DEPARTMENT OF THE INTERIOR
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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

HYDROLOGIC INVESTIGATIONS
ATLAS HA-591 SHEET 1

BACKWATER AT BRIDGES AND DENSELY WOODED FLOOD PLAINS, BOGUE CHITTO NEAR JOHNSTON STATION, MISSISSIPPI

By B. E. Colson, C. O. Ming, and George J. Acrement.

FLOOD-FLOW DATA, BOGUE CHITTO NEAR JOHNSTON STATION, MISSISSIPPI

INTRODUCTION

New techniques for predicting water-surface profiles, needed in the design of economical, structurally sound, and environmentally compatible stream crossings, are under investigation. The investigation has accelerated with the advent of digital computers capable of analyzing large quantities of data. Among the techniques is the development of two-dimensional (2-D) digital models. Field data are essential for development and evaluation of these techniques for predicting water-surface profiles. This atlas is one of a series that will provide a wide range of field data.

Since 1969 the U.S. Geological Survey has been collecting flood data where wide, densely vegetated flood plains are crossed by highway embankments and single-opening bridges. This work was done in cooperation with the Federal Highway Administration Department of Transportation, the Alabama State Highway Department, the Louisiana Department of Transportation and Development, and the Mississippi State Highway Department. The objective of this cooperative project is to present the data in a format conducive to the development of improved models for predicting hydraulic responses of flow at highway crossings of streams in complex hydrologic and geographic settings.

Data were collected at the following 22 sites (fig. 1) for 35 floods; that is, 11 sites had 1 flood each; 9 sites, 2 floods each; and 2 sites, 3 floods each. Analysis of the data (Schneider and others, 1976) showed that backwater and discharge at these sites computed by methods presently in use, would be inaccurate. The floodflow data are unique in the range and detail in which information was collected and provide a base for evaluating digital models relating to open-channel flow. This atlas shows flood data obtained on Bogue Chitto near Johnston Station, Mississippi, one of 22 sites plotted in figure 1.

HYDROLOGIC INVESTIGATIONS ATLAS NUMBER

DESCRIPTION OF DATA

TYPE OF DATA

Data collected at all study sites consist of (1) depths, velocities, and discharges measured through the bridge openings, and (2) water-surface elevations along the highway embankment and along cross sections. A minimum of eight valley cross sections were surveyed at highway crossings and valley-width intervals in the vicinity of the bridge at each site. Locations of the cross sections were alined perpendicular to the assumed direction of flow. Cross sections were extended to intersect the edge of the valley at equal water-surface elevations. Surveying procedures described in the U.S. Geological Survey Techniques of Water-Resources Investigations series (Matthai, 1967; Benson and Dalrymple, 1967) were followed.

HIGH-WATER MARKS

Water-surface elevations were determined from high-water marks identified along the cross sections and the edges of the valley after each flood. During peak discharge measurements, water-surface elevations were marked with standard surveying stakes along the upstream and downstream sides of the highway embankment. For some floods additional high-water marks were identified in the valley adjacent to the bridge to define in detail the water surface in the approach and exit reaches.

BRIDGE GEOMETRY

Detailed bridge geometry was obtained at each site. The bridge cross section was surveyed at the most contracted section. Piers, spur dikes, wingwalls, abutment slopes, and other pertinent geometry were measured.

MANNING'S ROUGHNESS COEFFICIENT

Schneider and others (1976) used composite Manning's roughness coefficient values n where frequent changes in roughness occurred. In their study, composite values of n were verified by matching step backwater computations of the water surface with actual water-surface profiles for measured discharges. The range of n values used in this report is based on values used by Schneider and others (1976). Roughness varies from open fields to dense forests.

Roughness values or ranges of roughness values in difference parts of the flood plain are shown on the maps. The values shown are based on water depth. The high value is the value where water depth is less than 0.6 meter and the low value applies where water depth is greater than 1.0 meter. A linear relation of roughness to water depth is assumed for water depths between 0.6 and 1.0 meter.

PRESENTATION OF DATA

The data are presented on topographic maps enlarged from standard 1:24,000 (or 1:62,500) scale Geological Survey topographic maps which comply with National Map Accuracy Standards. Accuracy limitations of the base maps are retained on the enlargements. Although positions may be scaled closely on the enlargements, they are not defined with greater accuracy than positions on the base maps.

