APPENDIX 11

AQUATICS

EFFECTS OF YAZOO BACKWATER REFORMULATION PROJECT ON FISH HABITAT

K. Jack Killgore and Jan Jeffrey Hoover

Environmental Laboratory

DEPARTMENT OF THE ARMY
Engineer Research and Development Center
Waterways Experiment Station
Vicksburg, Mississippi 39180-6199

September 2007

Prepared for
U.S. Army Engineer District, Vicksburg
Vicksburg, MS 39180

PREFACE

This report describes fish assemblages in the Yazoo Backwater area, Mississippi, and evaluates impacts of proposed flood control measures on fish habitat. This report is an appendix to the Supplemental Environmental Impact Statement for the Yazoo Backwater Reformulation Study being prepared by the US Army Engineer District, Vicksburg (CEMVK).

Numerous individuals contributed to this evaluation as a member of the HEP Team: Marvin Cannon and Gary Young, CEMVK; Garry Lucas and Dennis Riecke, Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP); Larry Marcy and Ken Quackenbush, United States Fish and Wildlife Service (USFWS). Interagency meetings were held in March 1994, November 1994, and March 1995. During these meetings, the Team determined approaches for habitat quantification (floodplain habitat delineation for larval fishes), discussed evaluation species, and provided input on Habitat Suitability Index Scores. Team members were updated during a meeting in January 1999.

The following individuals at WES assisted with field work: Steven G. George, Sherry L. Harrel, James Morrow, Erik H. Nelson, Catherine Murphy, and Larry G. Sanders. Field assistance and identification of juvenile and adult fishes were provided by Neil H. Douglas, Northeast Louisiana University. Bob Wallus identified larval fishes. Marvin Cannon and Gary Young were project biologists for CEMVK.

ABSTRACT

Potential effects of flood damage reduction measures in the Yazoo Backwater Area, which encompasses the lower Big Sunflower River system, lower Steele Bayou system, and numerous tributaries and oxbow lakes, were quantified for 7 structural and 3 nonstructural plans. Baseline data on fishes were collected in representative habitats during spring and summer 1994 and supplemented with periodic sampling between 2002-2006. Juvenile and adult fishes were collected in the outlet channel of the Steele Bayou water control structure by hoop nets and in isolated and contiguous oxbow lakes of Delta National Forest by gill nets. Light traps were used to collect larval fishes in floodplain habitats upstream and downstream of the control structure, lakes of Delta National Forest, and floodplain of lower Big Sunflower River system.

Twenty-three species of juvenile/adult fishes were collected with gill or hoop nets. The numerically dominate groups of gar, gizzard shad, common carp, buffalo, catfish, crappie, and freshwater drum are characteristic of Mississippi delta fish assemblages. Species richness was highest below Steele Bayou structure, lowest in Delta National Forest Lakes. Flathead catfish and freshwater drum comprised almost 80% of the fish collected in the channel below Steele Bayou structure; gizzard shad, common carp, bigmouth buffalo, and white crappie were abundant in the borrow areas below the structure. Gar, bowfin, and bullheads were common in the Delta National Forest lakes. Overall, 57 species of fish were documented during the field study. There were no long-term (1993-2006) trends in mean species richness or total number of fish collected during the evaluation period. However, a reduction of intolerant fish species was noted over time, although this may have been related to different water years (low versus high water during sampling).

A total of 281 light trap samples collected 10,184 larval fishes representing 17 taxa. Species richness was highest in the fringing floodplain connected to the outlet/inlet channel of the structure. Abundant larval fishes in the floodplain were buffalo, white crappie, shad, freshwater drum, and sunfishes. Mean number of larval fish was highest in borrow areas below the structure (195 fish per trap, mostly sunfishes) and in Lake George (89 fish per trap, mostly buffalo). Black bass larvae were rare, except in an isolated section of a Delta National Forest lake where they were the dominant taxa. Mean dissolved oxygen ranged from 4-5 mg/l at all locations during sampling, but stratification occurred in the Delta National Forest Lakes and behind Steele Bayou Control Structure. Fish kills were noted behind the structure during July, 1994 and 1996 following prolonged flood events.

Habitat Evaluation Procedures were used to determine losses in floodplain spawning habitat for nine evaluation species. Within the two-year floodplain, agricultural fields and bottomland hardwood forests were the most common floodplain habitat. Plans that included non-structural flood-damage reduction (e.g., reforestation) resulted in a net gain in Average Annual Habitat Units (AAHU) for spawning of fishes. In addition, plans that hold water at higher elevations (Plans 2, 6, and 7) resulted in a net increase in AAHUs. The preferred alternative (Plan 5) without the influence of the Big Sunflower project had the least impacts of the remaining plans, and if implemented, will result in a net percent increase of spawning AAHU of 34.7% due to the added benefits of nonstructural reforestation. In addition, construction impacts of 38 acres of cleared BLH (26.6 HUs) will have to be mitigated. Mitigation can be accomplished through reforesting cleared lands or other techniques that provide spawning and rearing habitat in the floodplain. Elevating the water level in the pool behind the Steele Bayou Structure for extended periods was identified as an effective technique to maximize rearing and adult habitat for fishes.

INTRODUCTION

The Yazoo Backwater Area occurs between the east bank Mississippi River levee and Will M. Whittington Auxiliary Channel, and extends north into the lower reaches of the Steele Bayou and Big Sunflower Rivers. There are 135,300 average acres flooded within the two-year floodplain during spawning season (March 1 through June 30). The area is a ponding area, or floodplain ponding area, that receives water from Deer Creek, Steele Bayou, Big Sunflower River, and Little Sunflower River. Backwater effects extend into Steele Bayou and Little Sunflower sub-basins, which constitute two distinct hydraulic reaches. The Steele Bayou Flood Control Structure regulates water elevation in the ponding area. When the water elevation of the Yazoo River exceeds the gate elevation, the structure is closed to prevent further flooding into the ponding area. When the gates are closed, headwater floods from Steele Bayou and Big Sunflower River increase ponding area elevation that may persist through mid-summer. Measures to alleviate flooding in the backwater area are being studied by the Vicksburg District, Corps of Engineers. There were nine plans grouped into three categories that were evaluated:

a. Plan 1: No action, which was equivalent to baseline conditions.
b. Nonstructural plans (Plans 2, 2A-C): These plans exclude a pump station at the Steele Bayou structure, but include additional pooling of water during the summer (Plan 2 only); all include different levels of reforestation of agricultural land within the 2-year floodplain.
c. Structural plan (Plans 3): These plan include the construction of a pumping station with a maximum operating capacity of 14,000 cfs. Year-round pump elevation for Plan 3 is 80.0 ft NGVD.
d. Combination Plans (Plans 4-7). These include both nonstructural reforestation and construction of the pumping station. Year around pump elevations differ among the plans; Plan 4 – 85.0 ft; Plan 5 – 87.0 ft; Plan 6 – 88.5 ft; and Plan 7 – 91.0 ft.

There is concern that reduction of stage elevations on the floodplain associated with the Backwater Project may negatively impact fish habitat. Fish communities are a mixture of the Yazoo River system and Lower Mississippi River ichthyofaunas. Studies of the Mississippi River (Baker et al. 1991), Steele Bayou (Killgore and Hoover 1991), Upper Yazoo River (Killgore and Hoover 1993), and Big Sunflower River (Hoover and Killgore 1994) indicate that a diverse ichthyofauna can potentially utilize the floodplain for spawning and rearing. Many of these fishes undergo regular migrations to utilize inundated floodplains as spawning, nursery, and foraging areas (Guillory 1979, Ross and Baker 1983, Finger and Stewart 1987, Copp 1989, Scott and Nielson 1989), while others reside year-round in permanent pools and oxbow lakes on the floodplain (Lietman et al. 1991). For both types of fish, seasonally inundated floodplains provide additional feeding areas that coincide with periods of increased energetic needs for reproduction and growth (Whitaker 1977, de la Cruz 1978, Lambou 1990).

Reproduction of most wetland fishes is closely related to timing, extent, and duration of flooding, and annual variations in periodic flooding of rivers affects reproductive success and year-class strength of many species (Starrett 1951, Guillory 1979, Larson et al. 1981). Flow rate influences abundance of larval fish within different floodplain habitats (Turner et al. 1994) and contributes to downstream movement of ichthyoplankton (Harvey 1987, Copp and Cellot 1988), many of which may accumulate behind the Steele Bayou Control Structure. Lateral movements of adult fish on the floodplain, however, decrease exponentially with reductions in stage elevation (Kwak 1988). Spawning failure may occur if water levels remain low and population numbers are high (Starrett 1951). However, those waterbodies that are connected to main river channels, either continuously or during floods, could function as important fish nursery areas (Beecher et al. 1977; Dewey and Jennings 1992; Hoover et al. 1995).

This document describes potential impacts of the project on fish habitat. The objectives of our study were:

a. To describe baseline aquatic habitat and associated fish assemblages in the Yazoo Backwater Area.
b. To quantify changes in fish habitat associated with each project plan using the Habitat Evaluation Procedure (HEP).

