APPENDIX 10

WETLANDS

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APPENDIX 10
WETLAND

INTRODUCTION

1. This appendix is a revision of the 2000 Wetland Appendix, which was included with the Draft Supplemental Environmental Impact Statement (SEIS). This revision addresses all comments received during the public comment period. The revisions were coordinated with the Environmental Protection Agency (EPA) and other state and Federal agencies. This study was conducted by the U.S. Army Corps of Engineers (USACE), Vicksburg District, to delineate wetland boundaries in the Yazoo Backwater Project Area. The methods described in this appendix are new and were not used in the 2000 Draft Report and DRAFT SEIS. The study was designed to delineate wetlands using the "Corps of Engineers Wetlands Delineation Manual (WDM)" (Y-87-1) as a technical basis. The WDM describes technical criteria, field indicators, and methods for identifying and delineating jurisdictional wetlands. Although the WDM is for delineating jurisdictional wetlands, this study was designed to delineate wetlands for planning purposes and not for regulatory purposes. The use of the term “wetland” in this Appendix will be applied only to those areas that meet the Federal definition of wetlands found in the 87 WDM. The estimates of wetland acreage and wetland maps in this appendix only identify wetlands likely to be impacted by the project. Other regulated wetlands are not identified; therefore, the maps in this appendix should not be used alone to identify or delineate wetlands in the Yazoo Basin for regulatory purposes. The delineation effort was supported by an interagency team comprised of personnel from EPA, Natural Resources Conservation Service (NRCS), U.S. Fish and Wildlife Service (FWS), and the U.S. Army Engineer Research and Development Center (ERDC). This appendix is divided into four parts--the body and three supplements. The first supplement is authored by EPA and will report on an extensive Environmental Monitoring and Assessment Program (EMAP)-based field verification of wetlands. The second supplement is authored by ERDC and details the functional assessment of wetland values performed utilizing the Hydrogeomorphic (HGM) approach. The third supplement is the Wetland Appendix from the 2000 draft Supplemental Environmental Impact Statement. The study area is shown in Plate 10-1. This appendix has a body and several addendums. The body is divided into seven sections. Each section will address a separate wetland issue or analysis. The seven sections will provide information on the following subjects: (a) background information, (b) wide-area wetland delineation, (c) wetland impact assessment, (d) wetland functional assessment, (e) a field study to verify wetland extent, (f) a comparison of the three estimates of wetland extent, and (g) cumulative impacts.

OBJECTIVE

2. The objective of this appendix is to provide detailed information to explain the information relied upon in the Final Report and Final SEIS with respect to wetlands. The information provided in this appendix is the result of collaborative work done by USACE, EPA, and ERDC to delineate the

areal extent and functional value of wetlands in the study area. Two offsite delineation methods were used to determine the areal extent of wetlands and the project impacts for this study. This methodology will be used in this planning study to estimate the impact of the Yazoo Backwater Project on wetland extent and values. The functional values of wetlands were determined utilizing HGM wetland values established in the Yazoo Basin Regional Guide Book (Smith and Klimas, 2002). The HGM approach was developed by ERDC in cooperation with EPA.

METHODOLOGY

3. The areal extent of wetlands was determined with offsite methods utilizing a combination of remote-sensing and Geographic Information System (GIS) techniques. Although routine jurisdictional wetland determinations for regulatory purposes are based on the presence of indicators of wetland hydrology, hydrophytic vegetation, and hydric soils, the methodology in this appendix uses only hydrology data to determine wetland extent. The exclusive use of hydrologic data is justified for three reasons. The first reason is that the structural feature of the proposed project will directly alter the basin's hydrology. The second reason is that although vegetation and soils are valuable indicators of wetlands, it is hydrology that makes and maintains a wetland. The third reason is that by assuming the vegetation and soils will be present if the hydrology is present, conservatively estimates wetland extent. The Wetland Appendix contained in the September 2000 draft report included a report by Kirchner, et. al. (1991). That report concluded that “quantitative hydrologic data were virtually nonexistent for the Delta, and it was assumed that wetland hydrology continued to exist in most of the 'tight' alluvial soils, despite recent changes in hydrology due to drainage projects.” The conclusion that “quantitative hydrologic data were virtually nonexistent” was incorrect. Quantitative hydrologic data do exist, but there were no means to apply the data to the study area. Advances in GIS have changed that condition. Through GIS, the period-of-record stage data were interpolated between gages, adjusted for slope and applied to the study area. The GIS model (Flood Event Assessment Tool (FEAT), 1999; Flood Event Simulation Model (FESM), 2004) interpolated stage values every 300 meters (m) (1,000 feet) along the main channels and applied these elevations laterally across the landscape. This provides current hydrologic data for the entire study area. Although the FEAT model was first available as the Draft 2000 Report and DRAFT SEIS were being completed, it was not utilized in the hydrologic or wetlands analyses of the project in that Report.

BACKGROUND INFORMATION

INTRODUCTION

4. This section will provide information that will be useful in understanding this wetlands assessment. The first section will cover the Federal Definition of Wetlands. The second section will provide a brief review of previous wetlands reviews in the basin. The next section will cover a series of reports on the geomorphology of the Mississippi Alluvial Valley with emphasis on the Yazoo Basin. Finally, there will be a brief introduction of GIS and remote sensing.

FEDERAL DEFINITION OF WETLANDS

5. Joint EPA/Corps wetlands definitions: Those 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 a life in saturated soils conditions.

6. Using the Corps criteria for wetland hydrology to further refine the conditions which define the hydrology of wetlands:

a. An area may have wetland hydrology if it is inundated or saturated to the surface for at least 5 percent of the growing season in most years.

(1) The growing season is defined as the portion of the year when soil temperature (measured 20 inches below the surface) is above biological zero (5 degrees C or 41 degrees F). In the absence of data on soil temperature, growing season can be estimated from data given in most NRCS county soil surveys. Starting and ending dates generally are based on the 28 degrees F air temperature thresholds 5 years in 10 (HQUSACE, 1991).

(2) The minimum 5 percent duration refers to a single, continuous episode of inundation or saturation.

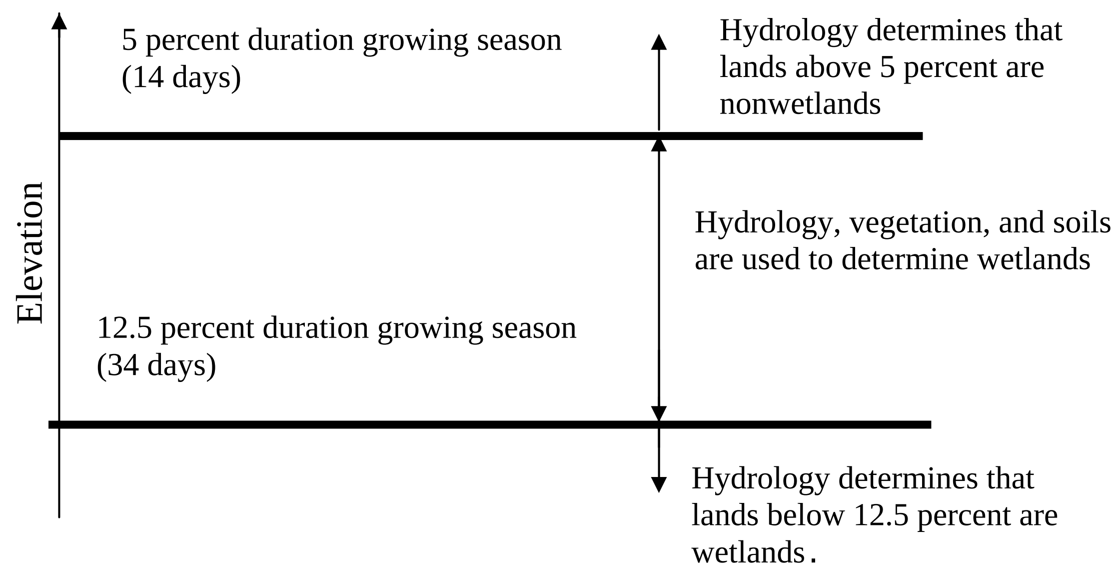
(3) Growing season for Yazoo Backwater Area was determined from NRCS data from the website:

ftp://ftp.wcc.nrcs.usda.gov/support/climate/wetlands/ms/28149.txt

Computed growing season was the period 1 March - 27 November (270 days X 0.05 = 13.5 days rounded to 14 days). (NOTE: Although the Corps definition of the growing season is based on soil temperatures, these data are not readily available. Therefore, the Vicksburg District refers to the Department of Agriculture to determine the growing season.)

b. Table 5 in the ERDC Technical Report Y-87-1 (Corps Wetlands Delineation Manual, WDM) summarizes wetland hydrology in the following manner. Areas that are inundated or saturated less than 5 percent of the growing season are not wetlands. Areas that are seasonally inundated or saturated for 12.5 (34 days) percent of the growing season continuously are wetlands. Many areas that are intermittently inundated or saturated between 5 and 12.5 percent (14 to 34 days) of the growing season in most years (50 percent probability of recurrence) may or may not be wetlands. In the analysis of wetlands in the Yazoo Backwater study area, the conservative assumption was made that all lands inundated continuously for a minimum 5 percent or more of the growing season would be classed as wetlands. The Vicksburg District has utilized the 5 percent duration elevation as the hydrologic indicator of wetland extent in previous wide area delineations. For instance, it was used as the primary hydrologic indicator of wetlands for the Mississippi River Mainline Levees and Seepage Control Project, 1998. It was used to delineate wetlands between the levees in the Memphis, Vicksburg, and New Orleans Districts for that project. The wetland extent was field verified by personnel from USACE, EPA, FWS, NRCS, and state resource agencies from the seven states in the MRL project area.

7. Schematic depicting wetland hydrology is as follows:



PREVIOUS STUDIES

1991, Upper Yazoo Projects

8. In 1989, the EPA, FWS, NRCS, and the Vicksburg District jointly performed a study, which classified the soils of the Yazoo Basin as hydric or nonhydric. The classification was performed based on the 1989 Manual (Federal Interagency Committee for Wetland Delineation, 1989). The results of this study are documented in a report (Kirchner, et al., 1991), which determined 690,000 of the 930,000 acres in the Yazoo Backwater Project Area had hydric soils and were therefore wetlands due to the unique definitions in the 1989 Manual. The 1989 determination, that nearly 690,000 acres of hydric soils were wetlands, was due to differences between the 1987 and 1989 Manuals. Two of the more significant differences are: (1) the 1989 Manual required only 7 consecutive days of flooding or inundation instead of 14, and (2) the 1989 Manual allowed areas to be declared wetlands without current hydrology information if they had hydric soils and hydrophytic vegetation and there was no evidence of altered hydrology. Although the interagency group agreed that the remaining natural vegetation in the Delta was hydrophytic, it was recognized that cleared agricultural land would be the most prevalent or normal condition for the majority of the study area. Therefore, in accordance with the disturbed area criteria in the Manual, in areas where indicators of hydrology and hydric soils were present, it was necessary to assume that the typical plant community on the cropland prior to agricultural conversion would have met the criteria for hydrophytic vegetation (83.5 percent of the land had altered vegetation and hydrophytic vegetation was assumed). The study group stated that "wetland hydrology continued to exist in most of the 'tight' alluvial soils, despite recent changes in hydrology due to drainage projects." Their conclusion meant that the areal extent of wetlands in the basin (690,000 acres) exceeded the areal extent of the 2-year frequency flood (330,000 acres) and even the 100-year frequency flood (630,000 acres). In 1991, Congress instructed the Corps and EPA to cease using the 1989 Manual and to use the 1987 Manual for wetland determinations. Congress' action effectively invalidated the determination that the 690,000 acres of hydric soils were wetlands (1992, Energy and Water Development Appropriations Act). Therefore, the conclusion of the 1989 study that the 690,000 acres of hydric soils were wetlands is unsupported by current Federal wetland regulatory standards.

2000, Yazoo Backwater Project
Draft Wetland Appendix

9. The 2000 Draft Wetland Appendix differs in two ways from this document. The major difference was that the areal extent of wetlands was determined by the "average daily acres flooded" method. That method was unable to map the wetland extents and only identified 48,500 acres of wetlands in the study area. The Draft Wetland Appendix contained a functional assessment of wetlands. It was used to determine changes in wetland functions due to the project. The functional assessment was similar to the method used in this appendix, but it was not the HGM approach. The functional assessment that was used incorporated many of the same wetland functions as HGM. The six functional areas used in the 2000 Draft Report were short-term storage of floodwaters, long-term storage of floodwaters, onsite erosion control, sediment retention, nutrient and dissolved substance removal, and organic carbon export. The Functional Capacity Index (FCI) values were not determined by field measurements within the study area, but were estimated from other published reports.

Yazoo Basin Geomorphology

10. A comprehensive discussion of the Mississippi Valley's geology and geomorphology was done by Fisk (1944) and later synthesized by Saucier (1974 and 1994). This synopsis comes primarily from the latter work. The Mississippi alluvial valley was formed by continental rifting, warping, and uplifting. The resultant valley was first filled with glacial outwash. This glacial outwash was then reworked to a general depth of 30 meters (m) by the meandering Mississippi River. The modern valley is bounded by Tertiary and Mesozoic sediments of the Gulf Coastal Plain (Autin, et al., 1991). These sediments reflect various depositional environments ranging from marine, estuarine, fluvial, and finally eolian (wind blown). Thus, the sediments moving out of the hills bordering the valley contain a wide variety of materials. These materials include limestone, marl, and clays deposited in marine and estuarine environments and sands and gravels transported from the continental interior. They also contain wind-blown fine silts (loess) carried into the valley from glacial deposits from the last ice age. In recent historic times (last 100 years), sedimentation rates have been increased by forest clearing and agricultural activities within the alluvial valley and the surrounding upland areas.

Geomorphic Features

11. The meandering Mississippi River and its tributaries have removed the glacial outwash deposits and replaced them with depositional material to form the present day geologic features. According to Saucier, there are at least six distinct meander belts from the Mississippi River that run through the Mississippi alluvial valley. These differ in size and texture due to changes in the flows, sedimentation, and base level. Each of these meander belts is at least 5 kilometers (km) wide. The current meander belt has held the Mississippi River for the last 2000 years. Because sedimentation rates are highest within the active channel, meander belts tend to develop into an alluvial ridge. This ridge or natural levee is elevated above the rest of the flood plain. Within the meander belts, the Mississippi and Arkansas Rivers, in conjunction with smaller rivers, have reworked the glacial outwash into several distinct features which include valley trains, back swamps, abandoned stream channels, abandoned stream courses, point bar deposits, and natural levees. These features will be discussed in the following paragraphs, and a representative geologic quad sheet which depicts these features is provided in Plate 10-2.

a. Valley trains are composed of Pleistocene glacial outwash deposits from the Mississippi and Ohio Rivers. These deposits have features which reflect braided-stream depositional environments that have been overlain with 1 to 3 m of fine-grained silts and clays. The braided features are still visible beneath the fine-grained surface deposits.

b. Back swamps are flat, poorly drained areas bounded by the natural levees and uplands. The surface deposits contain fine-grained deposits of silts and clays like the valley trains, but differ in the depth of the deposits because the underlying features are obscured. The fine-grained clays can be as much as 30 m deep. These poorly drained areas were created by the slow deposition of clays under slack-water conditions. These areas may include some depressional areas that pond water for long periods.

c. Point bars form the dominant depositional type within most of the Mississippi alluvial valley, and they represent approximately 60 percent of the land within the lower Yazoo Basin. They are formed of coarse-grained materials (silts and sands) deposited on the inside bend of migrating river channels. The rate and height of these deposits depend on the stream energy, sediment supply, and flood stage of the river forming these features. Point bars create distinctive curved ridges within the flood plain. Migrating rivers often formed several sets of parallel ridges with swales between them as the channel moved across the meander belt.

d. Abandoned channels are formed when the migrating channel cuts off a portion of its own channel. This can be done as a chute or neck cutoff. Chute cutoffs tend to be relatively small and shallow. They quickly fill in with sediment. Neck cutoffs vary in size depending on the size of the river that formed them. The two ends of these fill in rapidly with sediment, and the rest fills in slowly with fine-grained materials. If the forming river meanders away, the cutoff may form a lake that persists for a long period of time.

e. Abandoned courses are stream channels that have been left behind when a meandering river finds a new path. These differ from abandoned channels in their length. Abandoned courses can be hundreds of miles long. If an abandoned course is abandoned, gradually it may slowly fill as streamflow declines. Many abandoned courses are captured by smaller streams. When this happens, the new stream will meander through the old channel creating natural levees, point bars, and other channel features. Examples of smaller streams capturing the abandoned channel of larger streams exist within the Yazoo Backwater Area. Silver Creek has captured an abandoned channel of the Yazoo River, and Deer Creek has captured the abandoned channel of the Arkansas or Mississippi Rivers.

f. Natural levees form where overbank flow deposits coarse-grained material as floodflows leave the channel. The material is deposited as continuous sheets that thin as they move away from the channel. The height and width of the natural levee are dependent upon the size of the river and the nature of the materials present to build the levee. The natural levee of the Mississippi River extends up to 4.5 m above the flood plain and may extend several kilometers away from the channel. This process gradually builds up the land adjacent to the channel. This natural levee is often the highest land in the basin, and precipitation will drain away from the river channel into back swamps or other low-lying areas which exist between stream channels. The natural levees function as barriers to flooding.

HISTORIC PATTERNS OF FLOODING

12. The Yazoo Backwater Area received its name because it is subject to backwater flooding from the Mississippi River. When the Mississippi River at Vicksburg is high, its waters back up the Yazoo River and flood low-lying areas. The Backwater levee was completed in 1978 to prevent water from the Mississippi River from backing into the basin. The Backwater levee contains two drainage structures: the Steele Bayou Structure and the Little Sunflower Structure. These structures are closed when stages on the Mississippi River side are higher than interior stages. When this happens, rainfall in the Sunflower Basin does not have an outlet and flooding commences in the Backwater area. The Backwater area contains two primary ponding areas. These have been labeled the “lower ponding area” and the “upper ponding area.” These two areas are clearly evident in a surface elevation model of the basin (Plate 10-3). Backwater floods are often typified by a mild slope of the water surface. Plate 10-4 compares a 2-year frequency

backwater flood (without slope) with a 2-year headwater flood (with slope). The backwater flood is illustrated with a flat 91 foot, National Geodetic Vertical Datum (NGVD), elevation at the Steele Bayou gage. A satellite image of a typical backwater flood is provided on Plate 10-5 (10 March 1989). This flood has a mild slope in the vicinity of the two ponding areas, then the slope of the water surface increases more rapidly as you move upstream from Holly Bluff, Mississippi. The major areas of flooding are within the ponding areas; however, some flooding occurs in off-channel areas upstream of Holly Bluff, Mississippi. The satellite image includes permanent water bodies such as lakes and catfish ponds and shows other off-channel areas where water has ponded (isolated depressional wetlands).

HYDROGRAPHS

13. An example hydrograph for Steele Bayou landside gage (SB-Base 1) is plotted in Plate 10-6. The 11 years plotted represent one-fifth of the period-of-record. The figure contains the Base condition (backwater levee in place), the Steele Bayou riverside elevations (SB-RS1), and with-project Steele Bayou-landside (SB-LS) hydrographs for Alternatives 3-7. The with-project hydrographs are visible inside many of the flood peaks, and they indicate the extent the various pump station options would have on the height of the flood peaks. Some pumping would occur in most years, but no pumping would have occurred in 15 of the 55 years in the period-of-record for SB-LS. The Base condition for SB-LS is plotted in red, and the Base riverside is plotted in dark blue. When red is visible, there is a difference between the landside and riverside gages. These differences represent changes in hydrology due to the backwater levees. Red is visible above many of the annual peaks in the hydrograph, showing when the levees have successfully kept Mississippi River backwater out of the basin. In addition to modifying the heights of the peaks, the backwater levees, along with the Steele Bayou and Little Sunflower structures, have been used to maintain higher interior stages during the summer and fall months. While the levees have lowered flood stages by as much as 5 feet on landside during spring, these features have increased the summer and fall stages by as much as 20 feet. The current Water Control Plan for the Steele Bayou Structure calls for the maintenance of a minimum stage between 68.5 and 70 feet, NGVD. The annual minimum observed at the riverside gage is generally in the low 50s, but has gone as low as 47.4 in 1988. The recommended plan will increase the minimum stage at the Steele Bayou structure to between 70 to 73 feet, NGVD. This water is held to provide habitat for fish, waterfowl, and semi-aquatic species such as mink.

