ATLAS HA-600

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

BACKWATER AT BRIDGES AND DENSELY WOODED FLOOD PLAINS, ALEXANDER CREEK NEAR ST. FRANCISVILLE, LOUISIANA

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

Prepared in cooperation with the
DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
and the
LOUISIANA DEPARTMENT OF
TRANSPORTATION AND DEVELOPMENT

HYDROLOGIC INVESTIGATIONS ATLAS
Published by the U.S. Geological Survey, 1979
W

Prepared in cooperation with the
DEPARTMENT OF TRANSPORTATION FEDERAL HIGHWAY ADMINISTRATION
AND THE LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

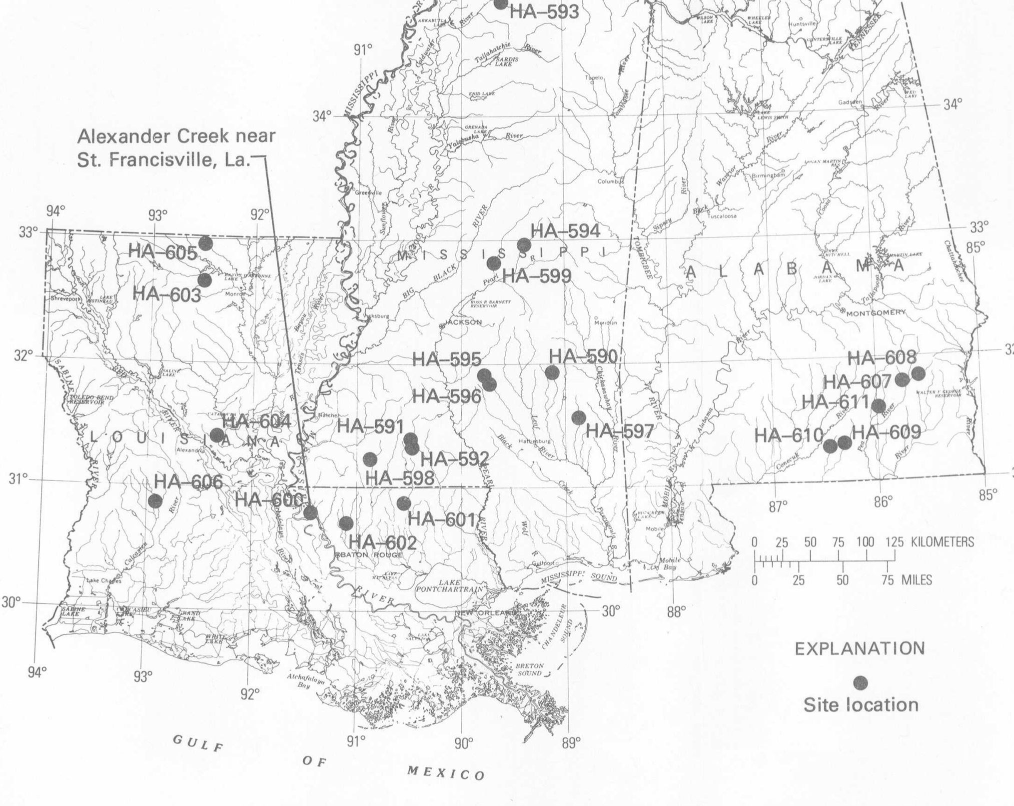

FIGURE 1.—INDEX MAP OF STUDY SITES IN THE BRIDGE BACKWATER INVESTIGATION PROJECT, ALABAMA, LOUISIANA, AND MISSISSIPPI.