METHODS

Field Studies

None of the project plans are expected to negatively impact aquatic habitat within river channels, because the pump-on elevation used by the structural plans exceeds the bank-full elevation for most of the study area. Therefore, evaluation of aquatic resources was confined to floodplain habitats and the area immediately associated with the proposed pump location. Field data were collected over a wide range of habitat conditions to provide:

a. expanded species lists and comprehensive characterization of the ichthyofauna
b. relative abundance of individual species
c. relationships between fish abundance and floodplain habitats

Fishes were sampled at three general locations that corresponded to peak abundance (during and immediately following spawning seasons), physically heterogeneous stations, and pronounced and progressive changes in physical habitat (summer declines in water level):

a. Lower Big Sunflower River. This area corresponded to the floodplain of the lower Big Sunflower River between Cypress Bend and Campbellville which included five habitats: bottomland hardwoods, agricultural land, fallow land, oxbow lake (Lake George), and tributary mouth (Silver Creek). Hardwoods and cleared lands were seasonally connected to the river; the oxbow lake and tributary mouth were permanently connected. Larval fishes were sampled March-June 1994 in each floodplain habitat. Based on field data from the upper Yazoo system, this period encompasses portions of two modes of total larval fish abundance, and portions of the spawning season for all evaluation species (Turner et al. 1994). In 1993-94, juvenile and adult fishes were sampled twice in the lower Big Sunflower River at three locations between Anguilla and immediately downstream of the entrance to Lake George (i.e., Poor Joe Larkin). The middle site, Choctaw, was sampled repeatedly over a 12-year period (1993-2006; n=5 spring samples, n=7 fall samples) and these data were used to evaluate temporal trends in species abundance while the overall project was being evaluated.

b. Steele Bayou Structure. This structure, at the downstream boundary of the Yazoo Backwater Project Area, is near the proposed pump location and could concentrate fishes in large numbers. The channel provides a route for the movement of adult fishes. Fringe floodplain habitats provide spawning and nursery grounds representative of the ponding area. Borrow areas that retain water during the summer are numerous along the levee. Therefore, composition of fishes that potentially occur throughout the project area were readily evaluated at this location. Adult and juvenile fish were sampled in the outlet channel downstream of the structure on 22-24 June 1994. Larval fish were sampled in the floodplain immediately above and below the structure April and May 1994. During June and July 1994 when the gates were closed, larval fish were sampled in fringing floodplains immediately upstream of the structure and in two borrow areas below the structure adjacent to the levee. Juvenile and adult fishes were sampled in spring 2002 and autumn 2003 immediately above the structure to evaluate fish communities in the pool.

c. Oxbow Lakes. There are approximately 180 permanent floodplain waterbodies in the project area that range in size from less than an acre to over 500 acres (excluding Eagle Lake). Most of these waterbodies are oxbow lakes that are either permanently isolated or seasonally connected to mainstem rivers. Larval fish were collected in two waterbodies from April-July 1994: Plaquemine Bayou and Howlett Bayou. Plaquemine Bayou, an oxbow lake of the Big Sunflower River in Sharkey County near Delta National Forest, is separated by a road into an isolated and a seasonally connected segment. Howlett Bayou, a tributary of the Little Sunflower River in the Delta National Forest, includes an isolated lake, Fish Lake, and a seasonally connected lake, Lost Lake. Each was concurrently sampled in April, May, and July to evaluate composition of larval fishes relative to degree of connectivity. Adult and juvenile fishes were sampled once in each lake during July 1994.

Slotted light traps (Killgore 1994) were used to collect larval fish; standard effort was 5-10 traps per site during each sampling event. Trap contents were poured through a 425 μm-mesh plankton net and field preserved in 5% formalin. Fishes were identified from trap samples to the lowest taxonomic category. Groups that are speciose (sunfish, minnows, darters) present special problems in that the larvae were difficult to identify to species with any reliability. For those taxa, specimens were identified to genus with the exception of *Cyprinella* and *Notropis,* collectively referred to as Cyprinids, and the darters *Etheostoma* and *Percids*. Fishes that exhibited fully differentiated fins were classified as juveniles. Larvae and juveniles were treated as separate taxa. Temporal trends in relative abundance of larval fish were expressed for each site, including oxbow lakes that are isolated and contiguous with the river.

Adult and juvenile fishes were collected with gillnets (90' X 6' with 0.75, 1.5, 2.0, 2.5, 3.0, 3.5" stretch mesh) and hoopnets (15' long, 3' diameter, 1" square mesh). Standard effort in oxbow lakes were overnight sets of 3 gillnets. Channel samples consisted of 10 hoopnets set overnight. All fish were measured for total length to the nearest mm and released. Species abundance was enumerated for each sample. To evaluate long-term trends in the lower Big Sunflower River, the five fish community metrics were calculated for each sample taken at Choctaw: number of species, total number collected, percent of individuals that are invertivores (i.e., specialized feeders), number of species classified as intolerant to habitat and water quality degradation according to Jester et al. 1992, and percent of individuals that prefer flowing water (i.e., rheophilic).

Concurrent with all fish collections, depth, dissolved oxygen, temperature, pH, and conductivity were measured using a Hydrolab or Cole-Palmer probes. Turbidity was measured with a Hach 2100P turbidimeter. Water depth was measured at 10 points along a cross-sectional transect in the channel, or at each trap location in floodplains, using a stadia rod (< 20 ft) or depth recorder.

Impact Analysis

The Habitat Evaluation Procedures (HEP) (USFWS, 1980) was used to quantify changes in fish spawning and rearing habitat for pre- and post-project conditions. Habitat Units (HUs), calculated by multiplying a Habitat Suitability Index (HSI) value ranging from 0.0 (unusable habitat) to 1.0 (optimum habitat) by a measurement of area (e.g., acres of flooded bottomland hardwood), were used to express the quality and quantity of fish habitat for different project plans.

The underlying assumption of this approach is that the abundance and distribution of evaluation species respond in a predictable fashion to changes in habitat quality defined by the variables in the HSI model. However, changes in HUs may not be directly associated with population density but areas with higher HUs are assumed to have potential to support more fish than areas with lower HUs.

Evaluation species were chosen from a guild to represent different habitat and reproductive preferences of the fish community in the Yazoo Backwater area. For the purposes of this analysis, a guild is a group of species that occupy the same habitat, have similar spawning preferences, and therefore, tend to be similarly impacted or benefited by a particular habitat change. The HEP Team recommended conducting a separate aquatic floodplain evaluation for spawning and rearing. Spawning, the deposition and incubation of eggs, has specific hydrologic requirements in the floodplain: duration of flooding must be 8 days and depth of flooding must be 1 foot. A minimum depth of 1 foot is considered necessary for adult fishes to move onto the floodplain. Duration of flooding is important for egg incubation since eggs can be stranded and desiccate if water levels drop before hatching. Incubation times range from 1-14 days for most Mississippi River fishes, but documented incubation times for most of the evaluation species are 8 days (Breder and Rosen 1966; Carlander 1969; Carlander 1977; Becker 1983; Robison and Buchanan 1988). A flood duration of 8 days then is environmentally conservative because it emphasizes longer development times, and provides a margin for temporal variation in spawning activities (adult movement onto the floodplain, nest construction and guarding, dispersal of fry). Rearing includes yolk-sac and post yolk-sac larval phases. Larval fish can potentially use any area of the inundated floodplain regardless of flood duration, so no hydrologic restrictions were used to delineate rearing habitat.

Floodplain acres were determined by reach using three criteria: defining the upper limit of the floodplain, incorporating variation in the hydroperiod during the spawning and rearing season within the defined floodplain, and calculating acres flooded for each floodplain habitat. A 2-year frequency flood was used to evaluate hydrology and land use of the floodplain for two primary reasons:

a. Most fish species reach sexual maturity at Age One or Two. Thus, a flood that typically occurs once every two years is considered necessary to maintain reproductive populations in the basin. The more extreme hydrologic events may result in higher fish abundance, but do not represent flooding regimes that maintain baseline population levels over the life of the project (i.e., 50 year project life).

b. The life span of small-sized species is 2-3 years and some may only reproduce once. Thus, a flood frequency less than 2-years may result in successive reproductive failures by species with short life spans. Flood frequencies greater than two years are an overestimate of the usable floodplain utilized by species with short life spans. Larger-sized species can live up to 10 years, but those that utilize floodplains to reproduce on an annual basis require regular flooding to maintain population integrity.

Flood frequency analysis provided a basis to select the 2-year flood using statistical principles found in Engineering Manual 1110-2-1415, titled "Engineering and Design-Hydrologic Frequency Analysis." The upper limit of the two-year floodplain was determined by compiling the maximum stage during a given year and ranking these values in descending order of magnitude. The median stage value (50^{th} percentile) of the ranked data corresponded to the upper limit of the 2-year frequency flood and this elevation was used as a maximum flood stage in subsequent analysis.

The Vicksburg District created a Geographical Information System (GIS) which utilized satellite imagery and other spatial information to delineate six floodplain habitats within the 2-year floodplain based on their position (e.g., river mainstem, floodplain), land use (e.g., agriculture, fallow), vegetation (e.g., bottomland hardwoods), permanence, and elevation (reference Appendix 6 for landuse classifications):

1. Seasonally inundated agricultural land,
2. Seasonally inundated fallow and herbaceous marsh land,
3. Seasonally inundated bottomland hardwoods,
4. Recently reforested lands within the 2-year floodplain with an average age of 10 years when project begins.
5. Oxbow lakes or other large (>1-acre) permanent waterbodies seasonally connected to the mainstem river,
6. Small, permanent backwaters (scatters, brakes, sloughs, and tributary mouths) seasonally connected to the mainstem river.

Impacts on floodplain acres were determined for each alternative. The Vicksburg District computed average acres flooded within the 2-year floodplain by habitat type for spawning (with hydraulic restrictions) and rearing (without hydraulic restrictions). The hydraulic restrictions for spawning habitat were defined by the HEP Team as: (a) a minimum 1 foot depth, (b) maximum 10 foot depth, and (c) a minimum flood duration of 8 days during the period 1 March through 30 June. There were no flood depth or duration restrictions on rearing habitat. Acres were determined without (B1) and with (B2) the influence of the Big Sunflower Maintenance Project to characterize cumulative impacts of these projects. This analysis was conducted over the period of record using a hydraulic program called EnviroFish. EnviroFish calculates average flooded acres using the period-of-record daily stages and the stage-area curve (see Engineering Appendix). Average acres flooded incorporate variations in the hydroperiod (onset, duration, and magnitude of flooding) and includes flood peaks within the 2-year floodplain.

HSI values were previously developed by consensus of an interagency team of biologists (Delphi technique) and, supplemented by field data and professional opinion of the authors of this document for the current evaluation. Professional opinion was based on field data and experience from a variety of projects in the lower Mississippi River Basin: 1993-1994, Yazoo Backwater, original Big Sunflower Maintenance Project, and Mississippi Delta Project (CEMVK); 1995-1996, Low Flow Study (Mississippi Department of Environmental Quality, MSDEQ); 1996, Delta Tributary Study; 2002-2003, Yazoo Basin Study (MSDEQ). HSI values for spawning and rearing were determined for each floodplain habitat, and the average HSI value for all evaluation species was used in the actual calculations of Habitat Units. Habitat Units were annualized (Average Annual Habitat Units, AAHUs) over the 54-year project life to account for construction (4 years) and project-induced stage reductions (50 years). Pre-project, or baseline conditions, were assumed to remain the same over the project life in terms of the extent of cleared and forested lands. Impacts were calculated as the difference between pre- and post-project AAHUs for each alternative.