REMOTE SENSING

14. Remote sensing is the technique of obtaining measurements from a distance. While the variety of measurements that can be obtained remotely is great, this study is specifically referring to the use of satellites to measure the reflectance of light off of the earth’s surface. This study

used satellite imagery collected by the Landsat series of satellites. The first Landsat satellite was launched in 1972. Since then, several more satellites have successfully been put into operation. Landsat satellites 1-3 were equipped with the Multi-spectral Scanner (MSS), which provided pixels with a ground resolution of 57 x 79 meters (m). The MSS provided 4 bands of reflected data, two bands of visible (red and green), and two bands of infrared. In 1982, the Landsat-4 satellite was launched. Landsat-4 was equipped with two scanners--the MSS and the Thematic Mapper (TM). The TM scanner provided seven bands of data, three visible (blue, green, and red) and four bands of infrared. The TM scanner also provided a higher resolution product that had a ground resolution of 28.5 m squared. The newest Landsat satellite 7 continues to offer the MSS data, but it also offers an Enhanced Thematic Mapper (ETM) product that provides an eighth panchromatic band with a resolution of 14.25 m in addition to the seven bands offered by Landsat-4 and -5. This study has used satellite imagery provided by all three Landsat scanners. Most of the scenes are either TM or ETM imagery. Satellite imagery was used to map flood events and to provide land use/land cover maps (LULC). By using the reflectance data from three or more of the bands, the imagery can be statistically grouped into categories with similar characteristics. This process is termed classification. After a satellite scene has been classified, the LULC of the raw classes must be determined. This step is generally called ground truthing. The ground truthing information comes from many sources. The Farm Services Administration (FSA) or the Natural Resource Conservation Service (NRCS) provide the information on crops. Forest cover and water classes are obtained from the U.S. Geological Survey (USGS) digital maps. Flood maps are classified in the same manner as LULC, but the raw classes are sorted into only two categories, flooded or not flooded. This can be done without additional information. Satellite imagery provides a synoptic view of the earth or a snap-shot in time. Satellite images of past flood events provide a means of determining the areal extent of flooding within the project area. Pairing the flood extent with the water surface information provided by the Vicksburg District’s stage data provides a means to determine a relationship between areas flooded and water surface stage or elevation. Plotting the stage versus the area for several flood events and finding the best fit of a line through the points creates a stage-area or elevation-area curve. These curves can then be used to predict the extent of flooding from future flood events.

GEOGRAPHIC INFORMATION SYSTEMS

15. The GIS refers to a combination of software and hardware that enables users to take many different sets of information and use them as layers in a large visual database. Each data layer must be referenced to the earth’s surface (georeferenced) using coordinate pairs which reference specific locations on the earth’s surface. Because the earth’s surface is curved and maps and computer screens are flat, the data must be transformed into map-oriented (spatially explicit) information. The process of transforming information from a curved surface onto a flat surface is termed projecting, and the mathematical relationship between the curved surface and a flat one is termed a projection. Once the data layers have been georeferenced, they can be displayed and manipulated with a computer. The data layers generally consist of two general types of data--

vector and raster. Vector data consist of points (wells, gages, houses, bridges, etc.), lines (roads and rivers), and polygons (lakes, ponds, cities, parks, forests, and other land cover types). Raster data consist of a grid of equal sized rectangles or squares. The individual elements of the grid are given various names such as raster elements, grid cells, and picture elements (pixels). Each element has a coordinate pair identifying its position on the earth's surface. Examples of raster data include aerial photography, satellite imagery, digital maps (digital raster graphics (DRG)), and surface models such as digital elevation models (DEM). The GIS systems allow the simultaneous display and querying of the raster and vector data.

LAND-USE/LAND COVER (LULC) CLASSIFICATION

16. Two new LULC classifications were developed after the 2000 Draft Report and Draft SEIS as part of the wetland study. The first new LULC classification was performed in 2001 and was based on four satellite scenes acquired in 1999. All four were acquired by the LANDSAT-7 satellite. Images from 5 August , 22 September, 24 October, and 27 December 1999 were utilized. One or more bands from each of the scenes were composited into a single file and a multitemporal classification was performed on the composite satellite scene. The use of imagery from several dates aided in the determination of crop type, due to the differences in planting and harvesting dates for the crops in the project area. For instance, corn is generally planted in March and harvested in August or early September. Cotton is generally planted in May and harvested in October or November. The raw classified scene contained 70 to 75 classes which were clustered into seven land-use classes. The seven classes are crop, noncrop, forest, water, pond, cloud, and miscellaneous. Noncrop represents cleared lands not in row crops such as pasture, fallow fields, catfish pond levees, and reforested lands. The reforested subclass represented cleared lands which were replanted in trees. These include almost all of the Conservation Reserve Program (CRP) and Wetland Restoration Program (WRP) lands. The water class includes permanent water bodies and some marginal land adjacent to the water body. The actual water surface elevations differ between the satellite images. The land use was based on the highest water surface of the scenes, which means some adjacent wetlands are included in the water land-use class.

17. The second new LULC was developed using 2005 imagery and was done in May 2006. Again, four scenes were utilized and they were 25 May, 12 July, 16 October, and 17 November 2005. All four were Landsat-5 images. The raw classified scene contained 70 to 75 classes which were clustered into 16 and 7 classes for the full and simplified LULC, respectively. The total crop acreage remained almost the same as the 1999 LULC. There was a slight increase in forested acres as some of the reforested acres (herb2) from the 1999 classification were identified as forested (BLH1) in 2005. The 1999 and 2005 LULC classifications are very similar with regard to total crop acreage, but the 2005 LULC shows a slight increase in forested acreage due to the maturation of some of the reforested plots. Table 10-1 compares the acreages of the three LULC data sets. The 2005 LULC acreage figures will be used for this study.

TABLE 10-1
YAZOO PROJECT AREA LAND USE

LULC	1988	1999	2005
Crop	529,507	465,560	514,722
Noncrop	60,362	138,356	78,862
Forest	272,421	264,491	288,310
Water	21,375	17,914	19,324
Catfish Pond	40,312	38,821	24,358
Miscellaneous	1,600	435	0
Total	925,578	925,578	925,578

YAZOO BACKWATER OFFSITE WETLAND DELINEATION

INTRODUCTION

18. The offsite wetland delineation described in this appendix is completely different from the method used in the 2000 Draft Report and Draft SEIS. In order for an area to be a federally defined wetland, it must have all three of the following components: (a) hydrophytic vegetation, (b) hydric soils, and (c) current wetland hydrology. In order to meet the hydrology requirement, an area must be inundated or saturated to the surface continuously for 12.5 percent (34 days) of the growing season in most years. However, in some cases that requirement can be met with inundation or saturation to the surface continuously for as little as 5 percent of the growing season (14 days in the project area). The wetland delineation described in this document uses the minimum (5 percent) inundation duration requirement as the basis for the estimation of the areal extent of wetlands. The use of the minimum period of inundation will provide a larger estimate of wetland extent and will offset the error induced by the method's inability to consider wetlands sustained by soil saturation. This method provides a means to determine wetland extent during periods when the required hydrologic conditions are no longer being met. The preferred method of the WDM of determining the hydrology of wetlands is visual observation of flooding. For this offsite estimation of wetland extent, a satellite image, which represents the 5 percent duration condition, is used as the visual indication of flooding.

OFFSITE WETLAND DELINEATION METHODOLOGY

19. The Vicksburg District (CEMVK) has been utilizing and perfecting a GIS-based wetland delineation method since 1990. This method is called the 5 percent Duration Flood Method or sometimes it is shortened to the Flood Method. The first use of satellite imagery of floods and

GIS to delineate wetlands was made for the Yalobusha-Tallahatchie River Maintenance Project in 1990. The method has subsequently been utilized on several other studies including Upper Steele Bayou; Upper Yazoo Projects; Shreveport, Louisiana, to Daingerfield, Texas; Big Sunflower River Maintenance; Sicily Island; and Mississippi River Levees. Each application has included some refinements to the basic concept of utilizing a combination of satellite imagery and GIS to delineate the areal extent of wetlands. The basic process involves these four steps:

a. Wetland elevation development. Analyze stage data to determine the 5 percent duration elevation at each gage. Daily gage records from six gages within the study area were used. Stage records from 1943 to 1997 were used, when available (see paragraph 31 for a description of how the 5 percent duration elevations are determined).

b. Satellite imagery. Find and classify a satellite image (or images) where the observed stages are similar to the 5 percent duration elevation for each gage.

c. Verify flood extent. Verify that the flooded areas on the classified satellite images accurately reflect the stages on the date of the flood scene.

d. Field Verification of wetland delineation. Field verification of the wetland delineation using onsite methods by wetland experts.

ASSUMPTIONS

20. All areas flooded in the 5 percent flood scene are either permanent waters or wetlands.

21. All wetlands in the study area sustained by backwater flooding will be flooded by a 5 percent duration event.

22. Areas flooded by the 5 percent duration event will meet the three (hydrologic, vegetative and soils) criteria of wetlands.

RESULTS OF OFFSITE WETLAND DELINEATION

WETLAND ELEVATION DEVELOPMENT

23. As was previously noted, the Corps WDM defines wetland hydrology as: “An area may have wetland hydrology if it is inundated or saturated to the surface for at least 5 percent of the growing season in most years.” The Vicksburg District interprets the “in most years” as the median (50th percentile) annual 5 percent duration for a period-of-record. The 5 percent wetland

elevation data for the wetland delineation were developed from the six recording gage locations throughout the study area (Plate 10-7). The six gage locations are highlighted in yellow in Plate 10-7. These gages, along with other pertinent data, are listed in Table 10-2. The period-of-record for most gages was approximately 50 years. Observed stage data were utilized at four of the gages while computed stage data were used for the Steele Bayou and Little Sunflower gages. This computed period-of-record stage data are the same data that were utilized in the economic, terrestrial, waterfowl, and aquatic analyses. Observed data at these two gages were limited, and the stage data from these two gages were key elements to the overall analysis of the project. Observed stage data from the Little Sunflower gage did not include the flood of record (1973); therefore, it was necessary to compute daily stages for the entire period-of-record at these two locations. The computed stages were calibrated to the observed data and adjusted for future conditions. This is described in more detail in the H&H Section of the Engineering Appendix.

TABLE 10-2
STAGE DATA PERIOD-OF-RECORD BY GAGE

Gage	Period-of-Record Available	Period-of-Record Used
Steele Bayou Landside at the Steele Bayou Structure	21 October 1968 to Present	1943 to 1997, computed
Steele Bayou at Rolling Fork	22 September 1955 to Present	1956 to 1997, observed 1943 to 1955, computed
Little Sunflower Landside at the Little Sunflower Structure	April 1978 to Present	1943 to 1997, computed
Big Sunflower at Holly Bluff	28 August 1910 to Present	1943 to 1997, observed
Big Sunflower at Anguilla	18 February 1949 to Present	1949 to 1997, observed 1943 to 1948, computed
Big Sunflower at Little Callao	3 February 1948 to Present	1948 to 1997, observed 1943 to 1947, computed

WETSORT

24. The wetland elevations were developed using the Vicksburg District WETSORT computer program. WETSORT statistically analyzes the period-of-record stage data and computes the annual stages for the 2.5, 5, 7.5, 10, and 12.5 percent duration events during the growing season; sorts the data by stage; and calculates the median elevation for each duration event. Required input data are the beginning and ending dates of the growing season and period-of-record stage data. An example of the output for the 5 percent duration event at the Steele Bayou structure is provided in Table 10-3.

TABLE 10-3
WETSORT OUTPUT FOR THE BASE 5 PERCENT DURATION EVENT AT THE
STEELE BAYOU STRUCTURE (LANDSIDE)
MONTH/DAY GROWING SEASON BEGINS 1 MARCH
MONTH/DAY GROWING SEASON ENDS 27 NOVEMBER
NUMBER OF DAYS IN 5 PERCENT DURATION=14

Rank	Elevation	Starting Date	Ending Date
1	99.69	5/14/1973	5/27/1973
2	96.38	4/27/1945	5/10/1945
3	95.43	3/2/1950	3/15/1950
4	95.08	4/29/1979	5/12/1979
5	95.01	6/1/1983	6/14/1983
6	94.48	4/11/1975	4/24/1975
7	94.45	5/10/1944	5/23/1944
8	92.96	5/12/1993	5/25/1993
9	92.9	5/23/1984	6/5/1984
10	92.85	3/1/1949	3/14/1949
11	92.8	5/4/1994	5/17/1994
12	92.78	3/29/1997	4/11/1997
13	91.99	4/12/1980	4/25/1980
14	91.78	4/19/1948	5/2/1948
15	91.2	3/30/1961	4/12/1961
16	91.06	4/19/1962	5/2/1962
17	90.58	4/30/1991	5/13/1991
18	90.19	6/15/1974	6/28/1974
19	90.01	4/29/1947	5/12/1947
20	90	5/9/1970	5/22/1970
21	89.8	4/1/1955	4/14/1955
22	89.56	3/9/1989	3/22/1989
23	89.26	4/13/1952	4/26/1952
24	89.25	6/16/1995	6/29/1995
25	89.19	6/14/1996	6/27/1996
26	89.04	5/15/1958	5/28/1958
27	88.78	4/12/1951	4/25/1951
28	88.64	3/1/1990	3/14/1990
29	87.65	4/3/1943	4/16/1943
30	87.58	3/9/1971	3/22/1971
31	87.43	3/27/1964	4/9/1964
32	87.09	3/22/1985	4/4/1985
33	86.93	4/9/1968	4/22/1968
34	86.83	4/2/1963	4/15/1963
35	86.68	4/25/1957	5/8/1957
36	86.51	4/22/1965	5/5/1965
37	86.4	5/6/1972	5/19/1972
38	86.19	4/27/1969	5/10/1969
39	85.82	5/19/1978	6/1/1978
40	85.62	3/9/1987	3/22/1987
41	85.39	4/3/1982	4/16/1982
42	84.2	5/9/1966	5/22/1966

TABLE 10-3 (Cont)

Rank	Elevation	Starting Date	Ending Date
43	83.91	2/29/1956	3/13/1956
44	83.82	3/30/1946	4/12/1946
45	83.28	3/4/1976	3/17/1976
46	82.36	5/20/1953	6/2/1953
47	82.09	5/22/1967	6/4/1967
48	80.33	4/19/1960	5/2/1960
49	79.77	6/11/1981	6/24/1981
50	79.7	4/11/1988	4/24/1988
51	79.06	3/20/1992	4/2/1992
52	78.79	3/12/1977	3/25/1977
53	77.88	11/10/1986	11/23/1986
54	76.38	3/2/1959	3/15/1959
55	72.6	5/6/1954	5/19/1954

NOTE: The median value is shaded.

SATELLITE IMAGERY

25. The areal extent of wetlands for this study is based on the classified satellite image of a 5 percent duration flood. The TM satellite imagery was utilized for this step. A TM image contains seven separate bands of data and has a pixel size of 28.5 m squared. Each TM scene has three visible bands and four infrared bands. Classification is the systematic clustering of the image pixels into classes based on their similar reflectance characteristics within the separate bands of the image. There are two basic types of classifications, supervised and unsupervised. For a supervised classification, a trained individual makes the decisions about classes. This is generally done by selecting areas from the satellite scene that represent a known land-cover class of pixels. These sites are called training sites. Computer software then determines the reflectance characteristics of these training sites and finds all other pixels in the image which share these characteristics. For an unsupervised classification, a computer program analyzes the reflectance data from the satellite image, creates classes based on the statistical analysis of the reflectance data, and sorts the image into the classes. Basically, the difference is that a human makes the decisions in a supervised classification based on their knowledge and experience, while a computer makes the decisions in an unsupervised classification based on the statistical analysis of the satellite images reflectance of light. This study utilized an unsupervised classification of satellite imagery. After the raw classification is completed, the identified classes must be labeled based on ground-truth information.

5 Percent Flood Scene

26. The second step in the offsite wetland delineation is the selection and classification of the flood scene. The observed stages on the dates of the flood scenes used to make the elevation-area curves were compared to the 5 percent duration elevation. Plate 10-8 shows the water surface profiles for a number of flood scenes and for the 5 percent duration event. The profiles of the flood scenes cover a wide range of conditions. Several of the floods exhibit near backwater conditions and have nearly flat water surface profiles (6 May 1973, 1 February 1993, 28 May 2003, and 17 June 1990). Other floods exhibit conditions with almost no backwater influence, such as 17 February 1984 and 12 March 1973. Other flood events have near constant slopes, but show some influence from backwater flooding (24 December 2001 and 21 March 1987). After examining the stage data from ten dates, the 10 March 1989 flood scene was selected as most representative of the 5 percent elevation for this study. Table 10-4 shows the 5 and 12.5 percent duration elevations, the elevation of the 10 March 1989 flood scene, and the 1- and 2-year frequency flood elevations at the gage locations within the Yazoo Backwater Area. The 1987 Wetland Delineation Manual gives the 5 percent duration elevation as the possible upper bounds of federally defined wetlands. Plate 10-9 shows the Big Sunflower River profiles

for the 5.0 and 12.5 percent durations and the 1- and 2-year frequency events. These profiles were developed in the same fashion as the stage-frequency profiles using the gages listed in Table 10-4. The use of these other hydrologic events as indicators of wetland status is discussed later in this document (paragraph 66).

TABLE 10-4
BASE WATER SURFACE ELEVATIONS
BY GAGE

Gage Location	12.5 percent Duration	5 percent Duration	10 March 1989	1-Year	2-Year
Steele Bayou Landside Gage	84.0	88.6	89.7	87.0	91.0
Steele Bayou at Grace	89.4	91.9	89.7	91.5	94.0
Little Sunflower Landside Gage	86.0	89.3	90.0	87.8	91.6
Big Sunflower at Holly Bluff	88.4	91.0	91.5	90.7	93.0
Big Sunflower at Anguilla	89.3	93.3	93.1	95.5	97.1
Big Sunflower at Little Callao	89.8	94.4	94.0	100.4	101.8

27. The raw satellite image was classified as described earlier. All pixels in the wet category were compared to the 2005 land-use classification to determine the land use of the flooded acres. Because the satellite sensors cannot distinguish between floodwater, lakes, and intentionally ponded water such as catfish ponds, the classification returns all areas covered by water. Therefore, all pixels from the resultant map, except the intentionally ponded water classes of the land use classification, were considered wetlands. Plate 10-10 shows the land use of the 10 March 1989 flooded areas.

Verify Flood Scene Elevations

28. Verification of the flood stages on 10 March 1989 was determined in the same fashion as for the elevation-area curves. The classified flood scene was printed at 1:24000 on transparent vellum and sandwiched with a 1:24000-scale quadrangle map. Alternately, this was done digitally by overlaying a translucent image of the flood scene on top of a digital quad sheet (USGS Digital Raster Graphics). The extent of flooding was compared to the flood elevations for that date and the elevation contours by visual comparison on a light table. The 10 March 1989 flood scene has falling stages and generally overestimates the areal extent of flooding

for the river stages on that date. For example, the river stages at Holly Bluff and Little Sunflower Structure were 91.5 and 90.0 feet, NGVD, respectively, but the areal extent of flooding indicates the water surface was higher. Thus, the selected flood scene conservatively estimates the areal extent of wetlands. This is illustrated on Plates 10-11 and 10-12. Plates 10-11 and 10-12 each depict two flood scenes, 10 March 1989 and 21 March 1987. The 21 March 1987 scene is depicted in dark blue. The areal extent of the 10 March 1989 flood is represented by the combined areas in dark and light blue. The water surface at points along the river between gages was determined by linear interpolation. Plate 10-10 shows that the water surface elevation at Holly Bluff is above the 90-foot contour and less than the 95-foot contour. Plate 10-12 shows that the flooded area is very close to the 90-foot contour, which is the water surface elevation at the Little Sunflower gage. This type of analysis was performed for each flood scene at each gage to insure that the observed gage elevations matched the flood elevations on these dates.

