Estimation of Scour and Channel Stability for Selected Highway Crossings of Streams in Louisiana

LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
Water Resources Technical Report No. 67C

STATE OF LOUISIANA

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
OFFICE OF PUBLIC WORKS AND INTERMODAL
PUBLIC WORKS AND WATER RESOURCES DIVISION
in cooperation with the
U.S. GEOLOGICAL SURVEY

2003

STATE OF LOUISIANA

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

PUBLIC WORKS AND WATER RESOURCES DIVISION

WATER RESOURCES SECTION

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By

J. Josh Gilbert and Elliot J. Green

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Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per foot (ft/ft)	0.3048	meter per meter (m/m)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
inch per year (in/yr)	25.4	millimeters per year (mm/yr)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Horizontal coordinate information in this report is referenced to the North American Datum of 1983.

Estimation of Scour and Channel Stability for Selected Highway Crossings of Streams in Louisiana

By J. Josh Gilbert and Elliot J. Green

ABSTRACT

Maximum pier and contraction scour from a 500-year flood were estimated at 36 bridges that cross streams in northeastern and southern (excluding the Florida Parishes area) Louisiana. The selected highway crossings were located over the Mississippi, Ouachita, Tensas, Black, Calcasieu, Sabine, and Atchafalaya Rivers; Inner Harbor Navigation Canal; and Whiskey Bay Pilot Channel. Of the sites investigated, the maximum estimated pier scour ranged from 4 to 77 feet. Estimates of contraction scour generally were not substantial in magnitude or were not applicable due to site characteristics at all but four sites. For sites along the Mississippi River, the maximum estimated pier scour was 77 feet at U.S Highway 190. Contraction scour estimation is not applicable for conditions at the sites along the Mississippi River where levees limit flood-plain flow. For sites along the Ouachita and Tensas Rivers, the maximum estimated pier scour was 19 feet. The Black River at U.S. Highway 84 had pier scour estimates ranging from 5 to 22 feet. For sites along the Calcasieu River, the maximum estimated pier scour was 24 feet at Interstate Highway 10. Of the two Sabine River sites, the maximum pier scour estimate was 33 feet at Louisiana Highway 12. At the Interstate Highway 10 crossing of the Atchafalaya River, the maximum pier scour estimate was 57 feet.

INTRODUCTION

The design, construction, and maintenance of highway crossings over streams and flood plains require a balance of design variables such as bridge and embankment lengths, pier spacing, and pile penetration. The Federal Highway Administration requires that all state highway agencies evaluate bridges in the Federal aid system for scour susceptibility. The U.S. Geological Survey (USGS), in cooperation with the Louisiana Department of Transportation and Development (DOTD), has completed three major studies between 1992 and 2002 designed to evaluate scour potential and channel stability at selected bridges that cross streams in Louisiana. The first study evaluated 13 bridges that cross the Red River in the northwestern part of the State (Gilbert and Ensminger, 1996, 1999a). The second study evaluated selected bridges that cross streams in the Florida Parishes area of the State (Gilbert and Ensminger, 1999b). The third study, which is the focus of this report, evaluated selected bridges that cross streams in the northeastern and southern (excluding the Florida Parishes area) parts of the State.

Purpose and Scope

This report describes estimated maximum pier and contraction scour and channel stability at 36 bridges. The selected highway crossings were located over the Mississippi, Ouachita, Tensas, Black, Calcasieu, Sabine, and Atchafalaya Rivers; Inner Harbor Navigation Canal; and Whiskey Bay Pilot Channel. Maximum scour estimates were computed using methods outlined by the Federal Highway Administration to evaluate potential scour and channel stability. General hydrologic, hydraulic, hydrographic, and bathymetric information for these evaluations was obtained from existing information from DOTD, U.S. Army Corps of Engineers (USACE), and the

USGS. The 500-year flood was estimated from streamflow-gaging station records at the site, streamflow-gaging station records transferred to the site, or by a region of influence regression model. The existing information at some sites was not adequate to provide contraction scour estimates with reasonable confidence, so contraction scour estimates were not always performed. Contraction scour estimation is not applicable for conditions at some sites along the Mississippi River where levees limit flood-plain flow. All bridge, pier, and pile geometries examined in this report were derived from DOTD bridge plans, unless alternate or additional information sources are specified on a site specific basis. The report includes tabulated scour data, a photograph, and a cross section for the bridge sites evaluated. Values listed in tables are rounded from computations. Summing the rounded values in the tables may not agree by the smallest significant digit.

Approach

General hydrologic, topographic, and hydrographic information was assembled from available information in USGS, USACE, or DOTD files. The 500-year flood was determined from statistical analysis of streamflow-gaging station records. If sufficient streamflow-gaging station records were available at a site, these records were used to estimate the 500-year flood. At locations where streamflow data were not available, the 500-year flood estimate was adjusted based on values established at the nearest appropriate location along the stream, or a region of influence regressional model (RIRM) (Ensminger, 1998) was used. The distribution of flow within the bridge openings was computed using the one-dimensional Water Surface Profile (WSPRO) flow model (Shearman and others, 1986).

Estimates of maximum pier and contraction scour were based on Federal Highway Administration guidelines presented in Hydraulic Engineering Circulars (HEC) 18 (Richardson and others, 1995) and 20 (Lagasse and others, 1991). Local scour at the pier locations (pier scour) was calculated using the Colorado State University equation (modified from Richardson and others, 1995, eq. 2).

$$y_s / y_1 = 2.0 \times K_1 \times K_2 \times K_3 \times K_4 \times (a/y_1)^{0.65} \times (Fr)^{0.43} \tag{1}$$

$$y_d = GSE - y_s, \tag{2}$$

where y_s = estimated depth of pier scour, in ft;
y_1 = flow depth directly upstream of the pier, in ft;
K_1 = dimensionless correction factor for pier nose shape;
K_2 = dimensionless correction factor for skew;
K_3 = dimensionless correction factor for bed form;
K_4 = dimensionless correction factor for bed armoring;
a = width of pier, in ft;
Fr = Froude number;
y_d = channel-bed elevation of the computed scour hole, in ft above NGVD of 1929; and
GSE = observed existing ground-surface (channel-bed) elevation, in ft above NGVD of 1929.

The value for y_1 at each pier was based upon the difference between the computed water-surface elevation and the appropriate ground-surface elevation. The minimum channel-bed elevation historically observed at that location, or the potential channel-bed elevation, may be chosen as the most appropriate ground-surface elevation. The values for K_1, K_2, K_3, and K_4 were taken from values recommended by Richardson and others (1995, p. 36-39) for pier geometry as represented on DOTD bridge plans and anticipated bed conditions. The Froude number at the pier location was based upon the value of depth and velocity, which was computed using WSPRO.

In estimation of contraction scour, the average depth in the section or subsection was used. The scour estimate computed from the average depth was applied to the actual depths at pier and abutment locations for determination of the cumulative scour depth.

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7}\left(\frac{W_1}{W_2}\right)^{k_1} \tag{3}$$

$y_s = y_2 - y_o$ = (average scour depth)

where:

y_1 = average depth in the upstream main channel, in ft;
y_2 = average depth in the contracted section, in ft;
y_o = existing depth in the contracted section before scour, in ft;
Q_1 = flow in the upstream channel, in ft^3/s;
Q_2 = flow in the contracted channel, in ft^3/s;
W_1 = bottom width of the upstream main channel, in ft;
W_2 = bottom width of the main channel in the contracted section; in ft;
k_1 = exponent based on mode of bed material transport 0.69 for all sites evaluated.

Acknowledgments

The assistance of Jack C. Manno, Hydraulics Engineer Administrator, and Fred Cifreo, Hydraulics Engineer Supervisor, of the Louisiana Department of Transportation and Development, and John Miller of the U.S. Army Corps of Engineers, New Orleans District, in providing hydrographic survey information on the streams is gratefully acknowledged.

EVALUATION OF SELECTED HIGHWAY CROSSINGS OF STREAMS

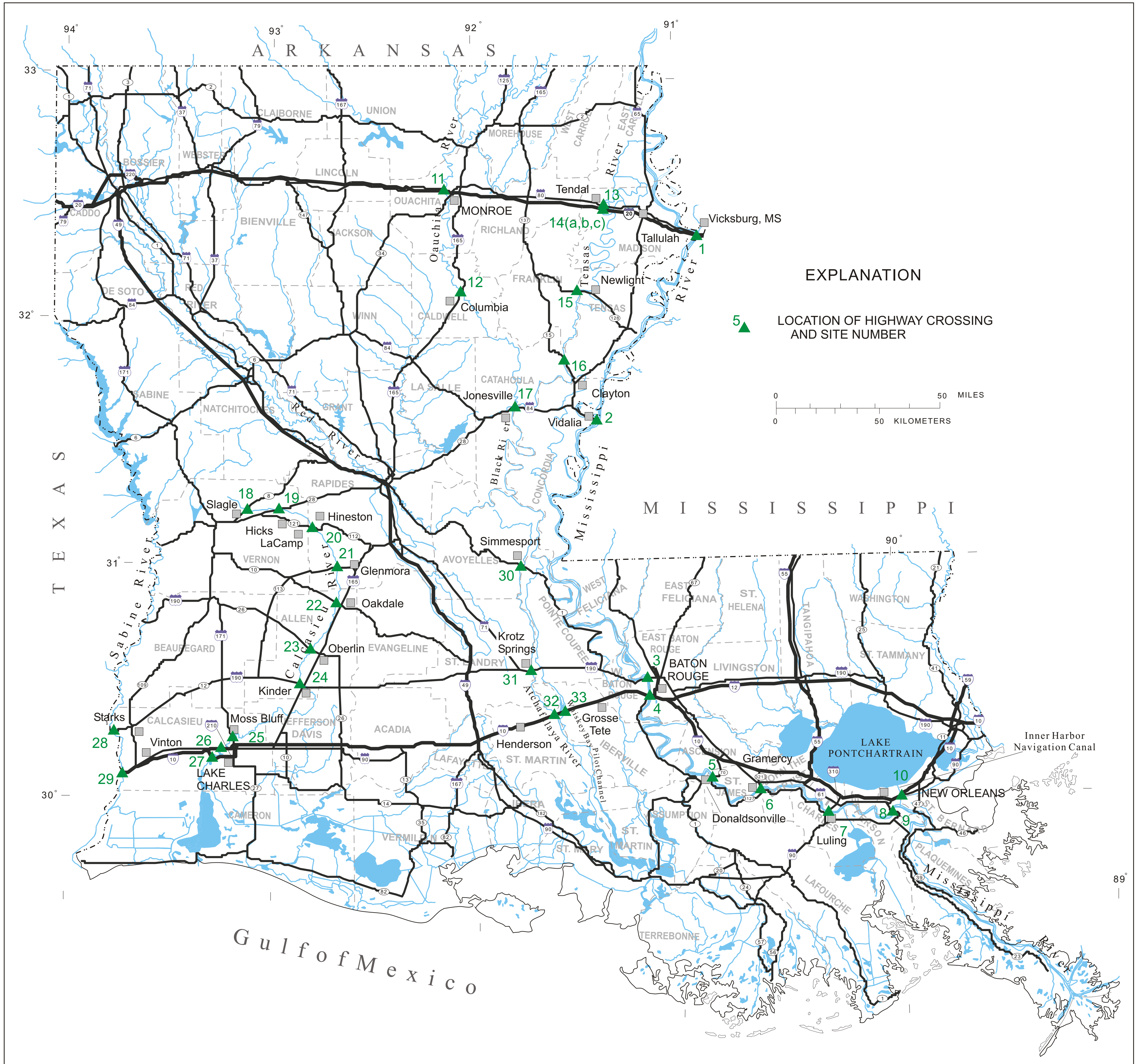
The sites evaluated for scour and channel stability are highway crossings located in Louisiana or on the border of Louisiana with Mississippi or with Texas. Of the streams discussed in this report, only the Tensas and Calcasieu Rivers have their originating headwater areas within Louisiana. The Black and Atchafalaya River designations originate in Louisiana, but their origins are confluences of other streams. The sites evaluated are listed in table 1 and shown in figure 1.

Mississippi River Basin

The Mississippi River originates in Minnesota and is the largest river in the United States. The Mississippi River and its tributaries drain 31 states and parts of Canada. Such a large river system has a large natural flood plain that periodically becomes inundated. To maintain access to the river channel and utilize the flood plain, flood protection levees have been constructed at many locations along the river. With minor exceptions, both sides of the river are constrained by levees, which cause flood plain and channel widths to be nearly equal for the lower 300-mile reach to the Gulf of Mexico. In addition to protection levees, diversion of flood water from the river is effective in lowering flood peaks. The Old River flood control structure is located in south-central Louisiana about 300 mi upstream from the mouth of the river. This structure is the largest flood control

Table 1. Sites evaluated for scour and channel stability at selected highway crossings of streams in Louisiana

Site number (fig. 1)	Site name and location
	Mississippi River Basin
1	Interstate Highway 20 crossing of the Mississippi River near Tallulah (at Vicksburg, Mississippi)
2	U.S. Highway 65 crossing of the Mississippi River at Vidalia
3	U.S. Highway 190 crossing of the Mississippi River at Baton Rouge
4	Interstate Highway 10 crossing of the Mississippi River near Baton Rouge
5	Louisiana Highway 70 crossing of the Mississippi River at Donaldsonville
6	Louisiana Highway 3213 crossing of the Mississippi River at Gramercy
7	Interstate Highway 310 crossing of the Mississippi River at Luling
8	U.S. Highway 90 crossing (Huey P. Long bridge) of the Mississippi River at New Orleans
9	U.S. Highway 90 crossing (Greater New Orleans bridge no. 2) of the Mississippi River at New Orleans
10	Interstate Highway 10 crossing of the Inner Harbor Navigation Canal at New Orleans
	Ouachita River Basin
11	Interstate Highway 20 crossing of the Ouachita River at Monroe
12	U.S. Highway 165 crossing of the Ouachita River at Columbia
	Tensas River Basin
13	U.S. Highway 80 crossing of the Tensas River at Tendal
14a	Interstate Highway 20 crossing (west) of the Tensas River near Tendal
14b	Interstate Highway 20 crossing (middle) of the Tensas River near Tendal
14c	Interstate Highway 20 crossing (east) of the Tensas River near Tendal
15	Louisiana Highway 128 crossing of the Tensas River (near Tensas River National Wildlife Refuge) near Newlight
16	Louisiana Highway 15 crossing of the Tensas River at Clayton
	Black River Basin
17	U.S. Highway 84 crossing of the Black River at Jonesville
	Calcasieu River Basin
18	Louisiana Highway 8 crossing of the Calcasieu River near Slagle
19	Louisiana Highway 28 crossing of the Calcasieu River near Hicks-LaCamp
20	Louisiana Highway 121 crossing of the Calcasieu River near Hineston
21	Louisiana Highway 113 crossing of the Calcasieu River near Glenmora
22	Louisiana Highway 10 crossing of the Calcasieu River near Oakdale
23	Louisiana Highway 26 crossing of the Calcasieu River near Oberlin
24	U.S. Highway 190 crossing of the Calcasieu River near Kinder
25	U.S. Highway 171 crossing of the Calcasieu River near Moss Bluff
26	Interstate Highway 10 crossing of the Calcasieu River at Lake Charles
27	Interstate Highway 210 crossing of the Calcasieu River near Lake Charles
	Sabine River Basin
28	Louisiana Highway 12 crossing of the Sabine River near Starks
29	Interstate Highway 10 crossing of the Sabine River near Vinton
	Atchafalaya River Basin
30	Louisiana Highway 1 crossing of the Atchafalaya River at Simmesport
31	U.S. Highway 190 crossing (eastbound and westbound) of the Atchafalaya River near Krotz Springs
32	Interstate Highway 10 crossing of the Atchafalaya River near Henderson
33	Interstate Highway 10 crossing of the Whiskey Bay Pilot Channel near Henderson-Grosse Tete



Source: Office of Planning and Programming, Louisiana Department of Transportation and Development

Figure 1. Location of sites evaluated for scour and channel stability at selected highway crossings of streams in Louisiana.

diversion on the Mississippi River, and it can divert about one third of the flood flow. Flow is diverted into the Lower Old River, which flows west about 6 mi and joins the Red River. The confluence of the Lower Old River and the Red River near Simmesport, Louisiana, is the origin of the Atchafalaya River. The drainage area of the Mississippi River at the diversion by the Lower Old River flood control structure is about 1.13 million square miles, but due to the effects of the diversion, the drainage area downstream of the diversion is indeterminate. The same indeterminate drainage-area conditions apply for the Lower Old River and Atchafalaya River, because they receive water diverted from the Mississippi River.

The Morganza Spillway flood control structure can divert flow from the Mississippi River at river mile 280. The Bonnet Carré Spillway flood control structure, which has a design capacity of 250,000 ft^3/s, can divert flow from the Mississippi River at river mile 128. For the purpose of this evaluation, the flow and diversions are as follows: Old River flood control structure 600,000 ft^3/s, Morganza Spillway flood control structure 600,000 ft^3/s, and Bonnet Carré Spillway 250,000 ft^3/s (U.S. Army Corps of Engineers, 2001). Based on this flow distribution, sites at Baton Rouge are evaluated at 1,500,000 ft^3/s, and sites at New Orleans are evaluated at 1,250,000 ft^3/s.

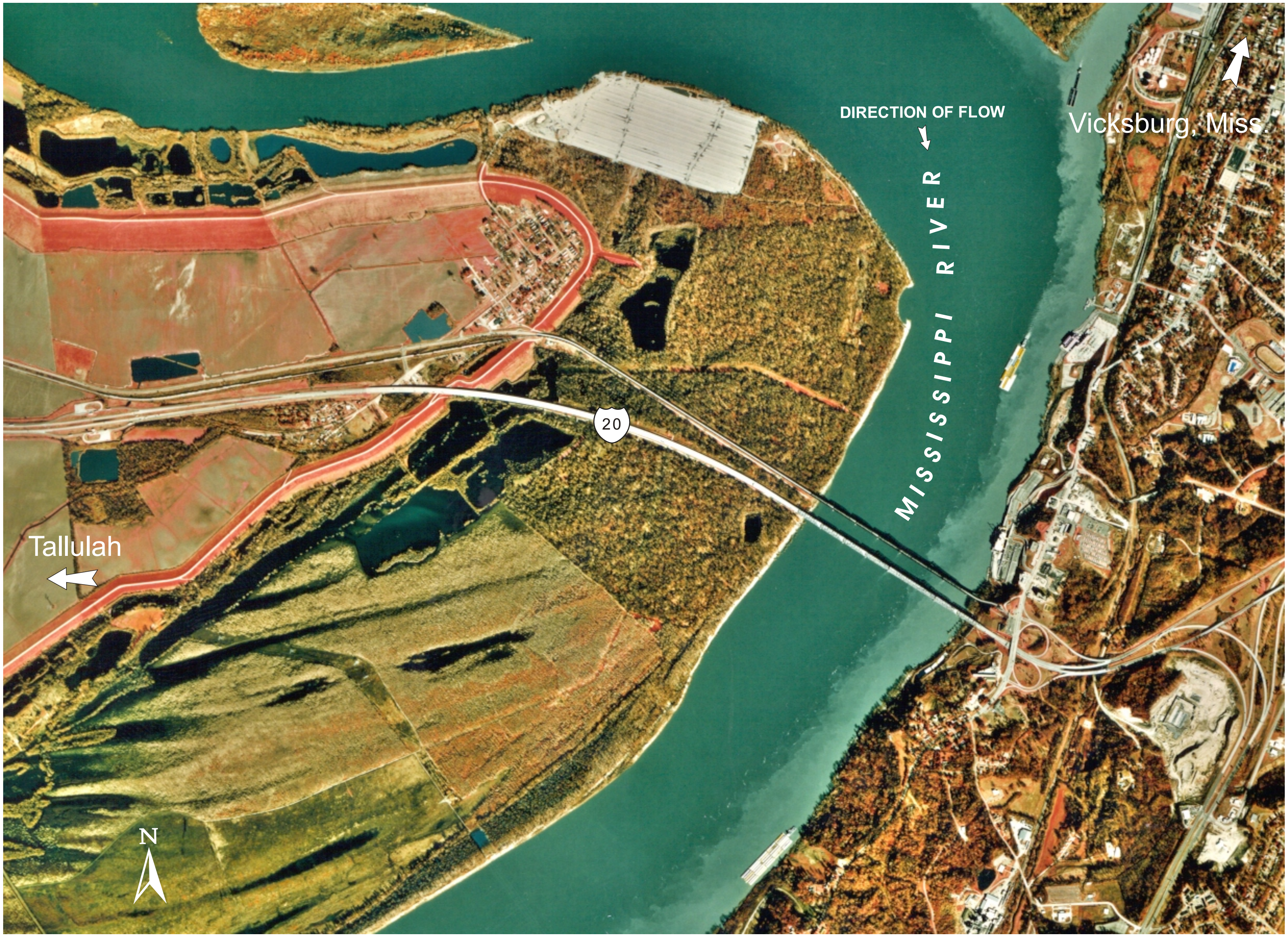
Interstate Highway 20 Crossing of the Mississippi River near Tallulah (at Vicksburg, Mississippi)

The estimate of the 500-year flood used for the hydraulic analysis is 2,060,000 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood was 103 ft above NGVD of 1929 (table 2). The width of the channel at the 500-year flood is approximately 6,000 ft; about 3,000 ft includes the main spans of the bridge (fig. 2). The downstream boundary condition for hydraulic computations using WSPRO was a water-surface elevation of 98 ft, based on calibration to the flood of 1973. Simulations of the 500-year flood indicate velocities ranging from 2.0 to 12.0 ft/s along the cross section at the bridge. Values of velocity at the pier locations are listed in table 2.

Table 2. Scour data for Interstate Highway 20 crossing of the Mississippi River near Tallulah (at Vicksburg, Mississippi), Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 103 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3, 1.1; ft, feet; ft/s, foot per second; footing elevations scaled from DOTD bridge plans; * = pile tip elevation; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Footing elevation (ft above or below NGVD of 1929)
162+93	21	Round	1.0	26	4.0	26	NA	-5	-70
158+70	51	Round	1.0	44	8.0	46	NA	5	-70
150+00	2	Round	1.0	44	9.0	53	NA	-51	-90
145+77	19	Round	1.0	33	10.0	45	NA	-26	-85
141+51	47	Round	1.0	20	12.0	33	NA	14	-50*
137+25	59	Round	1.0	20	9.0	28	NA	31	-30*
132+99	85	Round	1.0	20	5.0	20	NA	65	0*



Photograph source: U.S. Department of the Interior,
U.S. Geological Survey Maintainer:
earthexplorer@edcmail.cr.usgs.gov
Last modified: 2/5/01

Figure 2. Aerial photograph of the Interstate Highway 20 crossing of the Mississippi River near Tallullah (at Vicksburg, Mississippi), Louisiana.

Pier Scour

For evaluation of pier scour at Interstate Highway 20, values for y_1 at each pier were based on the DOTD hydrographic survey of 1993. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum estimated scour depth was approximately 53 ft for the pier at DOTD station 150+00 (table 2, fig. 3). The channel-bed elevation for this computed scour hole is about 51 ft below NGVD of 1929. Bridge plans indicate riprap protection at all piers. Willow mattress protection is indicated for the piers at DOTD stations 145+77 and 150+00. This protection will reduce the pier scour values indicated in table 2. The pier locations for the Interstate Highway 20 bridge are similar to those of the U.S Highway 80 and railroad bridge immediately upstream (fig. 2). There is the possibility that scour holes at the bridge piers could overlap for the two structures, increasing the potential scour depth.

Channel Stability

Cross-section information is shown in figure 3 for the years 1967, scaled from bridge plans, and 1993, from DOTD surveys. These surveys show minor changes in the channel bed in the center channel areas. The thalweg in both surveys is near the east bank, with an elevation of approximately 40 ft below NGVD of 1929. The 1967 survey was scaled from the bridge plans, which has some effect on its accuracy. The 1967 survey does not reflect the installation of willow mattresses and riprap, which may be an influence on higher bed elevations indicated in 1993. The 1993 survey represents the lowest bed elevations of the DOTD surveys of 1993 and 1994 post-construction surveys.

U.S. Highway 65 Crossing of the Mississippi River at Vidalia

The estimate of the 500-year flood used for the hydraulic analysis is 2,400,000 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate is 82.9 ft above NGVD of 1929 (table 3). The width of the channel (fig. 4) at the bridge for the 500-year flood simulation is approximately 3,500 ft. The downstream boundary condition for computations using the WSPRO model was a slope of 0.0007 ft/ft, which is the same slope determined from the calibration simulations at this site. Simulations of the 500-year flood indicate velocities ranging from 4.0 to 13.0 ft/s along the cross section at the bridge. Values of velocity at the pier locations are listed in table 3.

Pier Scour

For the evaluation of pier scour, values for water depths at each pier (y_1), were based on the DOTD hydrographic survey of 1993. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 56 ft for the pier at DOTD station 37+86 (table 3, fig. 5). The channel-bed elevation of the computed scour hole is about 99 ft below NGVD of 1929. Bridge plans indicate a willow mattress at this pier which will limit actual scour.

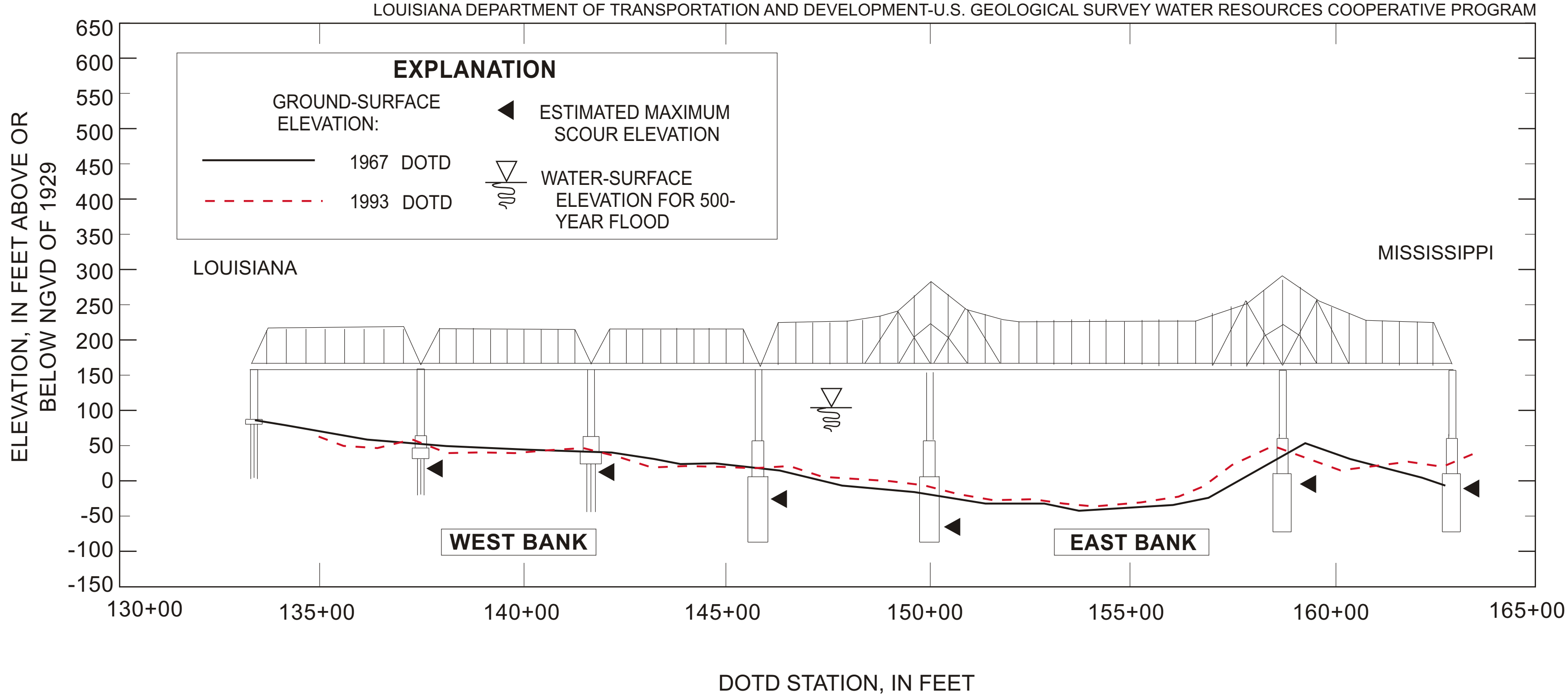


Figure 3. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 20 crossing of the Mississippi River near Tallulah (at Vicksburg, Mississippi), Louisiana.

Photograph source: U.S. Department of the Interior,
U.S. Geological Survey Maintainer:
earthexplorer@edcmail.cr.usgs.gov
Last Modified: 2/5/01

Figure 4. Aerial photograph of the U.S. Highway 65 crossing of the Mississippi River at Vidalia Louisiana.

