# Appendix 2

## Yazoo Backwater Area Faunal Species Lists

Appendix 2 contains a series of six faunal species lists for the Yazoo Backwater Area. The first (Table 1) is a master list of all amphibian, reptile, avian, mammalian, and fish species collected or observed in the Yazoo Backwater Area. This list was compiled from species collection records, by county, from the project area. Collection records were obtained from the U.S. Army Corps of Engineers (the Corps), U.S. Fish and Wildlife Service (FWS), Mississippi Museum of Natural Science (MMNS), and/or Mississippi Natural Heritage Program (MNHP).[1] Bird species lists for the project area were obtained from the FWS National Wildlife Refuge bird species list for the Yazoo Refuge Complex (including the Yazoo, Holt Collier, Theodore Roosevelt, and part of Panther Swamp National Wildlife Refuges) in the project area.[2]

Tables 2 – 5 compare amphibians (Table 2), reptiles (Table 3), birds (Table 4), and mammals (Table 5) found in the Yazoo Backwater Area to those found on the World Wildlife Fund's (WWF) vertebrate species list for the Mississippi Lowland Ecoregion (NA0409), within which the Yazoo Backwater Area is located.[3,4] This comparision illustrates the extensive diversity of species found in the Yazoo Backwater Area. Table 6 compares the list of fish species occurring in the Yazoo Backwater Area developed by MMNS to the Corps' Yazoo Backwater Area fish collection records and the FWS's list of Yazoo Backwater fish species that are backwater dependent.

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[1] See http://museum.mdwfp.com/.

[2] U.S. Fish and Wildlife Service. 1993. Birds of Yazoo National Wildlife Refuge Complex. U.S. Fish and Wildlife Service. Unpaginated. Jamestown, ND: Northern Prairie Wildlife Research Center Online, http://www.npwrc.usgs.gov/resource/birds/chekbird/r4/yazoo.htm (Version 22MAY98).

[3] The WWF database contains presence/absence data for the world's terrestrial amphibians, reptiles, birds, and mammals, by terrestrial ecoregion. Ecoregions are defined as relatively large units of land that contain a distinct assemblage of natural communities and species, with boundaries that approximate the original extent of the natural communities prior to major land use change. Where available, WWF used historic ranges of species (i.e., approximate distribution at 1500 AD) instead of current distributions. This was done for several reasons, the most pertinent of which is the inclusion of historic ranges to be consistent with the concept of ecoregions as reflecting historic or potential vegetation. The WWF species lists were used to represent the faunal potential of the project area. The species data are based on the ranges of extant species. Species that are introduced, present as human commensals, vagrants, or passage migrants were not recorded. For more information on how the WWF maps were compiled go to: www.worldwildlife.org/wildfinder/wildFinderDB.cfm.

[4] The species master lists have come from standard sources: American Museum of Natural History (Frost, Darrel R. 2008. Amphibian Species of the World: an Online Reference. Version 5.2. American Museum of Natural History, New York. http://research.amnh.org/herpetology/amphibia/index.php); The Reptile Database (Uetz, P. et al. 2008. http://www.reptile-database.org); Sibley and Monroe World List of Bird Names (http://www.ornitaxa.com/SM/SMOrg/sm.html); and, Smithsonian National Museum of Natural History (Wilson, D. E., and D. M. Reeder (eds). 2005. Mammal Species of the World. Johns Hopkins University Press, 2,142 pp. http://nmnhgoph.si.edu/msw/).

**Table 1. Master list of faunal species collected or observed in the Yazoo Backwater Area by the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Mississippi Museum of Natural Science, and/or Mississippi Natural Heritage Program**

| Class | Common Name | Scientific Name |
|---|---|---|
| Amphibia | Northern Cricket Frog | Acris crepitans |
| Amphibia | Southern Cricket Frog | Acris gryllus |
| Amphibia | Marbled Salamander | Ambystoma opacum |
| Amphibia | Mole Salamander | Ambystoma talpoideum |
| Amphibia | Smallmouth Salamander | Ambystoma texanum |
| Amphibia | Three-toed Amphiuma | Amphiuma tridactylum |
| Amphibia | American Toad | Bufo americanus |
| Amphibia | Fowler's Toad | Bufo fowleri |
| Amphibia | Eastern Narrowmouth Toad | Gastrophryne carolinensis |
| Amphibia | Bird-voiced Treefrog | Hyla avivoca |
| Amphibia | Cope's Gray Treefrog | Hyla chrysoscelis |
| Amphibia | Green Treefrog | Hyla cinerea |
| Amphibia | Eastern Newt | Notophthalmus viridescens |
| Amphibia | Mississippi slimy salamander | Plethodon mississippi |
| Amphibia | Spring Peeper | Pseudacris crucifer |
| Amphibia | | Pseudacris feriarum |
| Amphibia | Bullfrog | Rana catesbeiana |
| Amphibia | Green Frog | Rana clamitans |
| Amphibia | Pickerel Frog | Rana palustris |
| Amphibia | Southern Leopard Frog | Rana sphenocephala |
| Amphibia | Lesser Siren | Siren intermedia |
| **Total:** | | **21** |
| Reptilia | Copperhead | Agkistrodon contortrix |
| Reptilia | Water Moccasin | Agkistrodon piscivorus |
| Reptilia | American Alligator | Alligator mississippiensis |
| Reptilia | Green Anole | Anolis carolinensis |
| Reptilia | Spiny Softshell | Apalone spinifera |
| Reptilia | Snapping Turtle | Chelydra serpentina |
| Reptilia | | Chrysemys dorsalis |
| Reptilia | Painted Turtle | Chrysemys picta |
| Reptilia | Six-lined Racerunner | Cnemidophorus sexlineatus |
| Reptilia | Racer | Coluber constrictor |
| Reptilia | Timber Rattlesnake | Crotalus horridus |
| Reptilia | Ring-necked Snake | Diadophis punctatus |
| Reptilia | Rat Snake | Elaphe obsoleta |
| Reptilia | Five-lined Skink | Eumeces fasciatus |
| Reptilia | Broadhead Skink | Eumeces laticeps |
| Reptilia | Mud Snake | Farancia abacura |
| Reptilia | Ouachita Map Turtle | Graptemys ouachitensis |
| Reptilia | Mississippi Map Turtle | Graptemys pseudogeographica kohnii |
| Reptilia | Eastern Hognose Snake | Heterodon platirhinos |

| Class | Common Name | Scientific Name |
|---|---|---|
| Reptilia | Eastern Mud Turtle | Kinosternon subrubrum |
| Reptilia | Common Kingsnake | Lampropeltis getula |
| Reptilia | Milk Snake | Lampropeltis triangulum |
| Reptilia | Allig Snapping Turtle | Macrochelys temminckii |
| Reptilia | Green Water Snake | Nerodia cyclopion |
| Reptilia | Plain-bellied Water Snake | Nerodia erythrogaster |
| Reptilia | Southern Water Snake | Nerodia fasciata |
| Reptilia | | Nerodia rhombia |
| Reptilia | Rough Green Snake | Opheodrys aestivus |
| Reptilia | River Cooter | Pseudemys concinna |
| Reptilia | Graham's Crayfish Snake | Regina grahami |
| Reptilia | Ground Skink | Scincella lateralis |
| Reptilia | | Sternotherus minor |
| Reptilia | Common Musk Turtle | Sternotherus odoratus |
| Reptilia | Dekay's Brown Snake | Storeria dekayi |
| Reptilia | Western Ribbon Snake | Thamnophis proximus |
| Reptilia | Common Garter Snake | Thamnophis sirtalis |
| Reptilia | Common Slider | Trachemys scripta |
| **Total** | | **37** |
| Aves | Acadian Flycatcher | Empidonax virescens |
| Aves | American Avocet | Recurvirostra americana |
| Aves | American Bittern | Botaurus lentiginosus |
| Aves | American Black Duck | Anas rubripes |
| Aves | American Coot | Fulica americana |
| Aves | American Crow | Corvus brachyrhynchos |
| Aves | American Golden Plover | Pluvialis dominica |
| Aves | American Goldfinch | Carduelis tristis |
| Aves | American Kestrel | Falco sparverius |
| Aves | American Pipit | Anthus rubescens |
| Aves | American Redstart | Setophaga ruticilla |
| Aves | American Robin | Turdus migratorius |
| Aves | American Tree Sparrow | Spizella arborea |
| Aves | American White Pelican | Pelecanus erythrorhynchos |
| Aves | American Wigeon | Anas americana |
| Aves | American Woodcock | Scolopax minor |
| Aves | Anhinga | Anhinga anhinga |
| Aves | Baird's Sandpiper | Erolia bairdii |
| Aves | Bald Eagle | Haliaeetus leucocephalus |
| Aves | Barn Owl | Tyto alba |
| Aves | Barn Swallow | Hirundo rustica |
| Aves | Barred Owl | Strix varia |
| Aves | Bay-breasted Warbler | Dendroica castanea |
| Aves | Belted Kingfisher | Ceryle alcyon |
| Aves | Bewick's Wren | Thryomanes bewickii |
| Aves | Black Tern | Chlidonias niger |

| Class | Common Name | Scientific Name |
|---|---|---|
| Aves | Black Vulture | Coragyps atratus |
| Aves | Black-and-white Warbler | Mniotilta varia |
| Aves | Black-bellied Whistling-Duck | Dendrocygna autumnalis |
| Aves | Blackburnian Warbler | Dendroica fusca |
| Aves | Black-crowned Night-Heron | Nycticorax nycticorax |
| Aves | Black-necked Stilt | Himantopus mexicanus |
| Aves | Blackpoll Warbler | Dendroica striata |
| Aves | Black-throated Blue Warbler | Dendroica caerulescens |
| Aves | Black-throated Green Warbler | Dendroica virens |
| Aves | Blue Grosbeak | Passerina caerulea |
| Aves | Blue Jay | Cyanocitta cristata |
| Aves | Blue-gray Gnatcatcher | Polioptila caerulea |
| Aves | Blue-winged Teal | Anas discors |
| Aves | Blue-winged Warbler | Vermivora pinus |
| Aves | Bobolink | Dolichonyx oryzivorus |
| Aves | Bonaparte's Gull | Larus philadelphia |
| Aves | Brewer's Blackbird | Euphagus cyanocephalus |
| Aves | Broad-winged Hawk | Buteo platypterus |
| Aves | Brown Creeper | Certhia americana |
| Aves | Brown Thrasher | Toxostoma rufum |
| Aves | Brown-headed Cowbird | Molothrus ater |
| Aves | Bufflehead | Bucephala albeola |
| Aves | Burrowing Owl | Athene cunicularia |
| Aves | Canada Goose | Branta canadensis |
| Aves | Canada Warbler | Wilsonia canadensis |
| Aves | Canvasback | Aythya valisineria |
| Aves | Carolina Chickadee | Poecile carolinensis |
| Aves | Cattle Egret | Bubulcus ibis |
| Aves | Cedar Waxwing | Bombycilla cedrorum |
| Aves | Cerulean Warbler | Dendroica cerulea |
| Aves | Chestnut-sided Warbler | Dendroica pensylvanica |
| Aves | Chimney Swift | Chaetura pelagica |
| Aves | Chipping Sparrow | Spizella passerina |
| Aves | Chuck-will's-widow | Caprimulgus carolinensis |
| Aves | Cinnamon Teal | Anas cyanoptera |
| Aves | Cliff Swallow | Petrochelidon pyrrhonota |
| Aves | Common Goldeneye | Bucephala clangula |
| Aves | Common Grackle | Quiscalus quiscula |
| Aves | Common Ground-Dove | Columbina passerina |
| Aves | Common Loon | Gavia immer |
| Aves | Common Merganser | Mergus merganser |
| Aves | Common Moorhen | Gallinula chloropus |
| Aves | Common Nighthawk | Chordeiles minor |
| Aves | Common Snipe | Gallinago gallinago |
| Aves | Common Yellowthroat | Geothlypis trichas |
| Aves | Cooper's Hawk | Accipiter cooperii |

| Class | Common Name | Scientific Name |
|---|---|---|
| Aves | Crested Caracara | Caracara cheriway |
| Aves | Dark-eyed Junco | Junco hyemalis |
| Aves | Dickcissel | Spiza americana |
| Aves | Double-crested Cormorant | Phalacrocorax auritus |
| Aves | Downy Woodpecker | Picoides pubescens |
| Aves | Dunlin | Calidris alpina |
| Aves | Eared Grebe | Podiceps nigricollis |
| Aves | Eastern Bluebird | Sialia sialis |
| Aves | Eastern Kingbird | Tyrannus tyrannus |
| Aves | Eastern Meadowlark | Sturnella magna |
| Aves | Eastern Phoebe | Sayornis phoebe |
| Aves | Eastern Screech-Owl | Otus asio |
| Aves | Eastern Wood-Pewee | Contopus virens |
| Aves | European Starling | Sturnus vulgaris |
| Aves | Evening Grosbeak | Coccothraustes vespertinus |
| Aves | Field Sparrow | Spizella pusilla |
| Aves | Fish Crow | Corvus ossifragus |
| Aves | Fox Sparrow | Passerella iliaca |
| Aves | Franklin's Gull | Larus pipixcan |
| Aves | Fulvous Whistling-Duck | Dendrocygna bicolor |
| Aves | Gadwall | Anas strepera |
| Aves | Glossy Ibis | Plegadis falcinellus |
| Aves | Golden Eagle | Aquila chrysaetos |
| Aves | Golden-crowned Kinglet | Regulus satrapa |
| Aves | Golden-winged Warbler | Vermivora chrysoptera |
| Aves | Grasshopper Sparrow | Ammodramus savannarum |
| Aves | Gray Catbird | Dumetella carolinensis |
| Aves | Gray-cheecked Thrush | Catharus minimus |
| Aves | Great Blue Heron | Ardea herodias |
| Aves | Great Crested Flycatcher | Myiarchus crinitus |
| Aves | Great Egret | Ardea alba |
| Aves | Great Horned Owl | Bubo virginianus |
| Aves | Greater Scaup | Aythya marila |
| Aves | Greater White-fronted Goose | Anser albifrons |
| Aves | Greater Yellowlegs | Tringa melanoleuca |
| Aves | Green Heron | Butorides Virescens |
| Aves | Green-winged Teal | Anas crecca |
| Aves | Hairy Woodpecker | Picoides villosus |
| Aves | Harlan's Hawk | Buteo jamaicensis |
| Aves | Henslow's Sparrow | Ammodramus henslowii |
| Aves | Hermit Thrush | Catharus guttatus |
| Aves | Herring Gull | Larus argentatus |
| Aves | Hooded Merganser | Lophodytes cucullatus |
| Aves | Hooded Warbler | Wilsonia citrina |
| Aves | Horned Grebe | Podiceps auritus |
| Aves | Horned Lark | Eremophila alpestris |

| Class | Common Name | Scientific Name |
|---|---|---|
| Aves | House Finch | Carpodacus mexicanus |
| Aves | House Sparrow | Passer domesticus |
| Aves | House Wren | Troglodytes aedon |
| Aves | Indigo Bunting | Passerina cyanea |
| Aves | Kentucky Warbler | Oporornis formosus |
| Aves | Killdeer | Charadrius vociferus |
| Aves | King Rail | Rallus elegans |
| Aves | Lapland Longspur | Calcarius lapponicus |
| Aves | Lark Sparrow | Chondestes grammacus |
| Aves | Le Conte's Sparrow | Ammodramus leconteii |
| Aves | Least Bittern | Ixobrychus exilis |
| Aves | Least Sandpiper | Calidris minutilla |
| Aves | Least Tern | Sterna antillarum |
| Aves | Lesser Scaup | Aythya affinis |
| Aves | Lesser Yellowlegs | Tringa flavipes |
| Aves | Lincoln's Sparrow | Melospiza lincolnii |
| Aves | Little Blue Heron | Egretta caerulea |
| Aves | Loggerhead Shrike | Lanius ludovicianus |
| Aves | Long-billed Dowitcher | Limnodromus scolopaceus |
| Aves | Louisiana Waterthrush | Seiurus motacilla |
| Aves | Magnolia Warbler | Dendroica magnolia |
| Aves | Mallard | Anas platyrhynchos |
| Aves | Marbled Godwit | Limosa fedoa |
| Aves | Marsh Wren | Cistothorus palustris |
| Aves | Merlin | Falco columbarius |
| Aves | Mississippi Kite | Ictinia mississippiensis |
| Aves | Mourning Dove | Zenaida macroura |
| Aves | Mourning Warbler | Oporornis philadelphia |
| Aves | Nashville Warbler | Vermivora ruficapilla |
| Aves | Northern Bobwhite | Colinus virginianus |
| Aves | Northern Cardinal | Cardinalis cardinalis |
| Aves | Northern Flicker | Colaptes auratus |
| Aves | Northern Harrier | Circus cyaneus |
| Aves | Northern Mockingbird | Mimus polyglottos |
| Aves | Northern Oriole | Icterus galbula |
| Aves | Northern Parula | Parula americana |
| Aves | Northern Pintail | Anas acuta |
| Aves | Northern Rough-winged Swallow | Stelgidopteryx serripennis |
| Aves | Northern Shoveler | Anas clypeata |
| Aves | Northern Waterthrush | Seiurus noveboracensis |
| Aves | Oldsquaw | Clangula hyemalis |
| Aves | Olive-sided Flycatcher | Contopus cooperi |
| Aves | Orange-crowned Warbler | Vermivora celata |
| Aves | Orchard Oriole | Icterus spurius |
| Aves | Osprey | Pandion haliaetus |
| Aves | Ovenbird | Seiurus aurocapillus |

| Class | Common Name | Scientific Name |
|---|---|---|
| Aves | Painted Bunting | Passerina ciris |
| Aves | Pectoral Sandpiper | Calidris melanotos |
| Aves | Philadelphia Vireo | Vireo philadelphicus |
| Aves | Pied-billed Grebe | Podilymbus podiceps |
| Aves | Pileated Woodpecker | Dryocopus pileatus |
| Aves | Pine Siskin | Carduelis pinus |
| Aves | Pine Warbler | Dendroica pinus |
| Aves | Prairie Warbler | Dendroica discolor |
| Aves | Prothonotary Warbler | Protonotaria citrea |
| Aves | Purple Finch | Carpodacus purpureus |
| Aves | Purple Gallinule | Porphyrula martinica |
| Aves | Purple Martin | Progne subis |
| Aves | Red-bellied Woodpecker | Melanerpes carolinus |
| Aves | Red-breasted Nuthatch | Sitta canadensis |
| Aves | Red-eyed Vireo | Vireo olivaceus |
| Aves | Redhead | Aythya americana |
| Aves | Red-headed Woodpecker | Melanerpes erythrocephalus |
| Aves | Red-necked Phalarope | Phalaropus lobatus |
| Aves | Red-shouldered Hawk | Buteo lineatus |
| Aves | Red-tailed Hawk | Buteo jamaicensis |
| Aves | Red-winged Blackbird | Agelaius phoeniceus |
| Aves | Ring-billed Gull | Larus delawarensis |
| Aves | Ring-necked Duck | Aythya collaris |
| Aves | Rock Dove | Columba livia |
| Aves | Roseate Spoonbill | Ajaia ajaja |
| Aves | Rose-breasted Grosbeak | Pheucticus ludovicianus |
| Aves | Ross' Goose | Chen rossii |
| Aves | Ruby-crowned Kinglet | Regulus calendula |
| Aves | Ruby-throated Hummingbird | Archilochus colubris |
| Aves | Ruddy Duck | Oxyura jamaicensis |
| Aves | Rufous Hummingbird | Selasphorus rufus |
| Aves | Rufous-sided Towhee | Pipilo erythrophthalmus |
| Aves | Rusty Blackbird | Euphagus carolinus |
| Aves | Sanderling | Calidris alba |
| Aves | Sandhill Crane | Grus canadensis |
| Aves | Savannah Sparrow | Passerculus sandwichensis |
| Aves | Scarlet Tanager | Piranga olivacea |
| Aves | Scissor-tailed Flycatcher | Tyrannus forficatus |
| Aves | Sedge Wren | Cistothorus platensis |
| Aves | Semipalmated Plover | Charadrius semipalmatus |
| Aves | Semipalmated Sandpiper | Calidris pusilla |
| Aves | Sharp-shinned Hawk | Accipiter striatus |
| Aves | Short-billed Dowitcher | Limnodromus griseus |
| Aves | Short-eared Owl | Asio flammeus |
| Aves | Snow Goose | Chen caerulescens |
| Aves | Snowy Egret | Egretta thula |

| Class | Common Name | Scientific Name |
|---|---|---|
| Aves | Solitary Sandpiper | Tringa solitaria |
| Aves | Solitary Vireo | Vireo solitarius |
| Aves | Song Sparrow | Melospiza melodia |
| Aves | Sora | Porzana carolina |
| Aves | Spotted Sandpiper | Actitis macularia |
| Aves | Spotted Towhee | Pipilo maculatus |
| Aves | Summer Tanager | Piranga rubra |
| Aves | Surf Scoter | Melanitta perspicillata |
| Aves | Swainson's Thrush | Catharus ustulatus |
| Aves | Swainson's Warbler | Limnothlypis swainsonii |
| Aves | Swamp Sparrow | Melospiza georgiana |
| Aves | Tennessee Warbler | Vermivora peregrina |
| Aves | Tree Swallow | Tachycineta bicolor |
| Aves | Tricolored Heron | Egretta tricolor |
| Aves | Tufted Titmouse | Baeolophus bicolor |
| Aves | Tundra Swan | Cygnus columbianus |
| Aves | Turkey Vulture | Cathartes aura |
| Aves | Upland Sandpiper | Bartramia longicauda |
| Aves | Veery | Catharus fuscescens |
| Aves | Vermilion Flycatcher | Pyrocephalus rubinu |
| Aves | Vesper Sparrow | Pooecetes gramineus |
| Aves | Warbling Vireo | Vireo gilvus |
| Aves | Western Kingbird | Tyrannus verticali |
| Aves | Western Sandpiper | Calidris mauri |
| Aves | Whip-poor-will | Caprimulgus vociferus |
| Aves | White Ibis | Eudocimus albus |
| Aves | White-breasted Nuthatch | Sitta carolinensis |
| Aves | White-eyed Vireo | Vireo griseus |
| Aves | White-throated Sparrow | Zonotrichia albicollis |
| Aves | White-winged Dove | Zenaida asiatica |
| Aves | White-winged Scoter | Melanitta fusca |
| Aves | Wild Turkey | Meleagris gallopavo |
| Aves | Wilson's Warbler | Wilsonia pusilla |
| Aves | Winter Wren | Troglodytes troglodytes |
| Aves | Wood Duck | Aix sponsa |
| Aves | Wood Stork | Mycteria americana |
| Aves | Wood Thrush | Hylocichla mustelina |
| Aves | Worm-eating Warbler | Helmitheros vermivorus |
| Aves | Yellow Warbler | Dendroica petechia |
| Aves | Yellow-bellied Flycatcher | Empidonax flaviventris |
| Aves | Yellow-bellied Sapsucker | Sphyrapicus varius |
| Aves | Yellow-billed Cuckoo | Coccyzus americanus |
| Aves | Yellow-breasted Chat | Icteria virens |
| Aves | Yellow-crowned Night-Heron | Nyctanassa violacea |
| Aves | Yellow-rumped Warbler | Dendroica coronata |
| Aves | Yellow-throated Vireo | Vireo flavifrons |

| Class | Common Name | Scientific Name |
| --- | --- | --- |
| Aves | Yellow-throated Warbler | Dendroica dominica |
| **Total** | | **257** |
| Mammalia | Southern Short-tailed Shrew | Blarina carolinensis |
| Mammalia | Coyote | Canis latrans |
| Mammalia | American Beaver | Castor canadensis |
| Mammalia | Rafinesque's Big-eared Bat | Corynorhinus rafinesquii |
| Mammalia | Least Shrew | Cryptotis parva |
| Mammalia | Nine-banded Armadillo | Dasypus novemcinctus |
| Mammalia | Virginia Opossum | Didelphis virginiana |
| Mammalia | Big Brown Bat | Eptesicus fuscus |
| Mammalia | Southern Flying Squirrel | Glaucomys volans |
| Mammalia | Silver-haired Bat | Lasionycteris noctivagans |
| Mammalia | Red Bat | Lasiurus borealis |
| Mammalia | Hoary Bat | Lasiurus cinereus |
| Mammalia | Seminole Bat | Lasiurus seminolus |
| Mammalia | Northern River Otter | Lutra canadensis |
| Mammalia | Bobcat | Lynx rufus |
| Mammalia | Striped Skunk | Mephitis mephitis |
| Mammalia | Woodland Vole | Microtus pinetorum |
| Mammalia | Nutria | Myocaster coypus |
| Mammalia | Long-tailed Weasel | Mustela frenata |
| Mammalia | American Mink | Mustela vison |
| Mammalia | Southeastern Myotis | Myotis austroriparius |
| Mammalia | Eastern Woodrat | Neotoma floridana |
| Mammalia | Nycticeius humeralis | Nycticeius humeralis |
| Mammalia | Golden Mouse | Ochrotomys nuttalli |
| Mammalia | White-tailed Deer | Odocoileus virginianus |
| Mammalia | Muskrat | Ondatra zibethicus |
| Mammalia | Marsh Rice Rat | Oryzomys palustris |
| Mammalia | Cotton Mouse | Peromyscus gossypinus |
| Mammalia | White-footed Mouse | Peromyscus leucopus |
| Mammalia | Eastern Pipistrelle | Pipistrellus subflavus |
| Mammalia | Northern Raccoon | Procyon lotor |
| Mammalia | Fulvous Harvest Mouse | Reithrodontomys fulvescens |
| Mammalia | Eastern Harvest Mouse | Reithrodontomys humulis |
| Mammalia | Eastern Mole | Scalopus aquaticus |
| Mammalia | Eastern Gray Squirrel | Sciurus carolinensis |
| Mammalia | Eastern Fox Squirrel | Sciurus niger |
| Mammalia | Hispid Cotton Rat | Sigmodon hispidus |
| Mammalia | Southeastern Shrew | Sorex longirostris |
| Mammalia | Eastern Spotted Skunk | Spilogale putorius |
| Mammalia | Swamp Rabbit | Sylvilagus aquaticus |
| Mammalia | Eastern Cottontail | Sylvilagus floridanus |

| Class | Common Name | Scientific Name |
|---|---|---|
| Mammalia | Brazilian Free-tailed Bat | Tadarida brasiliensis |
| Mammalia | Eastern Chipmunk | Tamias striatus |
| Mammalia | Gray Fox | Urocyon cinereoargenteus |
| Mammalia | American Black Bear | Ursus americanus |
| Mammalia | Louisiana Black Bear | Ursus americanus luteolus |
| Mammalia | Red Fox | Vulpes vulpes |
| Mammalia | Wild pig | Sus scrofa |
| **Total** | | **48** |
| Osteichthyes | Alosa chrysochloris | Skipjack herring |
| Osteichthyes | Ameiurus melas | Black bullhead |
| Osteichthyes | Ameiurus natalis | Yellow bullhead |
| Osteichthyes | Ameiurus nebulosus | Brown bullhead |
| Osteichthyes | Amia calva | Bowfin |
| Osteichthyes | Ammocrypta vivax | Scaly sand darter |
| Osteichthyes | Anguilla rostrata | American eel |
| Osteichthyes | Aphredoderus sayanus | Pirate perch |
| Osteichthyes | Aplodinotus grunniens | Freshwater drum |
| Osteichthyes | Campostoma anomalum | Central stoneroller |
| Osteichthyes | Carpiodes carpio | River carpsucker |
| Osteichthyes | Carpiodes cyprinus | Quillback |
| Osteichthyes | Centrarchus macropterus | Flier |
| Osteichthyes | Cycleptus elongatus | Blue sucker |
| Osteichthyes | Cyprinella camura | Bluntface shiner |
| Osteichthyes | Cyprinella venusta venusta | Blacktail shiner |
| Osteichthyes | Cyprinus carpio | Common carp |
| Osteichthyes | Dorosoma cepedianum | Gizzard shad |
| Osteichthyes | Dorosoma petenense | Threadfin shad |
| Osteichthyes | Elassoma zonatum | Banded pygmy sunfish |
| Osteichthyes | Erimyzon oblongus | Creek chubsucker |
| Osteichthyes | Esox americanus | Redfin pickerel |
| Osteichthyes | Etheostoma asprigene | Mud darter |
| Osteichthyes | Etheostoma chlorosoma | Bluntnose darter |
| Osteichthyes | Etheostoma fusiforme | Swamp darter |
| Osteichthyes | Etheostoma gracile | Slough darter |
| Osteichthyes | Etheostoma whipplei artesiae | Redfin darter |
| Osteichthyes | Fundulus chrysotus | Golden topminnow |
| Osteichthyes | Fundulus dispar | Starhead topminnow |
| Osteichthyes | Fundulus notatus | Blackstripe topminnow |
| Osteichthyes | Fundulus olivaceus | Blackspotted topminnow |
| Osteichthyes | Gambusia affinis | Mosquitofish |
| Osteichthyes | Hiodon alosoides | Goldeye |
| Osteichthyes | Hiodon tergisus | Mooneye |
| Osteichthyes | Hybognathus hayi | Cypress minnow |

| Class | Common Name | Scientific Name |
|---|---|---|
| Osteichthyes | Hybognathus nuchalis | Mississippi silvery minnow |
| Osteichthyes | Hypophthalmichthys nobilis | Bighead carp |
| Osteichthyes | Ichthyomyzon castaneus | Chestnut lamprey |
| Osteichthyes | Ictalurus furcatus | Blue catfish |
| Osteichthyes | Ictalurus punctatus | Channel catfish |
| Osteichthyes | Ictiobus bubalus | Smallmouth buffalo |
| Osteichthyes | Ictiobus cyprinellus | Bigmouth buffalo |
| Osteichthyes | Ictiobus niger. | Black buffalo |
| Osteichthyes | Labidesthes sicculus | Brook silverside |
| Osteichthyes | Lepisosteus oculatus | Spotted gar |
| Osteichthyes | Lepisosteus ossens | Longnose gar |
| Osteichthyes | Lepisosteus platostomus | Shortnose gar |
| Osteichthyes | Lepomis cyanellus | Green sunfish |
| Osteichthyes | Lepomis gulosus | Warmouth |
| Osteichthyes | Lepomis humilis | Orangespotted sunfish |
| Osteichthyes | Lepomis macrochirus | Bluegill |
| Osteichthyes | Lepomis marginatus | Dollar sunfish |
| Osteichthyes | Lepomis megalotis | Longear sunfish |
| Osteichthyes | Lepomis microlophus | Redear sunfish |
| Osteichthyes | Lepomis miniatus | Spotted sunfish |
| Osteichthyes | Lepomis symmetricus | Bantum sunfish |
| Osteichthyes | Luxilus chrysocephalus isolepis | Striped shiner |
| Osteichthyes | Lythrurus umbratilis cyanocephalus | Redfin shiner |
| Osteichthyes | Macrhybopsis aestivalis | Speckled chub |
| Osteichthyes | Macrhybopsis storeriana | Silver chub |
| Osteichthyes | Menidia beryllina | Inland silverside |
| Osteichthyes | Micropterus punctulatus | Spotted bass |
| Osteichthyes | Micropterus salmoides | Largemouth bass |
| Osteichthyes | Morone chrysops | White bass |
| Osteichthyes | Morone mississippiensis | Yellow bass |
| Osteichthyes | Morone saxatilis | Striped bass |
| Osteichthyes | Moxostoma poecilurum | Blacktail redhorse |
| Osteichthyes | Notemigonus crysoleucas | Golden shiner |
| Osteichthyes | Notropis atherinoides | Emerald shiner |
| Osteichthyes | Notropis blennius | River shiner |
| Osteichthyes | Notropis buchanani | Ghost shiner |
| Osteichthyes | Notropis longirostris | Longnose shiner |
| Osteichthyes | Notropis lutrensis | Red shiner |
| Osteichthyes | Notropis maculatus | Taillight shiner |
| Osteichthyes | Notropis rafinesquei | Yazoo shiner |
| Osteichthyes | Notropis sabinae | Sabine shiner |
| Osteichthyes | Notropis shumardi | Silverband shiner |
| Osteichthyes | Notropis texanus | Weed shiner |

| Class | Common Name | Scientific Name |
|---|---|---|
| Osteichthyes | Notropis volucellus | Mimic shiner |
| Osteichthyes | Noturus gyrinus | Tadpole madtom |
| Osteichthyes | Noturus nocturnus | Freckled madtom |
| Osteichthyes | Opsopoeodus emiliae | Pugnose minnow |
| Osteichthyes | Percina caprodes | Logperch |
| Osteichthyes | Percina sciera | Dusky darter |
| Osteichthyes | Percina shumardi | River darter |
| Osteichthyes | Polyodon spathula | Paddlefish |
| Osteichthyes | Phoxinus erythrogaster | Southern redbelly dace |
| Osteichthyes | Pimephales notatus | Bluntnose minnow |
| Osteichthyes | Pimephales promelas | Fathead minnow |
| Osteichthyes | Pimephales vigilax | Bullhead minnow |
| Osteichthyes | Pomoxis annularis | White crappie |
| Osteichthyes | Pomoxis nigromaculatus | Black crappie |
| Osteichthyes | Pylodictis olivaris | Flathead catfish |
| Osteichthyes | Semotilus atromaculatus | Creek chub |
| Osteichthyes | Stizostedion canadense | Sauger |
| **Total** | | **95** |

| Table 2. Amphibian species from World Wildlife Fund (WWF) Mississippi Lowland Ecoregion occurring in Yazoo Backwater Area (YBA) according to Mississippi Natural Heritage Program | | | | |
|---|---|---|---|---|
| **Class** | **Common Name** | **Scientific Name** | **WWF*** | **YBA Only^** |
| Amphibia | Northern Cricket Frog | Acris crepitans | X | |
| Amphibia | Southern Cricket Frog | Acris gryllus | X | |
| Amphibia | Spotted Salamander | Ambystoma maculatum | | |
| Amphibia | Marbled Salamander | Ambystoma opacum | X | |
| Amphibia | Mole Salamander | Ambystoma talpoideum | X | |
| Amphibia | Smallmouth Salamander | Ambystoma texanum | X | |
| Amphibia | Tiger Salamander | Ambystoma tigrinum | | |
| Amphibia | Three-toed Amphiuma | Amphiuma tridactylum | X | |
| Amphibia | American Toad | Bufo americanus | X | |
| Amphibia | Fowler's Toad | Bufo fowleri | | X |
| Amphibia | Gulf Coast Toad | Bufo valliceps | | |
| Amphibia | Woodhouse's Toad | Bufo woodhousii | | |
| Amphibia | Southern Dusky Salamander | Desmognathus auriculatus | | |
| Amphibia | Dusky Salamander | Desmognathus fuscus | | |
| Amphibia | Southern Two-lined Salamander | Eurycea cirrigera | | |
| Amphibia | Longtail Salamander | Eurycea longicauda | | |
| Amphibia | Dwarf Salamander | Eurycea quadridigitata | | |
| Amphibia | Eastern Narrowmouth Toad | Gastrophryne carolinensis | X | |
| Amphibia | Bird-voiced Treefrog | Hyla avivoca | X | |
| Amphibia | Cope's Gray Treefrog | Hyla chrysoscelis | X | |
| Amphibia | Green Treefrog | Hyla cinerea | X | |
| Amphibia | Squirrel Treefrog | Hyla squirella | | |
| Amphibia | Gray Treefrog | Hyla versicolor | | |
| Amphibia | Mudpuppy | Necturus maculosus | | |
| Amphibia | Eastern Newt | Notophthalmus viridescens | X | |
| Amphibia | Zigzag Salamander | Plethodon dorsalis | | |
| Amphibia | Mississippi Salamander | Plethodon mississippi | | X |
| Amphibia | Spring Peeper | Pseudacris crucifer | X | |
| Amphibia | | Pseudacris feriarum | X | |
| Amphibia | Crawfish Frog | Rana areolata | | |
| Amphibia | Bullfrog | Rana catesbeiana | X | |
| Amphibia | Green Frog | Rana clamitans | X | |
| Amphibia | Pig Frog | Rana grylio | | |
| Amphibia | Pickerel Frog | Rana palustris | X | |
| Amphibia | Southern Leopard Frog | Rana sphenocephala | X | |
| Amphibia | Eastern Spadefoot Toad | Scaphiopus holbrookii | | |
| Amphibia | Lesser Siren | Siren intermedia | X | |
| **Number of species documented in YBA = 21** | | | **19** | **2** |

All species are on Mississippi Natural Heritage Program (MNHP) list.
*Species on MNHP list that also occur on WWF Mississippi Lowland Ecoregion list and in YBA.
^ Species on MNHP list that also occur in YBA, but not on the WWF Mississippi Lowland Ecoregion list.

**Table 3. Reptilian species from World Wildlife Fund (WWF) Mississippi Lowland Ecoregion occurring in Yazoo Backwater Area (YBA) according to Mississippi Natural Heritage Program**

| Class | Common Name | Scientific Name | WWF* | YBA Only^ |
|---|---|---|---|---|
| Reptilia | Copperhead | Agkistrodon contortrix | X | |
| Reptilia | Water Moccasin | Agkistrodon piscivorus | X | |
| Reptilia | American Alligator | Alligator mississippiensis | X | |
| Reptilia | Green Anole† | Anolis carolinensis | X | |
| Reptilia | Smooth Softshell | Apalone mutica | | |
| Reptilia | Spiny Softshell | Apalone spinifera | X | |
| Reptilia | Scarlet Snake | Cemophora coccinea | | |
| Reptilia | Snapping Turtle | Chelydra serpentina | X | |
| Reptilia | | Chrysemys dorsalis | | X |
| Reptilia | Painted Turtle | Chrysemys picta | X | |
| Reptilia | Six-lined Racerunner† | Cnemidophorus sexlineatus | X | |
| Reptilia | Racer† | Coluber constrictor | X | |
| Reptilia | Timber Rattlesnake | Crotalus horridus | X | |
| Reptilia | Chicken Turtle | Deirochelys reticularia | | |
| Reptilia | Ring-necked Snake | Diadophis punctatus | X | |
| Reptilia | Rat Snake | Elaphe obsoleta | X | |
| Reptilia | Five-lined Skink | Eumeces fasciatus | X | |
| Reptilia | Broadhead Skink | Eumeces laticeps | X | |
| Reptilia | Mud Snake | Farancia abacura | X | |
| Reptilia | Ouachita Map Turtle | Graptemys ouachitensis | | X |
| Reptilia | Mississippi Map Turtle | Graptemys pseudogeographica kohnii | X | |
| Reptilia | Eastern Hognose Snake† | Heterodon platirhinos | X | |
| Reptilia | Eastern Mud Turtle | Kinosternon subrubrum | X | |
| Reptilia | Prairie Kingsnake | Lampropeltis calligaster | | |
| Reptilia | Common Kingsnake | Lampropeltis getula | X | |
| Reptilia | Milk Snake | Lampropeltis triangulum | X | |
| Reptilia | Allig Snapping Turtle | Macrochelys temminckii | X | |
| Reptilia | Green Water Snake | Nerodia cyclopion | X | |
| Reptilia | Plain-bellied Water Snake | Nerodia erythrogaster | X | |
| Reptilia | Southern Water Snake | Nerodia fasciata | X | |
| Reptilia | | Nerodia rhombia | X | |
| Reptilia | Rough Green Snake | Opheodrys aestivus | X | |
| Reptilia | River Cooter | Pseudemys concinna | X | |
| Reptilia | Graham's Crayfish Snake | Regina grahami | X | |
| Reptilia | Eastern Fence Lizard | Sceloporus undulatus | | |
| Reptilia | Ground Skink† | Scincella lateralis | X | |
| Reptilia | | Sternotherus minor | | X |
| Reptilia | Common Musk Turtle | Sternotherus odoratus | X | |
| Reptilia | Dekay's Brown Snake | Storeria dekayi | X | |
| Reptilia | Eastern Box Turtle | Terrapene carolina | | |
| Reptilia | Western Ribbon Snake | Thamnophis proximus | X | |
| Reptilia | Common Garter Snake | Thamnophis sirtalis | X | |
| Reptilia | Common Slider | Trachemys scripta | X | |
| **Number of species documented in YBA = 37** | | | **34** | **3** |

All species are on Mississippi Natural Heritage Program (MNHP) list.
*Species on MNHP list that also occur on WWF Mississippi Lowland Ecoregion list and in YBA.
^ Species on MNHP list that also occur in YBA, but not on the WWF Mississippi Lowland Ecoregion list.
† Reptile species not adversely affected by the proposed project.