RESULTS AND DISCUSSION

Baseline Habitat Conditions

The Yazoo Backwater area was engineered in the 1960's for flood control; channel improvements consisted of clearing, cleanout, and enlargement. The Steele Bayou water control structure was constructed to regulate interior water levels in the ponding area. Prior to flood control measures, the Yazoo delta was cleared for lumber. Over a hundred years of landuse changes have resulted in impaired streams and bayous. The existing aquatic resource is typical of delta streams in the lower Mississippi River valley. Littoral areas usually have soft, unconsolidated substrates, and instream cover is sparsely distributed. Sedimentation and the lack of riparian vegetation are often the major impediments to recovery of aquatic resources in the Yazoo delta. Turbidity is often high in the study area, with mean values ranging from 114 to 306 NTU. Mean dissolved oxygen ranged from 4-5 mg/l at all sampling locations, but stratification occurred in the Delta National Forest Lakes and behind Steele Bayou Control Structure. Stratification was most prevalent behind the closed structure due to stagnant conditions and high water temperatures. As summer progressed, the thermocline moved from approximately six feet below the water surface up to only 1-2 feet. During July of 1994 and 1996, fish kills were noted behind the structure.

Bottomland hardwood forests cover more than a third of the 2-year floodplain, and large continuous tracts occur in Delta National Forest. Agriculture is intensive and occupies over one third of the two-year floodplain. Most acreage is devoted to soybean cultivation, lesser acreage's are fallow and rice. Within the Yazoo Backwater Project Area, there are 135,300 average acres flooded within the 2-year floodplain. Floodplain habitats include seasonally inundated agricultural land, fallow land, and bottomland hardwoods. Permanent floodplain waterbodies include oxbow lakes, scatters, brakes, and tributary mouths.

Fish Community

Total number of fish known for the Yazoo drainage (delta and hills) is 123 (Ross 2002). A total of 81 species of fish have been collected in the delta of the Yazoo River system; 57 species were collected or observed in the Big Sunflower River system and Yazoo Backwater area (Table 1). Ichthyofauna is taxonomically dominated by minnows, sunfishes, and to a lesser extent, by catfishes and suckers. Most species collected in the Yazoo Backwater are considered "moderately tolerant" or "tolerant" of degraded water quality and habitat (Jester et al. 1992). This reflects high turbidities and hypoxic conditions characteristic of the system and previous alteration of the streams in the 1940's and 1950's (U.S. Army Engineers 1955).

Twenty-three species of juvenile/adult fishes were collected with gill or hoop nets overall (Table 2). Species richness was highest below Steele Bayou structure; lowest in Delta National Forest Lakes, particularly Plaquemine Lake. Flathead catfish and freshwater drum comprised almost 80% of the fish collected in the channel below Steele Bayou structure; gizzard shad, common carp, bigmouth buffalo, and white crappie were abundant in the floodplain below the structure. However, spotted and shortnose gars, bowfin, and bullheads were more common in the Delta National Forest Lakes above the structure. Buffalo were more common in connected lakes, whereas bowfin were more common in isolated lakes. Ranges of total lengths of fishes included sizes appropriate for commercial and recreational exploitation.

Repeated sampling at the Big Sunflower River near Choctaw indicated no significant differences ($p<0.05$; ANOVA with Student-Neuman-Keuls means comparison) among three sampling periods (1993-94, 2002-2003, 2005-2006) for three primary metrics that describe the overall fish community: species richness, total number collected, and percent of individuals that are specialized feeders (i.e., invertivores) (Table 3). However, number of intolerant species and percent of individuals that prefer flow (i.e., rheophilic) were significantly higher in the 1990's than the 2000's. Differences in water levels during time of sampling may account for some disparity.

A total of 281 light trap samples collected 10,184 larval fishes representing 17 taxa (Table 4). Species richness was relatively uniform, except at Steele Bayou Control structure. Number of species was highest in the fringing floodplain connected to the outlet/inlet channel of the structure but was lowest in borrow areas below the structure. Mean number of larval fish collected was also relatively uniform among sampling stations with a few exceptions. Mean number was considerably higher in borrow pits below the structure (195 fish) and in Lake George (89 fish). Mean number was lowest in Plaquemine Lake (6.9-10.2 fish) and in fallow fields (5.9 fish). Overall, species richness was relatively lower than comparable systems in the lower Mississippi River system (Finger and Stewart 1987; Killgore and Baker 1996).

Shad and crappie larvae were commonly collected at all sampling stations, although these species were most abundant in oxbow lakes. In the Big Sunflower floodplain, buffalo larvae were caught in the agricultural field, but were also most abundant in the oxbow lake. Buffalo were uncommon in the Delta National Forest Lakes and around the Steele Bayou Control Structure. These trends are supported by observations of buffalo spawning (Yeager 1936; Johnson 1963; Burr and Heidinger 1983) and by documented concentrations of larval crappie, offshore in deep water (Hoover et al. 1995).

Drum larvae exhibited similar trends, but were most common in the fallow field and bottomland hardwood forest of the Big Sunflower floodplain. However, freshwater drum larvae are not typically found in bottomland hardwoods. Eggs and protolarvae occur in upper levels of offshore waters, especially in reservoirs and pools; meso and meta-larvae occur near the bottom in main channels migrating to the surface at night or during high turbidity (Fremling 1978; Matthews 1984; Holland-Bartels et al. 1990; Dewey and Jennings 1992). Large numbers observed in Mississippi Delta hardwoods are believed to have resulted from an unusual hydrologic condition. In 1994, water pooled for a prolonged period (3 weeks) and at unusually high stages coinciding with this species' late April-early May spawning season (Pflieger 1977). We believe that spawning took place offshore in the old channel, and that larvae drifted inshore into adjacent bottomland hardwoods that experienced abnormally prolonged, and extensive flooding. Absence or low numbers of drum from other floodplain habitats may have resulted from different hydraulic conditions downstream or from lower population densities. Drum inhabit shallow shorelines, briefly, as small (20-40 mm) juveniles and seining data for 1993 (Hoover and Killgore 1994) suggest that drum are more abundant in the old channel (Cypress Bend) of the lower Big Sunflower than in the channelized reach (Holly Bluff cut-off). Abundance (per 10 seine hauls) of drum were:

	Big Sunflower River	
	Old Channel (near Choctaw Bayou)	Channelized River (Holly Bluff Cutoff)
9 May 93	0	0
2 Jun 93	61	0
29 Jun 93	11	1
20 Jul 93	0	0

Common carp larvae were moderately abundant in the Big Sunflower floodplain and below the structure. Sunfish (*Lepomis* sp.) larvae were collected at all sampling stations, but were the overwhelming dominant taxa in borrow areas below Steele Bayou structure. Black bass larvae were rare, except in the isolated section of Plaquemine lake where they were the dominant taxa. Darter larvae were also rare, except in Fish Lake where they comprised 7.4% of the total number of fish collected. All other taxa contributed less than 1.5% of the total individuals collected at any one particular sampling station.

Larval minnows are most common in tributary mouths indicating that these fishes prefer permanent water bodies adjacent to the river. In other systems, larval minnows are also more abundant in tributaries, close to the main channels (Dewey and Jennings 1992; Turner et al. 1994). Blacktail shiners are distinctive, however, as crevice spawners with complex mating and defensive behaviors (Heins 1990). Agricultural and fallow fields would not provide spawning habitat as favorable as bottomland hardwoods and tributary mouths that generally have an abundance of woody debris. We believe that larvae move into or remain in tributary mouths, or move out into the main channel. Tributaries and channels as rearing habitat for blacktail shiners are documented (Killgore and Baker 1996; Hoover et al. 1995).

Larval largemouth bass and flathead catfish were not collected. There is no evidence to suggest that black bass larvae prefer seasonally inundated floodplain (agricultural fields / bottomland hardwoods) as rearing habitat. Since largemouth bass are primarily a lentic species, they likely prefer permanent floodplain water bodies. A study of oxbow lakes in the Tallahatchie River (Killgore and Miller 1994) confirmed presence of black bass in this habitat, albeit at low densities. Based on the prevalence of small juvenile flathead catfishes in riffles (Carlander, 1969; Pflieger 1975; Robison and Buchanan 1988), it is presumed that larvae move into flowing water after absorbing the yolk-sac and that post-yolk sac larvae do not rear in the floodplain (R. Wallus, pers. comm.). Furthermore, flathead catfish spawn during the summer when the floodplain is not extensively inundated (Floyd et al. 1984; Holland-Bartels et al. 1990).

Fish spawned principally from March through June. Peak spawning of most species occurred in early or mid-April (shad, buffalo, crappie) and early and mid-May (drum, black bass, darters) when water temperatures ranged from 20-25 °C. Fishes that spawned in summer were primarily comprised of sunfishes, and to a lesser extent minnows. Appearance of individual taxa was similar among the three sampling locations (Big Sunflower floodplain, Delta National Forest Lakes, Steele Bayou Control Structure). Taxa that exhibited a punctuated, or short-term spawning strategy based on presence of larvae were buffalo, drum, and black bass; carp, shad, crappie, and sunfish had longer spawning periods.

Habitat Suitability Index Values

The 57 species of fish documented in the Yazoo Backwater were assigned to a guild based on reproductive strategy and habitat preference (Table 5). Reproductive strategy of fishes was defined according to Balon (1984), and included species that release floating eggs (i.e., pelagic spawners), and those that deposit demersal and often adhesive eggs over sand, gravel, and vegetation. Another category included species that hide their eggs in crevices. Habitat preference was delineated according to swiftwater and slackwater inhabitants. In addition, those species that tolerate a wide range of habitat conditions with no well-defined preference were placed into the "Generalist" guild. This arrangement resulted in 12 guild cells that represented the broad range of reproductive requirements and habitat preferences of the fish assemblage in the Yazoo Backwater.