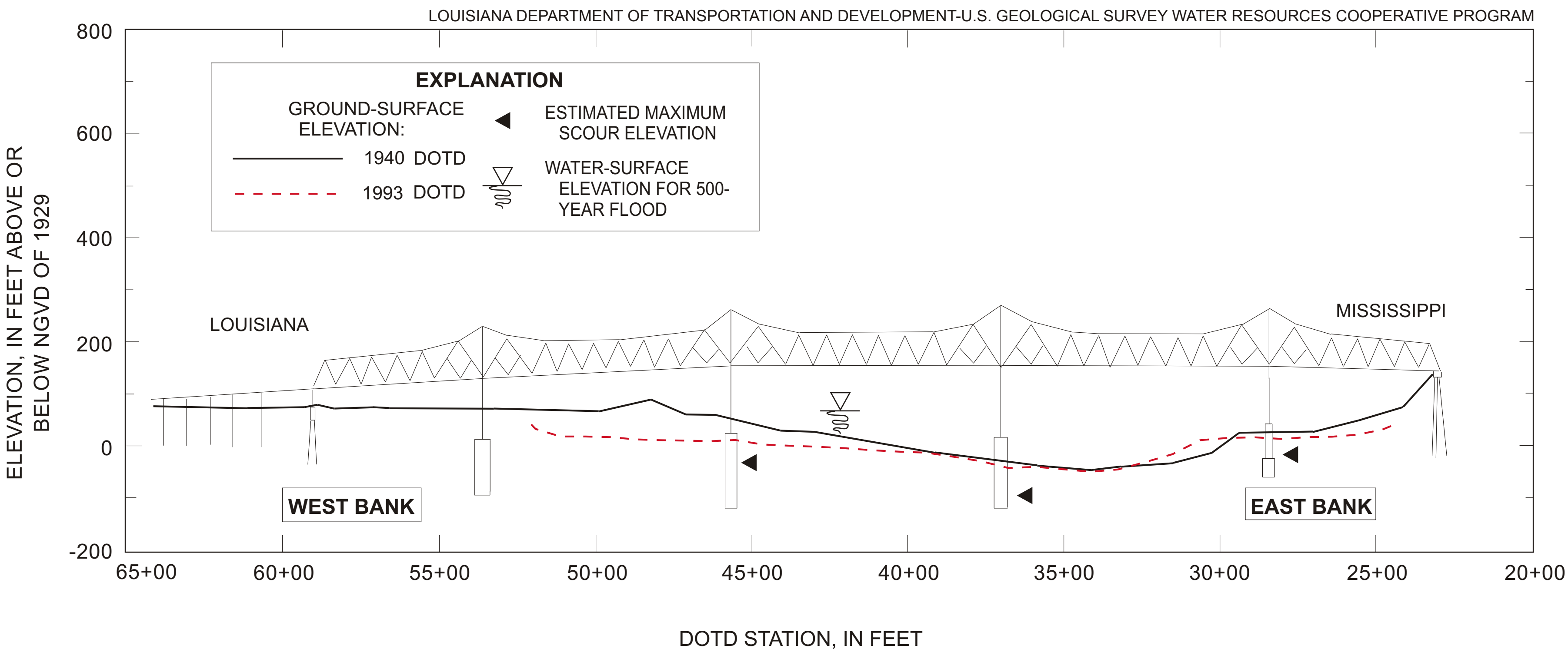


Figure 5. Bridge schematic, comparative cross sections, and scour estimates at the U.S. Highway 65 crossing of the Mississippi River at Vidalia, Louisiana.

Table 3. Scour data for U.S. Highway 65 crossing of the Mississippi River at Vidalia, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 82.9 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack, K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Bottom of footing elevation (ft above or below NGVD of 1929)
29+11	15	Round	1.0	30	8.0	41	NA	-26	-60
37+86	-43	Round	1.0	30	13.0	56	NA	-99	-120
46+61	13	Round	1.0	30	9.0	42	NA	-29	-120

Channel Stability

Cross-section information is shown in figure 5 for the years 1940 and 1993. These surveys indicate significant changes in elevations at the west bank, but little change in the thalweg. The thalweg elevations observed were approximately the same elevation of about 50 ft below NGVD of 1929. The changes in elevation at the west bank indicate a decrease in elevation of approximately 50 ft in 1993, resulting in a larger and wider cross section than the 1940 conditions. Bed material was removed on the west bank by dredging as specified in the bridge plans and shown by results from the DOTD survey of 1993.

U.S. Highway 190 Crossing of the Mississippi River at Baton Rouge

The estimate of the 500-year flood used for the hydraulic analysis is 1,500,000 ft^3/s. The water-surface elevation used for the 500-year estimate is 45.6 ft above NGVD of 1929. The width of the channel (fig. 6) at the 500-year flood is approximately 3,000 ft. Simulations indicate velocities ranging from 4.0 to 11.0 ft/s along the cross section at the bridge. Values of velocity at the pier locations are listed in table 4.

Pier Scour

Values for y_1 at each pier are based on the DOTD hydrographic survey of 1992. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity, which is computed using WSPRO. The maximum computed scour depth is approximately 77 ft for the pier at DOTD station 73+68 (table 4, fig. 7). The channel-bed elevation of the computed scour hole is 135 ft below NGVD of 1929.

Table 4. Scour data for U.S. Highway 190 crossing of the Mississippi River at Baton Rouge, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 45.6 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; bottom of footing scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Bottom of footing elevation (ft above or below NGVD of 1929)
65+20	-4	Round	1.0	31	4.0	30	NA	-33	-183
73+68	-58	Round	1.0	62	10.0	77	NA	-135	-157
80+18	-30	Round	1.0	56	7.0	59	NA	-89	-181

Photograph source: Louisiana Department of Transportation and Development, 11/6/87

Figure 6. Aerial photograph of the U.S. Highway 190 crossing of the Mississippi River at Baton Rouge, Louisiana.

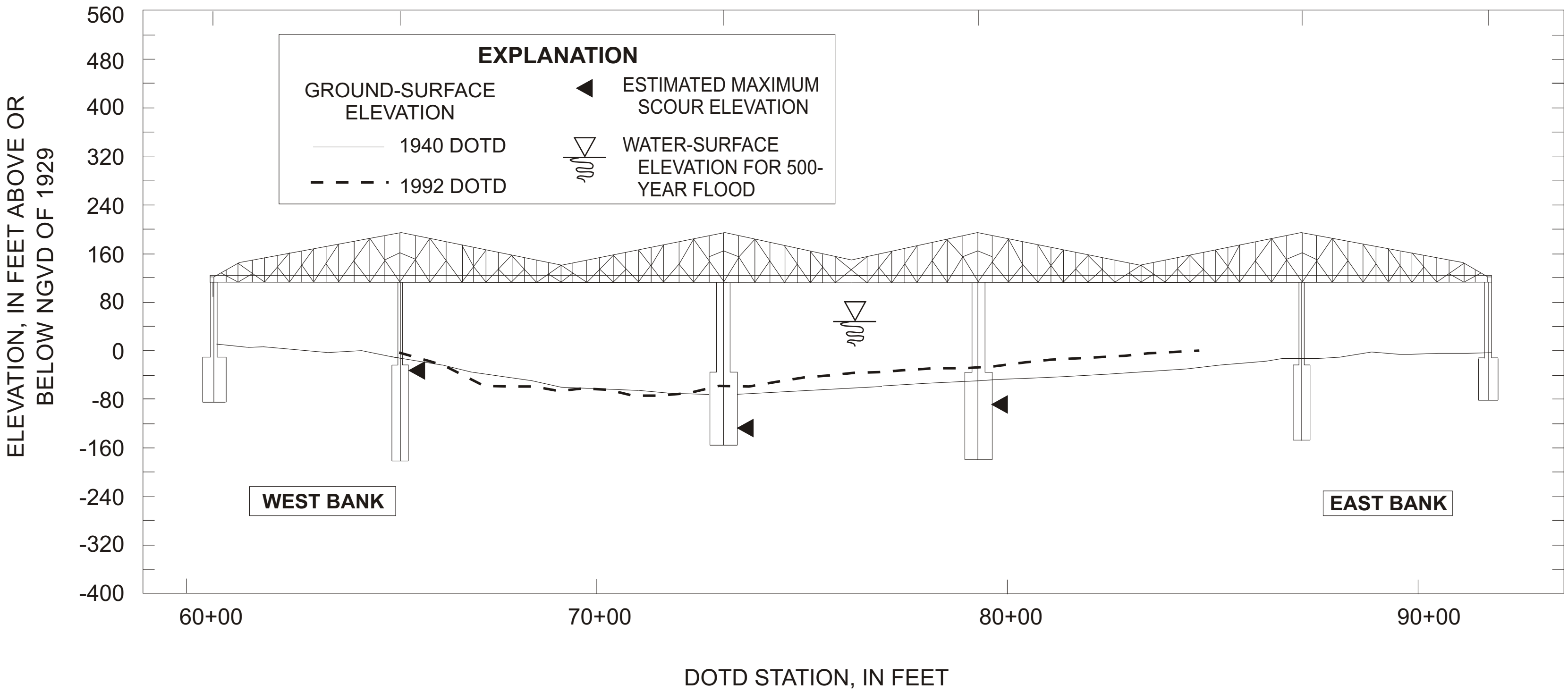


Figure 7. Bridge schematic, comparative cross sections, and scour estimates at the U.S. Highway 190 crossing of the Mississippi River at Baton Rouge, Louisiana.

Channel Stability

Cross-section information is shown in figure 7 for the years 1940 and 1992. These surveys do not indicate significant changes in the main channel part, but increased bed elevations of about 30 ft are indicated in the channel near the east bank. A part of this bed change may possibly be man-made. There are effects from dredging in the channel near the west bank and a pipeline crossing that is riprap protected the channel near the east bank. Levees on both banks confine the channel along this reach of the river (fig. 6).

Interstate Highway 10 Crossing of the Mississippi River near Baton Rouge

The 500-year flood estimate used for the hydraulic analysis is 1,500,000 ft^3/s. The water-surface elevation used for the 500-year estimate is 44.3 ft above NGVD of 1929 (table 5). The width of the channel (fig. 8) at the 500-year flood is approximately 3,000 ft. Simulations indicate velocities of 4.0 to 9.0 ft/s along the cross section at the bridge. Values of velocity at the pier locations are listed in table 5.

Pier Scour

Values for y_1 at each pier are based on the DOTD hydrographic survey of 1994 for evaluations of pier scour at Interstate Highway 10. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity, which is computed using the WSPRO model. The maximum computed scour depth is approximately 34 ft for the pier at DOTD station 387+63 (table 5, fig. 9). The channel-bed elevation of the computed scour hole is about 78 ft below NGVD of 1929. None of the predicted scour depths produce bed elevations that are below the design bottom of footing elevations.

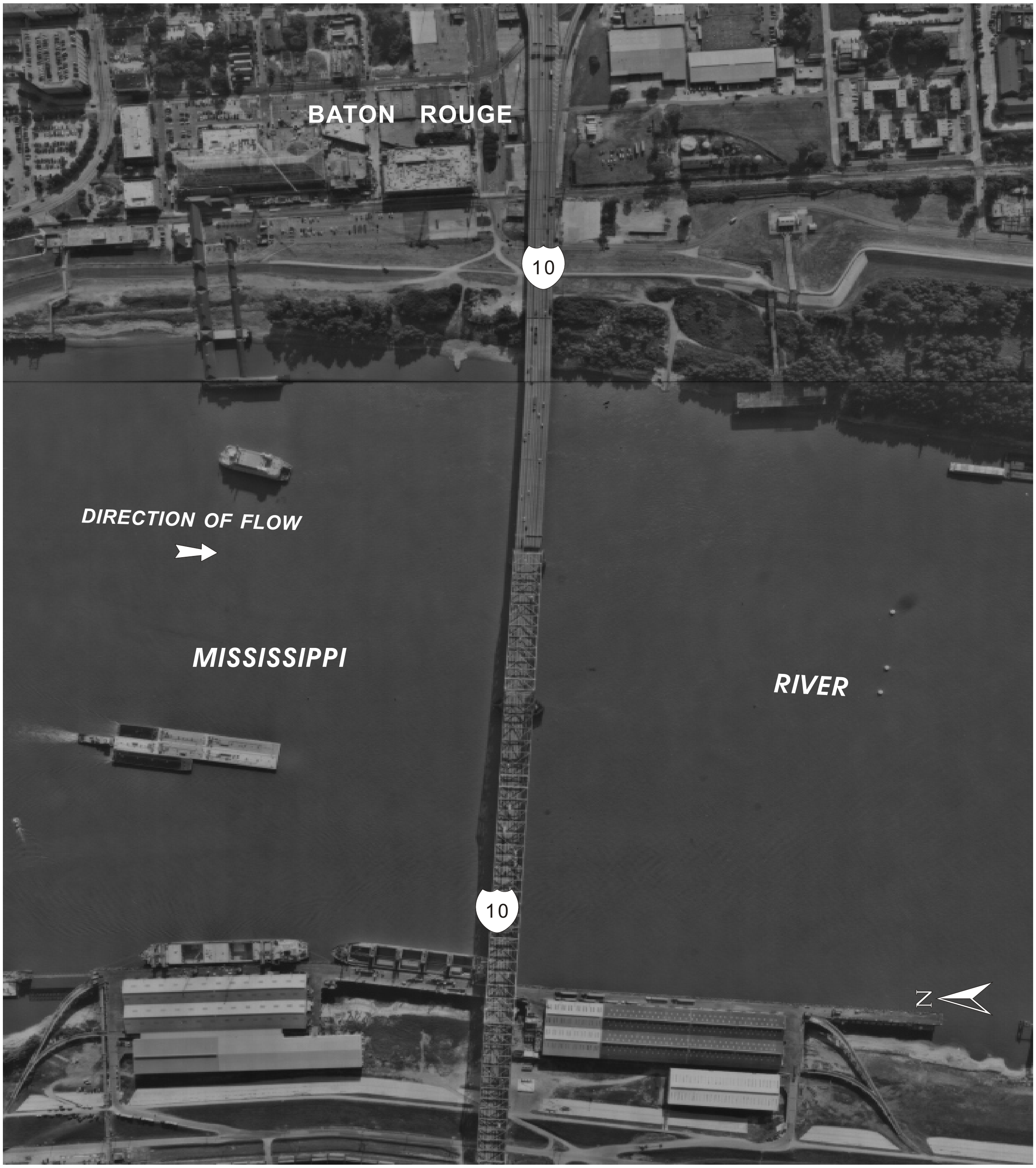
Table 5. Scour data for Interstate Highway 10 crossing of the Mississippi River near Baton Rouge, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 44.3 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3, 1.1; ft, feet; ft/s, foot per second; bottom of footing scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Bottom of footing elevation (ft above or below NGVD of 1929)
402+48	17	Round	1.0	14	4.0	15	NA	2	NA
398+20	-14	Round	1.0	14	8.0	22	NA	-36	-105
393+57	-24	Round	1.0	25	6.0	29	NA	-53	-110
387+63	-44	Round	1.0	30	6.0	34	NA	-78	-155
375+28	-18	Round	1.0	30	4.0	27	NA	-45	-120

Channel Stability

Cross-section information is shown in figure 9 for the years 1968, 1975, and 1994. The 1975 and 1994 surveys do not indicate significant changes in the shape of the cross-section. The 1968 DOTD bed elevation data was scaled from a reduced copy of the bridge plans. Some of the differences noted between the 1968 data and the 1975 and 1994 data may be due to the errors in scaling the source drawing. The 1975 USACE cross section is close to the bridge but not along the exact alignment as the DOTD cross section. The increased bed elevations near station 375+00 and near the pier result from industrial development along the bank.



Photograph source: Louisiana Department of Transportation and Development, 9/7/95

Figure 8. Aerial photograph of the Interstate Highway 10 crossing of the Mississippi River near Baton Rouge, Louisiana.

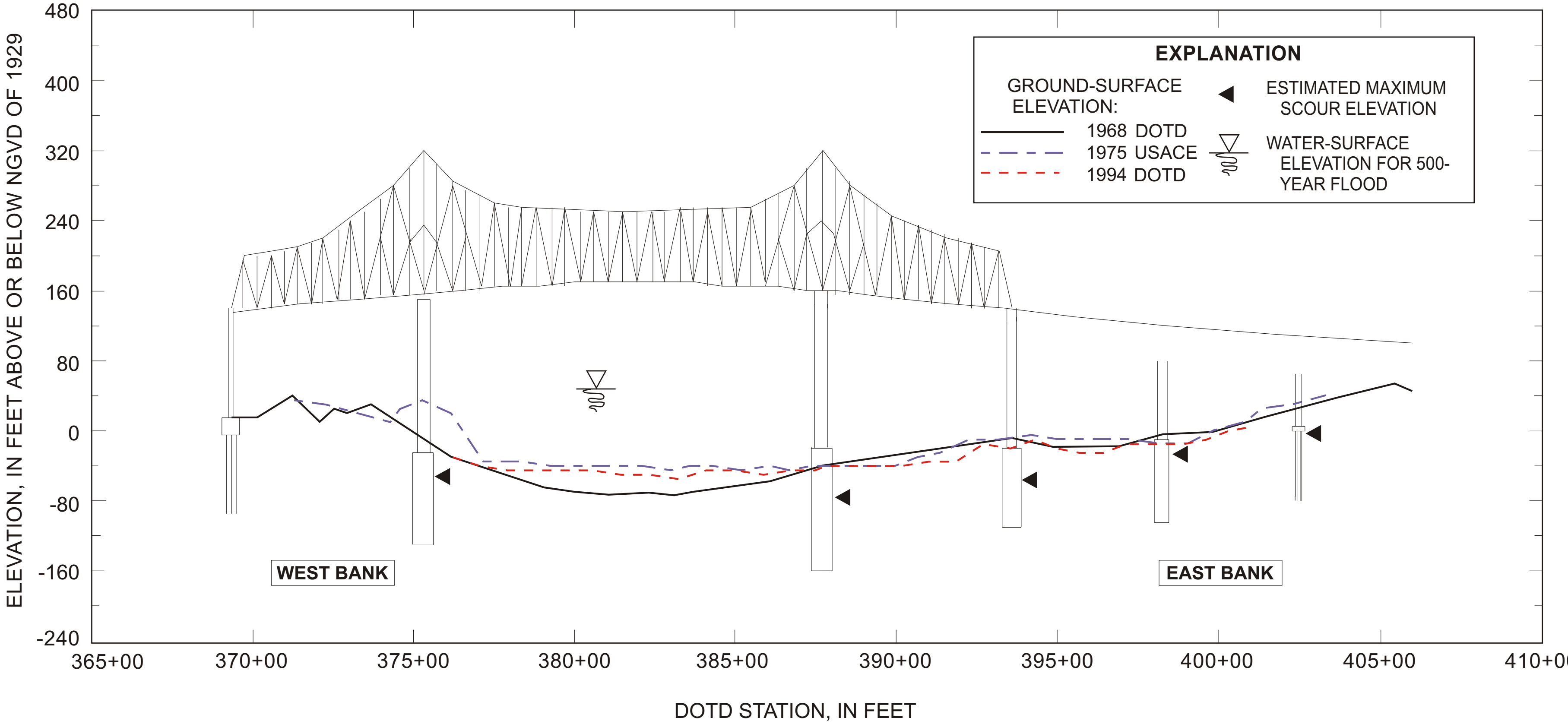


Figure 9. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 10 crossing of the Mississippi River near Baton Rouge, Louisiana.

The 1994 DOTD cross section is similar to the 1975 cross section. Bed elevation differences in the main channel of about 15 ft are within the expected difference considering seasonal variation in data collection and different cross section locations. The willow mattresses and heavy riprap armoring indicated on the bridge plans at the piers should limit scour to values less than the estimates in table 5.

Louisiana Highway 70 Crossing of the Mississippi River at Donaldsonville

The 500-year flood estimate used in the hydraulic analysis was 1,500,000 ft^3/s. The water-surface elevation used for the 500-year estimate is 34.7 ft above NGVD of 1929 (table 6). The width of the channel (fig. 10) at the 500-year flood estimate is approximately 3,200 ft. Simulations indicate velocities ranging from 5.0 to 9 ft/s along the cross section at the bridge. Values of velocity at the pier locations are listed in table 6.

Pier Scour

Values for y_1 at each pier are based on the DOTD hydrographic survey of 1991 for evaluations of pier scour at Louisiana Highway 70. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity, which is computed using WSPRO.

The pier footings become partially exposed when the estimated bed elevations are considered. The width of the pier used in computations is 40 ft, an average of the pier width and footing width. This approximate width produces an over-estimation of the scour, but the bottom of the footings are not exposed. Timber fenders protect the piers in the navigation area of the channel, which can reduce the amount of scour. The abrupt increase in width at the top of the footing may also disrupt the downward component of pier scour currents, reducing the actual amount of scour.

The maximum computed scour depth is approximately 52 ft for the piers at DOTD stations 3971+75 and 3980+00 (table 6, fig. 11). The channel-bed elevation of the computed scour hole is about 109 ft below NGVD of 1929. None of the predicted scour depths produce bed elevations that are below the design bottom of footing elevations.

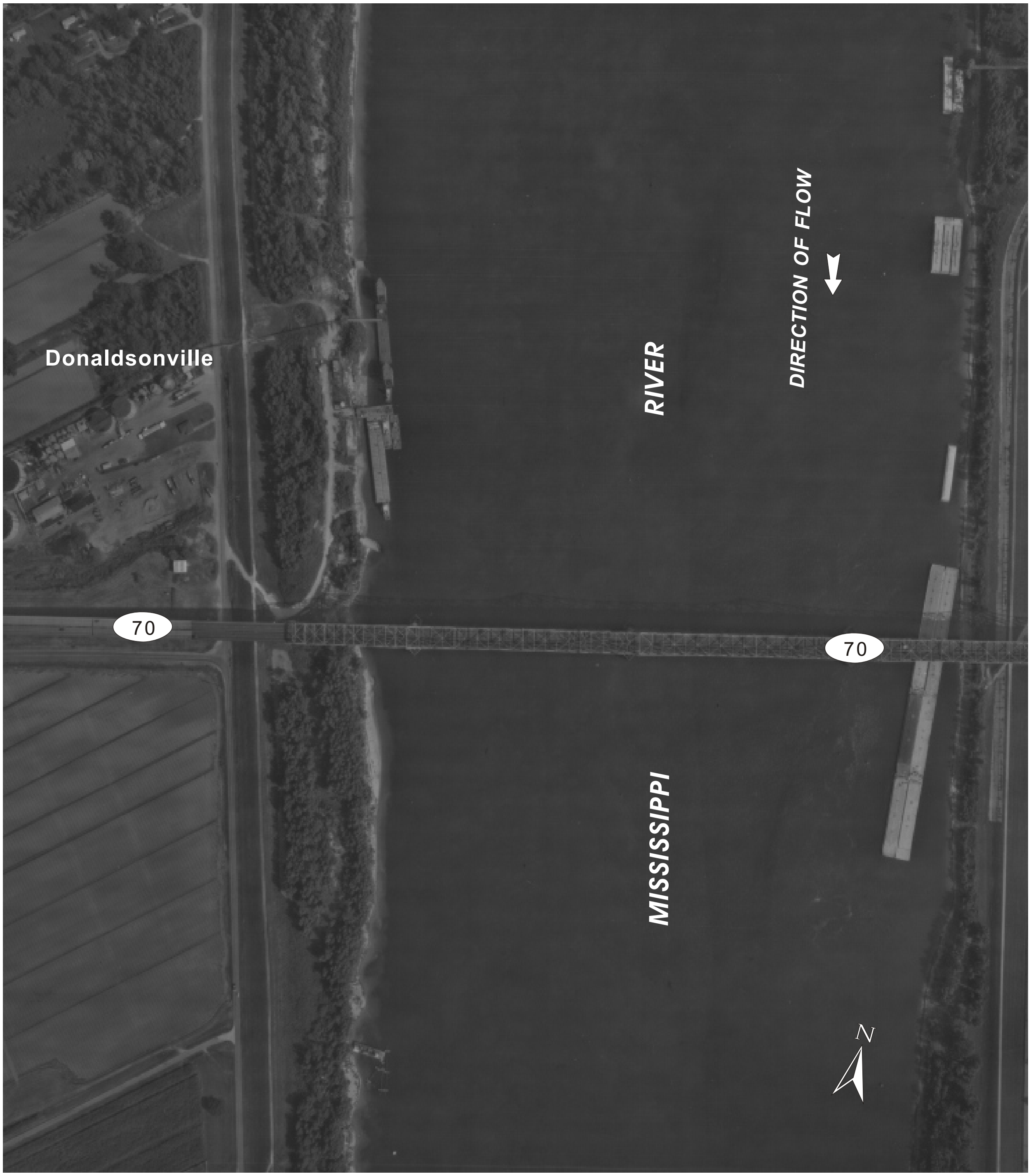
Table 6. Scour data for Louisiana Highway 70 crossing of the Mississippi River at Donaldsonville, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 34.7 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3, 1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Bottom of footing elevation (ft above or below NGVD of 1929)
3963+75	-48	Round	1.0	40	5.0	42	NA	-90	-130
3971+75	-57	Round	1.0	40	8.0	52	NA	-109	-130
3980+00	-57	Round	1.0	40	8.0	52	NA	-109	-130

Channel Stability

The bridge crossing is located in one of the straight sections of channel along this reach of the river. Cross-section information is shown in figure 11 for the years 1961, 1975, 1989, and 1991. These surveys show minor changes in the bed elevation which may have been caused by seasonal differences at the time of the survey. The 1961 survey was scaled from a reduced bridge plan drawing, and is subject to the errors in that process.



Photograph source: Louisiana Department of Transportation and Development, 8/20/91

Figure 10. Aerial photograph of the Louisiana Highway 70 crossing of the Mississippi River at Donaldsonville, Louisiana.

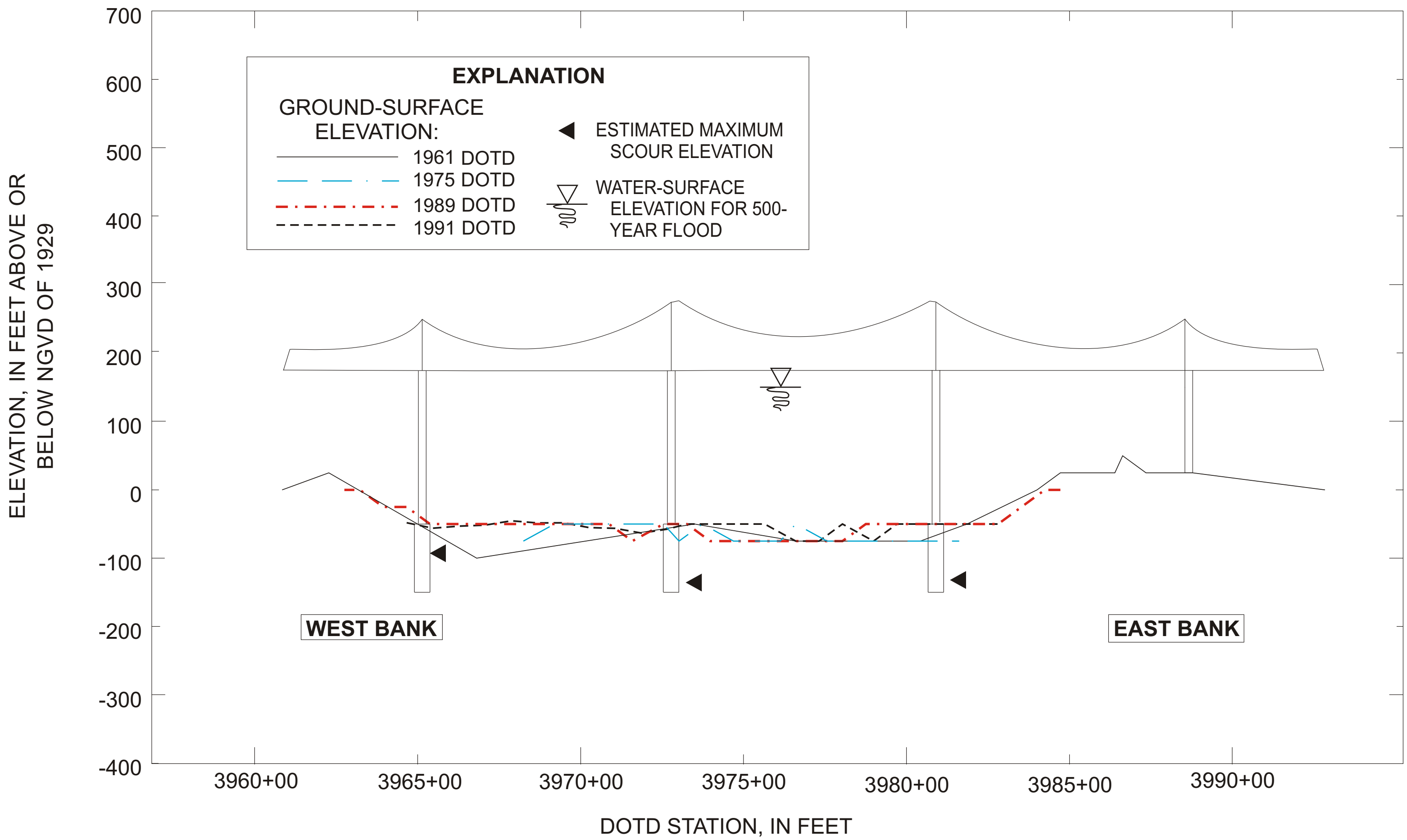


Figure 11. Bridge schematic, comparative cross sections, and scour estimates at the Louisiana Highway 70 crossing of the Mississippi River at Donaldsonville, Louisiana.

Louisiana Highway 3213 Crossing of the Mississippi River at Gramercy

The 500-year flood estimate used in the hydraulic analysis was 1,500,000 ft^3/s. The water-surface elevation used for the 500-year estimate is 29.0 ft above NGVD of 1929. The width of the channel (fig. 12) at the 500-year flood estimate is approximately 2,900 ft. Simulations indicate velocities ranging from 4.0 to 10.0 ft/s along the cross section at the bridge. Values of velocity at the pier locations are listed in table 7.

Pier Scour

Values for y_1 at each pier are based on the DOTD hydrographic survey of 1997 for evaluations of pier scour at Louisiana Highway 3213. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity, which is computed using WSPRO.

The maximum computed scour depth is approximately 50 ft for the pier at DOTD station 230+18 (table 7, fig. 13), which corresponds to a channel-bed elevation of the computed scour hole of 108 ft below NGVD of 1929. None of the predicted scour depths produce bed elevations that are below the pile tip elevations.