Field Verification of Wetland Delineation

29. Verification was performed by the Vicksburg District's Regulatory Branch using the 1987 Manual during the summer of 2001. Onsite techniques or visual verification was performed utilizing Digital Raster Graphics maps with the flood scene superimposed on the quadrangle map. Fifty-four sites were checked using these techniques. The sites were not randomly selected. Instead, the sites were selected along the gradient separating the wet areas from nonwet. More sites were selected in areas where the gradient was poorly defined. Agreement was found in 52 of the 54 sites. The high level of agreement supported the use of the 5 percent duration elevation as an offsite indicator of wetland hydrology. The sampling sites are shown on Plate 10-13.

CONCLUSION OF OFFSITE WETLAND DELINEATION

30. The Vicksburg District applied an offsite wetland delineation method that utilized a satellite image of a 5 percent duration flood as the visual indicator of wetland hydrology. All areas flooded in the satellite image were considered wetlands. Results of the delineation were field tested using the WDM, and agreement was found at 52 of 54 sites. The Vicksburg District considered this level of agreement acceptable, and the results were used to depict the base wetlands in the study area. Although the Vicksburg District considered the results acceptable, EPA requested a more extensive randomly sampled verification. The Vicksburg District agreed to the request, and that verification study is described later in this report (paragraphs 47-59) and Supplement B.

WETLAND IMPACTS DETERMINATION

INTRODUCTION

31. There are many possible ways that wetlands can be affected by projects. Physical alterations are the most severe and generally involve draining or filling of the wetlands. Draining involves the digging of a ditch or deepening a channel such that a wetland will no longer store water. Filling involves the physical placement of material in the wetland, such that it no longer floods. Other than 38 acres at the pump station site, this project will not physically alter any wetlands. The structural feature of this project will change the water surface of floods greater than the 1-year frequency flood. This will reduce the areal extent and the duration of floods greater than the 1-year flood. The change in the water surface will be slow and gradual. If the pump station were the sole means of evacuating flood water, it would take 25.2 days to reduce the water surface elevation at the Steele Bayou structure from 91 to 87 feet (2-year frequency flood = 90.0 feet, 1-year frequency flood = 87.0 feet). This amounts to an average daily change in the water surface of 0.16 foot. Thus, it would take just over 6 days to lower the water surface 1 foot. The above is the average change in the flood water surface. It was determined by subtracting the 1-year flood volume from the 2-year flood volume and dividing by the daily pumping capacity (approximately, 27000 acre-feet per day). The actual change in the water surface will be greater near the pump station and less in the headwaters of the study area. The impacts to wetland hydrology described in this section are based on the assumption that backwater flooding is the only source of water to sustain wetlands. It assumes that precipitation does not have any effect on wetland hydrology in the study area. This is a very conservative assumption, given that the basin averages more than 51 inches of rain a year. After the base condition wetlands are delineated, the postproject wetland extent must be predicted. It is possible to determine the postproject wetland extent by repeating the previously described procedure; however, finding a flood scene with stages that closely approximates the postproject condition for each of the alternatives that were carried into the final array would be difficult. Instead, a GIS-based flood model was applied for the base condition and each of the alternatives.

METHOD

32. The period-of-record stages for the five pump station alternatives (Alternatives 3-7) were developed by the routing model. These stages were also analyzed by the WETSORT Program to determine the postproject wetland elevations for each gage. The WETSORT Program was

discussed previously (paragraph 24) and in the Engineering Appendix. The program sorts the annual duration periods from highest to lowest and determines the median elevation. There are two reasons for using the median elevations instead of the means. The first is that the Federal Wetlands definition of wetlands states that wetlands must be inundated or saturated to the surface continuously for a minimum of 5 percent of the growing season in most years. As the median value is the 50th percentile value, it guarantees that the requirement "in most years" is met in a period-of-record analysis for exactly 50 percent of the years. The second reason is that the median value is greater than or equal to the mean at most stations (five of six) for the base 5 percent duration condition. (NOTE: Steele Bayou at Rolling Fork was the only station with the mean 5 percent duration elevation greater than the median.) This station is more than 40 miles upstream of the Steele Bayou structure and it is upstream of two weirs. The use of the mean at this gage would have had little impact on the wetlands delineation.) The decision to use the median wetland elevation instead of the mean elevation provides a conservative estimate of base wetland extent.

UNCERTAINTY

33. A GIS model (Flood Event Simulation Model (FESM)) was used to model both the mean and the median 5 percent duration extents for comparison. The median 5 percent duration area is 189,600 acres, while the mean 5 percent duration area is 174,600 acres. The difference between the two is 15,000 acres which represents 7.5 percent of the total wetland extent. The larger areal extent based on the median values was used as the base for this study because it is more protective of wetlands. Whether the mean or median elevations are used to determine the areal extent of wetlands, there is a margin of error associated with those statistics. The 90th percent confidence band was calculated about the mean and median 5 percent duration elevations at all gages. This 90th percentile elevation range was used to determine a range for the areal extent of the 5 percent duration wetlands. The areal extent based on the lower confidence band about the median elevations is 150,800 acres and is 228,200 acres for the upper confidence band. The 90th percent confidence range of the areal extents of the 5 percent duration wetlands based on the mean elevations is 140,500 to 211,800 acres.

GIS-FLOOD SIMULATION MODEL

34. The Vicksburg District used two GIS models to simulate flooding. They were called the Flood Event Assessment Tool (FEAT) and FESM models. The FEAT model is an Arc-View extension developed by ERDC, Environmental Laboratory (EL), for the Vicksburg District. The FESM model is a stand-alone model that uses the same input files as the FEAT model. It was developed in-house by the Vicksburg District. The model adds the ability to determine the depth of flooded areas, as well as some other features. The models were developed to show the areal

extent of flooding using stage data. Both models gave very similar results, with respect to flood simulations. The models are described in the Engineering Appendix. The FEAT model was developed in 1999 and was used through 2004. The FESM model was completed in 2004, and all of the modeling results described in this report were products of the FESM model. Studies utilizing the FEAT model have been published in peer-reviewed journals (Ballard and Kress, 1998 and 1999). Studies utilizing the FESM have been presented at professional conferences, but no study has been published in a peer-reviewed journal to date. There are five steps in applying these models to predict changes in wetland area--acquire or create input data layers, calibrate the model output to one or more satellite scenes, verify the model output versus another satellite scene, run the base and with-project conditions, and determine the changes in wetland area for each of the alternatives.

FESM Model Data

35. The first step in applying the FESM model is building the required input data sets. The model uses five data layers. Three are required input, while two are optional. All five were used in this modeling effort. The required input layers are: an elevation model of the basin, point coverage with water surface elevations, and line coverage of the basins major streams. The optional layers are a line file with secondary channels and a grid coverage of land cover to provide the land use of flooded areas. The quality of the model output is dependent mainly on the quality and accuracy of the elevation data. The elevation data used in this study were developed from USGS 1:24000-scale Digital Elevation Model (DEM) files. These are grid files with elevations posted every 30 m and are based on the hypsography layer (elevation contours) from 1:24000-scale quadrangle sheets. A map scale of 1:24,000 means that each inch on the map represents 24,000 inches or 2,000 feet. According to the National Map Standards, the minimum resolution between two objects on a map is 1/50th of and inch or 40 feet on a 1:24,000 scale map. For instance, the minimum distance between two elevation contour lines would be 40 feet. Thus obtaining an elevation every 30 m (98.43 feet), as for the DEMs, is within the resolution of the maps. For most of the United States, the elevation contour interval on 1:24,000 scale maps is 20 feet, but because the Mississippi Delta is so flat, the contour interval is 5 feet. Although the minimum distance between contour lines is 40 feet, the average distance is much greater. Thus, most of the posting on a DEM was determined by interpolation of the elevation between adjacent contour lines. The elevations are interpolated to the nearest tenth of a foot. The accuracy of the elevations on a 1:24,000 quadrangle map are plus or minus one-half a contour interval or 2.5 feet. The accuracy of elevations on the DEMs is also ±2.5 feet. The channel file was digitized from 1:24000-scale Digital Line Graph (DLG, hydrography) files or from Digital Raster Graphics (DRG) data files. The water surface elevation file was digitized from the 1:24000-scale DRG files of the quadrangle sheets. An example of the three vector layers and the DEM is presented on Plate 10-14. The water surface values were determined from stage records by interpolation between gages.

FESM Model Calibration

36. The second step in applying the model is to calibrate the model. Calibration is accomplished by simulating one or more flood scenes. The 10 March 1989 flood scene was the first calibration scene used in this study. Before running the model, the areal extent of the flood scene is checked for reasonableness. The areal extent of flooding does not track the changes in gage elevation perfectly. When stages are rising, the areal extent will be less than expected, but will be greater than expected when stages are falling. This scene has falling stages in the upper part of the basin and nearly constant stages in the lower part of the basin (Table 10-5). The combination of falling stages and the gage elevation greater than the 5 percent duration elevation at two gages means that the 10 March 1989 flood scene will overestimate wetland extent in the study area. The second calibration scene was 21 March 1987. The 21 March 1987 scene was acquired one day past the peak at most gages, and the flood scene may underestimate flooding somewhat. Plate 10-11 shows the March 1989 and 1987 floods in the vicinity of Holly Bluff. Both floods have gage readings of 90.5 feet at Holly Bluff, and the areal extent of flooding is nearly identical. Plate 10-12 shows the same two floods near the Little Sunflower Control Structure. The March 1989 flood has a water surface of 90.0 feet, and the March 1987 flood has a water surface of 86.3 feet at that gage. The 3.7-foot difference in the water surface elevations creates greatly different flood extents. The FESM model accurately reflected this difference in the water surface slope between the two gages. Once the appropriate stages that match the extent of a flood scene are determined, the model simulations can begin. The model output is then compared to the TM flood scene. Intermediate nodes and secondary channels are added to calibrate the model output to the observed flood. This is an iterative process of running the model, comparing the model to the flood scene, and adjusting the model until a satisfactory fit is obtained. When the DEM indicates depressions that are flooded in the satellite image, but not flooded by the model, the DLG hydrology layer is checked to see if stream channels exist that would connect these depressions. If streams existed, then secondary channels are added to connect these depressions. Off-channel flooded areas, with no corresponding depressions in the DEM or no stream connection, are considered detached, and it is unlikely that these areas will be impacted by the project. In some cases, the addition of secondary channels is not enough to achieve a good fit to a flood scene, then additional main channels are added. Main channels differ from secondary channels in that they require additional water surface nodes. The water surface at these nodes may be unknown and must be estimated by examination of the satellite image or extrapolated from existing stage data and stream profiles. Examples of major tributaries that were added to the gaged (main channels) streams are Silver Creek, Straight Bayou, Dowling Bayou, and Panther Creek. These are illustrated on Plate 10-15. (Added main channels are highlighted in yellow.) More sites were selected in areas where the gradient was poorly defined.

TABLE 10-5
SATELLITE SCENE GAGE ELEVATIONS
(feet, NGVD)

Scene Date	Big Sunflower Moorhead	BigSunflower L. Callao	BigSunflower Anguilla	BigSunflower Holly Bluff	Little Sunflower Landside	Steele Bayou Landside	Steele Bayou Rolling Fork
6-Mar-89	102.9	96.6	94.7	92.2	89.7	89.3	89.7
7-Mar-89	102.0	96.0	94.3	92.0	89.8	89.4	89.5
8-Mar-89	101.1	95.4	93.5	91.9	89.9	89.6	89.5
9-Mar-89	100.0	94.7	92.7	91.7	89.9	89.7	89.6
10-Mar-89	99.2	94.0	92.5	91.5	90.0	89.7	89.7
19-Mar-87	104.8	98.1	94.8	90.7	85.6	84.0	91.9
20-Mar-87	105.7	98.7	95.2	91.6	86.2	83.5	91.6
21-Mar-87	105.5	98.3	95.1	91.5	86.3	83.1	90.6
9-Jan-83	111.1	102.5	99.0	95.7	92.9	91.8	94.6
10-Jan-83	110.3	102.0	98.9	95.7	93.1	91.9	94.3
11-Jan-83	109.3	101.7	98.6	95.6	93.2	92.0	94.0
12-Jan-83	108.1	101.3	98.4	95.6	93.2	92.0	93.7
13-Jan-83	107.0	100.8	98.1	95.5	93.1	91.9	93.5

37. In general, when using the FESM model to simulate backwater flooding, tributaries with ungaged nodes should not be added. Flooding along these tributaries must be due to headwater flooding, which results from a water surface that rises as you move upstream in the tributary. However, calibration to flood scenes often requires the addition of these streams, because the flood scene may represent a combination of headwater and backwater flooding. The calibration was considered complete when the model output matched the flood scene for flooded areas contiguous to the river as illustrated on Plate 10-16. (Main channels contiguous to flooding are highlighted in yellow.) The areas contiguous to the streams are given priority because these are the major areas affected by backwater flooding. A perfect fit between the FESM model flood and the satellite image of the flood is not possible because the satellite scenes capture all areas flooded, including ponded precipitation. The major difference between the extent of flooding between satellite scenes and the FESM model is likely because the FESM model only captures riverine flooding, while the flood scenes capture both riverine flooding and direct ponding of precipitation. Other differences in the extent of flooding are due to the DEM and whether stages are rising or falling on the date of acquisition of the satellite scene. Table 10-6 provides the LULC information for the two calibration and the validation flood scenes. The three scenes represent varying amounts of flooding. The 10Mar89 scene is primarily a backwater flood. The 21Mar87 scene is a headwater flood, while 13Jan83 is a combination headwater-backwater flood. Because the flood scene classifications capture all areas inundated by water, including intentionally ponded areas such as catfish ponds and waterfowl impoundments, the total flooded area for each of the flood scenes has been adjusted to remove catfish ponds. Other permanent

water bodies and ponded precipitation have not been removed. The FESM model will flood most depressional areas that form lakes, but it cannot flood catfish ponds because the DEM files do not include the elevations of catfish pond levees. The effect of removing the catfish ponds will be discussed later in this section. A second category of intentionally ponded water is greentree reservoirs (GTR). Delta National Forest (DNF) contains five impoundments that are located in the DNF. These impoundments are isolated by levees and are filled by pumping. They generally contain water from November through March of most years. The GTRs are shown with cross hatching in Plates 10-17 and 10-18. The DNF also contains 12 water control structures which pond water in sloughs during the waterfowl season. The flooding in the 13Jan83 flood was so extensive that all of the GTR levees were overtopped.

TABLE 10-6
2005 LAND USE OF CALIBRATION AND VALIDATION
SATELLITE FLOODS

LULC- Acres	10-Mar-89	21-Mar-87	13-Jan-83
Crop	28,277.6	22,038.4	147,313.7
Noncrop	23,959.6	16,784.7	43,568.5
Forest	129,032.5	111,191.1	211,472.5
Water	16,487.3	16,520.8	17,180.9
Catfish Pond	277.8	332.4	3,019.4
Total a/	198,034.8	166,867.4	422,555.0
Total Less Permanent Water	181,269.7	150,014.2	402,354.7

a/ Total area covered by floodwaters on the date of the satellite scene.

38. When comparing the FESM model to flood scenes, the effect of changing water surface elevations must be considered. Table 10-5 provides the water surface elevations for the calibration and validation flood scenes on the date of the scene and for several days prior to the scene. The four gages on the right side of the table show less than 1 foot of elevation change over the period from 6Mar89 to 10Mar89. The upper three gages exhibit a drop in water surface elevation from 2.2 to 3.7 feet over the same period. The 10Mar89 FESM simulation (Plate 10-17) does not indicate any flooding in the upper part of the Big Sunflower Basin, but the 6Mar89 FESM simulation does indicate minor flooding in that area (Plate 10-17 inset). The delay between the observed flooding and stages at gages is more pronounced in the second calibration scene. The FESM model does a good job of simulating the 21Mar87 flood in the Big Sunflower Basin, but does not do so well in the Steele Bayou Basin (Plate 10-18). The hydrograph of the stage elevations over the period of the flood is provided on the bottom of Plate 10-18. All of the upstream gages show that two similar flood events passed through the basin during March of 1987. The lower two gages were, however, more influenced by mild backwater flooding. The Steele Bayou gage starts rising before the first flood, reaches a peak

between the events, and then falls slowly. An FESM simulation of 13Mar87 in the Steele Bayou Basin is provided an inset in Plate 10-18. This simulation reflects the observed flooding in the Steele Bayou Basin much better than one using the stages on the date of the flood. Although the stage had been dropping slowly for 8 days, the extent of flooding was much closer to the peak stage than the actual stage on the date of the satellite scene acquisition. Plate 10-19 shows the FESM simulation of the 13Jan83 satellite flood versus the observed flood. This flood is similar to the 10Mar89 flood in that the stages in the lower part of study area are fairly stable, but stages in the upper Big Sunflower Basin are dropping quickly. Stages dropped more than 4 feet from 9Jan83 to 13Jan83 at the Moorhead gage. The inset in Plate 10-19 shows the results of a FESM simulation using the 9Jan83 observed stages. The observed flooding in the upper Big Sunflower Basin matches the stages on 9Jan83 much better than the 13Jan83 stages. The above discussion illustrates that the flooding and draining of lands susceptible to flooding is not an instantaneous process, but one that takes considerable time. The calibration of the FESM model to flood scenes is improved when the changes in the water surface elevations over several days are taken into consideration. Table 10-7 shows the results of the comparison of the FESM modeled floods to the actual floods. In addition, FESM results for other dates prior to the actual flood scene are also provided to better assess the FESM models capabilities.

39. The second block of data in Table 10-7 is from the same 10Mar89 calibration run, but the acres of catfish ponds from the satellite scene are removed from the total flooded area. This changes the total area flooded in the satellite scene from 233,755 to 198,027 acres (cells D15 and D25). This changes the gross estimate of the area flooded by the FESM model from 85.9 to 101.5 percent (cells H16 and H26). Examining the <2Yr zone shows that the FESM model provided a gross estimate of 113 percent of the satellite flood, and the FESM model shared 83.4 percent of the satellite flood. This improves the gross and spatially explicit estimates by around 5 percent. More importantly, the percent of the total flood in the frequently flooded zone changes from 75 to 84 percent. The comparisons for the remaining calibration and validation runs will be based on the catfish acres being excluded.

