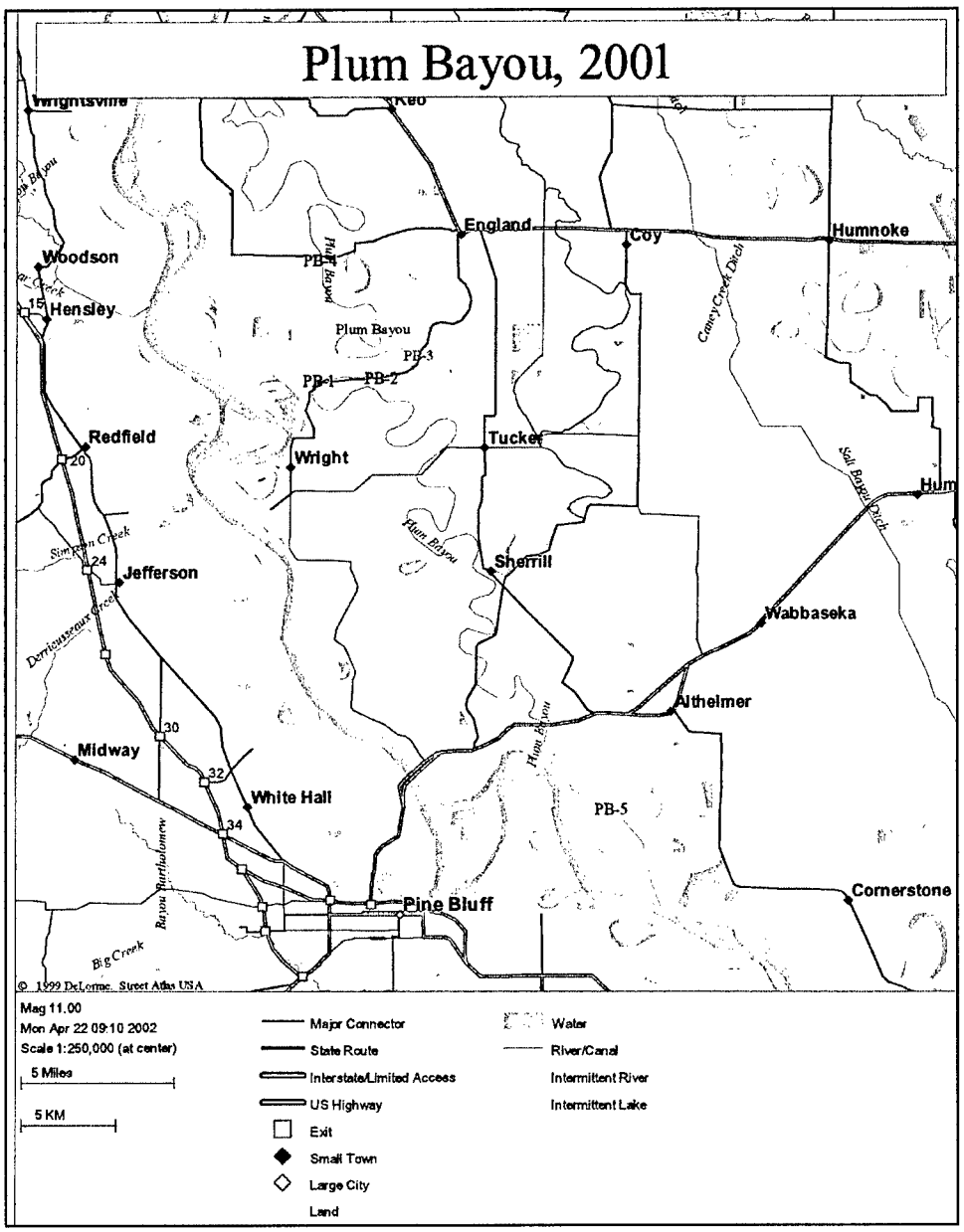


Figure 12. Five sites (PB-1 through PB-5) searched for zebra mussels along Plum Bayou, 18 September 01

## PB-1

The first location inspected was the outlet channel immediately downstream of the receiving end of the four pipes at the Plum Bayou pump station off Highway 256 slightly north of Wright, AR. The pumps were not operating during the inspection. The outlet embayment is a riprapped channel for approximately 40 m. Downstream of the riprapped reach the channel is approximately 15 m wide with moderately steep clay banks. Channel substratum, excluding the riprap, is a mix of buckshot clay and relatively hard

clay with some shell debris (*C. fluminea* and some native mussels). Channel depth was approximately 1.75 m; recent high-water marks on the riprapped banks were approximately 1 m. The channel was probably near ordinary low water at the time of inspection.