Table 7. Scour data for Louisiana Highway 3213 crossing of the Mississippi River at Gramercy, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 29.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3, 1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

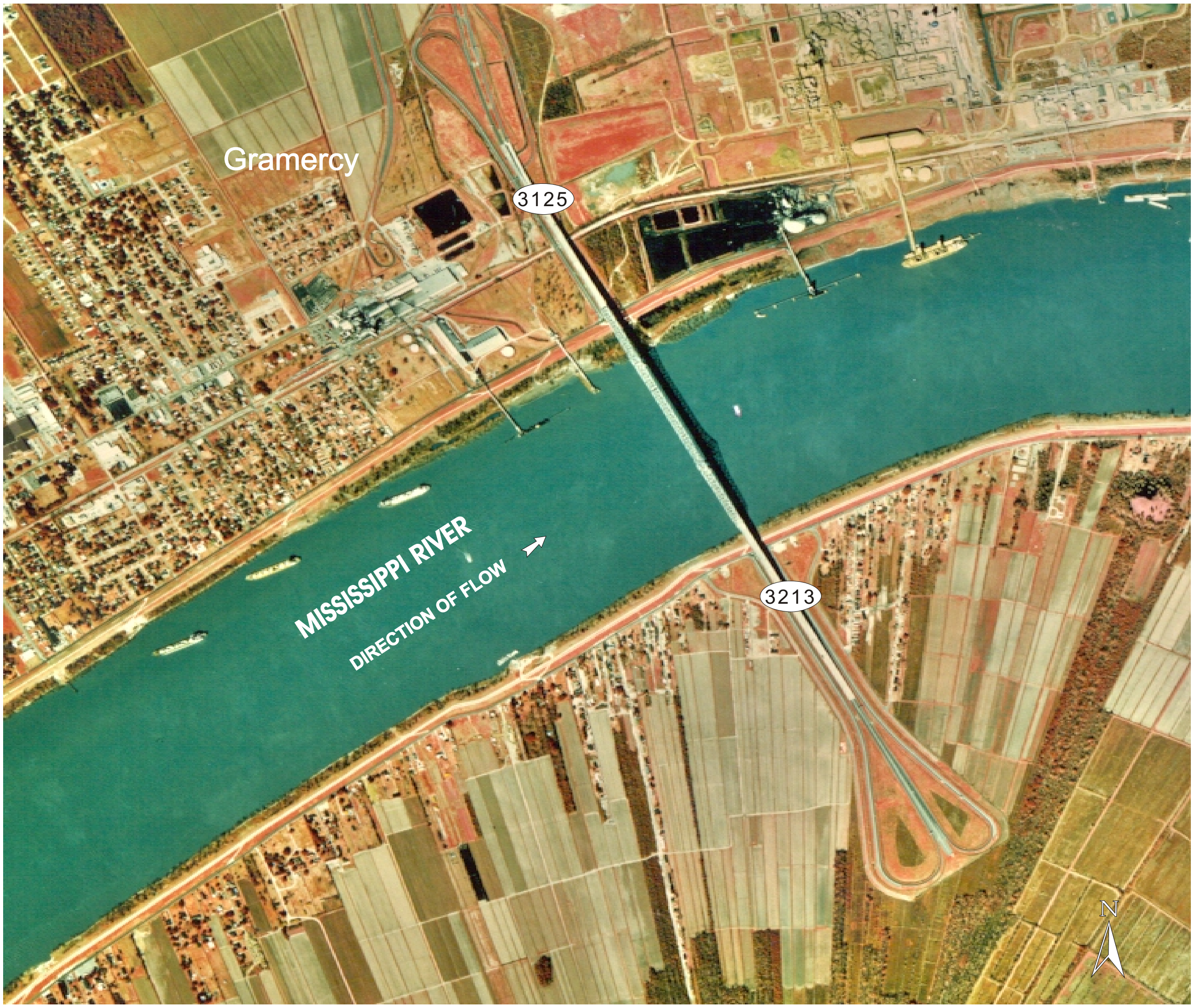
DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
222+41	-9	Round	1.0	16	5.0	21	NA	-30	-190
230+18	-58	Round	1.0	38	8.0	50	NA	-108	-190
244+80	-8	Round	1.0	38	4.0	33	NA	-41	-190

Channel Stability

The bridge crossing is located in a reach where the channel is straight for several channel widths upstream from the crossing (fig. 12), and bends to the right about one channel width downstream from the bridge crossing along this reach of the river. Cross-section information is shown in figure 13 for the years 1981 and 1997. At the thalweg, the 1997 elevation is about 20 ft lower than the 1981 elevation. However, the general shape of the cross section is the same when the two years are compared. The lower elevations indicated from the 1997 survey compared to those from the 1981 survey may result from the mobile character of the sand bed parts of the river.

Interstate Highway 310 Crossing of the Mississippi River at Luling

The 500-year flood estimate used in the hydraulic analysis is 1,250,000 ft^3/s. This discharge is the discharge from upstream sites with diversion through the Morganza and Bonnet Carré Spillways. The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate was 15.0 ft above NGVD of 1929 (table 8) with a channel width of approximately 3,100 ft (fig. 14). Simulations indicate velocities ranging from 4.0 to 10.0 ft/s along the cross section at the bridge. Values of velocity at the pier locations are listed in table 8.



Photograph source: U.S. Department of the Interior,
U.S. Geological Survey Maintainer:
earthexplorer@edcmail.cr.usgs.gov
Last Modified: 2/5/01

Figure 12. Aerial photograph of the Louisiana Highway 3213 crossing of the Mississippi River at Gramercy, Louisiana.

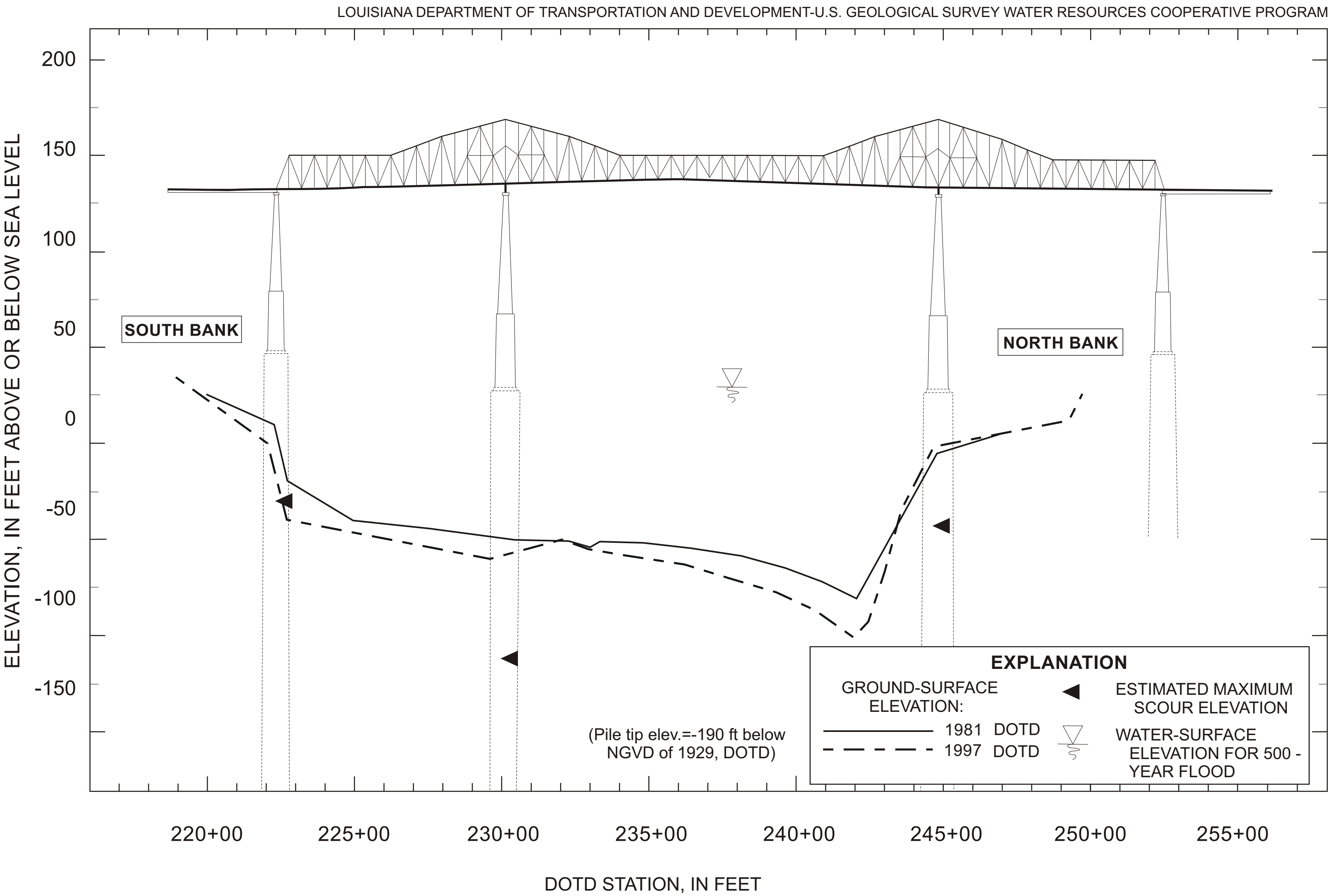
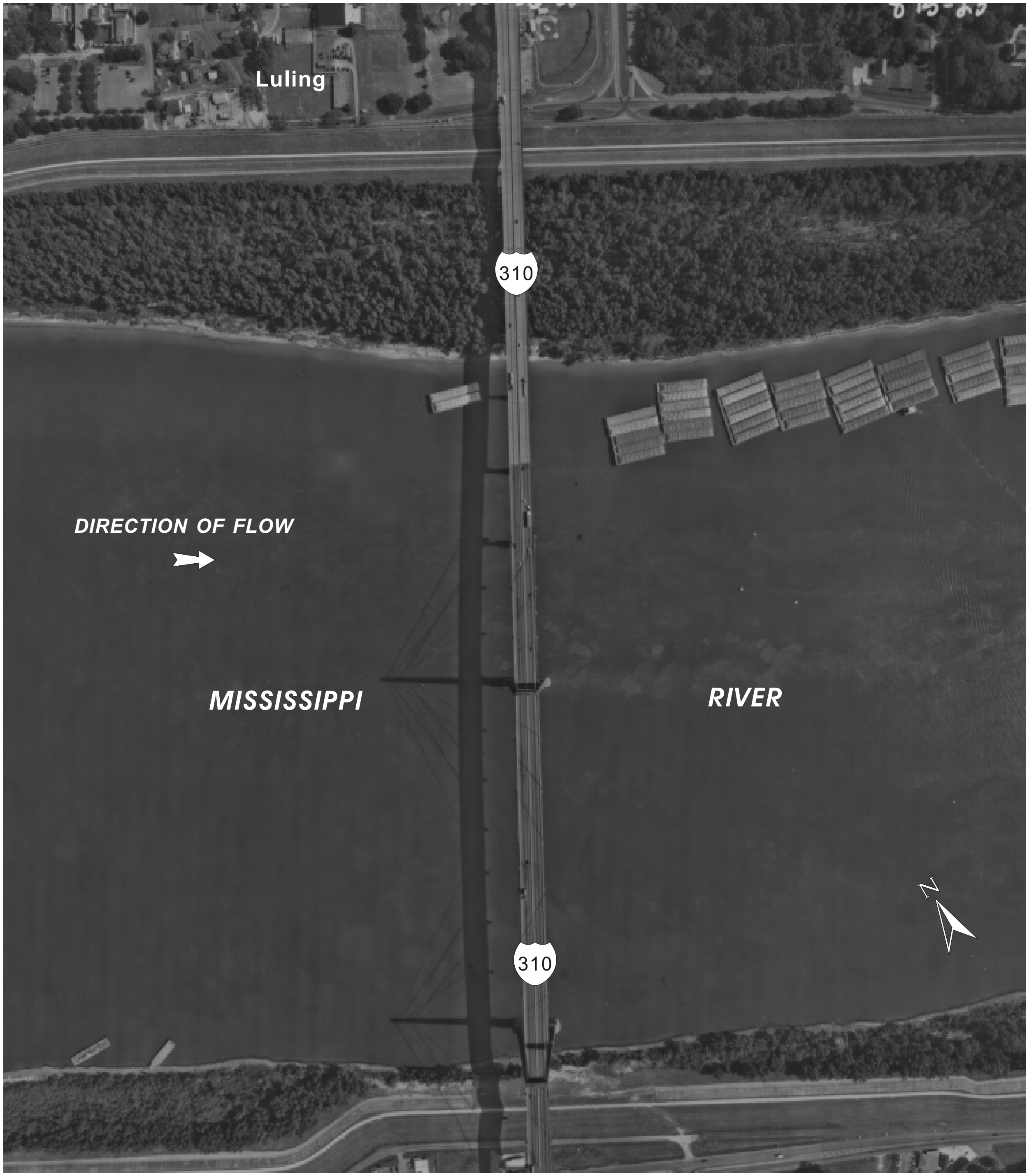


Figure 13. Bridge schematic, comparative cross sections, and scour estimates at the Louisiana Highway 3213 crossing of the Mississippi River at Gramercy, Louisiana.



Photograph source: Louisiana Department of Transportation and Development, 9/28/94

Figure 14. Aerial photograph of the Interstate Highway 310 crossing of the Mississippi River at Luling, Louisiana.

Pier Scour

Values for y_1 at each pier were based on the DOTD hydrographic survey of 1991. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity, which was computed using the WSPRO model.

The maximum computed scour depth was approximately 53 ft for the pier at DOTD station 261+70 (table 8). The channel-bed elevation for this computed scour hole is about 117 ft below NGVD of 1929. Predicted scour depths are not below the pile tip elevations at any of the piers.

Table 8. Scour data for Interstate Highway 310 crossing of the Mississippi River at Luling, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 15.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
249+35	-26	Round	1.0	35	5.0	35	NA	-61	-166
261+70	-64	Round	1.0	43	8.0	53	NA	-117	-185
266+65	-50	Round	1.0	27	6.0	33	NA	-83	-149
269+25	-39	Round	1.0	20	6.0	27	NA	-66	-109
271+90	-8	Round	1.0	17	4.0	18	NA	-26	-100

Channel Stability

Cross-section information is shown in figure 15 for the years 1973, 1975, 1990, and 1991. The surveys indicate some shifting in the location and elevation of the thalweg, but the most recent elevations are above the 1973 elevations. The bridge crossing is located in a relatively straight reach of the river (fig. 14) where levees to confine flood flows are constructed on each bank. Values of velocity at the pier locations are listed in table 8.

U.S. Highway 90 Crossing (Huey P. Long bridge) of the Mississippi River at New Orleans

The 500-year flood estimate used in the hydraulic analysis was 1,250,000 ft^3/s. The water-surface elevation used for the 500-year estimate is 10.6 ft above NGVD of 1929 (table 9). The width of the channel (fig. 16) at the 500-year flood is approximately 2,300 ft. Simulations indicate velocities range from 5.0 to 8.0 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 9.

Pier Scour

Values for y_1 at each pier are based on the DOTD hydrographic survey of 1991 for evaluations of pier scour. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity, which is computed using the WSPRO model.

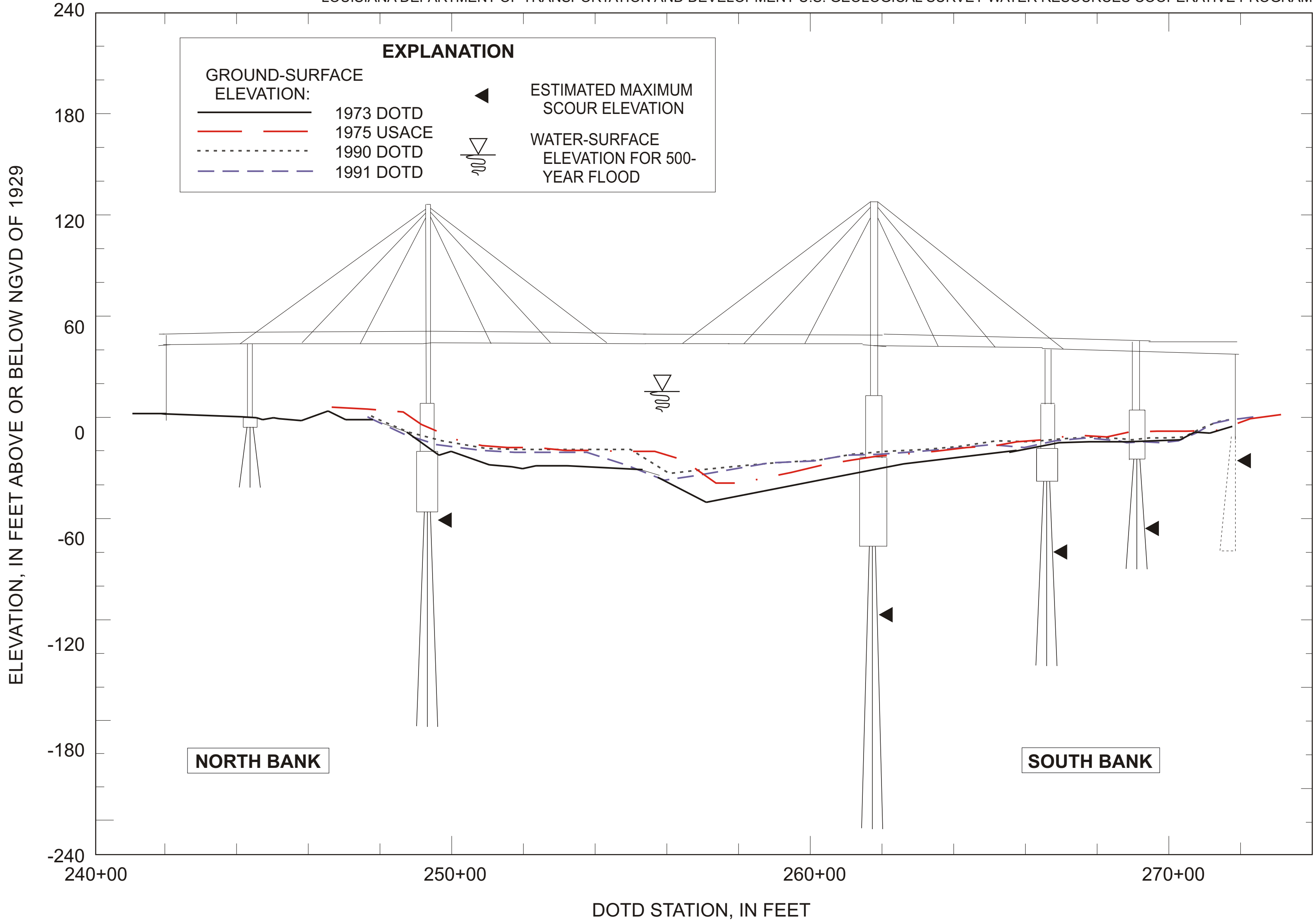


Figure 15. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 310 crossing of the Mississippi River at Luling, Louisiana.

Photograph source: Louisiana Department of Transportation and Development, 10/6/92

Figure 16. Aerial photograph of the U.S. Highway 90 crossing (Huey P. Long bridge) of the Mississippi River at New Orleans, Louisiana.

The maximum computed scour depth is approximately 73 ft for the pier at DOTD station 113+20 (table 9). The channel-bed elevation of the computed scour hole is about 140 ft below NGVD of 1929. None of the estimated scour depths produce bed elevations that are below the bottom of the footings. Willow mattresses and riprap protection at the piers will limit the actual depth of pier scour.

Table 9. Scour data for U.S. Highway 90 crossing (Huey P. Long bridge) of the Mississippi River at New Orleans, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 10.6 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; footing elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Footing elevation (ft above or below NGVD of 1929)
105+28	-61	Round	1.0	70	8.0	72	NA	-133	-170
113+20	-67	Round	1.0	70	8.0	73	NA	-140	-169
118+49	-67	Round	1.0	50	8.0	58	NA	-126	-169
123+81	-33	Round	1.0	50	5.0	44	NA	-77	-168

Channel Stability

Cross-section information is shown in figure 17 for the years 1936, 1975, and 1991. The two more recent surveys indicate a decrease in the elevation of the thalweg from the original 1936 survey. The 1936 bed elevations were scaled from a reduced copy of DOTD bridge plans and could have some error from that process. With that in consideration, the general shape of the cross section is consistent, and differences between 1975 and 1991 elevations across the section are generally less than 15 ft. Some shifting of the thalweg is apparent when comparing the 1975 and 1991 surveys. The bridge crosses the river at a relatively straight reach about 1 mi upstream of a turn to the right. Flood flows are confined by levees on each bank (fig. 16).

U.S. Highway 90 Crossing (Greater New Orleans bridge no. 2) of the Mississippi River at New Orleans

The 500-year flood estimate used for hydraulic analysis is 1,250,000 ft^3/s. The water-surface elevation used for the 500-year estimate is 9.0 ft above NGVD of 1929 (table 10). The width of the channel (fig. 18) at the 500-year flood estimate is approximately 2,500 ft. Simulations indicate velocities ranging from 5.0 to 10.0 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 10.

Pier Scour

Values for y_1 at each pier are based on the DOTD hydrographic survey of 1991. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of velocity, which is computed using the WSPRO model. The maximum computed scour depth is approximately 50 ft for the pier at DOTD station 125+78 (table 10, fig. 19). The channel-bed elevation of the computed scour hole is about 107 ft below NGVD of 1929. None of the estimated scour depths produce bed elevations that are below the bottom of the footings. Willow mats and riprap protection at the piers will limit the actual pier scour depths.

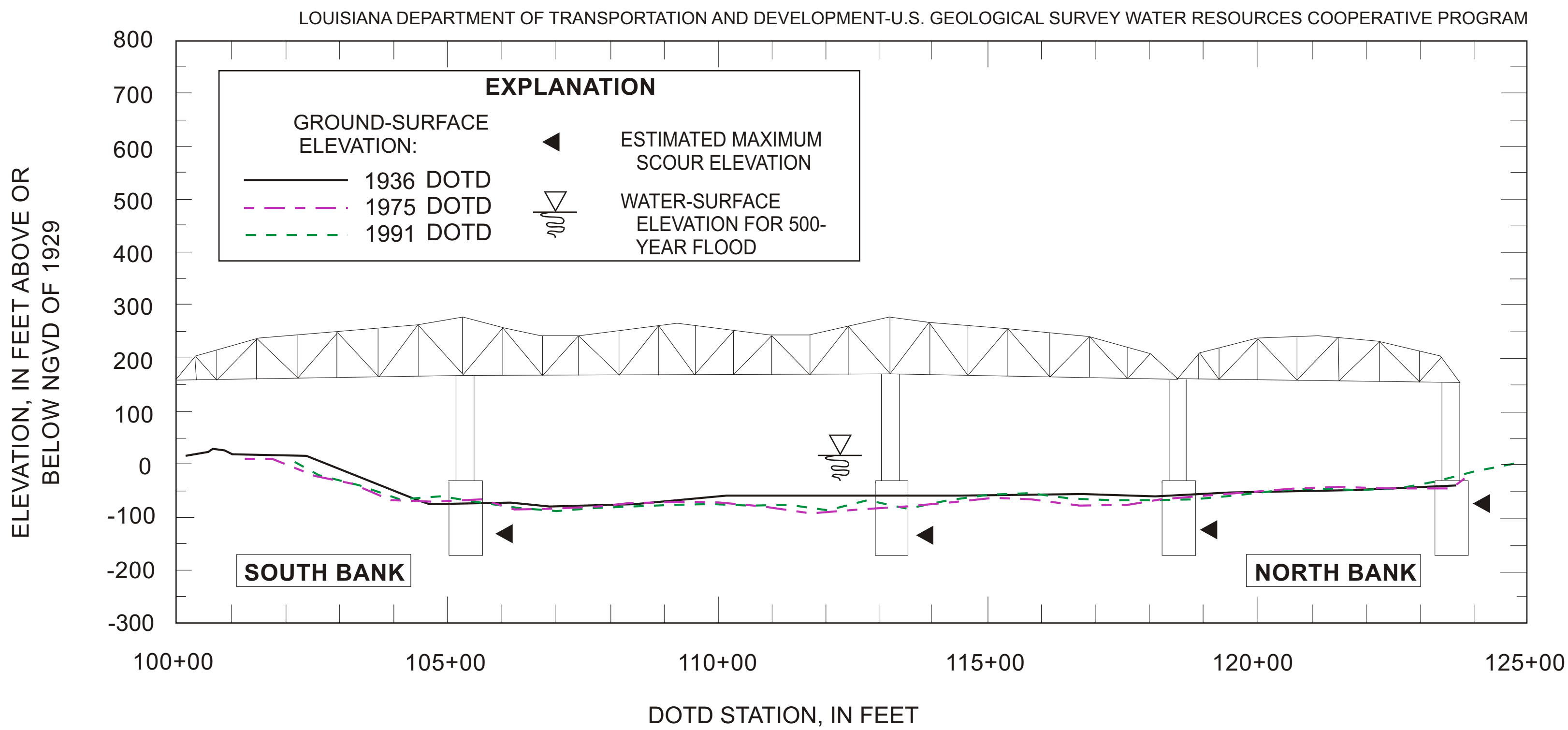
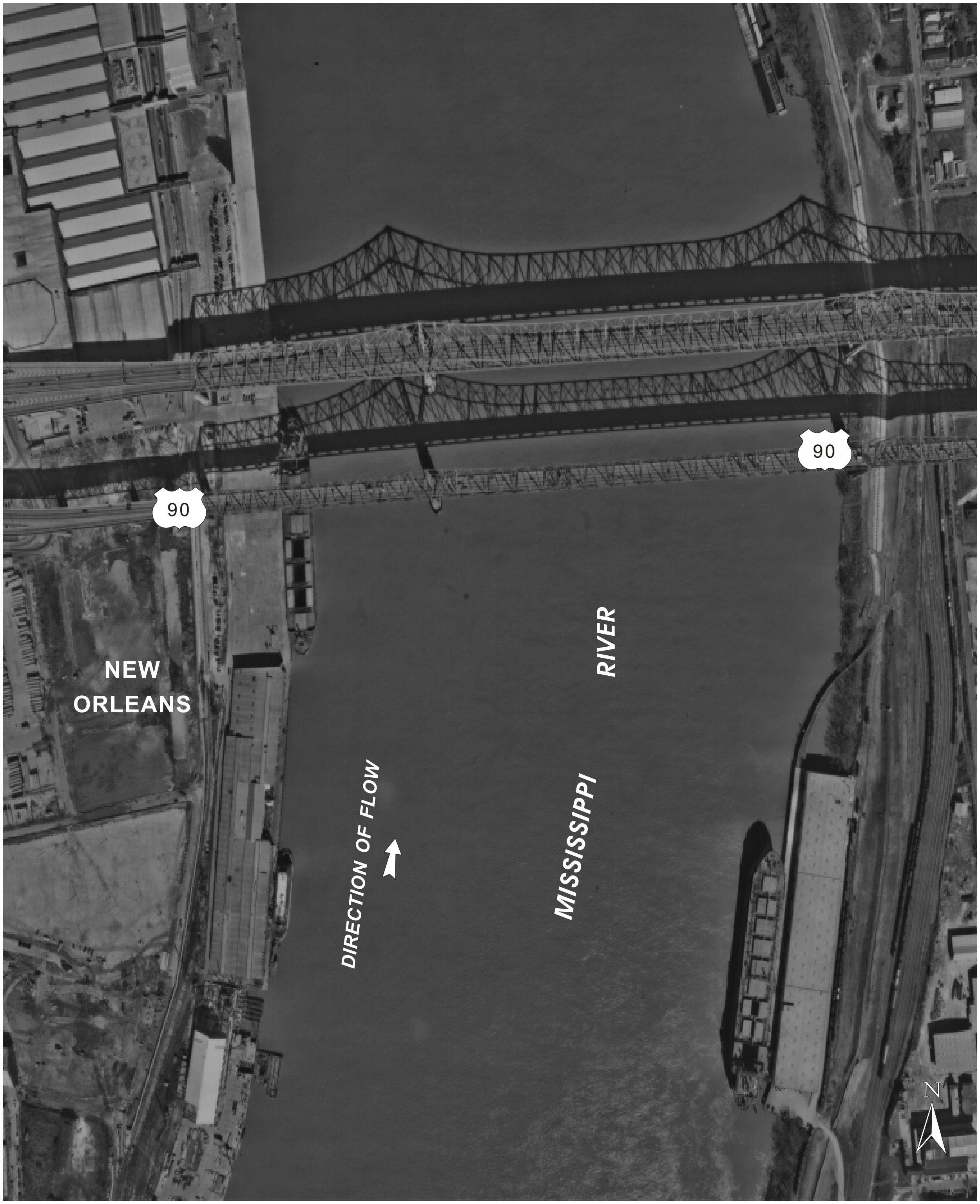


Figure 17. Bridge schematic, comparative cross sections, and scour estimates at the U.S. Highway 90 crossing (Huey P. Long bridge) of the Mississippi River at New Orleans, Louisiana.



Photograph source: Louisiana Department of Transportation and Development, 1/24/95

Figure 18. Aerial photograph of the U.S. Highway 90 crossing (Greater New Orleans bridge no. 2) of the Mississippi River at New Orleans, Louisiana.