**Table 4. Avian species from World Wildlife Fund (WWF) Mississippi Lowland Ecoregion occurring in Yazoo Backwater Area (YBA) according to the U.S. Fish and Wildlife Service (FWS)**

| Class | Common Name | Scientific Name | YBA Occur* |
|---|---|---|---|
| Aves | Acadian Flycatcher | Empidonax virescens | X |
| Aves | American Bittern | Botaurus lentiginosus | X |
| Aves | American Black Duck | Anas rubripes | X |
| Aves | American Coot | Fulica americana | X |
| Aves | American Crow | Corvus brachyrhynchos | X |
| Aves | American Goldfinch | Carduelis tristis | X |
| Aves | American Kestrel | Falco sparverius | X |
| Aves | American Pipit | Anthus rubescens | X |
| Aves | American Redstart | Setophaga ruticilla | X |
| Aves | American Robin | Turdus migratorius | X |
| Aves | American Tree Sparrow | Spizella arborea | X |
| Aves | American White Pelican | Pelecanus erythrorhynchos | X |
| Aves | American Wigeon | Anas americana | X |
| Aves | American Woodcock | Scolopax minor | X |
| Aves | Anhinga | Anhinga anhinga | X |
| Aves | Bachman's Sparrow | Aimophila aestivalis | |
| Aves | Bald Eagle | Haliaeetus leucocephalus | X |
| Aves | Baltimore Oriole | Icterus galbula | |
| Aves | Barn Owl | Tyto alba | X |
| Aves | Barn Swallow | Hirundo rustica | X |
| Aves | Barred Owl | Strix varia | X |
| Aves | Bell's Vireo | Vireo bellii | |
| Aves | Belted Kingfisher | Ceryle alcyon | X |
| Aves | Bewick's Wren | Thryomanes bewickii | X |
| Aves | Black Skimmer | Rynchops niger | |
| Aves | Black Vulture | Coragyps atratus | X |
| Aves | Black-and-white Warbler | Mniotilta varia | X |
| Aves | Black-crowned Night-Heron | Nycticorax nycticorax | X |
| Aves | Blue Grosbeak | Passerina caerulea | X |
| Aves | Blue Jay | Cyanocitta cristata | X |
| Aves | Blue-gray Gnatcatcher | Polioptila caerulea | X |
| Aves | Blue-headed Vireo | Vireo solitarius | |
| Aves | Blue-winged Teal | Anas discors | X |
| Aves | Blue-winged Warbler | Vermivora pinus | X |
| Aves | Boat-tailed Grackle | Quiscalus major | |
| Aves | Brewer's Blackbird | Euphagus cyanocephalus | X |
| Aves | Broad-winged Hawk | Buteo platypterus | X |
| Aves | Brown Creeper | Certhia americana | X |
| Aves | Brown Thrasher | Toxostoma rufum | X |
| Aves | Brown-headed Cowbird | Molothrus ater | X |
| Aves | Bufflehead | Bucephala albeola | X |
| Aves | Canada Goose | Branta canadensis | X |
| Aves | Canvasback | Aythya valisineria | X |
| Aves | Carolina Chickadee | Poecile carolinensis | X |
| Aves | Carolina Wren | Thryothorus ludovicianus | |
| Aves | Caspian Tern | Sterna caspia | |
| Aves | Cedar Waxwing | Bombycilla cedrorum | X |

| Class | Common Name | Scientific Name | YBA Occur* |
|---|---|---|---|
| Aves | Cerulean Warbler | Dendroica cerulea | X |
| Aves | Chimney Swift | Chaetura pelagica | X |
| Aves | Chipping Sparrow | Spizella passerina | X |
| Aves | Chuck-will's-widow | Caprimulgus carolinensis | X |
| Aves | Cliff Swallow | Petrochelidon pyrrhonota | X |
| Aves | Common Goldeneye | Bucephala clangula | X |
| Aves | Common Grackle | Quiscalus quiscula | X |
| Aves | Common Ground-Dove | Columbina passerina | X |
| Aves | Common Merganser | Mergus merganser | X |
| Aves | Common Moorhen | Gallinula chloropus | X |
| Aves | Common Nighthawk | Chordeiles minor | X |
| Aves | Common Snipe | Gallinago gallinago | X |
| Aves | Common Yellowthroat | Geothlypis trichas | X |
| Aves | Cooper's Hawk | Accipiter cooperii | X |
| Aves | Dark-eyed Junco | Junco hyemalis | X |
| Aves | Dickcissel | Spiza americana | X |
| Aves | Downy Woodpecker | Picoides pubescens | X |
| Aves | Dunlin | Calidris alpina | X |
| Aves | Eared Grebe | Podiceps nigricollis | X |
| Aves | Eastern Bluebird | Sialia sialis | X |
| Aves | Eastern Kingbird | Tyrannus tyrannus | X |
| Aves | Eastern Meadowlark | Sturnella magna | X |
| Aves | Eastern Phoebe | Sayornis phoebe | X |
| Aves | Eastern Screech-Owl | Otus asio | X |
| Aves | Eastern Towhee | Pipilo erythrophthalmus | |
| Aves | Eastern Wood-Pewee | Contopus virens | X |
| Aves | Evening Grosbeak | Coccothraustes vespertinus | X |
| Aves | Field Sparrow | Spizella pusilla | X |
| Aves | Fish Crow | Corvus ossifragus | X |
| Aves | Forster's Tern | Sterna forsteri | |
| Aves | Fox Sparrow | Passerella iliaca | X |
| Aves | Fulvous Whistling-Duck | Dendrocygna bicolor | X |
| Aves | Gadwall | Anas strepera | X |
| Aves | Glossy Ibis | Plegadis falcinellus | X |
| Aves | Golden Eagle | Aquila chrysaetos | X |
| Aves | Golden-crowned Kinglet | Regulus satrapa | X |
| Aves | Grasshopper Sparrow | Ammodramus savannarum | X |
| Aves | Gray Catbird | Dumetella carolinensis | X |
| Aves | Great Blue Heron | Ardea herodias | X |
| Aves | Great Crested Flycatcher | Myiarchus crinitus | X |
| Aves | Great Egret | Ardea alba | X |
| Aves | Great Horned Owl | Bubo virginianus | X |
| Aves | Greater White-fronted Goose | Anser albifrons | X |
| Aves | Green-winged Teal | Anas crecca | X |
| Aves | Groove-billed Ani | Crotophaga sulcirostris | |
| Aves | Gull-billed Tern | Sterna nilotica | |
| Aves | Hairy Woodpecker | Picoides villosus | X |
| Aves | Harris's Sparrow | Zonotrichia querula | |
| Aves | Henslow's Sparrow | Ammodramus henslowii | X |
| Aves | Hermit Thrush | Catharus guttatus | X |

| Class | Common Name | Scientific Name | YBA Occur* |
|---|---|---|---|
| Aves | Herring Gull | Larus argentatus | X |
| Aves | Hooded Merganser | Lophodytes cucullatus | X |
| Aves | Hooded Warbler | Wilsonia citrina | X |
| Aves | Horned Lark | Eremophila alpestris | X |
| Aves | House Finch | Carpodacus mexicanus | X |
| Aves | House Wren | Troglodytes aedon | X |
| Aves | Indigo Bunting | Passerina cyanea | X |
| Aves | Ivory-billed Woodpecker | Campephilus principalis | |
| Aves | Kentucky Warbler | Oporornis formosus | X |
| Aves | Killdeer | Charadrius vociferus | X |
| Aves | King Rail | Rallus elegans | X |
| Aves | Lapland Longspur | Calcarius lapponicus | X |
| Aves | Lark Sparrow | Chondestes grammacus | X |
| Aves | Le Conte's Sparrow | Ammodramus leconteii | X |
| Aves | Least Bittern | Ixobrychus exilis | X |
| Aves | Least Sandpiper | Calidris minutilla | X |
| Aves | Least Tern | Sterna antillarum | X |
| Aves | Lesser Scaup | Aythya affinis | X |
| Aves | Lincoln's Sparrow | Melospiza lincolnii | X |
| Aves | Little Blue Heron | Egretta caerulea | X |
| Aves | Loggerhead Shrike | Lanius ludovicianus | X |
| Aves | Long-eared Owl | Asio otus | |
| Aves | Louisiana Waterthrush | Seiurus motacilla | X |
| Aves | Mallard | Anas platyrhynchos | X |
| Aves | Marsh Wren | Cistothorus palustris | X |
| Aves | Merlin | Falco columbarius | X |
| Aves | Mississippi Kite | Ictinia mississippiensis | X |
| Aves | Mourning Dove | Zenaida macroura | X |
| Aves | Northern Bobwhite | Colinus virginianus | X |
| Aves | Northern Cardinal | Cardinalis cardinalis | X |
| Aves | Northern Flicker | Colaptes auratus | X |
| Aves | Northern Harrier | Circus cyaneus | X |
| Aves | Northern Mockingbird | Mimus polyglottos | X |
| Aves | Northern Parula | Parula americana | X |
| Aves | Northern Pintail | Anas acuta | X |
| Aves | Northern Rough-winged Swallow | Stelgidopteryx serripennis | X |
| Aves | Northern Saw-whet Owl | Aegolius acadicus | |
| Aves | Northern Shoveler | Anas clypeata | X |
| Aves | Orange-crowned Warbler | Vermivora celata | X |
| Aves | Orchard Oriole | Icterus spurius | X |
| Aves | Ovenbird | Seiurus aurocapillus | X |
| Aves | Painted Bunting | Passerina ciris | X |
| Aves | Palm Warbler | Dendroica palmarum | |
| Aves | Peregrine Falcon | Falco peregrinus | |
| Aves | Pied-billed Grebe | Podilymbus podiceps | X |
| Aves | Pileated Woodpecker | Dryocopus pileatus | X |
| Aves | Pine Siskin | Carduelis pinus | X |
| Aves | Pine Warbler | Dendroica pinus | X |
| Aves | Prairie Warbler | Dendroica discolor | X |
| Aves | Prothonotary Warbler | Protonotaria citrea | X |

| Class | Common Name | Scientific Name | YBA Occur* |
|---|---|---|---|
| Aves | Purple Finch | Carpodacus purpureus | X |
| Aves | Purple Gallinule | Porphyrula martinica | X |
| Aves | Purple Martin | Progne subis | X |
| Aves | Red Crossbill | Loxia curvirostra | |
| Aves | Red Knot | Calidris canutus | |
| Aves | Red-bellied Woodpecker | Melanerpes carolinus | X |
| Aves | Red-breasted Nuthatch | Sitta canadensis | X |
| Aves | Red-cockaded Woodpecker | Picoides borealis | |
| Aves | Reddish Egret | Egretta rufescens | |
| Aves | Red-eyed Vireo | Vireo olivaceus | X |
| Aves | Redhead | Aythya americana | X |
| Aves | Red-headed Woodpecker | Melanerpes erythrocephalus | X |
| Aves | Red-shouldered Hawk | Buteo lineatus | X |
| Aves | Red-tailed Hawk | Buteo jamaicensis | X |
| Aves | Red-winged Blackbird | Agelaius phoeniceus | X |
| Aves | Ring-billed Gull | Larus delawarensis | X |
| Aves | Ring-necked Duck | Aythya collaris | X |
| Aves | Roseate Spoonbill | Ajaia ajaja | X |
| Aves | Rough-legged Hawk | Buteo lagopus | |
| Aves | Royal Tern | Sterna maxima | |
| Aves | Ruby-crowned Kinglet | Regulus calendula | X |
| Aves | Ruby-throated Hummingbird | Archilochus colubris | X |
| Aves | Ruddy Turnstone | Arenaria interpres | |
| Aves | Rusty Blackbird | Euphagus carolinus | X |
| Aves | Saltmarsh Sharp-tailed Sparrow | Ammodramus caudacutus | |
| Aves | Sanderling | Calidris alba | X |
| Aves | Sandwich Tern | Sterna sandvicensis | |
| Aves | Savannah Sparrow | Passerculus sandwichensis | X |
| Aves | Say's Phoebe | Sayornis saya | |
| Aves | Scarlet Tanager | Piranga olivacea | X |
| Aves | Seaside Sparrow | Ammodramus maritimus | |
| Aves | Sedge Wren | Cistothorus platensis | X |
| Aves | Sharp-shinned Hawk | Accipiter striatus | |
| Aves | Short-eared Owl | Asio flammeus | |
| Aves | Snowy Egret | Egretta thula | X |
| Aves | Song Sparrow | Melospiza melodia | X |
| Aves | Sora | Porzana carolina | X |
| Aves | Spotted Sandpiper | Actitis macularia | X |
| Aves | Sprague's Pipit | Anthus spragueii | |
| Aves | Striated Heron | Butorides striatus | |
| Aves | Summer Tanager | Piranga rubra | X |
| Aves | Swainson's Warbler | Limnothlypis swainsonii | X |
| Aves | Swallow-tailed Kite | Elanoides forficatus | |
| Aves | Swamp Sparrow | Melospiza georgiana | X |
| Aves | Tree Swallow | Tachycineta bicolor | X |
| Aves | Tricolored Heron | Egretta tricolor | X |
| Aves | Tufted Titmouse | Baeolophus bicolor | X |
| Aves | Turkey Vulture | Cathartes aura | X |
| Aves | Vesper Sparrow | Pooecetes gramineus | X |
| Aves | Virginia Rail | Rallus limicola | |

| Class | Common Name | Scientific Name | YBA Occur* |
|---|---|---|---|
| Aves | Warbling Vireo | Vireo gilvus | X |
| Aves | Western Meadowlark | Sturnella neglecta | |
| Aves | Western Sandpiper | Calidris mauri | X |
| Aves | Whip-poor-will | Caprimulgus vociferus | X |
| Aves | White Ibis | Eudocimus albus | X |
| Aves | White-breasted Nuthatch | Sitta carolinensis | X |
| Aves | White-crowned Sparrow | Zonotrichia leucophrys | |
| Aves | White-eyed Vireo | Vireo griseus | X |
| Aves | White-faced Ibis | Plegadis chihi | |
| Aves | White-throated Sparrow | Zonotrichia albicollis | X |
| Aves | White-winged Dove | Zenaida asiatica | X |
| Aves | Wild Turkey | Meleagris gallopavo | X |
| Aves | Willow Flycatcher | Empidonax traillii | |
| Aves | Winter Wren | Troglodytes troglodytes | X |
| Aves | Wood Duck | Aix sponsa | X |
| Aves | Wood Stork | Mycteria americana | X |
| Aves | Wood Thrush | Hylocichla mustelina | X |
| Aves | Worm-eating Warbler | Helmitheros vermivorus | X |
| Aves | Yellow Warbler | Dendroica petechia | X |
| Aves | Yellow-bellied Sapsucker | Sphyrapicus varius | X |
| Aves | Yellow-billed Cuckoo | Coccyzus americanus | X |
| Aves | Yellow-breasted Chat | Icteria virens | X |
| Aves | Yellow-crowned Night-Heron | Nyctanassa violacea | X |
| Aves | Yellow-rumped Warbler | Dendroica coronata | X |
| Aves | Yellow-throated Vireo | Vireo flavifrons | X |
| Aves | Yellow-throated Warbler | Dendroica dominica | X |
| **Number of species on WWF list documented in YBA =** | | | **184** |

All species on the list occur on WWF Mississippi Lowland Ecoregion list.
*Species on the FWS's species list for the Yazoo National Wildlife Refige Complex (including the Yazoo, Holt Collier, Theodore Roosevelt, and part of Panther Swamp National Wildlife Refuges).

**The following species have been observed in the Yazoo National Wildlife Refuge Complex, according to the FWS, but they are not included on the WWF Mississippi Lowland Ecoregion species list.**

| Class | Common Name | Scientific Name | YBA Occur |
|---|---|---|---|
| Aves | American Avocet | Recurvirostra americana | X |
| Aves | American Golden Plover | Pluvialis dominica | X |
| Aves | Baird's Sandpiper | Erolia bairdii | X |
| Aves | Bay-breasted Warbler | Dendroica castanea | X |
| Aves | Black Tern | Chlidonias niger | X |
| Aves | Black-bellied Whistling-Duck | Dendrocygna autumnalis | X |
| Aves | Blackburnian Warbler | Dendroica fusca | X |
| Aves | Black-necked Stilt | Himantopus mexicanus | X |
| Aves | Blackpoll Warbler | Dendroica striata | X |
| Aves | Black-throated Blue Warbler | Dendroica caerulescens | X |
| Aves | Black-throated Green Warbler | Dendroica virens | X |
| Aves | Bobolink | Dolichonyx oryzivorus | X |
| Aves | Bonaparte's Gull | Larus philadelphia | X |
| Aves | Burrowing Owl | Athene cunicularia | X |
| Aves | Canada Warbler | Wilsonia canadensis | X |
| Aves | Cattle Egret | Bubulcus ibis | X |
| Aves | Chestnut-sided Warbler | Dendroica pensylvanica | X |

| Class | Common Name | Scientific Name | YBA Occur |
|---|---|---|---|
| Aves | Cinnamon Teal | Anas cyanoptera | X |
| Aves | Common Loon | Gavia immer | X |
| Aves | Crested Caracara | Caracara cheriway | X |
| Aves | Double-crested Cormorant | Phalacrocorax auritus | X |
| Aves | European Starling | Sturnus vulgaris | X |
| Aves | Franklin's Gull | Larus pipixcan | X |
| Aves | Golden-winged Warbler | Vermivora chrysoptera | X |
| Aves | Gray-cheecked Thrush | Catharus minimus | X |
| Aves | Greater Scaup | Aythya marila | X |
| Aves | Greater Yellowlegs | Tringa melanoleuca | X |
| Aves | Green Heron | Butorides Virescens | X |
| Aves | Harlan's Hawk | Buteo jamaicensis | X |
| Aves | House Sparrow | Passer domesticus | X |
| Aves | Horned Grebe | Podiceps auritus | X |
| Aves | Lesser Yellowlegs | Tringa flavipes | X |
| Aves | Long-billed Dowitcher | Limnodromus scolopaceus | X |
| Aves | Magnolia Warbler | Dendroica magnolia | X |
| Aves | Marbled Godwit | Limosa fedoa | X |
| Aves | Mourning Warbler | Oporornis philadelphia | X |
| Aves | Nashville Warbler | Vermivora ruficapilla | X |
| Aves | Northern Oriole | Icterus galbula | X |
| Aves | Northern Waterthrush | Seiurus noveboracensis | X |
| Aves | Oldsquaw | Clangula hyemalis | X |
| Aves | Olive-sided Flycatcher | Contopus cooperi | X |
| Aves | Osprey | Pandion haliaetus | X |
| Aves | Pectoral Sandpiper | Calidris melanotos | X |
| Aves | Philadelphia Vireo | Vireo philadelphicus | X |
| Aves | Red-necked Phalarope | Phalaropus lobatus | X |
| Aves | Rock Dove | Columba livia | X |
| Aves | Rose-breasted Grosbeak | Pheucticus ludovicianus | X |
| Aves | Ross' Goose | Chen rossii | X |
| Aves | Ruddy Duck | Oxyura jamaicensis | X |
| Aves | Rufous Hummingbird | Selasphorus rufus | X |
| Aves | Rufous-sided Towhee | Pipilo erythrophthalmus | X |
| Aves | Sandhill Crane | Grus canadensis | X |
| Aves | Scissor-tailed Flycatcher | Tyrannus forficatus | X |
| Aves | Semipalmated Plover | Charadrius semipalmatus | X |
| Aves | Semipalmated Sandpiper | Calidris pusilla | X |
| Aves | Sharp-shinned Hawk | Accipiter striatus | X |
| Aves | Short-billed Dowitcher | Limnodromus griseus | X |
| Aves | Short-eared Owl | Asio flammeus | X |
| Aves | Snow Goose | Chen caerulescens | X |
| Aves | Solitary Sandpiper | Tringa solitaria | X |
| Aves | Solitary Vireo | Vireo solitarius | X |
| Aves | Spotted Towhee | Pipilo maculatus | X |
| Aves | Surf Scoter | Melanitta perspicillata | X |
| Aves | Swainson's Thrush | Catharus ustulatus | X |
| Aves | Tennesse Warbler | Vermivora peregrina | X |
| Aves | Tundra Swan | Cygnus columbianus | X |
| Aves | Upland Sandpiper | Bartramia longicauda | X |

| Class | Common Name | Scientific Name | YBA Occur |
|---|---|---|---|
| Aves | Veery | Catharus fuscescens | X |
| Aves | Vermilion Flycatcher | Pyrocephalus rubinu | X |
| Aves | Western Kingbird | Tyrannus verticali | X |
| Aves | White-winged Scoter | Melanitta fusca | X |
| Aves | Wilson's Warbler | Wilsonia pusilla | X |
| Aves | Yellow-bellied Flycatcher | Empidonax flaviventris | X |
| **Number of species documented by FWS, but not WWF =** | | | **73** |

**Table 5. Mammalian species from World Wildlife Fund (WWF) Mississippi Lowland Ecoregion occurring in Yazoo Backwater Area (YBA) according to Mississippi Natural Heritage Program**

| Class | Common Name | Scientific Name | WWF* | YBA Only^ |
|---|---|---|---|---|
| Mammalia | Southern Short-tailed Shrew | Blarina carolinensis | X | |
| Mammalia | Elliot's Short-tailed Shrew | Blarina hylophaga | | |
| Mammalia | Coyote | Canis latrans | X | |
| Mammalia | American Beaver | Castor canadensis | X | |
| Mammalia | Rafinesque's Big-eared Bat | Corynorhinus rafinesquii | X | |
| Mammalia | Least Shrew | Cryptotis parva | X | |
| Mammalia | Nine-banded Armadillo | Dasypus novemcinctus | X | |
| Mammalia | Virginia Opossum | Didelphis virginiana | X | |
| Mammalia | Big Brown Bat | Eptesicus fuscus | X | |
| Mammalia | Southern Flying Squirrel | Glaucomys volans | X | |
| Mammalia | Silver-haired Bat | Lasionycteris noctivagans | X | |
| Mammalia | Red Bat | Lasiurus borealis | X | |
| Mammalia | Hoary Bat | Lasiurus cinereus | X | |
| Mammalia | Northern Yellow Bat | Lasiurus intermedius | | |
| Mammalia | Seminole Bat | Lasiurus seminolus | X | |
| Mammalia | Northern River Otter | Lutra canadensis | X | |
| Mammalia | Bobcat | Lynx rufus | X | |
| Mammalia | Striped Skunk | Mephitis mephitis | X | |
| Mammalia | Prairie Vole | Microtus ochrogaster | | |
| Mammalia | Woodland Vole | Microtus pinetorum | X | |
| Mammalia | Long-tailed Weasel | Mustela frenata | X | |
| Mammalia | American Mink | Mustela vison | X | |
| Mammalia | Nutria | Myocaster coypus | | X |
| Mammalia | Southeastern Myotis | Myotis austroriparius | X | |
| Mammalia | Gray Myotis | Myotis grisescens | | |
| Mammalia | Eastern Small-footed Myotis | Myotis leibii | | |
| Mammalia | Little Brown Bat | Myotis lucifugus | | |
| Mammalia | Myotis septentrionalis | Myotis septentrionalis | | |
| Mammalia | Indiana Bat | Myotis sodalis | | |
| Mammalia | Eastern Woodrat | Neotoma floridana | X | |
| Mammalia | Nycticeius humeralis | Nycticeius humeralis | X | |
| Mammalia | Golden Mouse | Ochrotomys nuttalli | X | |
| Mammalia | White-tailed Deer | Odocoileus virginianus | X | |
| Mammalia | Muskrat | Ondatra zibethicus | X | |
| Mammalia | Marsh Rice Rat | Oryzomys palustris | X | |
| Mammalia | Cotton Mouse | Peromyscus gossypinus | X | |
| Mammalia | White-footed Mouse | Peromyscus leucopus | X | |
| Mammalia | Deer Mouse | Peromyscus maniculatus | | |
| Mammalia | Eastern Pipistrelle | Pipistrellus subflavus | X | |
| Mammalia | Northern Raccoon | Procyon lotor | X | |
| Mammalia | Fulvous Harvest Mouse | Reithrodontomys fulvescens | X | |
| Mammalia | Eastern Harvest Mouse | Reithrodontomys humulis | X | |
| Mammalia | Western Harvest Mouse | Reithrodontomys megalotis | | |
| Mammalia | Eastern Mole | Scalopus aquaticus | X | |
| Mammalia | Eastern Gray Squirrel | Sciurus carolinensis | X | |
| Mammalia | Eastern Fox Squirrel | Sciurus niger | X | |

| Class | Common Name | Scientific Name | WWF* | YBA Only^ |
|---|---|---|---|---|
| Mammalia | Hispid Cotton Rat | Sigmodon hispidus | X | |
| Mammalia | Southeastern Shrew | Sorex longirostris | X | |
| Mammalia | Eastern Spotted Skunk | Spilogale putorius | X | |
| Mammalia | Wild pig | Sus scrofa | | X |
| Mammalia | Swamp Rabbit | Sylvilagus aquaticus | X | |
| Mammalia | Eastern Cottontail | Sylvilagus floridanus | X | |
| Mammalia | Southern Bog Lemming | Synaptomys cooperi | | |
| Mammalia | Brazilian Free-tailed Bat | Tadarida brasiliensis | X | |
| Mammalia | Eastern Chipmunk | Tamias striatus | X | |
| Mammalia | American Badger | Taxidea taxus | | |
| Mammalia | Gray Fox | Urocyon cinereoargenteus | X | |
| Mammalia | American Black Bear | Ursus americanus | X | |
| Mammalia | Louisiana Black Bear | Ursus americanus luteolus | | X |
| Mammalia | Red Fox | Vulpes vulpes | X | |
| Mammalia | Meadow Jumping Mouse | Zapus hudsonius | | |
| **Number of species documented in YBA = 48** | | | **45** | **3** |

All species are on Mississippi Natural Heritage Program (MNHP) list.
*Species on MNHP list that also occur on WWF Mississippi Lowland Ecoregion list and in YBA.
^ Species on MNHP list that also occur in YBA, but not on the WWF Mississippi Lowland Ecoregion list.

| Table 6. List of potential fish species occurring in the Yazoo Backwater Area (YBA) based on collections by the U.S. Army Corps of Engineers (Corps) and the Mississippi Museum of Natural Science from Sharkey, Issaquena, Yazoo and Humphreys Counties | | | | |
|---|---|---|---|---|
| **Class** | **Common name** | **Scientific Name** | **Corps*** | **Backwater Dependant^** |
| Osteichthyes | Skipjack herring | Alosa chrysochloris | | |
| Osteichthyes | Black bullhead | Ameiurus melas | X | X |
| Osteichthyes | Yellow bullhead | Ameiurus natalis | X | X |
| Osteichthyes | Brown bullhead | Ameiurus nebulosus | | X |
| Osteichthyes | Bowfin | Amia calva | X | X |
| Osteichthyes | Scaly sand darter | Ammocrypta vivax | X | |
| Osteichthyes | American eel | Anguilla rostrata | X | |
| Osteichthyes | Pirate perch | Aphredoderus sayanus | X | X |
| Osteichthyes | Freshwater drum | Aplodinotus grunniens | X | X |
| Osteichthyes | Central stoneroller | Campostoma anomalum | | |
| Osteichthyes | River carpsucker | Carpiodes carpio | X | |
| Osteichthyes | Quillback | Carpiodes cyprinus | | |
| Osteichthyes | Flier | Centrarchus macropterus | X | X |
| Osteichthyes | Blue sucker | Cycleptus elongatus | X | |
| Osteichthyes | Bluntface shiner | Cyprinella camura | X | |
| Osteichthyes | Blacktail shiner | Cyprinella venusta venusta | X | X |
| Osteichthyes | Common carp | Cyprinus carpio | X | |
| Osteichthyes | Gizzard shad | Dorosoma cepedianum | X | X |
| Osteichthyes | Threadfin shad | Dorosoma petenense | X | X |
| Osteichthyes | Banded pygmy sunfish | Elassoma zonatum | X | X |
| Osteichthyes | Creek chubsucker | Erimyzon oblongus | | |
| Osteichthyes | Redfin pickerel | Esox americanus | X | X |
| Osteichthyes | Mud darter | Etheostoma asprigene | X | X |
| Osteichthyes | Bluntnose darter | Etheostoma chlorosoma | X | X |
| Osteichthyes | Swamp darter | Etheostoma fusiforme | X | X |
| Osteichthyes | Slough darter | Etheostoma gracile | X | X |
| Osteichthyes | Redfin darter | Etheostoma whipplei artesiae | X | |
| Osteichthyes | Golden topminnow | Fundulus chrysotus | X | X |
| Osteichthyes | Starhead topminnow | Fundulus dispar | X | |
| Osteichthyes | Blackstripe topminnow | Fundulus notatus | X | X |
| Osteichthyes | Blackspotted topminnow | Fundulus olivaceus | X | X |
| Osteichthyes | Mosquitofish | Gambusia affinis | X | X |
| Osteichthyes | Goldeye | Hiodon alosoides | X | |
| Osteichthyes | Mooneye | Hiodon tergisus | X | |
| Osteichthyes | Cypress minnow | Hybognathus hayi | | X |
| Osteichthyes | Mississippi silvery minnow | Hybognathus nuchalis | X | X |
| Osteichthyes | Bighead carp | Hypophthalmichthys nobilis | | |
| Osteichthyes | Chestnut lamprey | Ichthyomyzon castaneus | X | |
| Osteichthyes | Blue catfish | Ictalurus furcatus | X | X |
| Osteichthyes | Channel catfish | Ictalurus punctatus | X | X |
| Osteichthyes | Smallmouth buffalo | Ictiobus bubalus | X | X |
| Osteichthyes | Bigmouth buffalo | Ictiobus cyprinellus | X | X |
| Osteichthyes | Black buffalo | Ictiobus niger. | | X |
| Osteichthyes | Brook silverside | Labidesthes sicculus | X | X |

| Class | Common name | Scientific Name | Corps* | Backwater Dependant^ |
|---|---|---|---|---|
| Osteichthyes | Spotted gar | Lepisosteus oculatus | X | X |
| Osteichthyes | Longnose gar | Lepisosteus ossens | X | X |
| Osteichthyes | Shortnose gar | Lepisosteus platostomus | X | X |
| Osteichthyes | Green sunfish | Lepomis cyanellus | X | X |
| Osteichthyes | Warmouth | Lepomis gulosus | X | X |
| Osteichthyes | Orangespotted sunfish | Lepomis humilis | X | X |
| Osteichthyes | Bluegill | Lepomis macrochirus | X | X |
| Osteichthyes | Dollar sunfish | Lepomis marginatus | X | X |
| Osteichthyes | Longear sunfish | Lepomis megalotis | X | X |
| Osteichthyes | Redear sunfish | Lepomis microlophus | X | X |
| Osteichthyes | Spotted sunfish | Lepomis miniatus | X | X |
| Osteichthyes | Bantum sunfish | Lepomis symmetricus | X | X |
| Osteichthyes | Striped shiner | Luxilus chrysocephalus isolepis | X | |
| Osteichthyes | Redfin shiner | Lythrurus umbratilis cyanocephalus | X | X |
| Osteichthyes | Speckled chub | Macrhybopsis aestivalis | X | |
| Osteichthyes | Silver chub | Macrhybopsis storeriana | X | X |
| Osteichthyes | Inland silverside | Menidia beryllina | X | |
| Osteichthyes | Spotted bass | Micropterus punctulatus | X | |
| Osteichthyes | Largemouth bass | Micropterus salmoides | X | X |
| Osteichthyes | White bass | Morone chrysops | X | X |
| Osteichthyes | Yellow bass | Morone mississippiensis | | X |
| Osteichthyes | Striped bass | Morone saxatilis | X | |
| Osteichthyes | Blacktail redhorse | Moxostoma poecilurum | X | |
| Osteichthyes | Golden shiner | Notemigonus crysoleucas | X | X |
| Osteichthyes | Emerald shiner | Notropis atherinoides | X | X |
| Osteichthyes | River shiner | Notropis blennius | | |
| Osteichthyes | Ghost shiner | Notropis buchanani | X | X |
| Osteichthyes | Longnose shiner | Notropis longirostris | | |
| Osteichthyes | Red shiner | Notropis lutrensis | X | X |
| Osteichthyes | Taillight shiner | Notropis maculatus | | |
| Osteichthyes | Yazoo shiner | Notropis rafinesquei | X | |
| Osteichthyes | Sabine shiner | Notropis sabinae | X | |
| Osteichthyes | Silverband shiner | Notropis shumardi | X | X |
| Osteichthyes | Weed shiner | Notropis texanus | | |
| Osteichthyes | Mimic shiner | Notropis volucellus | X | X |
| Osteichthyes | Tadpole madtom | Noturus gyrinus | X | X |
| Osteichthyes | Freckled madtom | Noturus nocturnus | X | |
| Osteichthyes | Pugnose minnow | Opsopoeodus emiliae | X | X |
| Osteichthyes | Logperch | Percina caprodes | | |
| Osteichthyes | Dusky darter | Percina sciera | X | |
| Osteichthyes | River darter | Percina shumardi | | |
| Osteichthyes | Paddlefish | Polyodon spathula | X | X |
| Osteichthyes | Southern redbelly dace | Phoxinus erythrogaster | | |
| Osteichthyes | Bluntnose minnow | Pimephales notatus | X | |
| Osteichthyes | Fathead minnow | Pimephales promelas | X | X |
| Osteichthyes | Bullhead minnow | Pimephales vigilax | X | X |
| Osteichthyes | White crappie | Pomoxis annularis | X | X |
| Osteichthyes | Black crappie | Pomoxis nigromaculatus | X | X |
| Osteichthyes | Flathead catfish | Pylodictis olivaris | X | |

| Class | Common name | Scientific Name | Corps* | Backwater Dependant^ |
|---|---|---|---|---|
| Osteichthyes | Creek chub | Semotilus atromaculatus | | |
| Osteichthyes | Sauger | Stizostedion canadense | X | |
| **Number of species documented in YBA = 95** | | | **78** | **58** |

All species are on Mississippi Natural Heritage Program (MNHP) list.
*Collected by Corps in the YBA.
^Backwater dependency based on FWS literature or collection records in backwater areas.

# Appendix 3

## Yazoo Backwater Area Wetland Plant Species List

The following list was compiled from field samples of observed vegetation during the wetland determinations carried out in June 2003 as part of the Environmental Monitoring Assessment Program (EMAP) survey to determine jurisdictional wetland extent in the project area. The list is a composite of 70 EMAP wetland points.