Approximately 20 min were spent lifting riprap, inspecting it for zebra mussels and byssal bundles left by previously attached mussels, and scooping sediment from the nonriprapped channel with D-framed nets. Approximately four byssal bundles were noticed on rocks. Approximately 5 unbleached *D. polymorpha* shell valves or substantial fragments of valves and 10 bleached shell valves or fragments of valves were observed. None of the unbleached (i.e., more recently dead) valves were bysally attached to substratum or had any soft tissue or adductor muscle remaining. No live *D. polymorpha* were found.

The density of live *C. fluminea* was low to moderate; a scoop with a D-frame over a 0.5-m length typically yielded <10 live *C. fluminea* but many more empty shell valves. Native mussel shells recovered included *Lampsilis hydiana*, *Uniomerus tetralasmus*, *Pyganodon grandis*, and *Toxolasma parvus* (this was the only species obtained alive).

### BP-2

This site was at Morton's Weir, a structure northeast of Wright, AR, on Plum Bayou designed to hold water in Plum Bayou to support irrigation withdrawals. The weir is in the center of an earthen dam and is a shallow concrete trough approximately 10 m wide; the weir gate is approximately 0.75 m high. A 1- to 3-cm-deep flow of water was running through the trough downstream of the weir and spilled into a very sluggish and depositional slough on the downstream side. Upstream of the weir, the impounded bayou was a very wide cypress slough (a shallow reservoir). Depth was at least 1.75 m downstream of the weir structure. Researchers inspected riprap along the upstream face of the weir for approximately 20 min. No zebra mussels, zebra mussel shells, or byssal threads were observed. Many limpets and leeches occurred on the rocks. The natural substratum of the impoundment was soft mud.

### BP-3

This site was at a wooden bridge along Wells Road, south of Clear Lake, AR, and approximately 8 km upstream of BP-2. The bayou resembled that at BP-2 – a wide, shallow impoundment with a soft mud bottom. Wells Road crossed the bayou along an earthen dam; it constricted channel flow under the 15-m-wide bridge. Several fishermen were fishing from the bridge and from small boats just upstream of the bridge. No sampling was done here to avoid disrupting the fishermen; the only available substratum for zebra mussel was the wooden bridge pilings. No shells were evident along the shore.

### BP-4

This site was at the Highway 161 Bridge over the bayou, due west of the town of England, AR. The characteristics of the bayou here were similar to those upstream of the weir and bridge at BP-2 and BP-3, respectively. The bridge at Highway 161 was wide and supported by sets of concrete pilings; the bridge did not constrict the channel. A 20-min search of woody debris and the concrete pilings was conducted here. No evidence of zebra mussels was found. The bottom was very soft and smelled strongly of hydrogen sulfide once disturbed. Substratum was mud with much leaf litter and fine particulate detritus. Limpets and leeches were abundant. Limpets were especially abundance on emergent rush stems.

### BP-5

This site was well downstream of Morton's Weir at a low-water crossing approximately 1 km upstream of the Highway 79 Bridge over Plum Bayou. The low-water crossing was an old paved road that is now a spillway of the impounded bayou upstream and the straight channel downstream. Water was approximately 1.75 m deep below the spillway and 5 to 15 cm deep running over the old roadbed. The downstream slope from the roadway was riprapped. The riprap and streambed were searched with a D-frame net for approximately 30 min at this site. Flow was swift over the roadbed (approximately 1 m/sec). Invertebrates were abundant on the riprap and included stoneflies, helgammites, hydrophsychid caddisflies, limpets, and attached fingernail clams. The fingernails clams were a small, mottled species (approximately 6 mm maximum length) and seemed to be attached to the rocks by singular or few byssal threads (not secreted by a true byssus gland as in *Dreissena* spp.). This observation is noteworthy because someone in the future conceivably could mistake these small, attached bivalves for zebra mussels if they were not familiar with *D. polymorpha* but simply knew they live attached to rocks. Asian clams were moderately dense in gravel trapped between the roadbed and riprapped downstream slope. Substratum below the spillway was gravel and *C. fluminea* shell and shell debris. No evidence of *D. polymorpha* was found; this site should be an excellent zebra mussel monitoring station as it provides appropriate flow and substratum conditions.