The interagency HEP Team selected six evaluation species from the guild, and based on more recent fish collections in the Yazoo Delta, 3 additional species were selected to better represent the overall fish community that would be susceptible to project impacts. Overall, evaluation species represented greater than 80% of the taxa documented in the system

Evaluation species for the Yazoo Backwater Reformulation Project	
Threadfin shad, *Dorosoma petenense*	Channel catfish, *Ictalurus punctatus*
Blacktail shiner, *Cyprinella venusta*	Flathead catfish, *Pylodictis olivaris*
Ghost shiner, *Notropis buchanani*	White Crappie, *Pomoxis annularis*
Speckled chub, *Macrhybopsis aestivalis*	Freshwater drum, *Aplodinotus grunniens*
Smallmouth buffalo, *Ictiobus bubalus*	

All evaluation species were either numerically abundant in our collections(> 4.0% of total individuals) or are recreationally/commercially exploitable. All evaluation species can be potentially impacted from reduced floodplain inundation and loss of forested areas. Most evaluation species live in main channel environments as adults, but may move laterally onto the floodplain during spring and early summer to spawn or rear as larvae.

HSI scores for each evaluation species indicated a similar trend of increasing habitat value from cleared to forested lands (Table 6). Studies have confirmed that fishes in delta habitats preferentially occupy bottomland hardwood forests during seasonal inundation, and that larvae are more abundant in structurally complex habitats and permanent waterbodies (Hoover and Killgore 1998). Agricultural lands afforded minimal protection from predators and consequently had low spawning and rearing value for all evaluation species. Fallow fields had higher value for species that spawn and/or rear in floodplains. For example, smallmouth buffalo and minnows have been found to spawn over herbaceous cover typical of fallow fields or littoral areas of permanent waterbodies (Yeager 1936; Burr and Heidinger, 1983; Turner et al., 1994), and we assumed that ghost shiners may have a similar preference.

Species that spawn primarily in rivers (ghost shiners, speckled chubs) or in crevices along river banks (blacktail shiner, catfish) had lower spawning HSI values for seasonally inundated lands, but we assumed hardwood forests would provide greater value because of the availability of appropriate nesting substrates or structural features to construct crevices. Similar assumptions were made for white crappie, a species that constructs nests and defends developing eggs from predators. Freshwater drum and threadfin shad generally spawn in open river channels (Fremling 1978; Matthews 1984; Holland-Bartels et al. 1990; Dewey and Jennings 1992), so their HSI values for cleared lands are low. Both species can drift into bottomland hardwoods, however, where protection from predators is also greater than cleared lands.

Flooded bottomland hardwoods and permanent floodplain waterbodies had higher HSI values for spawning than cleared lands. Evaluation species that deposit eggs on flooded vegetation (smallmouth buffalo) or construct nests (white crappie, largemouth bass) may utilize cleared lands, but values are disproportionately lower when compared to permanent waterbodies and bottomland hardwood forests. Conversely, crevice spawning fishes (flathead catfish, blacktail shiner) require structurally complex habitats to successfully spawn and probably avoid cleared lands.

HSI values for rearing in cleared lands were also low (Table 6). Only invasive and ubiquitous species (shad and common carp) are commonly found in cleared lands (Hoover and Killgore 1998). Absence of cover, particularly in shallow water, makes fish more vulnerable to predation and possible stranding during receding water levels. Although fish may spawn in seasonally-inundated lands, larvae probably move into the river or permanent floodplain waterbodies that provide deeper water and structural complexity. Larval fish abundance generally coincides with the presence of vegetation, shade, submerged branches or other forms of structure (Wallus et al. 1990; Hoover and Killgore, 1998). Thus, permanent floodplain waterbodies (oxbow lakes, scatters, brakes, and tributary mouths) provided the highest habitat value for rearing although they were the least abundant.

Impact Analysis – Floodplain Habitat

Acreage of the six floodplain habitats was determined by multiplying land use percentages (see below) by the total flooded acres within the two-year floodplain for each plan. These acres were then multiplied by the corresponding HSI value for each evaluation species and annualized over the life of the project to determine indirect impacts. MVK provided 2005 land use that was used to delineate floodplain habitats between the one and two-year floodplain since this is the area that will be affected by the pump operation. Lands below the one year elevation will not be impacted by pump operation; however, changes in landuse will affect fisheries habitat (i.e. reforestation would improve fisheries habitat). The percentage of each land use category was multiplied by total acres (calculated by EnviroFish) to obtain acres of each landuse category. Landuse percentages are as follows:

Percent landuse applied to EnviroFish to determine acres by habitat type for the Yazoo Backwater Reformulation Project. Landuse between the 0 and 2-year floodplain was used for base conditions. Landuse between the 1 to 2-year floodplain was used for the structural alternatives since only this portion of the floodplain will be affected from hydraulic changes.

Plan	CAG	Fallow	BLH	Reforested	Oxbows	SBT
Base (0-2 year)	26.5	3.1	55.9	8.7	2.6	3.2
Alternatives (1-2 year)	37.0	4.7	50.2	7.8	0.1	0.2

CAG = Cultivated Agricultural Land
Reforested = Recently reforested lands
Fallow = Fallow fields
Oxbows = Oxbow Lakes
BLH = Bottomland hardwoods
SBT = Scatters, brakes, and tributary mouths

Reforested lands were comprised of bottomland hardwoods that averaged 10 years old. Based on the assumption that planted trees take 10 years to reach full functional maturity as fish rearing habitat, acres of existing reforested lands were multiplied by the BLH Habitat Suitability Index value to obtain AAHU for this category. An additional land use category, reforestation acres, was included in the final analysis. Reforestation Acres are a nonstructural component to reforest all cleared lands within the 2-year floodplain in addition to that required for fish mitigation.

EnviroFish uses depth and duration of flooded lands to evaluate project impacts on spawning habitat. Most fish have specific spawning requirements for spawning sites, whether those species construct nests (e.g., sunfishes), exploit existing crevices (e.g., catfish, some shiners), or broadcast their eggs with no parental care (e.g., buffalo). Requirements include minimum depth for adult movement and minimum duration for completion of embryo development, hatching, and dispersal of larvae before floodwaters recede. Hydrologic criteria used by EnviroFish to quantify "spawning habitat" in the Yazoo Backwater Project area were 1- ft minimum depth and 8-day flood duration. These criteria provide ample water and time for most species to successfully complete all stages of spawning.

Spawning habitat was considered "limiting" and impacts are based on the loss of those acreages. EnviroFish was developed specially to delineate spawning habitat because this life stage requires specific hydraulic conditions for eggs to survive. In contrast to spawning, most fish do not have specific hydrologic requirements for rearing. Deeper, persistent water, inclusive of spawning sites, is exploited for food (plankton, benthos) as is shallow, transient water for rapid growth (i.e., warmer water temperatures elevate larval fish metabolism). EnviroFish calculates flooded acres with no hydrologic requirements as "rearing habitat." Because rearing acres are more extensive than spawning acres (Tables 7 and 8) and are not hydraulically delineated, and because larval fish seek deeper water (indicated by high densities observed in the field), spawning habitat is considered "limiting' and impacts are based on those acreages.

Impacts on spawning (Table 7) habitat ranged from a net increase in AAHUs for Plans 2, 6, and 7, to a decrease for all structural and other combination plans. Impacts were slightly less once Big Sunflower Maintenance was completed. Impacts were greatest in the Little Sunflower reach because of its larger area and prevalence of bottomland hardwood forests. Similar trends were noted for rearing acres (Table 8). Plans that included non-structural flood-damage reduction (e.g., reforestation) resulted in a net gain in Average Annual Habitat Units (AAHU) for spawning of fishes. In addition, plans that hold water at higher elevations (Plans 2, 6, and 7) resulted in a net increase in AAHUs. The preferred alternative (Plan 5) without the influence of the Big Sunflower project had the least impacts of the remaining plans, and if implemented, will result in a net increase of spawning AAHU of 34.7% due to the added benefits of nonstructural reforestation. The construction impacts associated with the project are the clearing of 38 acres of trees at the pump site for Plans 3-7. This will result in a spawning loss of 26.6 AAHUs over the life of the project for each plan and will require mitigation.

Impact Analysis – Entrainment

Given the distribution of fish species in Steele Bayou, only a small percentage of the regionally available fish are likely to be in the waters above the structure in the periods of flooding when the pumps will be operating; that is, fish are widely distributed in the backwater area during flooding. Entrainment occurs when aquatic organisms, usually invertebrates or small fish, are moved through an intake structure where they could potentially be harmed or killed from pump impellers and excessive hydraulic forces. Impingement occurs when organisms, including adult fish, become trapped against the screening devices associated with pump intakes. The Corps acknowledges that entrainment may occur during operation of the pumps, but does not anticipate significant impacts to fish populations in the Project area for the reasons stated below. Impingement against the trash rack is also a possibility, but with a 6-inch wire mesh, most fish will either go through the rack into the pump or avoid the intake. Therefore, no significant adverse impacts are anticipated for impingement.

The type and operation of the pump indicates that entrainment will not be a major impact. The pump will draw water near the bottom of the sump, which is approximately 27 feet in total depth. Smaller, more entrainable fishes are usually found in the mid to upper water column where food and oxygen is more plentiful. The intake velocities are approximately 3 ft/sec. Most adult fishes, including minnows, have burst speeds of 3 ft/sec or greater that can be maintained for at least 30 seconds (Beamish 1978). In addition, most fish will avoid moving backwards in current (at the point of entrainment) and will exhibit burst swimming speeds to move out of the intake area if necessary.

For juvenile and larval fish that occur near the bottom of the forebay, entrainment is possible because of their weaker swimming ability. Based on previous sampling behind the Steele Bayou Control Structure, gizzard shad will be the primary species most susceptible to entrainment because they are locally abundant and their eggs and larvae are pelagic (Table 9). The impellers used for the 12 pumps are approximately 20-feet in diameter. Entrained organisms can be subjected to rapid changes in shear stress, pressure, acceleration, and turbulence. Reported mortality larvae through impellers or propellers range from less than 5% for turbine intakes (Cada 1990) to >75% for towboat propellers (Killgore et al. 2001). Eggs appear to be resistant to entrainment mortality, and larvae are only susceptible at small, developmental sizes (<15 mm).