**Table 1. Common Wetland Vegetation of the Lower Yazoo Basin, Mississippi. Plant species observed during field sampling in June 2003**

| Abbreviation | Scientific Name | Common Name | Status |
|---|---|---|---|
| ACNE | *Acer negundo* | box elder | FACW |
| ACRU | *Acer rubrum* | red maple | FACW |
| ALPH | *Alteranthera philoxeroides* | alligator weed | OBL |
| AMTR | *Ambrosia trifida* | ragweed | FAC |
| AMAR | *Ampelopsis arborea* | pepper vine | FAC+ |
| AMBR | *Amphicarpa bracteata* | hog peanut | FAC |
| ANVI | *Adropogon virginicus* | Broom sedge | FAC- |
| ANCA | *Anisostichus capreolata* | cross vine | Upland |
| ARGI | *Arundinaria gigantea* | cane | FACW |
| ARTR | *Arisaema triphyllum* | Jack-in-the-pulpit | FACW- |
| ASPE | *Asclepias perenius* | milkweed | OBL |
| ASPA | *Asimina parviflora* | Paw Paw | FACU |
| BAHA | *Bacccharis halmifolia* | saltbush | FAC |
| BESC | *Berchemia scandens* | rattan vine | FACW |
| BICA | *Bignonia capreolata* | cross vine | FAC |
| BOCY | *Boehmeria cylindrica* | bog hemp | FACW+ |
| BRCI | *Brunnichia cirrhosa* | redvine | FACW |
| CACAM | *Callicarpa americana* | beauty-berry | FACU- |
| CAFL | *Calycanthus floridus* | spicebush | FACU+ |
| CARA | *Campsis radicans* | trumpet creeper | FAC |
| CACH | *Carex cherokeenensis* | | FACW |
| CATA | *Carophyllum tainturieri* | | FAC |
| CACA | *Carpinus caroliniana* | ironwood | FAC |
| CAAQ | *Carya aquatica* | bitter pecan | OBL |
| CAGL | *Carya glabra* | pignut hickory | FACU |
| | *Carya illinoinensis* | pecan | FAC |
| CATO | *Carya tomentosa* | mockernut hickory | Upland |
| CEOC | *Cephalanthus occidentalis* | buttonbush | OBL |
| CECA | *Cercis canadensis* | redbud | FACU |
| CELA | *Celtis laevigata* | sugarberry | FACW |

| Abbreviation | Scientific Name | Common Name | Status |
|---|---|---|---|
| COCA | *Cocculus caroliniana* | | FAC |
| COCO | *Commelina communis* | dayflower | FAC |
| COAM | *Cornus amomum* | swamp dogwood | FACW+ |
| CODR | *Cornus drumondii* | roughleaf dogwood | FAC |
| COFL | *Cornus florida* | flowering dogwood | FACU |
| COST | *Cornus foemina (stricta?)* | stiff dogwood | FACW- |
| COVI | *Commelina virginica* | Virginia dayflower | FACW |
| CRSP | *Crataegus spathulata* | hawthorne | FAC |
| | *Crataegus viridis* | green hawthorne | FACW |
| DEBA | *Decumaria barbara* | climbing hydrangea | FACW |
| DEIL | *Desmanthus illinoensis* | | FAC |
| DIVI | *Diospyros virginiana* | persimmon | FAC |
| ECCR | *Echinochloa crus-galli* | | FACW |
| ELUM | *Elaeagnus umbellata* | silverberry | FACU |
| ELCA | *Elephantopus carolinianus* | elephant's-foot | FAC |
| FIAU | *Fimbristylis autumnalis* | beak rush | OBL |
| FOAC | *Foresteiria acuminata* | swamp privet | OBL |
| FRVI | *Fragaria virginiana* | wild strawberry | FAC- |
| FRAM | *Fraxinus americana* | white ash | FACU |
| FRPE | *Fraxinus pennsylvanica* | green ash | FACW |
| GECA | *Geum canadense* | | FAC |
| GLTR | *Gleditsia triacanthos* | honey locust | FAC- |
| HACA | *Halesia carolina* | Carolina silverbell | FACU+ |
| HIMI | *Hibiscus laevis (militaris)* | rose mallow | OBL |
| ILDE | *Ilex decidua* | deciduous holly | FACW- |
| IMCA | *Impatiens capensis* | jewel-weed | FACW |
| IVAN | *Iva annua* | Sump weed | FAC |
| JUNI | *Juglans nigra* | black walnut | FACU |
| JUEF | *Juncus effusus* | soft rush | OBL |
| JURE | *Juncus repens* | | OBL |
| JUTE | *Juncus tenuous* | | FAC |
| LELE | *Leersia lenticularis* | catchfly cutgrass | OBL |
| LISI | *Ligustrum sinense* | privet | FAC |
| LIST | *Liquidambar styraciflua* | sweetgum | FAC+ |
| LITU | *Liriodendron tulipifera* | yellow poplar | FAC |
| LOJA | *Lonicera japonica* | Japanese honeysuckle | FAC- |
| LUPA | *Ludwigia papilloides* | | OBL |
| MIVI | *Microstegium virmineum* | Microstegium | NL |
| MORU | *Morus rubra* | red mulberry | FAC |
| NYSY | *Nyssa sylvatica* | blackgum | FAC |
| OPHI | *Oplismenus hirtellus* | basket grass | FACU+ |
| OSVI | *Ostrya virginiana* | hop hornbeam | FACU- |

| Abbreviation | Scientific Name | Common Name | Status |
|---|---|---|---|
| PAQU | *Parthenocissus quinquefolia* | Virginia creeper | FAC |
| PIPU | *Pilea pumila* | clearweed | FACW+ |
| PITA | *Pinus taeda* | loblolly pine | FAC |
| PLAQ | *Planera aquatica* | | OBL |
| PLOC | *Platanus occidentalis* | sycamore | FACW- |
| POAC | *Polystichum acrostichoides* | Christmas fern | FAC |
| PODE | *Populus deltoides* | cottonwood | FAC+ |
| POHY | *Polygonum hydropiperoides* | | OBL |
| POPU | *Polygonum punctatum* | knotweed | FACW+ |
| POPE | *Polygonum pennsylvanica* | | FACW |
| PRSE | *Prunus serotina* | black cherry | FACU |
| PULO | *Pueraria lobata* | kudzu | Upland |
| QULY | *Quercus lyrata* | overcup oak | OBL |
| QUNI | *Quercus nigra* | water oak | FAC |
| QUNU | *Quercus nuttallii* | Nuttall oak | OBL |
| QUPH | *Quercus phellos* | willow oak | FACW- |
| QURU | *Quercus rubra* | red oak | FACU |
| RUAR | *Rubus argutus* | blackberry | FAC- |
| RUCR | *Rumex crispus* | Curly dock | FAC |
| SACE | *Sauraurus cernuus* | Lizard's tail | OBL |
| SANI | *Salix nigra* | black willow | OBL |
| SACA | *Sambucus canadensis* | elderberry | FACW- |
| SEEX | *Sesbania exaltata* | | FACW |
| SMLA | *Smilax laurifolia* | green briar | FACW+ |
| SMRO | *Smilax rotundifolia* | green briar | FAC |
| SOAL | *Solidago altisima* | Goldenrod | FACU |
| SOHA | *Sorghum halpense* | Johnson grass | FACU |
| TADI | *Taxodium distichum* | Cypress | OBL |
| TORA | *Toxicodendron radicans* | poison ivy | FAC |
| TRDE | *Treclospermum deforma* | | FACW |
| TOVI | *Tovara virginicum* | | FAC |
| ULAL | *Ulmus alata* | winged elm | FACU+ |
| ULCR | *Ulmus crassifolia* | cedar elm | |
| ULAM | *Ulmus americana* | American elm | FACW |
| UNLA | *Chasmanthium latifolium* | Spikegrass | FACU |
| VAST | *Vaccinium stamineum* | huckleberry | FACU |
| VEHA | *Verbena hastata* | | FAC |
| VEBR | *Verbena bracteata* | big bract verbena | FACU |
| VIFL | *Viola floridana* | | FACW- |
| VICI | *Vitus cinerea* | graybark grape | FAC+ |
| VIRO | *Vitus rotundifolia* | muscadine | FAC |

# Appendix 4

## U.S. Fish and Wildlife Service Report on Effects of Yazoo Backwater Pumps Project on Flood Dependent Fauna of the Area

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Mississippi Field Office
6578 Dogwood View Parkway, Suite A
Jackson, Mississippi 39213

June 1, 2008

Ronald J. Mikulak
U.S. Environmental Protection Agency (Region 4)
Wetlands, Coastal and Non-point Source Branch
Water Management Division
61 Forsyth Street, SW
Atlanta, Georgia 30303-8960

Dear Mr. Mikulak:

On April 29, 2008 the Department of Interior submitted comments on the U.S. Environmental Protection Agency's (EPA) March 19, 2008 proposed 404(c) determination for the Yazoo Backwater Area Reformulation Report, Issaquena County, Mississippi. Subsequent to this, the Fish and Wildlife Service has compiled additional information on fish and wildlife resources occurring within the Yazoo Backwater area and the effects that reductions in the frequency, extent, and duration of flooding proposed as a result of the project would likely have to those species. We wish to provide this supplemental information in support of the subject proposed determination.

Enclosed is information which outlines certain life history aspects, ecological relationships, and potential impacts of reductions in flooding to birds, fish, reptiles, amphibians, and vegetation. In compiling this information, we utilized expertise available within the Service's Ecological Services, Fisheries, Migratory Birds, and Refuge programs, as well as expertise from others knowledgeable of fish and wildlife in the area.

If you have any questions, please feel free to contact me at 601-321-1121.

Sincerely,

Ray Aycock
Field Supervisor

Enclosure

**Fish and Wildlife Resources Associated with the Yazoo Backwater Area
Certain Life History Aspects, Ecological Relationships, and
Effects Anticipated as a Result of Reduced Flooding**

**U.S. Fish and Wildlife Service
June 11, 2008**

## Table of Contents

**Proposed Yazoo Pumps Project Impacts to Wildlife**

General Impacts – Bottomland hardwood system

Seasonal dynamics of surface flooding and soil saturation are primary ecological processes that determine the structure, functions, and values of bottomland hardwood forest (BLH) (Heitmeyer et al. 2005). Almost all BLH habitats flood at least some portion of most years, and the Yazoo project area is certainly no exception. Waters inundate BLH from a variety of sources, including on-site rainfall, head- and back-water flooding from local rivers and streams, and recharges from groundwater aquifers. The source of flood water determines timing and extent of flooding, nutrient flow, and site productivity (Hupp et al. 2005). Precipitation and runoff are usually greatest in late winter and spring in BLH regions; therefore, most flooding occurs at this time. During the last century, anthropogenic activities have had serious negative effects on historic bottomland hardwood forests with high diversity and a rich and abundant fauna. Drainage and de-watering of these systems have caused the following modified conditions: shift in plant composition to less water tolerant species, disruption of sheetflow, reduced use and abundance of some fauna, invasion of exotic fishes, and reduced variability of flooding (Table 1 in Fredrickson, L.H. 2005).

Impacts to Birds

In wetland ecosystems, such as BLH, one of the most important elements of their productivity is the invertebrate population (Griffith and Welker 1987). In turn, hydrology is the most important factor that determines vegetative structure and function (Fredrickson 1979, Klimas et al. 1981, Schoenholtz 1996), and thus invertebrate communities in bottomland hardwood ecosystems (Moore 1970, Reid 1985, Fredrickson and Reid 1990, Magee et al. 1999, Sharitz and Batzer 1999). Wetland invertebrates, such as adult aquatic insects, insect larvae and nymphs, crustaceans and mollusks, provide an important food source for wetland bird species during critical physiological periods such as breeding and migration (Reid 1985). Short-term flooding regimes may determine the occurrence and abundance of invertebrates (Fredrickson and Reid 1988). The duration and timing of flooding in water basins, such as the Yazoo River Basin, directly influences availability of aquatic habitat and indirectly affects invertebrate populations. Densities of invertebrates change rapidly and dramatically as organisms break or enter dormant stages and otherwise respond to changing environmental conditions (Smock 1999). Fragmentation and modification of the timing and duration of natural flooding in BLH ultimately reduces long-term productivity of these wetlands, limiting habitat availability, and resulting in a decline of wetland bird use (Fredrickson and Reid 1990). For example, when forests become fragmented and drier, small rodent populations increase, greatly causing reduced survival of tree seedlings and changes to detrital bases which have ripple effects throughout most food chains in the system (Heitmeyer et al. 2005). "In Mississippi, invertebrate biomass was reduced by approximately one-half (80.05 vs. 40.64 kg/ha) in consecutive years in a naturally flooded bottomland hardwood forest with less frequent flooding during the second winter" (Wehrle et al. 1995). Wehrle (1992) also documented a positive correlation between water depth and invertebrate abundance in naturally flooded hardwood bottomlands at Noxubee National Wildlife Refuge in Mississippi, where lower site which flooded deeper and longer had greater invertebrate biomass.

Bird communities in BLH are abundant and diverse. Smith et al. (1993) listed 200 species of birds that occur in the Mississippi Alluvial Valley (MAV), largely in BLH, which is > 85% of 236 species of birds listed in eastern North America. Large numbers of 12 species of waterfowl commonly use BLH habitats in the southeastern US, small numbers of 11 species regularly use BLH areas, and 8 species less commonly use BLH (Fredrickson and Heitmeyer 1988, Heitmeyer 2001). All of these species of waterfowl utilize habitats in the Yazoo project area (Table 1). Waterfowl occupy many niches in BLH of the MAV. The flooded forests of the MAV provide waterfowl with many of their needs. Acorns, as well as seeds from wetland plants growing in forest openings are important foods. Leaf litter furnishes a rich substrate for invertebrates, which can be a significant component of waterfowl diets (Heitmeyer 1988). Nutrient reserves, such as invertebrates, fuel migration and help meet energetic requirements during periods of low, widely dispersed food availability (Heitmeyer et al. 2005). Population size and recruitment of most species of waterfowl are correlated with wetness of primary breeding habitats, and, at least for some species, also migration and wintering habitats. The amount and type of habitat flooded, annual food production, and availability of refuges within BLH and associated wetland habitats in the MAV influences local and regional distribution of species (e.g., Nichols et al. 1983), and subsequent production and survival of mallards and wood ducks (Heitmeyer and Fredrickson 1981, Reinecke et al. 1987). The wood duck is an important resident species in the Yazoo River Basin. Wood ducks require wetland areas that provide a high-quality plant and invertebrate food base. During the breeding season, female wood ducks may use stored lipid reserves to assist with egg production; however, they must consume essentially all of the protein needed for egg formation on a daily basis during the laying period (Drobney 1977). The required source of most of these proteins is a variety of invertebrates produced in these wetland habitats.

Most (14 of 18) species of wading birds found in North America use BLH habitats, and 12 of these species breed regularly in this system (Heitmeyer et al. 2005). Diets of most wading birds vary with seasonal availability, and many species forage extensively on small fish, amphibians, reptiles, and crayfish. Waders generally depend on seasonally-fluctuating water levels in BLH and associated wetlands to make prey more available. One species that nests in the Yazoo project area, the Little Blue Heron, has recently shown declines in its population. Although the overall causes for this population change cannot be directly determined, altered hydrocycles and habitat conversion have caused and continue to cause the greatest threats to this species. Food limitation, caused by this wetland destruction and degradation, appears to be a significant factor controlling its breeding success and, therefore, its population numbers (Rodgers and Smith 1995). Among the wading birds listed as priority species for management in the MAV are the following: Little Blue Heron, Tricolored Heron, American Bittern, Least Bittern, Black-crowned Night Heron, Yellow-crowned Night Heron, Great Egret, White Ibis, and Wood Stork (unpub. report 2002).

For many shorebird species, migration "stop-over" habitats play a vital role in their ability to accumulate fat reserves. Shorebirds unsuccessful in obtaining necessary fat are thought to have very low survival rates (Brown, Hickey, and Harrington 2000). If these fat deposits are crucial for breeding and if they are dependent on feeding conditions on migratory stopovers south of breeding area, then changes in quantity and quality of migratory habitat could influence breeding populations and fitness parameters (MacLean 1969, Wiens and Farmer 1996, A. H. Farmer and J. A. Wiens unpubl.).

According to Twedt et al. (1997), shallowly flooded wetlands must be present in the Yazoo River Basin for shorebirds during northbound (spring) migration. These ephemeral shallow mud flats and sandbars provide critical foods, primarily invertebrates, needed for adults during their long migration to breeding areas to the north. The shorebird species detected utilizing these wetlands included the following:

Common Snipe
Kildeer
Lesser Yellowlegs
Greater Yellowlegs
Semipalmated Sandpiper
Western Sandpiper
Least Sandpiper
Pectoral Sandpiper
White-rumped Sandpiper
Long-billed Dowitcher
Short-billed Dowitcher

Analyses of spring migratory patterns of female pectoral sandpipers (A. H. Farmer and J. A. Wiens unpubl., Wiens and Farmer 1996), yielded the following: (1) Beginning at Texas Gulf Coast, body fat of migrating females increases with latitude and remains significantly greater than that of males throughout spring migration, supporting the importance of feeding areas along migratory stopovers; (2) length of stay in stopover sites is positively related to invertebrate abundances, indicating longer stays at stopover points that offer higher ingestion rates; (3) females attain peak body fat at about 40°N latitude; (4) mean egg volume is positively related ($p = 0.027$, $n = 53$) to female body fat on breeding grounds, and clutches with higher egg volume hatched larger chicks ($p = 0.001$, $n = 7$), suggesting relationship between female condition and reproductive success; and (5) females are selected for both time and energy optimization in that there is apparent need for females to arrive early on breeding grounds, with excess energy reserves. All of these findings indicate the importance of spring migration stopover wetlands, such as the Yazoo project site, in the life history of shorebirds.

Recent studies of habitat use and energetics in spring migration stopover sites suggest the need to conserve complexes of small wetlands; such landscape connectivity is needed for maintenance of variety of foraging sites within close proximity (Farmer and Parent 1997). Management of wetland and agricultural units that maintain shallowly flooded fields (1–15 cm deep) during migratory periods provide good foraging sites (Helmers 1993).

If the frequency of spring flooding in the Yazoo project area is significantly reduced, then the loss of this seasonal wetland habitat would result in lower survival rates, and therefore, reduced northward shorebird migrations. Other shorebird species impacted by this reduced flooding frequency, which have been documented in the project area, include the following:

Spotted Sandpiper
Baird's Sandpiper
Sanderling
Dunlin
Black-necked Stilt
Solitary Sandpiper

Other aquatic-associated migrants utilizing the Yazoo area mostly restricted to deeper open water areas include the pied-billed grebe, double-crested cormorant, and anhinga. Anhingas breed in the area, typically in low elevation sites where large baldcypress trees and permanent water occur.

About 130 species of songbirds regularly use BLH habitats, most of which have been documented in the Yazoo project area (Table 1). Most songbirds in this system are insectivorous during spring migration and the breeding season. These birds capitalize on pulses of certain foods, such as insect hatches in spring and lepidopteran larvae in early summer (Heitmeyer et al. 2005). A much shorter list of forest breeding birds found in the Yazoo River Basin, which require seasonally flooded bottomland hardwood habitat, include the Acadian Flycatcher, Northern Parula, and Prothonotary Warbler.

Several species of secretive marsh birds, such as rails and gallinules, commonly use BLH habitats, primarily during migration. Some populations of this bird group, such as the King Rail, have declined alarmingly in the past 30 years, due mostly to loss of wetlands (Meanley 1992). Reid (1989) discusses this issue: "The Mississippi River corridor has historically formed important breeding and migratory habitat for King Rails…Major degradations to this ecosystem have occurred in the last century and include constriction of banks that modify flow and flood capacity, dike construction that impacts channel direction , and addition of toxicants through point and non-point pollution. Perhaps the greatest direct threat to King Rail habitats has been the large reduction in herbaceous floodplain wetlands through agricultural, urban, and industrial developments…" The most important food items for King Rails are crayfish and aquatic insects. Crayfish formed 61% by volume of foods in spring in ricefields and associated wetlands in eastern Arkansas (Meanley 1956). Seasonal flooding of wetlands such as the Yazoo project area is required for the production of these important foods as well as nesting cover.

The Corps selected plan would reduce the extent of flooding within the 2- to5- year floodplain by approximately 112,600 acres, potentially from January through June. The reductions to late winter and spring flooding would result in significant adverse impacts to those birds which not only utilize the Yazoo River Basin, but are dependent upon backwater flooding during these periods (Table 1). As discussed above, species that require flooded habitat for foraging and/or nesting would obviously be the most severely affected. The reduction in the extent and duration of the spring flood pulse would accelerate the decline of many bird species that depend upon the wetland habitats of the lower Yazoo River.

Table 1. Birds of the Yazoo River Basin documented as requiring seasonal flooding during winter (W), spring migration (M), or breeding season (B).

| Common Name | Scientific Name | Season Of Use | References |
|---|---|---|---|
| Spotted Sandpiper | *Actitis macularia* | M | Yazoo NWR list |
| Wood Duck | *Aix sponsa* | W, B | Heitmeyer et al. 1981, Reinecke et al. 1987, Drobney 1977 |
| Roseate Spoonbill | *Ajaia ajaja* | M | Yazoo NWR list |
| Northern Pintail | *Anas acuta* | W, M | Fredrickson & Heitmeyer 1988, Heitmeyer 2001 |
| American Wigeon | *Anas americana* | W, M | Fredrickson & Heitmeyer 1988, Heitmeyer 2001 |
| Northern Shoveler | *Anas clypeata* | W, M | Fredrickson & Heitmeyer 1988, Heitmeyer 2001 |
| Green-winged Teal | *Anas crecca* | W, M | Fredrickson & Heitmeyer 1988, Heitmeyer 2001 |
| Blue-winged Teal | *Anas discors* | W, M | Fredrickson & Heitmeyer 1988, Heitmeyer 2001 |
| Mallard | *Anas platyrhynchos* | W, M | Fredrickson & Heitmeyer 1988, Hietmeyer 1988, Heitmeyer 2001, Heitmeyer & Fredrickson 1981, Reinecke et al. 1987 |
| American Black Duck | *Anas rubripes* | W, M | Fredrickson & Heitmeyer 1988, Heitmeyer 2001 |
| Gadwall | *Anas strepera* | W, M | Fredrickson & Heitmeyer 1988, Heitmeyer 2001 |
| Anhinga | *Anhinga anhinga* | B | Yazoo NWR list |
| Greater White-fronted Goose | *Anser albifrons* | W, M | Yazoo NWR list |
| Great Egret | *Ardea alba* | B | Unpub. report 2002, Yazoo NWR list |
| Great Blue Heron | *Ardea herodias* | B | Unpub. report 2002, Yazoo NWR list |

| | | | |
|---|---|---|---|
| Ring-necked Duck | *Aythya collaris* | W, M | Fredrickson & Heitmeyer 1988, Heitmeyer 2001 |
| American Bittern | *Botaurus lentiginosus* | M, B | Unpub. report 2002, Yazoo NWR list |
| Canada Goose | *Branta canadensis* | W, M | Fredrickson & Heitmeyer 1988 |
| Green Heron | *Butorides virescens* | B | Yazoo NWR list |
| Sanderling | *Calidris alba* | M | Yazoo NWR list |
| Dunlin | *Calidris alpina* | M | Yazoo NWR list |
| Baird's Sandpiper | *Calidris bairdii* | M | Yazoo NWR list |
| Western Sandpiper | *Calidris mauri* | M | Twedt et al. 1997 |
| Pectoral Sandpiper | *Calidris melanotus* | M | Twedt et al. 1997 |
| Least Sandpiper | *Calidris minutilla* | M | Twedt et al. 1997 |
| Semipalmated Sandpiper | *Calidris pusilla* | M | Twedt et al. 1997 |
| Killdeer | *Charadrius vociferus* | M, B | Twedt et al. 1997 |
| Little Blue Heron | *Egretta caerulea* | B | Rodgers & Smith 1995, Unpub. report 2002 |
| Reddish Egret | *Egretta rufescens* | B | Yazoo NWR list |
| Snowy Egret | *Egretta thula* | B | Yazoo NWR list |
| Tricolored Heron | *Egretta tricolor* | B | Unpub. report 2002, Yazoo NWR list |
| Acadian Flycatcher | *Empidonax virescens* | B | Heitmeyer et al. 2005, Yazoo NWR list |
| White Ibis | *Eudocimus albus* | B | Unpub. report 2002 |
| Common Snipe | *Gallinago gallinago* | W, M | Twedt et al. 1997 |
| Common Moorhen | *Gallinula chloropus* | B | Yazoo NWR list |
| Black-necked Stilt | *Himantopus mexicanus* | M, B | Yazoo NWR list |
| Least Bittern | *Ixobrychus exilis* | M, B | Unpub. report 2002, Yazoo NWR list |
| Short-billed Dowitcher | *Limnodromus griseus* | M | Twedt et al. 1997 |
| Long-billed Dowitcher | *Limnodromus scolopaceus* | M | Twedt et al. 1997 |
| Hooded Merganser | *Lophodytes cucullatus* | W, B | Fredrickson & Heitmeyer 1988, Yazoo NWR list |
| Wood Stork | *Mycteria americana* | M | Unpub. report 2002 |
| Yellow-crowned Night-Heron | *Nyctanassa violacea* | B | Fredrickson 2005, Unpub. report 2002 |

| | | | |
|---|---|---|---|
| Black-crowned Night-Heron | *Nycticorax nycticorax* | B | Unpub. report 2002 |
| Northern Parula | *Parula americana* | B | Heitmeyer et al. 2005 |
| American White Pelican | *Pelecanus erythrorhynchos* | M | Yazoo NWR list |
| Pied-billed Grebe | *Podilymbus podiceps* | B | Yazoo NWR list |
| Purple Gallinule | *Porphyrula martinica* | B | Yazoo NWR list |
| Sora | *Porzana carolina* | M | Yazoo NWR list |
| Prothonotary Warbler | *Protonotaria citrea* | B | Fredrickson 2005 |
| King Rail | *Rallus elegans* | M, B | Meanley 1956, Meanley 1992, Reid 1989 |
| Virginia Rail | *Rallus limicola* | M | Yazoo NWR list |
| American Woodcock | *Scolopax minor* | W, M | Yazoo NWR list |
| Least Tern | *Sterna antillarum* | M, B | Yazoo NWR list |
| Lesser Yellowlegs | *Tringa flavipes* | M | Twedt et al. 1997 |
| Greater Yellowlegs | *Tringa melanoleuca* | M | Twedt et al. 1997 |
| Solitary Sandpiper | *Tringa solitaria* | M | Yazoo NWR list |

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**Proposed Yazoo Pumps Project Impacts to Fish**

The Mississippi River has been highly altered for navigation and flood control. During 1933-1942, 16 bendway cutoffs shortened the lower Mississippi River (LMR) by 245 km. Based on river stage data collected at Vicksburg, MS, the average period of floodplain inundation was 4-5 months (early February through early July) prior to cutoff construction compared to 2 months (mid-March to mid-May) following cutoff construction. Under current hydrologic conditions in the LMR, the duration of floodplain inundation when water temperature exceeds 15 C is only about one month per year on average. Such a brief period of time may be insufficient for floodplain-foraging fishes like the blue catfish (and other fishes) to achieve a detectable energetic benefit. The abbreviated period of warm, flooded conditions would also be expected to adversely affect recruitment of numerous warmwater fishes (Schramm and Eggleton, 2006). The LMR has lost 90 % of its connectivity with its historical floodplain due to an extensive levee system (Schramm et al. 1999). Only one major backwater area, the Arkansas/White River, is still connected to the LMR. Like the Yazoo backwater, the Red River and St. Johns Bayou/New Madrid floodway are backwaters that are leveed and gated from the Mississippi River, and a partially constructed Corps project threatens the St. John/New Madrid system.

Despite being leveed and gated: "The Yazoo system is an incredibly productive fishery for catfishes (flathead, blue and channel cats) and catostomids (primarily buffalofishes – a principal group exploited by subsistence and artisanal fishers). Blue sucker stocks are also fairly strong and dynamic (this is a fish that is not doing well in other parts of its range, but holding its own in the Yazoo system)" (Jackson pers. comm. 2008).

River floodplains and backwater ecosystems are crucial to numerous fish species. Flooding of these areas, particularly in late winter and spring, provide backwater dependent fish (Table 2) with required conditions including little or no current, soft-sediment bottom, or aquatic or inundated terrestrial vegetation during some portion of their life cycle (Schramm 2004). These conditions are needed for spawning, nursery, and juvenile and adult feeding. "Floodplain river ecosystems are some of the most productive inland fisheries in the world." Life history and production dynamics of fishes in river floodplain ecosystems are linked primarily to hydrologic regimes and heterotrophic processes (microbes convert organic materials to forms utilized by invertebrates which in turn are food for fishes). Flooding increases aquatic habitat for fish, as well as the amount of inundated organic materials from terrestrial areas (including seasonally inundated lands) that form the foundation for the biological dynamics of most rivers. Hydrologic factors influenced floodplain river fish stocks in the Yazoo River basin more than climatic factors did (Jackson 2005).

The warmer waters found in flooded backwater locations stimulate biological activity of aquatic invertebrates and fishes in these systems (Jackson 2005). As water gradually covers the forest floor, invertebrate eggs, such as water fleas, begin to hatch and feed upon bacteria and fungi colonizing detritus. Waste expelled form these bacteria and fungi are recolonized by new bacteria and fungi and the process begins again. Around the same time the above process is taking place, fish spawning is initiated and it is commonly accepted that temperature, day-length, and the rise in water level are important in spawning. Upon hatching, most freshwater fish possess a yolk sac, which supplies nutrients for the first 7-10 days. Once the sac is used up, the fry have reached a critical stage where they must encounter food quickly, or starve. Now the importance of the rich supply of invertebrates in the flooded hardwoods becomes evident to fish productivity, particularly the 60 species of backwater-dependent fish species (McCabe et al. 1982).

The presence of aquatic invertebrates in the relatively warmer backwater areas encourages spawning of fishes in the inundated floodplain, and the earlier that spawning can take place the longer the fish can remain on the floodplain and the higher the recruitment potential for the rivers' fish stocks (Jackson 2005). Colonization of inundated areas by invertebrates is rapid. In a stream swamp in eastern North Carolina, within one week of the start of flooding, the composition of the invertebrate community had stabilized; biomass peaked in six weeks (Wilkinson et al. 1987). Flooding also introduces snags which provide important instream habitat for fish and attachment substrates for invertebrates. Studies suggest that reproductive success of early spring spawners will be poorer when there is reduced spring flooding. "In both tropical and temperate rivers, fish yields per unit surface area are considerably greater in rivers with flood pulses and floodplains than in nearby impoundments where flood pulses are reduced or absent." (Jackson 2005).

There was a positive relationship between flooding and fish stock characteristics (i.e., more and bigger fish) for bigmouth buffalo, smallmouth buffalo and channel catfish, though there was a lag period of 1-2 years between flooding and stock response due to recruitment requirements. Much of the productive potential for fisheries in floodplain river ecosystems is determined by the dynamics of overbank flooding and riparian vegetation (Jackson and Ye 2000).

In the Atchafalaya Basin, Louisiana, the most diverse fish fauna collected was in the floodplain habitat along the protection levees. Mosquitofish were very abundant in December. Forage species, also found in the Yazoo project area, included golden shiners, pugnose and bullhead minnows, and juvenile shads. Among catfishes, the tadpole madtom and juveniles of the yellow bullhead were most abundant, followed by young of the black bullhead and channel catfish. Juveniles of the bluegill, warmouth, spotted sunfish, dollar sunfish, and orangespotted sunfish reached their greatest concentrations in the floodplain. Young-of the-year largemouth bass and black and white crappie were first collected here in April and even greater numbers were collected in May. Among percids, slough darters were most abundant followed by cypress, bluntnose, and swamp darters. Species collected only from floodplain areas were: cypress minnow, weedshiner, black bullhead, grass pickerel, bantum sunfish, pygmy sunfish, flier, and swamp darter (Bryan et al. 1974).

Statistical correlations indicate that spawning, in other than common riverine species, occurs in the backwater habitats among bottomland hardwood wetlands, grassbeds, and other extensions of the riparian habitat. Ichthyoplankters collected in the backwaters areas include *Promoxis* spp. (crappie), *Lepomis* spp. (sunfish), *Ictiobus* spp. (buffalo), *Morone* spp. (temperate bass), and *Carpiodes* spp. (carpsuckers) (Hall 1979).

The monstrous alligator gar (*Atractosteus spatula*) is one of the most intriguing reminders of the past and was once commonly found in the floodplains of the Mississippi River. This prehistoric predator commonly reaches 8 feet in length and weighs over 200 pounds. Little is known about this allusive gar, however, they are known to spawn in warm, sluggish, floodwaters from April through June. Eggs are laid in shallow water with sufficient submerged vegetation for the eggs to adhere (Prevost 2008). This backwater dependent species is now uncommon in the Yazoo River Basin (Campbell pers. comm.. 2008).

Flooded hardwoods and the abundance of food they produce enable fish larvae to encounter the critical food supply necessary for survival and growth. As the amount of flooded hardwoods increase, the supply of spawning and nursery habitat, and the associated invertebrate populations, also increase. The result is an acceleration in the productivity of the habitat and, therefore, greater survival and growth in the fish populations (McCabe, et al. 1982). In shallow flooded areas, such as the Yazoo Backwater, larval fish feed on roitifers, copepods, and cladocerans. Juvenile bluegill of less than 50 mm TL, as well as other species, feed primarily on aquatic insects, particularly midge larvae, and on small crustaceans (Ross 2001).

Crawfish (primarily *Procambrus clarkii*) constitute the principle food source for many juvenile and adult fishes during high water including largemouth bass, warmouth, yellow bullhead, and blue catfish (Bryan et al. 1975). During seasonal inundation of the Yockanookany River floodplain (central Mississippi), crayfish occupied open water on the floodplains. Adult channel catfish aggregated in locations where the river channel and floodplain were coupled and subsequently foraged heavily on crayfish. Decoupling floodplains from the river by flood control activities such as channelization, dredging, and levee construction can modify channel catfish interactions with terrestrially burrowing crayfish and reduce potential benefits from this foraging (Flotemersch and Jackson 2003).

The Corps stated that areas flooded one foot deep for eight days are sufficient for fish spawning. The Corps has stated that most fish species reach sexual maturity in one or two years, so a flood that occurs once every two years is necessary to maintain reproductive populations. Eight days is insufficient for any substrate spawning fish (Schramm pers. comm. 2008). Eggs take 3 to 5 days to hatch. Larval fish fry are barely able to swim the first 7 to 10 days, while the yolk sac is being absorbed. If floodwaters are drawn down in 8 days, fry would be forced to retreat to deeper channels and lake habitats where mortality rates are high. Longer periods of shallow inundation in hardwood and other vegetated areas provide critical nursery habitat for growth and escape from predators.

The Corps' selected plan would reduce the extent of flooding within the 2-to5- year floodplain by approximately 112,600 acres primarily during March through June. The reductions to spring flooding would result in significant adverse impacts to the fishery of the Yazoo Basin, particularly the 60 backwater dependent species (Table 1) that spawn in the floodplain and utilize flooded habitat for nursery areas. Foraging habitat and the growth of numerous juvenile and adult fish species would also be sharply reduced by the loss of the spring flood pulse. "Any reduction in extent or duration of inundation of flooded woods habitat is likely to reduce the productive capacity of the swamp…Permanent water channels…will not support a fishery comparable to that produced from a wooded swamp" (Wilkinson et al. 1987). The reduction in the extent and duration of the spring flood pulse would severely reduce the current fish productivity of the lower Yazoo Basin.

Conversely, "managing the existing leveed floodplain to prolong inundation, increase water temperatures during spring flooding, and maintain connectivity of floodplain habitats with the main river channel should benefit fish production in the LMR (Schramm et al. 1999)."