40. The second calibration flood scene was 21Mar87. This is a headwater flood. The stages at the lower end of the study area are 5.3 to 7.9 feet less than the 2-Year flood, but they are 2.0 to 3.7 feet higher than the 2-Year flood in the upper part of the study area. Roughly 79 percent of the flooding was inside the <2Yr flood zone, 14 percent was in the 2-100Yr zone, and the remaining 8 percent was in the >100Yr zone. The 79 percent of the total flood in the <2Yr zone, flooded 40.3 percent of the area. The FESM model provided a gross estimate of flooding that was 105.7 percent of the satellite flood, and 63.0 percent of the satellite flood was shared with

TABLE 10-7

STATISTICS FOR THE THREE FLOOD FREQUENCY BANDS

	A	B	C	D	E	F	G	H	I
10-Mar-89 Catfish Included									
11	Class	2-year	2-100Yr	>100Yr	Total	2-year	2-100Yr	>100Yr	% Total
12	Fesm	46299.9	5537.9	4947.0	56784.8	26.4%	15.4%	21.8%	24.3%
13	Flood	34146.7	34087.3	21514.6	89748.5	19.5%	94.9%	95.0%	38.4%
14	Shared	141215.2	1819.4	1136.0	144170.6	80.5%	5.1%	5.0%	61.6%
15	total Flood	175361.9	35906.7	22650.6	233919.2	54.0%	11.9%	7.6%	25.3%
16	Total Fesm	187515.1	7357.3	6083.0	200955.5	106.9%	20.5%	26.9%	85.9%
17	total Area	324905.7	302896.7	298079.4	925881.7	75.0%	15.4%	9.7%	100.0%
10-Mar-89 Catfish Excluded									
21	Class	2-year	2-100Yr	>100Yr	Total	2-year	2-100Yr	>100Yr	% Total
22	Fesm	48991.6	5642.7	5044.4	59678.6	29.5%	28.1%	42.5%	30.1%
23	Flood	27535.4	18392.0	10833.0	56760.3	16.6%	91.5%	91.3%	28.7%
24	Shared	138513.5	1714.6	1038.7	141266.8	83.4%	8.5%	8.7%	71.3%
25	total Flood	166048.9	20106.6	11871.6	198027.1	51.1%	6.6%	4.0%	21.4%
26	Total Fesm	187505.1	7357.3	6083.0	200945.4	112.9%	36.6%	51.2%	101.5%
27	total Area	324885.6	302622.0	296971.3	924478.8	83.9%	10.2%	6.0%	100.0%
21-Mar-87 Catfish Excluded									
31	Class	2-year	2-100Yr	>100Yr	Total	2-year	2-100Yr	>100Yr	% Total
32	Fesm	55787.3	1479.0	326.3	57592.7	42.6%	6.6%	2.4%	34.5%
33	Flood	48366.4	21828.1	13158.5	83353.0	37.0%	96.8%	98.2%	50.0%
34	Shared	82529.5	722.9	242.3	83494.7	63.0%	3.2%	1.8%	50.0%
35	total Flood	130895.9	22551.0	13400.8	166847.7	40.3%	7.5%	4.5%	18.1%
36	Total Fesm	138316.8	2202.0	568.6	141087.4	105.7%	9.8%	4.2%	84.6%
37	total Area	324885.6	302622.0	296826.7	924334.3	78.5%	13.5%	8.0%	100.0%
13-21Mar87 Catfish Excluded									
41	Class	2-year	2-100Yr	>100Yr	Total	2-year	2-100Yr	>100Yr	% Total
42	Fesm	64191.9	2625.4	1288.5	68105.9	49.0%	11.6%	9.6%	40.8%
43	Flood	36828.9	21309.7	12285.1	70423.7	28.1%	94.5%	91.7%	42.2%
44	Shared	94066.9	1241.4	1115.7	96424.0	71.9%	5.5%	8.3%	57.8%
45	total Flood	130895.9	22551.0	13400.8	166847.7	40.3%	7.5%	4.5%	18.1%
46	Total Fesm	158258.9	3866.8	2404.3	164529.9	120.9%	17.1%	17.9%	98.6%
47	total Area	324885.6	302622.0	296826.7	924334.3	78.5%	13.5%	8.0%	100.0%
13-Jan-83 Catfish Excluded									
51	Class	2-year	2-100Yr	>100Yr	Total	2-year	2-100Yr	>100Yr	% Total
52	Fesm	40892.6	28787.4	822.9	70502.9	15.0%	27.5%	1.8%	16.7%
53	Flood	7509.9	70903.4	42030.2	120443.5	2.8%	67.8%	93.9%	28.5%
54	Shared	265266.0	33741.9	2725.0	301732.8	97.2%	32.2%	6.1%	71.5%
55	total Flood	272775.8	104645.2	44755.2	422176.3	84.0%	34.5%	15.0%	45.6%
56	Total Fesm	306158.6	62529.3	3547.9	372235.8	112.2%	59.8%	7.9%	88.2%
57	total Area	324905.7	302897.5	297818.4	925621.6	64.6%	24.8%	10.6%	100.0%
9-Jan-83 Catfish Excluded									
61	Class	2-year	2-100Yr	>100Yr	Total	2-year	2-100Yr	>100Yr	% Total
62	Fesm	45537.6	55199.4	5570.8	106307.9	16.7%	52.7%	12.4%	25.2%
63	Flood	3980.8	44754.4	38090.4	86825.6	1.5%	42.8%	85.1%	20.6%
64	Shared	268795.0	59890.8	6664.9	335350.6	98.5%	57.2%	14.9%	79.4%
65	total Flood	272775.8	104645.2	44755.2	422176.3	84.0%	34.5%	15.0%	45.6%
66	Total Fesm	314332.6	115090.2	12235.7	441658.5	115.2%	110.0%	27.3%	104.6%
67	total Area	324905.7	302897.5	297818.4	925621.6	64.6%	24.8%	10.6%	100.0%

the FESM modeled flood in the <2Yr flood zone. Only 7.5 percent of the 2-100Yr zone was flooded by the satellite scene, and the FESM model estimated less than 10 percent of that area. Again, the observed stages on the date of the flood and the period immediately before the date of the satellite scene were much less than the 100Yr stages, thus the flooding in the third zone (>100Yr) must be from ponded rainwater.

41. Returning the discussion to the 10Mar89 flood scene, Plates 10-20 to 10-22 provide closeup views of the flooding observed in the three flood zones discussed above. Plate 10-20 shows the flooding in the <2Yr zone in the lower part of the study area. Flooding in the <2Yr flood zone is concentrated in and around the two ponding areas. The edges of these flooded areas are generally gentle curves following the contours of the land. Many of the bounding features are natural levees. Additional flooding is observed within abandoned channel features or in the swales between point bars. The pattern of flooding in the >100Yr flood zone is quite different. This can be observed in Plate 10-21. Approximately one-third of the flood acres in this flood zone are crop acres. Some of these crop acres are displayed in Plate 10-21. These flooded crop acres differ from those in Plate 10-20 because the edges of the flooded areas are straight lines. This generally indicates that the floodwater is being retained by levees. Many farmers will intentionally pond water in agricultural fields during the fall and winter to attract waterfowl. Because the land in this flood zone is above the 100-year flood elevation, the flooding on these agricultural lands is not from backwater flooding. Additional flooding in the >100Yr flood zone shows up as shadow flooding along the edge of Lake Washington and Steele Bayou. This is due to a slight difference in the positioning of the flood scene and the DEM. Most of the flooding in forested areas appears to be associated with depressional areas in abandoned channel geomorphic features. In summary, most of the flooding in the >100Yr flood zone appears to be in natural or manmade ponding areas and does not represent actual out-of-bank flooding as is observed in the <2Yr flood zone. Flooding in the 2-100Yr flood zone is displayed in Plate 10-22. The 10Mar89 flood scene was added to help illustrate the likely sources of flooding in this flood zone. Flooding in the three circled areas is a continuation of flooding from the <2Yr flood zone. This flooding was likely included due to small errors in the DEM elevations, which moved the lands out of the 2-year flood plain. One of the three circled areas includes a greentree reservoir and the floodwaters may actually be intentionally ponded waters for waterfowl. The greentree reservoirs are filled by pumps and therefore flood areas above the normal flood elevations. Flooding is also noted just outside of the boundary of the South GTR, but within the normal ponding elevation range of that reservoir. Some ponding is also observed in agricultural fields that exhibit linear edges, which indicates intentional ponding for waterfowl. The flooding in the 2-100Yr flood zone appears to be a mix of what is seen in the other two flood zones. Some of the flooding is in areas adjacent to the <2Yr zone and this is likely from backwater flooding. The rest of the flooding is scattered in small areas across the flood zone and likely represents ponded water in natural or manmade depressions, but not the result of backwater flooding.

42. Another way to view the flooding in the satellite flood scenes is to convert the flooded area into the basin's geomorphology. In Plate 10-23, the area flooded by the 10Mar89 satellite flood has been converted into its geomorphology. Also included in the plate are GIS layers for streams and natural levees. Almost all of the flooding is contained in areas bounded by the natural levees. The natural levees act as the sides of bowls and contain the flooding. Two areas identified with circles in the northwest corner of the basin show flooding on the natural levees. These are the same areas that were identified in Plate 10-21 as areas where the flooding was likely intentionally induced on agricultural lands for the management of wintering waterfowl. Knowing these areas are positioned on the sides of natural bowls and that there is very little flooding in the bottom of the bowls reinforces the possibility that the flooding is intentionally induced. It is also evident in Plate 10-23 that most of the major stream channels occur within natural levee features. The natural levees prohibit flooding in the lands adjacent to the channels because this is the highest land. Where the stream channel lies within the natural levee feature, flooding occurs on lower-lying lands away from the major streams. Within the two ponding areas, some of the major streams are no longer contained within the natural levee features, and flooding occurs in the lands immediately adjacent to the channel. The major stream segments not contained in natural levees are shown in yellow in Plate 10-23. Flooding within these ponding areas occurs on Backswamp deposits. Nearly one-half of all of the areas shown as flooded in the 10Mar89 flood scene occurs on Backswamp deposits (46.4 percent). The next largest category flooded is Point Bar (31.7 percent), and most of this is located next to the Backswamp within areas bounded by natural levees. Two conclusions arise from the analysis of the geomorphology of the 10Mar89 flood. First, most of the flooding depicted occurs within the ponding areas and occurs on lands whose geomorphology (Backswamp) is indicative of a long history of backwater flooding. Second, some of the flooding the occurs in the >100Yr flood zone occurs on natural levee features where flooding would not be expected except during extreme flood events and therefore the flooding is induced.

FESM Model Validation

43. Once the model is calibrated, it must be verified using an additional satellite scene. The 13Jan83 flood scene was used for model validation. The flood is a combination of a backwater flood in the lower portion of the basin, and a headwater flood in the upper part of the basin. The observed stages exceeded the 2-year flood at all, but the most upstream gage on the date of the satellite overpass, but the observed stages had been several feet higher at some locations in the days prior to the satellite scene acquisition. The total area flooded in the satellite scene was 422,176 acres. This exceeds the total area in the <2Yr flood zone by almost 100,000 acres, but only 272,775 acres in this zone were flooded. The FESM model provided a gross estimate of flooding in this zone that was 112.1 percent of the observed flood. The FESM modeled area shared 97.2 percent of the area flooded in the satellite scene. Because the observed stages exceeded the 2-year frequency flood for most of the area, much of the 2-100Yr flood zone was also flooded. Approximately 25 percent of the total flood was in the 2-100Yr zone, and

34.5 percent of the zone was flooded. The FESM model provided a gross estimate that was 59.8 percent of the observed flood and shared 32.2 percent of the area flooded in the satellite scene. Examination of the observed stages for the period of 9 through 13 Jan83 at the Moorhead and Little Callao gages will show that the stages were rapidly dropping during the period. Although one of the assumptions in the model study was that all areas would be flooded instantly, this assumption is generally valid for a long duration flood event, but not necessarily valid for a headwater flood. It takes time for floodwaters to move from the channels onto the land and back. The greater the distance the floodwaters are from the main channel, the longer it will take for the floodwaters to arrive or recede. To illustrate this, the FESM model was used to simulate the flood on 9Jan83 and this flood extent was compared to the observed flood on 13Jan83. Plate 10-19 has an inset which shows the results of the FESM simulation of the observed stages on 9Jan83 compared to the 13Jan83 flood event. The observed stages in the Steele Bayou and Little Sunflower ponding areas were relatively stable over this period, but the stages in the upper part of the study area fell from 2 to 4 feet during this period. The hydrograph for the project gages is provided at the bottom of Plate 10-19. The results of the 9Jan83 FESM simulation are presented in Table 10-7 lines 61 through 67. The FESM model provided a gross estimate of 112.2 percent of the observed flood in the <2Yr zone, with a shared area percentage of 98.5. The FESM model provided a gross estimate of flooding in the 2-100Yr flood zone that was 110.0 percent of the observed satellite flood and shared 57.2 percent of the flooded area. This is the best performance of the FESM model in this zone, but this was the first flood with significant flooding observed in the 2-100Yr flood zone. Overall, the FESM model performs very well when the flooding is in the two ponding areas that are adjacent to the main channel in the lower part of the study area. It does less well when flooding is in ponding areas away from the channel and when the observed water surface elevation is changing rapidly. This can be restated as the FESM model does a better job of predicting the areal extent of longer duration backwater floods, than it does of short duration headwater floods. In general, the FESM model overestimates flooding in the vicinity of the two ponding areas, which results in a conservative estimate of wetland extent.

44. Once the FESM model was calibrated, the postproject water surfaces for Alternatives 3-7 were developed with period-of-record stage data. The 5 percent duration wetland elevations for the base conditions and the respective plans are presented in Table 10-8. The areal extent of wetlands was determined based on the 5 percent duration elevations for each of these conditions. The areal extent for each of the plans is presented in Table 10-9 by land-use category. The land use of 5 percent duration wetlands for the base condition is depicted on Plate 10-24.

TABLE 10-8
GAGE ELEVATIONS FOR BASE AND WITH-PROJECT
CONDITIONS – 5 PERCENT WETLAND DURATION ELEVATION (NGVD)

Gage Location	Base	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
Steele Bayou, Landside	88.6	84.7	86.3	87.1	87.8	88.4
Steele Bayou, Grace	91.9	91.5	91.6	91.7	91.8	91.8
Little Sunflower, Landside	89.3	86	87.2	88	88.5	89
Big Sunflower at Holly Bluff	91	88.9	89.2	90.2	90.2	90.6
Big Sunflower at Anguilla	93.3	92.6	92.9	93	93.1	93.1
Big Sunflower at Little Callao	94.4	94.1	94.2	94.3	94.3	94.3

TABLE 10-9
LAND USE OF THE 5 PERCENT DURATION WETLANDS a/

5 Percent Duration Wetlands Land Use	Alternative					
	Base	3	4	5	6	7
Crop	26,100	15,600	17,400	19,500	20,700	22,800
Noncrop	9,300	6,100	6,500	7,100	7,600	8,500
Bottom-land Hardwoods	98,100	59,900	76,600	87,100	90,000	94,200
Reforest	40,000	26,300	30,900	34,200	35,800	38,400
Catfish	1,280	500	600	800	900	900
Permanent Water Bodies	14,600	14,000	14,300	14,400	14,400	14,600
Miscellaneous	220	200	200	200	200	200
Total	189,600	122,600	146,500	163,300	169,600	179,600

a/ Based on 2005 land use.

FESM Model Duration Zones

45. The FESM model wetland delineations were based on the 5 percent duration elevations. To facilitate a detailed determination of the project’s impacts to wetlands, the wetlands were subdivided into five intervals based on percent flood duration. The five periods of duration were 2.5, 5.0, 7.5, 10.0 and 12.5 percent duration of the growing season. These five periods represent intervals of approximately 7 days each. The five durations were 7, 14, 20, 27 and 34 days respectively. The use of several duration periods improves our ability to accurately monitor the change in wetland functional values due to project-induced changes in the duration of flooding. Plate 10-25 shows the area flooded by the base 5 percent duration period. This area will be called the 5 percent duration zone. Plate 10-26 shows the base 7.5 percent duration zone plotted on top of the base 5 percent duration zone. The smaller 7.5 percent duration zone covers part of the 5 percent duration zone. The 7.5 percent duration range is totally encompassed by the

5 percent duration range, for every area flooded for 20 days continuously is also flooded for 14 days continuously. The portion of the 5 percent duration range that remains visible represents the area flooded for 5 to 7.5 percent of the growing season (14-20 days), and it will be labeled the 5 to 7.5 percent duration interval (5 to 7.5 interval). In the same fashion, the 10 and 12.5 percent duration ranges are plotted on top of the 5 and 7.5 percent duration ranges, the visible portions of each are the 7.5 to 10 percent duration interval and the 10 to 12.5 percent duration interval. The 12.5 percent duration range is shown in its entirety, as that is the range with the longest duration and the smallest area. All five of the base composite duration ranges are plotted on Plate 10-27. The five ranges are merged into a single grid layer in ArcView. The base intervals are given the following grid values: <5 to 5 percent interval = 10, 5 to 7.5 percent interval = 20, 7.5 to 10 percent interval = 30, 10 to 12.5 percent interval = 40, and the >12.5 percent interval = 50. In a similar fashion, the with-project duration elevations are modeled with the FESM model and with-project duration ranges are plotted creating the with-project duration intervals. The base <5 percent duration zone is also merged with the with-project intervals to provide a grid coverage with exactly the same areal extent as the base condition. The individual ranges for each pump station alternative are also merged into a single grid file for each alternative. Plate 10-28 displays an example of the postproject (Alternative 5) composite duration intervals. The grid cell values for the composite with-project (post) duration intervals are: base <5 to post <5 percent interval = 0, post <5 to 5 percent interval = 1, post 5 to 7.5 percent interval = 2, post 7.5 to 10 percent interval = 3, post 10 to 12.5 percent interval = 4, and the post >12.5 percent interval = 5.

46. With these numerical assignments of grid values, each pre- and postproject duration interval has a unique value. The two grid files are then added pixel by pixel and the resulting file will be called the Plan X composite wetlands. The resulting grid file has grid cell (pixel) values ranging from 10 to 55. Each grid cell value reflects both the pre- and postproject wetland duration interval. For instance a grid cell value of 22 means that that grid cell is in the 5 to 7.5 percent duration interval both pre- and postproject. A composite wetland grid value of 32 means, the cell was in the 7.5 to 10 percent duration interval preproject and in the 5 to 7.5 percent duration interval postproject. This shows that the wetland would experience a shorter duration of flooding postproject than it had experienced under preproject conditions. The areal extent of each cell in acres for the base and each alternative is provided in Table 10-10. The base conditions acreage is provided in the cell values that show no change (11, 22, 33, 44, and 55). The composite wetland file for each pump station alternative has 30 possible cell values. The composite wetlands for the Alternative 5 alternative is shown in Plate 10-29. In order to evaluate the impacts to wetlands by the various structural or combination alternatives (Alternatives 3-7), the number of cells with each value are summed, and the areal extent of the wetlands represented by each value calculated. Functional values for eight wetland functions are evaluated for each of these composite wetland maps. The functional assessment of wetland values are fully discussed in Supplement B of this Appendix. The total areas, within each duration interval and each duration zone by Alternative, are presented in Table 10-11. Table 10-11 also shows the losses to the base

TABLE 10-10
ACRES OF WETLANDS BY COMPOSITE
WETLAND CELL VALUE

Cell Value	Description	Base	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
10	Base <5 to Post <2.5		31,873	29,564	27,722	23,975	14,970
11	Base and Post <5	39,251	7,361	9,687	11,509	15,276	24,280
12	Base <5 to Post 5		16	-	18	-	1
13	Base <5 to Post 7.5		0	-	1	-	-
14	Base <5 to Post 10		0	-	0	-	-
15	Base <5 to Post >12.5		0	-	0	-	-
20	Base 5 to Post <2.5		28,014	26,316	11,702	3,748	948
21	Base 5 to Post <5		4,459	5,463	13,371	16,032	8,990
22	Base and Post 5	35,402	2,890	3,622	10,285	15,622	25,454
23	Base 5 to Post 7.5		39	-	42	-	9
24	Base 5 to Post 10		1	-	0	-	-
25	Base 5 to Post >12.5		0	-	1	-	-
30	Base 7.5 to Post <2.5		12,098	5,300	362	-	-
31	Base 7.5 to Post <5		16,932	5,914	848	165	-
32	Base 7.5 to Post 5		13,543	28,852	18,267	12,991	6,852
33	Base and Post 7.5	44,612	2,027	4,545	25,116	31,456	37,760
34	Base 7.5 to Post 10		11	-	18	-	-
35	Base 7.5 to Post >12.5		0	-	1	-	-
40	Base 10 to Post <2.5		3,575	-	-	-	-
41	Base 10 to Post <5		1,858	0	-	-	-
42	Base 10 to Post 5		11,804	1,716	6	-	-
43	Base 10 to Post 7.5		6,111	14,247	8,553	5,044	1,778
44	Base and Post 10	29,859	6,506	13,879	16,515	18,110	19,322
45	Base 10 to Post >12.5		6	17	4,786	6,705	8,759
50	Base >12.5 to Post <2.5		-	-	-	-	-
51	Base >12.5 to Post <5		-	-	-	-	-
52	Base >12.5 to Post 5		1,885	-	-	-	-
53	Base >12.5 to Post 7.5		9,576	2,919	227	59	7
54	Base >12.5 to Post 10		8,805	11,066	8,876	3,427	1,196
55	Base and Post >12.5	79,694	59,428	65,709	70,591	76,209	78,490

TABLE 10-11
LOSSES TO WETLAND ACRES BY DURATION
INTERVAL AND DURATION ZONE

Duration Intervals	Base	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
<5 to 5.0	39,251	30,610	21,065	25,728	31,472	33,270
5 to 7.5	35,402	30,137	34,191	28,576	28,613	32,307
7.5 to 10	44,612	17,753	21,711	33,939	36,559	39,554
10 to 12.5	29,859	15,323	24,945	25,409	21,537	20,518
>12.5	79,694	59,434	65,726	75,379	82,914	87,250
Losses to Intervals	Base	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
<5 to 5.0	-	8,641	18,186	13,523	7,779	5,981
5 to 7.5	-	5,265	1,211	6,826	6,789	3,095
7.5 to 10	-	26,858	22,901	10,673	8,053	5,057
10 to 12.5	-	14,536	4,914	4,450	8,323	9,341
>12.5	-	20,260	13,968	4,315	-3,220	-7,556
Duration Zones	Base	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
<5	228,818	153,258	167,637	189,032	201,095	212,900
5	189,567	122,648	146,573	163,304	169,622	179,630
7.5	154,165	92,511	112,382	134,727	141,009	147,323
10	109,553	74,757	90,671	100,788	104,451	107,768
>12.5	79,694	59,434	65,726	75,379	82,914	87,250
Losses to Zones	Base	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7
<5	-	75,560	61,181	39,787	27,724	15,918
5	-	66,919	42,994	26,263	19,945	9,937
7.5	-	61,654	41,783	19,438	13,156	6,843
10	-	34,796	18,883	8,765	5,103	1,785
>12.5	-	20,260	13,968	4,315	-3,220	-7,556

wetlands by duration interval and duration zone. The negative numbers in the loss table indicate increases in wetlands within the >12.5 percent duration interval for Alternatives 6 and 7. Table 10-11 shows that the largest decreases in wetland acres for Alternatives 3, 4 and 5 come from the 7.5 to 10 percent duration interval. The next largest changes occur in the >12.5 percent interval. These two intervals have the largest areas for the base conditions. The greatest changes for Alternatives 6 and 7 are in the 10 to 12.5 percent interval. Table 10-10 shows that most of these changes are for the interval class 45. This class indicates that the wetlands are moving to a longer duration class. This is because these alternatives allow additional water into the basin from the Yazoo and Mississippi Rivers when the stage at the Steele Bayou structure is less than 87.0 feet, NGVD.