Ground elevations are placed adjacent to solid squares. Elevations of floodmarks are indicated by numerical values adjacent to solid triangles. Floodmark elevations for separate floods are shown on sheet 3. Bridge geometry and road-embankment dimensions are shown with brief notations of pier spacing and configuration.
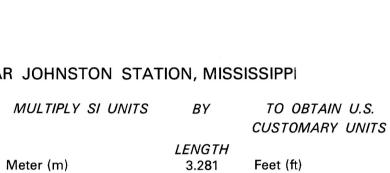
In addition to the data points shown on the maps, discharge measurements of selected floods, plots of cross sections, and velocity distribution diagrams are shown. Cross-section elevations are tabulated to define stream channels and flood-plain features in greater detail. Each cross section is referred to a zero station established at the extreme left edge (facing downstream) of the valley.

DATUM

All elevations presented in this report are referred to National Geodetic Vertical Datum of 1929 (NGVD).

FLOOD FREQUENCY

Flood-frequency relations are presented graphically. Techniques for deriving flood-frequency relations are those described by the U.S. Water Resources Council (1977), and by Colson and Hudson (1976).

INTERNATIONAL SYSTEM OF UNITS (SI)

The International System of Units (SI) is used throughout this report. All data were measured in the U.S. customary units and converted to SI units. Ground elevations which were originally determined to the nearest tenth of a foot are rounded to the nearest 0.01 meter. Water-surface elevations which were surveyed to hundredths of a foot are rounded to millimeters. The same criteria apply to all other dimensions, except contour elevations which are shown to the nearest tenth of a meter.

MULTIPLY SI UNITS	BY	TO OBTAIN U.S. CUSTOMARY UNITS
LENGTH		
Meter (m)	3.281	Feet (ft)
AREA		
Square meter (m²)	10.76	Square feet (ft²)
VOLUME		
Cubic meter (m³)	35.31	Cubic feet (ft³)
VELOCITY		
Meter per second (m/s)	3.281	Feet per second (ft/s)
FLOW RATE		
Cubic meter per second (m³/s)	35.31	Cubic feet per second (ft³/s)

DATA FOR BOGUE CHITTO NEAR JOHNSTON STATION, MISSISSIPPI

Data for Bogue Chitto near Johnston Station, Miss. obtained in a 6.4 kilometer reach crossed about midway by a county road are presented on five sheets (fig. 2). Sheet 1 contains tables showing cross-section data (table 1) and discharge data (table 2). An aerial view looking downstream in the vicinity of the bridge is shown in figure 3. Relative magnitudes of the floods are shown on the frequency curve (fig. 4).

The locations of representative ground elevations are shown on sheet 2. These are points of significant changes in cross section elevation and alignment of the axis. Plots of the cross sections are graphic interpretations of the tabular data. Bridge geometry and road embankments are shown on sheet 2 as they existed at the time of the floods. The cross section surveyed at the downstream side of the bridge is tabulated on sheet 1. The cross section shown for velocity distribution was obtained by sounding from the upstream side of the bridge during the discharge measurement.

Data for three floods on Bogue Chitto are presented. The first flood occurred December 7, 1971 (sheet 3). Nine cross sections were surveyed after this flood (sheet 2). A second flood occurred on March 25, 1973 (sheet 3). The third flood occurred April 14, 1974 (sheet 3).

The 1971 flood damaged the left abutment, causing the revetment at the downstream side to collapse. Both the 1973 and 1974 floods overtopped the roadfill to depths less than 0.1 meter. Both of these floods undermined the left abutment sufficiently to cause partial collapse of the roadway but did not breach the fill. The roadway, including the abutment, was repaired after each flood. After the 1974 flood an earthen spur dike extending upstream from the left abutment was constructed to protect the abutment, and to reduce scour at the downstream side of the bridge.

A profile of the roadway crown was surveyed after the 1973 flood. Valley cross sections as surveyed are considered valid for all floods.

Manning's roughness coefficient values and the 1973 flood boundaries are shown on sheets 2 and 3.

FLOOD OF DECEMBER 7, 1971

Peak water-surface elevations, the measured cross section, and velocities for the flood of December 7, 1971, are shown on sheet 3. The flood crested at an elevation of 102.379 meters at the reference point located on the downstream guardrail 53 meters from the left abutment. The peak discharge was 708 cubic meters per second (m³/s), from a stage-discharge relation developed for the site. A discharge of 620 m³/s was measured on the recession at an elevation of 102.312 meters at the reference point (table 2). The recurrence interval of the peak discharge is 50 years (Colson and Hudson, 1976). See figure 4.

FLOOD OF MARCH 25, 1973

Peak water-surface elevations for the flood of March 25, 1973, are shown on sheet 3. The flood crested at an elevation of 102.471 meters at the reference point located on the downstream guardrail. The peak discharge was 892 m³/s from the stage-discharge relation for the site. A discharge of 362 m³/s was measured at an elevation of 101.895 meters at the reference point on December 21, 1972 (table 2). The measured cross section and velocity distribution for the measurement of December 21, 1972 are shown on sheet 3. The recurrence interval of the peak discharge is greater than 100 years (Colson and Hudson, 1976). See figure 4.