**Table 2. Fish of the Yazoo River Basin from the Atlas of North American Freshwater Fishes (Lee et al. 1980) compared with Corps of Engineers ERDC field sample of fish species from Lower Yazoo Basin.**

| Class | Common Name | Scientific Name | Yazoo Occur? (Corps Collection) | Backwater[1] Dependent |
|---|---|---|---|---|
| | | | | |
| Osteichthyes | Chestnut lamprey | *Ichthyomyzon castaneus* | *X* | |
| Osteichthyes | Southern brook lamprey | *Ichthyomyzon gagei* | | |
| Osteichthyes | Lake sturgeon | *Acipenser fulvescens* | | |
| Osteichthyes | Shovenose sturgeon | *Scaphirhynchus platorynchus* | | |
| Osteichthyes | Paddlefish | *Polyodon spathula* | *X* | *Campbell 2008* |
| Osteichthyes | Spotted gar | *Lepisosteus oculatus* | *X* | *X* |
| Osteichthyes | Longnose gar | *Lepisosteus ossens* | *X* | *X* |
| Osteichthyes | Shortnose gar | *Lepisosteus platostomus* | *X* | *X* |
| Osteichthyes | Alligator gar | *Lepisosteus spatula* | *X* | *X* |

[1]Schramm, H.L., Jr. 2004. Status and management of Mississippi River Fisheries. In *Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries* (Vol. 1), Welcomme R, Petr T(eds). RAP Publication 2004/16: Bangkok, Thailand; 301-333.

| | | | | |
|---|---|---|---|---|
| Osteichthyes | Bowfin | *Amia calva* | *X* | *X* |
| Osteichthyes | American eel | *Anguilla rostrata* | *X* | |
| Osteichthyes | Gizzard shad | *Dorosoma cepedianum* | *X* | *X* |
| Osteichthyes | Threadfin shad | *Dorosoma petenense* | *X* | *X* |
| Osteichthyes | Goldeye | *Hiodon alosoides* | *X* | |
| Osteichthyes | Mooneye | *Hiodon tergisus* | *X* | |
| Osteichthyes | Redfin pickerel | *Esox a. americanus* | *X* | *Bryan et al. 1974* |
| Osteichthyes | Chain pickerel | *Esox niger* | | |
| Osteichthyes | Central stoneroller | *Campostoma anomalum* | | |
| Osteichthyes | Cypress minnow | *Hybognathus hayi* | | *X* |
| Osteichthyes | Mississippi sivery minnow | *Hybognathus nuchalis* | *X* | *X* |
| Osteichthyes | redfin shiner | *Lythrurus umbratilis* | *X* | |
| Osteichthyes | Speckled chub | *Macrhybopsis aestivalis* | *X* | |
| Osteichthyes | Silver chub | *Macrhybopsis storeriana* | *X* | *Bryan et al. 1974* |
| Osteichthyes | Golden shiner | *Notemigonus crysoleucas* | *X* | *X* |
| Osteichthyes | Emerald shiner | *Notropis athorinoides* | *X* | *Bryan et al. 1974* |
| Osteichthyes | Ghost shiner | *Notropis buchanani* | *X* | *X* |
| Osteichthyes | Bluntface shiner | *Notropis camurus,* Cyprinella camura* | *X* | |
| Osteichthyes | Striped shiner | *Notropis chrysocephalus,* Luxilus chrysocephalus* | *X* | |
| Osteichthyes | Pugnose minnow | *Notropis emiliae,* Opsopoeodus emiliae* | | |
| Osteichthyes | Beautiful shiner | *Notropis formosus, * Cyprinella* | | |

| | | | | |
|---|---|---|---|---|
| | | *formosa* | | |
| Osteichthyes | Ribbon shiner | *Notropis fumeus,* Lythrurus fumeus* | | |
| Osteichthyes | Red shiner | *Notorpis lutrensis, * Cyprinella lutrensis* | X | X |
| Osteichthyes | Taillight shiner | *Notropis maculatus* | | |
| Osteichthyes | Yazoo shiner | *Notropis rafinesquei* | X | |
| Osteichthyes | Cherryfin shiner | *Notropis roseipinnis, *Lythrurus roseipinnis* | | |
| Osteichthyes | Sabine shiner | *Notropis sabinae* | X | |
| Osteichthyes | silverband shiner | *Notropis shumardi* | X | *Bryan et al. 1974* |
| Osteichthyes | Redfin shiner | *Notropis umbratilis,* Lythrurus umbratilis* | X | X |
| Osteichthyes | Blacktail shiner | *Cyprinella venusta* | X | *Bryan et al. 1974* |
| Osteichthyes | Mimic shiner | *Notropis volucellus* | X | *Bryan et al. 1974* |
| Osteichthyes | Pugnose minnow | *Opsopoeodus emiliae* | X | X |
| Osteichthyes | Southern redbelly dace | *Phoximus erythrogaster* | | |
| Osteichthyes | Bluntnose minnow | *Pimephales notatus* | X | |
| Osteichthyes | Fathead minnow | *Pimephales promelas* | X | X |
| Osteichthyes | Bullhead minnow | *Pimephales vigilax* | X | X |
| Osteichthyes | Creek chub | *Semotilus atromaculatus* | | |
| Osteichthyes | River carpsucker | *Carpiodes carpio* | X | |
| Osteichthyes | Highfin carpsucker | *Carpiodes velifer* | | |
| Osteichthyes | Blue sucker | *Cycleptus elongatus* | X | |
| Osteichthyes | Creek | *Erimyzon* | | |

| | | | | |
|---|---|---|---|---|
| | chubsucker | *oblongus* | | |
| Osteichthyes | Lake chubsucker | *Erimyzon sucetta* | | |
| Osteichthyes | Northern hog sucker | *Hypentelium nigricans* | | |
| Osteichthyes | Smallmouth buffalo | *Ictiobus bubalus* | *X* | *X* |
| Osteichthyes | Bigmouth buffalo | *Ictiobus cyprinellus* | *X* | *X* |
| Osteichthyes | Black buffalo | *Ictiobus niger* | | *X* |
| Osteichthyes | Spotted sucker | *Minytrema melanops* | | *X* |
| Osteichthyes | Blacktail redhorse | *Moxostoma poecilurum* | *X* | |
| Osteichthyes | Blue catfish | *Ictalurus furcatus* | *X* | *Bryan et al. 1974* |
| Osteichthyes | Black bullhead | *Ictalurus melas,* Ameiurus melas* | *X* | *X* |
| Osteichthyes | Yellow bullhead | *Ictalurus natalis,* Ameiurus natalis* | *X* | *X* |
| Osteichthyes | Brown bullhead | *Ictalurus nebulosus, * Ameiurus nebulosus* | | *X* |
| Osteichthyes | Channel catfish | *Ictalurus punctatus* | *X* | |
| Osteichthyes | Smoky madtom | *Noturus baileyi* | | |
| Osteichthyes | Tadpole madtom | *Noturus gyrinus* | *X* | *Bryan et al. 1974* |
| Osteichthyes | Least madtom | *Noturus hildebrandi* | | |
| Osteichthyes | Speckled madtom | *Noturus leptacanthus* | | |
| Osteichthyes | Brindled madtom | *Noturus miurus* | | |
| Osteichthyes | Freckled madtom | *Noturus nocturnus* | *X* | |
| Osteichthyes | Brown madtom | *Noturus phaeus* | | |
| Osteichthyes | Flathead catfish | *Pylodictis olivaris* | *X* | |
| Osteichthyes | Pirate perch | *Aphredoderus sayanus* | *X* | *X* |
| Osteichthyes | Golden topminnow | *Fundulus chrysotus* | *X* | *X* |
| Osteichthyes | Starhead | *Fundulus dispar* | *X* | |

| | | | | |
|---|---|---|---|---|
| | topminnow | | | |
| Osteichthyes | Blackstripe topminnow | *Fundulus notatus* | X | X |
| Osteichthyes | Blackspotted topminnow | *Fundulus olivaceus* | X | X |
| Osteichthyes | Mosquitofish | *Gambusia affinis* | X | X |
| Osteichthyes | Brook silverside | *Labidesthes sicculus* | X | *Bryan et al. 1974* |
| Osteichthyes | Inland silverside | *Menidia beryllina* | X | |
| Osteichthyes | White bass | *Morone chrysops* | X | *Bryan et al. 1974* |
| Osteichthyes | Yellow bass | *Morone mississippiensis* | | *Bryan et al. 1974* |
| Osteichthyes | Striped bass | *Morone saxatilis* | X | |
| Osteichthyes | Flier | *Centrarchus macropterus* | X | X |
| Osteichthyes | Banded pygmy sunfish | *Elassoma zonatum* | X | X |
| Osteichthyes | Green sunfish | *Lepomis cyanellus* | X | X |
| Osteichthyes | Warmouth | *Lepomis gulosus* | X | X |
| Osteichthyes | Orangespotted sunfish | *Lepomis humilis* | X | X |
| Osteichthyes | Bluegill | *Lepomis macrochirus* | X | X |
| Osteichthyes | Dollar sunfish | *Lepomis marginatus* | X | *Bryan et al. 1974* |
| Osteichthyes | Longear sunfish | *Lepomis megalotis* | X | X |
| Osteichthyes | Redear sunfish | *Lepomis microlophus* | X | X |
| Osteichthyes | Spotted sunfish | *Lepomis miniatus* | X | *Bryan et al. 1974* |
| Osteichthyes | Bantum sunfish | *Lepomis symmetricus* | X | X |
| Osteichthyes | Spotted bass | *Micropterus punctulatus* | X | |
| Osteichthyes | Largemouth bass | *Micropterus salmoides* | X | X |
| Osteichthyes | White crappie | *Pomoxis annularis* | X | X |
| Osteichthyes | Black crappie | *Pomoxis nigromaculatus* | X | X |
| Osteichthyes | Scaly sand darter | *Ammocrypta* | | |

| | | | | |
|---|---|---|---|---|
| | | *vivax* | | |
| Osteichthyes | Mud darter | *Etheostoma asprigene* | *X* | *Bryan et al. 1975* |
| Osteichthyes | Rainbow darter | *Etheostoma caeruleum* | *X* | |
| Osteichthyes | Bluntnose darter | *Etheostoma chlorosoma* | *X* | *Bryan et al. 1974* |
| Osteichthyes | Fountain darter | *Etheostoma fonticola* | | |
| Osteichthyes | Swamp darter | *Etheostoma fusiforme* | *X* | *X* |
| Osteichthyes | Slough darter | *Etheostoma gracile* | *X* | *Bryan et al. 1974* |
| Osteichthyes | Harlequin darter | *Etheostoma histrio* | | |
| Osteichthyes | Goldstripe darter | *Etheostoma parvipinne* | | |
| Osteichthyes | Cypress darter | *Etheostoma proeliare* | | |
| Osteichthyes | Speckled darter | *Etheostoma stigmaeum* | | |
| Osteichthyes | Gulf darter | *Etheostoma swaini* | | |
| Osteichthyes | Redfin darter | *Etheostoma whipplei* | *X* | |
| Osteichthyes | Banded darter | *Etheostoma zonale* | | |
| Osteichthyes | Backwater darter | *Etheostoma zonifer* | | |
| Osteichthyes | Logperch | *Percina caprodes* | | *X* |
| Osteichthyes | Blackside darter | *Percina maculata* | | |
| Osteichthyes | Dusky darter | *Percina sciera* | *X* | |
| Osteichthyes | Sauger | *Stizostedion canadense* | *X* | |
| Osteichthyes | Freshwater drum | *Aplodinotus grunniens* | *X* | *Bryan et al. 1974* |
| Total | | 116 | 80 | 60 |

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Campbell, Richard.  Hatchery Manager.  Pvt. John Allen Hatchery.  U.S. Fish and Wildlife Service.  Tupelo, MS

Jackson, Don.  Professor of Fisheries, Dept. of Wildlife and Fisheries, Mississippi State Univ., for 22 years, as of July 1, 2008.  Principal focus: river fisheries research, management, and development.

Schramm, Hal.  Fisheries Research Biologist and Unit Leader, USGS Mississippi Cooperative Fish and Wildlife Research Unit, Mississippi State, MS.  Dr. Schramm has been in this position and engaged in fisheries research in the Lower Mississippi River for more than 14 years.

## Floodplain Flooding Pulses Benefit Most Herptiles

Of the roughly 25 million acres of original Lower Mississippi River floodplain, a stunning 93% now lie behind levees. A growing body of evidence indicates that the ecological diversity and integrity of large floodplain rivers are maintained by flood pulses, channel-forming floods, and by river-floodplain connectivity. Suppression of the natural flood regime and restraint of channel migration reduces ecological diversity and integrity (http://www.umesc.usgs.gov/reports_publications/psrs/psr_1997_02.html).

To the extent that flooding which still occurs (and for which the pumps plan is proposed as a remedy) simulates that which occurred historically over these floodplains, prior to the re-plumbing of most of the Mississippi's basin, myriad aquatic and terrestrial species benefit from this pulse-driven system. This includes numerous amphibians and reptiles (including many which aren't primarily aquatic), too, as system productivity trapped within floodwaters, particularly in pools beyond the low-flow channel, is captured by fish, invertebrates, and most larval amphibians, and ultimately finds its way into higher trophic levels occupied by predatory fish, adult amphibians, reptiles, mammals and birds native to the Delta. This vast, productive, nutrient trap is a much better system than the alternative, which exports all these materials downstream to the Gulf's already over-enriched and expanding dead zone.

Though none of the Delta's herptiles are obligatorily tied to a pulse system of the magnitude of that which prevailed historically, and most are common and widespread, all of the 19 amphibian species and all but 5 of the 35 reptiles benefit at least to some degree proportional to an increased duration and extent of seasonally-appropriate flooding.

Shallow areas at the periphery of the flooded zone will hold water for the shortest period, from days to a couple of months, and will provide breeding habitat for species such as the mole salamanders, which are winter breeders in Mississippi, and for winter-breeding frogs such as leopard frogs, pickerel frogs, spring peepers, and chorus frogs. These are unlikely to occur in the areas which are deeper and flooded for longer periods, places closer to the main channel of the river, but these, depending on their size, will be tapped by the summer-breeding frog species as water levels drop with the approach of late spring and summer.

Two examples of the importance of herptiles using flooded areas to the general natural economy follow. Larval amphibians make significant contributions to the biomass of other vertebrates, including many of the wading birds, which will faithfully track the retreating shallows. Even aquatic turtles, like the common red-ear slider, have much more significance in the food-chain than is generally appreciated, as many species of fish, birds, and mammals eat hatchling turtles, and their eggs provision oophagous snakes, birds, and mammals, often remote from the water itself. So these long-lived animals, although relatively impervious to predation as adults, in essence contribute most of their reproductive output of several clutches of eggs per season over a reproductive lifetime of several decades, to feeding numerous aquatic and terrestrial species. The lipids sequestered in the eggs originate, of course from the aquatic plants and invertebrates flourishing in flooded areas.

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## Acknowledgements

Mann, Tom. Zoologist, Natural Heritage Program, Mississippi Dept. of Wildlife, Fisheries & Parks. Specialist in amphibian and reptile studies for 18 years.

**Expected Changes to the Bottomland Hardwood Forests on Panther Swamp National Wildlife Refuge if Backwater Flooding is Reduced or Eliminated**

Panther Swamp National Wildlife Refuge (Panther Swamp NWR) was established in 1978 under the Migratory Bird Conservation Act (1929). The primary purpose of the refuge is for use as an inviolate sanctuary, or for any other management purposes, for migratory birds. The refuge is located in the Lower Mississippi Alluvial Valley (LMAV). More specifically, Panther Swamp NWR is situated in the floodplains of the Yazoo and Sunflower Rivers. The predominant habitat is seasonally flooded bottomland hardwood forest (BLH). Maintaining this BLH forest system in a diverse, healthy and productive condition is paramount to Panther Swamp NWR being able to fulfill the primary purpose of the refuge.

The hydrologic regimes in the BLH forests of Panther Swamp NWR have been previously altered to some degree by earlier drainage/flood control projects in the LMAV by construction of various levee and channelization projects. Although altered, backwater flooding continues to occur on refuge lands providing some of the hydrological functions necessary to maintaining a healthy, diverse and productive BLH forest system.

"The timing, extent and duration of flooding is quite variable in BLH forest not only within a season (short term) but also over longer periods (cycles of approx. 4 – 6 yrs.). Annual variation in precipitation influences timing, extent and duration of flooding, and provides proximate cues that determine the timing of biological events. Long-term precipitation cycles (4 -6 years) also influence characteristics of flooding, but in contrast to annual precipitation variations, long-term cycles provide the ultimate cues that are associated with adaptive strategies of flora and fauna in BLH forests. Thus, hydrology is the major driving force that impacts structure (e.g., vegetation and soils) and function (e.g., processes such as decomposition, nutrient cycling) in BLH forest". (Fredrickson and Batema 1993).

"Three natural patterns of succession are recognized for floodplain sites of major river bottoms – those occurring on permanently flooded sites, those on low elevation wet sites, and those on higher elevation, better drained sites. Floristic composition and successional patterns are strongly influenced by the hydrologic events on the sites and particularly by rates and types of deposition. Small differences in elevation can result in great differences in site quality primarily because of differences in hydrology". (Hodges 1997).

After speaking with several BLH Forest Ecology professionals and reviewing the current literature, no studies or documentation were found that reliably and accurately predict exactly what vegetative changes will take place in the BLH forest system on Panther Swamp NWR if periodic backwater flooding is further reduced or eliminated. However, the studies and literature do strongly suggest that the vegetative component of the BLH forest system will change over-time to a more drought tolerant / less flood tolerant species composition if backwater flooding is significantly reduced or eliminated.

Reduction or elimination of hydrologic regimes has resulted in species composition change of vegetation in BLH forest. For example, loblolly pine *(Pinus taeda)* and red maple *(Acer rubrum)* are replacing swamp tupelo *(Nyssa sylvatica)* in the lower reaches of South Carolina's Santee River as a result of a water diversion project that caused the site to become significantly drier. The diversion of water from the Santee River took place during the 1930's and the change in species composition took nearly 60 years to become evident on the site. (Kellison et al. 1998)

A study conducted in the Ouachita River basin in South Arkansas recorded that intolerance to soil saturation/flooding is an important factor in the development of various floodplain community types. It serves to exclude those species that might otherwise grow there if the soils were not saturated/flooded during part of the growing season. This became evident in those areas where flooding and/or soil saturation are no longer a factor, since these sites were commonly invaded by flood intolerant woody species such as shortleaf pine (*Pinus echinata*) and blackjack oak (*Quercus marilandica*) (Huffman 1980).

Changes in species composition and structure of a BLH forest are inevitable over time because of natural succession in the plant community and the dynamic nature of a floodplain ecosystem. Literature clearly documents that hydrology (periodic flooding during some portion of the growing season) is the "life's blood" of a BLH forest system. Current scientific knowledge infers that if the hydrology of a given site is significantly reduced or eliminated we can expect the vegetation on that site to change to a species composition that is more drought tolerant and not common to BLH forest systems. The BLH forest system, complete with a healthy, diverse and productive flood tolerant plant community is key to Panther Swamp NWR accomplishing the successful migratory bird management set forth as a primary purpose in the enabling legislation that established the refuge.

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# Appendix 5

## Additional Wetland Impacts and Connectivity

### I. Additional Wetland Impacts

EPA's November 3, 2000, comment letter on the Draft Supplemental Environmental Impact Statement (DSEIS), recommended that the U.S. Army Corps of Engineers (the Corps) expand its scope of the wetlands impact assessment to include jurisdictional wetlands in the 2-year floodplain [i.e., areas extending out to the 91.0 foot, National Geodetic Vertical Datum (NGVD) elevation]. While the Final Supplemental Environmental Impact Statement (FSEIS) implies that there are more wetlands in the 100-year floodplain than previously estimated in the DSEIS, the FSEIS assumes that only those wetlands flooded for 5 percent of the growing season and which occur at or below the 88.6 foot, NGVD elevation [i.e., the wetland impact assessment area established in the FSEIS using the Flood Event Assessment Tool (FEAT)/Flood Event Simulation Model (FESM)] will be affected by this project. The FSEIS also concludes that any wetlands occurring outside the FEAT/FESM modeled boundary are not connected to the backwater ecosystem and thus would not be impacted by the pumping project. EPA disagrees and, as discussed further below, notes that data included in the FSEIS supports EPA's position that a significant amount of wetlands outside the FEAT/FESM modeled boundary is indeed connected to the backwater ecosystem, and thus will likely be adversely impacted by the proposed project.

During the course of this project several attempts have been made to estimate the spatial extent of wetlands based upon remote sources of data [i.e., Geographic Information Systems (GIS), satellite images, hydrologic models]. These remote based estimates of wetland extent ranged from approximately 60,000 to over 200,000 acres. Since these landscape level estimates were based on remote data with unestimated error, EPA determined that a field based, statistical survey would provide a more precise and scientifically defensible basis for establishing the extent and spatial distribution of wetlands in the study area. Therefore, in 2003, EPA, in cooperation with the Corps, U.S. Fish and Wildlife Service (FWS), and Natural Resource Conservation Service (NRCS), implemented a field sampling survey using EPA's Environmental Monitoring and Assessment Program (EMAP). EMAP survey designs and methods have been developed and tested within EPA's Office of Research and Development over the past decade with published results. The results of this study were included in the FSEIS (FSEIS Appendix 10, Supplement A) and are included at the end of this Appendix as Attachment A.

The spatial extent and distribution of wetlands in the Yazoo Backwater Area was determined with known confidence using EPA's EMAP survey design and analysis. Based on this design, the total wetland extent for the 100-year floodplain is approximately 212,000 acres. As illustrated by Table 1, within the Study Region (i.e., the 100-year floodplain) three categories of potential wetlands were identified: 1) wetlands depicted by the Corps' FEAT/FESM flood model (Feat Potential), 2) forested areas outside the FEAT/FESM modeled boundary (NLCD/WRP

Potential) and 3) remaining areas in the 100-year floodplain not captured by the first two categories and which were thought to not likely contain wetlands (Low Potential).

Table 1. EMAP wetland results for Lower Yazoo Basin

| Wetland Category | Wetland Status | N Resp | Estimate (%) | StdErr. (%) | LCB90 (%) | UCB 90 (%) | Estimate (ac) | StdErr (ac) | LCB90 (ac) | UCB90 (ac) |
|---|---|---|---|---|---|---|---|---|---|---|
| Study region | Not wet | 82 | 67.8 | 2.1 | 64.3 | 71.3 | 446244 | 14023 | 423178 | 469311 |
| Study region | Wet | 70 | 32.2 | 2.1 | 28.7 | 35.7 | **212284** | 14023 | 189218 | 235351 |
| Study region | Total | 152 | 100.0 | | | | 658529 | | | |
| FEAT Potential | Not wet | 8 | 16.3 | 4.0 | 9.8 | 22.9 | 25544 | 6207 | 15335 | 35753 |
| FEAT Potential | Wet | 41 | 83.7 | 4.0 | 77.1 | 90.2 | **130914** | 6207 | 120705 | 141123 |
| FEAT Potential | Total | 49 | 100.0 | | | | 156458 | | | |
| NLCD/WRP Potential | Not wet | 25 | 51.5 | 6.2 | 41.3 | 61.7 | 70161 | 8431 | 56294 | 84028 |
| NLCD/WRP Potential | Wet | 27 | 48.5 | 6.2 | 38.3 | 58.7 | **66091** | 8431 | 52224 | 79959 |
| NLCD/WRP Potential | Total | 52 | 100.0 | | | | 136252 | | | |
| Low potential | Not wet | 49 | 95.8 | 2.6 | 91.6 | 100.0 | 350539 | 9330 | 335192 | 365818 |
| Low potential | Wet | 2 | 4.2 | 2.6 | 0.0 | 8.4 | **15279** | 9330 | 0 | 30626 |
| Low potential | Total | 51 | 100.0 | | | | 365818 | | | |

LCB90 = Lower Confidence Band, 90th percentile
UCB90 = Upper Confidence Band, 90th percentile

Most of the wetlands were found in the FEAT/FESM predicted area. However, EMAP also found approximately 81,370 acres of wetlands occurring outside the wetland boundary predicted by the Corps' FEAT/FESM model (i.e., in the NLCD Potential category and the Low Potential category). It is the potential impacts to these wetlands that EPA believes were not analyzed in the FSEIS.

In order to determine how many of these 81,000 acres of additional wetlands may be impacted by the project, EMAP statisticians calculated the extent of wetlands in an area bounded by the 2-year floodplain. The areal extent of the 2-year floodplain was provided to EPA, by the Corps as an output of their flood model in 2005. As Table 2 indicates, the total area of wetlands in the 2-year floodplain is 179,120 acres. There are approximately 127,327 acres of wetlands within the FEAT/FESM boundary and 51,792 acres outside the Corps' assessment area (i.e., in the NLCD Potential category and the Low Potential category).

EMAP statisticians then evaluated how many of the wetlands in the 2-year floodplain, but outside the FEAT/FESM predicted area, would be impacted by the proposed project (Attachment B). The lower section of Table 2 shows the extent of wetlands predicted to exist with the project. This is a conservative estimate of wetland impacts in the 2-year flood plain because it looks only at hydrologic impacts as a result of the change in flood frequency. As illustrated in Table 3, approximately 24,000 acres of wetlands outside the Corps' assessment area would experience this level of hydrologic impact. Despite EPA's recommendations to do so, none of these impacts were evaluated in the FSEIS.

Table 2. EMAP estimates of wetland extent in the 2 year floodplain with- and with-out project

| Wetland Category | Wetland Status | NResp | Estimate % | StdError % | LCB 90 % | UCB90 % | Estimate (ac) | Std Error (ac) | LCB 90 (ac) | UCB 90 (ac) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Without Project** | | | | | | | | | | |
| 2yr floodplain | Not Wet | 36 | 46.8 | 3.4 | 41.3 | 52.4 | 157707 | 11368 | 139008 | 176406 |
| 2yr floodplain | Wet | 55 | 53.2 | 3.4 | 47.6 | 58.7 | **179120** | 11368 | 160421 | 197819 |
| 2yr floodplain | Total | 91 | 100.0 | | | | 336827 | | | |
| Feat Potential | Not Wet | 8 | 16.7 | 4.0 | 10.1 | 23.2 | 25465 | 6093 | 15443 | 35488 |
| Feat Potential | Wet | 40 | 83.3 | 4.0 | 76.8 | 89.9 | **127327** | 6093 | 117305 | 137350 |
| Feat Potential | Total | 48 | 100.0 | | | | 152793 | | | |
| NLCD/WRP | Not Wet | 11 | 45.8 | 7.8 | 33.0 | 58.7 | 31552 | 5385 | 22694 | 40410 |
| NLCD/WRP | Wet | 13 | 54.2 | 7.8 | 41.3 | 67.0 | **37289** | 5385 | 28431 | 46147 |
| NLCD/WRP | Total | 24 | 100.0 | | | | 68842 | | | |
| NonWet(3) | Not Wet | 17 | 87.4 | 6.9 | 76.1 | 98.8 | 100689 | 7944 | 87622 | 113755 |
| NonWet(3) | Wet | 2 | 12.6 | 6.9 | 1.2 | 23.9 | **14503** | 7944 | 1437 | 27570 |
| NonWet(3) | Total | 19 | 100.0 | | | | 115192 | | | |
| **With Project** | | | | | | | | | | |
| 2yr floodplain | Not Wet | 24 | 40.5 | 3.5 | 34.8 | 46.3 | 105697 | 9072 | 90775 | 120619 |
| 2yr floodplain | Wet | 49 | 59.5 | 3.5 | 53.7 | 65.2 | **155073** | 9072 | 140151 | 169996 |
| 2yr floodplain | Total | 73 | 100.0 | | | | 260770 | | | |
| Feat Potential | Not Wet | 6 | 13.3 | 3.9 | 7.0 | 19.7 | 19555 | 5657 | 10250 | 28861 |
| Feat Potential | Wet | 39 | 86.7 | 3.9 | 80.3 | 93.0 | **127109** | 5657 | 117803 | 136414 |
| Feat Potential | Total | 45 | 100.0 | | | | 146664 | | | |
| NLCD/WRP | Not Wet | 7 | 43.8 | 9.8 | 27.6 | 59.9 | 15789 | 3538 | 9968 | 21609 |
| NLCD/WRP | Wet | 9 | 56.3 | 9.8 | 40.1 | 72.4 | **20300** | 3538 | 14480 | 26120 |
| NLCD/WRP | Total | 16 | 100.0 | | | | 36089 | | | |
| NonWet(3) | Not Wet | 11 | 90.2 | 7.9 | 77.2 | 100.0 | 70353 | 6146 | 60243 | 78018 |
| NonWet(3) | Wet | 1 | 9.8 | 7.9 | 0.0 | 22.8 | **7665** | 6146 | 0 | 17774 |
| NonWet(3) | Total | 12 | 100.0 | | | | 78018 | | | |

Table 3. Change in EMAP wetland acres on 2 year floodplain, outside Corps' wetland assessment area (FEAT/FESM), as a result of Yazoo Backwater project

| Wetland Strata | Without Project Wetland Acres | With Project Wetland Acres | Change in acres |
|---|---|---|---|
| Feat Potential | **127327** | **127109** | **219** |
| NLCD/WRP | **37289** | **20300** | **16989** |
| NonWet(3) | **14503** | **7665** | **6838** |
| 2yr floodplain | **179120** | **155073** | **24047** |

This analysis evaluated the changes in wetland acres in the 2-year floodplain. It did not attempt to evaluate changes in the FEAT/FESM predicted area; the 219 acres of change reflected in Table 3 is considered statistically insignificant.

**II. Wetland Connection with Backwater Flooding**

The stated effect of the Yazoo Backwater Area Project is the reduction of the areal extent and duration of floods greater than the 1-year flood (FSEIS, Appendix 10, paragraph 31). Therefore, areas within the Yazoo Backwater Area typically covered/inundated by 2-, 5-, 10-, 25-, 50-, and 100-year flood events will be reduced with the proposed project (i.e., less area will be flooded). These areas contain a substantial acreage of wetlands.

Data included in the FSEIS indicates that hydrologic connections exist to wetlands beyond those depicted by FEAT/FESM. The Wetlands Appendix of the FSEIS (FSEIS, Appendix 10, Table 10-7) indicates that the March 10, 1989; March 21, 1987; and the January 9 and 13, 1983 satellite scenes show between 18,000 and 71,000 acres flooded in the area between 91.0 feet and 100 feet, NGVD (i.e., 2-100 year band). Hence, it is likely that the wetlands between the 2-year and 100-year flood elevations currently experience flooding. This conclusion is further supported by the statement in the FSEIS that the FESM model overestimates flooding close to the channels utilized by the model, but does “less well” when flooded areas are away from the channels (FSEIS, paragraph 43). EPA interprets this to mean that areas away from the FESM channels could flood, but the model is unable to depict those flooded areas. The Wetlands Appendix in the FSEIS [FSEIS, Appendix 10, Tables 10-10 (Areal extent of wetlands by composite wetland cell value) and 10-11 (Wetland losses by duration interval and duration zone) and Plate 10-25] further indicate there are wetland areas beyond the FEAT boundary that flood and would be affected by the proposed pump by virtue of having decreased flood durations after the project. These items in Appendix 10 of the FSEIS indicate impacts to be approximately 60,000 acres. The Wetland Appendix also indicates that approximately 41,000 acres outside the Corps’ assessment area (i.e., “Tier 2” wetlands in FSEIS Table 10-16) flood during the 2-year return period flood.

The Corps’ hydrologic data also indicates that flooded wetlands exist in the 2-year floodplain *and* will be impacted through a change in flood duration as well as a change in flood frequency. In 2004, the Corps provided EPA with a copy of the Period of Record gage data for the years

1943 to 1997. The data provided contained daily gage records, presumably as outputs from the Period of Record Routing model, for the with- and with-out project scenarios at Steele Bayou and Little Sunflower gages. A frequency analysis of this data indicates the 2-year flood elevation (stage) is 91.0 feet, NGVD, in the Lower Ponding area and 91.6 feet, NGVD, in the Upper Ponding area (FSEIS, Appendix 6 – Engineering Summary and Appendix 10). A stage duration analysis of these data indicates that, over the entire period of record, flooding sufficient for wetland hydrology occurs in areas between 89.0 feet and 92.0 feet, NGVD, at Steele Bayou under base conditions (Attachment C). As a result of the proposed project, durations would be decreased, on an average annual basis, by 4.5 percent or 15 days. Flood frequency would be changed, at this 2-year return interval elevation, approximately 45 percent. This corresponds to the Corps' calculated stage reductions of approximately 4.5 feet (92.9 feet, NGVD, reduced to 88.5 feet, NGVD) at Steele Bayou. The project sponsor raised concerns that the frequency analysis conducted under contract to EPA was not appropriate. As thoroughly discussed in our May 30, 2008, and June 19, 2008, correspondence with the project sponsor regarding this issue, EPA's Proposed Determination, Recommended Determination, and this Final Determination rely principally upon the information contained in the Corps' Draft and Final SEISs for this project, on the EMAP study conducted by EPA in conjunction with the Corps and other federal agencies, and on our understanding of the project based on EPA/Corps discussions. Furthermore, the Corps acknowledges in their comments on the Recommended Determination that, despite the differences between the hydrologic analyses conducted by the Corps and those conducted by EPA, the two techniques corroborate each other.

The Corps' stage-frequency data indicates flooding will become much less frequent in the 2-and 5-year floodplains, increasing from a 2-year return interval to a 10-year return interval and a 5-year return interval to a 50-year return interval (FSEIS, Appendix 6, Tables 6-14 and 6-15). This would result in significant impacts to, among other functions, the hydrologic functions of wetlands in the 2-year floodplain. However, as discussed previously, the Corps failed to evaluate these impacts by restricting their assessment area to only the FEAT/FESM modeled areas.

Existing information regarding the extensive hydrologic network in the Yazoo Backwater Area offers further support that wetlands outside of the Corp's assessment area would be affected by the proposed project. The National Hydrography Dataset (NHD) is a comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of water and paths through which water flows. The NHD is mapped at a 1:100,000 scale. When the NHD for the Yazoo River Basin is overlain with the wetland points surveyed in EMAP, the density of stream channels at this scale strongly indicates that backwater has a great many conduits and that many wetlands on the 2-year floodplain represented by EMAP data points are connected or adjacent to channels (see Figure 1). The Yazoo Basin HGM Guidebook points out that these channels can drain adjacent areas or serve as conduits for backwater during backwater flood events (Smith and Klimas, 2002). An analysis of the distance between EMAP wetland points and the nearest NHD stream indicates that, on average, wetland points are 0.2 miles away from streams. If the area around a wetland point is expanded to encompass the forest tract within which it is situated, then all 70 EMAP wetland points are intersected by streams (Attachment D).

For these reasons, EPA believes that as much as 24,000 additional acres of wetlands outside the FSEIS wetland assessment area are connected to backwater flooding and will be adversely impacted by the project. However, the FSEIS did not evaluate impacts to these wetlands. In their comments on the Recommended Determination, the Corps asserts that although wetlands occur in the 2-year frequency floodplain, they are not the result of backwater hydrological events and connection of wetlands in the 2-year floodplain is unconfirmed. However, the wetlands identified by the field-based EMAP survey are within the area identified by the Corps as flooded by backwater on a 2-year return. Furthermore, based on the analysis of the NHD noted above and based on the area of inundation shown by the Corps in their flood models, EPA maintains that these wetlands are hydrologically connected.

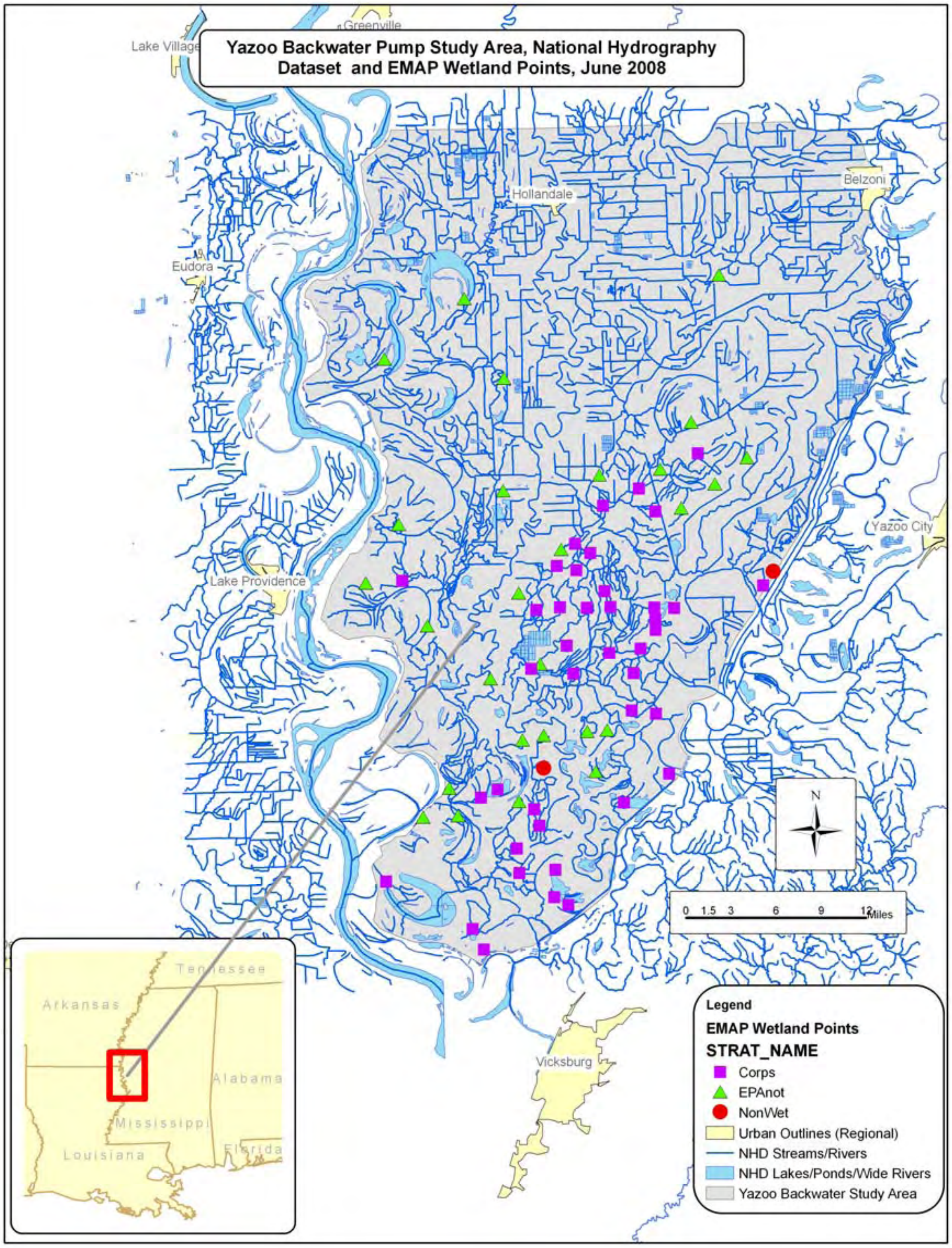


Figure 1. Yazoo River Basin NHD overlain with EMAP wetland points

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# Attachment A

## EPA Environmental Monitoring and Assessment Program (EMAP) Report, July 2005

**EMAP Report**

# An Estimate of Wetland Extent in the Lower Yazoo Basin Using an EMAP Probabilistic Sampling Design

William B. Ainslie
Wetlands Regulatory Section
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303-8960

and

Anthony Olsen
NHEERL Western Ecology Division
U.S. Environmental Protection Agency
200 S.W. 35th Street
Corvallis, Oregon 97333

July 05, 2005

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# Contents

## Introduction

The Yazoo Backwater Pumps project area encompasses 926,000 acres between the east bank of the Mississippi River Levee and the Will M. Whittington Auxiliary Channel and from Vicksburg approximately 65 miles north to a line through Belzoni, Mississippi. The area of interest in this report is the approximately 630,000 acre 100-year floodplain contained within the project area (Figure 1). The proposed project entails the construction of a series of pumps that at maximum capacity could discharge 14,000 cubic feet/ second (cfs) in an effort to decrease the effects/extent of flooding in the project area.

The National Environmental Policy Act (NEPA) (PL 91-1-90) is required for those major federal actions that significantly affect the quality of the human environment. Due to the expenditure of federal funds NEPA requires an assessment of impacts along with justification of proposed benefits for the project. Section 404 of the Clean Water Act (40 CFR Part 230) also requires the evaluation of primary and secondary impacts associated with proposed discharges of fill material into wetlands or other waters of the United States. Therefore, the establishment of the extent of the resources at risk and the expected impacts to them is pivotal to this project.

During the course of this project there have been several attempts to estimate the spatial extent of wetlands based upon remote sources of data (i.e., Geographic Information Systems (GIS), satellite images, hydrologic models). These remote-based estimates of jurisdictional wetland extent have ranged from approximately 60,000 to over 200,000 acres. Since these estimates were based on remote data with unestimated error, it was reasoned that a field-based, statistical design would provide a more precise and scientifically defensible basis for establishing the extent of wetlands in the study area.

The objective of this project was to determine the extent of jurisdictional wetlands within the 100-year floodplain with known confidence (90%). The 100-year floodplain was selected as the area of evaluation because it would be the greatest area which could be affected by the pump and is an area consistent with that used in other analyses for this project (e.g., economic).

## Background

Smith and Klimas (2002) characterized the factors contributing to wetland ecology in the entire Yazoo Basin which includes the project area. The following is largely a summarization of this information in terms of historic hydrology, vegetation and soils which contributed to wetland development.

Wetlands within the Yazoo Basin are on landforms created by the action of the Mississippi River or its tributaries. Human modifications within the Yazoo Basin have significantly altered both the hydrology of the basin and certain physical features that influence wetland conditions. Thus, the history and effects of human alterations to the hydrology and vegetation of the Basin are important to understand the current extent of jurisdictional wetlands.

The dominant drainage feature of the Mississippi Alluvial Valley is the Mississippi River, which formed the topography of the basin, determined the configuration and locations of most of the existing wetlands and stream systems and dominated the hydrology of the valley during major floods. Prior to construction of modern levees, major Mississippi River floods would have inundated most or all of the Yazoo Basin. While modern main stem levees prevent overbank Mississippi River flooding, construction of these levees did not completely eliminate the influence of the river on hydrology of the Yazoo Basin. High stages on the Mississippi River cause impeded drainage of tributary streams, which results in backwater flooding (Smith and Klimas 2002).

**Hydrology**

In the Yazoo Basin in general, except during major floods, the dominant source of water is precipitation, and runoff from the hills along the eastern flank of the basin. The only surface outlet is through the Yazoo River, which enters the Mississippi River at the southern end of the basin near Vicksburg. Most stream flow in the Yazoo River originates in the uplands along the eastern flank of the basin, and is carried to the Yazoo via the Coldwater, Yokona, Tallahatchie, and Yalobusha Rivers as well as several smaller streams. Interior drainage is provided by numerous small streams that discharge to Deer Creek, the Big Sunflower River, or Bogue Phalia, all of which flow to the lower Yazoo River. The pattern of drainage within the basin is generally southward, but can be complicated by the topography left by the abandoned meander belts of the Mississippi River (Smith and Klimas 2002, Saucier 1994).

The hydrology of the Yazoo Basin has been modified extensively. Federal projects have largely protected the basin from the effects of major floods, allowing extensive land clearing and agricultural development. Water entering or underlying the modern basin is rerouted, stored, and exported from the system in complex patterns that can result in more or less water available to remaining wetlands. For example, heavy winter and spring rains make drainage necessary for agricultural operations while low rainfall periods in summer and fall warrant irrigation (Brown et al. 1971). Drainage may involve land leveling as well as ditching, and can have various effects on wetlands, which may serve as sumps to which adjacent fields drain, and/or they may themselves be drained to streams or larger ditches. During periods of backwater flooding, these same artificial drainage networks may function in reverse, and deliver water to low areas far from the source stream channels. (Smith and Klimas 2002).