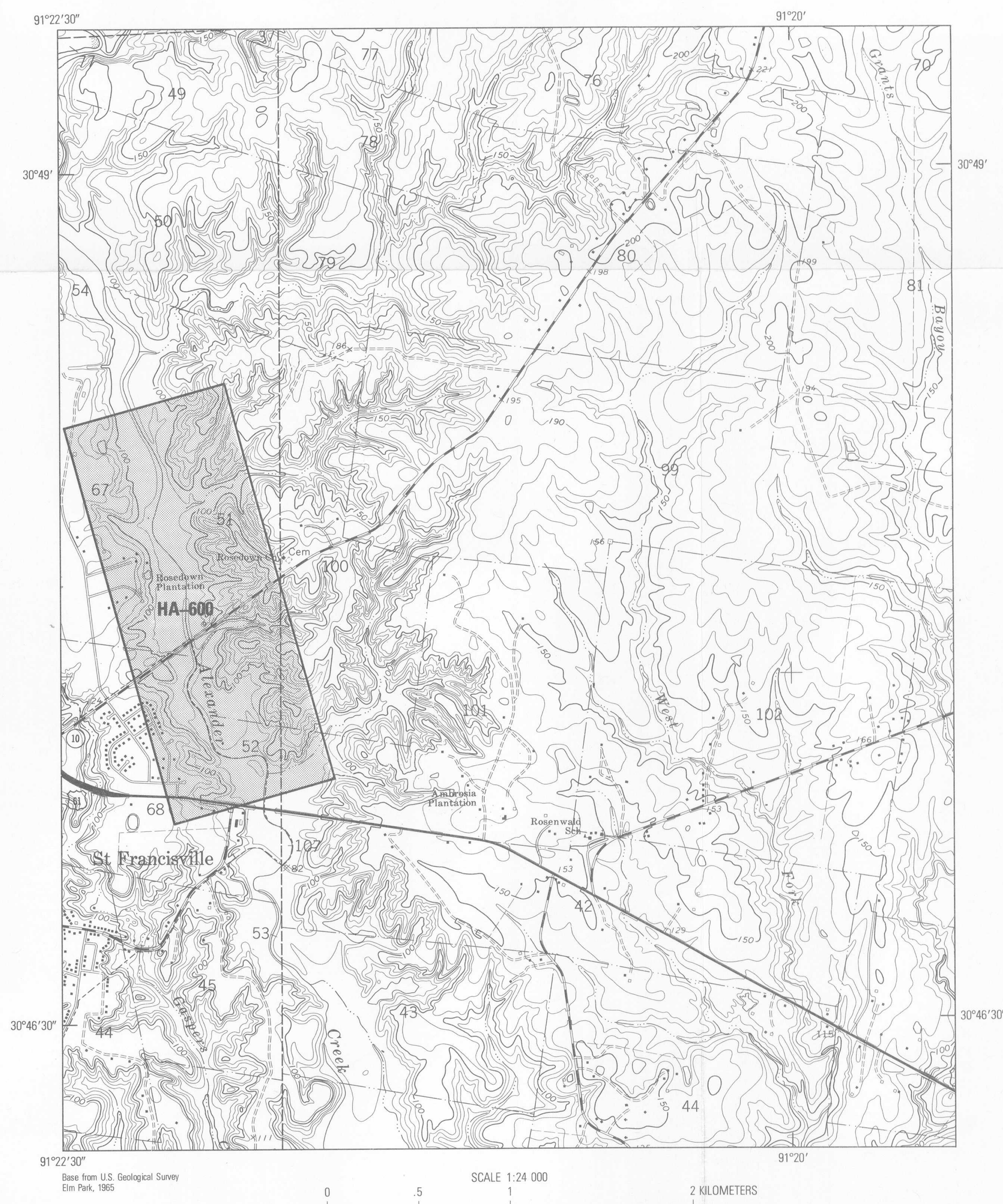

FIGURE 2—INDEX MAP SHOWING STUDY REACH, ALEXANDER CREEK NEAR ST. FRANCISVILLE, LOUISIANA

BACKWATER AT BRIDGES AND DENSELY WOODED FLOOD PLAINS ALEXANDER CREEK NEAR ST. FRANCISVILLE, LOUISIANA

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 provide a wide range of field data.

Since 1969 the U.S. Geological Survey has been collecting backwater 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.

Backwater data were obtained at 22 sites for 35 floods; that is, 11 sites had 1 flood each; 9 sites, 2 floods each; and 2 sites, 3 floods each. Analysis of 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.