## Summary

This survey confirms the zebra mussel sittings near the pump outlet previously reported by Jim Petereson, U. S. Geological Survey, Little Rock, AR. Dense populations of *D. polymorpha* in the Arkansas River almost certainly provide juveniles to Plum Bayou via the pump station near Wright, AR. Continued introductions are likely, especially during peak periods of reproduction that may occur in spring and fall. However, habitat for *D. polymorpha* is poor in Plum Bayou. Lack of flow and high water temperatures during sustained low-water conditions in summer and fall are stressful. Additionally, very little firm substratum for zebra mussel attachment is available in Plum Bayou. Despite

continued introductions via the pump station, it is unlikely that this species will establish high-density populations in Plum Bayou. The pump outlet channel, Morton's Weir, and the low-water crossing upstream of Highway 79 represent ideal locations to monitor zebra mussel infestation; these locations provide the best substratum in a system that is generally too depositional to support zebra mussels in abundance.

# 3 Discussion

## Summary of Major Findings

Approximately 19 hr (1,131.5 min) were spent searching for native mussels at 45 sites in the Bayou Meto Drainage in the spring of 2001. A total of 18 species of mussels were identified, and more than 1,000 individuals were collected using qualitative and quantitative methods combined. In addition to native species, the Asian clam, *C. fluminea,* was found in the project area. The nonindigenous zebra mussel, *D. polymorpha,* was not found in the project area, although it was collected in the Arkansas River where the pumping plant will be placed. Approximately 75 percent of all mussels collected during this survey were found at a single site, Waypoint 6, located in Indian Bayou. Live mussels were found at 15 of the 45 sites surveyed. No Federally listed endangered or threatened mussels were found.

Total species richness in the study area (18 species based on quantitative and qualitative methods) is only slightly less than at most mussel beds in large rivers. In a survey of the lower Tennessee River Miller, Payne, and Tippit (1992) collected 4,768 individuals and identified 23 species. While low quality habitat can be partially to blame in the project area, it is also true that the lower species richness is caused in part by the overall nature of the habitat. This is a comparatively small river, and it lacks the habitat diversity (extensive pools and riffles, cobble and gravel substratum), which can support many fish species and ultimately high unionid species richness.

Mean unionid density at Waypoint 6 (14.7 individuals/$m^2$) is much less than that reported by other workers in medium-sized to large rivers in the United States. At an inshore and offshore site sampled in 1986 at river mile (RM) 18.6 in the lower Tennessee River (32 quantitative samples were collected at each), total mussel density was 187.7 and 79.7 individuals/$m^2$, respectively (Way, Miller, and Payne 1989). In the middle Ohio River near Cincinnati, mussel density ranged from 4.4 to 52.4 individuals/$m^2$ (Miller and Payne 1993).

Southern rivers in the south often vary from extremely high to extremely low mussel densities. At a narrow mussel bed in the White River near De Valls Bluff, AR, mean density (10 samples per subsite) ranged from 0.8 to 19.6 individuals/$m^2$ with an overall average of 6.4 individuals/$m^2$. In the Big Sunflower River, MS, an alluvial river smaller in size than either the White River

or the Ouachita River, mean density at a site below a lock and dam (10 samples per subsite) was greater than 200 individuals/$m^2$ (Miller and Payne 2001). These high density values were not common throughout the river however; mean density at two shoals was less than 50 individuals/$m^2$, and density throughout most of the river was less than 20 individuals/$m^2$ (Miller and Payne 1995).

