DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

BACKWATER AT BRIDGES AND DENSELY WOODED FLOOD PLAINS, LOBUTCHA CREEK AT ZAMA, MISSISSIPPI

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Prepared in cooperation with the
DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
and the
MISSISSIPPI STATE HIGHWAY DEPARTMENT

HYDROLOGIC INVESTIGATIONS ATLAS
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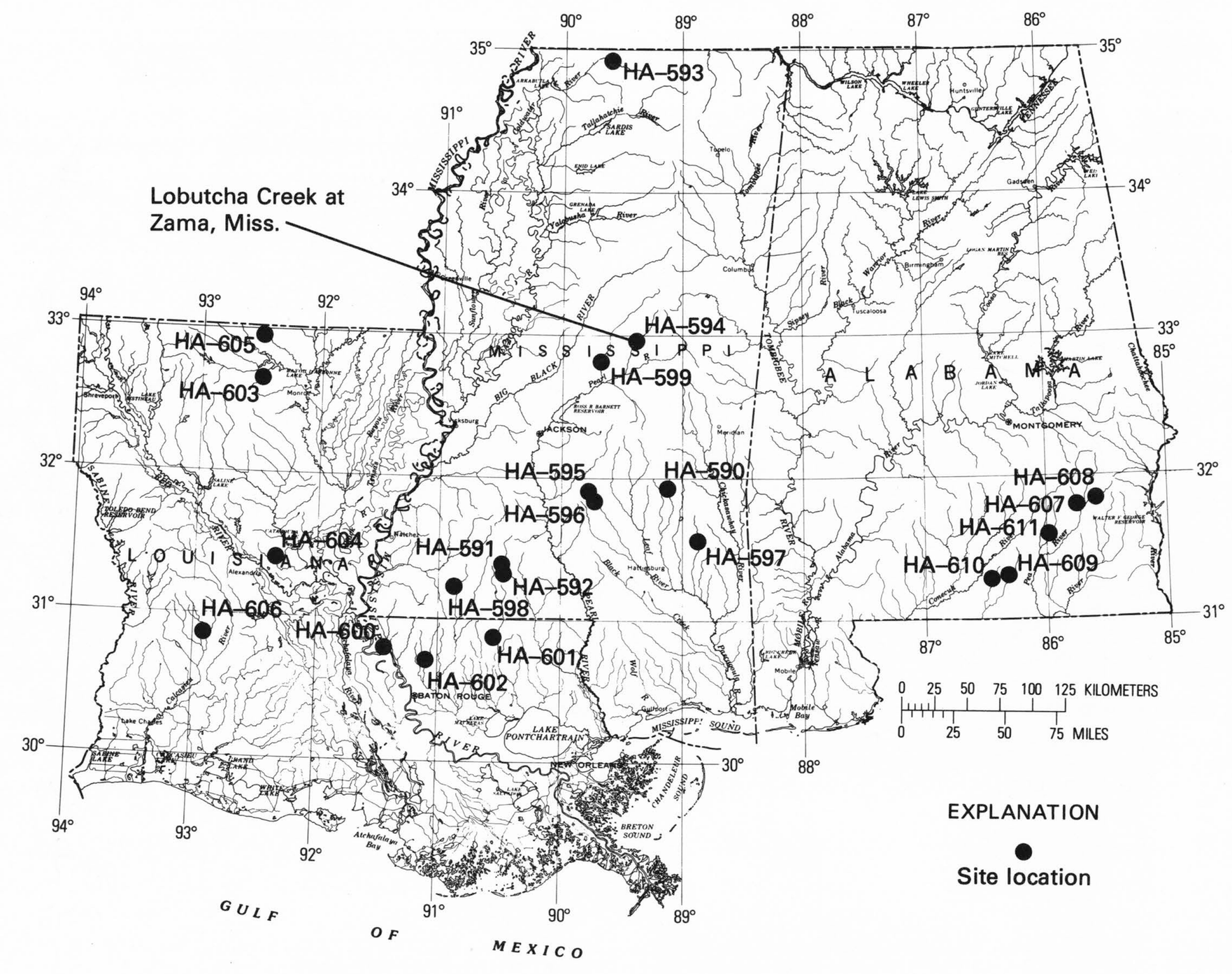

FIGURE 1.—INDEX MAP OF STUDY SITES IN THE BRIDGE BACKWATER INVESTIGATION PROJECT, ALABAMA, LOUISIANA, AND MISSISSIPPI.