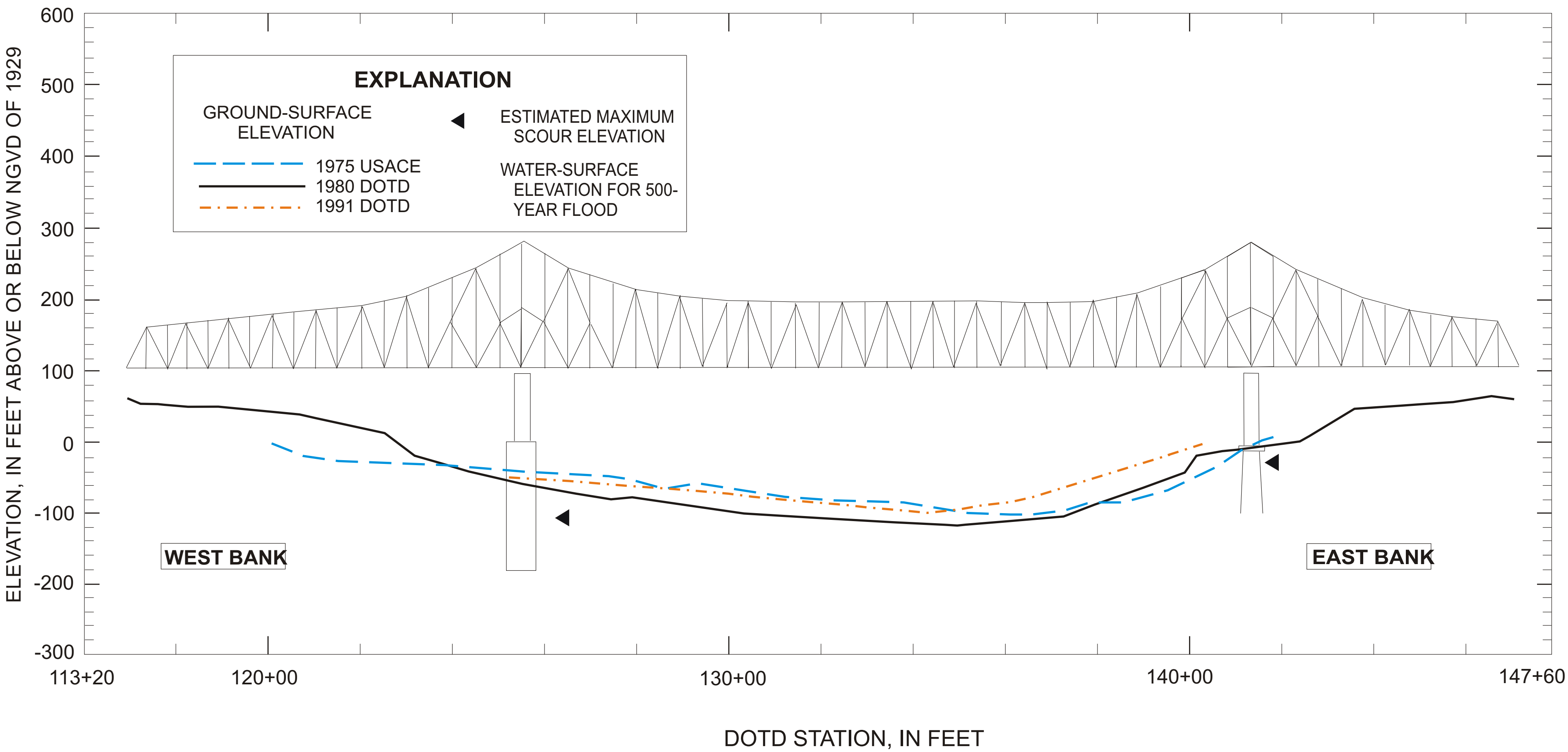


Figure 19. Bridge schematic, comparative cross sections, and scour estiamtes at the U.S. Highway 90 crossing (Greater New Orleans bridge no. 2) of the Mississippi River at New Orleans, Louisiana.

Table 10. Scour data for U.S. Highway 90 crossing (Greater New Orleans bridge no. 2) of the Mississippi River at New Orleans, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 9.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; footing or pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Footing or pile tip elevation (ft above or below NGVD of 1929)
125+78	-57	Round	1.0	50	6.0	50	0	-107	-180
141+53	5	Round	1.0	42	6.0	31	0	-26	-85

Channel Stability

Cross-section information is shown in figure 19 for the years 1975, 1980 and 1991. The 1980 cross section represents the lowest thalweg elevation among the three surveys. The change in bed elevation between the surveys near midchannel is about 25 ft. The horizontal location of the thalweg does not change significantly among the three surveys, and it is not near the main piers which are located out of the mid-channel area. The 1980 bed elevations were scaled from a reduced copy of DOTD bridge plans and could have some error from that process. The USACE and DOTD cross-section data were collected at slightly different locations, but comparison of these data does not indicate any major changes in the minimum bed elevations at the site.

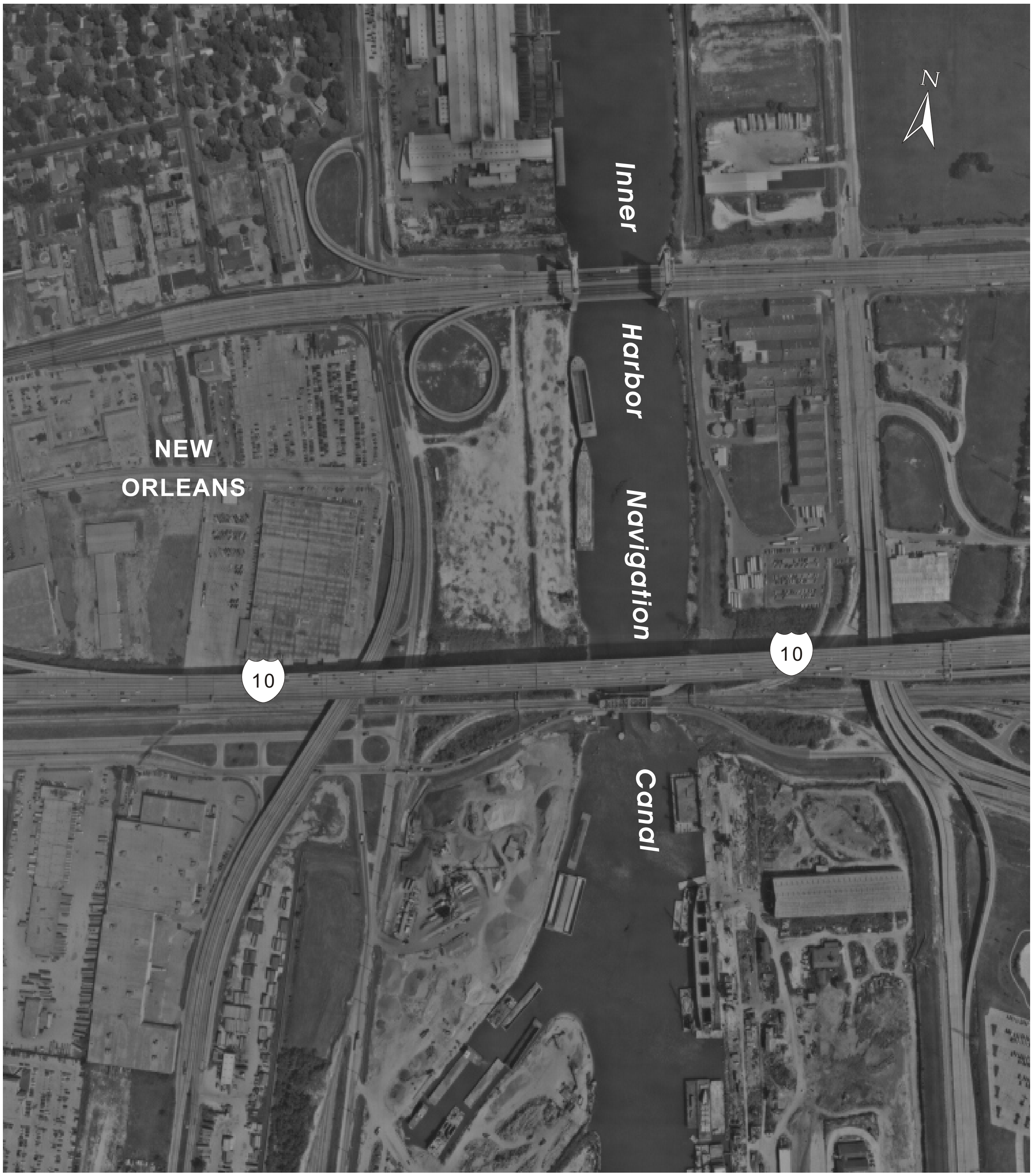
Interstate Highway 10 Crossing of the Inner Harbor Navigation Canal at New Orleans

The discharge used for hydraulic analysis was computed based on a conveyance weighted distribution of discharge between the Mississippi River main channel and the Inner Harbor Navigation Canal. Only the geometry of the canal was considered in this evaluation, even though it is not considered as a flood control feature. Losses through the navigation locks were not considered in this estimate, making the discharge estimate biased upward if the locks stayed open during the flood. The downstream water-surface elevation used for the simulations was estimated at 1.0 ft above NGVD of 1929 at Lake Pontchartrain and at the bridge (table 11). This represents a minimum normal elevation at the lake which will bias the velocity estimates upward. The combination of an upward biased discharge estimate, and a further upward bias in the velocity computations results in an over-estimation of scour depths (table 11). The width of the channel (fig. 20) at the estimated flood elevation is approximately 420 ft. The minimum channel-bed elevation for the cross section at the bridge is 37 ft below NGVD of 1929. Simulations indicate velocities ranging from 1.7 to 7.5 ft/s along the cross section at the bridge. Values of velocity at the pier locations are listed in table 11.

Table 11. Scour data for Interstate Highway 10 crossing of the Inner Harbor Navigation Canal at New Orleans, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 1.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
1525+23	-10	Round	1.0	20	5.1	20	0	-30	-95
1528+23	-8	Round	1.0	20	5.7	21	0	-29	-100



Photograph source: Louisiana Department of Transportation and Development, 5/6/94

Figure 20. Aerial photograph of the Interstate Highway 10 crossing of the Inner Harbor Navigation Canal at New Orleans, Louisiana.

Pier Scour

For evaluation of pier scour at Interstate Highway 10 crossing of Inner Harbor Navigation Canal, values for the depth of the pier were based on the DOTD hydrographic survey of 1994. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity, which was computed using WSPRO.

The maximum computed scour depth was approximately 21 ft for the pier at DOTD station 1525+23. The channel-bed elevation of the computed scour hole is about 30 ft below NGVD of 1929 (fig. 21). The elevation of the pile tip for this pier is about 95 ft below NGVD of 1929.

Channel Stability

An aerial view of this bridge crossing is shown in figure 20. Cross-section information is shown in figure 21 for the years 1966, 1988, and 1994. These surveys do not show significant changes in the pattern or minimum elevations of the channel bed.

Ouachita River Basin

The Ouachita River Basin originates in Arkansas and drains parts of Arkansas and Louisiana. The drainage area is approximately 19,000 mi^2 (Sloss, 1971, p. 73). The basin is bounded by the Tensas River Basin on the east and the Red River Basin on the west. At its mouth, the Ouachita River joins the mouth of the Tensas River and the mouth of Little River to form the origin of the Black River.

Interstate Highway 20 Crossing of the Ouachita River at Monroe

The estimate of the 500-year flood used for the hydraulic analysis is 103,000 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood was 81.5 ft above NGVD of 1929 (table 12). The width of the flood plain at the 500-year flood is approximately 1,000 ft. The width of the channel (fig. 22) at the 500-year flood is approximately 820 ft. Simulations indicate velocities ranging from 1.6 to 4.0 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 12.

Pier Scour

For evaluation of pier scour at Interstate Highway 20, values for y_1 at each pier were based on the DOTD hydrographic survey of 1993. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 18 ft for the pier at DOTD station 88+55 (table 12, fig. 23). The channel-bed elevation for this computed scour hole is about 17 ft above NGVD of 1929.

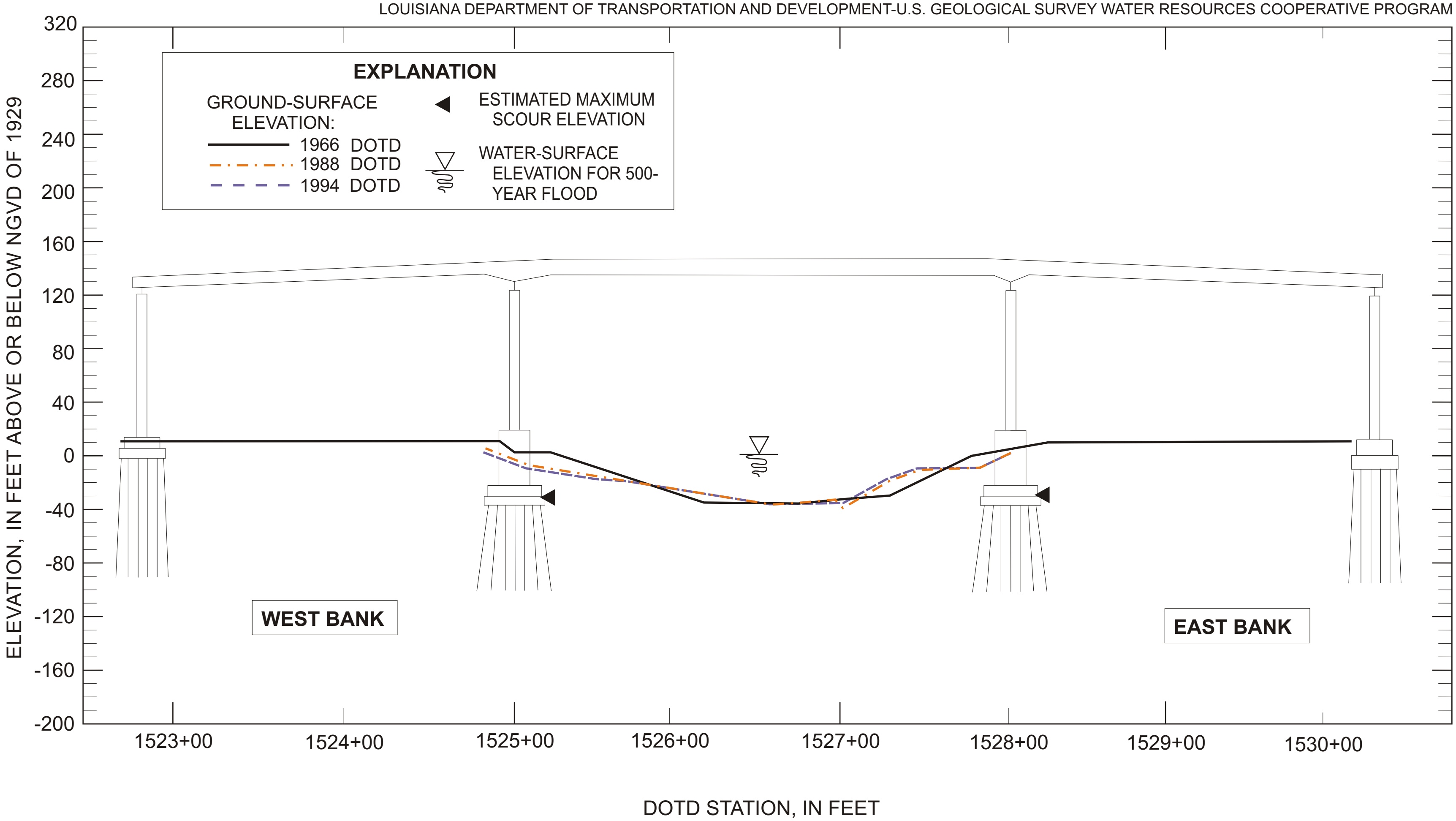


Figure 21. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 10 crossing of the Inner Harbor Navigation Canal at New Orleans, Louisiana.

Photograph source: Louisiana Department of Transportation and Development, 11/30/93

Figure 22. Aerial photograph of the Interstate Highway 20 crossing of the Ouachita River at Monroe, Louisiana.

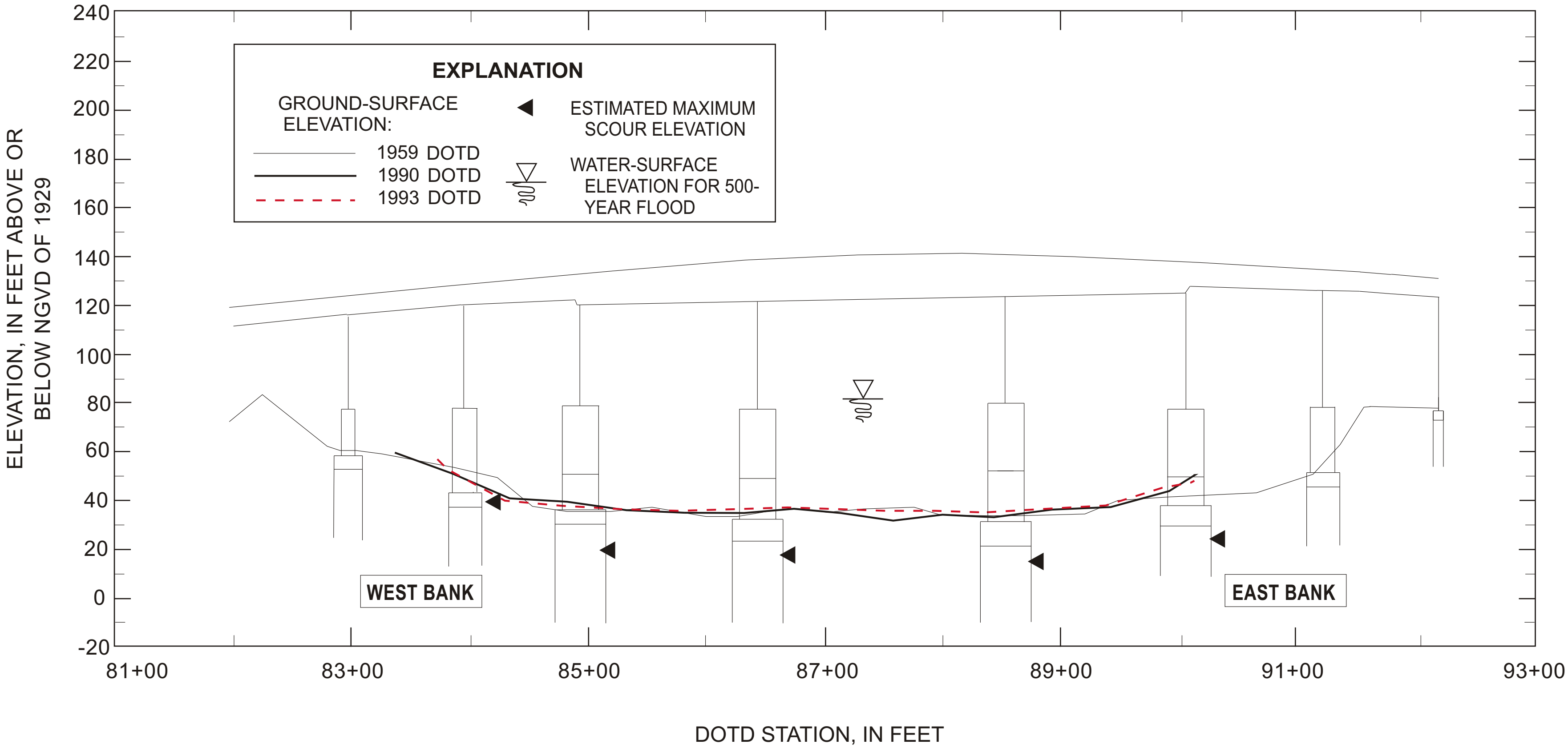


Figure 23. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 20 crossing of the Ouachita River at Monroe, Louisiana.

Table 12. Scour data for Interstate Highway 20 crossing of the Ouachita River at Monroe, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 81.5 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
83+97	50	Round	1.0	9	2.0	10	0	40	0
84+95	37	Round	1.0	14	4.0	17	0	20	-10
86+45	35	Round	1.0	14	4.0	17	0	18	-10
88+55	35	Round	1.0	14	4.0	18	0	17	-10
90+05	42	Round	1.0	14	3.0	15	0	27	0

Channel Stability

Cross-section information is shown in figure 23 for the years 1959, 1990, and 1993. The riverbed elevation indicated on figure 23, based on surveys of 1959, 1990, and 1993, show only minor differences in the bed elevations with no trend indicated. The differences can be attributed to seasonal flow variations and minor lateral position of the data collection vessel when the riverbed was surveyed.

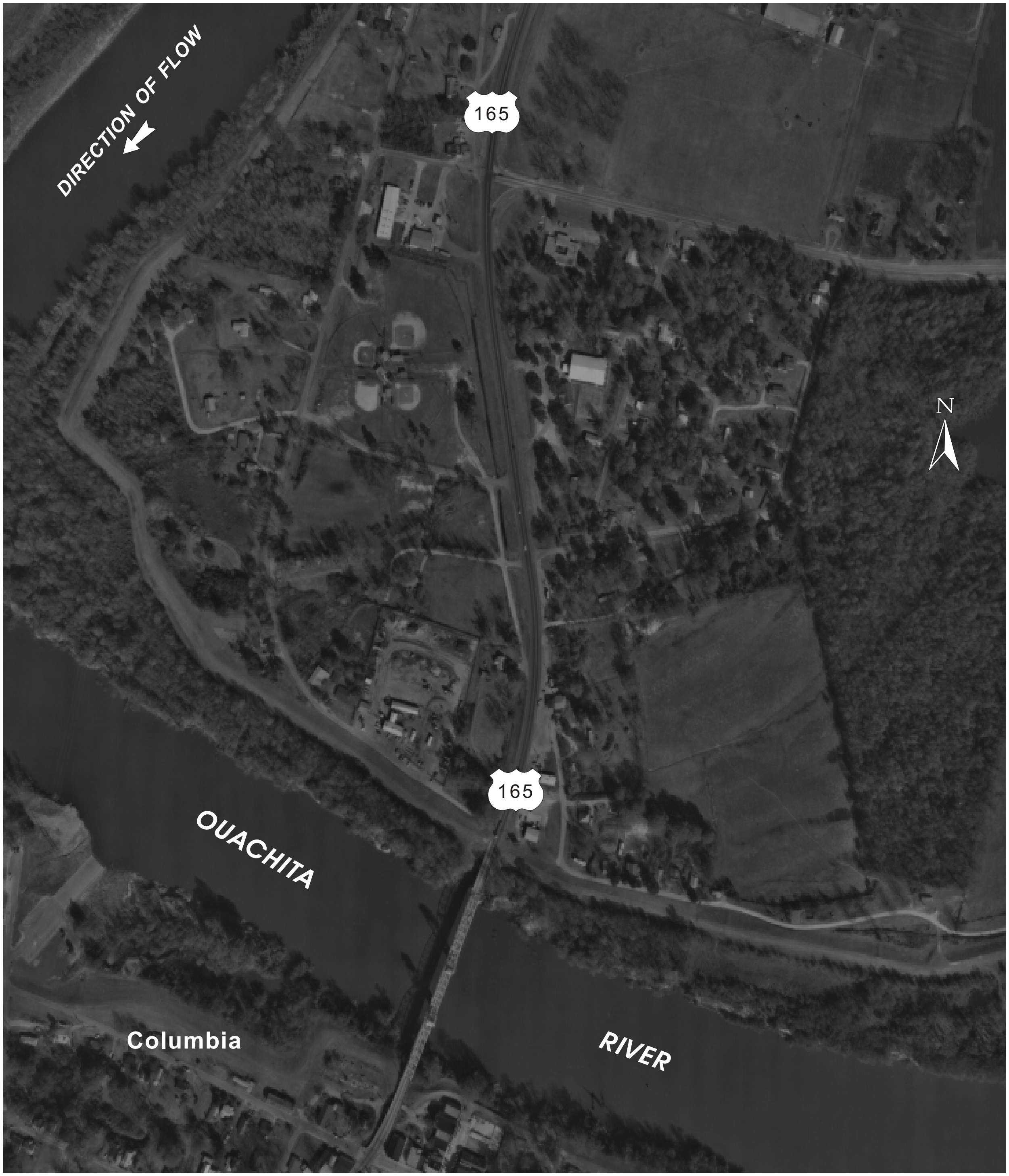
U.S. Highway 165 Crossing of the Ouachita River at Columbia

The estimate of the 500-year flood used for the hydraulic analysis is 76,400 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate is 58.0 ft above NGVD of 1929 (table 13). The width of the flood plain at the 500-year flood is approximately 1,280 ft. The width of the channel (fig. 24) at the bridge for the 500-year flood simulation is approximately 900 ft. The downstream boundary condition for computations using the WSPRO model was a slope of 0.00008 ft/ft, which is the same slope determined from the calibration simulations at this site. Simulations of the 500-year flood indicate velocities ranging from 1.1 to 5.1 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 13.

Pier Scour

For the evaluation of pier scour, values for water depths at each pier (y_1), were based on the DOTD hydrographic survey of 1994. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 17 ft for the pier at DOTD station 38+56 (table 13, fig. 25). The channel-bed elevation of the computed scour hole is about 8 ft below NGVD of 1929.



Photograph source: Louisiana Department of Transportation and Development, 11/25/91

Figure 24. Aerial photograph of the U.S. Highway 165 crossing of the Ouachita River at Columbia, Louisiana.

Table 13. Scour data for U.S. Highway 165 crossing of the Ouachita River at Columbia, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 58.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip and footing elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Footing and pile tip elevation (ft above or below NGVD of 1929)
38+56	9	Round	1.0	13	4.4	17	0	-8	-40
40+29	19	Round	1.0	13	4.0	16	0	3	-40

Channel Stability

The channel cross section has changed very little from the west bank to mid-channel. There are increases in bed elevations of about 10 ft on the east bank based on comparison of the 1931 and 1991 data. The comparison of the 1991 and 1994 data indicate some minor changes in bed elevation. These minor changes may be due in part to small differences in the location of the cross sections and horizontal approximations made on the original hydrographic records at the time of the data collection.

Tensas River Basin

The Tensas River Basin, located in southeastern Arkansas and northeastern Louisiana, is an area of low topographic relief that lies west of the Mississippi River. The drainage area of the Tensas River is 2,520 mi^2 at its mouth. (Sloss, 1971, p. 73). The basin has its headwaters in Arkansas and is bounded by the Mississippi River levee on the east, the Ouachita River Basin on the west, and the upper limits of the Atchafalaya River Basin on the south. The upper part of the basin can be affected by headwater flooding, and the lower part is affected by backwater from the Mississippi River and the Red River.

U.S. Highway 80 Crossing of the Tensas River at Tendal

The estimate of the 500-year flood used for the hydraulic analysis is 7,300 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate is 78.5 ft above NGVD of 1929 (table 14). The width of the flood plain at the 500-year flood is approximately 300 ft. The width of the channel (fig. 26) at the bridge for the 500-year flood simulation is also approximately 300 ft; without width reduction at the bridge, no contraction scour would be indicated. The downstream boundary condition for computations using the WSPRO model was a slope of 0.00005 ft/ft, which is the same slope determined from the calibration simulations at this site. A general calibration for the reach including U.S. Highway 80 and Interstate Highway 20 was based on the 1949 flood of 4,610 ft^3/s, which is the peak of record. The calibration also generally matched the 1979 flood of 3,800 ft^3/s. Roughness coefficients for the 500-year flood simulation were reduced by about 10 percent to account for geometric and roughness changes with the increased depth and flow. Simulations of the 500-year flood indicate velocities ranging from 0.7 to 1.6 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 14.

Pier Scour

For the evaluation of pier scour of the Tensas River at U. S. Highway 80, values for water depths at each pier (y_1), were based on the DOTD hydrographic survey of 1952. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions.

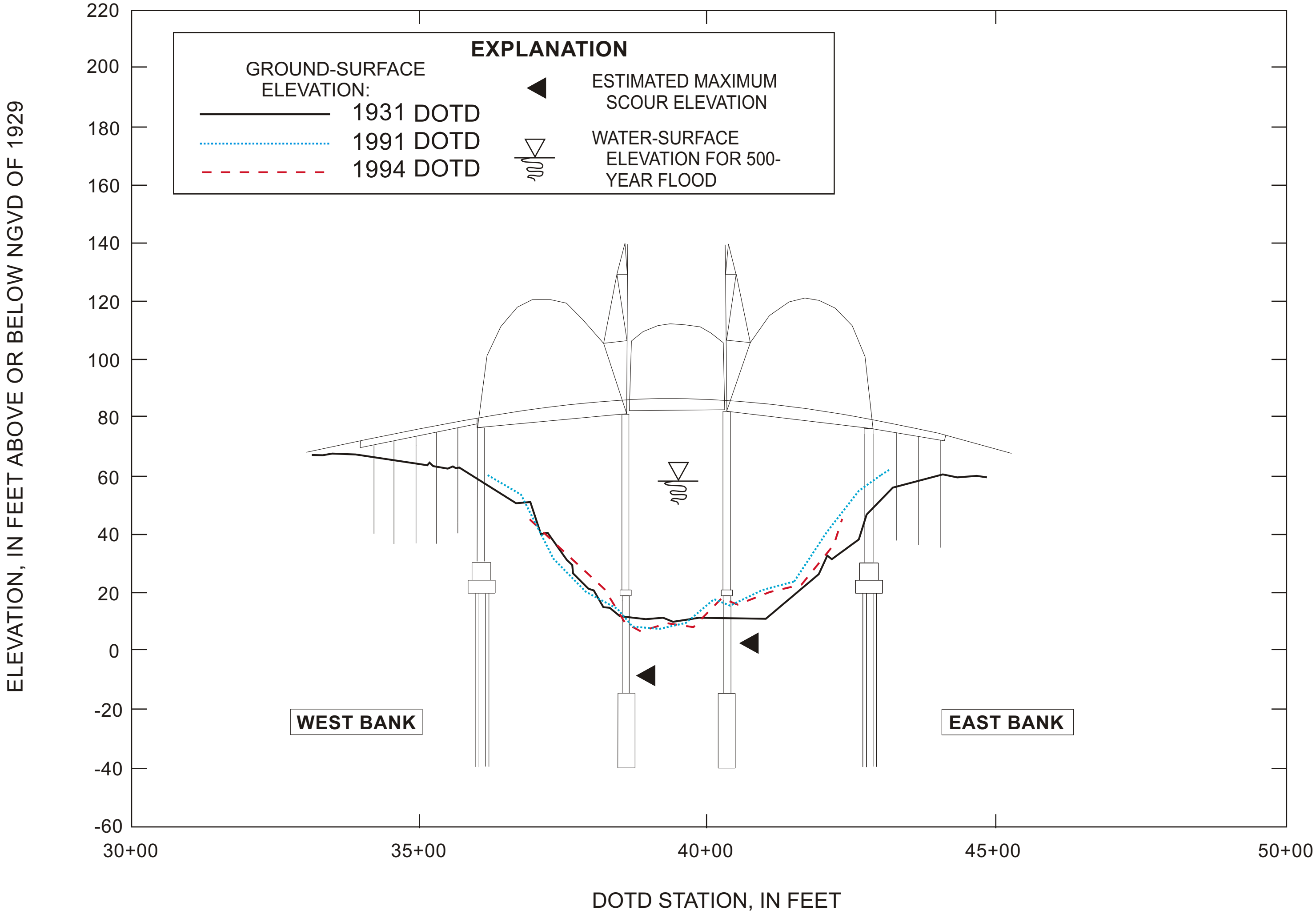


Figure 25. Bridge schematic, comparative cross sections, and scour estimates at the U.S. Highway 165 crossing of the Ouachita River at Columbia, Louisiana.

Source: Louisiana Oil Spill Coordinator's Office (LOSCO), 20001009, Color Infrared Orthophoto, SW quadrant of Tendal Quadrangle, LA, 50:1 MrSID compressed, UTM 15 NAD83, LOSCO (2000) [c3209138_sws_50]

Figure 26. Aerial photograph of the U.S. Highway 80 crossing of the Tensas River at Tendal, Louisiana.

