BACKWATER AT BRIDGES AND DENSELY WOODED FLOOD PLAINS, YELLOW RIVER NEAR SANFORD, ALABAMA

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HYDROLOGIC INVESTIGATIONS
ATLAS HA-610 SHEET 1

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 Yellow River near Sanford, Ala., one of the 22 sites plotted in figure 1.

	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 six 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 oriented 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 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 of *n* where frequent changes in roughness occurred. In their study, composite coefficient 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 forests 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 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. 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 derived using techniques described in "Floods in Alabama" (Hains, 1973) are presented graphically.

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 (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 YELLOW RIVER NEAR SANFORD, ALA.

Data for Yellow River near Sanford, Ala., obtained in a 2-kilometer reach crossed about midway by a Covington County road, 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 of the reach upstream from 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 elevations and alinement of the axis. Stationing along cross sections was projected along straight lines perpendicular to the flow. 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 the floods. The cross section surveyed at the downstream side of the bridge is tabulated. The cross section shown for velocity distribution was obtained by sounding from the upstream side of the bridge during the discharge measurement.

Data for two floods on Yellow River are presented. The first flood occurred December 21, 1972 (sheet 3). Six valley cross sections were surveyed after this flood. A second flood occurred on March 12, 1973 (sheet 4). A stage-discharge relation was developed for this site using five discharge measurements made from February 20, 1971 to March 12, 1973. Valley cross sections as surveyed are considered valid for both floods.

Manning's roughness coefficient values and the 1973 flood boundaries are shown on sheets 2 to 4.

FLOOD OF DECEMBER 21, 1972

Peak water-surface elevations, measured cross section, and velocities for the flood of December 21, 1972, are shown on sheet 3. The flood crested at an elevation of 71.12 meters at the reference point located on the downstream guardrail 37 meters from the left abutment. The peak discharge was 56.6 cubic meters per second, from a stage-discharge relation developed for the site. A discharge of 50.7 cubic meters per second was measured on the recession at an elevation of 71.085 meters at the reference point (table 2). The recurrence interval of the peak discharge is 2 years (Hains, 1973). See figure 4.

FLOOD OF MARCH 12, 1973

Peak water-surface elevations for the flood of March 12, 1973, are shown on sheet 4. The elevation of the flood crest, estimated from high-water marks at both abutments, was 71.942 meters. The peak discharge was 187 cubic meters per second. A discharge of 96.0 cubic meters per second was measured at an elevation of 71.402 meters, 0.540 meter below the crest. The measured cross section and velocity distribution are shown on sheet 4. The recurrence interval of the peak discharge is 30 years (Hains, 1973). 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 Yellow River near Sanford, Ala. Water depths, velocities, and discharges through bridge openings on Yellow River near Sanford, Ala., for floods of December 21, 1972, and March 12, 1973, were measured, 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 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
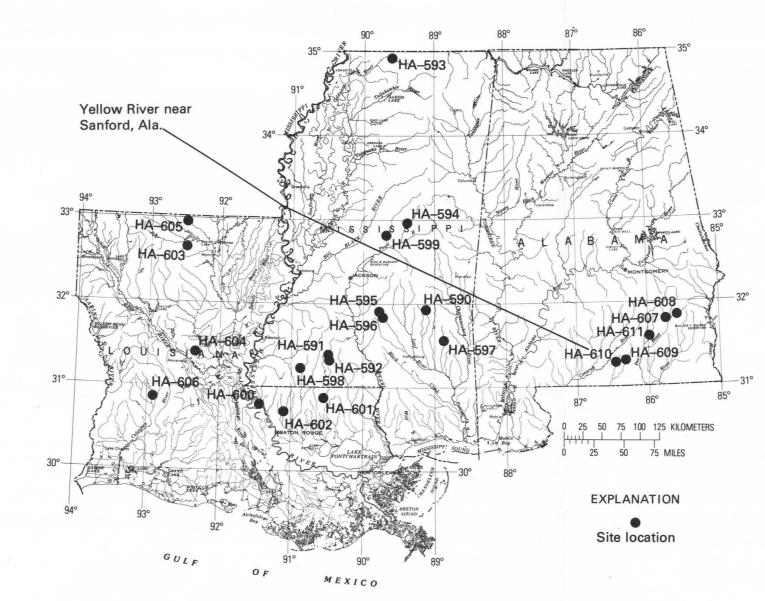430 Bounds Street
Jackson, Mississippi 39206