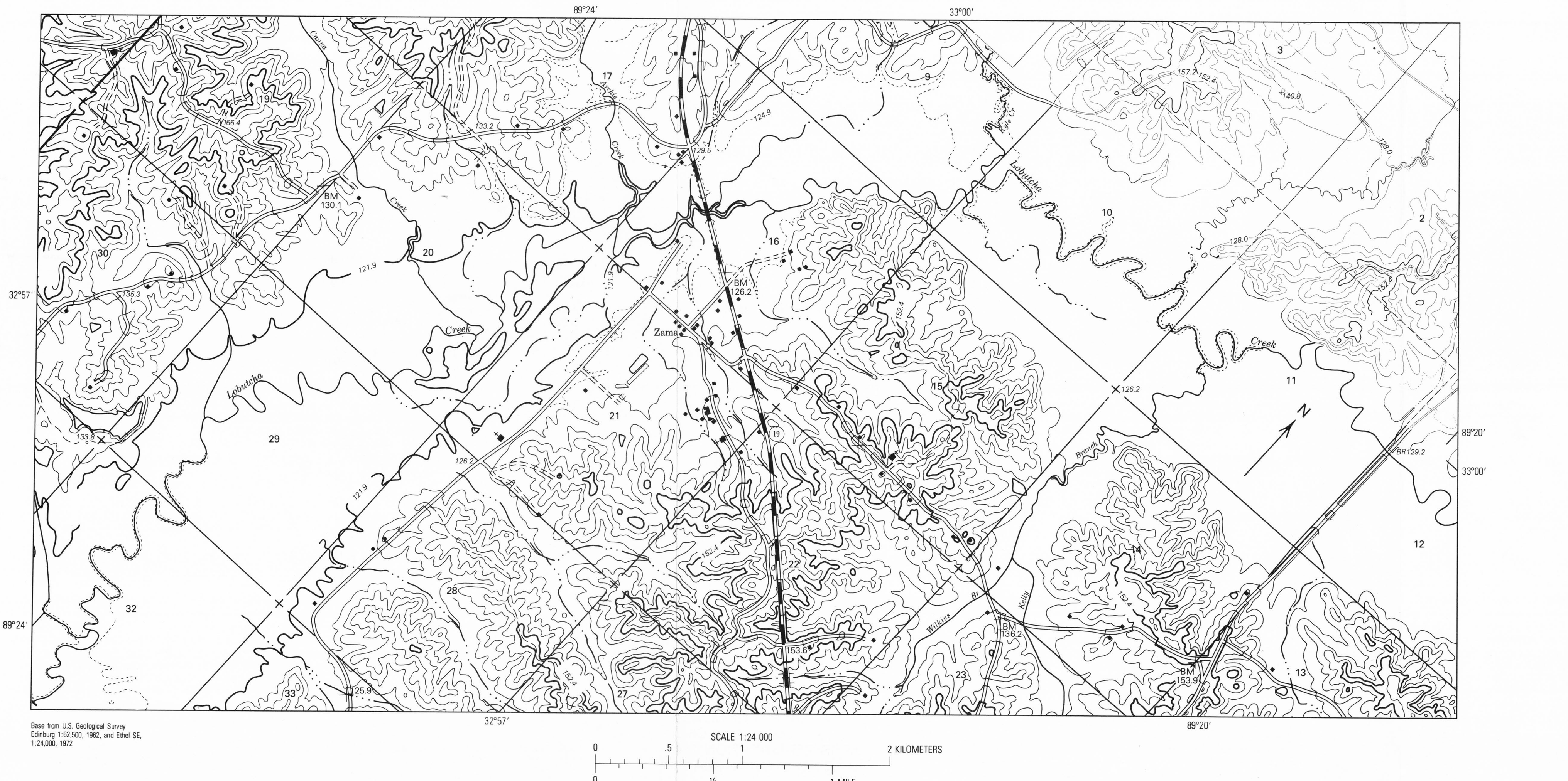

FIGURE 2—INDEX MAP SHOWING STUDY REACH, LOBUTCHA CREEK, AT ZAMA, MISSISSIPPI

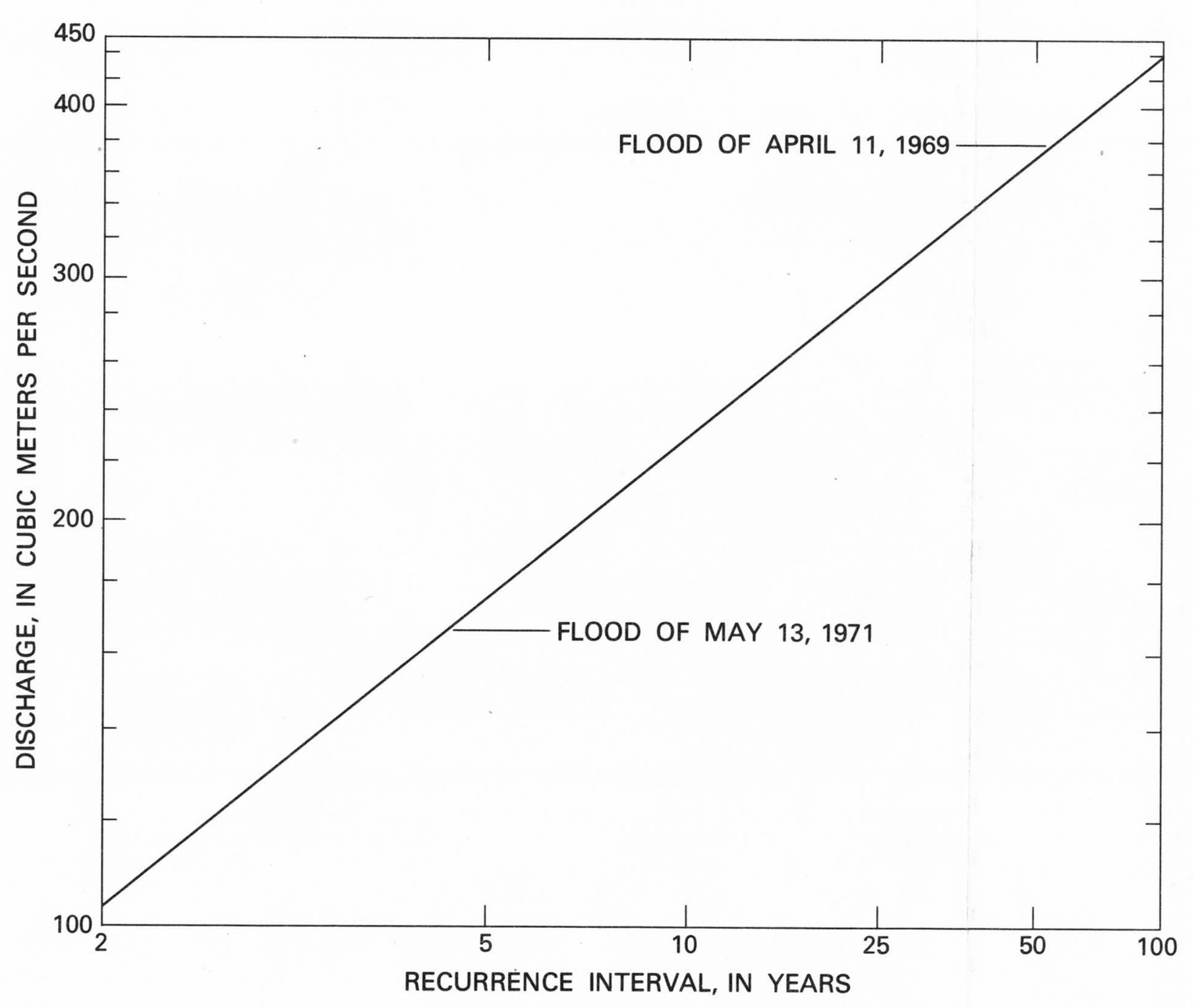

FIGURE 4—FREQUENCY OF FLOODS, LOBUTCHA CREEK, AT ZAMA MISSISSIPPI

BACKWATER AT BRIDGES AND DENSELY WOODED PLAINS LOBUTCHA CREEK AT ZAMA, 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 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 the 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.

The data sites (figure 1) are listed below. This atlas shows flood data obtained at Lobutcha Creek at Zama, Miss., 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 Tarentum 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*

*In press

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 (1976), 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 (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 LOBUTCHA CREEK AT ZAMA, MISSISSIPPI

Data for Lobutcha Creek at Zama, Miss., obtained in a 9-kilometer reach crossed about midway by State Highway 19, are presented on four sheets (fig. 2). Sheet 1 contains tables showing cross-section data (table 1) and discharge data (table 2). An aerial view looking upstream in vicinity of the bridge is shown in figure 3. Relative magnitudes of the floods of April 1969 and May 1971 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 alinement of the axis. Plots of the cross sections (sheet 2) are graphic presentations 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 upstream side of the bridge during the discharge measurement.

Data for two floods on Lobutcha Creek are presented. The first flood occurred April 11, 1969 (sheet 3). Floodmarks in vicinity of the bridge and an abandoned road embankment (section 7) about 100 meters downstream were surveyed after this flood. The abandoned road embankment was removed completely during July 1970. A second flood occurred May 13, 1971 (sheet 4). Twelve cross sections were surveyed after this flood, including section 6 along the downstream edge of the site of the former road embankment. Floodmark elevations were obtained along an abandoned railroad embankment (section 5) located about 800 meters downstream from the bridge. With the exception of sections 6 and 7, valley cross sections as surveyed are considered valid for both floods.