Considering that the backwater pump impellers will be approximately 20-feet in diameter, and the rotations per minute will be relatively slow (120-130 rpm), physical forces (shear stress, acceleration-deceleration, turbulence) will be lower than those created by smaller and faster propellers/impellers associated with intakes and towboats. In addition, slower moving propellers have a reduced probability of striking or injuring a fish passing through. The outlet velocities will be approximately 12 ft/sec, but flows will quickly subside to around 3 ft/sec in the stilling pond. Those fish that move through the pump unharmed will travel into the stilling pond, through a connecting channel approximately ½-mile long, and into the Yazoo River. Given these reasons, it is assumed that entrainment mortality will be low, and if fish are impacted, gizzard shad will be the most susceptible species. Since gizzard shad are ubiquitous throughout the lower Mississippi Valley (Ross 2002), no impacts to their population integrity are anticipated.

Mitigation Requirements

The primary approach to mitigate unavoidable impacts is reforesting frequently flooded agricultural land. This approach can be used for restoration purposes. However, reforestation must consider a transition period during which trees are planted and allowed to grow to some level of maturity before this habitat can be considered functional bottomland hardwood forests. Therefore, an Average Annual Habitat Unit (AAHU) gained per acre of reforested land was determined for spawning (0.46) and rearing (0.46) (Table 10). Without reforestation is the HSI of agricultural land multiplied by the project life (50 years plus 4-years of construction). The transition is the midpoint between agricultural and BLH HSI values. The AAHU assumed that a 10-year transition period was necessary before reforested lands gained full functional capacity for spawning and rearing. The BLH HSI value was used for the remaining 40 years of the project life plus the four years of construction. These annualized values can be used to determine AAHUs gained for each reforested average flooded acre within the 2-year floodplain. Although reforesting cleared lands is one option to mitigate impacts, other techniques such as creation or restoration of small and large permanent waterbodies can be evaluated using the HSI scores in Table 6.

One of the key features of the project is to increase minimum water surface elevation in the pool behind Steele Bayou structure during the summer. Although not included as mitigation credit, the increased pool elevation will have substantial benefits to rearing fishes. The plan to hold water at an elevation of 73 feet, rather than 70 feet, during the summer will pool water in an additional 34 miles of channel and create 1458 acres (or 11,429 acre-feet) of aquatic habitat that would otherwise not occur without project. Considering that the majority of habitat inundated from an increased stage elevation is bottomland hardwoods, an additional 1020 and 1166 HU's will occur for spawning and rearing habitat, respectively. Additional water during the summer will be particularly important for spawning and rearing fishes that reproduce late in the season (e.g., sunfish and minnows), and will provide prolonged habitat for juvenile and adults fishes. At least 24 species of juvenile and adult fish have been documented behind the structure (Table 9), and we have observed large aggregations of paddlefish, a state-protected species, in the pool. A summer pool will enhance feeding and growth opportunities for larger fish such as buffalo, paddlefish, white bass, and crappie, and serve as a refugia for all species during periods of low water.

LITERATURE CITED

Baker, J.A., K.J. Killgore, and R.L. Kasul. 1991. Aquatic habitats and fish communities in the lower Mississippi River. Reviews in Aquatic Sciences 3: 313-356.

Beamish, F. W. H. Swimming Capacity. 1978. Fish Physiology, Vol. VII. Academic Press. Pages 101-187.

Becker, G.C. 1983. Fishes of Wisconsin. The University of Wisconsin Press, Madison, Wisconsin.

Beecher, H.A., W.C. Hixson, and T.S. Hopkins. 1977. Fishes of a Florida oxbow lake and its parent river. Florida Scientist 40: 140-148.

Breder, C.M., Jr. and D.E. Rosen. 1966. Modes of reproduction in fishes. Natural History Press, Garden City, New Jersey. 941 pp.

Burr, B.M. and R.C. Heidinger. 1983. Reproductive behavior of the bigmouth buffalo *Ictiobus cyprinellus* in Crab Orchard Lake, Illinois. Amer. Midl. Nat. 110: 220-221.

Cada, G. F. 1990. A review of studies relating to the effects of propeller-type turbine passage on fish early life stages. North American Journal of Fisheries Management 10: 418-426.

Carlander, K.D. 1969. Handbook of freshwater fishery biology I: Life history data on freshwater fishes of the United States and Canada, exclusive of the Perciformes. Iowa State University Press, Ames, 752 pp.

Carlander, K.D. 1977. Handbook of freshwater fishery biology, Volume Two. The Iowa State University Press, Ames, Iowa.

Copp, G.H. 1989. The habitat diversity and fish reproductive function of floodplain ecosystems. Environmental Biology of Fishes 26:1-27.

Copp, G.H. and B. Cellot. 1988. Drift of embryonic and larval fishes, especially *Lepomis gibbosus*, in the upper Rhone River. Journal of Freshwater Ecology 4:419-424.

de la Cruz, A.A. 1978. Production and transport of detritus in wetlands. p. 162-174. *In* P.E. Greeson, J.R. Clar, and J.E Clark (eds.) Wetland Functions and Values: The State of Our Understanding. American Water Research Association, Minneapolis, MN, USA.

Dewey, M.R. and C.A. Jennings. 1992. Habitat use by larval fishes in a backwater lake of the upper Mississippi River. J. Freshwat. Ecol. 7: 363-372.

Finger, T.R. and E.A. Stewart. 1987. Response of fishes to flooding regime in lowland hardwood wetlands. p. 86-92. *In* W.J. Matthews and D.C. Heins (eds.) Community and Evolutionary Ecology of North American Stream Fishes. University of Oklahoma Press, Norman, OK, USA.

Floyd, K.B., R.D. Hoyt, and S. Timbrook. 1984. Chronology of appearance and habitat partitioning by stream larval fishes. Trans. Amer. Fish. Soc. 113: 217-223.
Fremling, C.R. 1978. The freshwater drum, *Aplodinotus grunniens* Rafinesque - laboratory manual. Nasco, Fort Atkinson. 46 pp.

Guillory, V. 1979. Utilization of an inundated floodplain by Mississippi River fishes. Florida Scientist 42:222-228.

Harvey, B.C. 1987. Susceptibility of young of the year fishes to downstream displacement by flooding. Transactions of the American Fisheries Society 116:851-855.

Heins, D.C. 1990. Mating behaviors of the blacktail shiner, *Cyprinella venusta*, from southeastern Mississippi. Proc. Southeastern Fishes Council #21: 5-7.

Holland-Bartels, L.E., S.K. Littlejohn, and M.L. Huston. 1990. A guide to larval fishes of the upper Mississippi River. U.S. Fish and Wildlife Service, La Crosse, 107 pp.

Hoover, J.J. and K.J. Killgore. 1994. Impacts of the Big Sunflower River maintenance project on fishes and fish habitat. Completion report submitted to the US Army Corps of Engineers, Vicksburg District, 35 pp.

Hoover, J.J., K.J. Killgore, and M.A. Konikoff. 1995. Larval fish dynamics in a riverine wetland of the lower Mississippi Basin. Technical Report WRP-SM-10, US Army Engineers Waterways Experiment Station, Vicksburg, MS.

Hoover, J.J. and K.J. Killgore. 1998. Fish communities. Chapter 10 *(pp. 237-260) In* M.G. Messina and W.H. Conner (eds): Southern Forested Wetlands, CRC Press, Boca Raton, FL.

Jester, D.B., A.A. Echelle, W.J. Matthews, J. Pigg, C.M. Scott, and K.D. Collins. 1992. The fishes of Oklahoma, their gross habitats, and their tolerance of degradation in water quality and habitat. Proc. Okla. Acad. Sci. 72: 7-19.

Johnson, R.P. 1963. Studies on the life history and ecology of the bigmouth buffalo, *Ictiobus cyprinellus* (Valenciennes). J. Fish. Res Bd. Can. 20: 1397-1429.

Killgore, K.J. 1994. Design and application of a larval fish trap. WRP Technical Note FW-EV-3.1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Killgore, K.J. And J.A. Baker. 1996. Patterns of larval fish abundance in a bottomland hardwood wetland. Wetlands 16: 288-295.

Killgore, K.J. and J.J. Hoover. 1991. Evaluation of Aquatic Resources associated with the Steele Bayou System Flood Control Project. Appendix 10 in Reformulation Report, Steele Bayou Projects, US Army Engineer District, Vicksburg.

Killgore, K.J., and J.J. Hoover. 1993. Evaluation of Aquatic Resources Associated with the Upper Yazoo River Reformulation Project. Appendix 10, Reformulation Report, Volume III, Upper Yazoo Projects Reformulation Study, US Army Corps of Engineers, Vicksburg District, Vicksburg, Miss.

Killgore, K.J., and G.L. Miller. 1995. Larval fish dynamics in oxbow lakes with varying connections to a temperate river. Technical Report WRP- SM-11. US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Killgore, K. J., S. T. Maynord, M. D. Chan, and R. P. Morgan II. 2001. Evaluation of propeller-induced mortality on early life stages of selected fish species. North American Journal of Fisheries Management 21: 521-529.

Kwak, T.J. 1988. Lateral movement and use of floodplain habitat by fishes of the Kankakee River, Illinois. Am. Midl. Nat. 120: 241-249.

Lambou, V.W. 1990. Importance of bottomland hardwood forest zones to fish and fisheries: the Atchafalaya basin, a case history. p. 125-193. *In* J.G. Gosselink, L.C. Lee, and T. A. Muir (eds.) Ecological Processes and Cumulative Impacts:Illustrated by Bottomland Hardwood Wetland Ecosystems. Lewis Publishers, Chelsea, MI, USA.

Larson, J.S., M.S. Bedinger, C.F. Bryan, S. Brown, R.T. Huffman, E.L. Miller, D.G. Rhodes, and B.A. Touchet. 1981. Transition from wetlands to uplands in southeastern bottomland hardwood forests. p. 225-273. *In* J.R. Clark and J. Benforado (eds.). Wetlands of Bottomland Hardwood Forests. Developments in Agricultural and Managed-forest Ecology, vol. 11. Elsevier Science Publishing Company, New York, NY, USA.

Leitman, H.M., M.R. Darst, and J.J. Nordhaus. 1991. Fishes in the forested flood plain of the Ochlockonee River, Florida, during flood and drought conditions. Water Resources Investigation Report 90-4202, U.S. Geol. Surv., Tallahassee. 38 pp.

Matthews, W.J. 1984. Influence of turbid inflows on vertical distribution of larval shad and freshwater drum. Trans. Amer. Fish. Soc. 113: 192-198.