FESM Model Conclusions

47. The FESM model performs well in predicting the areal extent of wetlands. Its predicted areal extents equal 101.5 and 98.6 percent of the calibration flood scenes and 104.6 percent of the validation scene. It tends to overestimate wetland extent in areas adjacent to the main channels and underestimate wetland extent in areas distant from the main channels. Wetlands adjacent to the channel are likely sustained by backwater flooding and may be affected by the project. Wetlands in areas not adjacent to channels may be sustained by ponding surface runoff and would not be affected by the project (local ponding of precipitation is discussed in more detail in paragraphs 72-79). Most of the differences in the areal extent of flooding predicted by the FESM model and the actual extent determined by the flood scenes are due to lack of detailed elevation information. Most off-channel areas are missed because the DEM surface does not contain depressions with elevation differences less than 5 feet. Sixty percent of the project area exhibits ridge and swale topography which is common to the Point Bar geomorphology. DEMs based on 5-foot contour data do not have sufficient detail to the capture small depressional wetlands that are observed in the satellite imagery. These isolated depressional wetlands generally capture rainwater and would be unaffected by the operation of the Yazoo Backwater Project. The discrepancy induced by this is easily offset by the over prediction of wetland extent in the lands adjacent to the two major ponding areas. This over prediction of wetlands adjacent to the ponding areas results in an over prediction of impacts to wetlands or a “conservative” estimate of wetland impacts.

EPA FIELD SAMPLING OF WETLANDS

INTRODUCTION

48. The Vicksburg District presented the preliminary results of this wetland delineation to the EPA in the spring of 2003. Because this was the first application of this offsite wetland delineation methodology, EPA wanted a statistically valid field testing of the results. In order to accomplish this, EPA wetland scientists utilized their Environmental Monitoring and Assessment Program (EMAP) to randomly choose 150+ sample sites within the study area for field testing. The goals of this sampling were to verify the Vicksburg District offsite wetland delineation, to produce a statistically significant estimate of the region's wetland acreage, and to compare that acreage to the amount estimated by the Vicksburg District FESM model. A complete report of the EPA field sampling program is provided as Supplement A of this appendix. The initial goal of this sampling effort as agreed upon by both the Vicksburg District and EPA was to achieve a 90 percent agreement between the results of the field study and the Vicksburg District offsite wetland delineation.

49. The EMAP program generated random sampling points from three strata (Tiers): (a) forested areas below the 5 percent flood elevation, (b) forested areas above the 5 percent flood elevation, and (c) nonforested areas above the 5 percent flood elevation. The EMAP program identified 400 points for each category. The goal of the field sampling was to sample at least 50 points in each category. During the first 2 weeks of June 2003, interagency teams of scientists and engineers representing EPA, FWS, NRCS, and the Vicksburg District collected onsite data in the study area. Global positioning satellite (GPS) equipment was used to locate each of the 150+ sample points. For the forested sites, data were collected using techniques described in the Wetland Determination Background section of this document.

METHODS

50. The 1987 Wetland Delineation Manual describes several sampling methods. The most common method used by Corps scientists for wetland determinations is the "routine onsite" method (Environmental Laboratory, 1987). This was the method used for EPA field sample points. In order to comply with methodology described in the 1987 Wetland Delineation Manual and prior to the initiation of sampling, EPA and Vicksburg District scientists mutually agreed that each sampling point would represent a landscape position and the particular plant community found at that position. The three EPA field sampling areas are displayed on Plates 10-30 through 10-32.

FEAT Modeled Areas at or below the
5 percent Duration Elevation (Tier 1)

51. These sample points were at or below the 5 percent hydrology duration elevation in those areas potentially impacted by the project. The 5 percent duration elevation was used because the Vicksburg District used it as the upper limit of wetlands; however, by definition, only some of these points would meet the hydrology criterion as defined in the 1987 Manual and supplemental guidance. Since a goal of EPA FIELD sampling process was to verify the original Vicksburg District wetland extent, the hydrology of each point was determined independently using field indicators. Of the 52 points sampled, 41 were determined wetlands (wet) and six were other waters of the United States. Five points were determined either nonwetland (NW) or prior-converted cropland. The Tier 1 sampling sites are displayed on Plate 10-30.

Forested Areas above the
5 percent Duration Elevation (Tier 2)

52. Since wetland hydrology can be established by soil saturation in addition to inundation, some of these sample points could be within the 5 percent saturation elevation. Fifty-five points were sampled and 54 were used. A total of 25 points were determined nonwetland, while 27 points were determined wetland. Two sites were determined other waters. The Tier 2 sampling sites are displayed on Plate 10-31.

53. Subsequent analysis of field data revealed that wetland hydrology for 9 of the 27 points determined wetlands in Tier 2 was based on the occurrence of 2 relatively weak secondary indicators ("local soil survey" and FAC-neutral test). The EPA personnel considered seven of these nine wetlands. The 1987 Manual advises that soils can remain hydric decades after the hydrology has been altered (page 6, paragraph 19). The Yazoo Basin's hydrology has been significantly altered by the construction of levees and numerous drainage ditches. By considering all seven as wetlands, the EPA field method is conservatively estimating wetland extent.

Nonforested Areas Above
5 percent Duration Elevation (Tier 3)

54. The NRCS is the lead agency for wetland determinations on currently farmed or recently converted agricultural land (Wetland Restoration Program, Conservation Reserve Program, etc.; USDA, et al., 1994). Since these sample points were selected based on the sites being nonwooded and such areas fall into the above categories, NRCS District Conservationists for each county provided determinations for these sample points. Fifty-one Tier 3 sites were visited. Forty-four of these points were determined to be prior-converted cropland and two of the points were determined farmed wetlands. The remaining five sites were other waters sites. The Tier 3 sampling locations are displayed on Plate 10-32.

55. The NRCS defines prior-converted cropland as wetlands, which were both manipulated and cropped before 23 December 1985 to the extent that they "no longer exhibit important wetland values." Specifically, prior-converted cropland is inundated no more than 14 consecutive days during the growing season. The farmed wetlands are defined by NRCS as wetlands which were both manipulated and cropped before 23 December 1985, but which "continue to exhibit important wetland values" (HQUSACE, 1990). Specifically, farmed wetlands are inundated for 15 or more consecutive days during the growing season. It is the policy of the Corps, as provided in guidance from HQUSACE (HQUSACE, 1990) that prior-converted cropland, as determined by NRCS, is considered non-wetland, and that farmed wetlands, as determined by NRCS, is considered wetland for Section 404 purposes. Impacts to farmed wetlands were accounted for in this analysis.

RESULTS OF EPA FIELD WETLAND VERIFICATION

56. During the first 2 weeks of June 2003, combined teams of EPA, Vicksburg District, NRCS, and FWS scientists identified a total of 169 randomly selected sampling sites, of which a total of 157 were sampled. Sites selected included points from 3 sampling tiers: (Tier 1) Areas below the 5 percent duration contour, (Tier 2) forested areas above the 5 percent duration contour, and (Tier 3) cleared lands above the 5 percent duration contour. The 169 sites included 12 that were inaccessible, 13 that were other waters of the United States, and 144 sites where wetland determinations were made by onsite techniques.

Tier 1

57. Of the 52 sample points in the forested below the 5 percent flood elevation category, 41 were determined wetland, 5 were determined nonwetland for the EPA field analysis, and 6 were other waters.

Tier 2

58. A total of 54 sample points were studied in the forested above the 5 percent flood elevation category. Twenty-seven were classified as wetlands, 25 were nonwetlands for EPA field analysis, and 2 were other waters.

Tier 3

59. Each of the 51 nonforested sample points were visited and documented. The NRCS determination was used in the final analysis. Forty-four were classified prior-converted cropland, 2 points were classified farmed wetlands, and 5 were other waters.

EPA ESTIMATED WETLAND AREA

60. The areal extent of wetlands in the Yazoo Backwater Study area was made using the results of the field sampling. The percent of wetland sites of the sampled sites in each tier was multiplied times the total area within the tier. The results of this estimation are presented in Table 10-12. The EPA estimated that there were 216,567 acres of wetlands in the study area based on the field sampling. The EPA estimated there were approximately 149,000 acres of wetlands in Tier 1, which is 40,000 acres less than the Vicksburg District estimate of 189,000 acres of wetlands. The EPA estimated there were an additional 53,500 and 14,200 acres of wetlands in Tiers 2 and 3, respectively. Tiers 2 and 3 are outside of the FESM 5 percent duration flood zone and therefore, did not contain any wetlands sustained by backwater flooding. The 90 percent confidence ranges of wetlands estimated by FESM and EPA overlap each other. The FESM 90 percent range is from 150,400 to 228,900 acres, while the EPA range is from 173,600 to 259,500 acres. The field sampling did not distinguish between wetlands sustained by riverine flooding or the local ponding of precipitation, while the FESM model only predicted

TABLE 10-12
EPA ESTIMATED WETLAND AREA a/

Tier	Indicator	Category	NResp	Estimate.P	StdError.P	90%Conf.P	LCB90%	UCB90%	Estimate.U	StdError.U	LCB90%U	UCB90%U
Tier 1	Wet	No	11	0.212	0.057	0.093	0.118	0.305	39,959	17,599	22,361	57,558
Tier 1	Wet	Yes	41	0.788	0.057	0.093	0.695	0.882	**148,940**	17,599	131,341	166,538
Tier 1	Wet	Total	52	1.000					188,899			
Tier 2	Wet	No	27	0.500	0.068	0.112	0.388	0.612	53,467	11,969	41,498	65,435
Tier 2	Wet	Yes	27	0.500	0.068	0.112	0.388	0.612	**53,467**	11,969	41,498	65,435
Tier 2	Wet	Total	54	1.000					106,933			
Tier 3	Wet	No	50	0.980	0.019	0.032	0.948	1.000	354,029	16,146	330,803	361,110
Tier 3	Wet	Yes	1	0.020	0.027	0.045	0.000	0.064	7,080	16,146	0	30,307
Tier 3	Wet	Total	51	1.000					361,110			
Total Area	Wet	No	88	0.561	0.040	0.065	0.495	0.626	440,375	42,910	397,465	483,285
Total Area	Wet	Yes	69	0.439	0.040	0.065	0.374	0.505	216,567	42,973	173,594	259,541
Total Area	Wet	Total	157	1.000					658,529			

a/ Table from Supplement B.

wetlands sustained by riverine flooding. The Yazoo Backwater Area receives approximately 52 inches of precipitation annually. The 27,000-acre difference between the two estimates (216,567 EPA; 189,600, FESM) may be the result of local ponding of precipitation. The EPA field sampling shows that the FESM model conservatively estimates wetland extent within the area likely to be impacted by the project.

CONCLUSION OF EPA FIELD SAMPLING

61. Although the 90 percent level of agreement between the EPA field sampling and either of the Vicksburg District offsite delineation methods was not achieved, EPA agreed that the FESM model was the best offsite method to use for the analysis of impacts to wetlands for the Yazoo Backwater Project. The agreement was reached for the following reasons. There was a greater than 90 percent agreement between the Tier 1 “wet” sites using both of the offsite methods, and there was a greater than 90 percent agreement between all methods for all Tier 3 sites. The FESM method overestimated wetland extent within Tier 1 by 40,000 acres, which is the area of likely project impacts to wetlands. Finally, both parties agreed that the lack of agreement between the EPA field and FESM methods in Tier 2 was because the FESM method only predicted the extent of riverine backwater wetlands, while the EPA field method identified all wetland subclasses.

COMPARISON OF THE THREE OFFSITE WETLAND DELINEATIONS

INTRODUCTION

62. In the following paragraphs, the results of the three wetland estimates used in this report will be compared. The three methods are as follows: the 5 percent duration flood-scene delineation, the FESM modeled 5 percent duration wetlands, and EPA field sampling estimated wetlands. These will be labeled Flood, FESM, and Field, respectively. The 144 Field sampling sites will be used for comparison to each of the methods. The Wet or Not Wet (NW) designation for the two GIS methods was determined for each Field site by inspection and the results recorded in Supplement A.

DESCRIPTION OF THE THREE METHODS

Flood Method

63. This method is based on the 10 March 1989 TM satellite scene. The scene represents the 5 percent duration flood which is utilized as a primary indicator of hydrology. The flood scene provides a synoptic view of the basin and captures all the areas covered with water at that point

in time. This method likely overestimates wetland extent because it assumes that all sites which are wet will remain wet for a minimum duration of 14 days. Providing a two-dimensional picture of the basin, at one moment in time, is the major strength of this method. Its major limitation is the pixel resolution of the satellite image, which is 28.5 m squared. This represents an area of approximately 0.2 acre. Features smaller than approximately 100 feet can be missed, e.g., portions of Deer Creek and other secondary streams are not captured. Deer Creek is a small perched stream in the basin. The stream is less than 28.5 m (90 feet) across in most places. Actual stream width is less than 15 m (<50 feet) in many areas. In spite of the small size of the stream relative to the pixel dimension, the flood scene captures 11,000 of the 14,300 pixels for Deer Creek or 76.9 percent of the pixels. In addition, it should be understood that the stream may not fall into a single pixel, but may be divided between two adjacent pixels. Another limitation is that there are no estimates of uncertainty associated with this wetland delineation. Finally, the flood method does not distinguish between wetlands sustained by flooding from those sustained by ponding precipitation. This method estimates that there are 198,000 acres of wetlands in the project area. Table 10-13 provides the land use breakdown of the flood scene using the 2005 land use. This method was field verified in 2000 by Vicksburg District wetland scientists. One disadvantage of the method is that it is difficult to find satellite scenes that match the pre- and postproject conditions.

TABLE 10-13
COMPARISON OF THE WETLAND EXTENT IN THE YAZOO PROJECT AREA
BY METHOD
(AREA IN ACRES)

Land Use	Flood	FESM	Field
Crop	28,277	27,153	60,332
Noncrop	23,959	22,602	
Forest	129,033	123,213	156,236
Water	16,487	15,690	
Catfish Pond	278	1,008	
Total	198,034	189,665	216,568
Total less water	181,269	172,967	216,568

FESM Method

64. This method is dependent on the period-of-record stage data and the surface elevation model of the basin and estimates wetlands that are maintained by out-of-bank flooding. It does not estimate the extent of wetlands that capture precipitation or floodwaters above the 5 percent duration elevation. The surface model is built from the 30-m DEM coverage of the basin. The

major strengths of this method are that it is based on more than 50 years of stage data at several stations within the basin, and it provides a two-dimensional map of the wetland areas. The model was calibrated and verified against satellite scenes of flood events. It is the only method that can both display and provide the areal extent of wetlands pre- or postproject conditions. The major weakness of the FESM method is the resolution of DEM coverage. The pixel size of DEM is 30 m. Features that are smaller than 30 m may not be present. This includes many of the smaller secondary streams. This method estimates that there are 189,700 acres of wetlands. Table 10-13 provides the 2005 land use of the wetland acres. This method was field verified by Vicksburg wetland scientists in 2001. The field verification is discussed in paragraph 38 of this report.

Field Method

65. This method is based on a field determination at more than 157 randomly selected sites in the Yazoo Backwater Study area in 2003. This method provides an estimate of the extent of all wetlands in the study area, but does not provide an estimate with a breakdown of land use. Each site was selected by EPA using EMAP and was located using a GPS unit. The major strength of this method is that it is based on field inspection of wetland sites. Its major weaknesses are that it cannot provide a two-dimensional map of either the pre- or postproject wetland areas at some sites at times, the field verifications used only secondary indicators of hydrology, and the areal estimate is extrapolated from a small number of sites. This method estimates there are 216,600 acres of wetlands, but does not distinguish between wetlands sustained by flooding from those sustained by ponding precipitation. Each sampling site represents from 2,000 to 6,000 acres.

RESULTS

66. Table 10-13 presents the areal estimates of wetlands obtained by the two offsite methods and one estimate based on representative onsite sampling. All three methods provide estimates within the 90 percent confidence interval of the Field method. However, it must be understood that these three methods are not comparing the same set of wetlands. The Flood and Field methods both estimate total wetlands including depressional wetlands above the 5 percent duration elevation. In contrast, the FESM method only estimates wetlands sustained by the 5 percent duration backwater flood (Tier 1 wetlands). The FESM method restricts its delineation to those wetlands which would likely be adversely affected by this project. The Field method does not provide estimates of cleared and forested land for Tier 1 and therefore the entire area was listed under miscellaneous. The Tier 2 wetlands are listed as forested, and the Tier 3 wetlands are listed as cleared. The estimates of total area by the three methods are remarkably similar. Comparing the total wetland extent of the three methods is somewhat misleading

because only two of the methods are actually trying to estimate total wetland extent. In order to have a valid comparison some adjustments are needed. The FESM and Flood methods both include permanent water bodies in their wetland estimates. If these land-use categories are removed, the wetland extents become—FESM-172,967; Field- 216,567; and Flood-186,269 acres. The second adjustment that is needed is to partition all of the estimates based on the three EMAP tiers. By definition, all of the FESM wetlands are in Tier 1. Querying the Flood scene by tiers provides the results presented in Table 10-14. The three methods determined that there were the following wetland acres in Tier 1--FESM-169,905; Field-148,940; and Flood-119,395. The FESM method significantly over estimates the Tier 1 wetland extent relative to the other methods, providing 114 percent of the Field method and 142 percent of the Flood method. The Flood method, which assumes all areas wet in the flood scene will remain wet for 14 days, should provide a conservative estimate of wetland extent. The Flood method's Tier 1 estimate of 119,359 acres of wetlands is 20 percent (30,000 acres) less than the Field methods estimate for that Tier. The Flood method's Tier 2 estimate of 30,155 wetland acres is only 56 percent of the Field methods estimate. The Flood method estimates that there are 24,131 acres of wetlands in Tier 3, which is 162 percent of the Field methods estimate. Tiers 2 and 3 wetlands are depressions above the 5 percent duration elevation which trap precipitation and/or runoff. Because these wetlands are above the 5 percent duration elevation, they will not be affected by the project.

DISCUSSION

67. One means to compare the three methods is to examine how the three methods would classify each Field site. To do this, Field sites were entered as a point-coverage into the ArcView GIS project file. Each site was then queried as to whether the Flood and FESM methods determined those sites as Wet or NW. The results were entered into an Excel spreadsheet by site and method (Attachment 1). The analysis below concerns only the 144 sites where the field teams made a determination of Wet or NW. There are three methods each making a determination of Wet or NW at the 144 sites. The Field sampling sites and the extent of the FESM and Flood methods are displayed in Plate 10-33. These individual determinations were not the same for all methods. Table 10-15 compares the results of the three methods using the Flood method as the base method. There were 47 Wet field points within the Flood delineation. Of those, 45 were determined wetlands by the field sampling (95.7 percent) and 2 were nonwetlands (4.3 percent). There were 97 field points outside of the flood delineation, and 72 (74.7 percent) were NW and 25 (25.8 percent) were WET. There is a high degree of agreement between what is wet based on the imagery and Field sampling (95.7 percent), but the satellite imagery does not fare as well in predicting nonwetlands (74.2 percent). The overall agreement between the Flood and Field methods was 81.3 percent (117/144). The overall agreement between the FESM and Flood methods is about the same (82.6 percent). The FESM and Flood methods agree on 74.5 percent of the Wet sites and 86.6 percent of the NW sites.