The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 5 ft for the pier at DOTD station 352+17 (table 14, fig. 27). The channel-bed elevations of the computed scour holes are about 58 ft, 53 ft, and 55 ft above NGVD of 1929, respectively.

Table 14. Scour data for U.S. Highway 80 crossing of the Tensas River at Tendal, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 78.5 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; footing elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Footing elevation (ft above NGVD of 1929)
350+85	75	Abut	1.0	1	0	0	0	75	NA
351+17	63	Round	1.0	5	1.2	5	0	58	35
352+17	58	Round	1.0	5	1.6	5	0	53	32
353+18	60	Round	1.0	5	1.3	5	0	55	35
353+50	64	Round	1.0	1	1.0	2	0	62	35
353+82	67	Round	1.0	1	0.7	1	0	66	35
354+14	75	Abut	1.0	1	0	0	0	75	NA

Channel Stability

An aerial photograph of this bridge crossing is shown in figure 26. Cross-section information is shown in figure 27 for the year 1952. Because this bridge is not in the DOTD channel monitoring program, there are no comparative bed elevation data. Changes in bed elevations can have significant effects on the scour estimates.

Interstate Highway 20 Crossing (West, Middle, and East) of the Tensas River near Tendal

The estimate of the 500-year flood used for the hydraulic analysis is 7,300 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations using the 500-year estimate is 78.3 ft above NGVD of 1929 at the western crossing, 76.9 ft above NGVD of 1929 at the middle crossing, and 76.6 ft above NGVD of 1929 at the eastern crossing (table 15). The width of the flood plain at the 500-year flood is approximately 300 ft. The width of the channel through all three bridges at the 500-year flood is approximately 180 ft. Figures 28, 29 and 30 show the west, middle, and east bridge crossings. The downstream boundary condition for computations using the WSPRO model was a slope of 0.0005 ft/ft, which is the same slope, determined from the calibration simulations at this site. A general calibration for the reach including U.S. Highway 80 and Interstate Highway 20 was based on the 1949 flood of 4,610 ft^3/s, which is the peak of record. The calibration also generally matched the 1979 flood of 3,800 ft^3/s. Roughness coefficients for the 500-year flood simulation were reduced by about 10 percent to account for geometric and roughness changes with the increased depth and flow. Simulations indicate velocities ranging from 0.6 to 5.5 ft/s along the cross sections at each of the bridges. Values of velocity at pier locations are listed in table 15.

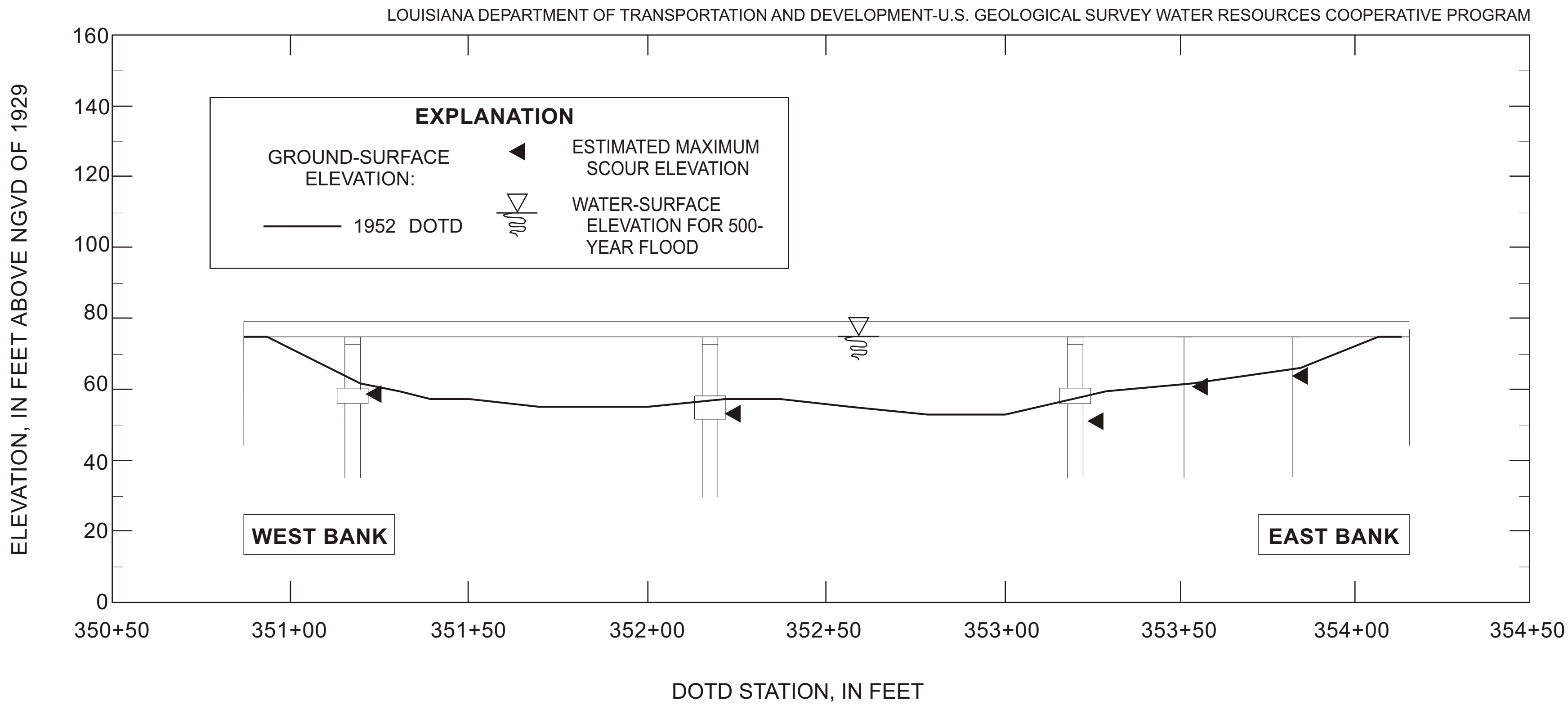
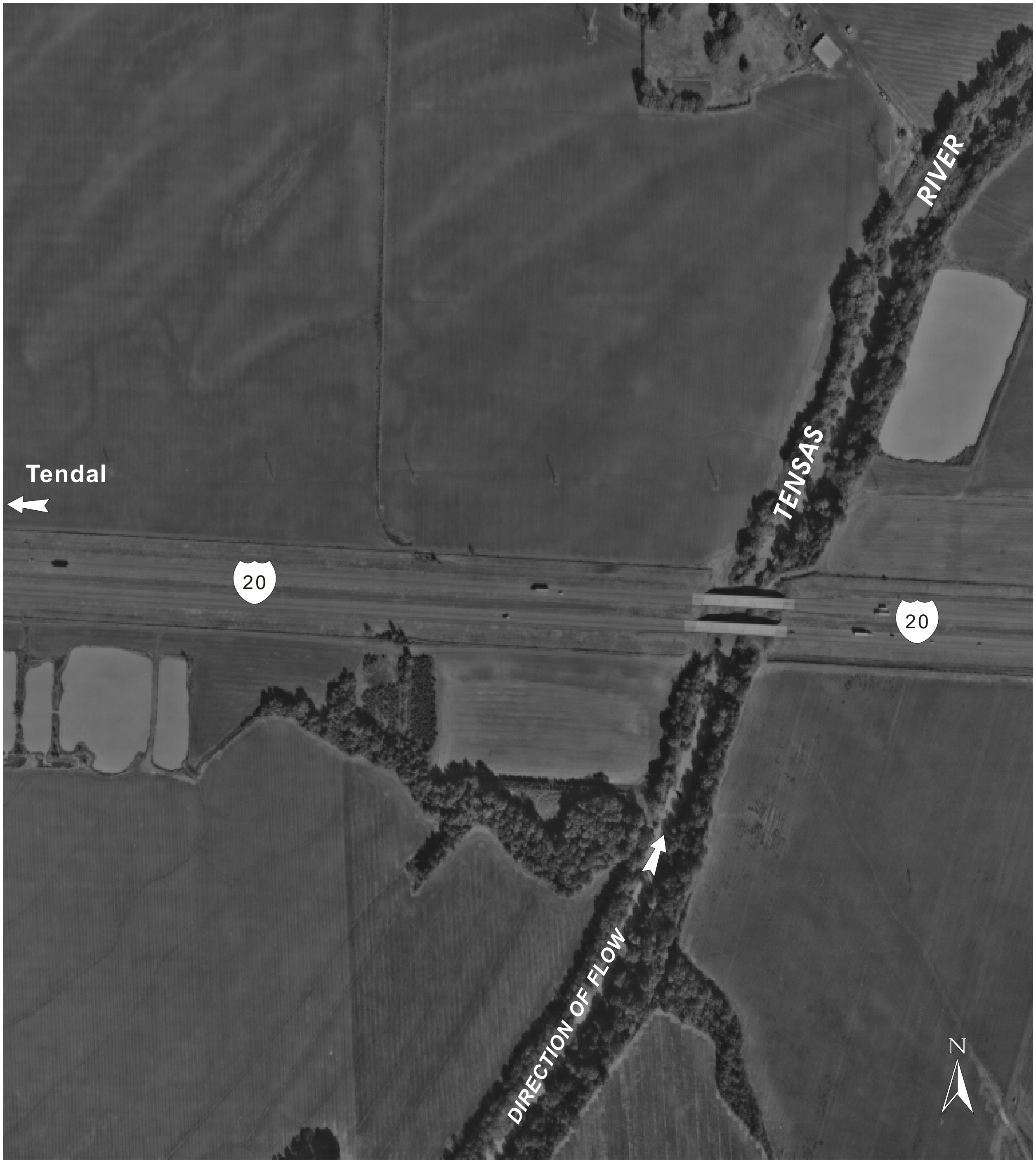


Figure 27. Bridge schematic, cross section, and scour estimates at U.S. Highway 80 crossing of the Tensas River at Tendal, Louisiana.

Photograph source: Louisiana Department of Transportation and Development, 11/10/93

Figure 28. Aerial photograph of the Interstate Highway 20 crossing (west) of the Tensas River near Tendal, Louisiana.



Photograph source: Louisiana Department of Transportation and Development, 11/10/93

Figure 29. Aerial photograph of the Interstate Highway 20 crossing (middle) of the Tensas River near Tendal, Louisiana.

Photograph source: Louisiana Department of Transportation and Development, 11/10/93

Figure 30. Aerial photograph of the Interstate Highway 20 crossing (east) of the Tensas River near Tendal, Louisiana.

Pier Scour

Values for y_1 at each pier are based on the DOTD hydrographic survey of 1970. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity, which is computed using WSPRO.

The maximum computed scour depth is approximately 5 ft for the pier at DOTD station 392+28 at the West Bridge, at 537+47 at the Middle Bridge, and at 592+57 at the East Bridge (table 15, figs. 31-33). The channel-bed elevation of the computed scour holes are about 40 ft below NGVD of 1929.

Table 15. Scour data for Interstate Highway 20 crossing (west, middle, and east) of the Tensas River near Tendal, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation are shown in the table in feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; footing elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Footing elevation (ft above NGVD of 1929)
West Bridge water surface = 78.3 above NGVD of 1929									
391+08	66	Round	1.0	2	0.7	3	2	61	25
391+68	56	Round	1.0	2	1.6	3	2	51	25
392+28	49	Round	1.0	4	1.9	5	2	42	25
392+88	59	Round	1.0	2	1.5	3	2	54	25
Middle Bridge water surface = 76.9 above NGVD of 1929									
536+26	61	Round	1.0	2	1.3	4	3	54	25
536+87	54	Round	1.0	2	1.8	3	3	48	25
537+47	48	Round	1.0	4	2.0	5	3	40	25
538+06	66	Round	1.0	2	0.7	2	3	61	25
East Bridge water surface = 76.6 above NGVD of 1929									
591+27	61	Round	1.0	2	0.6	3	0	58	25
591+92	46	Round	1.0	2	1.6	3	0	43	25
592+57	45	Round	1.0	4	1.6	5	0	40	25
593+22	61	Round	1.0	2	0.6	2	0	59	25

Channel Stability

Aerial photographs of these bridge crossings are shown in figures 28-30. Cross-section information is shown in figures 31-33 for the year 1970. Because these bridges are not in the DOTD channel monitoring program, there are no comparative bed elevation data. Any undocumented bed elevation changes could affect scour-elevation estimates.

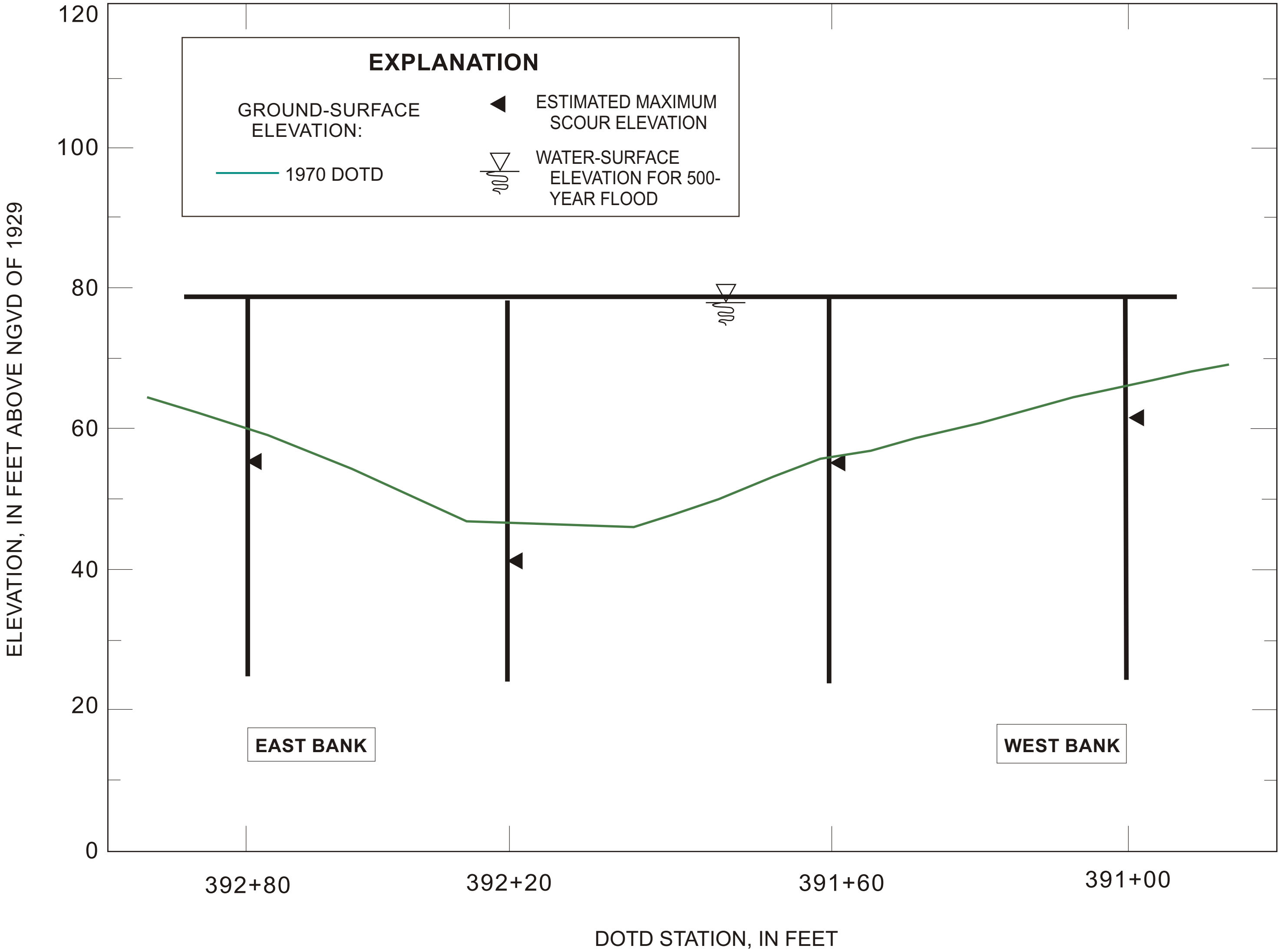


Figure 31. Bridge schematic, cross section, and scour estimates at the Interstate Highway 20 crossing (west) of the Tensas River near Tendal Louisiana.

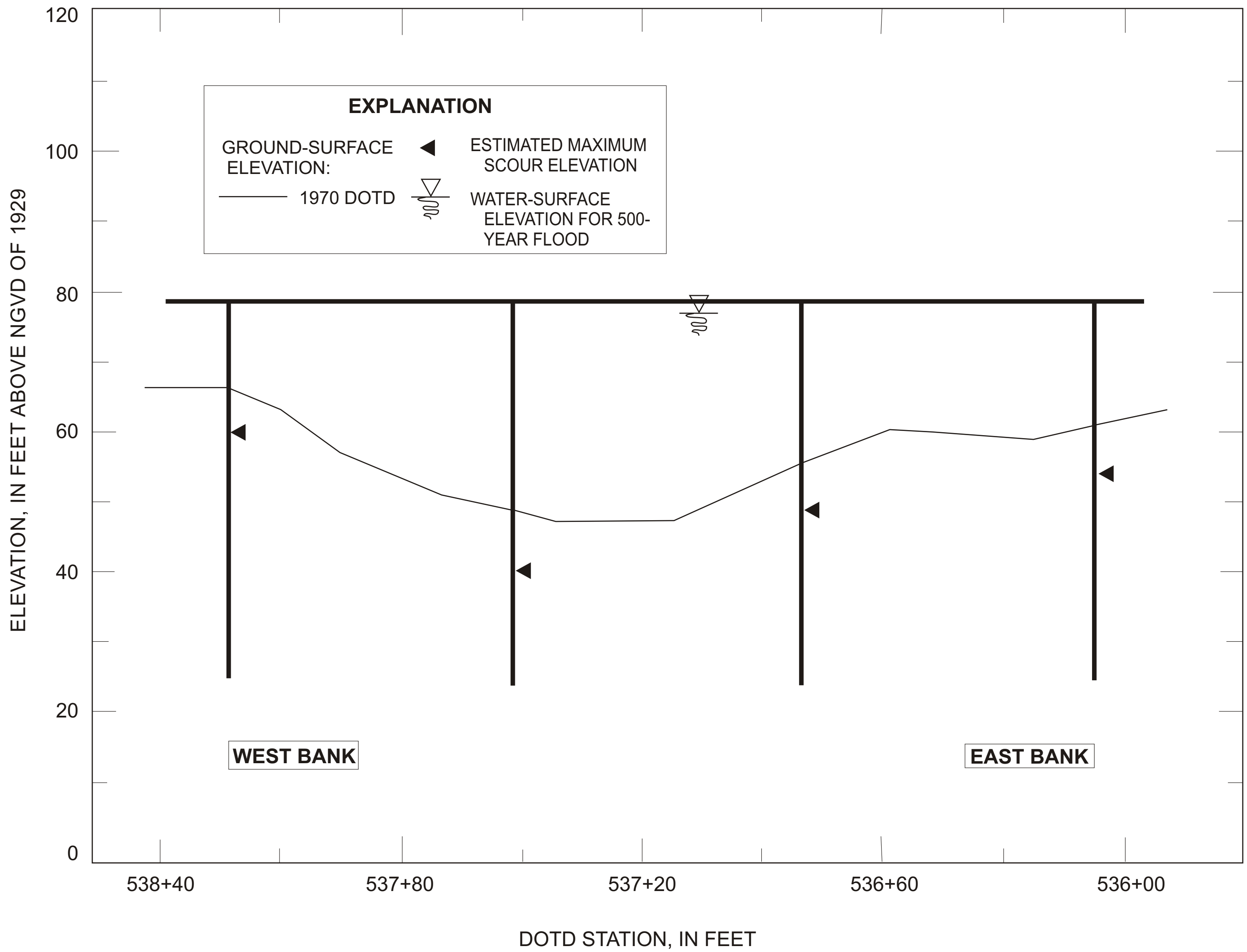


Figure 32. Bridge schematic, cross section, and scour estimates at the Interstate Highway 20 crossing (middle) of the Tensas River near Tendal, Louisiana.

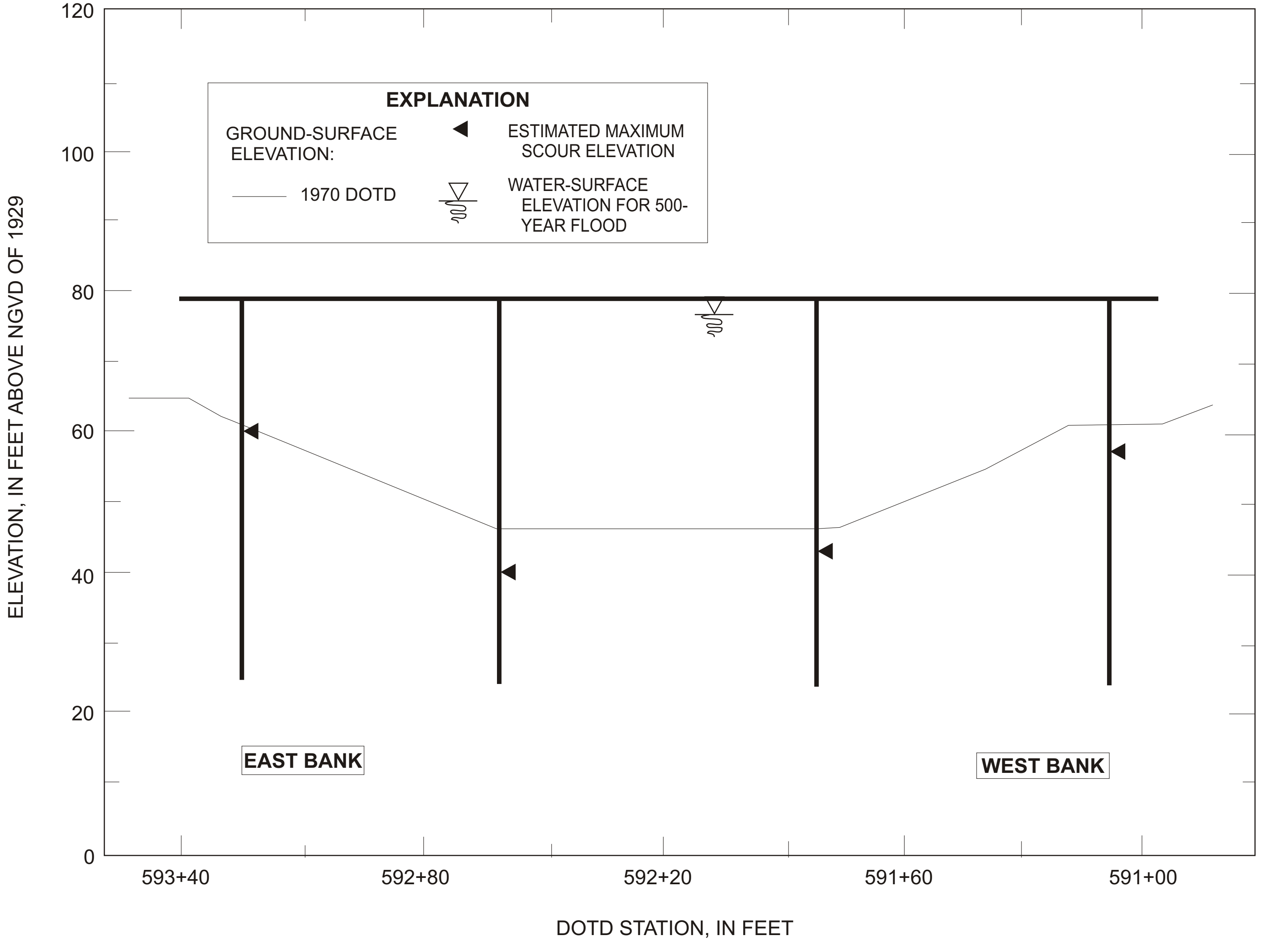


Figure 33. Bridge schematic, cross section, and scour estimates at the Interstate Highway 20 crossing (east) of the Tensas River, near Tendal, Louisiana.

Louisiana Highway 128 Crossing of the Tensas River (near Tensas River National Wildlife Refuge) near Newlight

The estimate of the 500-year flood used for the hydraulic analysis is 10,000 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations using the 500-year estimate is 60 ft above NGVD of 1929 (table 16). The width of the flood plain at the 500-year flood is approximately 425 ft. The width of the channel (fig. 34) at the 500-year flood is approximately 400 ft. The downstream boundary condition for computations using the WSPRO model was a water-surface elevation of 59 ft above NGVD of 1929. This value is based on backwater conditions and historical flood peak elevations observed at the site. Simulations indicate velocities ranging from 0.3 to 1.1 ft/s along the cross section at the bridge. Values of velocity at pier locations are shown in table 16.

Pier Scour

For evaluation of pier scour values for y_1 at each pier were based on the observed pile configuration cross section at the bridge and the distance to the ground surface from the deck of the bridge. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The geometric data collected at the bridge was combined and referenced to topographic map features. The Froude number at the pier locations is based upon the value of depth and velocity, which is computed using WSPRO.

The maximum computed scour depth is approximately 10 ft for the pier located 245 ft from the reference point on the west bank abutment (table 16, fig. 35). The channel-bed elevation of the computed scour hole is 7 ft above NGVD of 1929.

Table 16. Scour data for Louisiana Highway 128 crossing of Tensas River (near Tensas River National Wildlife Refuge) near Newlight, Louisiana

[Water-surface elevation is 60.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations unknown; NA, not applicable]

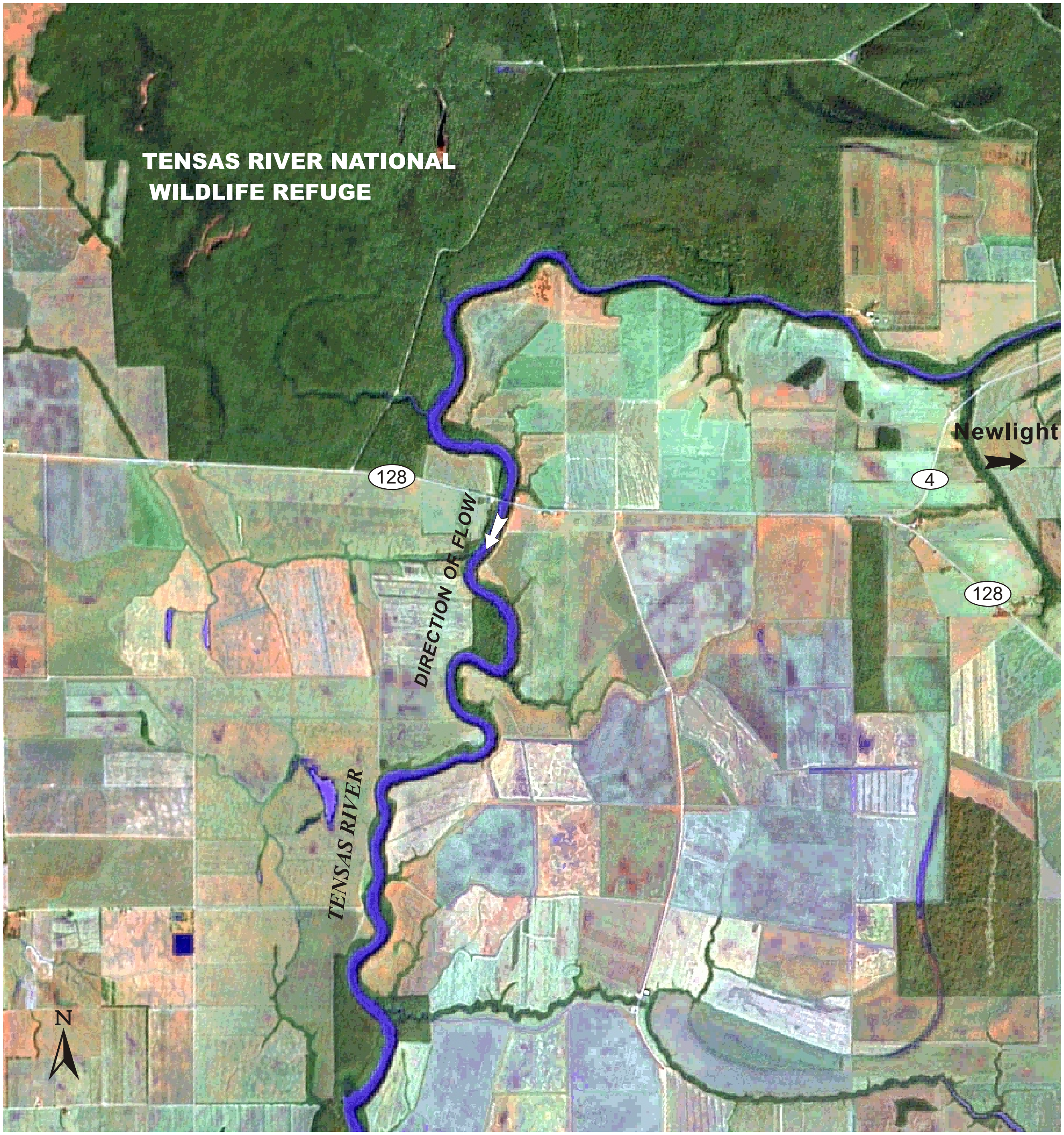
Distance from west bank abutment (ft)	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Pile tip elevation (ft above NGVD of 1929)
40	50	Round	1.0	4	0.3	2	0	48	NA
160	27	Round	1.0	6	0.9	5	0	22	NA
245	17	Round	1.0	16	1.0	10	0	7	NA
325	23	Round	1.0	4	1.0	4	0	19	NA
445	48	Round	1.0	4	0.3	2	0	46	NA

Channel Stability

There were not sufficient historic river bed elevation data available to evaluate previous conditions at the site. Bed changes that have occurred since construction can affect scour estimates.

Louisiana Highway 15 Crossing of the Tensas River at Clayton

The estimate of the 500-year flood used for the hydraulic analysis is 15,800 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood was 56.7 ft above NGVD of 1929 (table 17). The width of the flood plain at the 500-year flood is approximately 576 ft. The



Photograph source: Spot-Thematic Satellite Image provided by GIS Data Depot, May 1999

Figure 34. Aerial photograph of the Louisiana Highway 128 crossing of the Tensas River (near Tensas River National Wildlife Refuge) near Newlight, Louisiana.