## Possible Effects of Zebra Mussels in the Bayou Meto Area

The first report of *D. polymorpha* in North America was from Lake St. Clair in June 1988 (Hebert, Muncaster, and Mackie 1989). By the late summer of 1989, *D. polymorpha* had spread into the Detroit River, Lake Erie, Niagara River, and western Lake Erie (Griffiths, Kovalak, and Schloesser 1989). By late September 1990, these mussels had spread though Lake Ontario and down the St. Lawrence River to Massena, NY. They were also collected in Lake Huron, Lake Superior at Duluth, MN, and in western Lake Michigan at Gary, IN (*Dreissena polymorpha Information Review* 1990).

In June 1991, biologists from the Illinois Natural History Survey found adult *D. polymorpha* at Illinois RM 50, 60, and 110 (Moore 1991; Sparks and Marsden 1991). By early January 1993, *D. polymorpha* had spread throughout most of the inland waterway system. During that year they were found in the lower Mississippi River as far south as New Orleans, and in the upper Mississippi River near St. Paul, MN. Probably commercial and recreational navigation traffic had, and will continue to have, an important role in transporting and sustaining zebra mussels in the upper Mississippi River (see Keevin, Yarbrough, and Miller 1992).

A single zebra mussel introduction does not necessarily lead to infestation although obviously this can happen. Johnson and Carlton (1992) emphasized this point to quell an unfounded level of anxiety about the incipience of infestation at any particular location. Johnson and Carleton cite Karataev and Burlakova (1995), who reported that 80 percent of suitable lakes in Belarus remain uncolonized by zebra mussels. Regardless, if basic water quality and habitat conditions are suitable, the following conclusion of Morton (1997) is reasonable: "Undoubtedly, *Dreissena polymorpha* will spread to the remaining rivers of North America, as has *C. fluminea*, the only debate about this being the timetable."

There can be little doubt that *D. polymorpha,* mainly because of its high fecundity and ability to attach tenaciously to hard surfaces, has had severe impacts on native mussels in the Great Lakes and large rivers in this country (Nalepa 1994; Schloesser 1996; Schloesser and Nelepa 1994; and Schloesser, Nalepa, and Mackie 1996). However, it must be remembered that unionids are specifically adapted to large rivers; hence, they have an advantage over *D. polymorpha* throughout much of their range. Zebra mussels do not sustain themselves well in medium-sized to small rivers; these habitats are likely to be refugia for many (although certainly not all) native unionids. Many native

unionids live 30 or more years, tolerate long periods of desiccation, have an extremely strong shell, and can move about to a limited extent. Zebra mussels live 1 to 2 years at the most, are virtually intolerant of desiccation, and have a weak, easily broken shell.

With respect to concerns over zebra mussels in the Bayou Meto area, neither the habitat nor the temperature are particularly suitable to these species. Zebra mussels typically attach to firm substratum in large river or lake habitats. Typically, they are found attached to cobble or gravel, shells of live or dead native mussels, submersed woody vegetation, or any hard substratum. The substratum in the Bayou Meto drainage consists mainly of fine-grained sediments with little submersed hard surfaces.

Second, and perhaps most important, the zebra mussel is a northern species and does not tolerate higher water temperatures. The upper incipient lethal temperature for zebra mussels is approximately 29 °C – if this temperature is sustained for months in summer, zebra mussels will die (Claudi and Mackie 1993 and references within). Mean tolerance time to 30 °C exposure of mussels from Lakes Erie and St. Clair was approximately 4 days when acclimated to 25 °C (summer acclimated) and 3 days when acclimated to 2.5 °C (winter-acclimated) (Iwanyzki and McCauley 1992). Exposure to 33 °C water reduced tolerance time to only 18 hr even among summer-acclimatized mussels. McMahon and Ussery (1995) were able to acclimate zebra mussels from the Great Lakes to 30° C for 2 weeks with little or no mortality. Aldridge, Payne, and Miller (1995) were able to keep Great Lakes mussels alive at 32 °C for 42 days in an experimental study of sublethal effects of temperature. Both of these studies suggest substantially higher tolerance times than those observed by Iwanyzki and McCauley (1992). However, Aldridge, Payne, and Miller (1995) clearly showed that positive scope for growth could not be maintained even at 28 °C. Summer water temperatures in the Bayou Meto system probably routinely exceed 32 °C and stay above 30 °C for perhaps 2 months or more. Thus, it is relatively certain that zebra mussel populations cannot thrive in this system of shallow ditches and creeks, although it is possible that a few highly stressed individuals might be able to survive for a few weeks.