Manning's roughness coefficient values and the 1969 flood boundaries are shown on sheets 2, 3, and 4.

FLOOD OF APRIL 11, 1969

Peak water surface elevations, the measured cross section, and velocities for the flood of April 11, 1969, are shown on sheet 3. The flood crested at an elevation of 125.215 meters at the reference point located on the downstream guardrail 84 meters from the left abutment. The peak discharge of 379 cubic meters per second (m^3/s) was measured, which included 19 m^3/s through the culvert and 1 m^3/s over the road (table 2). The recurrence interval of the peak discharge is 50 years (Colson and Hudson, 1976). See figure 4.

FLOOD OF MAY 13, 1971

Peak water-surface elevations for the flood of May 13, 1971, are shown on sheet 4. The peak discharge of 165 m^3/s was measured at an elevation of 124.377 meters at the reference point located on the downstream guardrail. The recurrence interval of the peak discharge is 5 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 that backwater and discharges computed by standard indirect 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 Lobutcha Creek at Zama, Miss. Water depths, velocities, and discharges through bridge openings on Lobutcha Creek at Zama, Miss. for floods of April 11, 1969, and May 13, 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.
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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.
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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.

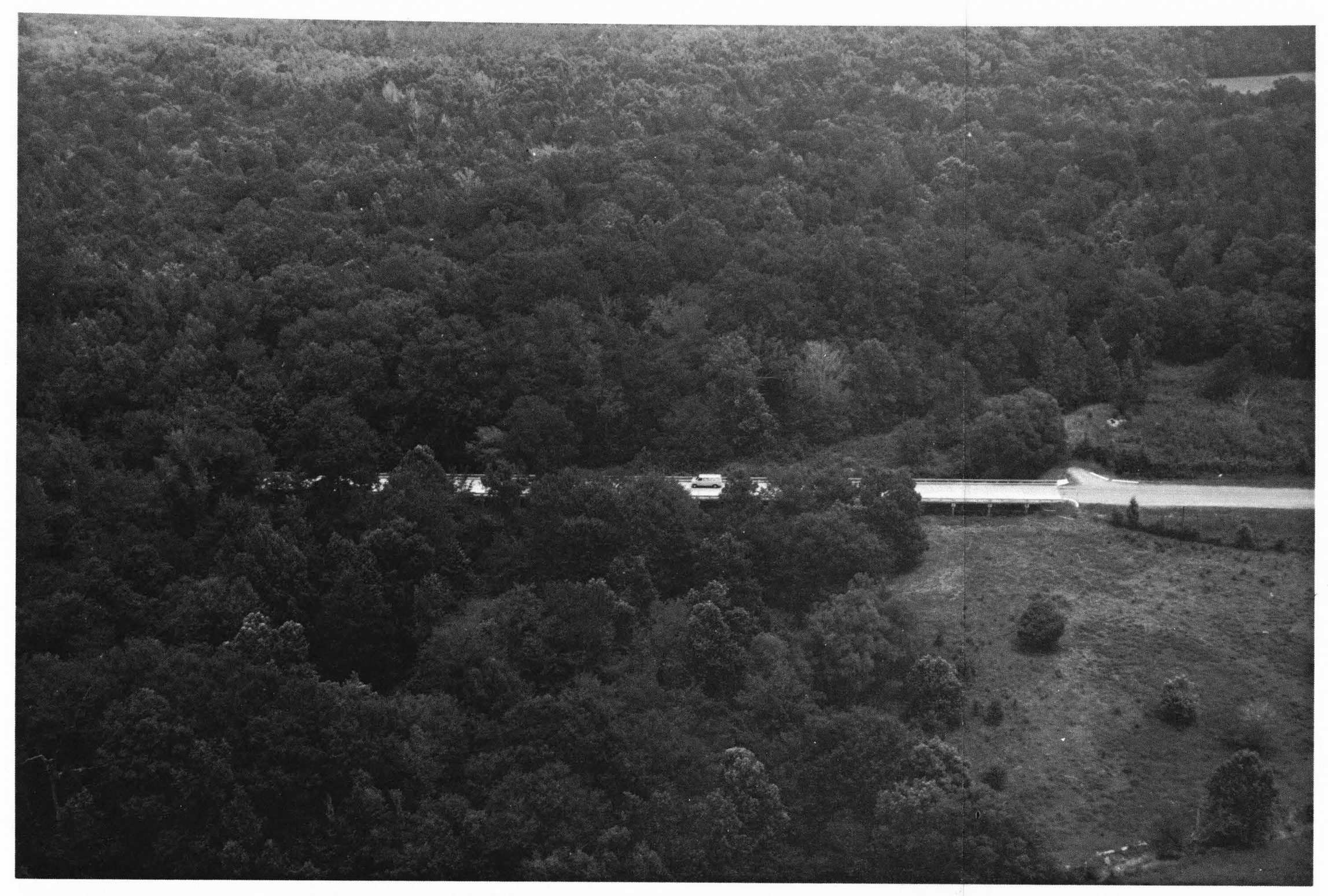

FIGURE 3—AERIAL VIEW LOOKING UPSTREAM IN THE VICINITY OF THE BRIDGE ON STATE HIGHWAY 19, LOBUTCHA CREEK AT ZAMA, MISS.