The data sites (fig. 1) are listed below. This atlas shows flood data obtained on Alexander Creek near St. Francisville, Louisiana, one of the 22 sites.

HYDROLOGIC INVESTIGATIONS ATLAS NUMBER

ALABAMA
Buckhorn Creek near Shiloh HA–607
Pea Creek near Louisville 608
Poley Creek near Sanford 609
Yellow River near Sanford 610
Whitewater Creek near Tarantum 611

LOUISIANA
Alexander Creek near St. Francisville HA–600
Beaver Creek near Kentwood 601
Comite River near Olive Branch 602
Cypress Creek near Downsville 603
Flagon Bayou near Libuse 604
Little Bayou de Loutre near Truxno 605
Tenmile Creek near Elizabeth 606

MISSISSIPPI
Bogue Chitto near Johnston Station HA–591
Bogue Chitto near Summit 592
Coldwater River near Red Banks 593
Lobutcha Creek at Zama 594
Okatoma Creek east of Magee 595
Okatoma Creek near Magee 596
Tallahala Creek at Waldrup 590
Thompson Creek near Clara 597
West Fork Amite River near Liberty 598
Yockanookany River near Thomastown 599

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) peak water-surface elevations along the highway embankment and along cross sections. A minimum of eight valley cross sections were surveyed at approximately one valley-width intervals in the vicinity of the bridge at each site. Locations of the cross sections were alined perpendicularly 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 downstreams 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 different 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 U.S. Geological Survey topographic maps which comply with National Map Accuracy Standards. Accuracy limitations of the base maps are retained in 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 separate sheets. 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 Neely (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.

The following factors may be used to convert SI units to the U.S. customary units:

MULTIPLY SI UNITS	*BY*	*TO OBTAIN U.S. CUSTOMARY UNITS*
	LENGTH	
Meter (m)	3.281	Feet (ft)
	AREA	
Square meter (m^2)	10.76	Square feet (ft^2)
	VOLUME	
Cubic meter (m^3)	35.31	Cubic feet (ft^3)
	VELOCITY	
Meter per second (m/s)	3.281	Feet per second (ft/s)
	FLOW RATE	
Cubic meter per second (m^3/s)	35.31	Cubic feet per second (ft^3/s)

DATA FOR ALEXANDER CREEK NEAR ST. FRANCISVILLE

Data for Alexander Creek near St. Francisville, La., obtained in a 2-kilometer reach crossed about midway by State Highway 10, are presented on three sheets (fig. 2). Sheet 1 contains tables showing cross-section data (table 1) and discharge data (table 2). An aerial view of the reach looking upstream at the bridge on State Highway 10 is shown in Figure 3. Relative magnitude of the floods is 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 elevations and alinement of the axis. Plots of the cross sections are graphic presentations of the tabular data.

Bridge geometry and road embankments are shown on sheet 2 as they existed at the time of floods. The cross section surveyed at the downstream side of the bridge is tabulated on sheet 1. The cross sections shown for velocity distribution were obtained by sounding from the downstream side of the bridge during the discharge measurements.

Data for two floods on Alexander Creek are presented. The first flood occurred September 16, 1971. Ten valley cross sections were surveyed after this flood (sheet 2). The second flood occurred December 7, 1971, and the third occurred March 24, 1973. The stability of the stage-discharge relation indicates that no significant changes have occurred in the flood plain downstream from the bridge. Valley cross sections as surveyed are considered valid for all floods.

Manning's roughness coefficient values and the December 7, 1971, flood boundaries are shown on sheets 2 and 3.

FLOOD OF SEPTEMBER 16, 1971

Peak water-surface elevations for the flood of September 16, 1971, are shown on sheet 3. The flood crested at an elevation of 26.737 meters at the reference point located on the downstream guardrail 43 meters from the left abutment. The peak discharge was 156 cubic meters per second, from a stage-discharge relation developed for the site. No discharge measurement was made during this flood. The recurrence interval of the peak discharge is 3 years (Neely, 1976). See Figure 4.

The March 24, 1973 measured cross section and velocity distribution are shown on sheet 3 as representative of the velocity distribution for the September 16, 1971 flood data.