**Vegetation**

Forests of the basin are referred to as bottomland hardwoods, a term which incorporates a wide range of species and community types, all of which can tolerate inundation or soil saturation for at least some portion of the growing season (Wharton et al. 1982). Most major overviews of bottomland hardwood forest ecology emphasize the relationship between plant community distribution and inundation, usually assuming that floodplain surfaces that occupy different elevations in relation to a river channel reflect different flood frequency, depth, and duration (e.g., Wharton 1978, Brinson et al. 1981, Larson et al. 1981, Wharton et al. 1982). This leads to classification of forests in terms of hydrologic “zones,” each zone having characteristic plant communities. Whereas the Yazoo River floodplain is geomorphically complex and supports mosaics of communities, the general zonal models imply that the principal hydrologic controls on community composition are flood frequency, depth and duration, as indicated by elevation relative to a stream channel. Overbank flooding is just one of many important sources of water in the wetlands of the Lower Yazoo Basin, and factors such as ponding of precipitation may be more important than flooding effects in many landscape settings (Smith and Klimas 2002).

**Soils**

Parent materials of soils in the Yazoo Basin are fluvial sediments which have developed under the influence of the Mississippi River. The fluvial sorting process of sediments has produced textural and topographic gradients that are fairly consistent on a gross level, and result in distinctive soils. Generally, within a meander belt, surface substrates grade from relatively coarse-textured, well-drained, higher elevation soils on natural levees directly adjacent to river channels through progressively finer-textured, and less well-drained materials on levee backslopes and point bar deposits. Very heavy clays are commonly found in closed basins within large swales and abandoned channels as well as in backswamps between successive meander belts. Valley train deposits are the result of glacial outwash which were subsequently influenced by braided stream development. Valley train deposits typically have a top stratum (upper 1.5-3m) of fine-grained material (clays and silts) that blankets the underlying network of braided channels and bars (Brown et al. 1971, Saucier 1994,). Backswamps are typically flat, poorly drained areas bounded by uplands or other features such as natural levees. Like valley trains, backswamps consist of coarse glacial outwash deposits overlain with fine grained deposits which give rise to the heavy clay soils characteristic of the study area. However, all of these patterns are generalizations, and quite different conditions occur regularly (Smith and Klimas 2002). Within the study area Kirchner et al.(1991) considered Alligator, Calhoun/Bonn Complex, Dowling, Rosebloom, Sharkey, Souve and Waverly soil series as hydric soils. Forestdale, Tunica, and Brittain series sometimes have inclusions of coarser textured soils and could not categorically be considered hydric soils. Thus, site inspection is often the only way to determine if soils have hydric indicators. An estimated 1,196,907 acres of hydric soils existed in the 6 counties in which the project is contained (Kirchner et al. 1991). Hydric soils in these 6 counties account for approximately 30% to 80% of the county area.

## Probability Survey Design Approach

Available estimates of jurisdictional wetland extent in the Lower Yazoo Basin, based on remote data with unestimated error, have ranged widely giving an unclear picture of wetland extent in the area. Field based determinations involving determining precise boundaries and areal extent of jurisdictional wetlands was not feasible due to time and resource constraints. A probability survey design approach incorporating field assessments at randomly selected sites was determined to be the best approach since it incorporated elements of both remote sensing and field determinations yielding statistically valid results within defined confidence limits. Probability survey designs for natural resources, specifically aquatic resources, have been developed by the Environmental Monitoring and Assessment Program (EMAP) of the Environmental Protection Agency's (EPA) Office of Research and Development (ORD) to advance the science of natural resource monitoring. A key aspect of EMAP is based upon the use of probabilistic sampling designs which require explicitly defined target populations; allowance for each element in the population having the opportunity to be selected with a known probability; and making the sample selection process explicitly random. These 3 characteristics, in conjunction with a well-defined field measurement protocol, ensure that data is collected without bias. Specifically, a goal of the EMAP program is to estimate the geographic coverage and extent of ecological resources such as wetlands with known confidence. EMAP achieves this goal by using statistical survey methods that allow assessment of the extent of large areas based on data collected from a representative sample of locations. By using probabilistic sampling, EMAP maximizes the efficiency of the sampling effort while permitting conclusions to be reached about the larger population within known confidence intervals. EMAP strategies and methods have been developed and tested within EPA-ORD over the past decade, and have proven to be effective, accurate, replicable, and readily available. Given the inherent uncertainty associated with remote sensing (e.g., GIS) estimates of wetland extent and the availability of EMAP protocols and technical support from EPA-ORD, EPA Region 4 initiated the EMAP survey design to provide an objective approach for assessing the extent of wetland acreage within the Yazoo Backwater project area.

## Methods

The study was done following established EMAP methods (www.epa.gov/nheerl/arm). The survey design for selecting samples in order to provide valid data, was developed to accurately estimate the extent of wetlands from the entire population or area of interest. Completion of the survey design required: establishment of objectives (as elucidated above); identification of resource characteristics; establishment of the target population; development of a sample frame and sample size; a field sampling protocol and statistical analysis.

For the purposes of the survey design, the wetlands of the Yazoo Basin are considered to be a 2-dimensional areal resource. The target population for this project was defined as the entire land area within the Corps of Engineer's (Corps) designated 100-year floodplain. Each location within the target population would be classified as either a jurisdictional wetland or not. Within the target population, 3 categories of potential wetlands were identified. These three categories, or strata, arose from discussions between the Corps and EPA on the extent of wetlands in the Lower Yazoo Basin. Several GIS data layers were used to depict the potential areas containing wetlands for the purposes of drawing a probabilistic sample.

The Corps based its interpretation of jurisdictional wetlands in the Lower Yazoo Basin on those areas inundated for 5% of the growing season. This definition allowed the District to utilize flooding models (Flood Event Assessment Tool (FEAT), Ballard and Kress, 2004) and satellite imagery to indicate the location and extent of potential jurisdictional wetlands in the project area. The FEAT model is a prototype geospatial model which utilizes stream gage data, digital elevation models (DEMs), primary and secondary channel centerlines or cross-sections to generate a geospatial based flood surface (Ballard and Kress, 2004). Inputs to the FEAT model were stage data from 6 gages, 30 meter (m) DEMs, channel centerlines and secondary channels. The Corps used this model to depict the location of wetlands based upon inundation for 5% of the growing season. The results of this model were calibrated against a single satellite Thematic Mapper (TM) scene with 25 m resolution, dated March 10, 1989, and verified with another, similar satellite scene dated 13 January 1983. The Corps determined the use of these 2 scenes as adequate to determine wetland extent in the project area. The Corps' FEAT model output was used as a category of potential wetlands for the Lower Yazoo Basin from which to draw a sample for the probabilistic survey design.

EPA utilized the Federal definition of wetlands as per Corps {33 CFR 328.3(b)} and EPA {40 CFR 230.3(t)} regulations, to include "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." EPA interpretation of this definition necessitates evaluation of the presence of hydrophytic vegetation, hydric soils, and wetland hydrology. Use of this definition expanded the potential geographic extent of sample sites. The National Land Cover Dataset (NLCD) was used to represent potential wetlands beyond those captured in previous analyses (http://landcover.usgs.gov/nationallandcover.asp) using the Corps' FEAT model. The NLCD uses Landsat TM imagery terrain-corrected using 3-arc-second digital terrain elevation data. The TM data were geo-registered to the Albers Equal Area projection grid using ground control points, resulting in a root mean square error of less than one pixel (30m). Two or more TM scenes were used for the final NLCD product to represent different times of the growing season (e.g., leaf-on and leaf-off) thus improving the quality of the landcover information. In addition to the multiple TM scenes, land use-land cover data from the U.S. Geological Survey, State Soil Geographic (STATSGO) and National Wetland Inventory were used to enhance the classification of the NLCD (Vogelmann et al. 2001).

Of the 21 landcover classes represented in the NLCD, only the forested classes were selected from the NLCD coverage and used to represent potential wetlands. This included the deciduous forest, mixed forest and woody wetland categories. The deciduous forest and mixed forest categories were included because previous wetland studies in the Yazoo Basin (Kirchner et al, 1991) found that in 275 wetland determination sites distributed in the Yazoo Basin all sites satisfied the hydrophytic vegetation criteria in the 1987 Wetland Delineation Manual (COE 1987). In addition, accuracy assessments have shown that NLCD is only 60% accurate in classifying Anderson Level 2 classes. In particular, error was associated with correctly classifying forested wetlands. Therefore, all NLCD forested classes were included in the sample frame in an effort to capture any potential wetlands. In this study the NLCD forested classes totaled 225,729 acres. Ninety-five percent (214,792) of these acres were classified as wetland forests while 5% (10,937) were classified as upland forests.

In addition, the U.S. Fish and Wildlife Service Lower Mississippi Alluvial Valley Joint Venture Office provided a shapefile depicting areas as having been enrolled in the Wetland Reserve Program (WRP) as restored wetlands. These WRP areas were included with the NLCD shapefile and the FEAT model output as potential wetlands.

Thus, the EMAP sample frame consisted of 3 sampling strata depicted as ArcView shape files in map form projected in North American Datum 27 (NAD27) (Figure 2). These previously described ArcView shape files were the basis for creating the sample frame used to generate the random sample points. A sample frame is defined as the specific information (e.g., a list or map) that identifies every unit within the population of interest. In this case the sample frame was the ArcView map with the FEAT, NLCD, WRP wetlands and the areas in between which were designated "non-wetlands". Areas which were not designated as wetlands in either the FEAT, NLCD, or WRP layers were also included in the sample frame to capture errors of omission.

Using the sample frame, the survey design was developed for the selection of a sample of units. A generalized random tessellation stratified (GRTS) design with reverse hierarchical ordering was used (Stevens and Olsen 2002). The study region polygons were assigned to one of three separate strata: FEAT model wetlands; NLCD/WRP wetlands; and other (non-wetlands). Thus the design is a stratified design. Within each stratum, instead of selecting a simple random sample a generalized random tessellation stratified survey design was applied to wetland polygons. The GRTS design maintains spatial distribution of a random sample and allows substitution of inaccessible points in an unbiased, random and spatially distributed way.

A sample size of 50 sites/strata was determined to meet the desired level of precision at a confidence of 90%. Thus a total sample of 150 sites over the 630,000 acre area was proposed to estimate wetland extent. EMAP provided geographic coordinates for the 150 sites as well as coordinates for an additional 150 oversample sites to be used in sequential order in the event one or more of the original sites was inaccessible.

**Field sampling protocol**

Once the sample points were selected using GIS, the spatial coordinates of each point were listed, then plotted using Mapsource (Version 4.13) Global Positioning System (GPS) compatible software (Garmin Corporation 1999-2003). This placed the EMAP generated points on digital topographic maps facilitating transportation to and from sites. Three teams of Corps, EPA, Natural Resource Conservation Service and U.S. Fish and Wildlife personnel located sites via Garmin 76S GPS units set on World Geodetic System datum 84 (WGS 84). Once on a site, a routine wetland determination as described in the 1987 Corps of Engineers Wetland Delineation Manual (1987 Manual)(Environmental Laboratory 1987) was completed (Figure 3). A wetland determination is defined by the 1987 Manual as, "the process or procedure by which an area is adjudged a wetland or nonwetland." Thus, this process did not establish wetland boundaries which are defined by the 1987 Manual as "the point on the ground at which a shift from wetlands to nonwetlands or aquatic habitats occurs" (Environmental Laboratory 1987), but determined the wetland status of the immediate area around the sample point. This determination included an ocular estimate of dominant vegetation, determination of presence of hydric soils, and notation of primary and/or secondary indicators of wetland hydrology. Data was recorded and a determination of the wetland status of the site was made at the time of the field visit. An area was determined to be wetland if it had a dominance of hydrophytic vegetation; had positive (1 primary or 2 secondary) indicators of hydrology and had hydric soils in accordance with the criteria established in the 1987 Manual. Results were reported to EMAP for statistical analysis as “wetland” or “not wetland”.

**Statistical analysis**

Population estimates for wetlands in the Lower Yazoo Basin can be extrapolated directly from observations at randomly selected sites. These estimates are computed using weights that are the inverse of the inclusion probabilities, and are equivalent to the number of acres in the target population that are represented by each site in the sample. For example, the number of acres with some attribute (such as being a wetland) can be estimated as the sum of the weights of the sampled sites with that attribute. If $s_1$, $s_2$, ..., $s_n$ is a sample selected according to a design with inclusion probabilities π(s), an unbiased estimator of the population total (acres of jurisdictional wetlands) is given by

$$\hat{z}_T = \sum_{i=1}^{n} \frac{z(s_i)}{\pi(s_i)}, \qquad (1)$$

where $z(s_i)$ is data value for site $s_i$ and the inclusion probability is π(s) is area of a particular stratum divided by the number of sample points evaluated in that stratum (Stevens and Olsen, 2003). A variance estimator for $\hat{Z}_T$ is then

$$\hat{V}_{IRS}(\hat{Z}_T) = \sum_i \left( \frac{z(s_i)}{\pi(s_i)} \right)^2 - \frac{1}{n-1} \sum_{i \neq j} \left( \frac{z(s_i)}{\pi(s_i)} \right) \left( \frac{z(s_j)}{\pi(s_j)} \right) = \frac{n}{n-1} \sum_i \left( \frac{z(s_i)}{\pi(s_i)} - \overline{\left( \frac{z}{\pi} \right)} \right)^2 = nV_{SRS}(z/\pi) \quad (2)$$

where $V_{SRS}(z/\pi)$ is the usual estimator of the population variance for a simple random sample (SRS) design applied to $z(s_i)/\pi(s_i)$ (Stevens and Olsen, 2003). Stevens and Olsen (2003) give an improved local neighborhood variance estimator that was used in this study. Further details on the estimation of weighted population statistics are available in Diaz-Ramos et al. (1996). For the Lower Yazoo Basin, a stratified GRTS survey design was implemented, estimates for each of the three strata were calculated as indicated above, and then the three estimates combined which is the norm for a stratified survey design (Cochran 1987).

## Results & Discussion

Field sampling was completed from June 2 - 14, 2003. Initially the three teams of interagency personnel worked together to discuss issues that might arise in the field and to develop consistency between teams in interpreting wetland field indicators. The members of the teams making the wetland determinations were all trained in the use of the 1987 Wetland Delineation Manual and followed procedures outlined in the Manual.

As noted previously, the original sample frame for the EMAP design were ArcView shapefiles of the FEAT delimited area, NLCD forested areas and WRP lands, and the area not included in the first two categories (Low Potential), all projected in NAD 27. Hence, the EMAP potential sample points were also projected in NAD 27. However, the GPS units were set to the default setting of WGS 84. This resulted in approximately a 25m shift to the south of each potential point. Thus each sample point evaluated in the field was located 25m south of the intended location. This difference in datums resulted in some of the original sample points actually being shifted into one of the other 2 strata. Table 1 shows the distribution of sampled points after field sampling. The original design entailed sampling 50 sites in each of the 3 strata. Table 1 indicates that only 2 points in the FEAT Potential stratum shifted to the Low Potential strata, 3 points shifted from the NLCD/WRP stratum, and 2 shifted from the Low Potential stratum. However, despite this shift, the survey design, field determinations, and statistical design remained intact.

Table 1. Strata shifts in EMAP sample points in the Lower Yazoo Basin Project.

| Stratum | Subpopulation | | | Total Number of sites |
|---|---|---|---|---|
| | FEAT Potential | NLCD/WRP Potential | Low Potential | |
| FEAT Potential | 55 | 0 | 2 | 57 |
| NLCD/WRP Potential | 0 | 55 | 3 | 58 |
| Low Potential | 0 | 2 | 53 | 55 |
| Total | 55 | 57 | 58 | 170 |

Table 2 presents the results of the EMAP survey design. A total of 169 sites was evaluated in the field (Figure 4). Of this total, 12 sites were determined to be inaccessible due to flooded conditions or landowner restricted access and were not sampled. These 12 sites were substituted for with 12 sites from the oversample list in order to preserve the minimum sample size of 50 sites/category.

Table 2. EMAP Wetland Results for Lower Yazoo Basin

| **Wetland Category** | **Wetland Status** | **N Resp** | **Estimate (%)** | **StdErr. (%)** | **LCB90 (%)** | **UCB90 (%)** | **Estimate (ac)** | **StdErr. (ac)** | **LCB90 (ac)** | **UCB90 (ac)** |
|---|---|---|---|---|---|---|---|---|---|---|
| Study region | no | 82 | 67.8 | 2.1 | 64.3 | 71.3 | 446244 | 14023 | 423178 | 469311 |
| Study region | yes | 70 | 32.2 | 2.1 | 28.7 | 35.7 | **212284** | 14023 | 189218 | 235351 |
| Study region | Total | 152 | 100.0 | | | | 658529 | | | |
| FEAT Potential | no | 8 | 16.3 | 4.0 | 9.8 | 22.9 | 25544 | 6207 | 15335 | 35753 |
| FEAT Potential | yes | 41 | 83.7 | 4.0 | 77.1 | 90.2 | **130914** | 6207 | 120705 | 141123 |
| FEAT Potential | Total | 49 | 100.0 | | | | 156458 | | | |
| NLCD/WRP Potential | no | 25 | 51.5 | 6.2 | 41.3 | 61.7 | 70161 | 8431 | 56294 | 84028 |
| NLCD/WRP Potential | yes | 27 | 48.5 | 6.2 | 38.3 | 58.7 | **66091** | 8431 | 52224 | 79959 |
| NLCD/WRP Potential | Total | 52 | 100.0 | | | | 136252 | | | |
| Low potential | no | 49 | 95.8 | 2.6 | 91.6 | 100.0 | 350539 | 9330 | 335192 | 365818 |
| Low potential | yes | 2 | 4.2 | 2.6 | 0.0 | 8.4 | **15279** | 9330 | 0 | 30626 |
| Low potential | Total | 51 | 100.0 | | | | 365818 | | | |

LCB90 = Lower Confidence Band, 90th percentile
UCB90 = Upper Confidence Band, 90th percentile

Eighty-two sites (67.8%) did not meet the criteria in the 1987 Manual and were categorized as “non-wetlands” (Figure 5), while 70 sites (32.2%) did meet the 3 criteria for being considered jurisdictional wetlands (Figure 6). Based on this sample, an estimated 212,284 ± 14,023 acres of wetlands occur in the 100-year floodplain of the Lower Yazoo Basin leaving 446,284 acres of non-wetland in the study area.

A comparison of the total number of sites sampled from Table 1 and Table 2 indicate a difference of 18 sites. Table 1 represents the total number of sites (170) which were attempted to be physically sampled in the field. Of these 170 sites, 12 sites were inaccessible and could not be located, and 1 site was deleted from the sample population. Hence, 13 sites were considered “inaccessible” and were not sampled. As a result of changes in the GIS shapefiles after the sample frame had been sampled, 5 additional sites were removed from further analysis due to their GIS location outside the boundary of the 100 year floodplain (i.e., the study boundary). Therefore, as indicated in Table 2, 152 sampled sites, were included in the analysis of the spatial extent of wetlands in the 100 year floodplain.

The highest percentage of wetlands in the study area occurred in the area the FEAT model predicted flooded for 5% of the growing season (Figure 6). In this case, 130,914 ± 6,207 acres, or 83.7 ± 4.0 % of the area was determined to be wetland, while 16.3 ± 4.0 % did not meet wetland criteria. Previous interpretations of the FEAT model outputs determined that the entire area depicted by the model as flooded for 5% of the growing season was wetland. Thus the FEAT predicted 189,600 acres of wetland. Differences with the EMAP estimate of 130,914 acres are due to the inclusion of nonwetland areas (i.e., agricultural fields, open water areas, and uplands) which EMAP detected but the FEAT model did not. Inaccessibility of 5 sites in this category was due to deep water caused by backwater flooding at the time of sampling. Substitute sites from the EMAP oversample list for this category were selected and sampled in the given sequence.

Of the approximately 136,000 acres represented by NLCD/WRP ArcView shapefiles as potential wetlands, 66,091 ± 8,431 acres or 48.5 ± 6.2 % were wetland by virtue of meeting the hydrologic, soils and vegetative criteria in the 1987 Manual. While the shapefiles for the NLCD/WRP overlap with portions of the FEAT shapefiles, the EMAP sample points for the NLCD/WRP category were all beyond the boundary of the area defined by the FEAT model. Consequently, at least 50 samples were taken from the FEAT area and 50 from the NLCD/WRP area that did not include overlaps with the FEAT area. Inaccessibility of 3 sites due to landowner restriction and flooded site conditions were substituted from the EMAP oversample list.

Finally, 15,279 ± 9330 acres or 4.2 ± 2.6 % of the "Low potential" areas were found to be wetlands. Of the 2 sites which were determined to be wetlands 1 was an area dominated by buttonbush (*Cephalanthus occidentalis*) and a variety of sedges and rushes (*Carex and Juncus spp*.) and the other was determined by the Natural Resources Conservation Service (NRCS) to be "farmed wetland". Areas determined to be nonwetlands in this category were primarily agricultural sites and catfish ponds. Of the 49 nonwetland sites in the Low Potential category none had hydrophytic vegetation, 31 sites had hydric soils, and none had indicators of hydrology.

## Conclusion

The spatial extent of wetlands in the Lower Yazoo Basin was determined with known confidence using an EMAP survey design and analysis. Based on this design the total wetland extent for the 100-year floodplain of the Lower Yazoo Basin is approximately 212,000 acres. This provides a sound, scientifically defensible basis for establishing the area of wetlands that can currently be identified using the 1987 Wetland Delineation Manual. The highest percentage of the total wetland acreage was found in the FEAT predicted area, with substantial acreage occurring outside this boundary. This study indicates that wetlands occur throughout the project area although they are concentrated in the southern half. The study also indicates that wetlands occur not only within the area modeled as wetland by the FEAT model, but also outside the modeled area in areas depicted by the NLCD/WRP shapefile and in low potential areas.

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## Figures

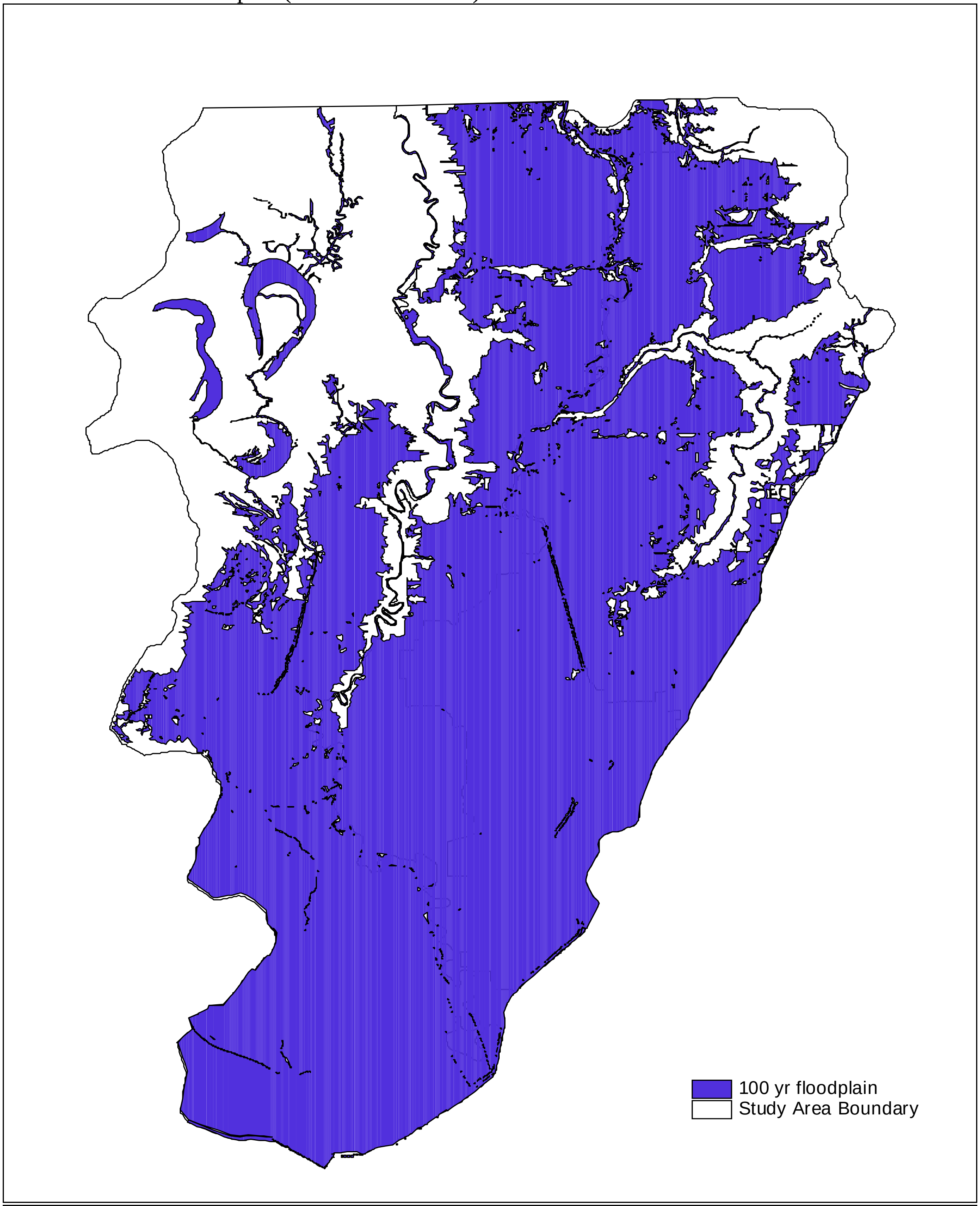


Figure 1. Study area and 100 year floodplain of the Lower Yazoo basin.

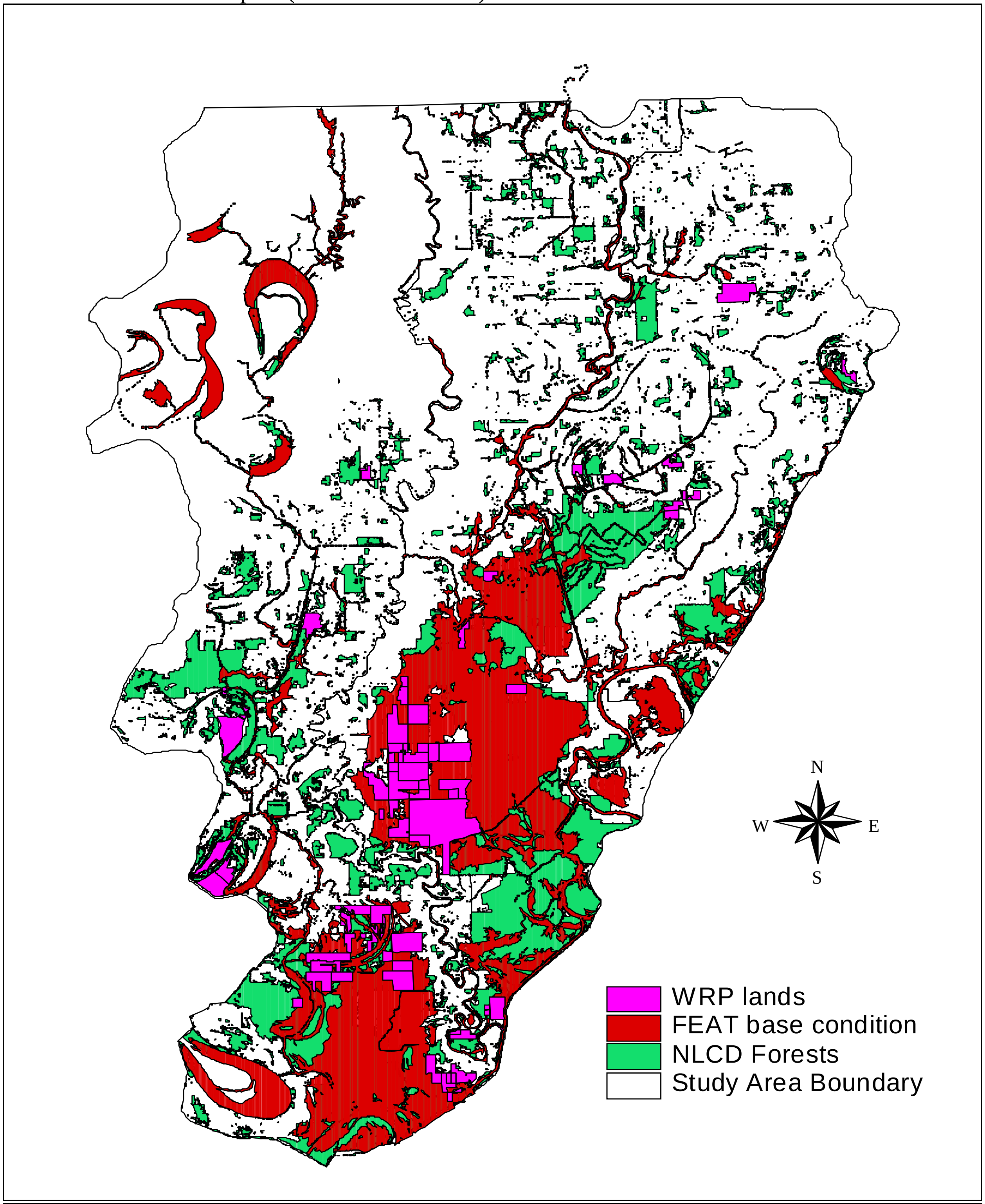


Figure 2. EMAP sample frame with FEAT model-predicted wetland area, and NLCD/WRP- predicted wetland area in the Lower Yazoo Basin.

Figure 3. Routine wetland determination form from the Corps 1987 Manual (Environmental Laboratory 1987).

**ROUTINE WETLAND DETERMINATION**
(1987 COE Wetlands Delineation Manual)

| | | | |
|---|---|---|---|
| Project Site: | | | Date: |
| Applicant/Owner: | | | County: |
| Investigator: | | | State: |
| | | | |
| Do normal circumstances exist on the site? | Yes | No | Community ID: |
| Is the site significantly disturbed (atypical situation)? | Yes | No | Transect ID: |
| | | No | Plot ID: |
| Is the area a potential problem area? (If needed, explain on reverse.) | Yes | | |

**VEGETATION**

| Dominant Plant Species | Stratum | Indicator | Dominant Plant Species | Stratum | Indicator |
|---|---|---|---|---|---|
| 1. | | | 9. | | |
| 2. | | | 10. | | |
| 3. | | | 11. | | |
| 4. | | | 12. | | |
| 5. | | | 13. | | |
| 6. | | | 14. | | |
| 7. | | | 15. | | |
| 8. | | | 16. | | |

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks:

**HYDROLOGY**

____ Recorded Data (describe in remarks):
- ____ Stream, Lake, or Tide Gauge`
- ____ Aerial Photographs
- ____ Other

____ No Recorded Data Available

Field Observations:

Depth of Surface Water ____(in.)

Depth to Free Water in Pit: ____(in.)

Depth to Saturated Soil: ___ (in.)

Wetland Hydrology Indicators:

Primary Indicators
- ____ Inundated
- ____ Saturated in Upper 12 Inches
- ____ Water Marks
- ____ Drift Lines
- ____ Sediment Deposits
- ____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):
- ____ Oxidized Root Channels in Upper 12 inches
- ____ Water-Stained Leaves
- ____ Local Soil Survey Data
- ____ FAC-Neutral Test
- ____ Other (Explain in Remarks)

Remarks:

**SOILS**

Map Unit Name
(Series and Phase):

Taxonomy (Subgroup):

Drainage Class: ___
Field Observations
Confirm Mapped Type Yes No

Profile Description:

| Depth (inches) | Horizon | Matrix Color (Munsell Moist) | Mottle Colors (Munsell Moist) | Mottle Abundance/Contrast | Texture, Concentrations Structure, etc. |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chrome Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

**WETLAND DETERMINATION**

Hydrophytic Vegetation Present? Yes No (Circle)

Wetland Hydrology Present? Yes No

Hydric Soils Present? Yes No

(Circle)

Is this Sampling Point Within a Wetland? Yes No

Remarks:

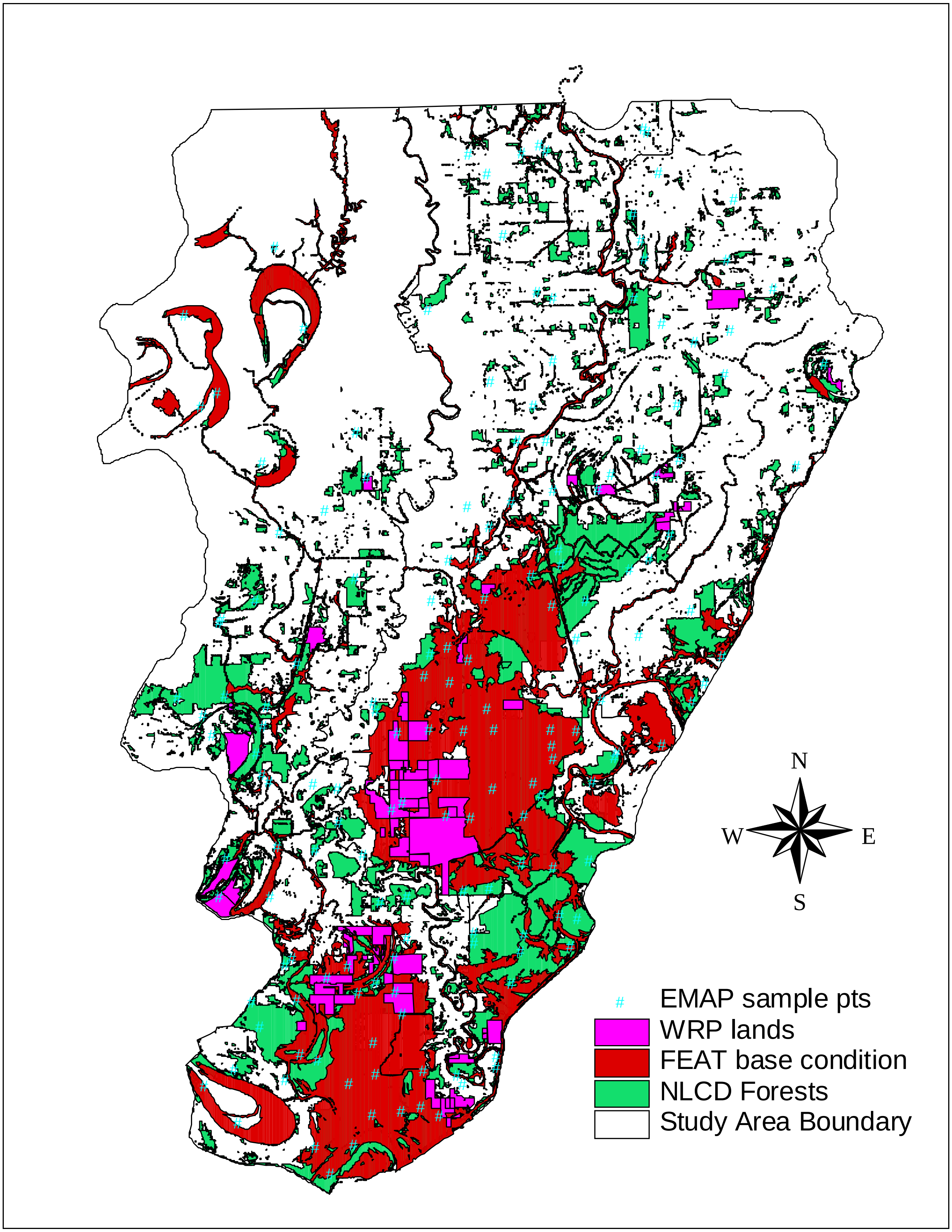


Figure 4. EMAP sample points in the Lower Yazoo Basin.

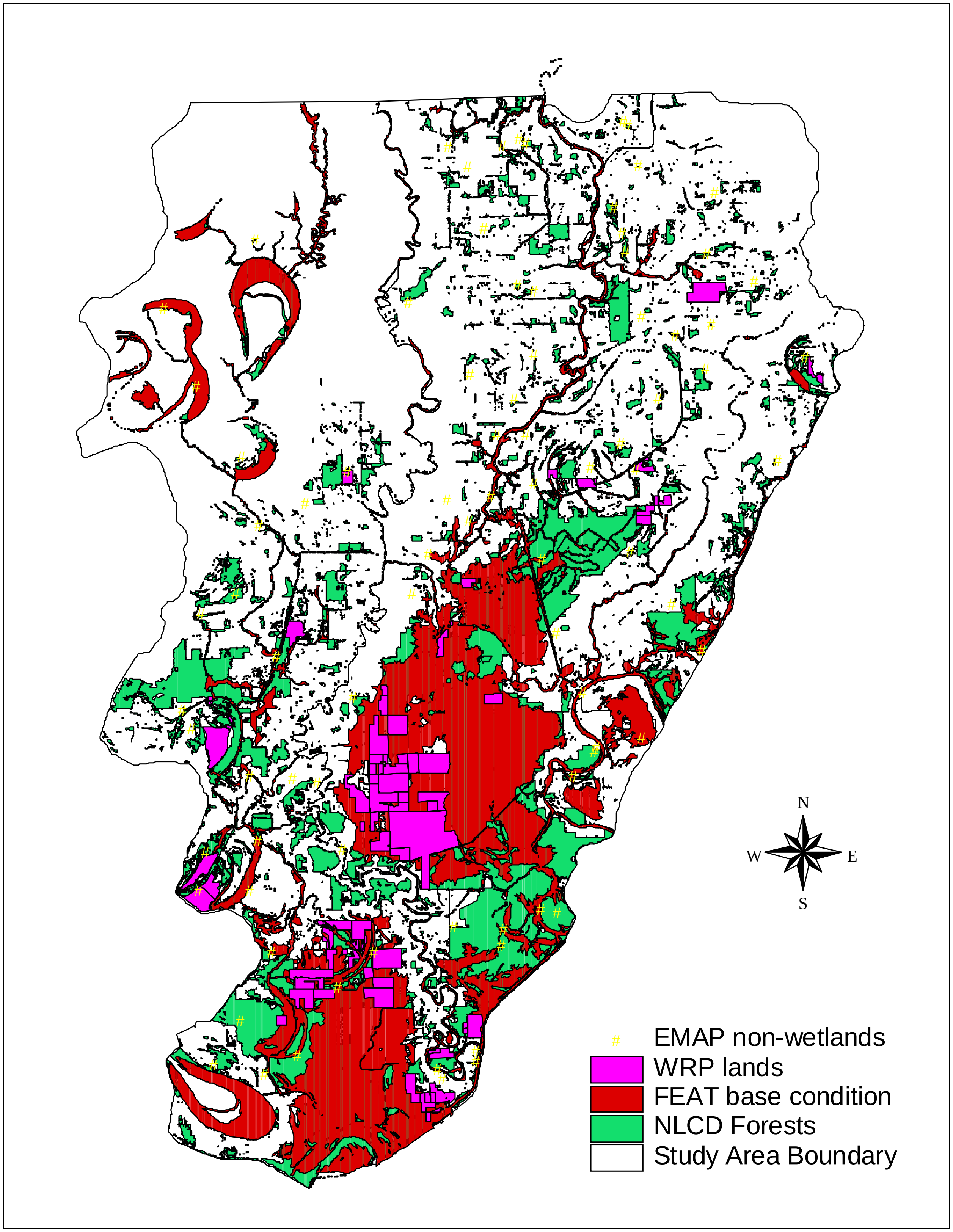


Figure 5. EMAP sample points that were found to be non-jurisdictional areas in the Lower Yazoo Basin.