FLOOD OF APRIL 14, 1974

Peak water-surface elevations for the flood of April 14, 1974, are shown on sheet 3. The flood crested at an elevation of 102.593 meters at the reference point. The average crest elevation at the downstream bridge abutments was 102.382 meters. The peak discharge was 606 m³/s from the stage-discharge relation. A discharge of 606 m³/s was measured on the recession at an elevation of 102.315 meters at the reference point (table 2). The recurrence interval of the 1974 peak discharge is greater than 100 years (Colson and Hudson, 1976). See figure 4.

SUMMARY

Floodflow data that will provide a base for evaluating digital models relating to open-channel flow were obtained at 22 sites on streams in Alabama, Louisiana, and Mississippi. Thirty-five floods were measured. Analysis of the data indicated methods currently in use would be inaccurate where densely vegetated flood plains are crossed by highway embankments and single-opening bridges. This atlas presents flood information at the site on Bogue Chitto near Johnston Station, Miss. Water depths, velocities, and discharges through bridge openings on Bogue Chitto near Johnston Station, Miss. for floods of December 7, 1971, March 25, 1973, and April 14, 1974, are shown, together with peak water-surface elevations along embankments and along cross sections. Manning's roughness coefficient values in different parts of the flood plain are shown on the maps, and flood-frequency relations are shown on graphs.

ADDITIONAL INFORMATION

Other information pertaining to floods in Alabama, Louisiana, and Mississippi may be obtained at the offices of the U.S. Geological Survey listed below:

U.S. Geological Survey
Room 202, Oil and Gas Board Building (P.O. Box V)
University, Alabama 35486

U.S. Geological Survey
6554 Florida Boulevard (P.O. Box 66492)
Baton Rouge, Louisiana 70896

U.S. Geological Survey
430 Bounds Street
Jackson, Mississippi 39206

SELECTED REFERENCES

Barnes, H. H., Jr., 1967, Roughness characteristics of natural channels: U.S. Geol. Survey Water Supply Paper 1849, 213 p.

Benson, M. A., and Dalrymple, T., 1967, General field and office procedures for indirect discharge measurements: U.S. Geol. Survey Techniques Water-Resources Inv., book 3, chap. A1, 30 p.

Bradley, J. N., 1970, Hydraulics of bridge waterways: Federal Highway Admin., Hydraulic Design Ser. No. 1, 111 p.

Colson, B. E., and Hudson, J. W., 1976, Flood frequency of Mississippi streams: Mississippi State Highway Dept., 34 p.

Hains, C. F., 1973, Floods in Alabama, magnitude and frequency: Alabama Highway Dept., 37 p.

Hedman, E. R., 1964, Effects of spur dikes on flow through constrictions: Am. Soc. Civil Engineers Proc., Jour. Hydraulics Div., v. 91, no. HY4, July 1965, p. 155-165.

Matthai, H. F., 1967, Measurements of peak discharge at width contractions by indirect methods: U.S. Geol. Survey Techniques Water-Resources Inv., book 3, chap. A4, 44 p.

Neely, B. L., Jr., 1976, Floods in Louisiana, magnitude and frequency, 3d ed.: Louisiana Dept. Highways, 340 p.

Schneider, V. R., Board, J. W., Colson, B. E., Lee, F. N., and Druffel, L., 1976, Computation of backwater and discharge at width constrictions of heavily vegetated flood plains: U.S. Geol. Survey Water-Resources Inv. 76-129, 64 p.