TABLE 10-14
2005 LAND USE OF THREE METHODS WETLAND ESTIMATES BY SAMPLING TIERS
(acres)

Base1 5% Duration (FESM)					
LULC	Tier 1	Tier 2	Tier 3	>100 Yr	Total
Crop	26,276	16	710	136	27,138
Noncrop	22,230	88	217	39	22,573
Forest	121,252	1,302	452	102	123,108
Water	15,308	80	214	86	15,688
Catfish Ponds	998	0	10	0	1,008
Total	186,063	1,485	1,603	364	189,514
Total less Water	169,758	1,405	1,379	278	172,819
10Mar89 Flood (Flood)					
Crop	10,526	629	12,406	4,713	28,274
Noncrop	17,214	1,968	3,712	1,054	23,948
Forest	91,655	27,556	6,348	3,457	129,016
Water	14,232	385	980	889	16,486
Catfish Ponds	129	14	70	64	278
Total	133,757	30,553	23,516	10,178	198,003
Total less Water	119,395	30,153	22,466	9,224	181,238
EPA (Field)					
Cleared	37,235		14,161		51,396
Forest	111,705	53,467			165,172
Total	148,940	53,467	14,161		216,568

NOTE: 2005 land use used for FESM and FLOOD methods.

However, the FESM method only predicts wetlands within Tier 1. The agreement between the FESM and Flood methods on Wet sites in Tier 1 is very high (30 of 33, 90.9 percent). The agreement on Wet sites within Tier 1 between the FESM and Field methods is even somewhat better (37 of 40, 94.7 percent). Overall, there was a somewhat higher percentage of agreement between the FESM and Flood methods (82.6 percent) than with the Field and the Flood methods (81.3 percent).

TABLE 10-15
5 PERCENT DURATION FLOOD VERSUS FIELD AND
FESM MODEL WETLANDS

Flood		Field					FESM			
Item	Site	Item	Site	Tier 1	Tier 2	Tier 3	Site	Tier 1	Tier 2	Tier 3
Wet	47	Wet	45	32	11	2	35	30	4	1
		NW	2	1	0	1	12	3	7	2
NW	97	NW	72	4	25	43	84	3	38	43
		Wet	25	9	16	0	13	10	3	0
		Agree	117	36	36	45	119	33	42	44
		Disagree	27	10	16	1	25	13	10	2
		% Agree	81.3	78.3	69.2	97.8	82.6	71.7	80.8	95.7
		% Disagree	18.8	21.7	30.8	2.2	17.4	28.3	4.3	4.3

SOURCES OF DISCREPANCIES

68. In remote sensing, "error" refers to the difference between the determination of a pixel and its true "ground" identity. In this document, we are referring to the difference in the wetland determination by one method to another method. Several sources of discrepancies can affect the resulting wetland classification. One potential source of discrepancy for the flood method is image resolution. The pixel (picture element) size of TM images is 28.5 m squared, or roughly a patch on the earth’s surface 95 feet on a side. Every pixel may not fall on a homogenous patch of earth's surface. Edge pixels represent areas where the reflectance is averaged from 2 or more cover types. The interpretation of these pixels is a possible source of error. Features smaller than 28.5 m on a side (~0.2 acre) can be missed. The software producing the unsupervised classifications generally provides between 65 and 75 raw classes. These raw classes or clusters must be identified. Identification is normally accomplished with some additional source of information, such as aerial photography or field-collected ground-truth data. The color table of the classified scene is constructed from the reflectance values of the different image bands. The resulting image can often be interpreted intuitively by a person experienced in remote sensing. A low-level classification, such as wet or dry, can generally be performed quite accurately without a secondary source of information. A second category of discrepancy is spatial errors. Each of the data layers has a spatial reference or a location on the earth’s surface. This positional reference can be incorrect. The field sites were located with GPS units, which are generally

accurate to within 10 m. (This error varies considerably with the model of the GPS unit and the length of time allowed for the positional fix.) The GPS units are less reliable in densely forested areas because they lose their fix on the satellite constellation due to the dense foliage. (The EPA field sampling was performed in early June 2003.) The satellite scenes are generally accurate within one pixel or 28.5 m. The surface model has 28.4-m pixels, thus a possible error of 28.4 m. Both of these grid layers were acquired already geo-corrected. Aside from discrepancies due to resolution and location, there are also two categories of classification errors--inclusion and exclusion. An error of inclusion describes the case when a pixel is included into the wrong class, while an error of exclusion is when a pixel is incorrectly excluded from a class. In this case, a dry pixel (or class of pixels) that is included in the wet class is an example of an error of inclusion. These errors can be due to cloud cover, spatial resolution, or lack of accurate ground-truth data. Examples of these two type errors are shown on Plates 10-34 and 10-35. They represent Field sites 15 (wet) and 412 (NW), respectively. The sites are highlighted in yellow on the plates.

CONCLUSION OF COMPARISON OF THREE OFFSITE WETLAND DELINEATIONS

69. The three independent estimates of wetland extent in this report provide remarkably similar results. Although a difference of 27,000 acres may seem large, it is small when it is compared to the difference in wetland extent between the two estimates in the 2000 Draft Report and Draft SEIS. In the 2000 Draft Report and Draft SEIS, the Vicksburg District estimated there were 48,500 acres of wetlands in the study area. This estimate contrasted greatly with an estimate made by USGS for EPA. The USGS, using an old report and a GIS coverage of hydric soils, estimated there were 690,000 acres of wetlands in the project area. The 690,000 acres estimate was made using the 1989 Manual and was based on the extent of hydric soils in the project area. The 2000 estimates differed by 641,500 acres, which makes the maximum difference of 27,000 acres in this study seem small. The smallest estimate in this study was made by the FESM model, and the FESM model only estimated wetland extent that was maintained by riverine backwater flooding. Both the Flood and Field methods provided estimates of total wetland extent from the direct ponding of precipitation and riverine backwater flooding. Thus, taking all factors into consideration, the three estimates of wetlands in this report agree there are approximately 200,000 acres of wetlands in the study area.

COMPARISON OF FIELD DATA TO OTHER HYDROLOGIC EVENTS

70. In the previous section, three different wide-area wetland delineation methods were compared. Although the results were acceptable, the target 90 percent agreement between the Field and either of the FESM or Flood methods was not achieved. Acceptable levels of agreement were found within in the Tier 1 sub-area for both methods (FESM or Flood - 84.8%).

As was explained in paragraphs 13 and 22, the Vicksburg District suggests that the 5 percent duration event describes the upper limit of the hydrologic conditions of wetlands. However, there are other hydrologic events that may provide a better fit to the observed field data. In the following paragraphs, three other hydrologic events will be compared to the Field results in an attempt to find a better fit between the observed wetland sites from the Field analysis and the predicted wetlands from the Flood and FESM methods. Plate 10-9 shows the water surface profiles for the 5 and 12.5 percent duration events and the 1 and 2-year frequency events. The water surface profiles for the two duration events have nearly constant slopes over the entire river length, while the two frequency event profiles exhibit distinct inflection points along their profiles. The 1-year profile has a slope similar to the two duration events for the lower 15 miles of its length. After mile 15.4, the 1-year profile has two increases in its slope as you move upstream. The 2-year profile also has a slope similar to the duration events along the first 15 miles, then the slope increases sharply and maintains the new slope along the rest of its length. None of the profiles reflect a condition of complete backwater control because the water surface profile would be flat. The steeply sloped areas of the frequency profiles indicate channel control. The mildly sloped areas of the frequency profiles and the complete duration profiles indicate that the water surface is controlled by a mixture of headwater and backwater conditions.

TWO-YEAR FREQUENCY FLOOD

71. The 2-year frequency flood is often incorrectly associated with wetland extent. A 2-year frequency flood is the peak annual stage that has a 50 percent probability of occurring in any year. The 2-year frequency flood has a minimum duration of 1 day. The 1987 manual defines the necessary hydrological condition for a wetland as “an area has wetland hydrology if it is inundated or saturated to the surface continuously for at least 5 percent of the growing season (5% duration) in most years. Some individuals interpret the “in most years” to the 50 percent probability of recurrence or the 2-year frequency flood. This interpretation ignores the requirement of “inundated or saturated for at least 5 percent of the growing season.” The difference between the 2-year frequency elevation and the 5 percent duration elevation varies from around 2 feet at the downstream gage locations to 7.4 feet at the most upstream gage. The difference in the aerial extent of the flooding of these two events is 127,800 acres when the floods have been adjusted to remove permanent water. The 2-year flood extent is 139 percent of the EMAP estimate for wetlands. Table 10-16 presents the 2-year frequency, 7.5 percent duration, and 10.0 percent duration wetland estimates by land-use and by the EMAP sampling tiers (strata). (Note - the EMAP estimates do not provide land-use information, so the estimates were made by applying the land-use percentages of the 89 Flood from the 3 tiers.) Comparing

TABLE 10-16
LAND USE OF ADDITIONAL HYDROLOGIC EVENTS BY SAMPLING TIER
(acres)

2-Year Flood				
Land use	Tier 1	Tier 2	Tier 3	Total
Crop	23,122	0	59,123	82,245
Noncrop	8,594	0	8,132	16,726
Forest	97,100	40,845	0	137,944
Reforest	39,053	0	24,288	63,341
Pond	866	0	13,055	13,921
Water	14,074	0	944	15,018
Miscellaneous	195	0	131	326
Total	183,003	40,845	105,673	329,521
Total less Water	168,063	40,845	91,674	300,582
7.5% Duration Flood				
Land use	Tier 1	Tier 2	Tier 3	Total
Crop	16,259	7	68	16,334
Noncrop	6,417	12	22	6,452
Forest	80,674	39	22	80,734
Reforest	32,921	0	12	32,933
Pond	582	0	1	583
Water	14,086	2	10	14,098
Miscellaneous	187	0	0	187
Total	151,126	60	135	151321
Total less Water	136,458	58	124	136,640
10.0% Duration Flood				
Land use	Tier 1	Tier 2	Tier 3	Total
Crop	11,109	7	62	11,177
Noncrop	5,233	12	22	5,266
Forest	51,482	35	21	51,538
Reforest	24,509	0	11	2,4521
Pond	209	0	0	209
Water	13843	2	10	13,855
Miscellaneous	155	0	0	155
Total	106,540	56	125	106,721
Total less Water	92,487	55	115	92,657

NOTE: 2005 land use.

the 2-year flood to the Field estimate by sampling tier shows the following--Tier 1, 113 percent; Tier 2, 76 percent; and Tier 3, 6400 percent. The 2-year frequency flood only differs by just under 2,000 acres from the Tier 1 estimate of the 5 percent duration flood (168,000 to 169,800 acres), and both estimates are 20,000 acres greater than the Field estimate of Tier 1 wetlands (148,900 acres). So far, we have compared the aerial extent of the 2-year flood to those of the 5 percent duration wetlands, Field wetlands, and the 89 Flood; now we will compare the footprints of these wetland extents. Plate 10-36 shows the extent of the 5 percent duration wetlands with the 2-year flood behind it. The major difference is in the extent of flooding in the upper third of the study area (Tier 3). It should be noted that most of the field sites flooded only by the 2-year flood are in red, which means that the field determination at the site was NW. Plate 10-37 highlights an additional 13 field sites that were determined Wet that are inside the 2-year extent, but were outside the extent of the 5 percent duration event. This increases the number of sites with an agreement for Wet from 41 to 54. However, Plate 10-38 highlights an additional 23 field sites that were determined to be NW in the field, but are inside the 2-year flood and should therefore be Wet. In addition, Plate 10-39 highlights 16 sites that were determined Wet in the field test, but are outside the limits of the 2-year flood. Thus, although the number of Wet sites with agreement between the field and this flood increases from 41 to 54, the percentage of the wet sites with agreement drops from 87 to 67 percent. The total number of sites which agree as either Wet or NW also decreases, and it must be concluded that the 2-year frequency flood is not a better fit with the EMAP field sites and should not be used as the areal extent of wetlands. The poor fit is mainly due to the increased flooded area in the northern third of the study area, which is unsupported by the field data as wetlands.

7.5 PERCENT DURATION EVENT

72. The FESM modeling method subdivided the wetlands into four duration intervals to provide an increased level of detail for the HGM functional assessment. The second duration zone was the 7.5 percent duration. This represents a continuous period of inundation of 20 days. The areal extent of this event under base conditions is 136,600 acres. This extent is less than the 5 percent duration by approximately 36,200 acres, but is almost totally within Tier 1 and matches the Field estimate of Tier 1 acres better than the 5 percent duration event (136,600/148,900 = 91.6%). There are 34 field sites within the 7.5 percent duration flooded area in Tier 1, and 33 were determined Wet (97%). There are 39 field sites within all 3 tiers in the 7.5 percent duration area, and 35 were determined Wet (89.7%). Among both the Wet and NW sites from all tiers, there are 106 sites which are in agreement (106/144 = 73.6%).

10 PERCENT DURATION EVENT

73. The third duration zone was the 10 percent duration. This represents a 27-day period of continuous inundation, and the areal of this zone is 92,700 acres. The areal extent is again smaller, and is 56,300 acres less than the Field estimate for Tier 1 (92,500/148,900 = 62%). The 10 percent duration flood overall extent is only 42 percent of the Field estimate (92,700/216,600). There are only 23 field sites within the area flooded by this event, and 21 were determined Wet. This means that there is a 91.7 percent agreement between the 10 percent duration flood and the field Wet sites, but the overall agreement between the two methods for all sites is only 64.6 percent (93/144).

CONCLUSION OF ALTERNATE FLOOD EVENT ANALYSIS

74. Three additional hydrologic events were compared to the field site determinations to see if some other hydrologic event provided a better fit with the field determinations than the 5% duration event. The three events were the 2-year frequency flood, the 7.5 and 10 percent duration events. The 2-year flood exceeded the areal extent of flooding by all other methods and exceeded the FESM and Field estimates of wetland extent by more than 100,000 acres. Most of the increased acres fell within Tier 3 of the field sampling. Twenty-five NW sampling sites were included in the flooded area, and the overall agreement of the field results to the modeled area decreased. The percent agreement of both duration events among modeled Wet sites increased to 89.7 and 91.7 percent for the 7.5 and 10 percent duration events, respectively, but the overall agreement and the agreement with all Tier 1 sites decreased. The difference in the areal extent of flooding within Tier 1 improved over the 5 percent duration event for the 7.5 percent duration event, but was much worse for the 10 percent duration event. The differences between the EMAP estimate and the 7.5 and 10 percent duration events were 12,400 and 56,400 acres, respectively. Although the overall agreement with EMAP sampling sites of the 7.5 percent duration event is nearly as good as that of the 5 percent duration event (73.6 versus 74.3 percent), and the areal extent of flooding in Tier 1 for the 7.5 percent duration event provides a better fit to the Field estimate than the 5 percent duration event, the Vicksburg District will continue to utilize the 5 percent duration event as the wetland defining event because it is more protective of wetlands.

FUNCTIONAL ASSESSMENT OF PROJECT WETLAND RESOURCES

INTRODUCTION

75. This functional assessment of wetland resources utilizes the HGM Approach. The HGM Approach identifies groups of wetlands based on three criteria--geomorphic setting, primary source of water, and hydrodynamics. Using these three criteria, any number of wetland groups can be identified. The HGM Approach measures the functions of reference wetlands and compares them to wetlands in the study area. The HGM is an accepted methodology to assign numerical values to wetland functions for purposes of comparing impacts of alternatives. It is also an accepted methodology for evaluating proposed mitigation projects. The HGM Approach consists of four components including (a) the HGM Classification, (b) reference wetlands, (c) assessment variables and assessment models from which functional indices are derived, and (d) assessment protocols. The HGM Approach is applied by utilizing the assessment variables, models, and protocols provided in the Yazoo Basin Regional Guidebook (Smith and Klimas, 2002) to assess wetland functions. The following four paragraphs describing the HGM Approach are summaries of material from the Yazoo Basin Regional Guidebook (2002).

HGM Classification

76. Wetland ecosystems share several common attributes, including hydrology, hydrophytic vegetation, and hydric soils. In spite of the common attributes, wetlands occur under a wide range of climatic, geologic, and physiographic situations and exhibit a wide range of physical, chemical, and biological characteristics and processes (Ferren, Fiedler, and Leidy (1996); Ferren, et al., 1996a,b; Mitch and Gosselink, 1993; Semeniuk, 1987; Cowardin, et al., 1979). Due to the variability of wetlands, it is difficult to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relatively short timeframe normally available for conducting assessments). The HGM Classification was developed to accomplish this task (Brinson, 1993a). It identifies groups of wetlands that function similarly using three criteria that fundamentally influence how wetland functions. These criteria are geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the landform and position of the wetland in the landscape. Water source refers to the primary source of water in the wetland, such as precipitation, overbank floodwater, or ground water. Hydrodynamics refers to the level of energy and the direction that water moves in the wetland. Based on these three criteria, any number of “functional” wetland groups can be identified at different spatial or temporal scales.

Reference Wetlands

77. Reference wetlands are the wetland sites selected to represent the range of variability that occurs in a regional wetland subclass as a result of natural processes and disturbance (e.g., succession, channel migration, fire, erosion, and sedimentation), as well as cultural alteration.

Reference wetlands serve several purposes. First, they establish a basis for defining what constitutes a characteristic and sustainable level of function across the suite of functions selected for regional wetland subclasses. Second, reference wetlands establish the range and variability of conditions exhibited by assessment variables and provide the data necessary for calibrating assessment variables and models. Finally, they provide representative wetland ecosystems that can be observed and measured repeatedly.

Assessment Models and Functional Indices

78. In the HGM Approach, an assessment model is a simple representation of a function performed by a wetland ecosystem. The assessment model defines the relationship between the characteristics and processes of the wetland ecosystem and the surrounding landscape that influences the functional capacity of a wetland ecosystem. Characteristics and processes are represented in the assessment model by assessment variables. Functional capacity is the ability of a wetland to perform a specific function relative to the ability of reference standard wetlands to perform the same function.. Assessment models result in a Functional Capacity Index (FCI) ranging from 0.0 to 1.0. The FCI is a measure of the functional capacity of a wetland relative to a reference standard wetlands in the reference domain. Wetlands with an FCI of 1.0 perform the assessed function at a level that is characteristic of reference standard wetlands. A lower FCI indicates that the wetland is performing a function at a level below the level that is characteristic of reference standard wetlands.

Assessment Protocol

79. The final component of the HGM Approach is the assessment protocol. The assessment protocol is a defined set of tasks, along with the specific instructions, that allows the end user to assess the functions of a particular wetland area using the assessment variables, assessment models, and functional indices in the Regional Guidebook. The first task is characterization of the wetland ecosystem and the surrounding landscape, describing the proposed project and its potential impacts, and identifying the wetland areas to be assessed. The second task is collecting field data for assessment variables. The final task is an analysis that involves calculation of functional indices.

HGM REGION WETLAND SUBCLASSES

80. The Yazoo Basin Regional Guidebook states there are seven wetland subclasses present in the project area--Riverine Backwater, Riverine Overbank, Flats, Connected Depressions, Disconnected Depressions, Connected Fringes (lacustrine), and Disconnected Fringes. The last four subclasses are all depressional wetlands. The difference between the two connected and the two disconnected subclasses is that the connected subclasses are within the 5 percent duration flood plain. The meandering of the Mississippi and other rivers through the alluvial valley has provided many geological features that provide depressions that capture backwater flooding,

overland flow, or precipitation. Oxbow lakes and abandoned channels are two examples. Of the seven subclasses, Riverine Backwater is the dominant subclass present in the lower study area within the two ponding areas. It is this subclass that is contained within the FESM modeled area, and it is this subclass that will be most affected by this project. Because the depressional wetland subclasses capture both overland flow and precipitation, they are less dependent on either source to maintain their wetland hydrology. The Riverine Backwater wetland subclass includes depressional areas (swales, oxbows, and abandoned channels). These depressions are also sustained by backwater flooding and precipitation. For this delineation, every effort was made to identify all Riverine Backwater wetlands within the study area, but the same degree of effort was not applied to identifying depressional wetlands, especially depressional wetlands outside the 5 percent duration flood plain. For a more complete discussion of these wetland subclasses, see the Yazoo Basin Regional Guidebook by Smith and Klimas.