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

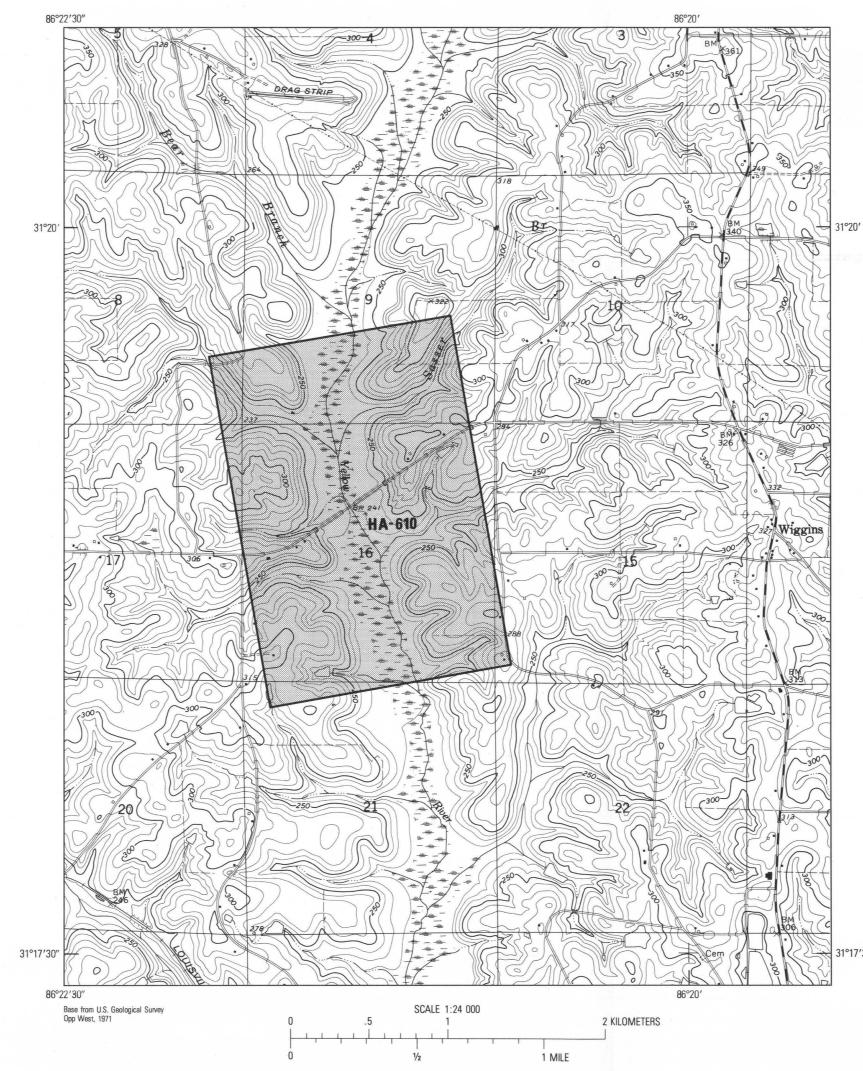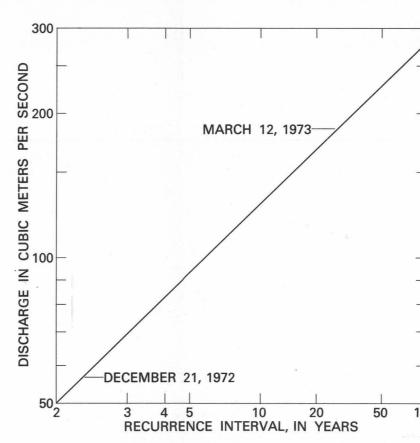EXPLANATION
● Site location