Live zebra mussels are in the Arkansas River where water will be taken for the Bayou Meto project. Therefore, it is certain that live zebra mussels, their larvae, as well as even live sperm and eggs will be carried into the project area. It is also likely that at least some live zebra mussels will be observed on firm substratum in the streams in the project area. However, because of the overall high temperatures in this region of the country, and the lack of suitable substratum in these comparatively small streams, it is extremely unlikely that zebra mussels will achieve even moderately high densities and are unlikely to have any effect on the native mussel populations.

Conditions for freshwater mussels are likely to show net improvement if flow augmentation occurs in the drainages of the Bayou Meto irrigation project, despite potential introduction of zebra mussels from the Arkansas River. Presently, low discharge greatly limits mussel habitat in the Bayou Meto system. In their existing condition, the potential negative effects to these drainages of

zebra mussel introduction are unlikely to be more deleterious to mussels than the extreme low flows that now limit flow and habitat. It is likely that native mussels have substantial competitive advantages over zebra mussels in this drainage system. Small stream size, stressfully high summer and early fall water temperatures, and lack of much firm substratum for byssal attachment characterize the streams and ditches of the Bayou Meto system. Zebra mussels, a species adapted to large lakes, are severely stressed by sustained, moderately high water temperature. Zebra mussels form sizable drusses in which a few individuals attach to small pieces of debris or hard substratum and then one to another. However, habitats with a moderate system-wide abundance of firm substratum are needed to support ubiquitous, high-density populations of zebra mussels.

If this project were taken place farther north (the Great Lakes Area), and all conditions (except temperature) were similar to those in Bayou Meto, water augmentation could introduce sustaining populations of zebra mussels that could negatively affect native mussels. However, it is very unlikely that the Bayou Meto water augmentation project will result in high-density populations of zebra mussels that are detrimental to the native mussel fauna.

## Effects of Channel Modification on the Mussel Fauna

Dredging to deepen and enlarge the channel at sites with moderate- to high-density assemblages (Waypoints 6 and 37, as well as parts of Salt Bayou Ditch) will certainly negatively affect native mussels at these locations. Direct effects include either being killed by the dredge or being disposed of in an upland site. Indirect effects, which might not necessarily be lethal, include stress caused by elevated suspended sediments or partial burial. Since mussels are located across the channel it is difficult to avoid all of them. Mussels along the edge of the water will probably not be damaged by the dredge, as will those in the center of the channel.

Dredging in reaches of the bayous that are clogged with vegetation and sediments would be beneficial to mussels and the aquatic habitat. Conditions would be improved not only for mussels, but also for aquatic insects, aquatic worms, and fishes. Increased flow as a result of clearing and snagging would scour the substratum and remove settled sediments.

# References


Aldridge, D. W., and McMahon, R. F. (1978). "Growth, fecundity, and bioenergetics in a natural population of the Asiatic freshwater clam, *Corbicula manilensis* Philippi, from North Central Texas," *Journal of Molluscan Studies* 44, 49-70.

Aldridge, D. W., Payne, B. S., and Miller, A. C. (1995). "Oxygen consumption, nitrogenous excretion, and filtration rates of *Dreissena polymorpha* at acclimation temperatures between 20 and 32 °C," *Canadian Journal of Fisheries and Aquatic Sciences* 52, 1761-1767.

Claudi, R., and Mackie, G. L. (1993). *Practical manual for zebra mussel control.* Lewis Publishers, Boca Raton, FL.

*Dreissena polymorpha Information Review.* (1990). Published by the Zebra Mussel Information Clearing House of New York Sea Grant, Brockport, NY.