A discharge of 214 cubic meters per second was measured at an elevation of 26.993 meters at the reference point on March 24, 1973 (table 2).

FLOOD OF DECEMBER 7, 1971

Peak water-surface elevations for the flood of December 7, 1971, are shown on sheet 3. The flood crested at an elevation of 27.231 meters at the reference point located on the downstream guardrail. The peak discharge was 269 cubic meters per second. A discharge of 88.4 cubic meters per second (table 2) was measured on December 6, 1971, at an elevation of 26.304 meters. The recurrence interval of the peak discharge is 8.0 years (Neely, 1976, fig. 3).

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 that backwater and discharges computed by standard indirect methods currently in use would be inaccurate where densely vegetated floodplains are crossed by highway embankments and single-opening bridges. This atlas presents flood information at the site on Alexander Creek near St. Francisville, La. Water depths, velocities, and discharges through bridge openings on Alexander Creek near St. Francisville, La., for floods of September 16, 1971, and December 7, 1971, 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 maps, and flood-frequency relations are shown on a graph.

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, Measurement 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 3—AERIAL VIEW LOOKING UPSTREAM AT BRIDGE ON STATE HIGHWAY 10 NEAR ST. FRANCISVILLE, LOUISIANA

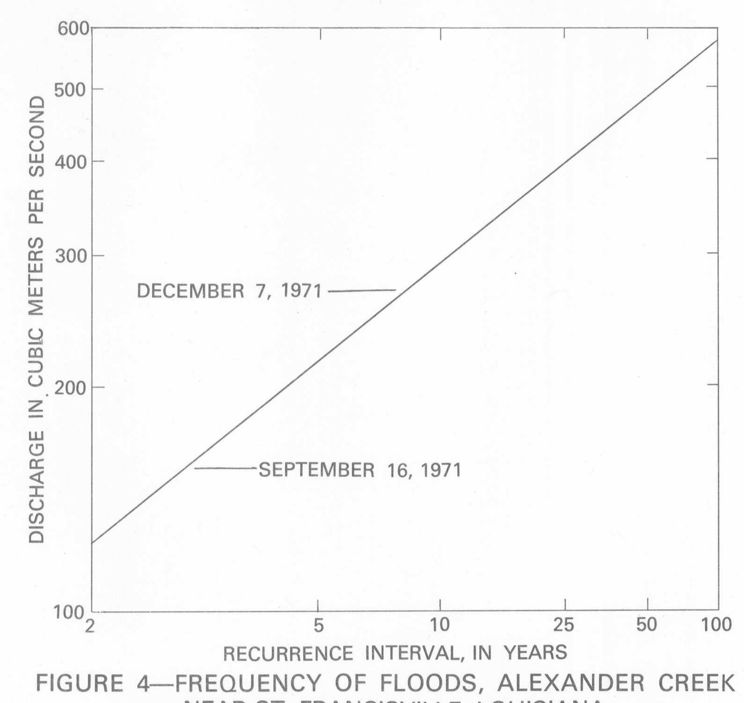

FIGURE 4—FREQUENCY OF FLOODS, ALEXANDER CREEK NEAR ST. FRANCISVILLE, LOUISIANA

TABLE 1.—VALLEY CROSS-SECTION DATA FOR ALEXANDER CREEK NEAR ST. FRANCISVILLE, LOUISIANA. ZERO STATION IS AT THE LEFT EDGE OF THE VALLEY (FACING DOWNSTREAM).

CROSS SECTION 1

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	27.37
2	25.85
3	24.48
12	24.36
15	23.93
17	23.69
20	24.42
40	22.71
43	23.38
49	23.56
51	24.14
52	24.72
64	24.84
85	25.03
104	24.81
128	24.84
145	24.84
166	24.97
194	24.66
207	24.36
223	24.42
232	25.33
235	25.82
251	27.71

CROSS SECTION 2

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	27.04
3	25.51
10	23.87
35	23.75
73	23.99
94	24.11
111	24.14
136	24.23
146	24.23
162	24.27
180	24.23
198	24.36
219	24.63
242	25.03
256	25.27
271	25.27
274	23.17
291	22.74
293	24.27
293	24.35
295	24.87
308	24.78
314	24.11
317	25.91
319	27.44