TABLE 1—VALLEY CROSS SECTION DATA FOR LOBUTCHA CREEK AT STATE HIGHWAY 19 AT ZAMA, MISS. ZERO STATION IS AT LEFT EDGE OF THE VALLEY (FACING DOWNSTREAM).

CROSS SECTION 1

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	121.95
12	121.71
37	121.01
45	120.85
96	120.79
111	120.27
155	120.15
182	120.18
211	120.03
255	120.03
392	120.15
433	120.03
468	119.91
490	120.00
501	120.15
545	120.15
585	120.06
623	120.06
648	119.94
661	119.94
665	120.18
699	119.97
714	119.97
786	120.27
793	120.46
796	120.09
809	120.73
813	118.08
816	117.44
822	117.74
823	118.08
824	118.96
832	120.55
857	120.70
888	120.67
930	120.64
965	120.49
1000	120.27
1036	120.33
1073	120.30
1096	120.40
1123	120.27
1148	120.67
1151	120.37
1157	122.04

CROSS SECTION 2

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	123.02
20	122.62
53	122.56
68	122.56
77	122.47
107	122.65
169	122.47
175	121.58
176	121.28
177	120.88
195	121.04
197	121.31
207	121.37
211	121.07
214	120.94
216	120.37
220	120.94
224	121.43
230	121.55
238	121.34
253	121.34
257	120.94
261	121.31
278	121.43
295	121.43
320	121.31
345	121.31
361	121.46
374	121.49
403	121.31
406	121.13
408	121.49
427	121.28
462	121.13
473	121.16
493	121.01
511	121.28
536	121.19
545	121.40
582	121.10
585	121.04
591	120.37
593	120.34
594	120.37
596	120.52
596	121.40
600	121.34
616	121.19
628	121.19
642	121.19
660	121.13
675	121.22
687	121.43
700	121.52
712	121.52
727	121.49
737	121.01
752	121.37
766	121.31
774	121.55
786	121.49
799	121.52
802	121.01
807	120.24
808	119.02
819	119.09
821	121.58
823	121.68
867	121.62
886	121.40
901	121.40
916	121.40
924	120.85
934	121.13
945	121.34
955	121.34
970	121.07
988	120.94
999	120.76
1006	120.67
1059	120.64
1068	120.64
1085	120.79
1103	120.76
1113	120.79
1122	120.85
1136	121.04
1141	121.10
1152	121.19
1162	121.34
1176	121.52
1186	121.83
1211	121.62
1221	121.83
1230	121.86
1243	121.92
1255	121.98
1267	122.07
1292	122.13
1309	122.16
1331	122.26
1352	122.38
1371	122.59
1377	122.74
1390	123.36

CROSS SECTION 3

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	124.66
36	123.75
41	123.69
53	123.75
65	123.60
81	123.41
85	123.32
109	122.65
127	122.22
147	121.92
161	121.83
184	121.71
206	121.71
224	121.77
239	121.68
241	121.40
252	121.89
266	121.55
285	121.98
298	122.16
300	121.10
303	121.68
319	121.98
346	121.86
366	121.86
386	121.83
418	122.01
444	122.26
466	122.47
494	122.83
514	122.83
538	122.80
550	122.74
595	122.19
616	122.13
643	121.98
668	122.13
692	122.01
713	121.92
742	122.04
757	121.71
773	121.98
797	121.98
798	122.07
811	122.26
819	122.19
821	121.52
824	121.13
827	119.60
834	119.57
838	122.47
863	122.47
904	122.07
919	121.80
935	121.74
946	121.71
967	121.92
989	121.83
1009	121.68
1035	121.62
1060	121.62
1074	121.71
1082	121.34
1089	121.55
1101	121.71
1110	121.04
1125	121.86
1143	121.68
1147	121.74
1150	121.68
1170	121.68
1188	121.58
1202	121.71
1225	121.77
1249	121.77
1271	121.74
1294	121.83
1314	121.74
1347	121.92
1384	122.01
1411	122.07
1457	122.29
1492	122.50
1534	122.90
1588	123.11
1626	123.50