Griffiths, R. W., Kovalak, W. P., and Schloesser, D. W. (1989). "The zebra mussel, *Dreissena polymorpha* (Pallas, 1771), in North America: Impacts on raw water users," *Service water system problems affecting safety-related equipment.* Charlotte, NC, Nuclear Power Division, Electric Power Institute, Palo Alta, CA, 11-26.

Hebert, P. D. N., Muncaster, B. W., and Mackie, G. L. (1989). "Ecological and genetic studies on *Dreissena polymorpha* (Pallas): A new mollusc in the Great Lakes," *Canadian Journal of Fisheries and Aquatic Sciences* 46, 1587-1561.

Iwanyzki, S., and McCauley, R. W. (1992). "Upper lethal temperatures of adult zebra mussels," *Zebra mussels: Biology, impacts, and control.* T.F. Nalepa and D.W. Schloesser, ed., Lewis Publishers, Boca Raton, FL, 537-554.

Johnson, L. E., and Carlton, J. T. (1992). "Counter-productive public information: The Noah fallacy and mussel myths," *Dreissena polymorpha Information Review* 3(3), 2-6.

Karataev, A. Yu., and Burlakova, L. E. (1995). "The role of *Dreissena* in lake ecosystems," *Russian Journal of Ecology* 26, 207-211.

Keevin, T. M., Yarbrough, R. E., and Miller, A. C. (1992). "Long-distance dispersal of zebra mussels (*Dreissena polymorpha*) attached to hulls of commercial vessels," *Journal of Freshwater Ecology* 7, 437.

McMahon, R. F., and Ussery, T. A. (1995). "Thermal tolerance of zebra mussels (*Dreissena polymorpha*) relative to rate of temperature increase and acclimation temperature," Technical Report EL-95-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Miller, A. C., and Payne, B. S. (1993). "Qualitative versus quantitative sampling to evaluate population and community characteristics at a large-river mussel bed," *The American Midland Naturalist* 130, 133-145.

_____ . (1995). "An analysis of freshwater mussels (Unionidae) in the Big Sunflower River, Mississippi, for the Big Sunflower River Maintenance Project: 1993 Studies," Technical Report EL-95-26, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Miller, A. C., Payne, B. S., and Farr, M. D. (2001). "Mussel survey in the Arkansas River for the Grand Prairie Area Demonstration Project Inlet Channel, White River, Arkansas," unpublished report, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Miller, A. C., Payne, B. S., and Tippit, R. (1992). "Characterization of a freshwater mussel community immediately downriver of Kentucky Lock and Dam in the Tennessee River," *Transactions of the Kentucky Academy of Sciences* 53(3-4), 154-161.

Miller, A. C., Payne, B.S., Shafer, D. S., and Neill, L. T. (1993). "Techniques for monitoring bivalve communities and populations in large rivers," *Conservation and management of freshwater mussels*. K. S. Cummings, A. C. Buchanan, and L. M. Koch, ed., Proceedings of a UMRCC Symposium, October 1993, 147-158.

Moore, S. G. (1991). "Zebra mussels enter riverine systems," *Dreissena polymorpha Information Review* 2(4), 9.

Morton, B. (1997). "The aquatic nuisance species problem: A global perspective and review," *Zebra mussels and aquatic nuisance species*. F. M. D'Itri, ed., Ann Arbor Press, Chelsea, MI, 1-54.

Nalepa, T. F. (1994). "Decline of native unionid bivalves in Lake St. Clair after infestation by the zebra mussel, *Dreissena polymorpha," Canadian Journal of Fisheries and Aquatic Sciences* 51, 2227-2233.

Schloesser, D. W. (1996). "Mitigation of unionid mortality caused by zebra mussel infestation: Cleaning of unionids," *North American Journal of Fisheries Management* 16, 942-946.

Schloesser, D. W., and Nalepa, T. F. (1994). "Dramatic decline of unionid bivalves in offshore waters of western Lake Erie after infestation by the zebra mussel, *Dreissena polymorpha," Canadian Journal of Fisheries and Aquatic Sciences* 51, 2234-2242.