CROSS SECTION 3

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	26.49
10	26.05
33	25.00
89	24.81
126	25.24
133	25.24
136	24.36
140	23.78
143	22.86
159	23.29
159	24.66
162	25.58
167	25.58
190	25.00
204	24.78
217	24.69
240	24.30
257	24.33
274	24.78
291	26.22
300	27.74

CROSS SECTION 4

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	28.53
10	27.13
15	26.12
24	24.91
38	25.30
58	25.79
88	26.22
90	24.97
91	23.99
93	23.38
115	23.38
121	25.76
155	25.73
183	25.45
196	25.12
210	25.03
226	25.21
232	27.10
238	28.32

CROSS SECTION 5

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	29.05
9	26.79
22	25.73
61	25.51
94	25.79
116	25.48
124	25.97
133	25.42
134	22.62
145	23.90
151	23.72
155	24.72
161	25.36
165	26.40
170	26.43
174	26.34
194	26.09
217	25.94
243	26.22
281	25.94
287	26.19
290	27.34
293	28.84

BRIDGE SECTION

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	28.32
2	27.86
3	27.50
4	26.73
5	26.79
6	25.82
8	25.64
9	25.61
11	25.09
12	25.33
14	25.06
15	24.63
17	24.36
18	23.81
20	23.56
21	23.53
23	23.47
24	23.75
26	24.11
27	24.17
29	24.17
29	23.41
30	23.41
32	23.41
34	23.84
35	23.93
37	24.11
38	23.41
40	23.75
41	23.66
43	23.69
44	23.69
45	23.66
47	23.69
48	23.81
49	24.14
50	24.81
52	25.12
53	25.27
55	25.36
56	25.58
58	25.70
59	25.70
61	25.27
61	25.58
62	25.88
64	26.55
66	26.58
67	26.49
68	26.58
68	26.73
69	26.79
70	27.56
72	28.11
73	28.35

CROSS SECTION 6

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	27.61
45	25.09
55	25.73
65	25.58
81	26.00
87	26.64
90	26.40
94	25.12
96	24.05
101	23.99
113	24.02
115	26.25
130	25.64
143	25.33
150	25.51
158	25.30
161	25.27
166	25.27
178	25.24
191	25.15
202	25.18
225	25.45
252	25.85
252	26.03

CROSS SECTION 6 (con't.)

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
268	26.55
277	26.83
283	27.22
290	27.61

CROSS SECTION 7

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	27.61
4	26.46
7	25.61
12	25.30
16	25.64
24	26.00
34	25.94
53	26.40
58	26.73
59	25.67
60	25.06
62	24.48
71	24.30
79	24.17
82	26.92
86	26.89
88	27.16
91	26.92
95	26.86
100	26.40
105	27.01
107	26.61
120	26.49
134	25.70
148	25.45
173	25.30
193	25.21
223	25.27
227	25.30
230	26.52
234	27.61

CROSS SECTION 8

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	27.89
11	27.28
34	25.88
46	25.64
59	25.61
63	25.85
71	25.85
73	25.64
79	25.82
91	25.91
102	26.31
110	26.31
113	26.61
116	26.83
120	26.61
123	26.40
126	25.58
133	24.60
141	24.57
144	24.51
147	26.61
149	26.73
151	26.37
151	26.64
156	27.07
159	26.86
161	26.64
162	26.98
171	26.96

CROSS SECTION 8 (con't.)