CROSS SECTION 4

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	124.39
45	123.63
62	122.16
146	122.07
146	121.62
148	121.01
148	121.37
149	122.59
158	122.99
160	122.86
160	121.98
162	120.76
173	121.95
174	122.56
200	122.74
214	122.71
266	122.99
325	123.41
368	123.29
372	123.29
374	121.01
385	121.65
385	122.41
418	122.41
458	122.77
557	122.80
566	122.80
568	122.35
574	122.19
577	122.65
585	123.23
593	123.41
603	123.14
604	122.26
609	120.00
622	120.30
624	121.28
632	121.16
632	122.01
638	122.71
644	122.74
649	123.08
659	122.50
670	121.58
681	121.71
695	121.62
699	122.65
708	122.71
730	122.65
740	120.76
748	120.82
752	122.04
753	123.20
753	123.72
770	125.27

CROSS SECTION 5

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	124.39
78	123.63
88	123.78
105	123.57
112	123.32
119	123.54
135	123.75
154	123.90
169	123.99
175	124.08
178	122.77
179	122.71
180	121.62
181	121.01
182	121.37
182	122.59
191	122.99
193	122.86
194	121.98
196	120.76
207	121.95
209	123.17
212	123.41
214	124.05
227	124.08
233	124.02
254	123.93
273	123.90
284	123.87
319	123.81
331	123.87
336	123.66
344	124.18
346	124.08
350	123.69
358	123.78
362	123.41
364	123.87
386	123.96
403	123.96
406	123.93
407	121.01
418	121.65
419	123.84
433	123.84
454	123.78
473	123.87
498	123.93
500	123.47
503	123.47
504	123.99
523	123.96
541	123.90
566	123.90
591	123.99
596	124.02
597	123.14
600	123.02
601	122.35
607	122.19
610	122.65
618	123.23
627	123.41
632	123.32
637	123.14
637	122.26
639	121.68
640	121.49
643	120.33
643	120.00
656	120.30
657	121.28
665	121.16
666	122.01
671	122.71
678	122.74
683	123.08
693	122.50
703	121.58
714	121.71
728	121.62
732	122.65
741	122.71
753	122.71
764	122.65
770	121.19
774	120.76
782	120.82
785	122.04
786	123.20
787	123.72
803	125.27

CROSS SECTION 6

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	125.79
19	124.85
22	123.14
41	123.02
50	120.88
53	120.52
59	120.85
65	122.53
65	122.59
69	123.47
80	123.47
110	123.47
148	123.14
173	123.47
200	123.57
224	123.44
266	123.20
287	123.26
315	123.11
350	123.29
366	123.35
380	123.38
414	123.63
430	123.99
436	124.79
441	124.85
514	126.34

CROSS SECTION 7

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	125.91
21	125.12
56	124.82
57	123.44
59	122.86
69	122.68
80	122.53
82	121.19
84	120.58
86	120.64
89	120.33
93	120.43
96	121.04
98	122.07
101	122.71
104	123.26
110	123.99
111	124.75
126	124.48
134	124.42
154	124.42
166	124.48
176	124.54
176	123.38
179	122.77
180	122.65
181	122.96
190	122.44
198	122.68
201	123.75
202	124.51
213	124.48
242	124.48
275	124.57
288	124.69
302	124.66
302	123.32
306	123.14
351	122.93
403	123.20
435	123.47
463	123.57
468	123.81
474	124.79
493	124.82
509	125.03
525	125.30
542	126.55

CROSS SECTION 8

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	124.72
7	124.27
93	123.78
126	123.60
142	123.60
162	123.60
194	123.54
213	123.63
237	123.54
264	123.57
286	123.57
298	123.35
321	123.60
348	123.38
362	123.75
369	122.62
377	123.11
394	123.63
417	123.44
423	123.29
424	122.16
427	121.28
427	120.79
433	120.52
434	121.28
438	123.57
455	122.93
475	123.26
487	123.57
515	123.35
534	123.02
550	122.83
558	122.07
573	122.41
584	122.59
597	123.14
625	122.96
650	122.99
675	123.08
696	123.26
717	123.32
770	123.47
823	124.08
835	126.49

CROSS SECTION 9

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	126.43
4	125.33
9	123.75
20	123.84
21	123.44
23	121.37
24	120.88
34	121.04
35	121.37
38	123.44
48	123.84
72	123.54
91	123.54
108	123.90
124	123.81
152	123.81
173	123.84
191	123.84
220	123.75
240	123.60
257	123.84
274	123.50
300	123.72
321	123.29
362	123.23
386	123.17
427	122.96
461	122.90
490	122.90
522	123.23
541	123.02
564	123.08
599	122.96
622	122.93
642	122.93
659	122.96
676	123.05
700	123.60
721	124.21
728	124.30
782	125.67