REGIONAL WETLAND SUBCLASSES APPLIED TO THE YAZOO BACKWATER PROJECT

81. The previous paragraph described the seven wetland subclasses from The Regional HGM Guidebook for the Yazoo Basin. The Guidebook is intended for determining the functional values of all wetlands, but not for making wetlands determinations. This appendix is restricting the functional assessment to those wetlands in the study area that are sustained by backwater flooding. The Guidebook uses an arbitrary hydrologic event (5-year frequency flood) to divide depressional wetland subclasses into two groups--connected and isolated. The authors selected the 5-year flood because the modeled area could be verified with a satellite image and because it included all depressional wetlands that were even minimally influenced by backwater or overbank flooding. Because this wetland analysis is focused on the impact of the project on wetlands, it will consider depressional wetlands as connected if they are within the 5 percent duration flood plain and isolated if they are outside the 5 percent duration flood plain. This does not alter their designation as wetlands, but clarifies the dominant source of water that sustains the wetlands. Depressional wetlands that are connected (within the 5 percent duration flood plain) receive backwater flooding on a frequency and duration that affects their status as wetlands, while isolated depressional wetlands do not receive backwater flooding on a frequency and duration that is sufficient to sustain their wetland status. Isolated depressional wetlands are thus unaffected by the project. Satellite imagery was used to calibrate and validate the hydrologic model used to determine the areal extent of backwater flooding. The satellite imagery simply captures where water is at any point in time, but does not determine whether the water came from precipitation or from backwater flooding. Plate 10-40 shows the extent of the 21Mar87 flood scene and the geologic map of the basin. This plate clearly shows that many abandoned channel features from the geologic map capture water and are either permanent water bodies (Eagle Lake and Lake Washington) or depressional wetlands (Swan Lake and Lake Jackson). In

order to calibrate the hydrologic model to flood scenes, additional main channels and added channels were created to connect the depressional wetlands and the permanent water bodies depicted in Plate 10-40. Plate 10-41 maps the extent of the 5 percent duration flood with and without added channels. The depressional wetlands included within the modeled flood without added channels are connected, while those only included in the modeled area with added channels are isolated. (Note: the Guidebook clearly states that isolated wetlands generally do have stream channels connecting them to other water bodies. These channels are simply not filled with water by the 5 percent duration flood.)

82. Depressional wetlands are like bowls pushed into the landscape. Rain that falls within the bowl is concentrated to the lowest point. As more rain falls, the depth of water in the bowl rises. The water in the bowl rises until it reaches the rim of the bowl. Any water entering after it is filled to the rim can run out. If the bowl is tipped slightly, the amount of water that it holds will be reduced, and the lowest edge will be the control point of the water that is retained. Water can enter the bowl from the outside if the elevation of the water surface on the outside is greater than the controlling edge of the bowl. Depressional wetlands are like this bowl--they can capture water directly from precipitation or indirectly when the water surface of a flood exceeds the controlling elevation of the depressions outlet. When the water surface of a flood exceeds the controlling elevation of the wetland, the wetland is then considered connected. For this evaluation of wetlands, all wetlands whose controlling elevation is less than the 5 percent duration elevation at that site are considered connected. All other depressional wetlands are considered disconnected, even if they would be connected at some higher elevation. This assumption does not constitute a position by the Vicksburg District that a connection for 5 percent of the growing season would or would not subject such wetlands to Federal jurisdiction.

83. Along the western edge of the project area, there are a number of depressional wetlands that occupy abandoned channel features of the landscape. There are also a number of depressional swales in point bar deposits that can capture water as well. Both of these features are illustrated in Plate 10-40. Lakes Jackson and Washington are terminal depressions. Terminal depressions are located at the most upstream end of the stream network. The land surrounding these wetlands varies from 110 to 115 feet (all elevation data in this section is in NGVD). The minimum elevation in Lake Jackson depression is 104.0 feet, and the minimum elevation in Lake Washington is 88 feet. The water level in Lake Washington is controlled by a weir with an elevation of 99 feet. The 100-year backwater flood elevation for Steele Bayou at Grace is 100.3 feet, while the 5 percent duration elevation at Grace is 91.9 feet. Clearly, it would take a flood greater than the 100-year flood to fill Lake Jackson with floodwater, and it is therefore sustained by the direct capture of precipitation. Although Lake Washington would receive water from a 100-year event, it would not receive floodwater from a 5 percent duration event, and therefore it is sustained by the direct capture of precipitation as well. This establishes that some of the water bodies in the basin that are depicted by flood scenes and the modeled 5 percent duration flood are filled by the direct capture of precipitation and not from flooding.

84. Plates 10-42 through 10-46 are satellite images from five separate flood events. The dates of the five images are respectively 17Jan05, 21Jan89, 21Mar87, 10Mar89, and 17Jun90. The images are the results of a 5-band unsupervised classification using around 75 classes. The water surface elevations for the three gages visible in the images are printed in yellow by the gage sites. The water surface elevations vary around the 5 percent duration stage at each of the gages. The first four images were obtained during leaf-off conditions, but the last image was collected during leaf-on conditions. The plates also have four areas circled in yellow and numbered 1 through 4. These circled areas represent four ponding areas in the Big Sunflower subbasin. The plates also have the green tree reservoirs in DNF enclosed in green polygons, and the waterfowl management areas of DNF enclosed in red polygons. The green tree reservoirs are filled by pumps, while the waterfowl management areas capture rain or floodwater with water control structures. Plate 10-42 has the lowest average water surface elevations. The observed water surface elevations are less than the 5 percent duration and the 1-year frequency events. Ponding area 1 encompasses the Little Sunflower River in lower DNF. The geomorphology of this area is backswamp. Several large ponding areas and many smaller ponding areas are evident in the satellite image. All of these ponding areas would be considered connected depressional wetlands. Plates 10-43 through 10-46 show gradually increasing water surface elevations at the Little Sunflower structure with a near constant water surface elevation at Holly Bluff. The included depressional areas gradually increase in size through the series of flood scenes. Plate 10-45 represents the 5 percent duration event, and the extent of flooding in the Little Sunflower ponding area 1 has increased to the point that the connected depressional areas are now merged into one contiguous area.

85. Plates 10-42 through 10-46 provide a similar gradient of flooding for ponding area 2, which encompasses the Big Bend reach of the Big Sunflower River in the upper half of DNF. This area also has backswamp geomorphology. The extent of flooding in ponding area 2 increases through the plates in this sequence: 10-42, 10-45, 10-44, and 10-43. Several isolated depressional areas are evident in Plates 10-42 and 10-45, but these merge into a single contiguous area in Plate 10-44. Plate 10-45 represents the 5 percent duration event. The flood extent of the 5 percent duration event in this ponding area does not quite form one large contiguous area.

86. Ponding area 3 shows the Dowling Bayou drainage area, which encompasses the northern most portion of DNF. Unlike the two previous areas, most of this drainage basin has point bar geomorphology. Plate 10-42 shows several depressional wetlands that occupy swales between the higher ridges. The water surface elevation at Anguilla (90.8 feet) is 2.5 feet less than the 5 percent duration event and is just a little bit greater than the minimum elevation (90.0+ feet) for the quad maps. Dowling Bayou joins the Big Sunflower several miles downstream of Anguilla, and therefore the water surface in the Dowling Bayou ponding area will be less than 90.0 feet. This means that the water ponded in the swales is likely directly ponded precipitation. Plate 10-45 (10Mar89-5 percent duration) shows more flooding in the swales, but the swales are still individually distinct. The extent of flooding from the 21Jan89 and 21Mar87 (Plates 10-43

and 10-44, respectively) is greater still and some of the swales have merged, but most of the swales remain individually identifiable. Flooding in the lower portion of area 3 is more extensive in Plate 10-45 than in Plates 10-43 or 10-44, despite the lower water surface at the Anguilla gage. This difference can only be explained by localized ponding of precipitation in the 10Mar89 flood scene. This suggests that at least some of the ponding in the swales of the Dowling Bayou area is due to the direct capture of local runoff, and that these swales may be disconnected wetlands, at the 5 percent duration flood elevation. The swales in the Dowling Bayou area do not become completely connected until the water surface elevation exceeds the 2-year event. Plate 10-18 shows the 13Jan83 flood scene. The water surface elevation was 98.1 feet at Anguilla for that flood event, and most of the swales in area 3 have merged into one contiguous block.

87. Area 4 contains the Lake George WMA. Lake George occupies an abandoned channel of the Yazoo River. The interior of the Lake George area (area 4) is surrounded by the natural levees of the Big Sunflower and Yazoo Rivers. These landscape features create a natural bowl. Although the interior is connected to the Big Sunflower River by two streams, most of the interior is actually isolated from the Big Sunflower by a water control structure and a local levee. The water control structure has a riverside flap gate which prevents all waters from the river from entering the basin. The interior receives additional protection from a pump. The pump station is used after the waterfowl season has ended to evacuate water that has ponded during the fall and winter. Area 4 contains two relatively large areas of flooding in the flood scenes displayed in Plates 10-42 through 10-46. The southern part of ponding area 4 is riverside of the local levee, while the northern ponding area is on the protected side of the levee. The extent of flooding in the southern ponding area is proportional to the water surface at the Little Sunflower gage. The extent of flooding in the northern area seems to be proportional to the Holly Bluff water surface elevations, but in Plate 10-46, the flooding is limited to the southern ponding area. The northern ponding area is an example of a structurally disconnected wetland.

88. In conclusion, in order to calibrate the FESM model to flood scenes which contain both directly ponded precipitation and backwater flooded areas, the FESM modeled area contains both connected and disconnected wetlands. In general, those flooded areas that are contiguous to the major rivers are connected wetlands, while flooded areas not contiguous with the main channel are likely disconnected wetlands. The flood scenes clearly display areas that are flooded at elevations above the water surface of the flood. These areas represent perched depressional areas that directly capture precipitation and are considered disconnected for this wetland evaluation. Many of these areas become connected at water surface elevations above the 5 percent duration event.

HGM REGIONAL WETLAND FUNCTIONS

89. The HGM Regional Guidebook identifies eight functions that are preformed by Riverine Backwater wetlands. Those eight functions are (1) detain floodwater, (2) detain precipitation, (3) cycle nutrients, (4) export organic carbon, (5) physical removal of elements and compounds, (6) biological removal of elements and compounds, (7) maintain plant communities, and (8) provide fish and wildlife habitat. These eight functions are described in detail in the Regional Guidebook for the Yazoo Basin, and are briefly described below. **Detaining floodwater** is the ability of a wetland to store, convey, and reduce the velocity of floodwater as it moves through a wetland. **Detaining precipitation** is the capacity of a wetland to slow or prevent runoff of rainfall to streams. This is primarily accomplished by microdepressional storage and infiltration. **Cycle nutrients** is the ability of a wetland to convert nutrients from inorganic forms to organic forms and back through a variety of biogeochemical processes such as photosynthesis and microbial decomposition. The **export organic carbon** function is defined as the capacity of a wetland to export dissolved and particulate organic carbon, which may be vitally important to downstream aquatic systems. The **remove elements and compounds** function is defined as the ability of a wetland to permanently remove or temporarily immobilize nutrients, metals, and other elements and compounds that are imported to the wetland from various sources, but primarily via flooding. This function has been subdivided into **physical** and **biological** removal of elements and compounds. **Maintain plant communities** is defined as the capacity of a wetland to provide the environment necessary for a characteristic plant community to develop and be maintained. **Provide fish and wildlife habitat** is defined as the ability of a wetland to support the fish and wildlife species that utilize wetlands during some part of their life cycles.

HGM VARIABLES AND MODELS

90. The HGM Regional Guidebook for the Yazoo Basin lists 18 variables that are used in the models to describe the eight wetland functions. Field data for these 18 variables were collected at more than 120 sites in reference wetlands in the study area. These 18 variables and the models are fully described in the Regional Guidebook. For illustrative purposes, the five variables used in the Detain Floodwater model and the equation for the model are given below. The Detain Floodwater model includes the following assessment variables:

V_{FREQ}: Frequency of flooding
V_{LOG}: Log density
V_{GVC}: Ground vegetation cover
V_{SSD}: Shrub-sapling density
V_{TDEN}: Tree density

The general form of the model is:

$$FCI = V_{FREQ} \times [V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN}]/4$$

The models for the other functions vary in complexity and contain from 2 to 10 variables each. No single model contains all 18 variables, but all 18 are used in the 8 models. Each of the models are described in the Regional Guidebook. Five of the models include the V_{FREQ} variable. The Vicksburg District requested that the Wetland and Coastal Ecology Branch, ERDC, consider adding a variable for duration to the eight models. The ERDC researchers determined that it was appropriate to add a duration variable (V_{DUR}) to four of the five functions with the V_{FREQ} variable in the models. The addition of the V_{DUR} variable to four of the models is discussed in greater detail in the HGM Functional Assessment, which is Supplement B of this appendix. All of the impacts due to this project are associated with the four wetland functions which had the V_{DUR} variable added to their models. Those four functions are Export of Organic Carbon, Physical Removal of Elements and Compounds, Biological Removal of Elements and Compounds, and Provide Fish and Wildlife Habitat. By adding the V_{DUR} variable, the HGM models could address the consequences of different durations and more closely replicate the potential impacts of this project (which will reduce flood duration).

SCOPE AND LIMITATIONS

91. The Vicksburg District requested the Wetland and Coastal Ecology Branch, ERDC, to assess the impacts of the proposed Yazoo Backwater Project using the Regional HGM Guidebook for the Yazoo Basin (Smith and Klimas, 2002). In addition, the Vicksburg District requested that ERDC estimate the potential for proposed nonstructural, structural, and other mitigation areas to offset the impacts of the proposed Yazoo Backwater Project. The results of that study are fully documented in Supplement B of this appendix.

92. Based on the1987 Manual, areas that are saturated or inundated for less than 5 percent of the growing season do not meet the Federal definition of wetlands and therefore, are not subject to Section 404 protection. Based on this, the functional analysis is restricted to those areas within the study area where the base duration of backwater flooding during the growing season was greater than 5 percent.

METHODS

93. The methods used to assess the impacts of each alternative plan under the Yazoo Backwater Project are described in the published Yazoo Basin Regional Hydrogeomorphic Guidebook (Smith and Klimas, 2002), except as noted below.

MODIFICATIONS OF THE HGM MODEL AND METHODS

94. Several modifications of the methods outlined in the Yazoo Basin Regional HGM Guidebook (Smith and Klimas, 2002) were necessary. These modifications were made by ERDC and approved by EPA. The first modification consisted of changes to some of the assessment models in the Yazoo Basin Regional HGM Guidebook functions to take advantage of the newly available data related to the percent duration of backwater flooding during the growing season. Detailed information on the incorporation of duration into the assessment models is found in Supplement B of this appendix.

95. A second modification was made because of the large size of the assessment area. It was not possible or practical to sample the entire assessment area as prescribed in the Yazoo Basin Regional HGM Guidebook. Therefore, an alternative procedure, consistent with available time, resource, and accessibility constraints, was developed. Under the alternative procedure, the assessment area was divided into six land cover classes--mature forest (dominant trees >50 years of age), middle-aged forest (dominant trees 20 to 50 years of age), early-aged forest/planted bottom-land hardwood mitigation areas (dominant trees <20 years of age), agricultural, recently logged, and other. The "other" land cover class included permanent water bodies, catfish ponds, roads, and other areas where a change in function would not occur as a result of project impacts. Impacted areas (i.e., areas shifting from one duration range to another) were classified by land cover classes using 1996 digital ortho quarter quadrangles imagery and was updated using 2005 land use data.

RESULTS

96. Table 10-17 provides an example of the process followed by ERDC to assess the change in wetland functional capacity units (FCU) for each alternative. The changes in wetland functional values where based on changes in duration. All of the changes in wetland functional values are due to the four wetland functions with duration as a variable in their models. The four functions with duration as a variable are export of organic carbon, physical removal of elements and compounds, biological removal of elements and compounds, and provide wildlife habitat. Because the remaining four functions are not dependent on the duration of flooding, they did not experience any change in their functional value from the base condition. Each of the 30 possible composite duration intervals with their areal extents for Alternative 5 are displayed. The development of the composite duration intervals is described in paragraph 47, and the results for the five structural alternatives are tabulated in Table 10-11 of this appendix. This table is essentially the same as Table 56 in Supplement B of this appendix. The various duration intervals are sorted into four groups based on the changes in the duration intervals. The first

TABLE 10-17
CHANGE IN WETLAND FCU FOR ALTERNATIVE 5
COMPOSITE WETLAND INTERVALS

	Intervals With No Change In Duration	Acres	Loss in Wetland FCUs	Gain in Wetland FCUs	Net Change in Wetland FCUs
22	Base and Post 5	10,252	0		
33	Base and Post 7.5	25,133	0		
44	Base and Post 10	16,403	0		
55	Base and Post >12.5	70,644	0		
	Total	122,432	0		
	Intervals Changing to <5% Duration				
20	Base 5 to Post <2.5	11,699	-5,856		-5,856
21	Base 5 to Post <5	13,384	-4,212		-4,212
30	Base 7.5 to Post <2.5	350	-245		-245
31	Base 7.5 to Post <5	844	-463		-463
40	Base 10 to Post <2.5	-	0		0
41	Base 10 to Post <5	-	0		0
50	Base >12.5 to Post <2.5	-	0		0
51	Base >12.5 to Post <5	-	0		0
	Total	26,277	-10,776		-10,776
	Intervals Decreasing Duration But >5%				
32	Base 7.5 to Post 5	18,279	-1,784		-1,784
42	Base 10 to Post 5	6	-1		-1
43	Base 10 to Post 7.5	8,511	-951		-951
52	Base >12.5 to Post 5	-	0		0
53	Base >12.5 to Post 7.5	226	-42		-42
54	Base >12.5 to Post 10	8,773	-789		-789
	Total	35,795	-3,567		-3,567
	Intervals Increasing Duration				
12	Base <5 to Post 5	18		6	6
13	Base <5 to Post 7.5	0		0	0
14	Base <5 to Post 10	0		0	0
15	Base <5 to Post >12.5	0		0	0
23	Base 5 to Post 7.5	42		2	2
24	Base 5 to Post 10	0		0	0
25	Base 5 to Post >12.5	1		0	0
34	Base 7.5 to Post 10	18		1	1
35	Base 7.5 to Post >12.5	1		0	0
45	Base 10 to Post >12.5	4,840		151	151
	Total	4,920		160	160
	Gross Change	66,993	-14,343		-14,183
	Net Change	57,152			-14,503

group contains the four composite intervals (22, 33, 44, and 55) which experienced no change in duration and thus, no change in their FCUs. These four intervals represent 122,500 wetland acres, which is 64 percent of the base 189,600 acres. The second group represents those duration intervals where the post-project duration falls below 5 percent. There are eight possible composite intervals in this group, but only four are populated. Intervals 20 plus 21 (25,017 acres) and 30 plus 31 (1,200 acres) are added together and each treated as one in Table 56 of Supplement B. The minor differences in the areal extents are due to the transformation of the grid cell files developed by the Vicksburg District into polygons for the functional analysis by ERDC. This group contains 26,300 acres of wetlands whose postproject duration becomes less than 14 days. The loss in FCU for this group is 10,800, which represents approximately 2 percent of the base wetland FCU. Most of these wetland acres experience a change in annual duration of 7 days. The third group contains six duration intervals that experience a loss in duration, but still will experience more than 14 continuous days of inundation in most years. This group represents 35,800 acres and they collectively will lose 3,570 FCU. The group contains 19 percent of the base wetland acres, but the loss in FCU is less than one percent of the base FCU. The final group represents those wetlands that experience an increase in duration due to the project. There are 10 intervals represented here most containing less than 50 acres each. They are likely artifacts of the GIS processes. One interval (Base 10 to 12.5 percent duration to >12.5 percent duration) contains several thousand acres for Alternatives 5 through 7. Alternatives 6 and 7 have provisions to allow floodwater into the basin up to elevation 87.0 feet, NGVD. These two alternatives do show slight increases in the 12.5 percent duration stages. The moderate increase in FCU due to this change in duration represents approximately 5 hundredths of 1 percent of the base FCU. Plate 46a shows the locations of those wetlands which potentially have <5 percent duration and those which will experience a change in duration due to the project.