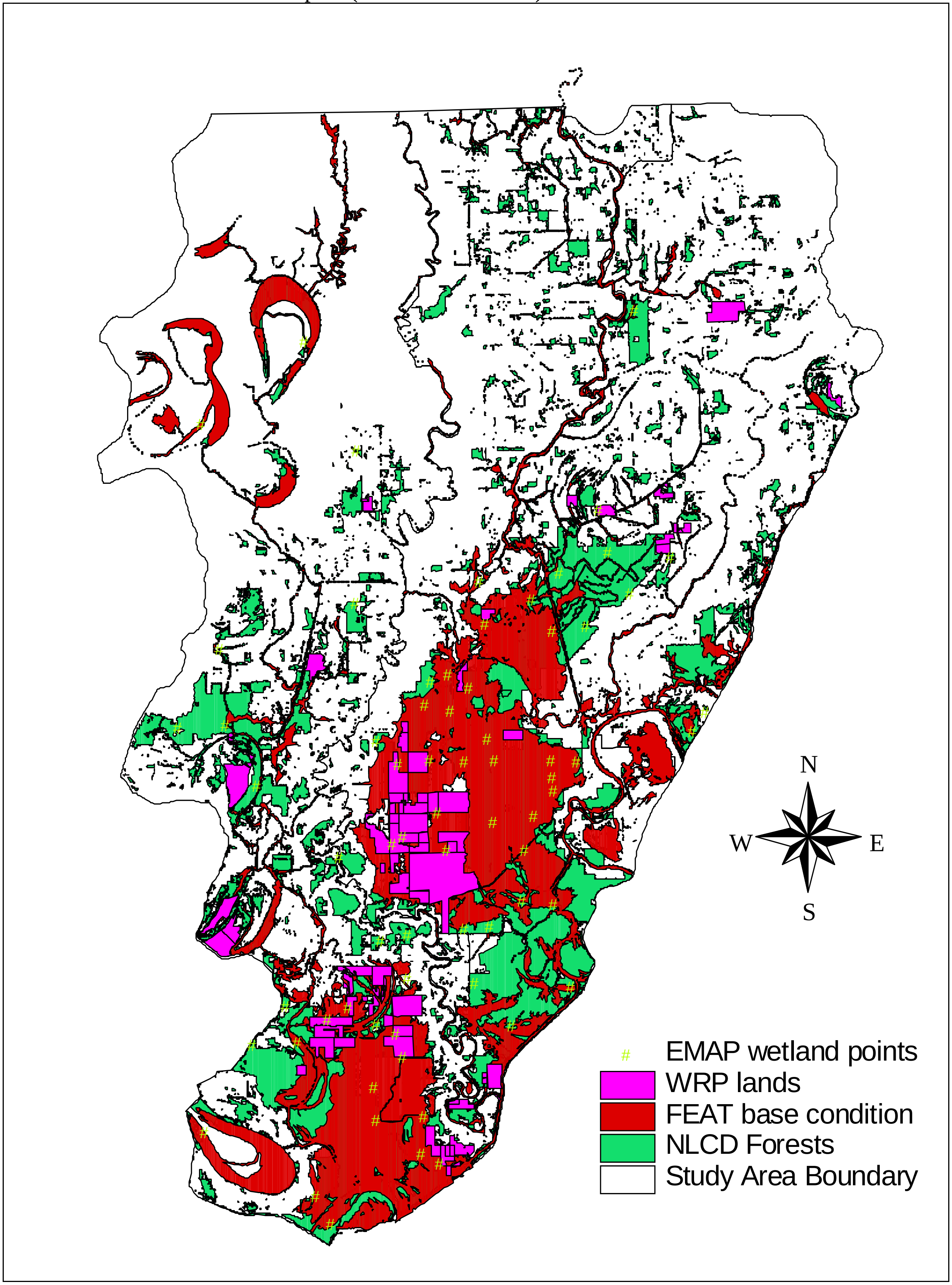


Figure 6. EMAP sample points that were determined to be jurisdictional wetlands in the Lower Yazoo Basin.

# Attachment B

# Analysis of Spatial Extent of Wetland Impacts

# Analysis of Spatial Extent of Wetland Impacts

## *Estimation of Wetlands in the 2-year floodplain*

The EMAP survey (Attachment A) statistically estimated that a total of 212,000 acres of wetlands were present within the 100-year floodplain of the study area. The survey estimated approximately 131,000 acres of wetlands occurred within the Corps' assessment area (FEAT/FESM stratum), and 81,000 acres outside (NLCD/WRP and NonWet strata). The Corps determined, based on duration of flooding, that approximately 67,000 acres would experience a change in hydroperiod. However, they did not estimate the number of acres that would experience a change in hydroperiod in the 2-year floodplain.

To determine how many of the 81,000 acres of additional wetlands that would potentially be impacted by the project, EMAP statisticians calculated the extent of wetlands in an area bounded by the 2-year floodplain. EMAP used the same statistical estimation techniques outlined in Appendix 2 to compare wetland acres in the 2-year floodplain with- and with-out the project. The EMAP points which fell in the 2-year "without project" floodplain were compared to those which fell into the 2-year "with project" floodplain (Figure 1). The polygon features for calculating the areal extent of the 2-year floodplain (with- and without project) were provided to EPA, by the Corps as an output of their flood model in 2005. The same strata used in the EMAP survey (Attachment A) were used in this analysis. Hence, points in the FEAT/FESM stratum do not coincide with those in the NLCD/WRP or NonWet strata. In other words, the acres estimated by this analysis are not the same acres estimated by the Corps. The change in the number of points represents an estimate of the change in acres as a result of the project in the 2-year floodplain (Figure 1).

As explained in the Recommended Determination and reiterated here, Table 1 indicates the total area of wetlands in the 2-year floodplain is 179,120 acres. There are approximately 127,327 acres of wetlands within the FEAT/FESM boundary and 51,792 acres outside the Corps' assessment area (i.e., in the NLCD Potential category and the Low Potential category). After the project, the area of wetlands remaining is approximately 27,900 acres. Hence, 23,892 acres of wetlands not included in the Corps' analysis are affected by the project. EPA Region IV shared these results with the Vicksburg District Corps in a letter dated December 6, 2005.

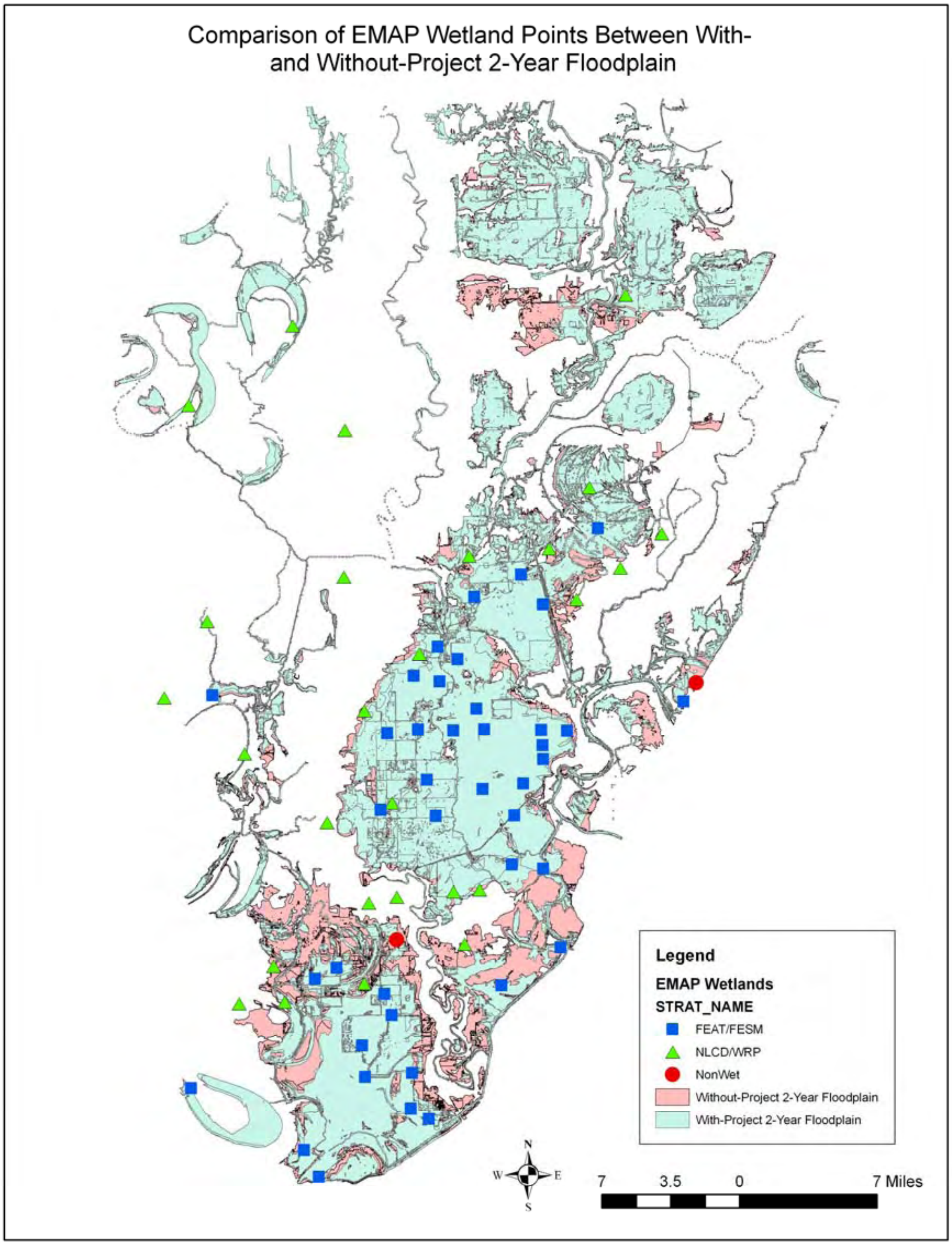


**Figure 1. EMAP points which fell in the 2-year "without project" floodplain were compared to those which fell into the 2-year "with project" floodplain**

**Table 1. EMAP estimates of wetland extent in the 2-year floodplain with- and with-out project.**

| Wetland Category | Wetland Status | NResp | Estimate % | StdError % | LCB 90 % | UCB90 % | Estimate (ac) | Std Error (ac) | LCB 90 (ac) | UCB 90 (ac) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Without Project** | | | | | | | | | | |
| 2yr floodplain | Not Wet | 36 | 46.8 | 3.4 | 41.3 | 52.4 | 157707 | 11368 | 139008 | 176406 |
| 2yr floodplain | Wet | 55 | 53.2 | 3.4 | 47.6 | 58.7 | **179120** | 11368 | 160421 | 197819 |
| 2yr floodplain | Total | 91 | 100.0 | | | | 336827 | | | |
| Feat Potential | Not Wet | 8 | 16.7 | 4.0 | 10.1 | 23.2 | 25465 | 6093 | 15443 | 35488 |
| Feat Potential | Wet | 40 | 83.3 | 4.0 | 76.8 | 89.9 | **127327** | 6093 | 117305 | 137350 |
| Feat Potential | Total | 48 | 100.0 | | | | 152793 | | | |
| NLCD/WRP | Not Wet | 11 | 45.8 | 7.8 | 33.0 | 58.7 | 31552 | 5385 | 22694 | 40410 |
| NLCD/WRP | Wet | 13 | 54.2 | 7.8 | 41.3 | 67.0 | **37289** | 5385 | 28431 | 46147 |
| NLCD/WRP | Total | 24 | 100.0 | | | | 68842 | | | |
| NonWet(3) | Not Wet | 17 | 87.4 | 6.9 | 76.1 | 98.8 | 100689 | 7944 | 87622 | 113755 |
| NonWet(3) | Wet | 2 | 12.6 | 6.9 | 1.2 | 23.9 | **14503** | 7944 | 1437 | 27570 |
| NonWet(3) | Total | 19 | 100.0 | | | | 115192 | | | |
| **With Project** | | | | | | | | | | |
| 2yr floodplain | Not Wet | 24 | 40.5 | 3.5 | 34.8 | 46.3 | 105697 | 9072 | 90775 | 120619 |
| 2yr floodplain | Wet | 49 | 59.5 | 3.5 | 53.7 | 65.2 | **155073** | 9072 | 140151 | 169996 |
| 2yr floodplain | Total | 73 | 100.0 | | | | 260770 | | | |
| Feat Potential | Not Wet | 6 | 13.3 | 3.9 | 7.0 | 19.7 | 19555 | 5657 | 10250 | 28861 |
| Feat Potential | Wet | 39 | 86.7 | 3.9 | 80.3 | 93.0 | **127109** | 5657 | 117803 | 136414 |
| Feat Potential | Total | 45 | 100.0 | | | | 146664 | | | |
| NLCD/WRP | Not Wet | 7 | 43.8 | 9.8 | 27.6 | 59.9 | 15789 | 3538 | 9968 | 21609 |
| NLCD/WRP | Wet | 9 | 56.3 | 9.8 | 40.1 | 72.4 | **20300** | 3538 | 14480 | 26120 |
| NLCD/WRP | Total | 16 | 100.0 | | | | 36089 | | | |
| NonWet(3) | Not Wet | 11 | 90.2 | 7.9 | 77.2 | 100.0 | 70353 | 6146 | 60243 | 78018 |
| NonWet(3) | Wet | 1 | 9.8 | 7.9 | 0.0 | 22.8 | **7665** | 6146 | 0 | 17774 |
| NonWet(3) | Total | 12 | 100.0 | | | | 78018 | | | |

# Attachment C

# Hydrological Technical Memorandum

# Hydrological Technical Memorandum

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
**REGION 4**
**Atlanta Federal Center**
**61 Forsyth Street S.W.**
**Atlanta, Georgia 30303-8960**

## Technical Memorandum

Date: 23 February, 2008

FROM: Bill Ainslie
Wetlands Regulatory Section

TO: File

SUBJECT: Synopsis of Yazoo Backwater Area Hydrology

This Technical Memorandum constitutes a summary of information regarding the pre- and post-project hydrology for the Yazoo Backwater Pumps Project. The objective of the project is to reduce flood damages to structures and agriculture by reducing the spatial extent, frequency and duration of flooding. Much of the baseline and “with-project” information is taken from Appendix 6 of the U.S. Army Corps of Engineers (the Corps or COE) Final Supplemental Environmental Impact Statement (FSEIS) . EPA interpretation of that information is based on an independent analysis conducted by Nutter and Associates, Inc. under contract to EPA in 2004 (Hydrological Analysis of COE Work at proposed Yazoo River Basin Flood Control Projects. Contract Order: 3R-0142-NASA). The objective of this Technical Memorandum is to provide a summary and EPA interpretation of the hydrologic information used by EPA in developing its position on the effects of the Yazoo Backwater project on wetlands, fisheries and wildlife. Specifically, this Tech Memo addresses information in both the FSEIS and the independent hydrologic review, on the proposed effects of the project on flood frequency and duration. The proposed project’s effect on flood/wetland extent is discussed in EPA’s “EMAP Report” provided as a supplement to Appendix 10 (Wetlands) in the FSEIS. Further, ecological ramifications of the hydrologic effects of this project will be discussed in subsequent Tech Memos.

At the time of European settlement, much of the Yazoo Basin was subject to prolonged, extensive ponding following the winter wet season in virtually all years, localized short term ponding following rains at any time of the year, and extensive inundation within tributary flood basins due to rainfall in headwater areas in most years. During major flood events large scale backwater flooding influenced numerous tributary systems, and complete inundation of most, or all, of the basin occurred when the Mississippi River overflowed its banks. Since this time, engineering and agricultural alterations have incrementally altered these sources of wetland hydrology (Smith and Klimas 2002).

Except during major floods, the dominant sources of water in the Yazoo basin are precipitation and runoff from the hills along the eastern flank of the basin. The only surface outlet is through the Yazoo River, which enters the Mississippi River at the southern end of the basin near Vicksburg. Most stream flow in the Yazoo River originates in the uplands along the eastern flank of the basin and is carried to the Yazoo via the Coldwater, Yokona, Tallahatchie, and Yalobusha Rivers, as well as several smaller streams. Interior drainage is provided by numerous small streams that discharge to Deer Creek, the Big Sunflower River, or Bogue Phalia - all of which flow to the lower Yazoo River. The direction of drainage within the basin is generally southward, but can be complicated by the topography left by the abandoned meander belts of the Mississippi River (Smith and Klimas 2002, Saucier 1994).

The hydrology of the Yazoo Basin has been modified extensively. Federal projects have largely protected the basin from the effects of major floods, allowing extensive land clearing and agricultural development. Water entering or underlying the modern basin is rerouted, stored, and exported from the system in complex patterns that can result in more or less water available to remaining wetlands. For example, heavy winter and spring rains make drainage necessary for agricultural operations while low rainfall periods in summer and fall warrant irrigation. This drainage may involve land leveling as well as ditching, and can have various effects on wetlands. The wetlands may serve as sumps to which adjacent fields drain or they may themselves be drained to streams or larger ditches. During periods of backwater flooding, these same artificial drainage networks may function in reverse, delivering water to low areas far from the source stream channels. (Smith and Klimas 2002).

Total precipitation within the Yazoo Basin averages between 50-52 inches per year, with little variation from year to year. Precipitation is typically highest from December to April with an average of more than 4.7 inches per month. August through October are typically the driest, averaging less than 3.1 inches per month. This distribution of precipitation typically provides for excess moisture in the winter and spring months, and frequent soil moisture deficits from May to October. This rainfall distribution coincides with runoff estimates calculated by the Corps, presented in Table 6-3, pg. 6-19 (Engineering Summary, Appendix 6), which indicate that the highest volume of runoff is from December (60% runoff) to May (60% runoff). The Corps defines runoff as the percentage of precipitation which falls on a site and does not infiltrate. Therefore, on average, 2.8 inches of rainfall per month runs off into adjacent waterways or is stored on the land surface from December to April. The timing of greatest rainfall and runoff also corresponds to the period of the year when evapotranspiration from plants is at its lowest. Evapotranspiration is the process by which water is released/recycled back to the atmosphere through uptake by plants and subsequent evaporation from plant surfaces (e.g., leaves). High precipitation, high runoff rates, and low evapotranspiration lead to the flooding conditions typical of this area.

**Current Flood Control Features** (Engineering Summary – Appendix 6, paragraphs 35-39)

Given the historic flooding in the Lower Yazoo Basin, certain flood control features have already been implemented. Existing flood control features in the Yazoo Backwater Area include:

1) **Yazoo Backwater Levee** - connects the east end of the Mississippi River mainline levee with the downstream end of the west bank Will M. Whittington Lower Auxiliary Channel Levee. The Yazoo Backwater levee is designed to be overtopped in the event of the project design flood, in order to prevent failure of the mainline levee.
2) **Steele Bayou Structure** - located 3200 ft upstream of the confluence of Steele Bayou and the Yazoo River.
3) **Two 200 foot Bottom Width Connecting Channels** - one between the Big and Little Sunflower Rivers and the other between the Little Sunflower River and Steele Bayou. The purpose of the connecting channels is to shunt water to the lower ponding area to make the most efficient use of the Pump.

4) **Little Sunflower River Structure -** located 21 miles northeast of Vicksburg adjacent to Yazoo River mile 32.6.
5) **Muddy Bayou Structure -** located 13 miles northwest of Vicksburg on Muddy Bayou, a tributary of Steele Bayou. The Muddy Bayou structure regulates flows into and out of Eagle Lake.

The result of these flood control measures, along with the effects of the mainline levee, on the 630,00 acres of 100 year floodplain is that 273,000 are currently in agricultural land uses (43%) and 23,000 acres are in ponds (Main Report, FSEIS Table 2, pg 30) . A majority of these ponds are presumed to be utilized in aquaculture (i.e., catfish rearing). The remaining 333,000 acres are forested, herbaceous, or open water.

The primary purpose of the Yazoo Backwater Project is to provide additional flood protection from the Mississippi and Yazoo Rivers to areas in the Lower Mississippi Delta. During periods of high water stages on the Mississippi and Yazoo Rivers, the Steele Bayou and Little Sunflower structures are closed causing ponding of interior drainage. The drainage area above the Steele Bayou structure is 4,093 square miles (2,620,000 acres). Since this structure can be manipulated, the Steele Bayou structure is the principal structure for the Yazoo Backwater project. When the Mississippi River and Yazoo River stages exceed those of the ponding area, the gates are closed. During low water periods the Steele Bayou Structure is operated to maintain minimum water levels (between 68.5 and 70 ft NGVD) in the ponding areas and prevent water stagnation behind the structure. Although this ponding is not the same as historic flooding, the phenomenon is similar in that the current flooding is backwater caused by the rise in the Mississippi and Yazoo Rivers. The hydrodynamics are therefore presumed, by EPA, to be similar to historic backwater events.

Therefore, when the gates are closed, drainage of water in the Big and Little Sunflower Rivers, Steele Bayou and Deer Creek and their tributaries becomes impeded. This causes water to back-up in the channels and rise to overtop stream banks and flood adjacent land (i.e., create a "backwater" flood event). Depending on time of year, antecedent moisture conditions, and rainfall, the closing of the Steele Bayou flood gates will lead to flood events of varying magnitudes. The regular slow rise of the "flood pulse" in the Yazoo Basin has maintained a level of ecological integrity reminiscent of the basin prior to flood control (Odum et al. 1995, Junk and Wantzen 2006).

**Pump Operation**

Under the recommended plan (Plan 5) the Pump would operate based on the available storage above 87 ft. NGVD. The "Pump" actually consists of 12 pumps, each with a capacity of 1167 cfs. As the inflows exceed 1167 cfs the Pumps will be turned on, in sequence, to keep pace with the inflows and to maintain the water level at the Steele Bayou gage at 87 ft NGVD. Once the inflows exceed the 14,000 cfs capacity of the Pump station, backwater floods will begin to fill the lower basin. Actual pump operation parameters were not outlined in the FSEIS, therefore Figure 1 (Plate 51 Engineering Summary) was used as an indication of the timing and duration of Pump operation.

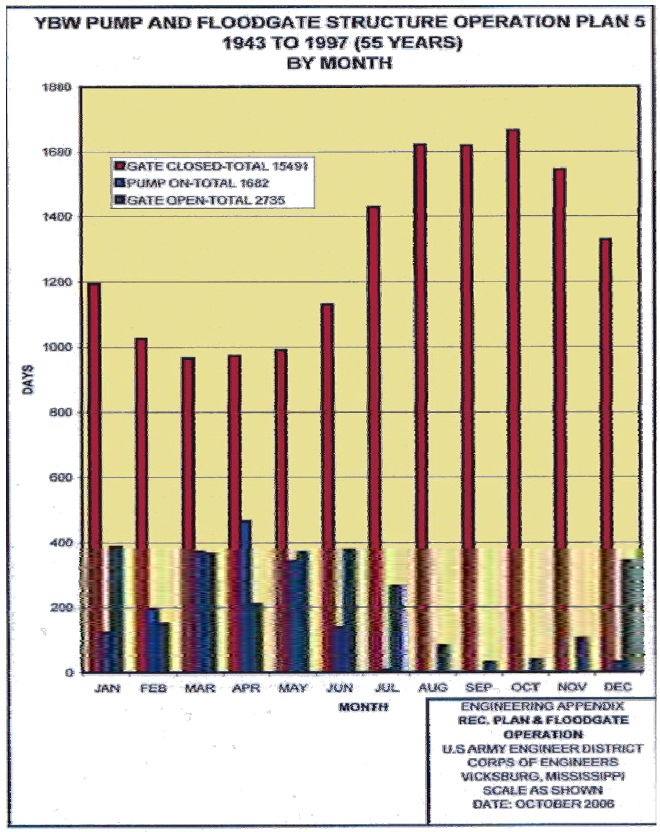


**Figure 1.** Plate 6-51 from Engineering Summary (Appendix 6) Yazoo Backwater Project FSEIS, recommended plan pump and floodgate operation.

Figure 1 indicates the Pumps will be used primarily in the winter and spring months (December – June). The Corps has stated that they anticipate the Pumps will be used, on average, for 31 days per year and will be based on the rise of Mississippi and Yazoo River waters, the closing of the gates, and rainfall and interior flooding in the basin. The floodgates at Steele Bayou can be closed in any month for lengthy periods of time. Based on Figure 1 and the objective of the Pump to keep flood levels as closely as possible to an 87’ NGVD elevation, it would appear as though the Pump would run from December – July, as conditions dictate (i.e., flooding anticipated above 87 ft NGVD). Use of the Pump over this range of winter and spring seasons could affect the timing of flood events. The possibility of using the pumps at any time would have the effect of reducing the timing, magnitude, and frequency of flooding.

Tables 1 & 2 (Tables 6-14 and 6-17, from the Engineering Appendix), show the change in stages under the prefered alternative of operating a 14,000 cfs pump with a pump-on elevation of 86-87 ft NGVD. A 2-year event (50% probability in a given year) under base conditions would occur at elevation 91 ft. NGVD in the lower ponding area and at 91.6 ft NGVD in the upper ponding area. Flooding at these elevations would occur less frequently under Plan 5 and fewer acres would be flooded (Table 1).

TABLE 6-14
STAGE-FREQUENCY AND STAGE AREA DATA

| Frequency Event | Base Conditions | | Alternative (Final Array) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Plan 3 | | Plan 4 | | Plan 5 | | Plan 6 | | Plan 7 | |
| Year | Elevation | Acres | Elevation | Acres | Elevation | Acres | Elevation | Acres | Elevation | Acres | Elevation | Acres |
| Lower Ponding Area a/ | | | | | | | | | | | | |
| 1 | 87.0 | 75,882 | 81.5 | 47,845 | 85.0 | 65,236 | 87.0 | 75,882 | 87.0 | 75,882 | 87.0 | 75,882 |
| 2 | 91.0 | 109,491 | 84.7 | 63,630 | 86.0 | 70,583 | 87.8 | 81,192 | 89.5 | 93,723 | 91.2 | 112,057 |
| 3 | 92.9 | 135,108 | 86.6 | 73,762 | 87.2 | 76,942 | 88.5 | 86,341 | 89.9 | 97,425 | 91.5 | 115,893 |
| 5 | 94.6 | 162,306 | 88.4 | 85,606 | 89.1 | 90,775 | 89.6 | 94,648 | 90.5 | 103,046 | 91.8 | 119,729 |
| 10 | 96.3 | 187,780 | 90.3 | 101,126 | 91.0 | 109,491 | 91.2 | 112,057 | 91.8 | 119,729 | 92.5 | 128,937 |
| 20 | 97.6 | 209,356 | 92.0 | 122,358 | 92.2 | 124,989 | 92.7 | 131,984 | 93.2 | 139,774 | 93.4 | 142,865 |
| 25 | 98.0 | 217,205 | 92.5 | 128,937 | 92.6 | 130,423 | 93.0 | 136,669 | 93.5 | 144,411 | 93.7 | 147,502 |
| 50 | 99.2 | 236,988 | 94.0 | 152,471 | 94.0 | 152,471 | 94.4 | 159,086 | 94.6 | 162,306 | 94.6 | 162,306 |
| 100 | 100.3 | 226,574 | 95.4 | 174,089 | 95.4 | 174,089 | 95.7 | 178,673 | 96.0 | 183,358 | 96.0 | 183,358 |
| Upper Ponding Area b/ | | | | | | | | | | | | |
| 1 | 87.8 | 140,317 | 83.2 | 73,747 | 85.9 | 109,140 | 87.8 | 140,317 | 87.8 | 140,317 | 87.8 | 140,317 |
| 2 | 91.6 | 208,044 | 86.8 | 123,543 | 87.3 | 131,856 | 88.9 | 162,872 | 90.0 | 181,981 | 91.8 | 211,543 |
| 3 | 93.4 | 240,407 | 88.3 | 150,092 | 89.0 | 165,002 | 89.7 | 176,887 | 90.8 | 194,435 | 92.0 | 215,041 |
| 5 | 95.0 | 268,727 | 89.9 | 180,283 | 90.2 | 185,095 | 90.7 | 192,879 | 91.5 | 206,295 | 92.7 | 227,624 |
| 10 | 96.8 | 300,369 | 91.5 | 206,295 | 91.8 | 211,543 | 92.0 | 215,041 | 92.9 | 231,219 | 93.8 | 247,796 |
| 20 | 98.1 | 325,661 | 92.8 | 229,422 | 93.2 | 236,712 | 93.5 | 242,254 | 94.0 | 251,491 | 94.6 | 261,833 |
| 25 | 98.5 | 334,125 | 93.3 | 238,559 | 93.5 | 242,254 | 93.8 | 247,796 | 94.4 | 258,385 | 94.8 | 265,280 |
| 50 | 99.5 | 355,946 | 94.3 | 256,662 | 94.8 | 265,280 | 95.1 | 270,481 | 95.3 | 273,989 | 95.5 | 277,497 |
| 100 | 100.3 | 403,413 | 95.6 | 279,251 | 96.0 | 286,267 | 96.4 | 293,318 | 96.5 | 295,081 | 96.7 | 298,606 |

NOTE: Elevation - feet, NGVD.
a/ Steele Bayou Structure landside gage location
b/ Little Sunflower Structure landside gage location

**Table 1.** Table 6-14 from Engineering Summary (Appendix 6) Yazoo Backwater project FSEIS. Comparison of base (current) conditions with project conditions for various flood frequency events showing change in flood frequency and flood extent.

TABLE 6-17
RECOMMENDED PLAN ON LOWER PONDING AREA REDUCTIONS

| Flood Frequency | Reduction in Stage | Reduction in Area | Reduction in Volume | Days to lower flood to 87 feet | Change in Water Surface per day |
|---|---|---|---|---|---|
| 1-Year | 0.0 | 0.0 | 0.0 | N/A | N/A |
| 2-Year | 3.2 | 31.1% | 38.6% | 25.2 | 0.16 |
| 5-Year | 5.0 | 30.3% | 46.5% | 58.3 | 0.11 |
| 10-Year | 5.1 | 31.6% | 47.9% | 82.7 | 0.07 |
| 25-Year | 5.0 | 28.4% | 47.0% | 110.5 | 0.06 |
| 50-Year | 4.8 | 27.3% | 45.4% | 129.0 | 0.06 |
| 100-Year | 4.6 | 25.0% | 42.6% | 145.3 | 0.07 |

**Table 2.** Table 6-17 from Engineering Summary (Appendix 6) Yazoo Backwater project FSEIS. Effects of proposed pump on stage, area flooded and volume of water available for flooding.

As indicated in Tables 1 and 2, Pump operation will result in an alteration of the frequency of flooding so that flooding at higher elevations (above 87' NGVD) will occur less frequently. This predicted effect is also shown in Figure 2 which reproduces Plates 6-34 and 6-35, from the FSEIS Engineering Summary, showing the effect of the Pumps on flood frequency in the Lower and Upper Ponding areas. It is clear, from the Corps data, that a result of this project would be the reduction of the 2-year flood event by 3.2 ft, and the 5-year and 10-year events by 5 ft.(see Table 6-17 above). Flooded area (extent) will also be reduced by approximately 30%. Thus, under the proposed plan, floods that currently occur regularly will occur less often and will cover one-third less area. Figure 2 reiterates the effect of the pump on frequency of flooding as compared to current conditions.

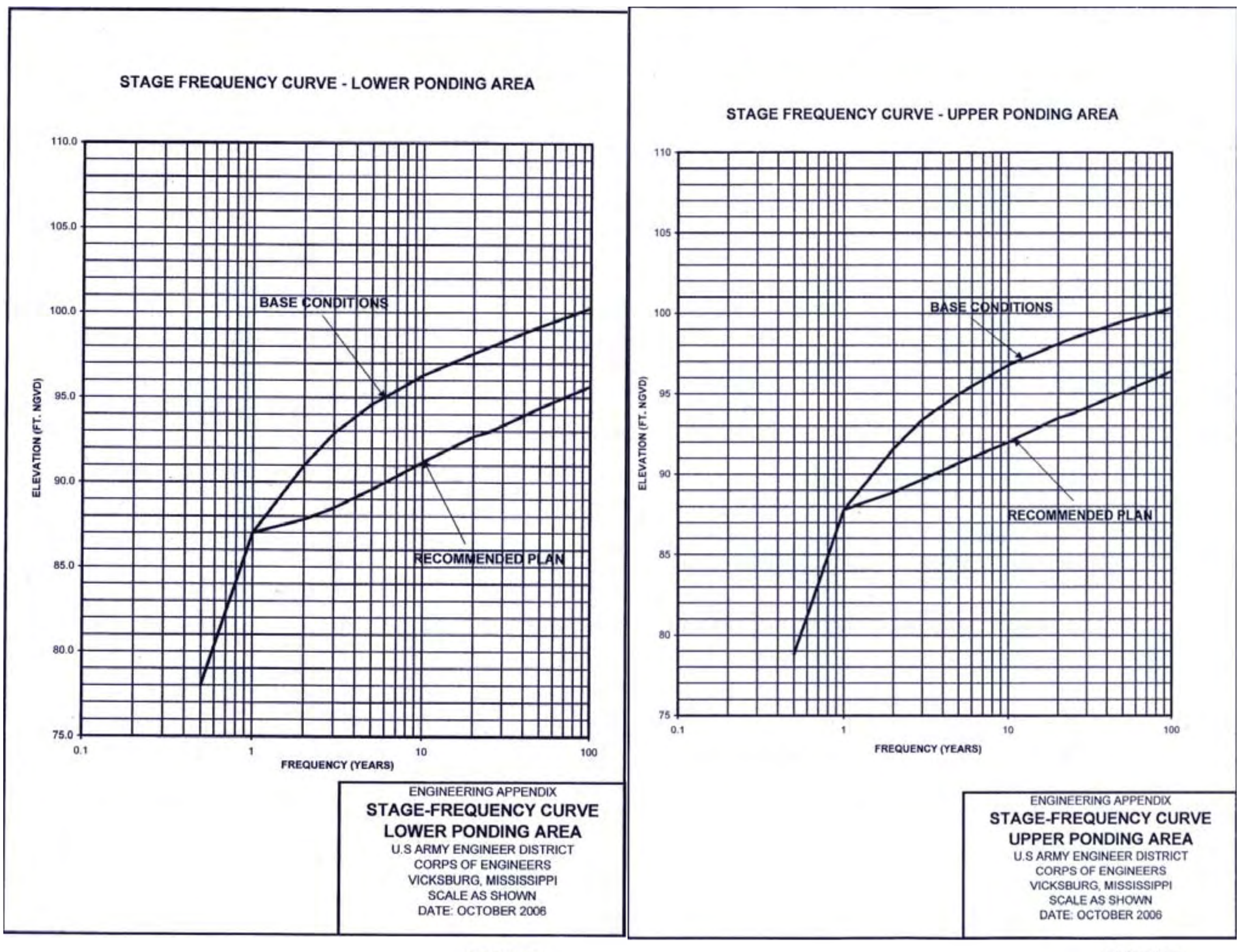


**Figure 2**. Plates 6-35 and 6-36 from the Engineering Summary of the Yazoo Backwater project FSEIS. Curves showing change in flood frequency in Upper and Lower Ponding areas as a result of the Pumps.

## EPA Hydrologic Analysis

An independent hydrologic analysis of the period of record data was conducted by Nutter and Associates, Inc. (NAI) in 2005 under contract with EPA (Hydrological Analysis of COE Work at proposed Yazoo River Basin Flood Control Projects. Contract Order: 3R-0142-NASA). The following discussion and accompanying figures are taken largely from their September 14, 2005 Technical Memorandum to EPA (Tech Memo). To understand daily stage data provided to EPA by the Corps, independent stage frequency curves were generated using standard procedures (Interagency Advisory Committee on Water Data, 1992) from the Corps' daily stage data. Peak stages were determined from each of the 55 years of record (1943-1997) for base and with-project conditions (alternative 5 or P5) at the Steele Bayou gage. Results of the NAI analysis support EPA's interpretation of Corps' hydrologic information that flood extent, frequency and duration will be reduced as a result of this project.