Schloesser, D. W., Nalepa, T. F., and Mackie, G. L. (1996). "Zebra mussel infestation of unionid bivalves (Unionidae) in North America," *American Society of Zoologists* 36, 300-310.

Sparks, R., and Marsden, E. (1991). "Zebra mussel alert," *Illinois Natural History Survey Reports* 310, 1-2.

Way, C. M., Miller, A. C., and Payne, B. S. (1989). "The influence of physical factors on the distribution and abundance of freshwater mussels (Bivalvia: Unionidae) in the lower Tennessee River," *The Nautilus* 103, 96-98.

Williams, J. D., Warren, M. L., Jr., Cummins, K. S., Harris, J. L., and Neves, R. J. (1993). "Conservation status of freshwater mussels of the United States and Canada," *Fisheries* 18(9), 6-22.

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



| 1. REPORT DATE *(DD-MM-YYYY)* | 2. REPORT TYPE | 3. DATES COVERED *(From - To)* |
|---|---|---|
| September 2002 | Final report | |

**4. TITLE AND SUBTITLE**

Effects of Channel Modification and Flow Augmentation on Freshwater Mussels in the Bayou Meto Area, Arkansas

**5a. CONTRACT NUMBER**

**5b. GRANT NUMBER**

**5c. PROGRAM ELEMENT NUMBER**

**6. AUTHOR(S)**

Andrew C. Miller, Barry S. Payne

**5d. PROJECT NUMBER**

**5e. TASK NUMBER**

**5f. WORK UNIT NUMBER**

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**

U.S. Army Engineer Research and Development Center
Environmental Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

**8. PERFORMING ORGANIZATION REPORT NUMBER**

ERDC/EL TR-02-34

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

U.S. Army Engineer District, Memphis
167 North Main St.
Memphis, TN 38103-1894

**10. SPONSOR/MONITOR'S ACRONYM(S)**

**11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

**12. DISTRIBUTION / AVAILABILITY STATEMENT**

Approved for public release; distribution is unlimited.

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**

A survey for freshwater mussels (Family: Unionidae) was conducted in the Bayou Meto area (including Bayou Meto, Bayou Two Prairie, Crooked Creek, Indian Bayou, Salt Bayou Ditch, Wabbaseka Bayou, and associated miscellaneous ditches) near Stuttgart, AR, in the spring of 2001. Approximately 19 hr of search time was expended at 45 sites in the study area. A separate search of five sites on Plum Bayou was conducted on 18 September 2001 to search for zebra mussels (*Dreissena polymorpha*). The overall purpose was to census the mussel fauna in the area to determine impacts of proposed channel modification (clearing, snagging, and channel enlargement by dredging) and proposed flow augmentation. Using both qualitative and quantitative methods, more than 1,000 individuals and 18 species of mussels were collected. The majority of the mussels were found at two sites in Indian Bayou (86 percent of the total), and approximately 13 percent were obtained at seven sites in Salt Bayou Ditch. No live mussels were found in Bayou Meto and adjacent ditches, and 1.14 percent of the total found were collected in Wabbaseka Bayou. No Federally listed endangered or threatened species were found. The fauna was dominated by *Amblema plicata* and *Quadrula quadrula* that together comprised more than 80 percent of the fauna. Overall, molluscs in the project area were negatively affected by low flow, high temperatures in the

*(Continued)*

**15. SUBJECT TERMS**

Arkansas
Dredging
Mussels
Unionidae

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | 19b. TELEPHONE NUMBER *(include area code)* |
| UNCLASSIFIED | UNCLASSIFIED | UNCLASSIFIED | | 44 | |

**14. (Concluded).**

summer, and substratum that consists mainly of sand, silt, and organic matter. At sites where mussels were collected, the density and diversity were low, and populations exhibited little evidence of recent recruitment. The proposed channel modification will negatively affect mussels in stream channels, although removing debris and increasing flow will ultimately benefit most aquatic organisms, including the mussels. Zebra mussels are in the Arkansas River and are likely to be brought into these bayous by this project; live specimens were found in Plum Bayou. However, it is unlikely that this species will survive in streams and bayous in the project area for long periods in high numbers because of inappropriate substratum and water temperatures above 29 °C during the summer.