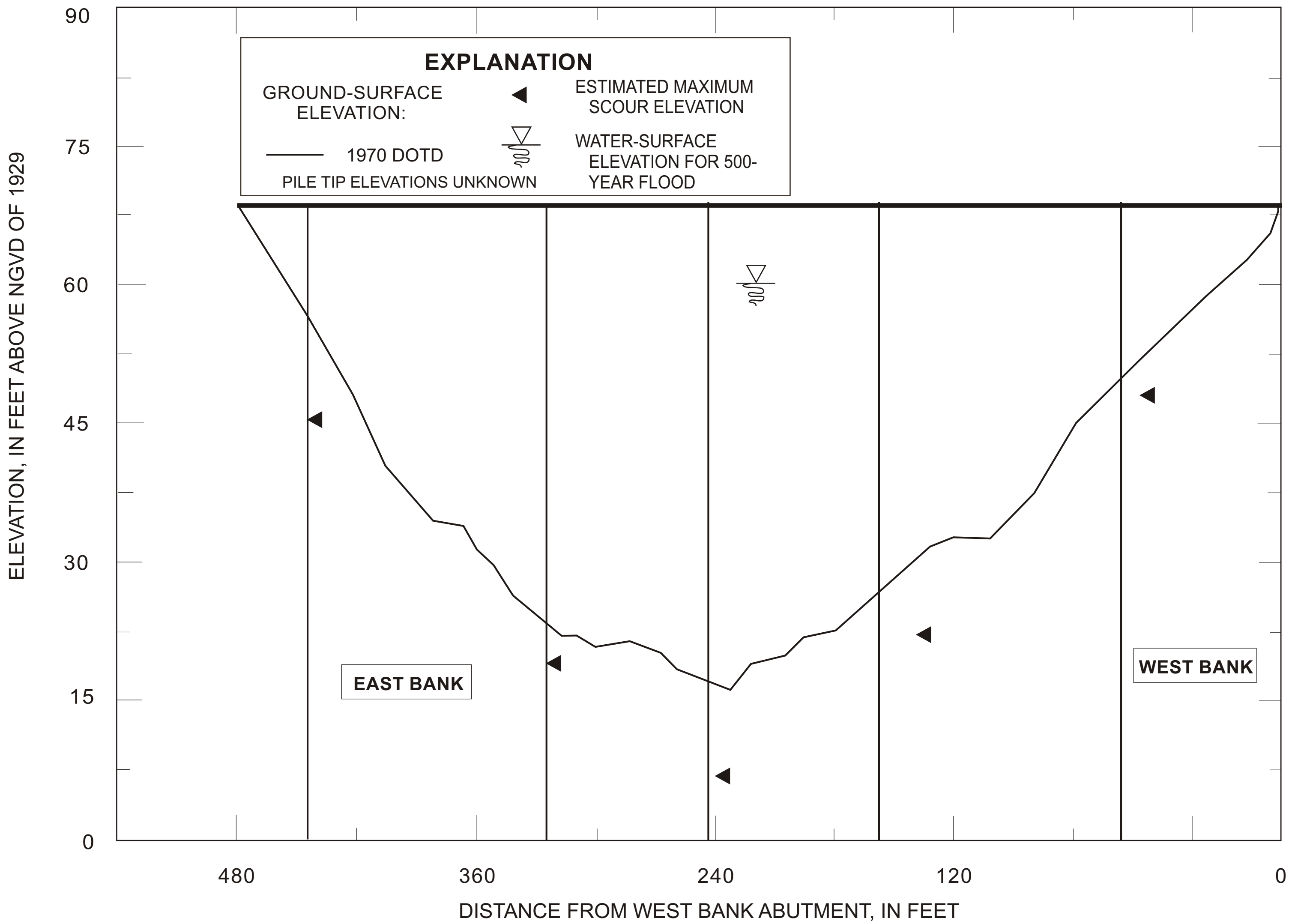


Figure 35. Bridge schematic, cross section, and scour estimates at the Louisiana Highway 128 crossing of the Tensas River (near New Tensas River National Wildlife Refuge) near Newlight, Louisiana.

width of the channel (fig. 36) at the bridge for the 500-year flood is approximately 344 ft. The downstream boundary condition for hydraulic computations using WSPRO was a slope of 0.00001 ft/ft, which is the same slope used in calibration simulations of this reach. Simulations indicate velocities ranging from 0.5 to 1.4 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 17.

Pier Scour

For evaluation of pier scour of the Tensas River at Louisiana Highway 15, values for y_1 at each pier were based on the DOTD hydrographic survey of 1994. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 19 ft for the pier at DOTD station 114+15 (table 17, fig. 37). The channel-bed elevation for this computed scour hole is about 6 ft above NGVD of 1929.

Table 17. Scour data for Louisiana Highway 15 crossing of the Tensas River at Clayton, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 56.7 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
112+40	48	Square	1.0	2	0.5	2	0	46	-11
113+20	33	Square	1.0	2	0.9	3	0	30	-13
114+15	25	Square	1.0	32	1.2	19	0	6	-51
116+27	28	Square	1.0	32	1.1	18	0	10	-46

Channel Stability

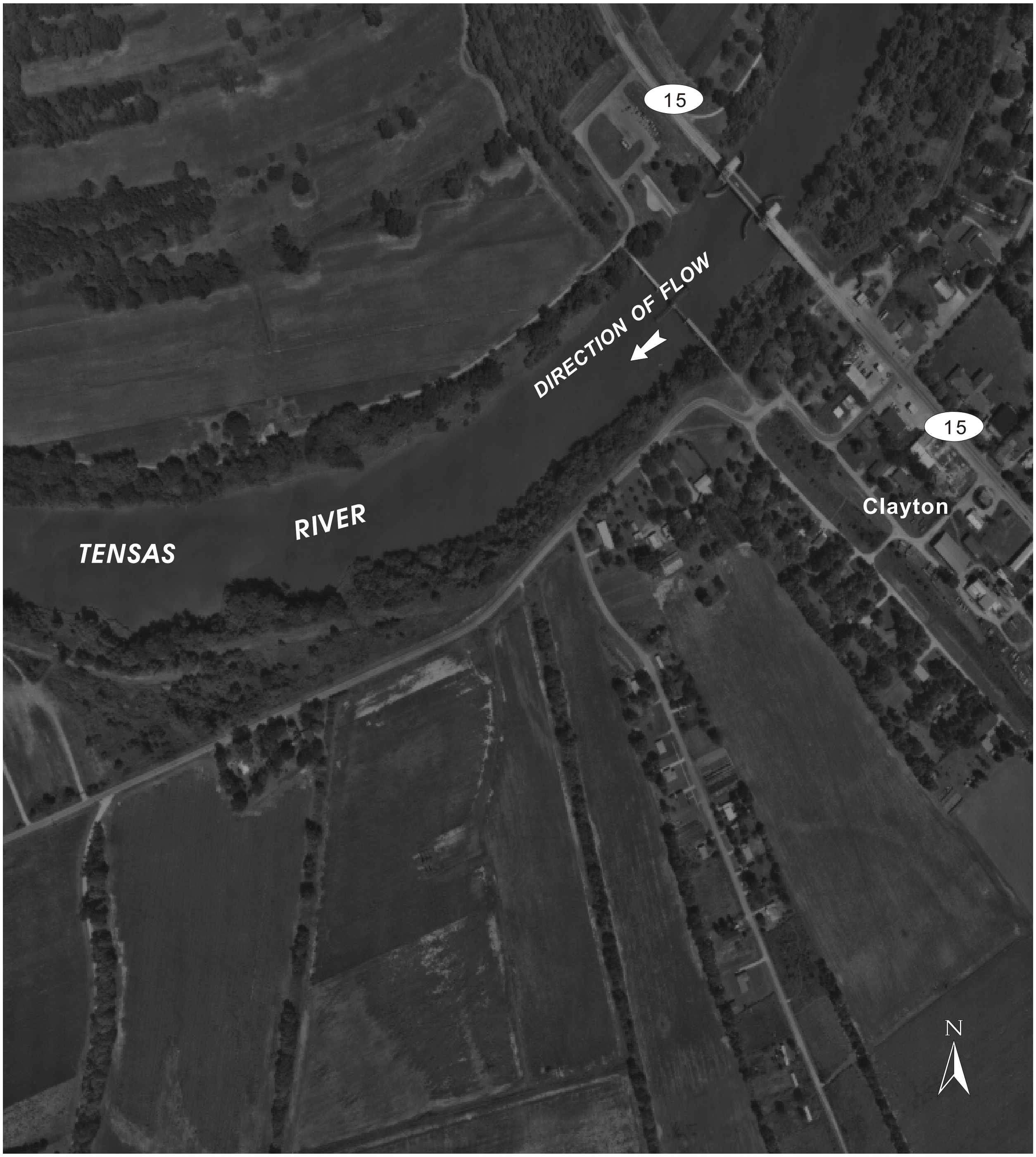
Cross-section information is shown in figure 30 for the years 1967 and 1994. These surveys do not show substantial changes in the elevation of the channel bed.

Black River Basin

The Black River is formed by the confluence of the Ouachita, Tensas, and Little Rivers. The drainage area is 21,000 mi^2 at the confluence of the three rivers and 24,500 mi^2 at the mouth (Sloss p. 73, 85). The mouth of the river is only about 30 mi south of the confluence. The Black River flows into the Red River about 25 mi upstream of the mouth of the Red River, where the confluence of the Lower Old River and the Red River forms the Atchafalaya River.

U.S. Highway 84 Crossing of the Black River at Jonesville

The estimate of the 500-year flood used for the hydraulic analysis is 86,000 ft^3/s. Hydraulic computations were based on calibration of the WSPRO model to the flood of 1973 which had a peak water-surface elevation of 50.75 ft above NGVD of 1929 and a discharge of 62,000 ft^3/s. The calibration



Photograph source: Louisiana Department of Transportation and Development, 9/20/91

Figure 36. Aerial photograph of the Louisiana Highway 15 crossing of the Tensas River at Clayton, Louisiana.

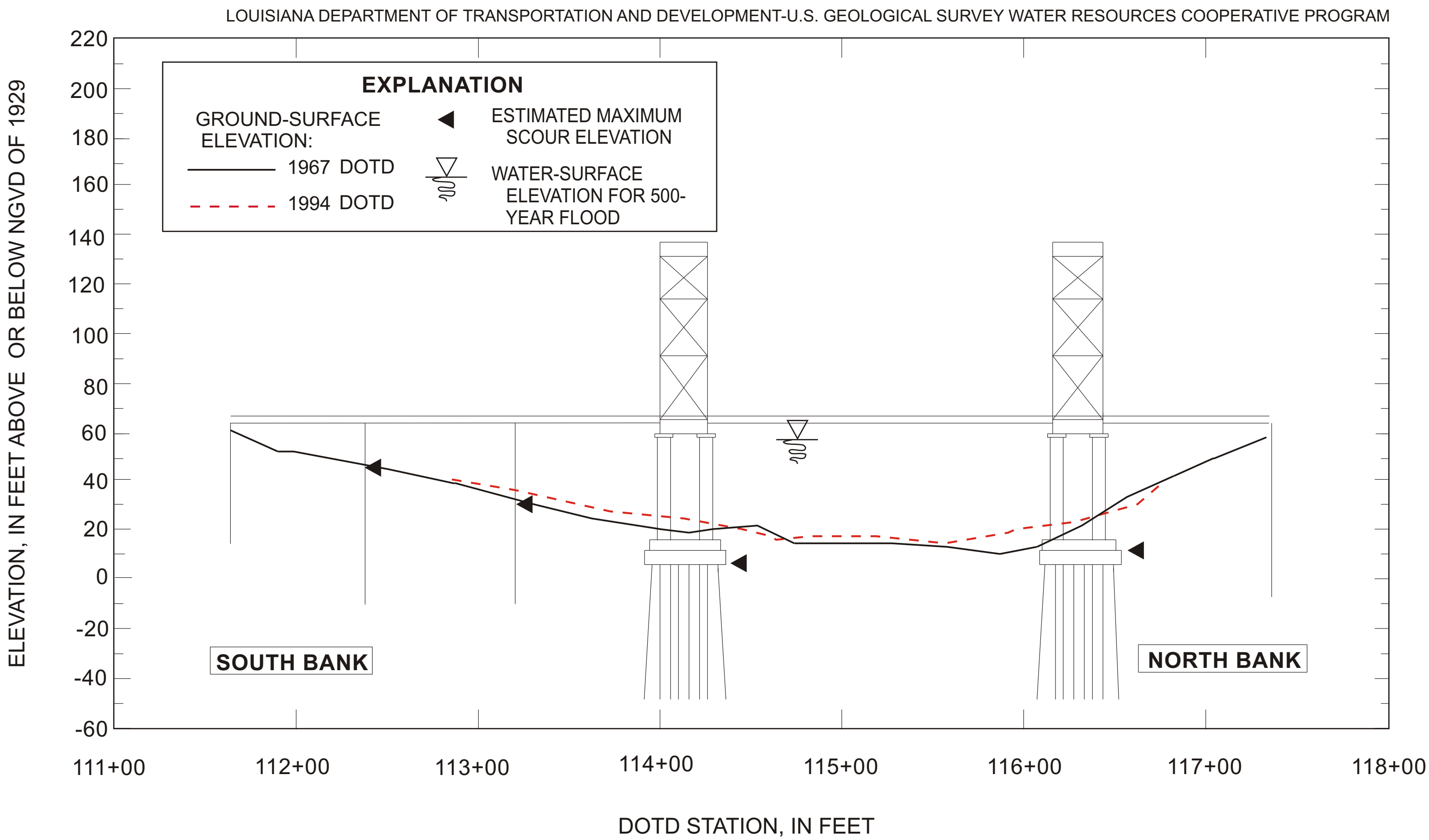


Figure 37. Bridge schematic, comparative cross sections, and scour estimates at the Louisiana Highway 15 crossing of the Tensas River at Clayton, Louisiana.

simulations determined a downstream boundary condition water surface slope of 0.000007 ft/ft to be used in the 500-year flood simulations. The magnitude of this slope is consistent with backwater conditions previously documented at the site (Neely, 1976). The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood was 59.7 ft above NGVD of 1929 (table 18). The normal width of the channel (fig. 38) is 575 ft. The width of the flood plain at the 500-year flood is approximately 2,400 ft. Simulations indicate velocities ranging from 0.6 to 2.6 ft/s along the cross section. Values of velocity at pier locations are listed in table 18.

Pier Scour

For evaluation of pier scour, values for y_1 at each pier were based on the DOTD bridge plans and the hydrographic survey of 1993. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier. The maximum computed scour depth was approximately 22 ft at DOTD station 102+20 (table 18, fig. 39). The channel-bed elevation for this computed scour hole is about 28 ft below NGVD of 1929. Limited information was available for the south overbank piers on the original bridge plans. The approximate conditions at the pier nearest the main channel on each bank were used to estimate scour for the overbank piers.

Table 18. Scour data for U.S. Highway 84 crossing of the Black River at Jonesville, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 59.7 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

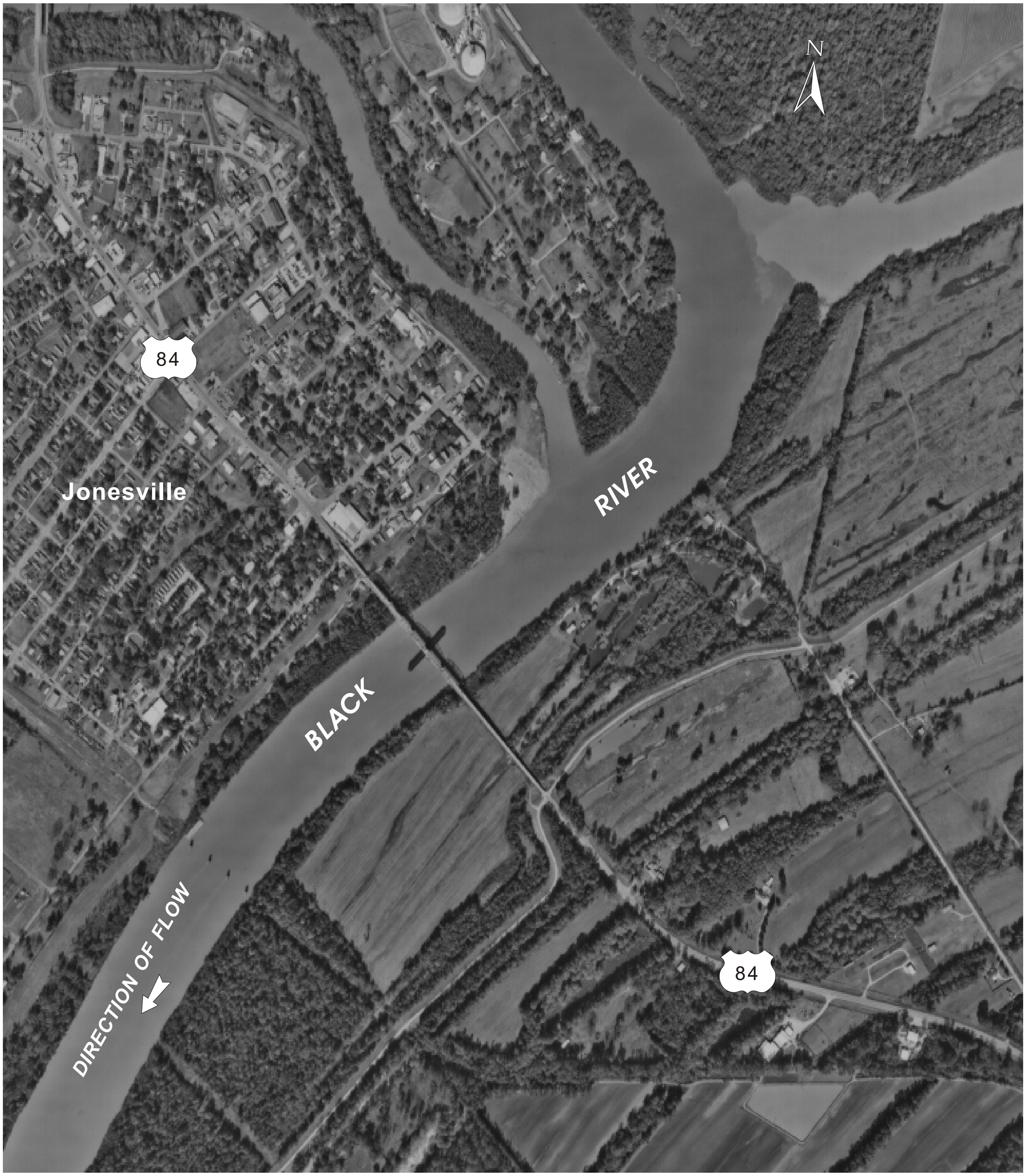
DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
95+54	51	Round	1.0	5.5	1.4	5	0	46	-34
98+05	31	Round	1.0	8	1.4	7	0	24	-40
100+57	3	Round	1.0	10	2.6	12	0	-9	-50
102+20	-6	Round	1.0	26	2.4	22	0	-28	-50
103+83	6	Round	1.0	10	2.4	12	0	-6	-50
106+33	47	Round	1.0	8	1.1	6	0	41	-50

Channel Stability

The results of surveys performed by DOTD in 1933, 1990, and 1993 are shown in figure 39. The two recent surveys do not indicate any large differences in the channel-bed elevation from the original survey. Some bed elevation reductions of less than 10 ft were observed near the piers. Some part of the increases in the bed elevation shown on the north bank may be due to the potential error in comparison of elevations observed from hydrographic surveys, and those scaled from reduced scale bridge plans.

Calcasieu River Basin

The Calcasieu River Basin is located in southwestern Louisiana. The Calcasieu River flows southwesterly into Calcasieu Lake. The basin consists of hills and prairies in the upper part and coastal wetlands along the lower part. The drainage area at the Intracoastal Waterway is 3,240 mi^2 (Sloss, 1971, p. 109). The City of Lake Charles is about 35 mi from the Gulf of Mexico, just



Photograph source: Louisiana Department of Transportation and Development, 11/13/82

Figure 38. Aerial photograph of the U.S. Highway 84 crossing of the Black River at Jonesville, Louisiana.

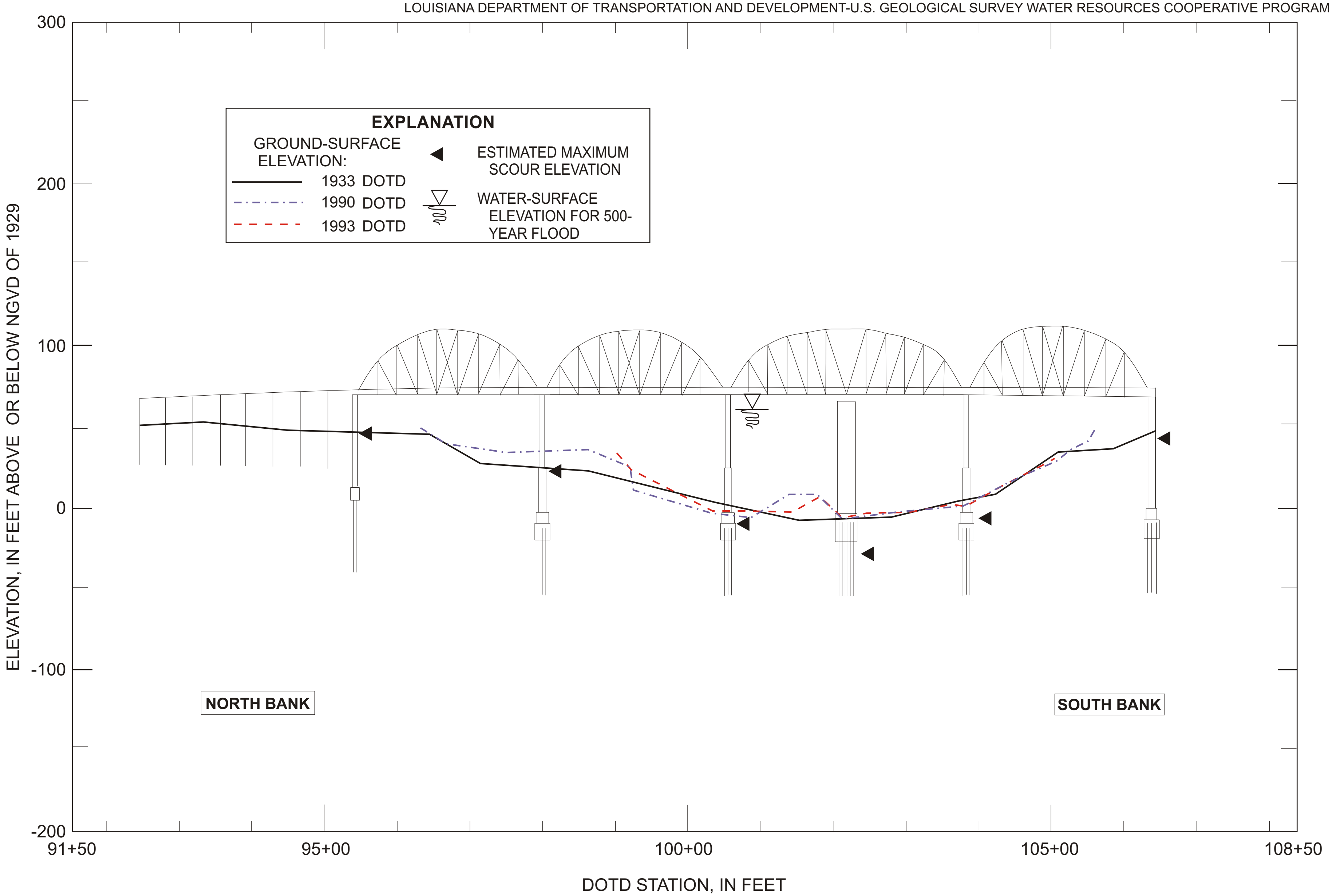


Figure. 39 Bridge schematic, comparative cross sections, and scour estimates at the U.S. Highway 84 crossing of the Black River at Jonesville, Louisiana.

downstream of the confluence of the West Fork Calcasieu River. Tidal influences from the Gulf of Mexico affect the water level in the river through the Lake Charles area. Tidal effects during low water levels have been observed as far upstream as a USGS gaging station located near Oberlin, Louisiana.

Louisiana Highway 8 Crossing of the Calcasieu River near Slagle

The estimate of the 500-year flood used for the hydraulic analysis was 25,200 ft^3/s. There are two openings at the site; the main channel bridge was apportioned 41 percent of the total flow. The 500-year flood simulations were based on a downstream boundary condition water surface slope of 0.0005 ft/ft. The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood was 247.0 ft above NGVD of 1929. This elevation is consistent with limited annual peak water elevations documented at the site (Neely, 1976). The width of the flood plain (fig. 40) at the 500-year flood is approximately 3,500 ft. Simulations indicate velocities ranging from 3.7 to 11.6 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 19.

Pier Scour

For evaluation of pier scour, values for y_1 at each pier were based on the observed pile configuration and ground elevation at the bridge. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The geometric data collected at the bridge was combined and referenced to topographic map features. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier. The maximum computed scour depth was approximately 4 ft at the first and second piers from the east bank abutment (table 19, fig. 41). The channel-bed elevation for this computed scour hole is about 230 ft.

Table 19. Scour data for Louisiana Highway 8 crossing of the Calcasieu River near Slagle, Louisiana

[Water-surface elevation is 247.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; NA, not applicable]

Distance from east bank abutment (ft)	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Pile tip elevation (ft above NGVD of 1929)
0	241	Round	1.0	1	0.0	0	0	241	NA
20	234	Round	1.0	1	10.2	4	0	230	NA
40	234	Round	1.0	1	11.1	4	0	230	NA
60	240	Round	1.0	1	6.3	3	0	237	NA
80	241	Round	1.0	1	5.5	3	0	238	NA
100	242	Round	1.0	1	5.1	3	0	239	NA
120	242	Round	1.0	1	4.5	2	0	240	NA
140	243	Round	1.0	1	3.9	2	0	241	NA
160	243	Round	1.0	1	3.9	2	0	241	NA
180	243	Round	1.0	1	4.0	2	0	241	NA
200	243	Round	1.0	1	4.0	2	0	241	NA
220	243	Round	1.0	1	4.0	2	0	241	NA
240	243	Round	1.0	1	4.0	2	0	241	NA
260	243	Round	1.0	1	4.0	2	0	241	NA
280	243	Round	1.0	1	3.7	2	0	241	NA
300	243	Round	1.0	1	0.0	0	0	243	NA

Photograph source: U.S. Department of the Interior,
U.S. Geological Survey Maintainer:
earthexplorer@edcmail.cr.usgs.gov
Last Modified: 2/5/01

Figure 40. Aerial photograph of the Louisiana Highway 8 crossing of the Calcasieu River near Slagle, Louisiana.

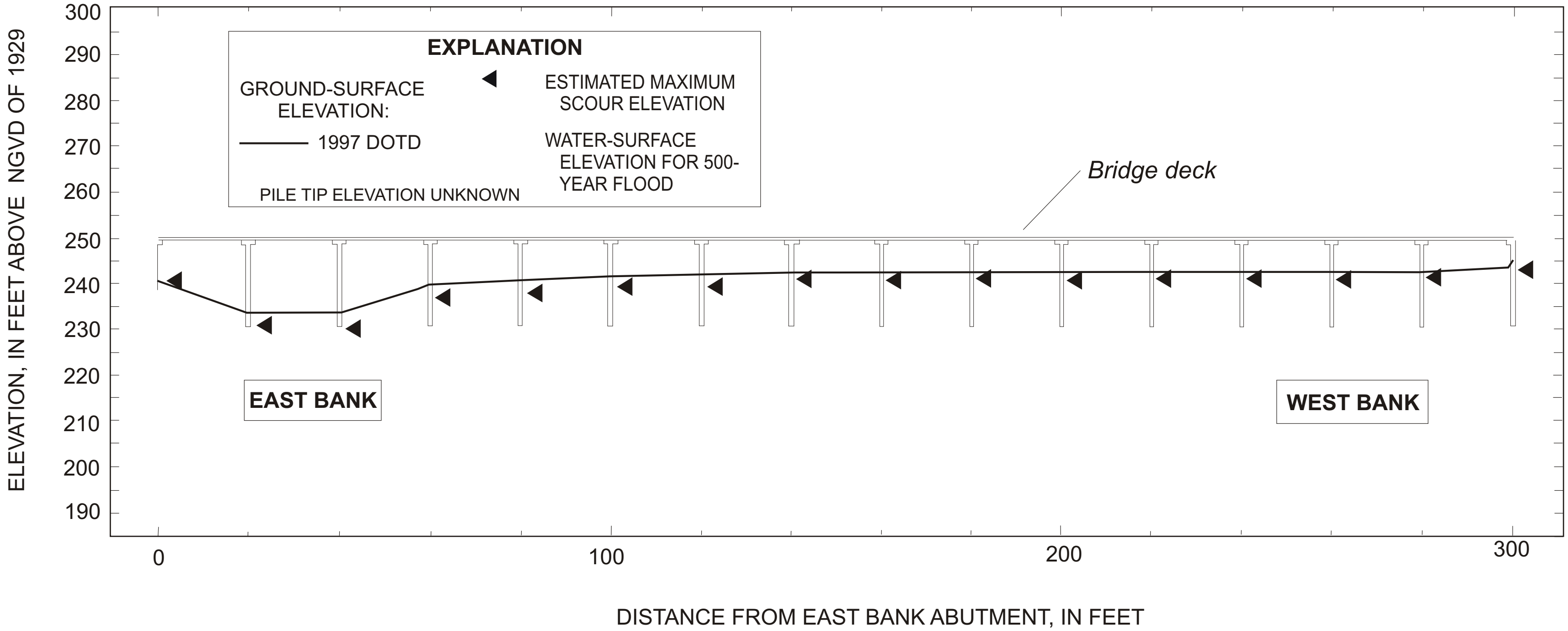


Figure 41. Bridge schematic, cross section, and scour estimates at the Louisianan Highway 8 crossing of the Calcasieu River near Slagle, Louisiana.