CROSS SECTION 10

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	125.61
3	124.24
9	124.24
16	123.23
18	123.29
44	123.90
48	123.02
51	121.77
51	121.31
58	120.85
59	121.77
61	124.30
65	124.45
78	124.30
102	124.82
132	124.11
139	124.30
151	124.05
156	123.26
158	123.35
162	124.27
177	123.63
180	123.99
194	124.14
227	124.36
250	124.24
270	124.18
278	124.14
295	123.38
305	122.68
316	123.38
327	124.45
348	123.96
359	123.69
367	124.05
379	123.87
385	123.90
410	124.02
430	124.02
457	124.02
482	123.84
504	123.93
536	123.99
566	123.93
592	124.14
617	124.08
641	124.21
669	124.45
689	124.24
706	124.14
729	124.14
751	124.30
813	124.69
843	126.00

CROSS SECTION 11

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	128.66
62	127.16
84	126.71
123	126.00
161	125.09
176	124.85
222	124.63
262	124.79
263	124.14
266	124.66
285	124.60
325	124.69
358	124.63
401	124.48
425	124.51
435	124.54
496	124.79
498	124.75
500	124.33
504	124.54
505	124.69
518	124.79
551	124.72
586	124.75
614	124.63
622	124.88
648	125.06
654	124.48
672	124.42
679	124.85
691	125.00
757	125.21
763	124.94
769	124.69
801	124.51
803	123.81
805	124.72
822	125.06
823	122.83
825	122.50
831	122.80
836	123.29
839	124.91
855	125.12
877	124.75
934	125.09
983	124.75
1022	124.57
1045	124.75
1072	124.69
1121	124.88
1149	124.88
1157	125.06
1192	124.79
1244	124.94
1263	124.94
1293	124.91
1335	125.09
1362	125.12
1416	125.43
1443	125.88
1465	126.49
1490	127.56

CROSS SECTION 12

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	127.10
0	126.55
94	126.40
208	126.16
266	125.88
299	125.82
335	125.52
363	125.43
379	125.39
410	125.39
440	125.36
461	125.30
489	125.18
491	125.61
494	125.21
514	125.24
534	125.15
548	125.12
582	125.06
627	125.03
645	125.30
647	124.94
648	124.63
655	125.03
657	125.18
664	125.18
669	125.09
670	124.91
673	124.63
676	124.11
680	125.03
703	124.97
737	124.97
764	125.39
766	124.79
768	124.91
770	125.12
807	125.33
838	125.43
843	125.58
844	123.75
845	123.38
854	123.29
856	123.75
858	124.66
865	125.43
905	124.88
915	124.63
927	124.63
936	125.55
959	125.43
965	125.36
970	125.09
975	124.54
977	124.33
1000	124.02
1013	124.57
1020	124.97
1043	125.18
1063	125.18
1068	124.94
1076	125.82
1080	125.94
1087	124.60
1092	125.27
1111	125.36
1166	125.03
1186	125.03
1214	125.00
1264	125.09
1287	124.91
1316	124.88
1342	124.82
1370	124.91
1395	124.85
1438	124.97
1467	125.33
1475	125.61
1489	125.55
1501	126.49
1504	127.07

CROSS SECTION 13

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	129.72
34	128.81
67	128.08
165	127.44
261	126.86
302	126.80
385	126.67
429	126.80
450	126.83
471	126.49
509	126.40
534	126.58
538	126.31
560	126.31
562	126.64
626	126.71
636	126.31
648	125.27
668	126.31
752	126.28
802	126.64
837	126.61
933	126.74
1046	126.22
1147	126.71
1147	126.77
1170	126.77
1174	125.21
1178	124.88
1183	125.21
1188	126.67
1204	126.86
1225	126.46
1243	127.62
1265	129.14

BRIDGE SECTION

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	125.27
6	123.63
9	122.90
24	123.02
27	122.65
30	122.29
37	122.44
43	122.32
46	122.47
52	122.41
58	122.71
61	122.86
67	122.74
72	122.71
73	122.29
76	121.62
79	120.15
81	120.15
82	120.49
84	120.46
85	120.52
87	120.82
88	120.82
90	121.43
91	122.04
94	123.02
107	122.96
122	123.20
137	123.50
152	123.08
168	123.08
178	123.14
183	125.15
183	125.27

TABLE 2—DISCHARGE MEASUREMENTS, APRIL 11, 1969, AND MAY 13, 1971, LOBUTCHA CREEK AT STATE HIGHWAY 19 AT ZAMA, MISS. ZERO STATION IS AT THE EDGE OF THE LEFT ABUTMENT (FACING DOWNSTREAM).