FIGURE 2—INDEX MAP SHOWING STUDY REACH, YELLOW RIVER NEAR SANFORD, ALABAMA

SCALE 1:24 000

FIGURE 3—AERIAL VIEW LOOKING UPSTREAM AT BRIDGE ON COVINGTON COUNTY ROAD, YELLOW CREEK NEAR SANFORD, ALABAMA

FIGURE 4—FREQUENCY OF FLOODS, YELLOW RIVER NEAR SANFORD, ALABAMA

TABLE 1—VALLEY CROSS SECTION DATA FOR YELLOW RIVER NEAR SANFORD, ALABAMA. ZERO STATION IS AT THE LEFT EDGE OF THE VALLEY (FACING DOWNSTREAM)

CROSS SECTION 1

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	71.58
15	70.57
24	69.87
30	69.35
91	69.35
113	69.17
114	68.99
116	67.68
116	67.40
117	67.43
119	69.17
157	69.11
187	68.99
212	68.90
251	69.05
282	69.78
283	69.87
303	71.12
326	72.04

CROSS SECTION 2

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	71.88
17	72.43
24	71.46
53	71.18
82	71.24
91	70.63
177	70.27
218	69.60
219	69.72
223	68.93
227	68.68
230	68.74
235	69.78
264	69.72
300	69.51
326	69.57
355	69.57
360	69.57
375	69.60
386	69.57
396	70.21
402	70.63
416	71.82
437	73.35

CROSS SECTION 3

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	72.98
17	72.43
44	72.07
72	71.67
98	71.46
99	70.94
99	70.57
108	68.90
110	68.50
113	68.53
114	69.20
119	70.12
128	70.06
146	70.06
174	69.75
201	69.78
215	69.75
230	70.12
238	70.36
247	70.76
251	70.94
255	71.03
267	71.00
268	71.00
297	71.24
325	71.52
343	71.79
360	72.16
369	72.43

BRIDGE SECTION

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	72.07
1	72.01
5	71.09
6	69.54
9	69.69
9	70.18
10	70.21
12	70.12
15	70.15
18	70.18
20	70.21
20	70.18
24	70.09
27	70.12
29	69.84
29	69.84
30	69.32
32	68.90
34	68.32
35	68.26
37	68.26
38	68.26
40	68.17
41	68.90
43	69.60
43	69.84
44	70.21
46	70.30
49	70.21
51	70.15
52	70.12
55	70.06
58	70.12
62	70.09
64	70.15
67	70.21
70	70.36
72	70.39
73	70.45
76	70.51
78	70.70
79	71.09
80	72.01
82	72.13

CROSS SECTION 4

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	72.80
14	72.43
19	71.37
29	71.34
34	70.42
43	70.39
66	70.30
81	70.24
88	70.24
93	69.51
94	70.27
104	70.21
123	70.18
142	70.21
151	70.21
160	70.18
168	69.84
180	70.18
195	70.15
210	70.09
213	70.09
216	69.35
219	69.23
224	69.48
226	70.24
236	69.48
244	70.24
251	69.75
271	70.15
282	70.45
297	71.06
312	71.15
334	71.37
349	71.88
367	72.13
387	72.37
401	72.80

CROSS SECTION 5

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	73.23
11	72.62
20	71.85
23	71.52
34	70.76
56	70.79
78	70.73
94	70.60
120	70.60
143	70.70
145	69.96
148	70.09
149	70.12
151	70.73
154	70.76
168	70.70
180	70.82
212	70.60
215	70.33
216	69.84
219	69.42
221	70.30
224	70.60
242	70.76
258	70.57
279	70.54
290	70.63
309	70.63
329	70.70
347	70.73
369	70.79
375	70.79
383	71.09
386	71.85
389	72.37
419	78.47