Channel Stability

There were no comparative channel-bed elevations available at this site. The conditions in the immediate areas of the bridge are similar to the natural flood-plain conditions observed in the area. No remnants of local scour were evident at the site. This may be an indication that floods occurring since the construction of the bridge have not induced any substantial channel changes.

Louisiana Highway 28 Crossing of the Calcasieu River near Hicks-LaCamp

The 500-year flood estimate of 41,900 ft^3/s was used for the hydraulic analysis. The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate was 195.1 ft above NGVD of 1929. The width of the flood plain (fig. 42) at the 500-year flood estimate ranges from 1,100 at the bridge to 3,700 ft in natural areas of the reach. The downstream boundary condition for computations using WSPRO was a slope of 0.0009 ft/ft, which is the same slope used in the calibration simulations. Simulations indicate velocities ranging from 4.7 to 12.7 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 20.

Pier Scour

For evaluation of pier scour, values for y_1 at each pier were based on the DOTD hydrographic survey of 1971. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed using WSPRO.

The maximum computed pier scour depth was approximately 6.0 ft for the pier at DOTD stations 1173+71 and 1174+16 (table 20, fig. 43). When added to the contraction scour estimate at these locations, the channel-bed elevation for these computed scour holes is about 171 ft above NGVD of 1929.

Table 20. Scour data for Louisiana Highway 28 crossing of the Calcasieu River near Hicks-LaCamp, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 195.1 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Pile tip elevation (ft above NGVD of 1929)
1173+26	190	Round	1.0	1.5	6.3	4	3	183	140
1173+71	180	Round	1.0	1.5	12.7	6	3	171	140
1174+16	180	Round	1.0	1.5	11.9	6	3	171	140
1174+61	190	Round	1.0	1.5	6.6	4	3	183	140

Channel Stability

Cross-section information is shown in figure 43 for the year 1975. The original bridge cross-section is the only survey because this bridge is not monitored by DOTD. The bed elevation at the bridge is generally uniform with about a 10 ft decrease in elevation for piers in the low-water channel. Any undocumented changes in the bed elevations may affect scour estimates.

Photograph source: Louisiana Department of Transportation and Development, 3/20/92

Figure 42. Aerial photograph of the Louisiana Highway 28 crossing of the Calcasieu River near Hicks-LaCamp, Louisiana.

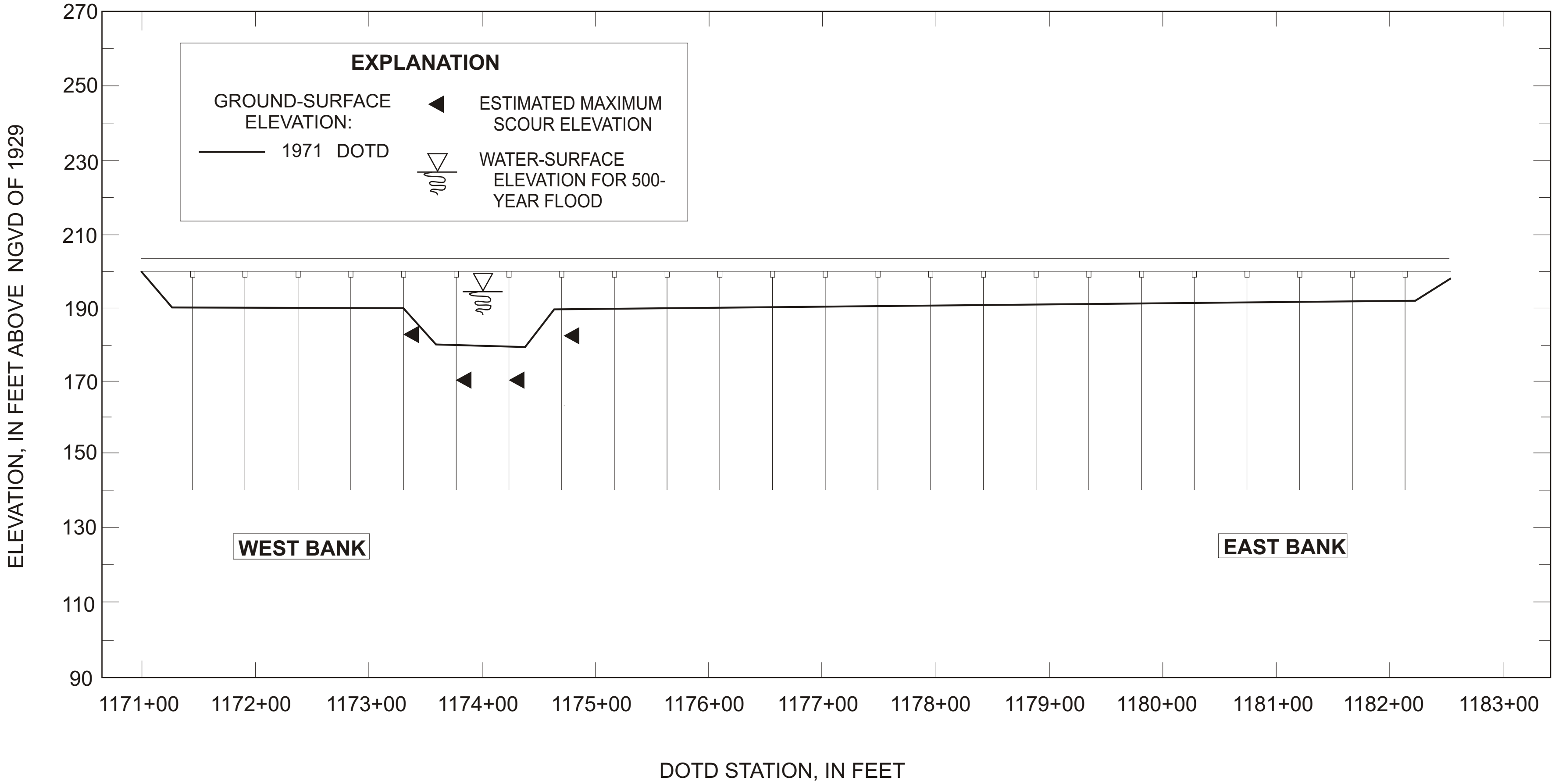


Figure 43. Bridge schematic, cross section, and scour estimates at the Louisiana Highway 28 crossing of the Calcasieu River near Hicks-LaCamp, Louisiana.

Louisiana Highway 121 Crossing of the Calcasieu River near Hineston

The estimate of the 500-year flood used for the hydraulic analysis was 89,300 ft^3/s. There are overflow openings at the site, the main channel bridge was apportioned 40 percent of the total flow based on relative flow areas. The simulations were based on a downstream boundary condition water-surface slope of 0.0006 ft/ft. The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood was 159.0 ft above NGVD of 1929 (table 21). The width of the flood plain at the 500-year flood is approximately 4,000 ft with channel widths (fig. 44) of approximately 400 ft. Simulations indicate velocities ranging from 3.5 to 16.4 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 21.

Pier Scour

For evaluation of pier scour, values for y_1 at each pier were based on the observed pile configuration and ground elevation at the bridge. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The geometric data collected at the bridge was combined with topographic map features. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier. The maximum computed scour depth was approximately 5 ft at the piers located 280 ft, 300 ft, and 320 ft from the north bank abutment (table 21, fig. 45). The minimum channel-bed elevation for these computed scour holes is about 129 ft.

Table 21. Scour data for Louisiana Highway 121 crossing of the Calcasieu River near Hineston, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is159.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; NA, not applicable]

Distance from north bank abutment	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Footing elevation (ft above NGVD of 1929)
20	156	Round	1.0	1	3.5	2	0	154	NA
40	154	Round	1.0	1	3.5	2	0	152	NA
60	153	Round	1.0	1	3.5	2	0	151	NA
80	153	Round	1.0	1	3.5	2	0	151	NA
100	152	Round	1.0	1	6.6	3	0	149	NA
120	151	Round	1.0	1	6.6	3	0	148	NA
140	150	Round	1.0	1	7.5	3	0	147	NA
160	148	Round	1.0	1	8.8	4	0	144	NA
180	146	Round	1.0	1	9.7	4	0	142	NA
200	143	Round	1.0	1	11.9	4	0	139	NA
220	147	Round	1.0	1	10.8	4	0	143	NA
240	151	Round	1.0	1	4.5	3	0	148	NA
260	155	Round	1.0	1	4.5	2	0	153	NA
280	145	Round	1.0	1	16.4	5	0	140	NA
300	134	Round	1.0	1	13.8	5	0	129	NA
320	135	Round	1.0	1	13.5	5	0	130	NA
340	140	Round	1.0	1	11.1	4	0	136	NA
360	145	Round	1.0	1	5.8	3	0	142	NA
380	150	Round	1.0	1	5.8	3	0	147	NA

Photograph source: U.S. Department of the Interior, U.S. Geological Survey Maintainer: earthexplorer@edcmail.cr.usgs.gov
Last Modified: 2/5/01

Figure 44. Aerial photograph of the Louisiana Highway 121 crossing of the Calcasieu River near Hineston, Louisiana.

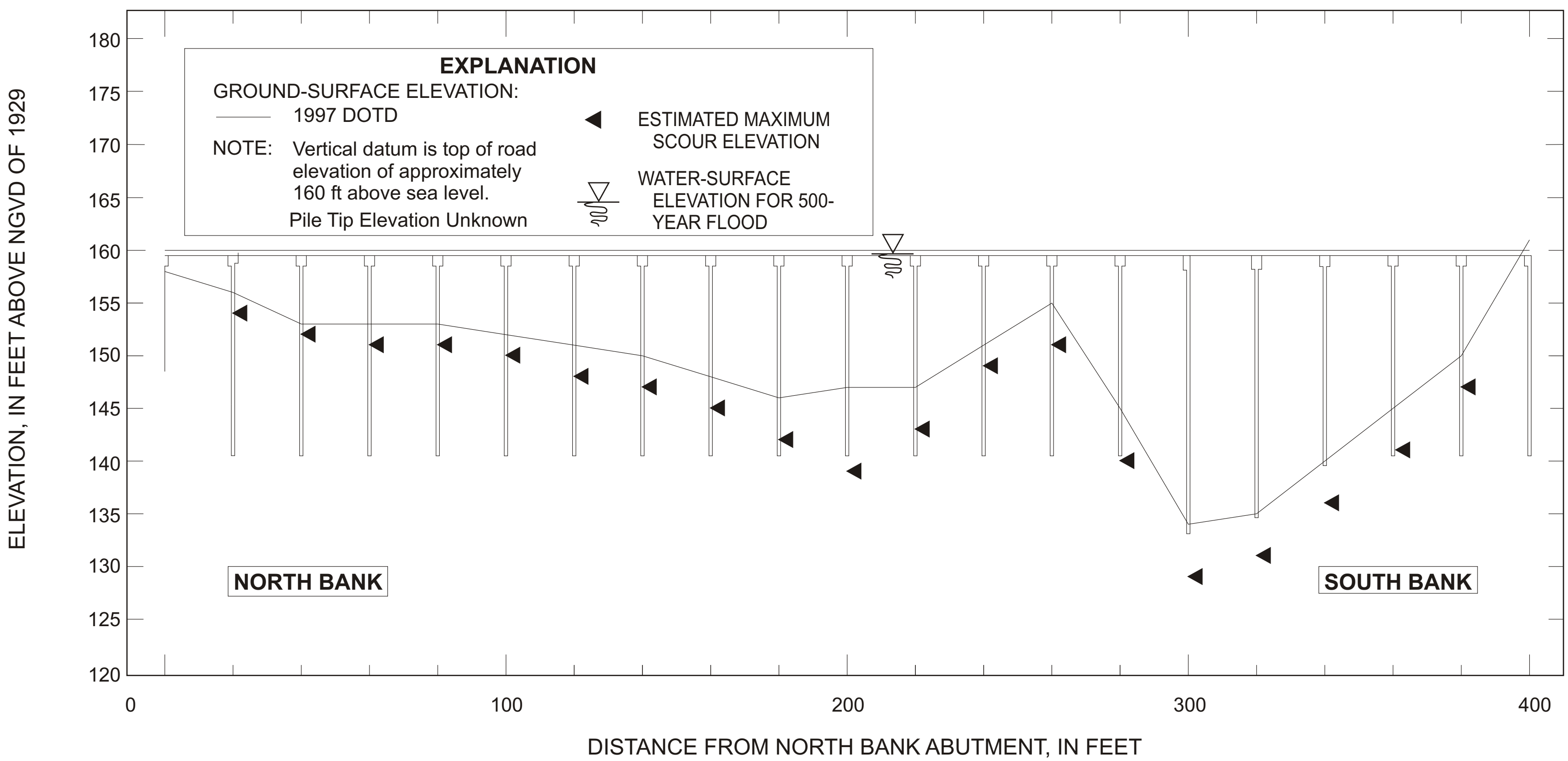


Figure 45. Bridge schematic, cross section, and scour estimates at the Louisiana Highway 121 crossing of the Calcasieu River near Hineston, Louisiana.

Channel Stability

There were no comparative riverbed elevations available at this site. The conditions in the immediate areas of the bridge are similar to the natural flood-plain conditions observed in the area. There are no remnants of scour, which may be an indication that floods occurring since the construction of the bridge have not induced any substantial scour or channel changes.

Louisiana Highway 113 Crossing of the Calcasieu River near Glenmora

The estimate of the 500-year flood used for the hydraulic analysis is 96,400 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood was 128.1 ft above NGVD of 1929 (table 22). There are multiple openings at this site, and 44 percent of the total discharge passes through the main bridge opening. The normal width of the channel (fig. 46) is approximately 400 ft. The width of the flood plain at the 500-year flood is approximately 5,900 ft. The downstream boundary condition for hydraulic computations using WSPRO was a slope of 0.00020 ft/ft, which is the same slope used in calibration simulations of this reach. Simulations indicate velocities ranging from 4.2 to 13.7 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 22.

Pier Scour

For evaluation of pier scour, values at each pier were based on the DOTD hydrographic survey of 1978. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 8 ft for the pier at DOTD station 129+00 (table 22, fig. 47). The channel-bed elevation for this computed scour hole is about 112 ft above NGVD of 1929.

Table 22. Scour data for Louisiana Highway 113 crossing of the Calcasieu River near Glenmora, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 128.1 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Pile tip elevation (ft above NGVD of 1929)
126+00	125	Round	1.0	1.5	6.3	4	0	121	70
126+50	122	Round	1.0	1.5	5.6	4	0	118	70
127+00	120	Round	1.0	1.5	4.3	4	0	116	70
127+50	120	Round	1.0	1.5	4.3	4	0	116	65
128+00	120	Round	1.0	1.5	9.4	5	0	115	65
128+50	112	Round	1.0	1.5	13.6	7	0	105	65
129+00	120	Round	1.0	3	9.2	8	0	112	80
129+50	120	Round	1.0	1.5	10.5	5	0	115	70
130+00	112	Round	1.0	1.5	13.2	7	0	105	70
130+50	120	Round	1.0	1.5	9.8	5	0	115	70
131+00	123	Round	1.0	1.5	5.7	4	0	119	75
131+50	125	Round	1.0	1.5	5.7	4	0	121	75

Photograph source: U.S. Department of the Interior,
U.S. Geological Survey Maintainer:
earthexplorer@edcmail.cr.usgs.gov
Last Modified: 2/5/01

Figure 46. Aerial photograph of the Louisiana Highway 113 crossing of the Calcasieu River near Glenmora, Louisiana.

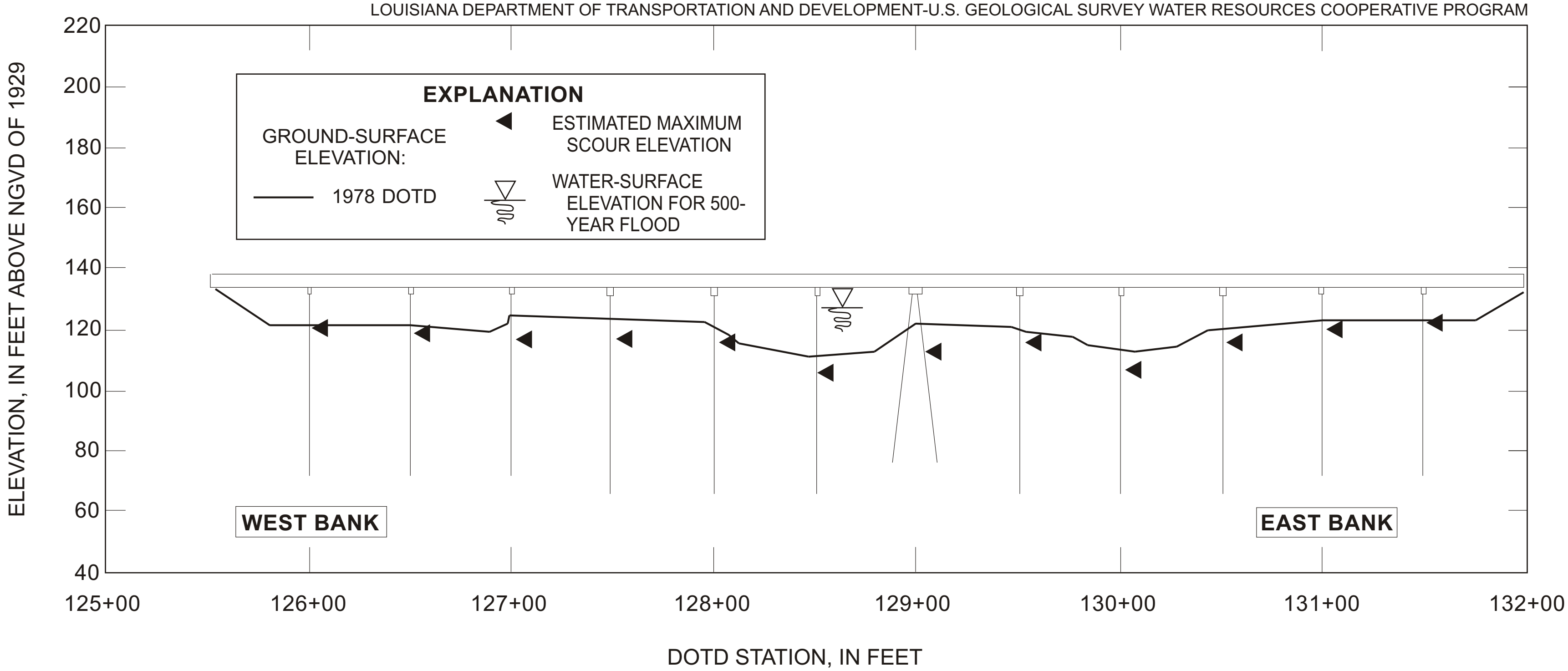


Figure 47. Bridge schematic, cross section, and scour estimates at the Louisiana Highway 113 crossing of the Calcasieu River near Glenmora, Louisiana.

Channel Stability

Cross-section information is shown in figure 47 for the year 1978. This survey shows bed elevations ranging from 112 to 125 ft above NGVD of 1929. An aerial photograph of this bridge crossing is shown in figure 46. Any undocumented changes in the bed elevations may affect the scour estimates.

Louisiana Highway 10 Crossing of the Calcasieu River near Oakdale

The estimate of the 500-year flood used for the hydraulic analysis is 85,500 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate is 102.8 ft above NGVD of 1929 (table 23). The width of the flood plain at the 500-year flood simulation is approximately 5,000 ft. The width of the at the bridge opening (fig. 48) is approximately 1,200 ft. The downstream boundary condition for computations using the WSPRO model was a slope of 0.0004 ft/ft, which is the same slope determined from the calibration simulations at this site. Simulations of the 500-year flood indicate velocities ranging from 2.8 to 9.6 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 23.

There are two small relief openings near the edges of the flood plain at this site that were not considered in this analysis. Using the unadjusted full value of the 500-year flood for the main bridge will exaggerate the scour estimates. Even with the exaggerated bias, scour estimates were well above the pile tips. The contraction scour estimate was less than 1 ft and was not considered in any tabulations.

Pier Scour

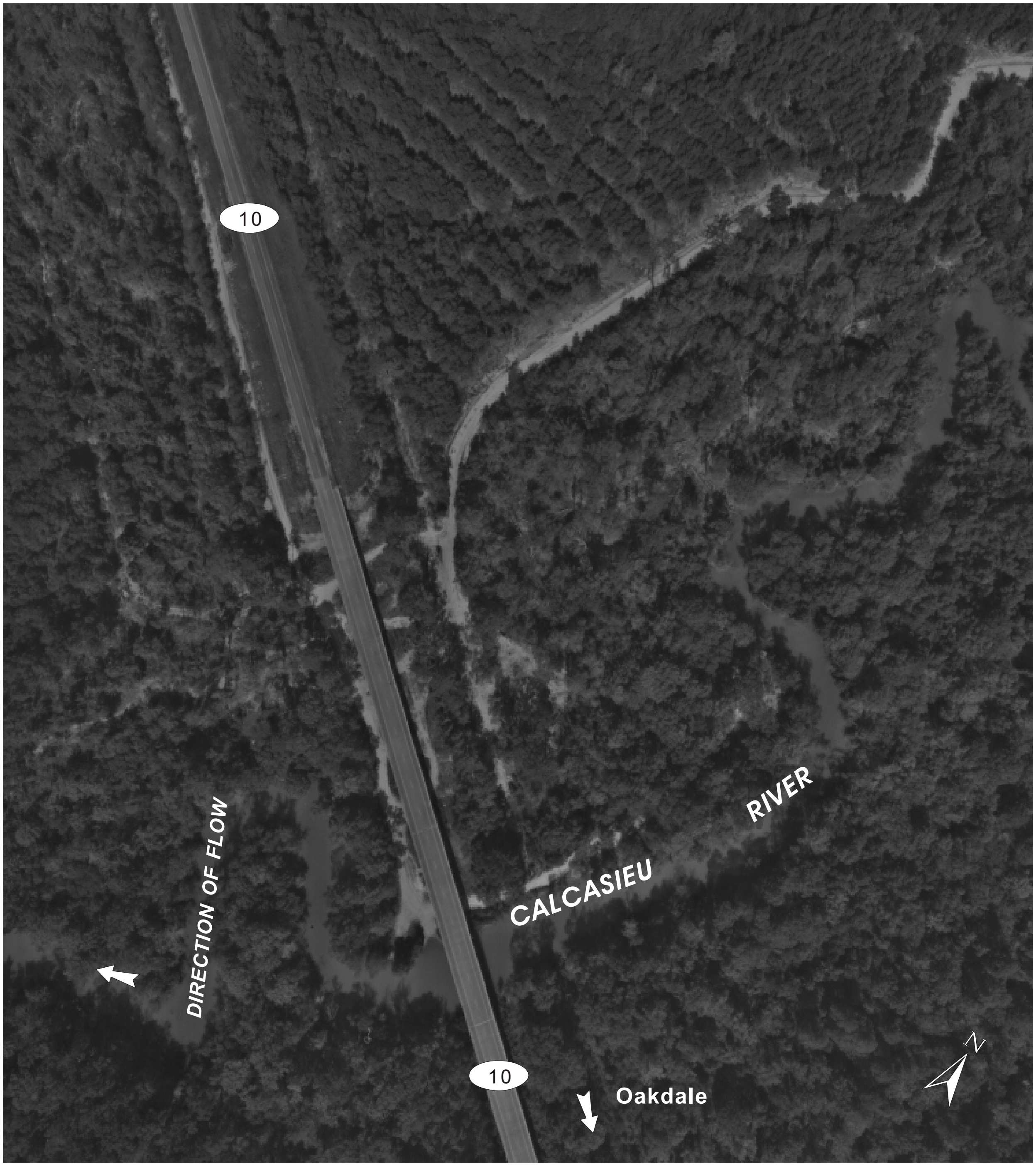
For the evaluation of pier scour, values for water depths at each pier were based on the DOTD hydrographic survey of 1977. Values for K_1=1.0, K_2=1.0, and K_3=1.1 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the values of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 7 ft for the pier at DOTD stations 153+33. 156+13, and 157+53 (table 23, fig. 49). The minimum estimated channel-bed elevations of the computed scour holes at these stations is about 85 ft, 74 ft, and 86 ft above NGVD of 1929.

Table 23. Scour data for Louisiana Highway 10 crossing of the Calcasieu River near Oakdale, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 102.8 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; footing elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Footing elevation (ft above NGVD of 1929)
149+83	94	Round	1.0	2	2.8	3	0	91	50
150+53	94	Round	1.0	2	2.8	3	0	91	50
151+23	93	Round	1.0	2	2.8	3	0	90	50
151+93	94	Round	1.0	2	2.8	3	0	91	50
152+63	94	Round	1.0	2	4.8	4	0	90	50
153+33	92	Round	1.0	4	4.8	7	0	85	50
154+03	89	Round	1.0	2	6.2	5	0	84	50
154+73	84	Round	1.0	2	8.5	6	0	78	50
155+43	90	Round	1.0	2	6.5	5	0	85	50
156+13	81	Round	1.0	2	9.5	7	0	74	50
156+83	87	Round	1.0	2	7.4	6	0	81	50
157+53	93	Round	1.0	4	5.3	7	0	86	50
158+23	90	Round	1.0	2	5.0	5	0	85	50
158+93	86	Round	1.0	2	5.9	5	0	81	50
159+63	86	Round	1.0	2	6.0	5	0	81	50
160+33	86	Round	1.0	2	6.1	5	0	81	50
161+03	88	Round	1.0	2	3.6	4	0	84	50



Photograph source: Louisiana Department of Transportation and Development, 9/27/90

Figure 48. Aerial photograph of the Louisiana Highway 10 crossing of the Calcasieu River near Oakdale, Louisiana.

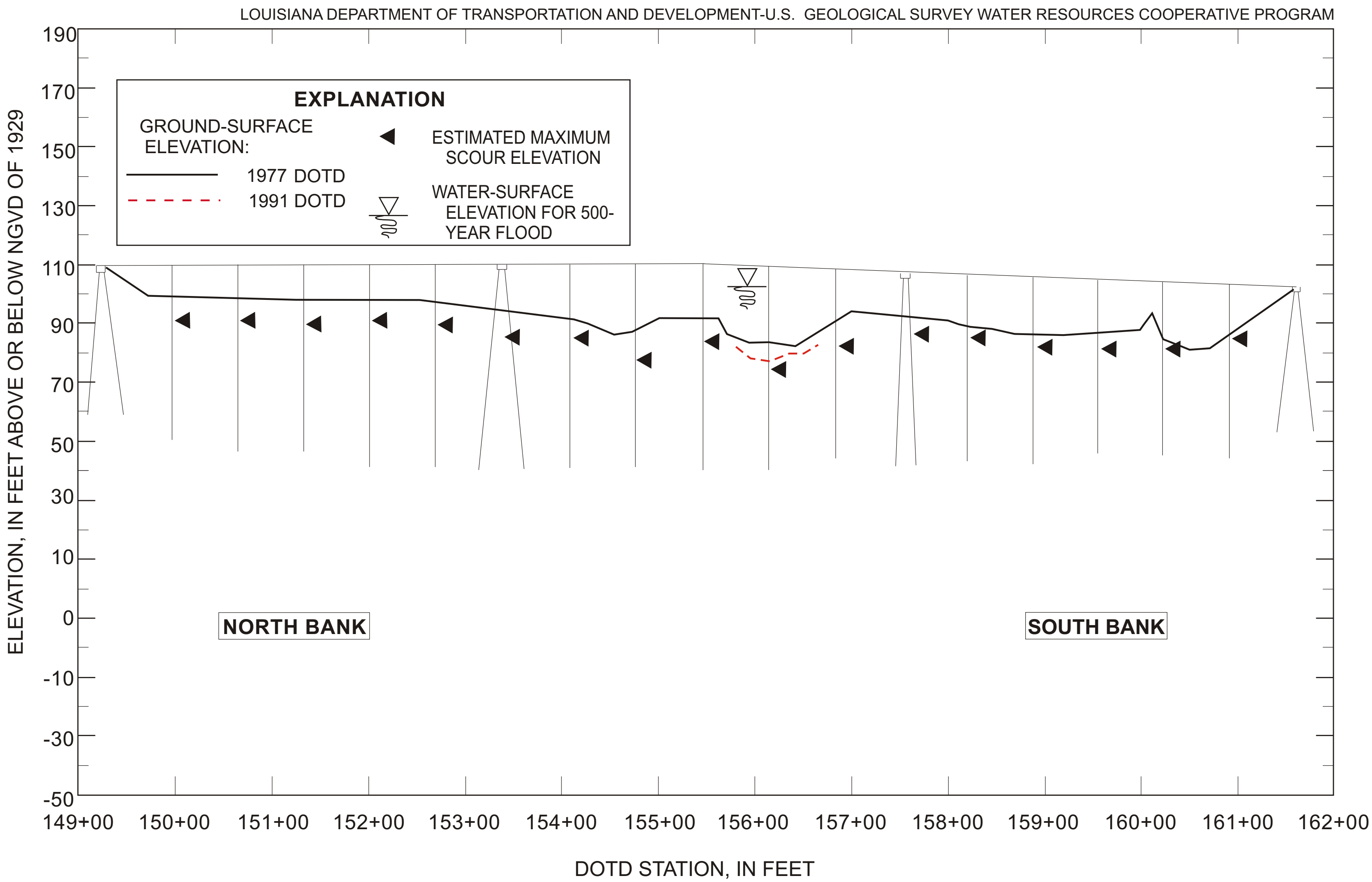


Figure 49. Bridge schematic, comparative cross sections, and scour estimates at the Louisiana Highway 10 crossing of the Calcasieu River near Oakdale, Louisiana.

Channel Stability

Cross-section information is shown in figure 49 for the years 1977 and 1991. Comparison of only these surveys indicates changes in elevations in the main channel portion of the cross section. The thalweg elevations observed from the limited main channel data indicate a minor decrease in elevation of approximately 5 ft. An aerial photograph of this bridge crossing is shown in figure 48.

Louisiana Highway 26 Crossing of the Calcasieu River near Oberlin

The estimate of the 500-year flood used for the hydraulic analysis is 94,300 ft^3/s. The water-surface elevation used for the 500-year estimate is 67.3 ft above NGVD of 1929. There are sinuous and sometimes braided channels (fig. 50) in the flood plain. The width of the flood plain at the 500-year flood simulation is approximately 1,700 ft. The downstream boundary condition for computations using the WSPRO model was a slope of 0.0003 ft/ft, which is the same slope determined from the calibration simulation based on historic flood data at the site. Simulations of the 500-year flood indicate velocities ranging from 2.2 to 5.4 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 24.