DISCHARGE MEASUREMENT APRIL 11, 1969, LOBUTCHA CREEK AT STATE HIGHWAY 19 AT ZAMA, MISS. (WATER-SURFACE ELEVATION=125.215 METERS) TOTAL DISCHARGE=379 CUBIC METERS PER SECOND

STATION	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
0.9	0.0	0	0.0	0.0
3.0	1.16	0	0.0	0.0
6.1	2.50	0	0.2	0.347
			0.8	0.140
12.2	2.71	0	0.2	0.640
			0.8	0.485
18.3	2.90	0	0.2	1.225
			0.8	1.146
21.3	3.11	0	0.2	1.868
			0.8	1.146
24.4	3.26	0	0.2	0.988
			0.8	0.786
27.4	3.14	0	0.2	1.433
			0.8	1.320
33.5	2.53	0	0.2	1.463
			0.8	1.036
39.6	2.38	0	0.2	1.012
			0.8	0.768
45.7	2.19	0	0.2	1.530
			0.8	1.283
51.8	2.19	8	0.2	1.125
			0.8	0.942
57.9	2.07	8	0.2	1.036
			0.8	0.863
64.0	1.89	8	0.2	1.079
			0.8	0.863
70.1	2.04	0	0.2	1.146
			0.8	0.704
76.2	2.68	11	0.2	1.036
76.2	2.68	11	0.2	1.036
			0.8	0.881
79.2	4.39	11	0.2	0.689
			0.8	0.881
82.3	4.97	0	0.2	0.543
			0.8	0.677
85.3	4.97	0	0.2	0.768
			0.8	0.604
88.4	4.51	0	0.2	0.427
			0.8	0.555
94.5	2.26	0	0.2	0.689
			0.8	0.378
100.6	2.07	0	0.2	0.576
			0.8	0.533
106.7	2.07	0	0.2	1.173
			0.8	0.719
112.8	2.07	0	0.2	0.719
			0.8	0.564
118.9	2.01	0	0.2	1.079
			0.8	0.494
125.0	2.01	0	0.2	0.509
			0.8	0.332
131.1	1.92	0	0.2	0.863
			0.8	1.125
137.2	1.68	0	0.2	1.058
			0.8	0.555
143.3	1.89	0	0.2	0.677
			0.8	0.326
149.4	2.19	0	0.2	1.198
			0.8	0.704
155.4	2.50	0	0.2	1.253
			0.8	0.844
161.5	2.32	0	0.2	0.786
			0.8	0.765
167.6	2.23	0	0.2	0.844
			0.8	0.735
173.7	2.44	0	0.2	0.704
			0.8	0.735
178.0	0.98	0	0.6	0.485
179.5	0.0	0	0.0	0.0

DISCHARGE MEASUREMENT MAY, 13, 1971, LOBUTCHA CREEK AT STATE HIGHWAY 19 AT ZAMA MISS. (WATER-SURFACE ELEVATION=124.377 METERS) TOTAL DISCHARGE=165 CUBIC METERS PER SECOND

STATION	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
3.7	0.0	0	0.0	0.0
7.6	1.77	0	0.2	0.351
			0.8	0.305
12.2	1.89	0	0.2	0.363
			0.8	0.259
18.3	2.13	0	0.2	0.692
			0.8	0.704
24.4	2.38	0	0.2	0.719
			0.8	0.588
30.5	2.19	0	0.2	0.881
			0.8	0.475
36.6	1.68	0	0.2	0.735
			0.8	0.631
42.7	1.40	0	0.6	0.661
48.8	1.34	0	0.6	0.988
54.9	1.34	0	0.6	0.588
61.0	1.22	0	0.6	0.509
67.1	1.07	0	0.6	0.899
73.2	1.22	0	0.6	0.753
77.7	1.89	16	0.2	0.753
			0.8	0.509
80.8	3.60	25	0.2	1.036
			0.8	0.844
83.8	4.11	36	0.2	0.768
			0.8	0.616
86.9	4.08	36	0.2	0.616
			0.8	0.415
89.9	3.90	19	0.2	0.427
			0.8	0.293
93.0	3.05	0	0.2	0.155
			0.8	0.177
97.5	1.28	0	0.6	0.259
103.6	1.40	0	0.6	0.405
109.7	1.22	0	0.6	0.381
115.8	1.34	0	0.6	0.140
121.9	1.16	0	0.6	0.329
128.0	1.22	0	0.6	0.347
134.1	0.85	0	0.5	0.555
140.2	0.91	0	0.5	0.497
146.3	1.07	0	0.6	0.616
152.4	1.40	0	0.6	0.381
158.5	1.68	0	0.2	0.805
			0.8	0.607
164.6	1.46	0	0.6	0.341
170.7	1.46	0	0.6	0.576
175.3	1.52	0	0.6	0.646
178.3	0.91	0	0.5	0.463
179.8	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.

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