Parker, W. and D.D. Robison. 1972. Pollution studies on Big Sunflower River, Little Sunflower River, and Deer Creek in Mississippi. Completion Report, Projects F-9- 14, 22, 12. 51 pp.

Pflieger, W.L. 1975. The Fishes of Missouri. Missouri Department of Conservation, Jefferson City, 343 pp.

Robison, H.W. and T.M. Buchanan. 1988. Fishes of Arkansas. University of Arkansas Press, Fayetteville. 536 pp.

Ross, S.T. and J.A. Baker. 1983. The response of fishes to periodic spring floods in a southeastern stream. Am. Midl. Nat, 109: 1-14.

Ross, S.T. 2002. Inland Fishes of Mississippi . University Press of Mississippi, 623 pp.

Scott, M.T. and L.A. Nielsen. 1989. Young fish distribution in backwaters and main channel borders of the Kanawha River, West Virginia. Journal of Fish Biology 35:21-27.

Starrett, W.C. 1951. Some factors affecting the abundance of minnows in the Des Moines River, Iowa. Ecology 32:13-27.

Turner, T.F., J.C. Trexler, G.L. Miller, and K.E. Toyer. 1994. Temporal and spatial dynamics of larval and juvenile fish abundance in a temperate floodplain river. Copeia 1994: 174-183.

Wallus, R., T.P. Simon, and B.L. Yeager. 1990. Reproductive biology and early life history of fishes in the Ohio River drainage. Vol. I: Acipenseridae through Esocidae. Tennessee Valley Authority, Chattanooga, TN, 273 pp.

Whitaker, J.O., Jr. 1977. Seasonal changes in food habits of some cyprinid fishes from the White River at Petersburg, Indiana. American Midland Naturalist 97:411-418.

U.S. Army Corps of Engineers. 1955. General design memorandum No. 1: Big Sunflower, Little Sunflower, Hushpuckena, and Quiver Rivers and their tributaries, and Deer Creek, Steel Bayou, and Bogue Phalia, Mississippi. Vicksburg District, Vicksburg, MS.

USFWS, 1980. Habitat evaluation procedures. ESM 102, U.S. Fish and Wildlife Service, Washington, DC.

Yeager, L.E. 1936. An observation on spawning buffalofish in Mississippi Copeia 1936: 238-39.

Table 1. Larval, juvenile, and adult fishes of the Yazoo Backwater Project Area compared to juvenile/adult fishes of Upper Yazoo River System (Killgore and Hoover, 1993). Larval fishes were collected on the floodplain of the lower Big Sunflower River, floodplain and borrow pits adjacent to the Steele Bayou Control structure, and oxbow lakes in Delta National Forest. Adult and juvenile fishes were collected in the channel of lower Big Sunflower River, outlet channel below Steele Bayou Control Structure, and oxbow lakes in Delta National Forest. The symbol '+' indicates that the species was collected.

Common and Scientific Names	Yazoo Backwater		Upper Yazoo River
	Larval Fish	Adult and Juvenile Fish	
Family Petromyzontidae, lampreys			
Ichthyomyzon castaneus, chestnut lamprey			+
Family Polyodontidae, paddlefishes			
Polyodon spathula, paddlefish		+	+
Family Lepisosteidae, gars			
Lepisosteus oculatus, spotted gar	+	+	+
L. osseus, longnose gar		+	+
L. platostomus, shortnose gar	+	+	+
Family Amiidae, bowfins			
Amia calva, bowfin		+	+
Family Anguillidae, freshwater eels			
Anguilla rostrata, American eel		+	+
Family Clupeidae, herrings			
Dorosoma cepedianum, gizzard shad	+	+	+
D. petenense, threadfin shad	+	+	+
Family Hiodontidae, mooneyes			
Hiodon alosoides, goldeye			+
H. tergisus, mooneye			+
Family Cyprinidae, carps and minnows			
Ctenopharyngodon idella, grass carp		+	
Cyprinella camura, bluntface shiner			+
C. lutrensis, red shiner		+	+
C. venusta, blacktail shiner		+	+
Cyprinus carpio, common carp	+	+	+
Hybognathus nuchalis, silvery minnow			+
Hypophthalmichthys nobilis, bighead carp		+	
Luxilis chrysocephalus, striped shiner			+
Lythrurus umbratilis, redfin shiner			+
Macrohybopsis aestivalis, speckled chub		+	+
M. storeriana, silver chub			+
Notemigonus crysoleucas, golden shiner	+	+	+
Notropis atherinoides, emerald shiner		+	+
N. buchanani, ghost shiner		+	+
N. rafinesquei, Yazoo shiner			+
N. sabinae, Sabine shiner			+
N. shumardi, silverband shiner			+
N. volucellus, mimic shiner		+	+
Opsopoeodus emiliae, pugnose minnow		+	+
Pimephales notatus, bluntnose minnow			+
P. promelas, fathead minnow		+	
P. vigilax, bullhead minnow		+	+
Notropis sp., minnow/shiner	+		

Table 1. Continued

Common and Scientific Names	Yazoo Backwater Larval Fish	Yazoo Backwater Adult and Juvenile Fish	Upper Yazoo River
Family Catostomidae, suckers			
Carpiodes carpio, river carpsucker		+	+
Carpiodes velifer, highfin carpsucker			
Cycleptus elongatus, blue sucker		+	+
Ictiobus bubalus, smallmouth buffalo		+	+
I. cyprinellus, bigmouth buffalo		+	+
I. niger, black buffalo		+	+
Ictiobus sp., buffalo	+		
Moxostoma poecilurum, blacktail redhorse			+
Family Ictaluridae, bullhead catfishes			
Ameiurus melas, black bullhead		+	+
A. natalis, yellow bullhead		+	+
Ictalurus furcatus, blue catfish		+	+
I. punctatus, channel catfish		+	+
Noturus gyrinus, tadpole madtom		+	+
N. nocturnus, freckled madtom		+	+
Pylodictis olivaris, flathead catfish		+	+
Family Esocidae, pikes			
Esox americanus, grass pickerel		+	+
Esox niger, chain pickerel			
Family Aphredoderidae, pirate perches			
Aphredoderus sayanus, pirate perch	+	+	+
Family Cyprinodontidae, killifishes			
Fundulus chrysotus, golden topminnow		+	+
F. dispar, starhead topminnow			+
F. notatus, blackstripe topminnow		+	+
F. olivaceus, blackspotted topminnow			+
Fundulus sp., topminnow	+		
Family Poeciliidae, livebearers			
Gambusia affinis, mosquitofish		+	+
Family Atherinidae, silversides			
Labidesthes sicculus, brook silverside			+
Menidia beryllina, inland silverside		+	+
Unidentified silverside	+		
Family Percichthyidae, temperate basses			
Morone chrysops, white bass	+	+	+
M. saxatilis, striped bass			+
Family Centrarchidae, sunfishes			
Centrarchus macropterus, flier	+	+	+
Elassoma zonatum, banded pygmy sunfish	+	+	+
Lepomis cyanellus, green sunfish		+	+
L. gulosus, warmouth		+	+
L. humilis, orangespotted sunfish		+	+
L. macrochirus, bluegill		+	+
L. marginatus, dollar sunfish		+	+
L. megalotis, longear sunfish		+	+
L. microlophus, redear sunfish			+
L. punctatus, spotted sunfish		+	+
L. symmetricus, bantam sunfish		+	+
Lepomis sp., unidentified sunfish	+		
Micropterus punctulatus, spotted bass			+
M. salmoides, largemouth bass		+	+
Pomoxis annularis, white crappie	+	+	+
P. nigromaculatus, black crappie	+	+	+

Table 1. Concluded.

Common and Scientific Names	Yazoo Backwater Larval Fish	Yazoo Backwater Adult and Juvenile Fish	Upper Yazoo River
Family Percidae, perches			
Etheostoma asprigene, mud darter			+
E. caeruleum, rainbow darter			+
E. chlorosomum, bluntnose darter		+	+
E. fusiforme, swamp darter		+	
E. gracile, slough darter		+	+
E. whipplei, redfin darter			+
*Etheostoma_* sp.			
Percina sciera, dusky darter			+
Stizostedion canadense, sauger			+
Unidentified percids	+		
Family Sciaenidae, drums			
Aplodinotus grunniens, freshwater drum	+	+	+
Total Number of Species	19	57	77

Table 2. Relative abundance of large fishes collected with gill nets and hoop nets in the Yazoo Backwater Project Area during summer 1994. Values are percentages of total number collected by gillnets (n=3 per site) and hoopnets (n=20 only in channel below structure). Size range of fishes (total length in mm)are indicated in parentheses. The outlet channel and borrow pit connected to the channel were sampled below Steele Bayou Structure. Lakes sampled above the structure were in or adjacent to the Delta National Forest.

	Below Structure		Above Structure			
	Channel	Borrow Pit	Fish Lake (isolated)	Lost Lake (connected)	Plaquemine (isolated)	Plaquemine (connected)
Paddlefish						
Paddlefish (245-805)	<1.0					
Gars						
Spotted gar (373-600)			25.0	13.7		
Longnose gar (470-1000)	<1.0					
Shortnose gar (347-723)	4.4	1.8		2.0		15.4
Bowfins						
Bowfin (166-628)	<1.0	1.8	25.0	9.8		
Herrings						
Gizzard shad (130-464)	1.2	21.8		17.6	71.0	
Carps and minnows						
Bighead carp (675)		1.8				
Common carp (447-750)	1.6	14.5	16.7	5.9	14.3	
Suckers						
Smallmouth buffalo(192-581)	3.2	1.8	8.3	33.3		7.7
Bigmouth buffalo (425-626)		12.7	8.3	3.9		61.5
Black buffalo (302-645)		5.5		2.0		
Bullhead catfishes						
Black bullhead (214-320)	<1.0	1.8	8.3	2.0	14.3	
Yellow bullhead (190-339)	<1.0			3.9		
Blue catfish (190-675)	1.6					
Channel catfish (204-535)	6.4					
Flathead catfish (212-993)	41.8					
Sunfishes						
Warmouth (140-200)		7.3				
Bluegill (176)		1.8				
Spotted sunfish (185-395)	1.8			2.0		
White crappie (117-380)		20.0		2.0		
Black crappie (129-204)		3.6	8.3			
Largemouth bas (332)		1.8				
Drums						
Freshwater drum (155-575)	36.7			2.0		15.4
Total number of fish	251	55	12	51	7	13
Number of species	13	15	7	13	3	4

Table 3. Summary of fish community metrics over three different periods of sampling at the Big Sunflower River at Choctaw Landing immediately upstream of the Holly Bluff cutoff. Metrics are average values for number of species (richness), total number collected, percent abundance of invertivores, number of intolerant species, and percent abundance of flow dependent (rheophilic) species.