Return intervals and percent exceedence were calculated from sorted and ranked peak stages (Table 3).

| Table 3. Comparison of base and predicted peak annual stages, return intervals and probability of exceedences (POE) Steele Bayou Structure. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Steele Bayou Structure, Base Conditions | | | | | | | Steele Bayou Structure, Alternative 5 | | | | | | |
| Annual Peak Series | | Sorted | | | | | Annual Peak Series | | Sorted | | | | |
| Year | Stage (ft) | Year | Stage (ft) | Rank | RI (yrs) | POE | Year | Stage (ft) | Year | Stage (ft) | Rank | RI (yrs) | POE |
| 1943 | 90.52 | 1973 | 100.33 | 1 | 56.00 | 0.018 | 1943 | 87.48 | 1973 | 95.87 | 1 | 56.00 | 0.018 |
| 1944 | 95.85 | 1945 | 97.88 | 2 | 28.00 | 0.036 | 1944 | 92.05 | 1944 | 92.05 | 2 | 28.00 | 0.036 |
| 1945 | 97.88 | 1950 | 97.05 | 3 | 18.67 | 0.054 | 1945 | 91.60 | 1945 | 91.60 | 3 | 18.67 | 0.054 |
| 1946 | 93.87 | 1983 | 97.04 | 4 | 14.00 | 0.071 | 1946 | 90.28 | 1974 | 91.46 | 4 | 14.00 | 0.071 |
| 1947 | 91.74 | 1979 | 96.82 | 5 | 11.20 | 0.089 | 1947 | 87.58 | 1991 | 91.39 | 5 | 11.20 | 0.089 |
| 1948 | 92.82 | 1975 | 95.87 | 6 | 9.33 | 0.107 | 1948 | 89.11 | 1980 | 90.98 | 6 | 9.33 | 0.107 |
| 1949 | 94.68 | 1944 | 95.85 | 7 | 8.00 | 0.125 | 1949 | 88.73 | 1983 | 90.59 | 7 | 8.00 | 0.125 |
| 1950 | 97.05 | 1997 | 95.72 | 8 | 7.00 | 0.143 | 1950 | 90.58 | 1950 | 90.58 | 8 | 7.00 | 0.143 |
| 1951 | 89.47 | 1984 | 95.38 | 9 | 6.22 | 0.161 | 1951 | 87.44 | 1993 | 90.56 | 9 | 6.22 | 0.161 |
| 1952 | 91.33 | 1991 | 95.37 | 10 | 5.60 | 0.179 | 1952 | 87.52 | 1979 | 90.51 | 10 | 5.60 | 0.179 |
| 1953 | 86.34 | 1994 | 95.00 | 11 | 5.09 | 0.196 | 1953 | 84.93 | 1946 | 90.28 | 11 | 5.09 | 0.196 |
| 1954 | 75.45 | 1993 | 94.69 | 12 | 4.67 | 0.214 | 1954 | 75.31 | 1997 | 90.09 | 12 | 4.67 | 0.214 |
| 1955 | 91.53 | 1949 | 94.68 | 13 | 4.31 | 0.232 | 1955 | 89.22 | 1975 | 89.77 | 13 | 4.31 | 0.232 |
| 1956 | 86.06 | 1974 | 94.59 | 14 | 4.00 | 0.250 | 1956 | 87.27 | 1994 | 89.62 | 14 | 4.00 | 0.250 |
| 1957 | 88.75 | 1946 | 93.87 | 15 | 3.73 | 0.268 | 1957 | 87.43 | 1982 | 89.42 | 15 | 3.73 | 0.268 |
| 1958 | 91.15 | 1980 | 93.12 | 16 | 3.50 | 0.286 | 1958 | 89.39 | 1958 | 89.39 | 16 | 3.50 | 0.286 |
| 1959 | 82.30 | 1948 | 92.82 | 17 | 3.29 | 0.304 | 1959 | 83.48 | 1955 | 89.22 | 17 | 3.29 | 0.304 |
| 1960 | 84.85 | 1962 | 92.81 | 18 | 3.11 | 0.321 | 1960 | 83.42 | 1948 | 89.11 | 18 | 3.11 | 0.321 |
| 1961 | 92.74 | 1961 | 92.74 | 19 | 2.95 | 0.339 | 1961 | 89.09 | 1961 | 89.09 | 19 | 2.95 | 0.339 |
| 1962 | 92.81 | 1995 | 92.14 | 20 | 2.80 | 0.357 | 1962 | 87.41 | 1990 | 88.88 | 20 | 2.80 | 0.357 |
| 1963 | 89.52 | 1982 | 92.11 | 21 | 2.67 | 0.375 | 1963 | 87.17 | 1949 | 88.73 | 21 | 2.67 | 0.375 |
| 1964 | 89.90 | 1990 | 91.97 | 22 | 2.55 | 0.393 | 1964 | 87.40 | 1970 | 88.58 | 22 | 2.55 | 0.393 |
| 1965 | 88.96 | 1996 | 91.84 | 23 | 2.43 | 0.411 | 1965 | 87.21 | 1968 | 87.89 | 23 | 2.43 | 0.411 |
| 1966 | 86.50 | 1970 | 91.83 | 24 | 2.33 | 0.429 | 1966 | 86.27 | 1984 | 87.71 | 24 | 2.33 | 0.429 |
| 1967 | 86.64 | 1947 | 91.74 | 25 | 2.24 | 0.446 | 1967 | 85.32 | 1989 | 87.59 | 25 | 2.24 | 0.446 |
| 1968 | 88.92 | 1955 | 91.53 | 26 | 2.15 | 0.464 | 1968 | 87.89 | 1947 | 87.58 | 26 | 2.15 | 0.464 |
| 1969 | 91.03 | 1989 | 91.49 | 27 | 2.07 | 0.482 | 1969 | 87.47 | 1971 | 87.54 | 27 | 2.07 | 0.482 |
| 1970 | 91.83 | 1952 | 91.33 | 28 | 2.00 | 0.500 | 1970 | 88.58 | 1952 | 87.52 | 28 | 2.00 | 0.500 |
| 1971 | 90.29 | 1958 | 91.15 | 29 | 1.93 | 0.518 | 1971 | 87.54 | 1987 | 87.49 | 29 | 1.93 | 0.518 |
| 1972 | 89.57 | 1969 | 91.03 | 30 | 1.87 | 0.536 | 1972 | 87.47 | 1943 | 87.48 | 30 | 1.87 | 0.536 |
| 1973 | 100.33 | 1943 | 90.52 | 31 | 1.81 | 0.554 | 1973 | 95.87 | 1969 | 87.47 | 31 | 1.81 | 0.554 |
| 1974 | 94.59 | 1971 | 90.29 | 32 | 1.75 | 0.571 | 1974 | 91.46 | 1972 | 87.47 | 32 | 1.75 | 0.571 |
| 1975 | 95.87 | 1964 | 89.90 | 33 | 1.70 | 0.589 | 1975 | 89.77 | 1951 | 87.44 | 33 | 1.70 | 0.589 |
| 1976 | 83.59 | 1985 | 89.66 | 34 | 1.65 | 0.607 | 1976 | 84.75 | 1957 | 87.43 | 34 | 1.65 | 0.607 |
| 1977 | 83.02 | 1972 | 89.57 | 35 | 1.60 | 0.625 | 1977 | 82.60 | 1962 | 87.41 | 35 | 1.60 | 0.625 |
| 1978 | 88.27 | 1963 | 89.52 | 36 | 1.56 | 0.643 | 1978 | 86.92 | 1964 | 87.40 | 36 | 1.56 | 0.643 |
| 1979 | 96.82 | 1951 | 89.47 | 37 | 1.51 | 0.661 | 1979 | 90.51 | 1996 | 87.37 | 37 | 1.51 | 0.661 |
| 1980 | 93.12 | 1965 | 88.96 | 38 | 1.47 | 0.679 | 1980 | 90.98 | 1985 | 87.35 | 38 | 1.47 | 0.679 |
| 1981 | 84.30 | 1987 | 88.93 | 39 | 1.44 | 0.696 | 1981 | 82.73 | 1995 | 87.31 | 39 | 1.44 | 0.696 |
| 1982 | 92.11 | 1968 | 88.92 | 40 | 1.40 | 0.714 | 1982 | 89.42 | 1988 | 87.30 | 40 | 1.40 | 0.714 |
| 1983 | 97.04 | 1957 | 88.75 | 41 | 1.37 | 0.732 | 1983 | 90.59 | 1956 | 87.27 | 41 | 1.37 | 0.732 |
| 1984 | 95.38 | 1978 | 88.27 | 42 | 1.33 | 0.750 | 1984 | 87.71 | 1965 | 87.21 | 42 | 1.33 | 0.750 |
| 1985 | 89.66 | 1988 | 86.96 | 43 | 1.30 | 0.768 | 1985 | 87.35 | 1963 | 87.17 | 43 | 1.30 | 0.768 |
| 1986 | 85.92 | 1967 | 86.64 | 44 | 1.27 | 0.786 | 1986 | 86.11 | 1978 | 86.92 | 44 | 1.27 | 0.786 |
| 1987 | 88.93 | 1966 | 86.50 | 45 | 1.24 | 0.804 | 1987 | 87.49 | 1966 | 86.27 | 45 | 1.24 | 0.804 |
| 1988 | 86.96 | 1953 | 86.34 | 46 | 1.22 | 0.821 | 1988 | 87.30 | 1986 | 86.11 | 46 | 1.22 | 0.821 |
| 1989 | 91.49 | 1956 | 86.06 | 47 | 1.19 | 0.839 | 1989 | 87.59 | 1967 | 85.32 | 47 | 1.19 | 0.839 |
| 1990 | 91.97 | 1986 | 85.92 | 48 | 1.17 | 0.857 | 1990 | 88.88 | 1992 | 85.22 | 48 | 1.17 | 0.857 |
| 1991 | 95.37 | 1960 | 84.85 | 49 | 1.14 | 0.875 | 1991 | 91.39 | 1953 | 84.93 | 49 | 1.14 | 0.875 |
| 1992 | 84.59 | 1992 | 84.59 | 50 | 1.12 | 0.893 | 1992 | 85.22 | 1976 | 84.75 | 50 | 1.12 | 0.893 |
| 1993 | 94.69 | 1981 | 84.30 | 51 | 1.10 | 0.911 | 1993 | 90.56 | 1959 | 83.48 | 51 | 1.10 | 0.911 |
| 1994 | 95.00 | 1976 | 83.59 | 52 | 1.08 | 0.929 | 1994 | 89.62 | 1960 | 83.42 | 52 | 1.08 | 0.929 |
| 1995 | 92.14 | 1977 | 83.02 | 53 | 1.06 | 0.946 | 1995 | 87.31 | 1981 | 82.73 | 53 | 1.06 | 0.946 |
| 1996 | 91.84 | 1959 | 82.30 | 54 | 1.04 | 0.964 | 1996 | 87.37 | 1977 | 82.60 | 54 | 1.04 | 0.964 |
| 1997 | 95.72 | 1954 | 75.45 | 55 | 1.02 | 0.982 | 1997 | 90.09 | 1954 | 75.31 | 55 | 1.02 | 0.982 |
| | minimum | | 75.45 | | | | | | | 75.31 | | | |
| | maximum | | 100.33 | | | | | | | 95.87 | | | |
| | average | | 90.71 | | | | | | | 87.84 | | | |
| | std dev | | 4.62 | | | | | | | 2.99 | | | |

As indicated in Table 3, the 2-year flood event occurred at a stage of 91.33 feet over the period of record (55 years). Flood frequency at 91.33 feet is predicted to be reduced to an 11.2 year flood event (8.9% probability) with P5 and the 2-year return flood elevation with-project will occur at 87.5 ft NGVD. This estimate of flood frequency reduction is similar to the Corps' estimate.

The Corps reported the elevation associated with the 5% duration to be 88.56 feet NGVD. In contrast, our assessment of the data sets provided by the Corps resulted in an elevation of 92.5 feet as being approximately equivalent to a 5% flood duration (Table 4). With P5 the flood duration at 92.5 feet will be reduced to less than 1% or approximately 2.7 days. In addition, based on P5 project conditions, the elevation associated with the 5% flood duration is predicted to be approximately 89 feet (Table 4).

Table 4. Cumulative frequency distribution of daily stages for without (base) and with-project (P5) for Steele Bayou Gage Dataset (Growing Season, Daily Record, 1943-1997)

| | Base Conditions | | | | With Project P5 | | Difference in | Difference in |
|---|---|---|---|---|---|---|---|---|
| Elevation Classes | Freq./ Class | Accumul Freq. | Percent of Total | Freq./ Class | Accumul Freq. | Percent of Total | Accumulated days (Entire Record) | Accumulated Days (Annual) |
| 70 | 8947 | 15130 | 100.0 | 9018 | 15130 | 100.0 | 0 | 0.0 |
| 71 | 297 | 6183 | 40.9 | 291 | 6112 | 40.4 | -71 | -1.3 |
| 72 | 265 | 5886 | 38.9 | 230 | 5821 | 38.5 | -65 | -1.2 |
| 73 | 248 | 5621 | 37.2 | 281 | 5591 | 37.0 | -30 | -0.5 |
| 74 | 255 | 5373 | 35.5 | 231 | 5310 | 35.1 | -63 | -1.1 |
| 75 | 247 | 5118 | 33.8 | 264 | 5079 | 33.6 | -39 | -0.7 |
| 76 | 283 | 4871 | 32.2 | 272 | 4815 | 31.8 | -56 | -1.0 |
| 77 | 266 | 4588 | 30.3 | 246 | 4543 | 30.0 | -45 | -0.8 |
| 78 | 267 | 4322 | 28.6 | 274 | 4297 | 28.4 | -25 | -0.5 |
| 79 | 225 | 4055 | 26.8 | 228 | 4023 | 26.6 | -32 | -0.6 |
| 80 | 244 | 3830 | 25.3 | 208 | 3795 | 25.1 | -35 | -0.6 |
| 81 | 269 | 3586 | 23.7 | 284 | 3587 | 23.7 | 1 | 0.0 |
| 82 | 234 | 3317 | 21.9 | 270 | 3303 | 21.8 | -14 | -0.3 |
| 83 | 195 | 3083 | 20.4 | 208 | 3033 | 20.0 | -50 | -0.9 |
| 84 | 167 | 2888 | 19.1 | 222 | 2825 | 18.7 | -63 | -1.1 |
| 85 | 164 | 2721 | 18.0 | 202 | 2603 | 17.2 | -118 | -2.1 |
| 86 | 400 | 2557 | 16.9 | 397 | 2401 | 15.9 | -156 | -2.8 |
| 87 | 315 | 2157 | 14.3 | 365 | 2004 | 13.2 | -153 | -2.8 |
| 88 | 286 | 1842 | 12.2 | 912 | 1639 | 10.8 | -203 | -3.7 |
| 89 | 259 | 1556 | 10.3 | 200 | 727 | 4.8 | -829 | -15.1 |
| 90 | 182 | 1297 | 8.6 | 187 | 527 | 3.5 | -770 | -14.0 |
| 91 | 253 | 1115 | 7.4 | 175 | 340 | 2.2 | -775 | -14.1 |
| 92 | 227 | 862 | 5.7 | 82 | 165 | 1.1 | -697 | -12.7 |
| 93 | 157 | 635 | 4.2 | 14 | 83 | 0.5 | -552 | -10.0 |
| 94 | 99 | 478 | 3.2 | 10 | 69 | 0.5 | -409 | -7.4 |
| 95 | 83 | 379 | 2.5 | 23 | 59 | 0.4 | -320 | -5.8 |
| 96 | 124 | 296 | 2.0 | 36 | 36 | 0.2 | -260 | -4.7 |
| 97 | 82 | 172 | 1.1 | 0 | 0 | 0.0 | -172 | -3.1 |
| 98 | 45 | 90 | 0.6 | 0 | 0 | 0.0 | -90 | -1.6 |
| 99 | 14 | 45 | 0.3 | 0 | 0 | 0.0 | -45 | -0.8 |
| 100 | 16 | 31 | 0.2 | 0 | 0 | 0.0 | -31 | -0.6 |
| 101 | 15 | 15 | 0.1 | 0 | 0 | 0.0 | -15 | -0.3 |

Table 4 is a cumulative frequency analysis of the daily stage data. The table is divided into two sections: "Base Conditions" (without project) and "With Project P5". Daily stage data is aggregated according to elevation classes (70-101) which correspond to stages in the period of record. Elevation class 70 corresponds to all recorded stages ≤ 70; class 71 corresponds to those stages ≥ 70 but ≤ 71; class 72 corresponds to stages ≥72 but ≤ 73; and so on. Recorded stages were assigned to the appropriate elevation class and the number of times a stage fell into a particular class is recorded in the "Frequency/Class" column. The "Accumulated Frequency" column compiles the number of days over the entire 55 years of record that the given stage was equaled or exceeded (e.g., elevation class 77 was equaled or exceeded 6300 times during the 55 years of record). The next column, "Percent Total" represents the percent of time during the 55 years that a given stage is equaled or exceeded. This column can also be interpreted as the duration of flooding above that elevation class. The same column headings appear in the next section of the table under the "With Project P5" heading. Hence, both sections display the number of times a stage fell into a particular class (frequency), how many times a stage was equaled or exceeded (accumulated frequency) and the percent of time a stage was equaled or exceeded. The final column represents the difference between the base and the with-project accumulated frequencies at a given stage. In other words this final column gives the difference in days flooded between the base and with-project conditions.

With project, 770 cumulative days of flooding are lost at stages above 91 ft over the 55 year period of record. On average, the project will reduce flooding by 14 days/year at stages 90 and 91 ft. and 15 days/year at stage 89. The greatest reduction in flood duration would occur between elevations 89 and 93 feet over the entire period of record during the growing season. The effect is emphasized by annualizing the data, in that greater than five (5) days of duration are lost within jurisdictional wetlands between 89 and 93 feet elevation (Figure 3).

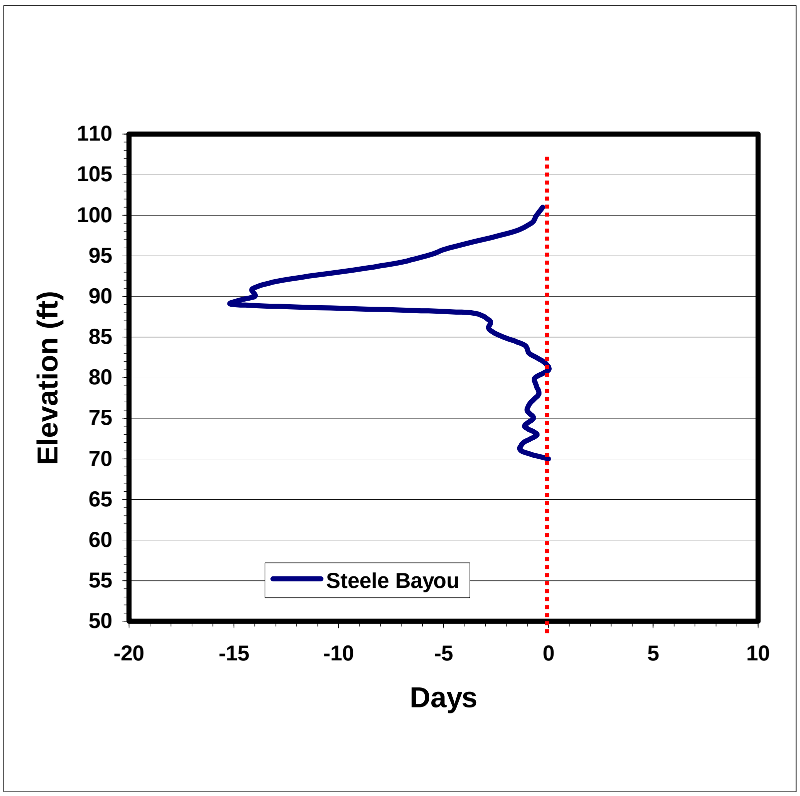


**Figure 3. Difference in days, base vs with-project, as a function of stage duration Steele Bayou - Growing season, entire record, annualized.**

Figure 3 shows the change in flood duration as a difference in days flooded between the current condition and the with project condition. The “red line” marks 0 days, or no change in flood duration. The trend line in Figure 3 indicates that, on an annual basis during the growing season, areas between elevations 88 and 95 ft will experience the greatest reduction in flood duration.

By comparing Table 1 (flood frequency probability) with Table 2 (stage duration) and Figure 3, both flood frequency and flood duration are predicted to be reduced following implementation of the proposed project. As stated above, reduction in flood frequency will occur at all elevations above 87 feet. Similarly, the most significant reduction in flood duration will occur at elevations between 89 and 93 feet.

Jurisdictional wetlands, as well as other short hydroperiod wetlands, that presently exist between elevations 89 and 92.5 feet would no longer meet minimal hydrology criteria following implementation of P5. This reduction of 3.5 feet in elevation is equivalent to approximately 70,000 acres (Engineering Summary Plates 6-19 and 6-20). This change in hydrology would be in addition to the change occurring between 87 and 89 feet NGVD. EPA’s EMAP Report estimated 212,000 acres of wetlands occurred within the 100 year floodplain. Of these acres, 130,000 occurred within the Corps designated FESM wetland area (between 87 and 88.5 feet NGVD) while 81,000 occurred above 88.5 feet NGVD. In their January 18, 2008 response to the FSEIS, U.S. Fish and Wildlife Service estimated 32,000 acres of public lands would be impacted by the Project. Therefore, based on the data available from the Corps and analyzed by the Corps and EPA, indicating significant reductions in flood extent, frequency and duration, the proposed project could have significant effects on wetlands, identified by the EMAP survey as well as on area wildlife and fisheries.

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# Attachment D

# Wetland Connectivity Analysis

[Available Upon Request]

# Appendix 6

## Underestimation of Project Impacts and Overestimation of Project Benefits in the FSEIS for the Yazoo Backwater Area Project

### I. Underestimation of Project Impacts

In addition to underestimating the spatial extent of impacts to wetlands and other aquatic resources, EPA has determined that the Final Supplemental Environmental Impact Statement (FSEIS) for the Yazoo Backwater Area Project understates the degree and nature of adverse impacts to the wetlands and other aquatic resources that were evaluated. EPA encouraged the use of the Hydrogeomorphic (HGM) assessment method and the Habitat Evaluation Procedure (HEP) as tools to help evaluate wetland functions for the FSEIS evaluations, and still supports the use of those tools. However, EPA believes that certain modeling assumptions and factors used by the U.S. Army Corps of Engineers (the Corps) in the application of these assessment tools lead to a significant underestimation of the proposed pumping station's adverse impacts on the aquatic ecosystem. EPA's primary concerns include:

- **The summation of assessment units (i.e., Functional Capacity Units and Habitat Units) in the FSEIS obscures significant wetland, fish, and wildlife impacts**. For example, the HGM assessment evaluated eight functions performed by affected wetlands and estimated how these functions would decrease at wetlands adversely impacted by the proposed pumping and increase at reforestation/mitigation sites. These functions are: *detain floodwater, detain precipitation, cycle nutrients, export organic carbon, physical removal of elements and compounds, biological removal of elements and compounds, maintain plant communities, and provide wildlife habitat.* In drawing its conclusion that the proposed project would result in an overall 19.5 percent increase in wetland functions, not only does the FSEIS factor in unsubstantiated and improbable benefits associated with the proposed restoration as discussed below, it also adds the losses and gains for each of the eight functions. This kind of comparison is of concern because it allows large predicted gains in functions such as maintaining plant communities to obscure losses, or significant degradation in other critical water quality related functions.
- **Impacts to key functions are omitted**. In the HGM assessment, no effect is shown in the *detain floodwater* function as a result of this project despite the fact that this is one of the functions which the proposed pumping project is designed to most dramatically impact. In its discussion of the *detain floodwater* function, the Yazoo Basin HGM Guidebook clearly states the importance of duration of flooding on the performance of this function. However, despite this recognition, the duration information which was incorporated into several other functions in the FSEIS's HGM assessment (which did indicate project related impacts) was not incorporated into the *detain floodwater* function.
- **The flood frequency variable shows no change in HGM assessment**. Despite information in the FSEIS Engineering Appendix (FSEIS, Appendix 6, Table 6-14) which indicates that the proposed project will result in less frequent flooding in areas above the 1-year floodplain, the frequency of flooding variable in the HGM assessment models

reflects no change, for any function. This is incongruous, since the overarching objective of the project is to modify the timing, frequency and duration of flooding.

- **Despite the pumping project, the HGM assessment assumes that vegetative species composition remains approximately static over time**. Over the course of the 50-year project and beyond, the vegetation structure of the Yazoo Backwater Area would change as significant areas at higher elevations shift to drier species composition. The FSEIS's HGM assessment assumes that vegetative species composition remains static through time or that the species shift would still be within the range of reference standards. However, if the hydrologic regime of the area is significantly changed, as proposed, there would be much larger changes in the plant and animal community than was accounted for in the FSEIS's HGM assessment. The HGM Guidebook recognizes variation in vegetative community with varied hydrologic regimes and documents those changes with reference data (i.e., riverine backwater subclass, flats subclass, connected depression, isolated depression, etc.). It is reasonable to expect if hydrologic regimes are changed from riverine backwater to flats, then a vegetative change will occur as well.
- **The HEP assessment underestimates the amount of aquatic spawning habitat adversely affected**. According to the HEP model used, fish spawning habitat requires 8 days of continuous inundation at least 1 foot in depth, from March to May. Based on these requirements and hydrologic data provided by the Corps, 3300 acres of habitat would be lost as a result of the project. However, this amount of lost habitat is inconsistent with values reported in the Wetland Appendix (FSEIS, Appendix 10, Table 10-10). The Wetland Appendix indicates that approximately 39,000 acres which currently flood for 14 days or less (but greater than 7 days) would, as a result of the proposed project, only flood for less than 7 days (i.e., shift to the <2.5 percent duration band). EPA's interpretation of Table 10-10 is that there is currently at least 39,000 acres of potentially suitable fish spawning habitat that will become unsuitable after project implementation. These impacts appear far greater than the 3300 acres of lost spawning habitat discussed in the FSEIS's Aquatics Appendix and would require far more compensation than that proposed in the FSEIS.
- **Inappropriate selection of fish species for the HEP assessment results in an underestimation of the proposed project's adverse effects on fisheries**. The nine fish species selected for the FSEIS's HEP assessment represent fish species whose life cycles would be affected to varying degrees by the proposed project's hydrological modifications within riverine backwater wetlands. We disagree with the Corps' assertion that all species in the HEP analysis utilize the floodplain for spawning and foraging. For example, as indicated by Appendix 11 of the FSEIS, ghost shiners and speckled chubs spawn primarily in rivers. Threadfin shad generally spawn in open river channels. Inclusion of species not as dependent on backwater areas as others causes the "average" effect of the project (i.e., averaging of habitat (HIS) scores across all species) to appear less severe. Thus, the HEP assessment underestimates how the proposed project would impact the large number of fish species which do require floodplain connections and periodic flooding events for key aspects of their life cycles such as spawning and rearing.
- **HEP does not evaluate the impacts of the proposed project on amphibians and reptiles.** The FSEIS's HEP assessments exclude entirely any assessment of the proposed project's adverse impacts on amphibians and reptiles. Species in both of these classes of

animals depend upon wetland habitat to meet numerous life history requirements and would experience extensive adverse effects from the proposed project.

The FSEIS's exclusion from analysis of wetlands above the 2-year, 5 percent flood duration elevation, and in particular wetlands above the 2-year, 5 percent flood duration elevation and within the 5-year flood elevation, does not acknowledge the influence and importance of shorter duration and less frequent flooding on establishing and maintaining the diversity of wetlands and the functions they provide. Nor does it recognize the impacts of the reduction in flooding resulting from the project on the maintenance of that diversity of wetlands and the biodiversity they support. The importance of wetland functions within and above the 2-year, 5 percent flood elevation is noted in the Yazoo Basin HGM Guidebook which states "one of the primary criteria used to identify wetland subclasses in the Yazoo Basin is flood return interval. A 5-year or less flood return interval is regarded as sufficient to support major functions that involve periodic connection to stream systems." Shorter duration and less frequent flooding will significantly and adversely affect the vegetation and aquatic animal communities within these wetlands, nutrient and sediment cycling, and other functions that establish and maintain the diversity of habitats critical for fish and wildlife dependent upon them, including waterfowl, shorebird, and wading bird foraging habitats, fish spawning and rearing habitats, and amphibian, reptile, and mammal habitats. Reducing the spatial extent, frequency, and duration of time project area wetlands flood will result in the reduction and loss of important wetland functions, according to the criteria outlined in the Yazoo Basin HGM Guidebook. These reductions and losses in wetland functions were not adequately factored into the FSEIS's HGM and HEP assessments.

## II. Overestimation of Environmental Benefits

Both the HGM and HEP analyses assume extensive yet unsubstantiated and improbable environmental benefits from the project's proposed reforestation. These analyses assume that the entire proposed 55,600 acres of reforestation and mitigation will be obtained and that every acre will be ideally situated in the target area (i.e., areas currently in agricultural production within the two-year floodplain that will flood for a sufficient period to yield equivalent wetland functions) to produce maximum environmental benefits for all affected resources. However, EPA's EMAP assessment and the Corps' land use assessment (FSEIS, Appendix 10, Table 10-9) indicate that there are not enough acres of cleared wetlands with the proper hydrology and soils in the target area to satisfy this goal.

EPA recognizes that a great deal of agricultural land in the project area could be reforested. However, the critical factor is the re-establishment of the hydrologic regime to those reforested acres to "fully" mitigate for lost wetland functions and/or to claim benefits for restoration of wetlands. The project does not ensure re-establishment of appropriate wetland hydrology but rather precludes it due to its large-scale hydrologic alterations to the Yazoo Backwater Area. Reforestation without re-establishment of wetland hydrology will not result in wetland restoration.

Aside from the project's compensatory mitigation there are no commitments to initiate any of the reforestation prior to initiating operation of the pumps. Further, no reforestation (or mitigation) sites have been identified or secured and the FSEIS indicates that these sites may not be located in the target area or even the greater Yazoo – Mississippi Delta (Main Report, paragraph 316).  If sites are found, the reliance on willing sellers would likely result in a noncontiguous patchwork of fragmented sites that cannot deliver the kinds of ecological benefits predicted by the HGM and HEP assessments.

# Appendix 7

## Clean Water Act 303(d)-Listed Waters and Waters with Approved Total Maximum Daily Loads (TMDLs) in the Yazoo Backwater Area

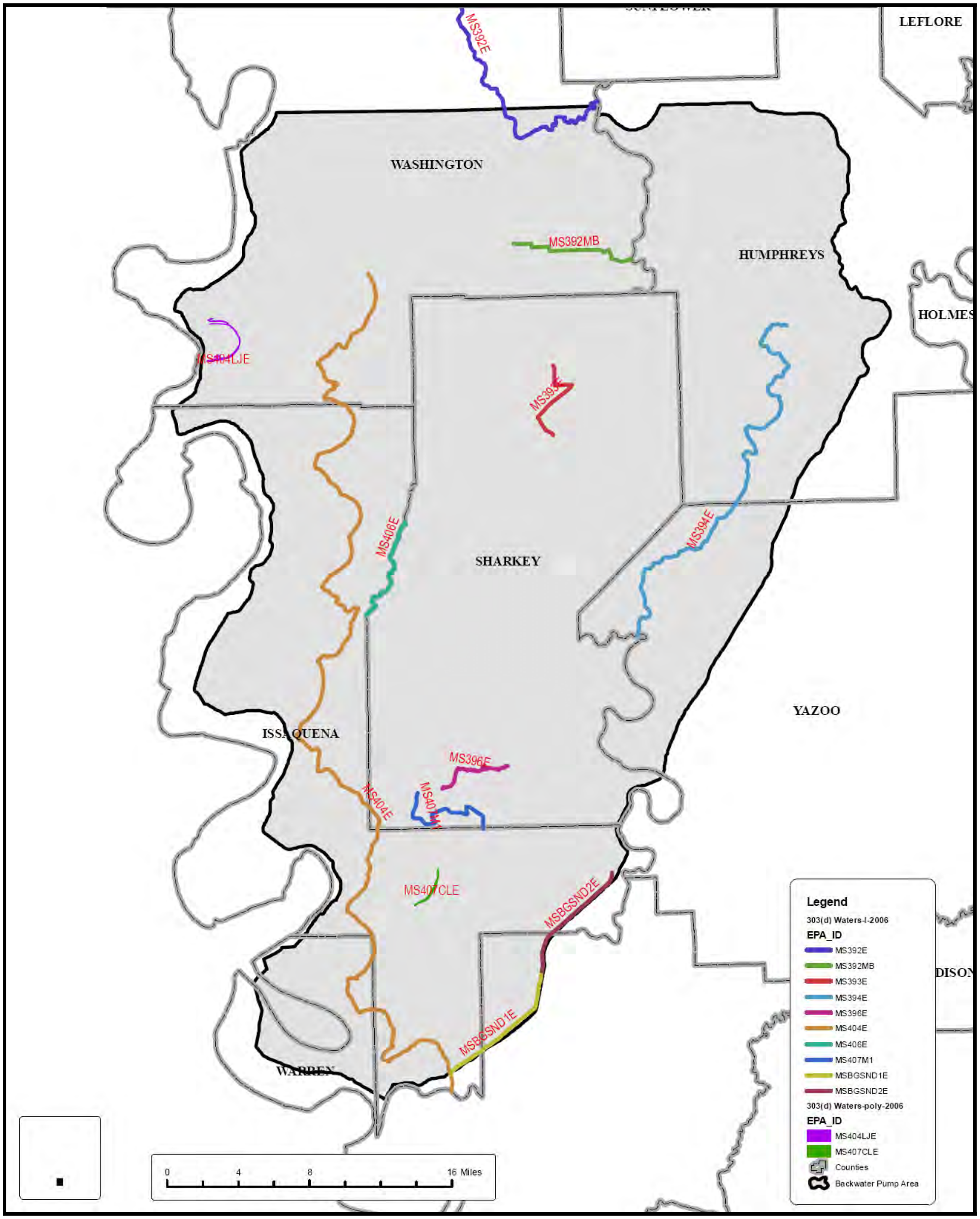


Figure 1. Clean Water Act section 303(d)-listed waters in the Yazoo Backwater Area

Table 1. Clean Water Act section 303(d)-listed waters in the Yazoo Backwater Area

| LIST ID | CAUSE DESCRIPTION | WATER BODY NAME | LOCATION | MILES 303D |
|---|---|---|---|---|
| MS392E | NUTRIENTS | BOGUE PHALIA | NEAR DARLOVE FROM CLEAR CREEK TO THE BIG SUNFLOWER RIVER | 37.55 |
| MS392E | ORGANIC ENRICHMENT/LOW DO | BOGUE PHALIA | NEAR DARLOVE FROM CLEAR CREEK TO THE BIG SUNFLOWER RIVER | 37.55 |
| MS392MB | CAUSE UNKNOWN | MURPHEY BAYOU | NEAR HOLANDALE FROM HEADWATERS TO THE BIG SUNFLOWER RIVER | 2.48 |
| MS393E | ORGANIC ENRICHMENT/LOW DO | JAYNES BAYOU | NEAR ROLLING FORK FROM HEADWATERS TO THE BIG SUNFLOWER RIVER | 1.84 |
| MS393E | SEDIMENT/SILTATION | JAYNES BAYOU | NEAR ROLLING FORK FROM HEADWATERS TO THE BIG SUNFLOWER RIVER | 1.84 |
| MS393E | NUTRIENTS | JAYNES BAYOU | NEAR ROLLING FORK FROM HEADWATERS TO THE BIG SUNFLOWER RIVER | 1.84 |
| MS394E | ORGANIC ENRICHMENT/LOW DO | SILVER CREEK | NEAR HOLLY BLUFF FROM HEADWATERS TO THE BIG SUNFLOWER RIVER | 31.84 |
| MS394E | SEDIMENT/SILTATION | SILVER CREEK | NEAR HOLLY BLUFF FROM HEADWATERS TO THE BIG SUNFLOWER RIVER | 31.84 |
| MS394E | NUTRIENTS | SILVER CREEK | NEAR HOLLY BLUFF FROM HEADWATERS TO THE BIG SUNFLOWER RIVER | 31.84 |
| MS396E | ORGANIC ENRICHMENT/LOW DO | FALSE RIVER | NEAR SMEDES FROM HEADWATERS TO THE LITTLE SUNFLOWER RIVER | 12.06 |
| MS396E | NUTRIENTS | FALSE RIVER | NEAR SMEDES FROM HEADWATERS TO THE LITTLE SUNFLOWER RIVER | 12.06 |
| MS396E | SEDIMENT/SILTATION | FALSE RIVER | NEAR SMEDES FROM HEADWATERS TO THE LITTLE SUNFLOWER RIVER | 12.06 |
| MS404E | ORGANIC ENRICHMENT/LOW DO | STEELE BAYOU | NEAR ISSAQUENA FROM BLACK BAYOU TO THE YAZOO RIVER | 40.10 |
| MS404E | SEDIMENT/SILTATION | STEELE BAYOU | NEAR ISSAQUENA FROM BLACK BAYOU TO THE YAZOO RIVER | 40.10 |
| MS404E | NUTRIENTS | STEELE BAYOU | NEAR ISSAQUENA FROM BLACK BAYOU TO THE YAZOO RIVER | 40.10 |
| MS404LJE | NUTRIENTS | LAKE JACKSON | OXBOW LAKE NEAR GLEN ALLEN | 0.74 |
| MS404LJE | SEDIMENT/SILTATION | LAKE JACKSON | OXBOW LAKE NEAR GLEN ALLEN | 0.74 |
| MS406E | NUTRIENTS | INDIAN BAYOU | NEAR FITLER FROM HEADWATERS TO WATERSHED 405 BOUNDARY | 5.55 |
| MS406E | ORGANIC ENRICHMENT/LOW DO | INDIAN BAYOU | NEAR FITLER FROM HEADWATERS TO WATERSHED 405 BOUNDARY | 5.55 |
| MS406E | SEDIMENT/SILTATION | INDIAN BAYOU | NEAR FITLER FROM HEADWATERS TO WATERSHED 405 BOUNDARY | 5.55 |
| MS407CLE | SEDIMENT/SILTATION | CYPRESS LAKE | OXBOW LAKE NEAR VALLEY PARK | 0.00 |
| MS407CLE | NUTRIENTS | CYPRESS LAKE | OXBOW LAKE NEAR VALLEY PARK | 0.00 |
| MS407M1 | ORGANIC ENRICHMENT/LOW DO | DEER CREEK | FROM SMEDES TO VALLEY PARK | 14.78 |
| MS407M1 | NUTRIENTS | DEER CREEK | FROM SMEDES TO VALLEY PARK | 14.78 |
| MSBGSND1E | NUTRIENTS | BIG SUNFLOWER RIVER DIVERSION CHANNEL | FROM HUC BOUNDARY 08030208 TO CONFLUENCE WITH STEELE BAYOU | 15.08 |
| MSBGSND1E | ORGANIC ENRICHMENT/LOW DO | BIG SUNFLOWER RIVER DIVERSION CHANNEL | FROM HUC BOUNDARY 08030208 TO CONFLUENCE WITH STEELE BAYOU | 15.08 |
| MSBGSND2E | SEDIMENT/SILTATION | BIG SUNFLOWER RIVER DIVERSION CHANNEL | FROM HUC BOUNDARY 08030207 TO HUC BOUNDARY 08030209 | 0.00 |
| MSBGSND2E | NUTRIENTS | BIG SUNFLOWER RIVER DIVERSION CHANNEL | FROM HUC BOUNDARY 08030207 TO HUC BOUNDARY 08030209 | 0.00 |