U.S. Water Resources Council, 1977, Guidelines for determining flood flow frequency: Washington, D.C., U.S. Water Resources Council Bull. 17A, 163 p.
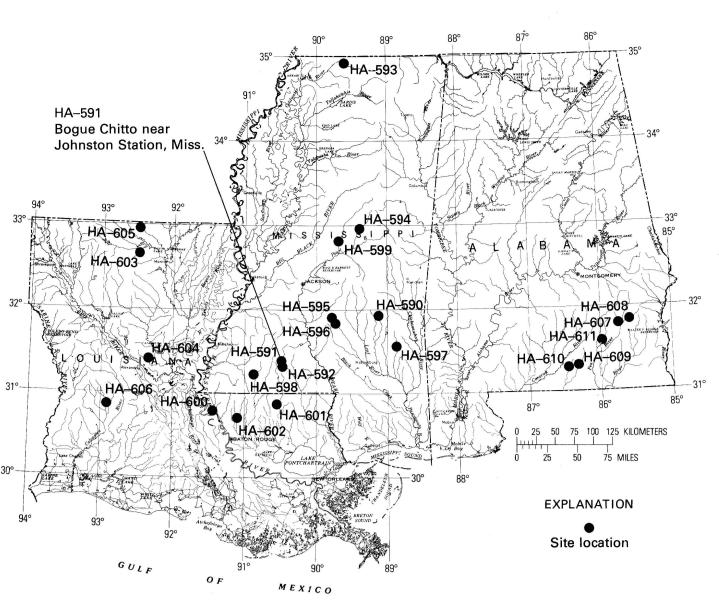
FIGURE 1.—INDEX MAP OF STUDY SITES IN THE BRIDGE BACKWATER INVESTIGATION PROJECT, ALABAMA, LOUISIANA, AND MISSISSIPPI.
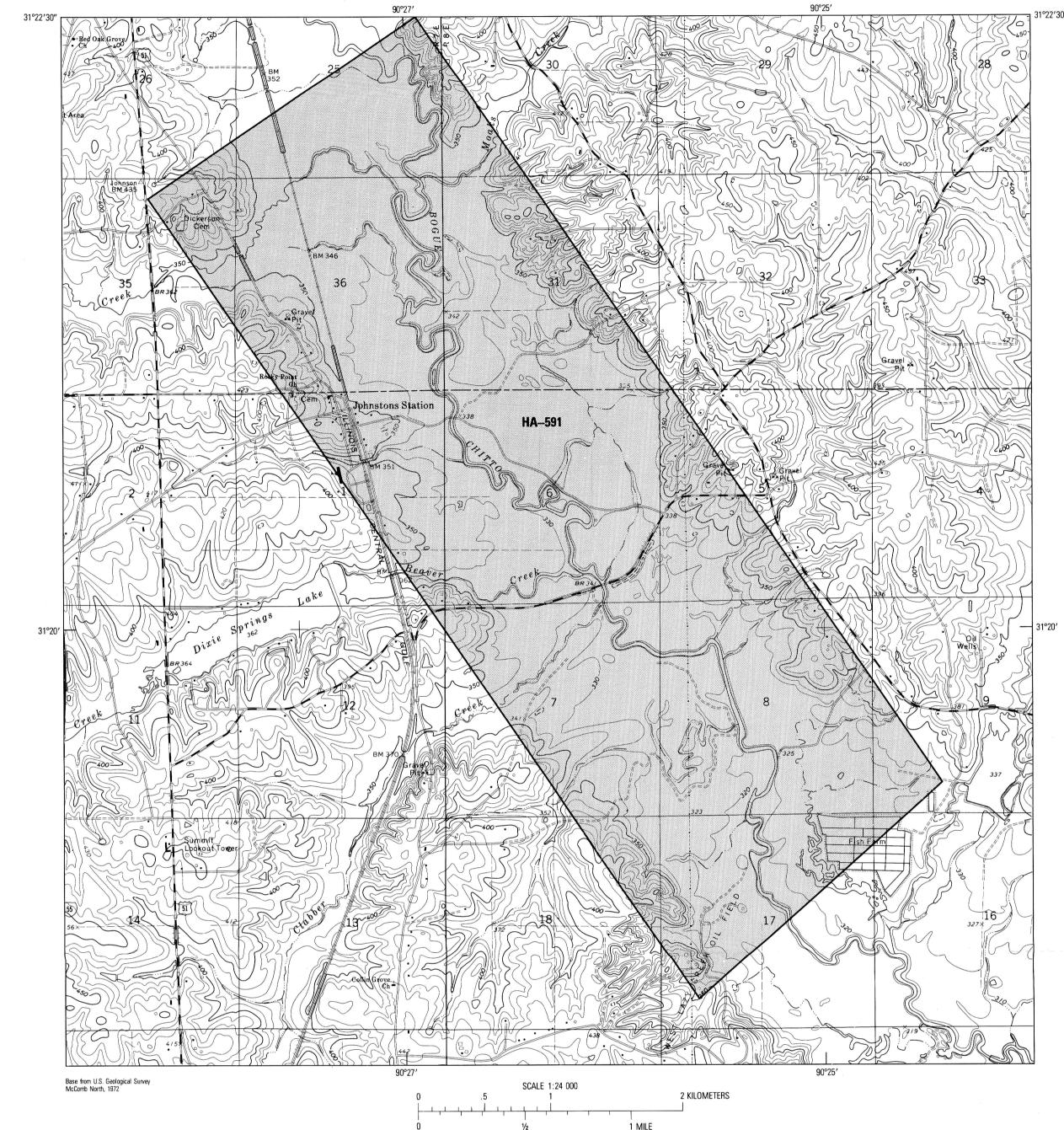