PERIOD	Variable	Mean	Std Dev	Minimum	Maximum
1993-94	RICHNESS	10.13	4.12	4.00	16.00
(N=8)	TOTAL NO	306.38	422.17	48.00	1288.00
	INVERTIVORES	0.26	0.23	0.03	0.64
	INTOLERANTS	5.63	0.52	5.00	6.00
	RHEOPHILS	0.20	0.27	0.00	0.65
2002-03	RICHNESS	11.50	4.95	8.00	15.00
(N=2)	TOTAL NO	325.00	5.66	321.00	329.00
	INVERTIVORES	0.45	0.58	0.04	0.86
	INTOLERANTS	2.00	1.41	1.00	3.00
	RHEOPHILS	0.79	0.29	0.59	1.00
2005-06	RICHNESS	13.50	3.54	11.00	16.00
(N=2)	TOTAL NO	404.00	190.92	269.00	539.00
	INVERTIVORES	0.23	0.23	0.06	0.39
	INTOLERANTS	3.50	0.71	3.00	4.00
	RHEOPHILS	0.54	0.12	0.46	0.63

Table 4. Relative abundance of larval fishes collected in the Yazoo Backwater Project Area during spring and summer 1994. Values are percentages of total number collected by light traps at the designated site. Sample size is the number of light traps fished overnight.

Taxa	Big Sunflower Floodplain					Delta National Forest				Steele Bayou Control Structure			
	Agfield n=20	Fallow n=24	BLH n=28	Trib Mouth n=30	Oxbow (Lake George) n=28	Fish Lake (isol.) N=20	Lost Lake (conn.) N=20	Plaq. Lake (isol.) n=20	Plaq. Lake (conn.) N=20	Above Dam n=21	Below Dam n=20	Borrow Pit (isol.) n=20	Borrow Pit (conn.) n=10
Shortnose Gar										<1.0			
Spotted Gar										<1.0	<1.0		
Shad	17.1	30.5	23.3	32.1	1.5	<1.0	14.5		21.2	70.4	39.6	1.4	2.9
Common carp	3.8	7.1	3.9	4.5	<1.0		2.2		1.0	2.7	12.5		
Golden shiner							<1.0		1.5	<1.0	1.5		
Buffalo	72.5	5.7	16.3	34.7	77.6		<1.0		7.9	1.9	<1.0		
Topminnows						<1.0					<1.0		
Pirate perch										<1.0			<1.0
Silversides											<1.0		
White bass									<1.0	<1.0			
Flier						<1.0				<1.0	<1.0		
B.P. Sunfish						<1.0		<1.0					
Lepomis sp.	1.4	12.8	15.4	9.1	1.6	6.0	41.0	<1.0	4.9	<1.0	14.8	98.1	95.6
Black bass						<1.0	5.3	48.9	1.0		1.5		
Crappie	2.3	14.2	5.0	7.1	19.0	84.3	34.4	49.6	59.1	22.5	25.6		
Darters						7.4	<1.0			<1.0	1.0		
Drum	2.9	29.8	36.0	8.6					3.0				
Unidentified	2.9	29.8	<1.0	3.7		<1.0	1.3				1.4	<1.0	1.4
Total number of individuals	444	141	773	616	2497	517	641	137	203	670	480	1114	1951
Number of Taxa	6	6	6	6	5	8	8	4	9	12	12	2	3
Mean ± SE	22.2 ±8.3	5.9 ±1.2	27.6 ±6.5	20.5 ±5.4	89.2 ±28.0	25.9 ±8.3	32.1 ±5.0	6.9 ±2.2	10.2 ±4.3	31.9 ±9.6	24.0 ±3.7	55.7 ±22.9	195.1 30.5

Table 5. Habitat guilds for fishes of the Yazoo Backwater. Guilds are determined by substrates used in reproduction (vertical axis) and characteristic water velocities used by juveniles and adults (horizontal axis). Evaluation species are underlined.

	LACUSTRINE/GENERALISTS	SLACK WATER	SWIFT WATER
PELAGIC	Gizzard Shad Mosquitofish	Threadfin shad Cypress minnow Silvery minnow	Bighead carp Grass carp Emerald shiner Mimic shiner Freshwater drum
SAND & GRAVEL	Red shiner Green sunfish Orangespotted sunfish Bluegill Largemouth bass White crappie Black crappie	Ghost shiner Pugnose shiner River carpsucker Golden topminnow Flier Banded pygmy sunfish Longear sunfish Warmouth Bantam sunfish	Paddlefish Speckled chub White bass
VEGETATION	Bowfin Common carp Golden shiner	Spotted gar Shortnose gar Grass pickerel Smallmouth buffalo Bigmouth buffalo Blackstripe topminnow Blackspotted topminnow Inland silverside Bluntnose darter Swamp darter Slough darter	Longnose gar Black buffalo
CREVICE	Bullhead catfish Black bullhead Yellow bullhead Channel catfish	Blue catfish Tadpole madtom Flathead catfish Pirate perch	Blacktail shiner Freckled madtom

Table 6. Floodplain HSI scores for spawning (S) and rearing (R) of fish in the Yazoo Backwater.										
EVALUATION SPECIES	FLOODPLAIN HABITATS									
	CAG		Fallow		BLH		Oxbow		SBT	
	S	R	S	R	S	R	S	R	S	R
Threadfin shad	0.2	0.2	0.4	0.1	0.8	0.5	0.8	1.0	0.7	0.8
Blacktail shiner	0.1	0.2	0.2	0.5	0.8	0.8	0.9	1.0	1.0	1.0
Ghost shiner	0.2	0.3	0.2	0.6	0.8	0.8	1.0	1.0	1.0	1.0
Speckled chub	0.1	0.2	0.4	0.7	0.8	1.0	0.6	0.8	0.7	0.7
Smallmouth buffalo	0.3	0.3	0.8	0.5	0.9	0.8	1.0	1.0	1.0	0.8
Channel catfish	0.1	0.2	0.2	0.4	0.7	0.7	1.0	1.0	1.0	1.0
Flathead catfish	0.1	0.1	0.2	0.2	0.7	0.7	0.8	0.8	1.0	1.0
White crappie	0.4	0.2	0.6	0.4	0.7	0.7	1.0	1.0	1.0	0.8
Freshwater drum	0.1	0.1	0.2	0.6	0.5	0.5	0.8	1.0	0.8	1.0
Average for all species	**0.2**	**0.3**	**0.3**	**0.4**	**0.7**	**0.8**	**0.8**	**0.9**	**0.9**	**0.9**

CAG = Cultivated Agricultural Land
Fallow=Fallow fields
BLH = Bottomland hardwoods
Oxbow = Oxbow lakes
SBT = Scatters, Brakes, and tributary mouths

Table 7. Hydrologic impacts of structural plans for the Yazoo Backwater Area Reformulation Study with and without the influence of the Big Sunflower River Flood Control Project on fish **SPAWNING** habitat. Average Annual Habitat Units (AAHU) were annualized over the life of the project (54 years) assuming a 4-year construction period. Values with plus sign indicate that plan will have a net increase in flooded acres or AAHU and no mitigation is required. Reforestation Acres are a nonstructural component to reforest all cleared lands within the 2-year floodplain in addition to that required for fish mitigation. Net change is the percent change in AAHU from nonstructural reforestation relative to baseline AAHU and without mitigation.

Alternative	Reach	Acres	AAHU	Loss of Acres	Loss of AAHU	Reforestation Acres	Reforestation AAHU	Net Percent Change in AAHU
				WITHOUT BIG SUNFLOWER				
BASELINE	**Steele**	11637	6595	0	0			
(Plan 1)	**Little Sunflower**	22485	12742	0	0			
	Total	**34122**	**19337**	**0**	**0**	**0**	**0**	**0.0**
Plan 2	Steele	11637	6595	0	0			
	Little Sunflower	22485	12742	0	0			
	Total	**34122**	**19337**	**0**	**0**	**40299**	**18538**	**95.9**
Plan 2A	Steele	11637	6595	0	0			
	Little Sunflower	22485	12742	0				
	Total	**34122**	**19337**	**0**	**0**	**26370**	**12130**	**62.7**
Plan 2B	Steele	6284	4034	5353	2561			
	Little Sunflower	13491	8439	8994	4303			
	Total	**19775**	**12473**	**14347**	**6864**	**8552**	**3934**	**-15.2**
Plan 2C	Steele	11637	6595	0	0			
	Little Sunflower	22485	12742	0	0			
	Total	**34122**	**19337**	**0**	**0**	**37060**	**17048**	**88.2**
Plan 3	Steele	4956	3399	6681	3196			
	Little Sunflower	12881	8147	9604	4595			
	Total	**17837**	**11546**	**16285**	**7791**	**0**	**0**	**-40.3**
Plan 4	Steele	8530	5109	3107	1486			
	Little Sunflower	17129	10179	5356	2563			
	Total	**25659**	**15288**	**8463**	**4049**	**12051**	**5543**	**7.7**
Plan 5	Steele	10182	5899	1455	696			
	Little Sunflower	20637	11857	1848	885			
	Total	**30819**	**17757**	**3303**	**1580**	**18012**	**8286**	**34.7**
Plan 6	Steele	11571	6564	66	31			
	Little Sunflower	22549	12772	+64	+30			
	Total	**34120**	**19336**	**2**	**1**	**26370**	**12130**	**62.4**
Plan 7	Steele	12610	7061	+973	+466			
	Little Sunflower	24340	13629	+1855	+887			
	Total	**36950**	**20690**	**+2828**	**+1353**	**40299**	**18538**	**102.9**
				WITH BIG SUNFLOWER				
BASELINE	Steele	11637	6595	0	0			
(Plan 1)	Little Sunflower	21689	12291	0	0			
	Total	**33326**	**18886**	**0**	**0**	**0**	**0**	**0.0**
Plan 2	Steele	11637	6595	0	0			
	Little Sunflower	21689	12291	0	0			
	Total	**33326**	**18886**	**0**	**0**	**40299**	**18538**	**98.2**
Plan 2A	Steele	11637	6595	0	0			
	Little Sunflower	21689	12291	0	0			
	Total	**33326**	**18886**	**0**	**0**	**26370**	**12130**	**64.2**