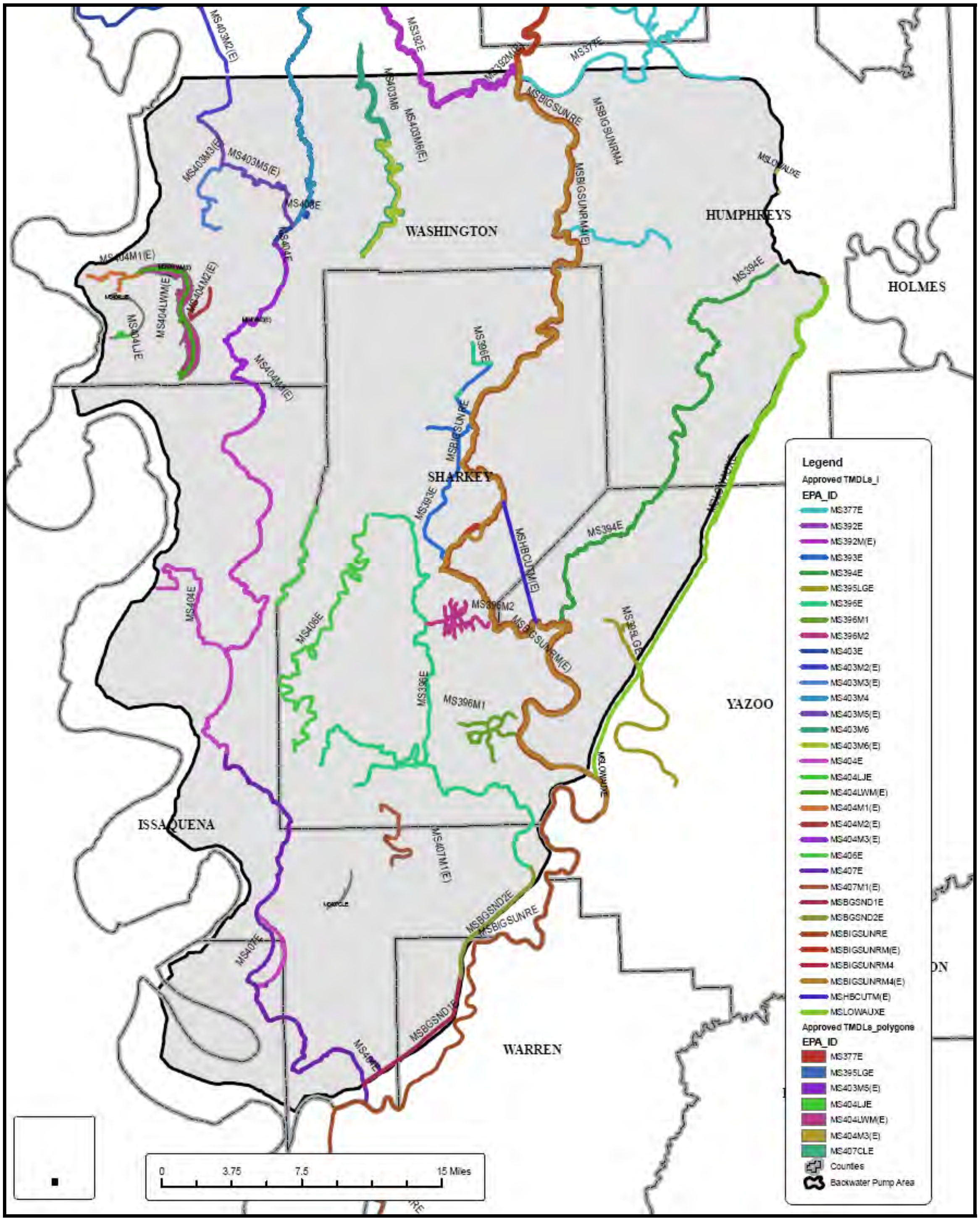


Figure 2. Waters with Approved Total Maximum Daily Loads (TMDLs) in the Yazoo Backwater Area

Table 2. Waters with Approved Total Maximum Daily Loads (TMDLs) in the Yazoo Backwater Area

| LIST_ID | TMDL_ID | WATER_BODY | TMDL_LINK |
|---|---|---|---|
| MS377E | 12247 | MOUND BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS377E | 12247 | MOUND BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSHBCUTM(E) | 9397 | HOLLY BLUFF CUTOFF | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MSLOWAUXE | 12247 | LOWER AUXILLARY CHANNEL | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSLOWAUXE | 12247 | LOWER AUXILLARY CHANNEL | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS392E | 12247 | BOGUE PHALIA | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS392E | 12247 | BOGUE PHALIA | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS392M(E) | 9397 | BOGUE PHALIA | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MS393E | 12247 | JAYNES BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS393E | 12247 | JAYNES BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS394E | 12247 | SILVER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS394E | 12247 | SILVER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS395LGE | 12247 | LAKE GEORGE | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS395LGE | 12247 | LAKE GEORGE | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS396E | 12247 | FALSE RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS396E | 12247 | FALSE RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS396M1 | 9412 | CYPRESS BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9412 |
| MS396M2 | 9412 | HOWLETT BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9412 |
| MS403E | 9387 | BLACK BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9387 |
| MS403E | 9398 | BLACK BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9398 |
| MS403E | 9398 | BLACK BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9398 |
| MS403E | 12247 | BLACK BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS403E | 12247 | BLACK BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS403M2(E) | 9387 | MAIN CANAL | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9387 |
| MS403M3(E) | 4202 | GRANNY BAKER BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MS403M3(E) | 4202 | GRANNY BAKER BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MS403M3(E) | 9387 | GRANNY BAKER BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9387 |
| MS403M3(E) | 9398 | GRANNY BAKER BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9398 |
| MS403M3(E) | 9398 | GRANNY BAKER BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9398 |
| MS403M4 | 9398 | BLACK BAYOU (INCLUDING RED BRIDGE BAYOU) | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9398 |
| MS403M5(E) | 9387 | GRANICUS BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9387 |

| LIST_ID | TMDL_ID | WATER_BODY | TMDL_LINK |
|---|---|---|---|
| MS403M5(E) | 9398 | GRANICUS BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9398 |
| MS403M6 | 9400 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9400 |
| MS403M6 | 9400 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9400 |
| MS403M6 | 9451 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9451 |
| MS403M6 | 12247 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS403M6 | 12247 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS403M6(E) | 9386 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9386 |
| MS403M6(E) | 12247 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS404E | 12247 | STEELE BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS404E | 12247 | STEELE BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS404LJE | 12247 | LAKE JACKSON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS404LJE | 12247 | LAKE JACKSON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS404LWM(E) | 9395 | LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9395 |
| MS404M1(E) | 4202 | UNNAMED TRIBUTARY OF LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MS404M1(E) | 4202 | UNNAMED TRIBUTARY OF LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MS404M1(E) | 9395 | UNNAMED TRIBUTARY OF LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9395 |
| MS404M1(E) | 9395 | UNNAMED TRIBUTARY OF LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9395 |
| MS404M1(E) | 9395 | UNNAMED TRIBUTARY OF LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9395 |
| MS404M2(E) | 4202 | UNNAMED TRIBUTARY OF LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MS404M2(E) | 4202 | UNNAMED TRIBUTARY OF LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MS404M2(E) | 9395 | UNNAMED TRIBUTARY OF LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9395 |
| MS404M3(E) | 9387 | STEELE BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9387 |
| MS406E | 12247 | INDIAN BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS406E | 12247 | INDIAN BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS407E | 12247 | STEELE BAYOU- DA | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS407E | 12247 | STEELE BAYOU- DA | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS407M1(E) | 12247 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |

| LIST_ID | TMDL_ID | WATER_BODY | TMDL_LINK |
|---|---|---|---|
| MS407M1(E) | 12247 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS407M1(E) | 12247 | DEER CREEK | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSBGSND1E | 12247 | BIG SUNFLOWER RIVER DIVERSION CHANNEL | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSBGSND1E | 12247 | BIG SUNFLOWER RIVER DIVERSION CHANNEL | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSBGSND2E | 12247 | BIG SUNFLOWER RIVER DIVERSION CHANNEL | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSBGSND2E | 12247 | BIG SUNFLOWER RIVER DIVERSION CHANNEL | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSBIGSUNRE | 12247 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSBIGSUNRE | 12247 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MSBIGSUNRM(E) | 4087 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4087 |
| MSBIGSUNRM(E) | 4202 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MSBIGSUNRM(E) | 4202 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MSBIGSUNRM(E) | 9397 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MSBIGSUNRM(E) | 9397 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MSBIGSUNRM(E) | 9397 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MSBIGSUNRM4 | 9397 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MSBIGSUNRM4 | 9397 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MSBIGSUNRM4 | 9397 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MSBIGSUNRM4(E) | 4202 | BIG SUNFLOWER RIVER | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MSHBCUTM(E) | 4202 | HOLLY BLUFF CUTOFF | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=4202 |
| MSHBCUTM(E) | 9397 | HOLLY BLUFF CUTOFF | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MSHBCUTM(E) | 9397 | HOLLY BLUFF CUTOFF | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9397 |
| MS377E | 12247 | MOUND BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS377E | 12247 | MOUND BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS395LGE | 12247 | LAKE GEORGE | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS395LGE | 12247 | LAKE GEORGE | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS403M5(E) | 9387 | GRANICUS BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9387 |
| MS403M5(E) | 9398 | GRANICUS BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9398 |
| MS404LJE | 12247 | LAKE JACKSON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS404LJE | 12247 | LAKE JACKSON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS404LWM(E) | 9395 | LAKE WASHINGTON | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9395 |
| MS404M3(E) | 9387 | STEELE BAYOU | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=9387 |

| LIST_ID | TMDL_ID | WATER_BODY | TMDL_LINK |
|---|---|---|---|
| MS407CLE | 12247 | CYPRESS LAKE | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |
| MS407CLE | 12247 | CYPRESS LAKE | http://iaspub.epa.gov/tmdl_waters10/waters_list.tmdl_report?p_tmdl_id=12247 |

# Appendix 8

## Compensatory Mitigation Analysis for the Yazoo Backwater Area Project

To offset the project's extensive adverse environmental impacts, the Final Supplemental Environmental Impact Statement (FSEIS) proposes 10,662 acres of compensatory mitigation to offset the project's hydrologic impacts to over 67,000 acres of wetlands.[1] Compensation would consist of reforestation and conservation of areas located in previously cleared wetlands to restore those areas to bottomland hardwood forests. However, compensation sites have not been specifically identified for the proposed mitigation. Rather, the FSEIS states that conservation easements will be purchased only from "willing sellers" to conduct the proposed compensatory mitigation.

EPA has significant concerns regarding the adequacy of the proposed compensatory mitigation. Based on our review of the FSEIS Hydrogeomorphic (HGM) analysis, we believe that compensation requirements for impacts of this type and on this scale would be much greater than that estimated in the FSEIS. To evaluate the adequacy of compensatory mitigation for this project, EPA used much of the information presented in the FSEIS HGM assessment of the Yazoo Backwater Area and the U.S. Army Corps of Engineers (the Corps)' HGM Compensation Ratio Calculator Version 3.3.[2] This tool, developed by the Corps' Engineers Research and Development Center (ERDC), uses the results of an HGM Assessment at an impacted site to calculate mitigation requirements at a restored site. For each function, the spreadsheet calculates a compensation ratio or functional equivalency ratio (i.e., the number of acres of mitigation required per acre of original wetland impacted to achieve equivalency between loss and gain of function). These ratios are based on the functional capacity index (FCI)[3] under current conditions and the predicted FCI that will be achieved over time at the restored wetland. In addition, the spreadsheet calculates a weighted average compensation ratio across all functions (the ratio with trade-offs) weighted by an index of the relative importance of each function in the study area. For this analysis, EPA weighted all functions equivalently to reflect maintenance of wetland ecosystem integrity.

The analysis of compensation ratios for this project is made extremely difficult because of the lack of specific sites identified for the compensatory mitigation. Without specific sites, assessment of beginning and ending conditions are purely conjecture. Compensation ratios are typically derived by comparing pre-project conditions with post-project conditions on both the

[1] As discussed in the Recommended Determination, EPA has estimated that up to 24,000 additional acres of wetlands in the project area (beyond the 67,000 acres estimated by the Corps) would be adversely impacted by the proposed project.

[2] See U.S. Army Corps of Engineers, Engineers Research and Development Center, Applications of HGM Results: http://el.erdc.usace.army.mil/wetlands/datanal.html

[3] Functional Capacity Indices (FCI) are the result of combining the HGM assessment's hydrologic, plant, soil and landscape indicators to estimate a change in function as the result of change in indicators. The FCIs are scaled between zero and one, with one being the optimal score for a function.

impact site and the proposed compensatory mitigation site.  This can be approximated for the impact site based on the FSEIS's estimates of hydrologic change.  The FSEIS HGM assessment made the following assumptions regarding the compensatory mitigation sites.  The compensation sites would:

1. be agricultural fields in the 2-year floodplain;
2. have numerous micro-depressions which hold water;
3. have unaltered soils, and would be planted with characteristic tree species indicative of the reference standard wetlands from the start of mitigation;
4. be incorporated into large forested tracts;
5. be planted with characteristic plant species indicative of the reference standard wetlands, plantings would occur at the beginning of the project and mature for life of project without failure; and,
6. have no flood duration (FSEIS, Appendix 10).

Given the above assumptions of proper site location, adequate growth of overstory vegetation, and development of soils and with the flood duration variable values set to zero, Table 1 shows the results of the FSEIS HGM assessment as the expected functional capacity indices over the 50 year life of the project.  It is important to note that if compensatory mitigation lands are restored according to these optimistic criteria, that Export of Organic Carbon (OCE), Physical and Biological Removal of Elements and Compounds (PREC and BREC) remain at 30 percent of reference standard in year 50.  Currently, many of the forested areas in the project area perform these functions at approximately twice this level (i.e., about 60 percent of the reference standards).

Table 1. FCI and FCU/acre change over 50 years for restoration sites based on Corps of Engineer assumptions

| FUNCTION | FCI Year 1 | Change in FCU/Acre | FCI Year 10 | Change in FCU/Acre | FCI Year 20 | Change in FCU/Acre | FCI Year 30 | Change in FCU/Acre | FCI Year 40 | Change in FCU/Acre | FCI Year 50 | Change in FCU/Acre |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Detain Floodwater | 0.00 | 0.00 | 0.44 | 0.44 | 0.59 | 0.59 | 0.80 | 0.80 | 0.94 | 0.94 | 0.97 | 0.97 |
| Detain Precipitation | 0.25 | 0.25 | 0.38 | 0.38 | 0.50 | 0.50 | 0.69 | 0.69 | 0.88 | 0.88 | 1.00 | 1.00 |
| Cycle Nutrients | 0.19 | 0.19 | 0.56 | 0.56 | 0.60 | 0.60 | 0.95 | 0.95 | 1.00 | 1.00 | 1.00 | 1.00 |
| Export Organic Carbon | 0.03 | 0.03 | 0.16 | 0.16 | 0.19 | 0.19 | 0.31 | 0.31 | 0.33 | 0.33 | 0.33 | 0.33 |
| Physical Removal of E and C | 0.00 | 0.00 | 0.04 | 0.04 | 0.08 | 0.08 | 0.17 | 0.17 | 0.25 | 0.25 | 0.33 | 0.33 |
| Biological Removal of E and C | 0.03 | 0.03 | 0.16 | 0.16 | 0.19 | 0.19 | 0.31 | 0.31 | 0.33 | 0.33 | 0.33 | 0.33 |
| Maintain Plant Communities | 0.00 | 0.00 | 0.53 | 0.53 | 0.68 | 0.68 | 0.82 | 0.82 | 0.91 | 0.91 | 0.98 | 0.98 |
| Provide Wildlife Habitat | 0.00 | 0.00 | 0.00 | 0.00 | 0.59 | 0.59 | 0.80 | 0.80 | 0.87 | 0.87 | 0.90 | 0.90 |
| Total | | 0.49 | | 2.27 | | 3.42 | | 4.86 | | 5.51 | | 5.86 |

Since the HGM Approach was intended to be interpreted in an ecosystem context and provide an indication of overall ecosystem integrity, appropriate compensatory mitigation would be that which restores at least the baseline level of all functions.  Additionally, no amount of acreage, or corresponding functional capacity units (FCUs) will adequately compensate for the functions lost if the hydrologic regime is not restored at the compensation sites to support wetland conditions. As discussed in greater detail below, close examination of the FSEIS HGM assessment indicates that the mitigation conceptually proposed is inadequate to restore functions lost as a result of this project.

EPA's analysis of the Corps' proposed compensatory mitigation utilized the baseline FCIs from the FSEIS's assessment in the HGM Compensation Ratio Calculator described above.  In other words, the starting conditions for the impact site were the FCIs calculated by the Corps for the mature, riverine backwater forested wetland baseline condition.  Impacts in the following scenarios involved changing the hydrologic variables to reflect project related changes. The time horizon coincides with the project life (50 years) and is the amount of time given for the compensatory mitigation site to mature. The risk free discount rate was set at 3 percent. Impact year was set to begin in 2008 and run through 2058 to coincide with the time horizon of 50 years. Relative importance values were set at 1.0 to represent that none of the functions evaluated were any more important or valuable than any others. This is consistent with how the HGM Approach is most frequently employed, which assesses wetlands as ecosystems. Pre- and Post-Impact FCIs were taken directly from the FSEIS HGM Assessment Report or from the HGM spreadsheet (Smith and Lin, 2007).

Mitigation Site factors include “Mitigation Timing” which was set at 50 years, the same time frame used by the FSEIS for its comparison of FCUs lost and gained, and “Risk” was set initially at a low 5 percent. Pre-work Mitigation site FCIs represent an evaluation of a mitigation site using the HGM Assessment before work on the site begins. In this project no actual site was evaluated but rather a presumed site was used making the assumptions noted above. Since agricultural sites are being targeted for potential restoration, EPA used FCIs from the “agricultural” cover type from the FSEIS HGM assessment. The “Immediately After Work” column represents functional lift gained as a result of actions which immediately take effect (e.g., break levees, plug ditches, move earth to reestablish elevations). Since no such actions are proposed, this column used the same FCI values as the Pre-work column. The “At Maturity” column is the projected FCI for each function at the end of the project life (50 years). These projections were made using recovery trajectory curves for certain variables in the Yazoo Basin HGM Guidebook. The FCIs placed in the HGM Compensation Ratio Calculator were those from the FSEIS HGM report at Year 50 (Smith and Lin, 2007, Table 30).

In the scenario below project impacts and mitigation conditions are the same as stated using the Corps assessment data, (i.e., only duration of flooding being affected). Thus, the baseline condition is that of a mature riverine backwater forested wetland and the impact is the change in duration of flooding from 6.25 percent to 1 percent duration flooding. Mitigation sites were assumed to flood on a 2-year return and for a duration of 1 percent of the growing season. Table 2 shows the results.

In this scenario, the assumptions used in the FSEIS HGM Report were placed into the spreadsheet for an impacted mature forested, riverine backwater wetland. In addition to the factors previously discussed (i.e., time horizon, discount rate, mitigation and project start date) the previous assumptions were incorporated.

**Table 2. Compensatory mitigation calculation for impacts to flood duration with compensatory mitigation occurring with reduced flood duration (1 percent) in 2-year floodplain**

*HGM Compensation Ratio Calculator Version 3.3*

**Inputs** — Time Horizon: 50 yrs; Discount Rate: 3.00 %

**Impacted Site** — Impact Year: 2008

**Mitigation Site**

| Function Name | Relative Importance (e.g., 0 to 10) | Functional Capacity Index: Pre-Impact | Functional Capacity Index: Post-Impact | Mitigation Work Timing & Risk: Year Started | Year Matured | Failure Risk | Functional Capacity Index: Pre-Work | Immediately After Work | At Maturity |
|---|---|---|---|---|---|---|---|---|---|
| Detain Floodwater | 1.0 | 0.98 | 0.98 | 2008 | 2058 | 5 % | 0.25 | 0.25 | 0.98 |
| Detain Ppt | 1.0 | 0.83 | 0.83 | 2008 | 2058 | 5 % | 0.56 | 0.56 | 0.83 |
| Cycling Nutrients | 1.0 | 0.95 | 0.95 | 2008 | 2058 | 5 % | 0.29 | 0.29 | 0.95 |
| Exporting Organic Carbon | 1.0 | 0.64 | 0.44 | 2008 | 2058 | 50 % | 0.10 | 0.17 | 0.38 |
| PREC | 1.0 | 0.53 | 0.36 | 2008 | 2058 | 50 % | 0.25 | 0.43 | 0.31 |
| BREC | 1.0 | 0.64 | 0.44 | 2008 | 2058 | 50 % | 0.10 | 0.17 | 0.38 |
| Maintain Plts | 1.0 | 0.93 | 0.93 | 2008 | 2058 | 5 % | 0.00 | 0.00 | 0.93 |
| Maintain Habitat | 1.0 | 0.92 | 0.88 | 2008 | 2058 | 5 % | 0.00 | 0.00 | 0.87 |
| | | | | | | % | | | |
| | | | | | | % | | | |

**Outputs**

| Function Name | Function-for-Function Compensation Ratios: Impact Site Per-Acre Loss | Mitigation Site Per-Acre Gain | | Ratio (mitigation site acres per impact site acre) | Overall Ratio with Trade-Offs Among Importance-Weighted Functions: Impact Site Per-Acre Loss | Mitigation Site Per-Acre Gain | Net Surplus or (Deficit) (@ mitigation site Overall-Ratio acres per impact site acre) |
|---|---|---|---|---|---|---|---|
| Detain Floodwater | 0.00 | 6.81 | (see note 14) | 0.00 | 0.00 | 6.81 | 2.57 |
| Detain Ppt | 0.07 | 2.52 | >= | 0.03 | 0.07 | 2.52 | 0.88 |
| Cycling Nutrients | (0.01) | 6.16 | (see note 14) | (0.00) | (0.01) | 6.16 | 2.33 |
| Exporting Organic Carbon | 5.18 | 2.84 | >= | 1.82 | 5.18 | 2.84 | (4.11) |
| PREC | 4.40 | 4.07 | >= | 1.08 | 4.40 | 4.07 | (2.87) |
| BREC | 5.18 | 2.84 | >= | 1.82 | 5.18 | 2.84 | (4.11) |
| Maintain Plts | 0.00 | 8.68 | (see note 14) | 0.00 | 0.00 | 8.68 | 3.27 |
| Maintain Habitat | 1.04 | 8.12 | >= | 0.13 | 1.04 | 8.12 | 2.03 |
| | | | | | 15.86 | 42.06 | 0.00 |
| | | | | | | Overall Ratio with Trade-offs = | 0.38 |

The FCIs for agricultural fields from the Corps assessment were used as the pre-work mitigation condition under the 1 percent flood duration regime. The mature forested wetland FCIs under the same hydrologic regime were then used for the mitigation "At Maturity" column.

In our analysis the impacts to existing wetlands occur as a change in flood duration. The "Overall Ratio with Tradeoffs" value is 0.38. Similar to the FSEIS's analysis, this means that a gain in one function can compensate for a loss in another. Those functions (i.e., detention of floodwaters, detention of precipitation, nutrient cycling, and plant community) which do not explicitly have a hydrology variable, over time, accrue functional capacity. Despite having a reduced hydrologic regime these functions reflect that forest structure, dead organic matter, and soil structure will develop even with a reduced hydrologic regime. In the FSEIS's compensatory mitigation analysis, as in this one, gains in one set of functions (i.e., detention of floodwaters, detention of precipitation, nutrient cycling, and plant community) are assumed to offset or compensate for rather significant losses in another set of functions (i.e., organic carbon export, biological and physical removal of elements and compounds and wildlife habitat). Thus, in this scenario, the overall ratio with tradeoffs is 0.38:1 which would require an estimated 9,880 acres of compensatory mitigation.

The ratio with tradeoffs, however, obscures the loss in functions as a result of decreasing hydrologic regime. Individually, the functions of Organic Carbon Export, Biological Removal of Elements and Compounds, and Physical Removal of Elements and Compounds show a significant impact as a result of the project. These functions reflect higher ratios due to the change in hydrology and the considerable risk involved in completing successful mitigation. The risk factor incorporates concern over location of compensatory mitigation in areas which do not have appropriate hydrology, the lack of a clear plan of when, where, and how to implement the compensatory mitigation, and the lack of an adequate monitoring plan to track these sites over time. A recent report on the ecological services provided by Natural Resources Conservation Service Wetland Reserve Program lands in the Mississippi Alluvial Valley (Faulkner et al., 2008) indicates that wetland functions on restored agricultural lands are not operating at the same level as bottomland hardwood wetlands. The assumption in the FSEIS HGM analysis and in the above scenario using the HGM Compensation Ratio Calculator is that through time, if structural features of the wetland are replaced (e.g., trees, shrubs, ground vegetation, logs, snags, etc.) then function will be replaced. However, this assumption is tenuous. Faulkner et al. (2008) found that 15-23 percent of restoration sites evaluated did not flood, denitrification rates were reduced on restored lands, and plant species composition differed from natural stands. Since locations of specific compensation sites for the proposed project are not known and monitoring of such sites, if found, is inadequate, the risk of compensation project failure is high.

The National Research Council's (NRC) report entitled *Compensating for Wetland Losses under the Clean Water Act* (2001) found that often wetland area and particularly wetland functions were not being replaced by compensatory mitigation projects. The NRC provided recommendations for improving wetland mitigation under the Clean Water Act. The majority of these recommendations involve improving mitigation project site selection, developing more detailed mitigation plans, developing site specific performance criteria to measure restoration progress, and conducting comprehensive monitoring of sites to determine if they are achieving stated goals and objectives. In the absence of these recommended measures (which the Corps and EPA have since spelled out in national guidance and more recently codified into regulation at 33 CFR part 332 and 40 CFR part 230 subpart J), EPA feels it is appropriate to assign risk factors to mitigation sites. Studies reviewed by the NRC, in preparing its report, indicate that mitigation projects which lack the key measures outlined above, as is the case with the proposed project, exhibit very high failure rates (e.g., up to 80% failure was noted).

EPA's concerns over functional recovery are illustrated by the mitigation analysis as Organic Carbon Export and Biological and Physical Removal of Elements and Compounds do not attain pre-impact levels. Therefore, the calculator estimates mitigation at ratios of 1.82:1 (OCE), 1.82:1 (BREC) and 1.08 (PREC) to reflect the effects of the project on these functions. To replace these functions, compensation acreage would need to range between 28,080 to 47,580 acres.

As a result of the EMAP Survey, EPA estimates an additional 24,000 acres of wetlands are at risk of no longer being flooded by the 2-year flood. Wetlands currently at or above the 2-year flood elevation will see a decrease in flood frequency to a 9-10 year return period and an elimination of flood duration. The same changes in frequency and duration of flooding that will adversely impact existing wetlands in the Yazoo Backwater Area will also impact the viability of compensatory mitigation wetlands sites in the Yazoo Backwater Area. As discussed in the Final Determination and the Yazoo Basin HGM Guidebook, if the frequency of flooding is reduced beyond a 5 year return, the type of wetland that results is no longer a riverine backwater wetland but a flat wetland. Flat wetlands do not perform flood related functions, like floodwater detention, organic carbon export, biological and physical removal of elements and compounds.

Table 3 shows the results of a compensation analysis where impacted wetlands have a reduced flood frequency (from 2-year return to 5+-year return) and duration of flooding (5 percent to 0 percent). Only these two variables were changed between the "Pre-impact" and "Post-impact" categories. In this analysis, mitigation was scored as occurring within a 2-year floodplain and for 6.25 percent of the growing season. If the current flood frequency and duration are impacted (not flooded as frequently or for as long) and the proposed mitigation is placed on lands that flood regularly (2-year return and 6.25 percent duration) then the overall ratio with trade-offs rises to 1.5:1, and individual hydrology dependent function ratios rise to 5-20:1. An overall ratio with trade-offs of 1.5:1 would require approximately between 34,000 and 39,000 acres to offset losses. To offset losses by individual functions would require significantly more acreage. These ratios incorporate a risk factor which reflects the lack of specific sites, plans, and monitoring.

**Table 3. Compensatory mitigation calculation for impacts to flood frequency and duration with mitigation occurring below "with-project" 2 year floodplain**

*HGM Compensation Ratio Calculator Version 3.3*

**Inputs** — Time Horizon: 50 yrs; Discount Rate: 3.00 %; Impacted Site Impact Year: 2008

| Function Name | Relative Importance (e.g., 0 to 10) | Impacted Site – Functional Capacity Index: Pre-Impact | Impacted Site – Functional Capacity Index: Post-Impact | Mitigation Site – Mitigation Work Timing & Risk: Year Started | Year Matured | Failure Risk | Mitigation Site – Functional Capacity Index: Pre-Work | Immediately After Work | At Maturity |
|---|---|---|---|---|---|---|---|---|---|
| Detain Floodwater | 1.0 | 0.98 | 0.49 | 2008 | 2058 | 5 % | 0.25 | 0.25 | 0.98 |
| Detain Ppt | 1.0 | 0.83 | 0.83 | 2008 | 2058 | 5 % | 0.56 | 0.56 | 0.83 |
| Cycling Nutrients | 1.0 | 0.95 | 0.95 | 2008 | 2058 | 5 % | 0.29 | 0.29 | 0.95 |
| Exporting Organic Carbon | 1.0 | 0.63 | 0.16 | 2008 | 2058 | 50 % | 0.17 | 0.17 | 0.64 |
| PREC | 1.0 | 0.52 | 0.13 | 2008 | 2058 | 50 % | 0.43 | 0.43 | 0.53 |
| BREC | 1.0 | 0.64 | 0.16 | 2008 | 2058 | 50 % | 0.17 | 0.17 | 0.64 |
| Maintain Plts | 1.0 | 0.93 | 0.93 | 2008 | 2058 | 30 % | 0.00 | 0.00 | 0.93 |
| Maintain Habitat | 1.0 | 0.91 | 0.79 | 2008 | 2058 | 30 % | 0.00 | 0.00 | 0.92 |
| | | | | | | % | | | |
| | | | | | | % | | | |

**Outputs**

| Function Name | Function-for-Function Compensation Ratios: Impact Site Per-Acre Loss | Mitigation Site Per-Acre Gain | | Ratio (mitigation site acres per impact site acre) | Overall Ratio with Trade-Offs Among Importance-Weighted Functions: Impact Site Per-Acre Loss | Mitigation Site Per-Acre Gain | Net Surplus or (Deficit) (@ mitigation site Overall-Ratio acres per impact site acre) |
|---|---|---|---|---|---|---|---|
| Detain Floodwater | 12.69 | 6.83 | >= | 1.86 | 12.69 | 6.83 | (2.35) |
| Detain Ppt | 0.00 | 2.50 | (see note 14) | 0.00 | 0.00 | 2.50 | 3.78 |
| Cycling Nutrients | 0.00 | 6.16 | (see note 14) | 0.00 | 0.00 | 6.16 | 9.34 |
| Exporting Organic Carbon | 12.17 | 2.33 | >= | 5.22 | 12.17 | 2.33 | (8.64) |
| PREC | 10.10 | 0.51 | >= | 19.72 | 10.10 | 0.51 | (9.32) |
| BREC | 12.43 | 2.33 | >= | 5.33 | 12.43 | 2.33 | (8.90) |
| Maintain Plts | 0.00 | 6.37 | (see note 14) | 0.00 | 0.00 | 6.37 | 9.65 |
| Maintain Habitat | 3.11 | 6.30 | >= | 0.49 | 3.11 | 6.30 | 6.44 |
| | | | | | 50.50 | 33.34 | 0.00 |
| | | | | | | Overall Ratio with Trade-offs = | 1.51 |

As in the previous scenario, the Organic Carbon Export, Biological Removal of Elements and Compounds, and Physical Removal of Elements and Compounds functions fall far short of being restored to reference standard levels even after 50 years of maturation. Thus, the compensation fails to offset these critical functions. In this scenario, detention of floodwater is to be mitigated at 1.86:1; organic carbon export at 5.22:1; biological removal at 5.33:1; and, physical removal would require a ratio of almost 20:1. This assumes that with the project, the mitigation takes place below the 2-year floodplain, meaning it would need to occur in the Lower Ponding Area at or below 87.8 feet, National Geodetic Vertical Datum (NGVD).

This analysis illustrates that compensation ratios can change dramatically depending on the assumptions made. In the event assumptions favor successful completion of the mitigation, in the absence of appropriate hydrology, certain functions, and therefore wetland integrity will be compromised.

A final analysis illustrates the challenges of offsetting reductions to flood frequency and duration on lands that have reduced hydrology as well. This scenario may occur in those wetlands identified by EMAP as being within the 2-year floodplain but outside the FSEIS assessment area. As before, to estimate the amount of compensation required for impacts to these acres, EPA utilized the field data and subsequent subindex scores for the cover types defined in the FSEIS HGM assessment (e.g., mature forested and agriculture). This assumes that the cover types in the area not assessed by the Corps are similar to those in the FSEIS assessment area. EPA also only assessed the change in functional capacity as a result of altered flood duration and frequency, and its effect on compensation. This change in hydrology was based on information summarized in Appendices 5 and 6 of the Recommended Determination.

In this scenario (Table 4), hydrology is estimated to change from a pre-impact condition of a 2-year return and 5 percent duration flood to a post-impact 5-year return and zero percent duration flood. Risk for the water quality functions was raised to 80 percent because of the decrease in flooding. This reflects the importance of flooding to these functions. The pre-work compensatory mitigation scores were taken from the agriculture cover type after adjusting FCIs for flooding. Mitigation "At Maturity" reflects a mature forested wetland with reduced flooding.

Again, as a result of the change in hydroperiod, overall ratio with trade-offs rises to over 2:1. Individual wetland function scores also become high due to the high risk involved and the lack of functional lift achieved in areas of reduced flooding. In other words, if compensatory mitigation lands do not flood adequately to achieve projected compensatory mitigation goals, additional acreage is required. As a result of this analysis over 48,000 acres of compensatory mitigation would be required (Table 4).

**Table 4. Compensatory mitigation analysis for impact and mitigation areas which experience reduced duration and frequency of flooding**

*HGM Compensation Ratio Calculator Version 3.3*

**Inputs** — Time Horizon: 50 yrs; Discount Rate: 3.00 %

**Impacted Site** — Impact Year: 2008

**Mitigation Site**

| Function Name | Relative Importance (e.g., 0 to 10) | Functional Capacity Index: Pre-Impact | Functional Capacity Index: Post-Impact | Mitigation Work Timing & Risk: Year Started | Year Matured | Failure Risk | Functional Capacity Index: Pre-Work | Immediately After Work | At Maturity |
|---|---|---|---|---|---|---|---|---|---|
| Detain Floodwater | 1.0 | 0.98 | 0.49 | 2008 | 2058 | 5 % | 0.12 | 0.12 | 0.49 |
| Detain Ppt | 1.0 | 0.83 | 0.83 | 2008 | 2058 | 5 % | 0.56 | 0.56 | 0.83 |
| Cycling Nutrients | 1.0 | 0.95 | 0.95 | 2008 | 2058 | 5 % | 0.29 | 0.29 | 0.95 |
| Exporting Organic Carbon | 1.0 | 0.63 | 0.16 | 2008 | 2058 | 80 % | 0.04 | 0.04 | 0.16 |
| PREC | 1.0 | 0.52 | 0.13 | 2008 | 2058 | 80 % | 0.10 | 0.10 | 0.13 |
| BREC | 1.0 | 0.64 | 0.16 | 2008 | 2058 | 80 % | 0.04 | 0.04 | 0.16 |
| Maintain Plts | 1.0 | 0.93 | 0.93 | 2008 | 2058 | 30 % | 0.00 | 0.00 | 0.93 |
| Maintain Habitat | 1.0 | 0.91 | 0.79 | 2008 | 2058 | 30 % | 0.00 | 0.00 | 0.79 |
| | | | | | | % | | | |
| | | | | | | % | | | |

**Outputs**

| Function Name | Function-for-Function Compensation Ratios: Impact Site Per-Acre Loss | Mitigation Site Per-Acre Gain | | Ratio (mitigation site acres per impact site acre) | Overall Ratio with Trade-Offs Among Importance-Weighted Functions: Impact Site Per-Acre Loss | Mitigation Site Per-Acre Gain | Net Surplus or (Deficit) (@ mitigation site Overall-Ratio acres per impact site acre) |
|---|---|---|---|---|---|---|---|
| Detain Floodwater | 12.69 | 3.45 | >= | 3.67 | 12.69 | 3.45 | (5.57) |
| Detain Ppt | 0.00 | 2.52 | (see note 14) | 0.00 | 0.00 | 2.52 | 5.20 |
| Cycling Nutrients | 0.00 | 6.16 | (see note 14) | 0.00 | 0.00 | 6.16 | 12.70 |
| Exporting Organic Carbon | 12.17 | 0.24 | >= | 51.61 | 12.17 | 0.24 | (11.68) |
| PREC | 10.10 | 0.06 | >= | 171.30 | 10.10 | 0.06 | (9.98) |
| BREC | 12.43 | 0.24 | >= | 52.71 | 12.43 | 0.24 | (11.94) |
| Maintain Plts | 0.00 | 6.40 | (see note 14) | 0.00 | 0.00 | 6.40 | 13.19 |
| Maintain Habitat | 3.11 | 5.43 | >= | 0.57 | 3.11 | 5.43 | 8.09 |
| | | | | | 50.50 | 24.50 | 0.00 |
| | | | | | | Overall Ratio with Trade-offs = | 2.06 |

There do not appear to be enough acres of cleared wetlands with the proper hydrology and soils in the target area to satisfy more accurate projections of the compensatory mitigation needs of the proposed project. The Corps proposes to acquire easements of up to 55,600 acres of agricultural land from willing sellers at or around the 87 foot, NGVD elevation (i.e., the 1-year floodplain). This total includes: 10,662 acres of compensatory mitigation for the proposed project, 4,367 acres of compensatory mitigation for impacts associated with already implemented aspects of related projects, and 40,571 acres of reforestation associated with the project's non-structural component. However, in order for any of the reforestation to be considered adequate compensatory wetland mitigation, the area of replanting must also exhibit appropriate hydric soils and wetland hydrology (i.e., the area must have hydric soils and flood at an appropriate frequency and duration). According to information in the FSEIS (FSEIS, Appendix 10, Table 10-9) there are only 26,000 acres of cleared land in the project area that conceivably have appropriate hydrology. As the EMAP survey indicated, 16 percent of the FSEIS wetland assessment area [i.e., Flood Event Assessment Tool (FEAT)/Flood Event Simulation Model (FESM) strata] is "Non-Wetland" (Appendix 5, Attachment A). Hence, EPA is concerned that only 20,000 acres of land suitable for wetland replacement would exist, which falls short of what EPA projects would be required based upon acreages discussed above. The acreage of compensatory mitigation required to replace all functions, especially the hydrologic dependent functions of organic carbon export, removal of compounds, and wildlife habitat, would be much greater than the amount of acreage available.

Even if sufficient compensation acreage were available, we do not believe that impacts of this scale and concentration could be effectively compensated for to avoid causing or contributing to significant degradation (40 CFR 230.10(c)), given that reliance on willing sellers would likely result in a noncontiguous patchwork of fragmented compensation sites that cannot deliver the ecological benefits predicted by the FSEIS. The fundamental purpose of the proposed project is to change the flood regime of the project area. Therefore, the same changes in frequency and duration of flooding that will adversely impact existing wetlands in the Yazoo Backwater Area will also impact the viability of compensatory mitigation wetlands sites in the Yazoo Backwater Area.

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