FIGURE 2.—INDEX MAP SHOWING STUDY REACH BOGUE CHITTO NEAR JOHNSTON STATION, MISSISSIPPI
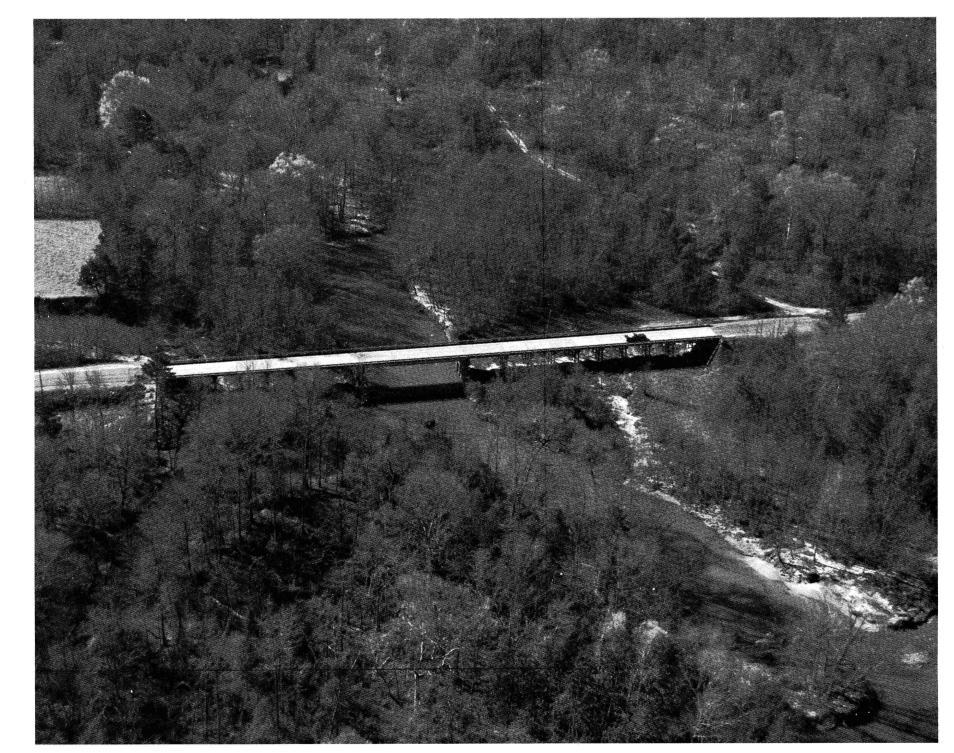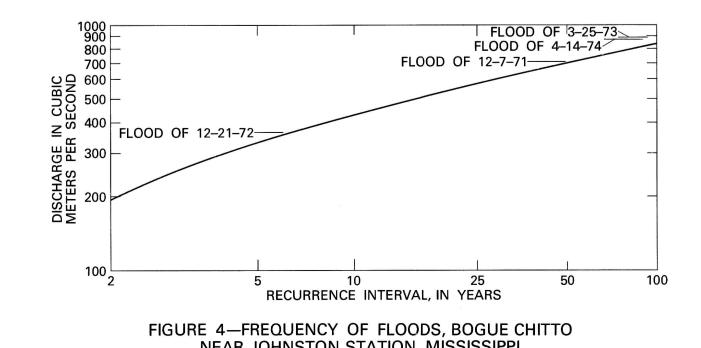

FIGURE 3.—AERIAL VIEW LOOKING DOWNSTREAM AT BRIDGE ON COUNTY HIGHWAY, BOGUE CHITTO NEAR JOHNSTON STATION, MISSISSIPPI

FIGURE 4.—FREQUENCY OF FLOODS, BOGUE CHITTO NEAR JOHNSTON STATION, MISSISSIPPI

TABLE 1.—VALLEY CROSS SECTION DATA FOR BOGUE CHITTO NEAR JOHNSTON STATION, MISSISSIPPI. ZERO STATION IS AT THE LEFT EDGE OF THE VALLEY (FACING DOWNSTREAM).

TABLE 2.—DISCHARGE MEASUREMENTS DECEMBER 7, 1971, DECEMBER 21, 1972, AND APRIL 14, 1974, AT COUNTY HIGHWAY NEAR JOHNSTON STATION, MISSISSIPPI. ZERO STATION IS AT THE EDGE OF THE LEFT ABUTMENT (FACING DOWNSTREAM)