97. The results of the functional assessment are found in Tables 10-18 through 10-20. Table 10-18 shows the wetland acres of each plan that would experience change in flood duration and the base and postproject FCUs of these affected wetlands and the resultant change in FCUs induced by each of the alternative plans. Table 10-19 shows the average annual change in FCU per acre over project life. Table 10-20 shows the net changes in wetland FCUs by project alternative after the benefits of reforestation are included.

TABLE 10-18
SUMMARY OF CHANGE IN FCU DUE TO CHANGES IN FLOOD DURATION

Alternative	Acres Indirectly Affected by a Change in Duration	Baseline FCU	Postproject FCU	Change in FCU
2 (B1)	0	0	0	0
2A (B1)	0	0	0	0
2B (B1)	92,104	365,395	314,562	-50,869
2C (B1)	0	0	0	0
3 (B1)	118,486	580,515	536,525	-43,390
4 (B1)	101,629	493,627	465,496	-28,132
5 (B1)	66,945	299,869	265,680	-14,188
6 (B1)	48,066	209,762	200,461	-9,300
7 (B1)	28,408	123,389	118,440	-3,949

TABLE 10-19
AVERAGE ANNUAL CHANGE IN FCU PER ACRE OVER PERIOD OF ANALYSIS

Function	FCU/Acre						Average Annual Change in FCU / Acre a/
	Restoration Year 1	Restoration Year 10	Restoration Year 20	Restoration Year 30	Restoration Year 40	Restoration Year 50	
Detain Floodwater	0.00	0.44	0.59	0.80	0.94	0.97	0.62
Detain Precipitation	0.25	0.38	0.50	0.69	0.88	1.00	0.61
Cycle Nutrients	0.19	0.56	0.60	0.95	1.00	1.00	0.72
Export Organic Carbon	0.03	0.16	0.19	0.31	0.33	0.33	0.23
Physical Removal of E/C	0.00	0.04	0.08	0.17	0.25	0.33	0.15
Biological Removal of E/C	0.03	0.16	0.19	0.31	0.33	0.33	0.23
Maintain Plant Communities	0.00	0.53	0.68	0.82	0.91	0.98	0.65
Provide Wildlife Habitat	0.00	0.00	0.59	0.80	0.87	0.90	0.53
Total	0.49	2.27	3.42	4.87	5.51	5.86	3.74

a/ Average Annual = (Sum of Year 1 through 50) / 6

TABLE 10-20
SUMMARY OF ANNUAL CHANGE IN FCU

Alternative	Annual Change in FCU Due to Physical Construction of Pump Site	Annual Change in FCU Due to Change In Duration	Acres of Nonstructural Mitigation (Projected)	Annual (average) Change in FCU Per Acre	Annual (average) Change in FCU for Nonstructural Mitigation Acres (Product of Column 4 and 5)	Acres of Other than Minimum Acres Required to Achieve No-Net-Loss (Projected)	Annual (average) Change in FCU Per Acre	Annual (average) Change in FCU for Other than Nonstructural Mitigation Acres (Product of Column 7 and 8)	Total Annual Change in FCU (Sum of Columns 2, 3, 6, and 9)
2	0	0	124,400	3.74	464,768	0	3..74	0	464,768
2A	0	0	81,400	3.74	304,116	0	3.74	0	304,116
2B	0	-50,869	26,400	3.74	98,632	0	3.74	0	47,763
2C	0	0	114,400	3.74	427,497	0	3.74	0	427,407
3	-240	-43,990	0	3.74	0	20,860	3.74	77,935	33,704
4	-240	-28,132	37,200	3.74	138,982	0	3.74	0	110,610
5	-240	-14,188	55,600	3.74	207,726	0	3.74	0	193,297
6	-240	-9,300	81,400	3.74	304,116	0	3.74	0	294,576
7	-240	-3,949	124,400	3.74	464,768	0	3.74	0	460,578

UNCERTAINTY

98. Earlier in this report the 90 percent confidence range in wetland area was given as 150,000 to 229,000 acres. This interval encompasses the EPA's FIELD estimate of wetland acres (216,600). The changes in wetland functional values were also calculated for the 90 percent confidence interval wetland extents. These calculation were only made for the recommended alternative. The minimum wetland extent had a total FCU of 759,500. There were hydrologic changes on 52,800 acres which resulted in a loss of 11,200 FCUs. Approximately 3,000 acres of reforestation would offset the functional losses to the minimum wetland extent. The upper 90 percent confidence limit had 1,144,643 base FCUs. The project would reduce the duration of flooding on 95,100 acres of wetlands, resulting in a loss of 29,900 FCUs. This loss in FCU for the maximum wetland extent could be offset by the reforestation of less than 8,000 acres of frequently flooded cleared lands. Table 10-21 lists the change in wetland acres, the changes in wetland FCUs, and the amount of reforestation required to offset impacts due to the project for Alternative 5 for the median, the lower 90 percent, and the upper 90 percent confidence range.

CUMULATIVE IMPACTS

INTRODUCTION

99. Cumulative impacts are the sum of all changes to an area by all of the projects. This discussion will be limited to the cumulative impacts due to Vicksburg District flood control projects to wetland resources in the study area. This cumulative wetland impacts analysis is a new section of the Wetland Appendix and was not addressed in the 2000 Draft Report and Draft SEIS. This analysis represents the first attempt to predict wetland extent in the study area prior to the 1927 flood and the initiation of construction of the Mississippi River and Tributaries Project. The impacts can be divided into categories past and future. The impacts to wetlands from past projects will be discussed first, and then the potential changes due to future projects will be discussed.

TABLE 10-21
90% CONFIDENCE INTERVAL CHANGE IN
WETLAND EXTENT AND FCU FOR ALTERNATIVE 5

Category	Lower 90% Confidence	Alternative 5	Upper 90% Confidence
Wetland Acres	150,000	189,600	229,000
Change to <5%	12,900	26,300	44,600
Change to >5%	39,900	40,700	50,500
No Change	97,100	122,600	133,800
Base FCUs (total)	759,500	885,300	1,144,600
Loss in FCUs <5%	-6,600	-10,800	-24,500
Loss in FCUs >5%	-4,700	-3,600	-5,400
Total loss FCUs	-11,300	-14,400	-29,900
Mitigation Acres	2,996	3,794	7,893

PAST PROJECTS

100. Although there may have been some impacts to wetlands from the construction of local levees along the Mississippi River prior to the 1927 flood, this section will only consider changes to wetland hydrology that have resulted from the Mississippi River and Tributaries Project (MR&T). The extent of wetland resources in the study area will be estimated for four periods during the last century (1901-1997). The four periods represent preproject and three successive components of the overall MR&T project. The four periods represent preproject (1901-1931), MR&T-Channel Cutoffs (1932-1957), Yazoo Basin Flood Control Projects (1958-1978), and Backwater Levee Completed (1979-1997 or 2003). An additional analysis period (1943-1997) was used to help compare the data from previous periods to the period-of-record for this study. This analysis of the historical wetlands extent was initiated in response to a request for data from FWS as a part of the formal consultation on the endangered plant pondberry.

METHODS

101. The analysis in this section is made based on stage data collected by the Vicksburg District and the FESM model. The 5 percent duration wetland extent for four periods in the 20th century were estimated using the FESM model. The Vicksburg District started collecting Mississippi River stage data in the mid-1800s. Plate 10-47 shows the annual peak elevation for the Mississippi River at Vicksburg from 1872 through 2003, and Plate 10-47a shows the annual 5 percent duration elevation at Vicksburg for the years 1901 through 2001. This information was used to help divide the period from 1901 to 2000 into four periods. Plate 10-47 shows that there was a general trend for the annual peaks to increase in elevation from 1872 until the 1927 flood. After the 1927 flood, the Corps of Engineers, under authorization from Congress, became involved in flood damage reduction in the Lower Mississippi River Valley, and the annual peak elevations started to decline. The average peak annual elevations for the five periods depicted in Plate 10-47 are 1872-1900, 89.8; 1901-1931, 92.7; 1932-1957, 86.3; 1958-1977, 85.2; and 1978-1997, 88.1 (all elevations are feet, NGVD). Stage data collection was initiated in the early 1900s at a single site (Yazoo City) within the Yazoo Basin. Two additional stations were added in 1932 (Big Sunflower at Sunflower and Holly Bluff), and more stations were added in the late 1940s. The available data from each period were used to compute the median 5 percent duration elevation at all gages in the Backwater Study area. Missing 5 percent duration elevations were estimated from the existing data by interpolation along the 5 percent duration channel profile for each period. Plate 10-48 plots the annual 5 percent duration elevation for the major gages used in this analysis. A simplified data set with no off-channel nodes or secondary channels was used for the FESM model runs. The simplified model was used because there are no flood scenes prior to 1972 for model calibration, and there is less stage data available for the earlier periods.

RESULTS

102. Wetland extent for the five historical periods is presented in Table 10-22. The maximum wetland extent was observed in the preproject period from 1901 to 1931, and the minimum extent was observed during the 1958 to 1978 period. Although this analysis treats the 1901 to 1931 period as the base condition, without flood control, Plate 10-47 shows that period has the highest annual peak elevations for the entire period 1872 through 2003. Thus, the period 1901 to 1931 likely overestimates the base wetland extent. The period from 1872 to 1900 would be a better choice for a base period, but no interior Yazoo Basin stage data are available for that period. The period with the minimum has the lowest 5 percent duration elevation for Vicksburg. The low wetland extent observed during that period is likely due to the combined effects of the Mississippi River bendway cutoffs and the low observed rainfall that occurred during that period. The subsequent period had greater wetland extent even though additional flood control projects had been completed within the Yazoo Basin. The most recent period has the second highest median wetland extent, although it occurs after the completion of the Backwater levees. The variation in wetland extent exhibited by all periods shows that it is difficult to isolate the impacts due to flood control projects from the normal fluctuations in wetland extent observed due to the natural variations in hydrology. Plate 10-49 compares the results of the minimal model for the period-of-record (1943-1997) to the results from the full model for the same period-of-record. The minimal model has 30,500 less acres of wetlands, but those wetlands are mostly depressional wetlands in abandoned channel features of the study area. Table 10-14 shows that there are nearly 17,000 acres of permanent water bodies included in the FESM estimate of base wetlands. When those acres are subtracted from the total, the full FESM model estimated that there were 172,800 acres of wetlands for the 1943-1997 period-of-record. The minimal model estimated that there were 157,700 acres of wetlands, thus the minimal model's estimate is 91.2 percent of the full model (157,700/172,800). The minimal model was used for all wetland extents in this analysis of historic wetland extent and thus, the estimates will all have the same bias and are therefore comparable. Plate 10-50 compares the preproject wetlands to those of the project period-of-record (1943-1997) and the most recent period (1979-1997). Plate 10-51 compares the areal extent of wetlands from the four historical periods.

TABLE 10-22
WETLAND EXTENT
YAZOO BACKWATER AREA

Period	1901-1931	1932-1957	1958-1978	1979-1997	1943-1997
Wetland Acres	251,839	154,543	109,342	166,143	157,689

DISCUSSION

103. A comparison of the minimal FESM model results to the full FESM model results for the 5 percent duration wetlands (Plate 10-49) shows that the major difference is the depiction of abandoned channel wetlands along the western edge of the project area. There are 35,000 acres of wetlands that are unique to the full model output. The other difference is the inclusion of secondary channel beds by the full model. Although these differences add up to approximately 35,000 acres, they represent areas not affected by the project. Plate 10-50 compares historical wetlands from the preproject era (1901-1931) to the project period-of-record (1943-1997) and to the most current period of the historical wetlands study (1979-1997). The extent of the preproject wetlands exceeds those of any other period. The period-of-record wetlands show slightly more wetlands in the northern parts of the two subbasins (these wetlands are displayed in light blue in Plate 10-50), while the most current period (1979-1997) indicates there is a slight increase of wetlands in the southern part of the Big Sunflower ponding area (displayed in orange in Plate 10-50). This increase in wetlands in the southern part of the Big Sunflower basin result from the combination of an increase of stages due to the Holly Bluff cutoff and increased rainfall. These increases come in spite of the completion of the Backwater Levee in 1978 and show the effect of bed aggradation of the Mississippi River at Vicksburg.

104. Plate 10-51 compares the wetland extent of the four historic periods (1901-1931, 1932-1957, 1958-1978, and 1979-1997). The 1901 period is used as a backdrop to provide a reference for the other periods. The 1958-1978 period has the smallest extent of wetlands (109,000 acres). The plot of the annual 5 percent durations (Plate 10-47a) shows that the lowest 5 percent elevation for most of the gages occurs during this period (1954). The overall trend at all stations increases after this period. The increase in wetland extent during the last period (1979-1997) has to be due to changes in rainfall, as this period should show the maximum impacts due to the completed flood control projects. The change from 109,000 acres of wetlands in the 1958 period to 166,000 acres in the most recent period represents a 50 percent increase in wetland extent. Although the 1958-1978 period exhibits the minimal wetland extent, it shows an increase in wetlands in the lower Steele Bayou ponding area when compared to the previous period (1932-1957). This increase in wetland extent in the lower Steele Bayou ponding area is likely due to the completion of the Holly Bluff and the Steele Bayou cutoffs and the lower connecting channel. All three of these features were designed to increase the conveyance of water downstream.

105. This historical analysis of wetland features has shown that the wetland extent in the basin has contracted and expanded due to the combination of flood control projects and the natural variation in rainfall. The Mississippi River cutoffs resulted in an initial loss of approximately 150,000 acres of wetlands in the 1930s through the 1950s, but wetland resources have apparently rebounded due in part to increases in the annual 5 percent duration elevation at Vicksburg since the mid-1950s.

FUTURE PROJECTS

106. The Vicksburg District has a second flood control project that shares much of the project area. The Big Sunflower Maintenance Project is the other project in the basin. Plate 10-52 shows the two project areas. The brown area in Plate 10-52 shows that portion of the Backwater Project Area that is unique to that project. The green area in Plate 10-52 shows the area that is unique to the Big Sunflower Maintenance Project, while the yellow zone is the area shared by the two projects. The Backwater Study Project area is 925,600 acres, and the Big Sunflower Project area is 723,980 acres. The two studies share a project area of 513,565 acres, or 55 percent of the Yazoo Backwater Study Project Area and 71 percent of the Big Sunflower Project Area.

METHOD

107. Additional wetlands analyses were performed in order to assess the potential for additive impacts. The 5 percent duration water surface was determined for a base condition with the Big Sunflower Maintenance Project complete. This condition was labeled Base2. Base1 is with the backwater levees, Steele Bayou, and the Little Sunflower structures complete. The with-project wetlands were then determined as before for each of the five structural alternatives (Alternatives 3 through 7). The base and with-project water surface profiles are shown on Plate 10-53. Before the results of the combined study are discussed, the Base1 wetlands for each project were compared.

RESULTS

108. Plate 10-52 shows the Base condition 5 percent duration wetlands for the two projects. There were 104,660 acres within the 5 percent duration flood in the joint area as determined by the Backwater model. The cumulative impacts of the Yazoo Backwater Project and the Big Sunflower Maintenance Project on wetland resources of the combined study area are shown in Plates 10-54 and 10-55. Plate 10-54 shows the 5 percent duration wetlands that will be

impacted by the two projects individually or together. Plate 10-56 shows the composite duration zones of the Base2 (with Big Sunflower Maintenance recommended plan) and the recommended plan (Alternative 5). The Big Sunflower Maintenance Project will reduce the 5 percent duration wetlands by 9,200 acres, and the combined projects will reduce the 5 percent duration wetlands by 35,508 acres. The cumulative impacts to wetland functional values are discussed in the Functional Assessment portion of this Appendix. Wetland functional values would be reduced by 17,600 habitat units, of which 14,200 are from the Backwater Project. Impacts to wetlands by the Big Sunflower Project will be mitigated independently under that project's authority by reforestation of frequently flooded farmland. Impacts to wetlands by the Yazoo Backwater Project will be offset by the nonstructural component of the recommended plan. <u>The purchase of conservation easements and reforestation of 56,600 acres of agricultural land by this project will provide a net increase up to 55,600 acres and wetland functional values, whether the project is completed alone or in combination with the Big Sunflower Maintenance Project</u>.

CONCLUSION

109. This appendix represents the results of three different wide-area wetland delineations (Flood, FESM, and Field). All three give an estimate of total project area wetlands of approximately 200,000 acres. There is less than 10 percent difference between the areal extent estimations. Of the three methods, only the FESM model method can estimate both the existing and postproject wetland extent. Thus, the FESM method enables the comparison of pre- and postproject wetland extent and the computation of the impacts to wetlands based on their HGM-calculated functional values. The HGM functional model was developed at ERDC with funding and direction provided by EPA. The study area was subdivided into five compartments based on their annual duration of flooding (2.5, 5, 7.5, 10, and 12.5 percent), and HGM classed the wetlands into six land-use categories to further refine the impacts analysis. These subdivisions enabled a more detailed evaluation of the losses in wetland functional values. The HGM approach evaluates the impacts to wetlands for eight different wetland functions. This project will only have an impact on four of the eight functions. This analysis represents a significant advancement in wetland impact assessment because it predicts changes in wetland extent and changes in functional capacity. Furthermore, these impacts are predicted based on changes in the basin’s hydrology resulting from the structural feature of the project. The structural component of the recommended plan will reduce the duration of flooding on 26,300 acres of wetlands to less than 14 days annually (5 percent duration). These wetlands would no longer meet the Federal definition of wetlands. Approximately 8,400 of these 26,300 acres are public lands that will continue to be protected from clearing. An additional 36,000 acres will experience a shorter annual duration of flooding, but will still receive at least 14 days of continuous flooding in most years. These wetlands would still meet the Federal definition of wetlands. These changes in the annual duration of flooding combined with the construction impacts at the pump station site will

result in a loss of approximately 25,300 Wetland FCUs, which could be offset under compensatory mitigation by the purchase and reforestation of 5,900 acres of agricultural land. The loss of 25,300 FCUs represents 2.9 percent of the base preproject wetland FCUs (25,300/870,000). The nonstructural project component of the recommended plan includes conservation easements and the reforestation/conservation measures of 55,600 acres of cleared agricultural land. This reforestation would more than compensate for the wetland losses due to the structural component. The reforestation of the 55,600 acres of cleared lands would provide a 28.3 percent increase in the base wetland FCUs. The losses in base wetland acres and FCUs are due solely to the reduction in the duration of backwater flooding based and on the assumption that the 52 inches of annual precipitation do not play an important role in sustaining the basins wetlands. Because precipitation does likely play an important role in sustaining wetlands, this analysis is overstating the impact of the project on wetland resources. The previous statement is just one example of several decisions within the Wetland Appendix which were protective of wetlands. The first decision was the assumption that backwater flooding was the sole source of water for the maintenance of wetlands. The comparison of the EPA field testing results and the FESM modeled wetlands suggests that approximately 23 percent of the wetlands are supported by local hydrology. The second decision was that all lands below the 5 percent duration elevation were wetlands. The Federal definition states that all lands below the 12.5 percent duration elevation are wetlands, and that lands between the 12.5 percent duration elevation and the 5.0 percent duration elevation may be wetlands. There are approximately 80,000 acres below the 12.5 percent duration elevation, and there are 189,000 acres below the 5.0 percent duration elevation. Thus more than 109,000 acres that were determined to be wetlands were in the hydrology zone of possible wetlands. The next decision was that lands that met the hydrology component of the wetlands definition were wetlands. This assumed that those lands would also meet the vegetative and soils components of the definition. The final decision that supported wetlands was to use the median duration elevations for base conditions instead of the mean. This increased the areal extent of base wetlands by approximately 14,000 acres. Each of the above decisions led to an over estimation of wetlands in the study area and to potential impacts to them. The decision to use the 5 percent duration elevation instead of the 12.5 percent duration elevation increased the base wetland extent by more than 109,000 acres and increased the impacts to wetlands from 4,315 to 26,263 acres for the recommended plan (from Table 10-11). In summary, this Wetland Appendix presents a state-of-the-art technique for the offsite delineation of wetlands which enables an accurate and detailed determination of project-induced impacts to wetlands that is consistently protective of wetland resources. Impacts to wetland resources were determined by the HGM approach which determines the functional values of wetlands based on reference wetlands.

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