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
179	26.64
180	26.58
182	26.09
183	26.46
190	26.46
197	26.12
207	26.00
213	27.89

CROSS SECTION 9

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	28.29
4	27.53
6	27.13
28	26.83
44	26.79
59	26.83
76	27.16
103	27.31
105	27.80
109	27.53
111	27.13
114	26.86
116	25.58
117	25.03
122	24.97
130	25.06
132	25.70
134	26.64
136	26.79
138	26.37
141	26.52
143	27.25
196	26.19
207	26.00
225	26.09
248	27.07
249	28.01
252	28.29

CROSS SECTION 10

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	28.59
8	28.04
34	26.55
48	26.31
55	26.67
69	27.28
77	27.31
79	27.04
80	26.49
81	25.64
82	25.39
87	25.39
93	25.33
95	26.19
98	27.22
99	27.71
101	27.40
104	27.77
108	27.95
117	27.59
133	27.16
139	26.79
156	26.92
197	27.10
202	26.86
205	26.92
209	27.16
223	27.95
236	28.59

TABLE 2.—DISCHARGE MEASUREMENTS DECEMBER 6, 1971, AND MARCH 24, 1973, ALEXANDER CREEK NEAR ST. FRANCISVILLE, LOUISIANA. ZERO STATION IS AT THE EDGE OF THE LEFT ABUTMENT (FACING DOWNSTREAM).

DISCHARGE MEASUREMENT OF DECEMBER 6, 1971. ALEXANDER CREEK NEAR ST. FRANCISVILLE, LA. (WATER-SURFACE ELEVATION=26.304 METERS) TOTAL DISCHARGE=88.4 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
5.5	0.0	0	0.0	0.0
9.1	0.91	45	0.6	0.369
12.2	0.61	45	0.6	0.424
16.8	2.38	36	0.2	0.206
			0.8	0.117
21.3	4.57	31	0.2	0.206
			0.8	0.303
24.4	4.42	36	0.2	0.323
			0.8	0.283
27.4	4.42	31	0.2	0.600
			0.8	0.588
30.5	4.11	16	0.2	0.780
			0.8	0.658
33.5	3.60	0	0.2	1.420
			0.8	0.838
36.6	2.74	0	0.2	0.600
			0.8	0.494
39.6	2.87	0	0.2	1.625
			0.8	1.585
42.7	2.59	0	0.2	1.451
			0.8	1.158
45.7	2.29	0	0.2	1.189
			0.8	1.244
50.3	1.83	0	0.6	0.780
54.9	3.51	0	0.2	0.588
			0.8	0.393
57.9	3.14	138	0.2	0.195
			0.8	0.219
63.4	0.0	0	0.0	0.0

[1]Observation depth is the ratio of the velocity-observation depth to the total depth at the station.

DISCHARGE MEASUREMENT OF MARCH 24, 1973. ALEXANDER CREEK NEAR ST. FRANCISVILLE, LA. (WATER-SURFACE ELEVATION=26.993 METERS) TOTAL DISCHARGE=214 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
4.3	0.0	0	0.0	0.0
6.1	0.79	0	0.6	0.808
11.0	1.37	0	0.6	0.786
14.0	1.58	0	0.2	0.844
			0.8	0.844
17.1	2.90	0	0.2	0.689
			0.8	0.719
20.1	4.72	23	0.2	0.631
			0.8	0.966
23.2	5.09	23	0.2	0.920
			0.8	0.966
26.2	4.82	23	0.2	1.372
			0.8	1.225
29.3	5.00	23	0.2	1.612
			0.8	1.317
32.3	4.30	14	0.2	1.225
			0.8	1.286
35.4	3.84	14	0.2	1.646
			0.8	1.686
38.4	3.23	16	0.2	1.317
			0.8	1.146
41.5	3.29	16	0.2	1.829
			0.8	1.975
44.5	3.51	0	0.2	1.530
			0.8	1.829
47.5	3.29	0	0.2	1.646
			0.8	1.344
50.6	2.59	0	0.2	1.055
			0.8	1.100
53.6	3.87	0	0.2	1.076
			0.8	1.076
56.7	4.21	0	0.2	0.753
			0.8	1.109
59.7	2.44	0	0.2	0.326
			0.8	0.335
64.0	0.46	0	0.6	0.524
67.1	0.55	0	0.6	0.357
68.9	0.0	0	0.0	0.0

[1]Observation depth is the ratio of the velocity-observation depth to the total depth at the station.

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1979—W79461

For sale by Branch of Distribution, U.S. Geological Survey 1200 South Eads Street, Arlington, VA 22202 and Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225