CROSS SECTION 6

STATION (METERS)	GROUND SURFACE ELEVATION (METERS)
0	73.10
56	72.19
61	71.88
70	71.70
107	71.34
120	71.34
136	71.03
151	71.09
169	70.76
180	71.06
186	71.00
187	70.02
190	69.99
197	70.48
197	71.00
213	70.91
230	70.88
255	70.76
265	71.15
267	70.51
270	70.33
271	70.36
274	71.09
288	70.85
344	71.00
354	71.52
360	71.88
370	72.55
398	74.08

TABLE 2—DISCHARGE MEASUREMENTS DECEMBER 21, 1972, AND MARCH 12, 1973, YELLOW RIVER NEAR SANFORD, ALABAMA. ZERO STATION IS AT THE EDGE OF THE LEFT ABUTMENT (FACING DOWNSTREAM)

DISCHARGE MEASUREMENT OF DECEMBER 21, 1972, OF YELLOW RIVER NEAR SANFORD, ALA. (WATER SURFACE ELEVATION=71.085 METERS) TOTAL DISCHARGE=50.7 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
2.4	0.0	0		0.0
4.6	1.37	23	0.8	1.600
			0.8	0.454
9.1	0.85	18	0.6	0.381
13.7	0.79	18	0.2	0.445
			0.8	0.844
18.3	0.91	11	0.6	0.485
22.9	1.07	0	0.2	0.494
			0.8	0.110
27.4	1.01	0	0.2	0.274
			0.8	0.085
30.5	1.28	0	0.2	0.287
			0.8	0.256
32.0	1.92	0	0.2	0.677
			0.8	0.768
33.5	2.44	0	0.2	1.036
			0.8	0.988
35.1	2.74	0	0.2	1.222
			0.8	1.222
36.6	2.74	0	0.2	1.100
			0.8	1.198
38.1	2.74	0	0.2	1.012
			0.8	1.079
39.6	2.59	0	0.2	0.988
			0.8	0.823
41.1	2.29	0	0.2	0.509
			0.8	0.509
42.7	0.79	0	0.6	0.491
45.7	0.76	0	0.6	0.415
50.3	0.85	0	0.6	0.305
			0.8	0.201
54.9	1.01	0	0.2	0.195
			0.8	0.196
59.4	0.94	0	0.2	0.445
			0.8	0.488
64.0	0.91	0	0.6	0.567
68.6	0.76	0	0.6	0.280
73.2	0.64	0	0.6	0.692
77.7	0.46	0	0.6	0.427
79.2	0.0	0		0.0

DISCHARGE MEASUREMENT OF MARCH 12, 1973, OF YELLOW RIVER NEAR SANFORD, ALA. (WATER SURFACE ELEVATION=71.402 METERS) TOTAL DISCHARGE=96.0 CUBIC METERS PER SECOND

STATION (METERS)	DEPTH (METERS)	ANGLE (DEGREES)	OBSERVATION DEPTH[1]	VELOCITY (METERS PER SECOND)
2.1	0.0	0		0.0
6.1	1.40	14	0.6	1.570
12.2	1.10	14	0.6	1.204
18.3	1.16	0	0.6	0.716
24.4	1.22	0	0.6	0.247
30.5	1.52	0	0.2	0.771
			0.8	1.082
33.5	3.02	0	0.2	1.082
			0.8	1.073
36.6	2.96	0	0.2	1.371
			0.8	1.381
39.6	3.11	16	0.2	0.936
			0.8	1.231
42.7	1.58	0	0.6	1.152
48.8	1.13	0	0.6	0.402
54.9	1.22	0	0.6	0.344
61.0	1.25	0	0.6	0.500
67.1	1.13	0	0.6	1.058
76.2	0.79	0	0.6	1.469
79.9	0.0	0		0.0

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

Base from U.S. Geological Survey
Opp West, 1971

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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