Table 7. (Concluded)

Alternative	Reach	Acres	AAHU	Loss of Acres	Loss of AAHU	Reforestation Acres	Reforestation AAHU	Net Percent Change in AAHU
				WITH BIG SUNFLOWER				
Plan 2B	Steele	6284	4034	5353	2561			
	Little Sunflower	13013	8591	8676	4151			
	Total	**19297**	**12625**	**14029**	**6711**	**8552**	**3934**	**-14.7**
Plan 2C	Steele	11637	6595	11637	6350			
	Little Sunflower	21689	12291	21689	11836			
	Total	**33326**	**18886**	**0**	**0**	**37060**	**17048**	**90.3**
Plan 3	Steele	4956	3399	6681	3196			
	Little Sunflower	12352	8275	9337	4467			
	Total	**7308**	**11674**	**16018**	**7663**	**0**	**0**	**-40.6**
Plan 4	Steele	8530	5109	3107	1486			
	Little Sunflower	16553	10285	5136	2457			
	Total	**25083**	**15394**	**8243**	**3943**	**12051**	**5543**	**8.5**
Plan 5	Steele	10182	5899	1455	696			
	Little Sunflower	19935	11903	1754	839			
	Total	**30117**	**17802**	**3209**	**1535**	**18012**	**8286**	**35.7**
Plan 6	Steele	11571	6564	66	32			
	Little Sunflower	21825	12807	+136	+65			
	Total	**33396**	**19371**	**+70**	**+33**	**26370**	**12130**	**64.4**
Plan 7	Steele	12610	7061	+973	+465			
	Little Sunflower	23543	13629	+1854	+887			
	Total	**36153**	**20690**	**+2827**	**+1352**	**40299**	**18538**	**113.1**

Table 8. Hydrologic impacts of structural plans for the Yazoo Backwater Area Reformulation Study with and without the influence of the Big Sunflower River Flood Control Project on fish **REARING** habitat. Average Annual Habitat Units (AAHU) were annualized over the life of the project (54 years) assuming a 4-year construction period. Values with plus sign indicate that plan will have a net increase in flooded acres and no mitigation is required. Reforestation Acres are a nonstructural component to reforest all cleared lands within the 2-year floodplain in addition to that required for fish mitigation. Net change is the percent change in AAHU from nonstructural reforestation relative to baseline AAHU and without mitigation.

Alternative	Reach	Acres	AAHU	Loss of Acres	Loss of AAHU	Reforestation Acres	Reforestation AAHU	Net Percent Change in AAHU
		WITHOUT BIG SUNFLOWER						
BASELINE (Plan 1)	Steele	48044	31752	0	0			
	Little Sunflower	87248	57662	0	0			
	Total	**135292**	**89414**	**0**	**0**	**0**	**0**	**0.0**
Plan 2	Steele	49990	32870	+1946	+1118			
	Little Sunflower	87655	57896	+407	+234			
	Total	**137645**	**90766**	**+2353**	**+1352**	**64902**	**29855**	**33.9**
Plan 2A	Steele	48044	31752	0	0			
	Little Sunflower	87248	57896	0	0			
	Total	**135292**	**89648**	**0**	**0**	**42468**	**19535**	**21.8**
Plan 2B	Steele	25940	19056	22104	12696			
	Little Sunflower	52350	37851	34898	20045			
	Total	**78290**	**56907**	**57002**	**32742**	**13773**	**6336**	**-29.5**
Plan 2C	Steele	48044	31752	0	0			
	Little Sunflower	87248	37851	0	0			
	Total	**135292**	**69603**	**0**	**0**	**59685**	**27455**	**30.7**
Plan 3	Steele	37313	25588	10731	6164			
	Little Sunflower	72450	29351	14798	8500			
	Total	**109763**	**54939**	**25529**	**14663**	**0**	**0**	**-16.4**
Plan 4	Steele	41800	28166	6244	3586			
	Little Sunflower	78128	24113	9120	5238			
	Total	**119928**	**52279**	**15364**	**8825**	**19408**	**8928**	**0.1**
Plan 5	Steele	44016	29439	4028	2313			
	Little Sunflower	82955	21647	4293	2466			
	Total	**126971**	**51086**	**8321**	**4779**	**29008**	**13344**	**9.6**
Plan 6	Steele	47957	31702	87	50			
	Little Sunflower	85749	20786	1499	861			
	Total	**133706**	**52488**	**1586**	**910**	**42468**	**19535**	**20.8**
Plan 7	Steele	49861	32796	+1817	+1044			
	Little Sunflower	87873	21145	+625	+359			
	Total	**137734**	**53941**	**+2442**	**+1403**	**64902**	**29855**	**34.9**
		WITH BIG SUNFLOWER						
BASELINE (Plan 1)	Steele	48044	31752	0	0			
	Little Sunflower	85057	56214	0	0			
	Total	**133101**	**87966**	**0**	**0**	**0**	**0**	**0.0**
Plan 2	Steele	49990	32990	+1946	+1238			
	Little Sunflower	85506	56500	+449	+286			
	Total	**135496**	**89490**	**+2395**	**+1524**	**64902**	**29855**	**33.9**
Plan 2A	Steele	48044	31752	0	0			
	Little Sunflower	85057	56214	0	0			
	Total	**133101**	**87966**	**0**	**0**	**42468**	**19535**	**18.5**

Table 8. (Concluded)								
Alternative	Reach	Acres	AAHU	Loss of Acres	Loss of AAHU	Reforestation Acres	Reforestation AAHU	Net Percent Change in AAHU
				WITH BIG SUNFLOWER				
Plan 2B	Steele	25940	19055	22104	12697			
	Little Sunflower	51034	36671	34023	19543			
	Total	**76974**	**55726**	**56127**	**32240**	**13773**	**6336**	**29.4**
Plan 2C	Steele	48044	31752	0	0			
	Little Sunflower	85057	56214	0	0			
	Total	**133101**	**87966**	**0**	**0**	**59685**	**27455**	**31.2**
Plan 3	Steele	37313	25588	10731	6164			
	Little Sunflower	70715	47976	14342	8238			
	Total	**108028**	**73564**	**25073**	**14402**	**0**	**0**	**-16.4**
Plan 4	Steele	41800	28165	6244	3587			
	Little Sunflower	76299	51183	8758	5031			
	Total	**118099**	**79348**	**15002**	**8617**	**19408**	**8928**	**0.3**
Plan 5	Steele	44016	29438	4028	2314			
	Little Sunflower	80909	53831	4148	2383			
	Total	**124925**	**83269**	**8176**	**4696**	**29008**	**13344**	**9.8**
Plan 6	Steele	47957	31702	87	50			
	Little Sunflower	83683	55425	1374	789			
	Total	**131640**	**87127**	**1461**	**839**	**42468**	**19535**	**21.2**
Plan 7	Steele	49861	32796	+1817	+1044			
	Little Sunflower	85716	56593	+659	+379			
	Total	**135577**	**89389**	**+2476**	**+1423**	**64902**	**29855**	**34.**1

.
.

7

Table 9. Species abundance and fish community metrics in the pool immediately above the Steele Bayou water control structure. Data collected spring 2002 and autumn 2003 using a 10-ft seine (n=2).

SPECIES	Frequency	Percent	Frequency	Percent
Mosquitofish	97	15.77	97	15.77
Smallmouth buffalo	92	14.96	189	30.73
Black crappie	78	12.68	267	43.41
Gizzard shad	73	11.87	340	55.28
White crappie	55	8.94	395	64.23
Bigmouth buffalo	45	7.32	440	71.54
Orangespotted sunfish	45	7.32	485	78.86
Green sunfish	28	4.55	513	83.41
Ghost shiner	25	4.07	538	87.48
Freshwater drum	15	2.44	553	89.92
Speckled chub	13	2.11	566	92.03
Bantam sunfish	10	1.63	576	93.66
Bluegill	8	1.30	584	94.96
Young of year buffalo	6	0.98	590	95.93
Warmouth	5	0.81	595	96.75
White bass	5	0.81	600	97.56
Golden shiner	5	0.81	605	98.37
Inland silverside	3	0.49	608	98.86
Common carp	1	0.16	609	99.02
Red shiner	1	0.16	610	99.19
Threadfin shad	1	0.16	611	99.35
Slough darter	1	0.16	612	99.51
Mississippi silvery minnow	1	0.16	613	99.67
Brook silverside	1	0.16	614	99.84
Tadpole madtom	1	0.16	615	100.00

Table 10. Calculation of Average Annual Habitat Units per acre of reforested agricultural land for spawning and rearing.

Spawning Values for Fish

Floodplain Habitats	HSI
Agricultural lands	0.2
Fallow Fields	0.3
Bottomland Hardwoods	0.7

Rearing Values for Fish

Floodplain Habitats	HSI
Agricultural lands	0.3
Fallow Fields	0.4
Bottomland Hardwoods	0.8

Calculation of Average Annual Habitat Units
for Reforested Agricultural Land - Spawning

Without Reforestation: (0.2)(54) = 10.8 HUs
Transition (10 Years): (0.5) (10) = 5.0 HUs
Reforested HUs: BLH = (0.7)(44) = 30.8 HUs
Net Habitat Unit Value: 35.8 (with) - 10.8 (without) = 25.0 HUs
AAHUs: 25.0 HUs/54 years = 0.46 AAHU per acre

Calculation of Average Annual Habitat Units
for Reforested Agricultural Land - Rearing

Without Reforestation: (0.3)(54) = 16.2 HUs
Transition (10 Years): (0.6) (10) = 6.0 HUs
Reforested HUs: BLH = (0.8)(44) = 35.2 HUs
Net Habitat Unit Value: 41.2 (with) – 16.8 (without) = 25.0 HUs
AAHUs: 25.0 HUs/54 years = 0.46 AAHU per acre