Pier Scour

Values for each pier are based on the DOTD hydrographic surveys of 1979 and 1991. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity, which is computed using WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth is approximately 6 ft for the pier at DOTD station 152+10 (table 24, fig. 51). The channel-bed elevation of the computed scour hole is 41 ft above NGVD of 1929.

Table 24. Scour data for Louisiana Highway 26 crossing of the Calcasieu River near Oberlin, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 67.3 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack and K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Pile tip elevation (ft above NGVD of 1929)
150+00	54	Round	1.0	2	2.1	3	3	48	15
150+70	54	Round	1.0	2	2.2	3	3	48	15
151+40	54	Round	1.0	2	2.4	3	3	48	15
152+10	50	Round	1.0	4	4.1	6	3	41	10
152+80	41	Round	1.0	2	5.4	5	3	33	5
153+50	42	Round	1.0	2	5.4	5	3	34	5
154+20	42	Round	1.0	2	5.3	5	3	34	10
154+90	46	Round	1.0	4	2.4	5	3	38	10
155+60	50	Round	1.0	2	2.4	3	3	44	15
156+80	54	Round	1.0	2	2.2	3	3	48	15
157+00	54	Round	1.0	2	2.2	3	3	48	15
157+70	54	Round	1.0	2	2.2	3	3	48	15
158+40	54	Round	1.0	2	2.2	3	3	48	15

Photograph source: Digital Orthophoto Quarter Quadrangle, U.S. Geological Survey
Identification number 30092184: accessed 5/29/01 at URL; http://www.atlas.lsu.edu

Figure 50. Aerial photograph of the Louisiana Highway 26 crossing of the Calcasieu River near Oberlin, Louisiana.

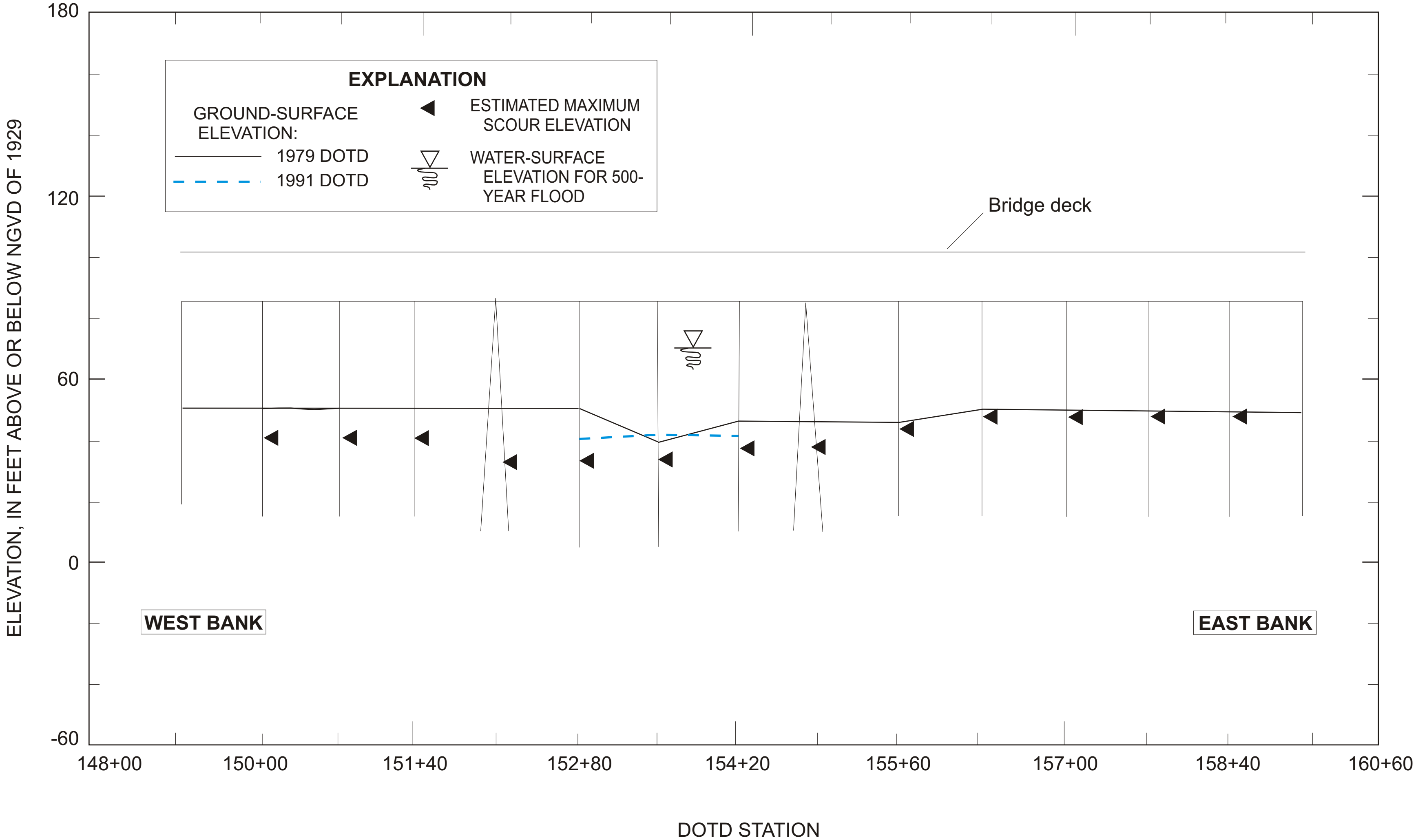


Figure 51. Bridge schematic, comparative cross sections, and scour estimates at the Louisiana Highway 26 crossing of the Calcasieu River near Oberlin, Louisiana.

Channel Stability

Cross-section information is shown in figure 51 for the years 1979 and 1991. The channel-bed elevations indicated that the limited 1991 bed-elevation data are lower than the 1979 data at DOTD stations 152+80 and 154+20. Bed elevations in 1991 at these locations, near the edge of the low water channel, are about the same as at the center of the channel. Elevations at the center of the channel show substantial change between 1979 and 1991. It is possible that this is an indication of only a minor change of the low water channel. Without greater amounts of monitoring data to verify changes, no trend should be implied. These surveys do not indicate substantial changes in the main channel. An aerial photograph of this bridge crossing is shown in figure 50.

U.S. Highway 190 Crossing of the Calcasieu River near Kinder

The estimate of the 500-year flood used for the hydraulic analysis is 168,000 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood was 38.8 ft above NGVD of 1929 (table 25). The width of the flood plain at the 500-year flood is approximately 7,000 ft. The width of the channel (fig. 52) at the 500-year flood is approximately 1,000 ft. The downstream boundary condition for hydraulic computations using WSPRO was a slope of 0.00015 ft/ft, which is the same slope used in calibration simulations of this reach. There are multiple bridges at this site. The main bridge opening was apportioned 79 percent of the total flow based on relative conveyance computations of the main channel opening and 2 relief openings. No significant contraction scour was estimated at the sites, and the main bridge abutments are protected with spur dikes. Simulations indicate velocities ranging from 4.0 to 9.2 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 25.

Pier Scour

For evaluation of pier scour, values for y_1 at each pier were based on the DOTD hydrographic surveys of 1977 and 1994. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

Pier scour estimates are in addition to a contraction scour estimate of 15 ft. The maximum computed scour depth was approximately 7 ft for the piers at DOTD station 140+15, 140+83, and 142+95 (table 25, fig. 53). The minimum channel-bed elevation of the scour hole at DOTD stations 140+15 and 140+83 is 12 ft below NGVD of 1929.

Table 25. Scour data for U.S. Highway 190 crossing of the Calcasieu River near Kinder, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 38.8 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Pile tip elevation (ft above NGVD of 1929)
135+25	19	Round	1.0	2	4.6	5	15	-1	-20
135+95	20	Round	1.0	2	5.0	5	15	0	-20
136+65	20	Round	1.0	2	5.0	5	15	0	-20
137+35	21	Round	1.0	2	4.3	5	15	1	-20
138+05	25	Round	1.0	2	4.3	4	15	6	-20
138+75	30	Round	1.0	4	4.2	6	15	9	-20

Table 25. Scour data for U.S. Highway 190 crossing of the Calcasieu River near Kinder, Louisiana—Continued

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above NGVD of 1929)	Pile tip elevation (ft above NGVD of 1929)
139+45	21	Round	1.0	2	4.2	4	15	2	-20
140+15	9	Round	1.0	2	9.0	7	15	-12	-30
140+83	9	Round	1.0	2	9.2	7	15	-12	-30
141+55	14	Round	1.0	2	8.1	6	15	-7	-30
142+25	21	Round	1.0	2	6.3	5	15	1	-20
142+95	26	Round	1.0	4	4.5	7	15	4	-20
143+65	25	Round	1.0	2	4.6	4	15	6	-20
144+35	21	Round	1.0	2	5.0	5	15	1	-20
145+05	21	Round	1.0	2	4.4	5	15	1	-20
145+75	25	Round	1.0	2	4.4	4	15	6	-20
146+45	25	Round	1.0	2	3.8	4	15	6	-20

Channel Stability

Cross-section information is shown in figure 53 based on the DOTD surveys of 1977, 1990, and 1994. The 1977 cross-section information was scaled from DOTD bridge plans. The 1990 and 1994 information was based on DOTD channel monitoring surveys. The channel bed conditions in 1990 indicate a lowering of the bed by as much as 10 ft. The 1994 data indicate conditions that are near the bed elevations in 1977. It is possible that the 1990 survey represents remnants of scour from the 25- to 50-year flood of July 1989 (101,000 ft^3/s). An aerial photograph of this bridge crossing is shown in figure 52.

U.S. Highway 171 Crossing of the Calcasieu River near Moss Bluff

The sites along the Calcasieu River are in a coastal plain environment. The flood flow estimates reflect attenuation of flood peaks due to increased storage and decreased channel slopes. Although there are changes in drainage area and basin slopes for the bridge crossings at U.S. Highway 171, Interstate Highway 10, and Interstate Highway 210, the flood frequency estimates at all three sites are similar enough to use the same value of the 500-year flood. The three “at site” values differ by only three percent from the average of the three estimates. The estimates are near the limits of extremes of the RIRM input variables, and grouping the three sites with a variability of three percent does not violate reasonable hydrologic practices. Although separate flood frequency computations yield different values of the 500-year flood, a single value produces scour estimates that are not significantly different from independent computations. The estimate of the 500-year flood used for the hydraulic analysis of U.S. Highway 171, Interstate Highway 10, and Interstate Highway 210 is 137,000 ft^3/s. This single value (rather than slightly scattered values) is used for consistency at these three sites because the sites are relatively close to each other.

The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate for U.S. Highway 171 crossing is 9.3 ft above NGVD of 1929 (table 26). The width of the flood plain at the 500-year flood is approximately 7,000 ft. The width of the channel (fig. 54) is approximately 600 ft. The main span of the bridge is 900 ft, with elevated approaches. The total bridge opening is approximately 5,700 ft (DOTD bridge plans). The downstream boundary condition for computations using the WSPRO model was a slope of 0.00008 ft/ft, which is the same slope, determined from the calibration simulations at this site. Simulations of the 500-year flood indicate velocities ranging from 1.3 to 8.0 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 26.

Photo source: Louisiana Department of Transportation and Development, 10/19/92

Figure 52. Aerial photograph of the U.S. Highway 190 crossing of the Calcasieu River near Kinder, Louisiana.

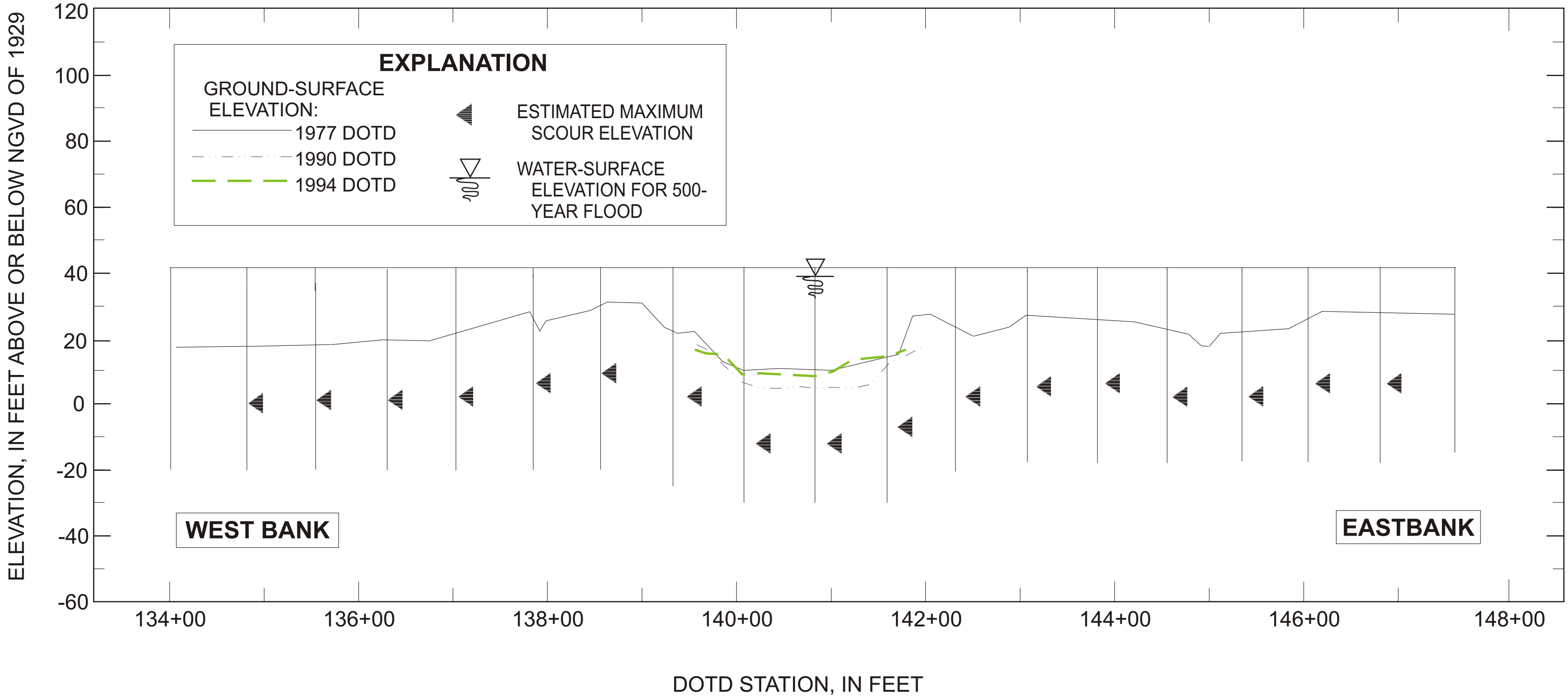


Figure 53. Bridge schematic, comparative cross sections and scour estimates at U.S. Highway 190 crossing of the Calcasieu River near Kinder, Louisiana.

Source: Louisiana Oil Spill Coordinator's Office (LOSCO), 19981229, Color Infrared Orthophoto, SW quadrant of Moss Bluff Quadrangle, LA, 50:1 MrSID compressed, LOSCO (1998) [c3009347_sws_50]

Figure 54. Aerial photograph of the U.S. Highway 171 crossing of the Calcasieu River near Moss Bluff, Louisiana.

Pier Scour

For the evaluation of pier scour, values for water depths at each pier (y_1), were based on the DOTD hydrographic survey of 1997. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 13 ft for the pier at DOTD stations 291+15 and 293+15 (table 26, fig. 55). The lowest channel-bed elevation of the computed scour holes is about -37 ft below NGVD of 1929.

Table 26. Scour data for U.S. Highway 171 crossing of the Calcasieu River near Moss Bluff, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 9.3 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
Approach Piers	2	Round	1.0	2	1.6	3	0	-1	NA
287+65	2	Round	1.0	6	1.5	5	0	-3	-50
289+15	1	Round	1.0	6	1.5	5	0	-4	-90
291+15	-21	Round	1.0	7.5	6.0	13	0	-34	-90
293+15	-24	Round	1.0	7.5	5.7	13	0	-37	-90
295+15	2	Round	1.0	6	2.2	6	0	-4	-90
296+65	2	Round	1.0	6	2.2	6	0	-4	-50
Approach Piers	2	Round	1.0	2	1.7	3	0	-1	NA

Channel Stability

Cross-section information is shown in figure 55 for the years 1965 and 1997. No substantial channel migration is evident based on this limited survey information. The two bed elevations shown may adequately document a generally stable geometry at the site. An aerial photograph of this bridge crossing is shown in figure 54.

Interstate Highway 10 Crossing of the Calcasieu River at Lake Charles

The estimate of the 500-year flood used for the hydraulic analysis of the Interstate Highway 10 crossing is 137,000 ft^3/s. The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate is 9.0 ft above NGVD of 1929 (table 27). The width of the flood plain at the 500-year flood is approximately 6,550 ft. The width of the channel (fig. 56) at the bridge for the 500-year flood simulation is approximately 700 ft. The downstream boundary condition for computations using the WSPRO model was a slope of 0.00009 ft/ft, which is the approximate slope from the calibration simulations at nearby U.S. Highway 171. Simulations of the 500-year flood indicate velocities ranging from 1.0 to 6.3 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 27.

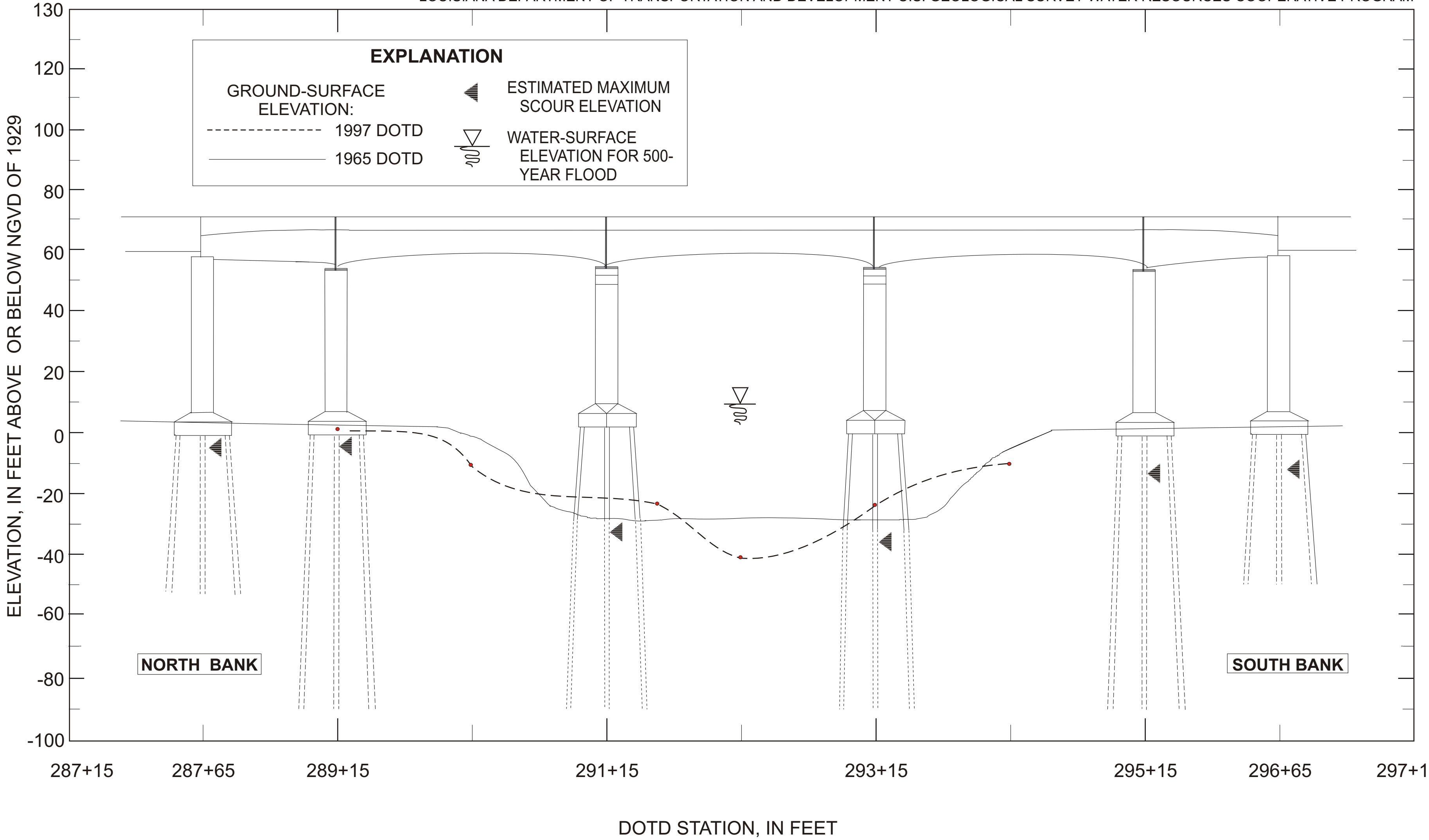


Figure 55. Bridge schematic, comparative cross sections, and scour estimates at the U.S. Highway 171 crossing of Calcasieu River near Moss Bluff, Louisiana.

Photograph source: Louisiana Department of Transportation and Development, 10/10/89

Figure 56. Aerial photograph of the Interstate Highway 10 crossing of the Calcasieu River at Lake Charles, Louisiana.

Pier Scour

For the evaluation of pier scour, values for water depths at each pier (y_1), were based on the DOTD hydrographic survey of 1994. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier evaluated.

The maximum computed scour depth was approximately 24 ft for the pier at DOTD station 594+54 (table 27, fig. 57). The channel-bed elevation of the computed scour hole is about 50 ft below NGVD of 1929.

Table 27. Scour data for Interstate Highway 10 crossing of the Calcasieu River at Lake Charles, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 9.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
588+24	15	Round	1.0	18	0	NA	0	NA	-40
590+33	-24	Round	1.0	19	3.5	19	0	-43	-120
594+54	-26	Round	1.0	19	5.9	24	0	-50	-120
596+64	-1	Round	1.0	19	1.8	12	0	-13	-40
598+46	-3	Round	1.0	19	1.8	13	0	-16	-40
600+30	-3	Round	1.0	19	2.1	13	0	-16	-40
Overbank piers	-4	Round	1.0	10	2.1	9	0	-13	NA

Channel Stability

Cross-section information is shown in figure 57 for the years 1952 and 1994. An aerial photograph of this bridge crossing is also shown. The crossing is on the northern edge of the lake, Lake Charles (fig. 50). The 1994 cross section shows slightly lower elevations than the original bridge plans in the channel areas and a part of one overbank. Comparing the two cross sections shows some vertical changes in the thalweg with the 1994 elevations being 4 to 6 ft lower.

Interstate Highway 210 Crossing of the Calcasieu River near Lake Charles

The estimate of the 500-year flood used for the hydraulic analysis is 137,000 ft^3/s. Flow though shallow parts of the flood plain to the south of the main channel was neglected and all flow was routed through the ship channel. The width of the opening in the simulation to estimate pier scour corresponds to the 900 ft main span of the bridge. This approximation may result in pier scour being overestimated. The computed water-surface elevation resulting from hydraulic simulations using the 500-year flood estimate is 4.0 ft above NGVD of 1929 (table 28). At this elevation, the overbank areas of the flood plain are not inundated and flow is confined to the main channel. The width of the channel (fig. 58) at the 500-year flood is approximately 800 ft. The downstream boundary condition for computations using the WSPRO model was a slope of 0.00007 ft/ft, which is representative of flood slopes in this area. Simulations of the 500-year flood indicate velocities ranging from 1.3 to 6.8 ft/s along the cross section at the bridge. Values of velocity at pier locations are listed in table 28.

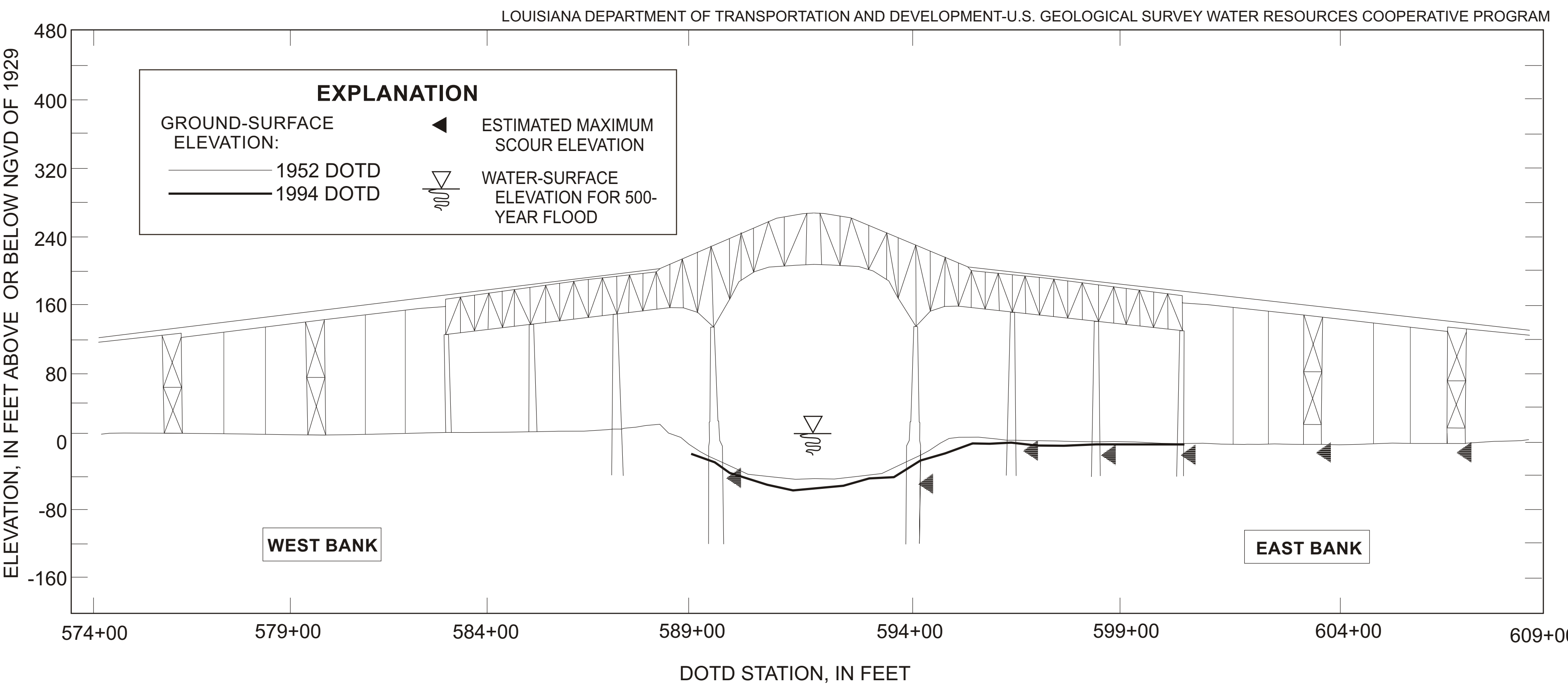


Figure 57. Bridge schematic, comparative cross sections, and scour estimates at Interstate Highway 10 crossing of the Calcasieu River at Lake Charles, Louisiana.

Source: Louisiana Oil Spill Coordinator's Office (LOSCO), 19981230, Color Infrared Orthophoto, NE quadrant of Westlake Quadrangle, LA, 50:1 MrSID compressed, LOSCO (1998) [c3009354_ses_50]

Figure 58. Aerial photograph of the Interstate Highway 210 crossing of the Calcasieu River near Lake Charles, Louisiana.

Pier Scour

For the evaluation of pier scour, values for water depths at each pier (y_1), were based on the DOTD hydrographic survey of 1997. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier location is based upon the value of depth and velocity computed by the WSPRO model at a position in the cross section that corresponds to the location of each pier.

The maximum computed scour depth was approximately 23 ft for the main channel piers at DOTD station 141+25 (table 28, fig. 59). Timber fenders to protect the piers may serve to reduce the pier scour potential at these piers (Abed and Richardson, 1993). The channel-bed elevation of the computed scour hole is about 49 ft below NGVD of 1929. The greatest scour estimate for the east bank overbank piers was 9 ft. In consideration of the variations in the marsh and overbank areas, this maximum value could be applied to all of the overbank piers.

Table 28. Scour data for Interstate Highway 210 crossing of the Calcasieu River near Lake Charles, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 4.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
West bank overbank piers	2.5	Round	1.0	10	1.3	6	0	-4	NA
139+00	0	Round	1.0	17	1.3	9	0	-9	-88
141+25	-26	Round	1.0	17	6.5	23	0	-49	-93
145+75	-26	Round	1.0	17	5.3	21	0	-47	-93
148+00	0	Round	1.0	17	2.7	12	0	-12	-88
East bank overbank piers	0	Round	1.0	10	2.9	9	0	-9	NA

Channel Stability

Cross-section information is shown in figure 59 for the years 1959 and 1997. An aerial photograph of this bridge crossing is shown in figure 58. The DOTD hydrographic survey of 1997 shows only minor differences when compared to the 1959 bed elevations in the main channel.

Sabine River Basin

The Sabine River Basin is located in the western part of Louisiana. The basin is bounded by the State of Texas on the west and Calcasieu River Basin on the east. Approximately half of the length of the river shared by Texas and Louisiana is the Toledo Bend Reservoir. The reservoir was formed by a dam completed in 1966 west of Leesville, Louisiana. The drainage area of the Sabine River at the Intracoastal Waterway is 9,760 mi^2. The Intracoastal Waterway interconnects the water bodies in the coastal regions of the State, which can make drainage area determinations uncertain south of the interconnection (Sloss, 1971).

Louisiana Highway 12 Crossing of the Sabine River near Starks

The Louisiana Highway 12 crossing of the Sabine River (fig. 60) consists of an earthen embankment with multiple bridge openings to convey the main channel and overbank flow. A gaging station has been maintained at this location since 1924. The maximum discharge of record was 121,000 ft^3/s that occurred in May 1953. The

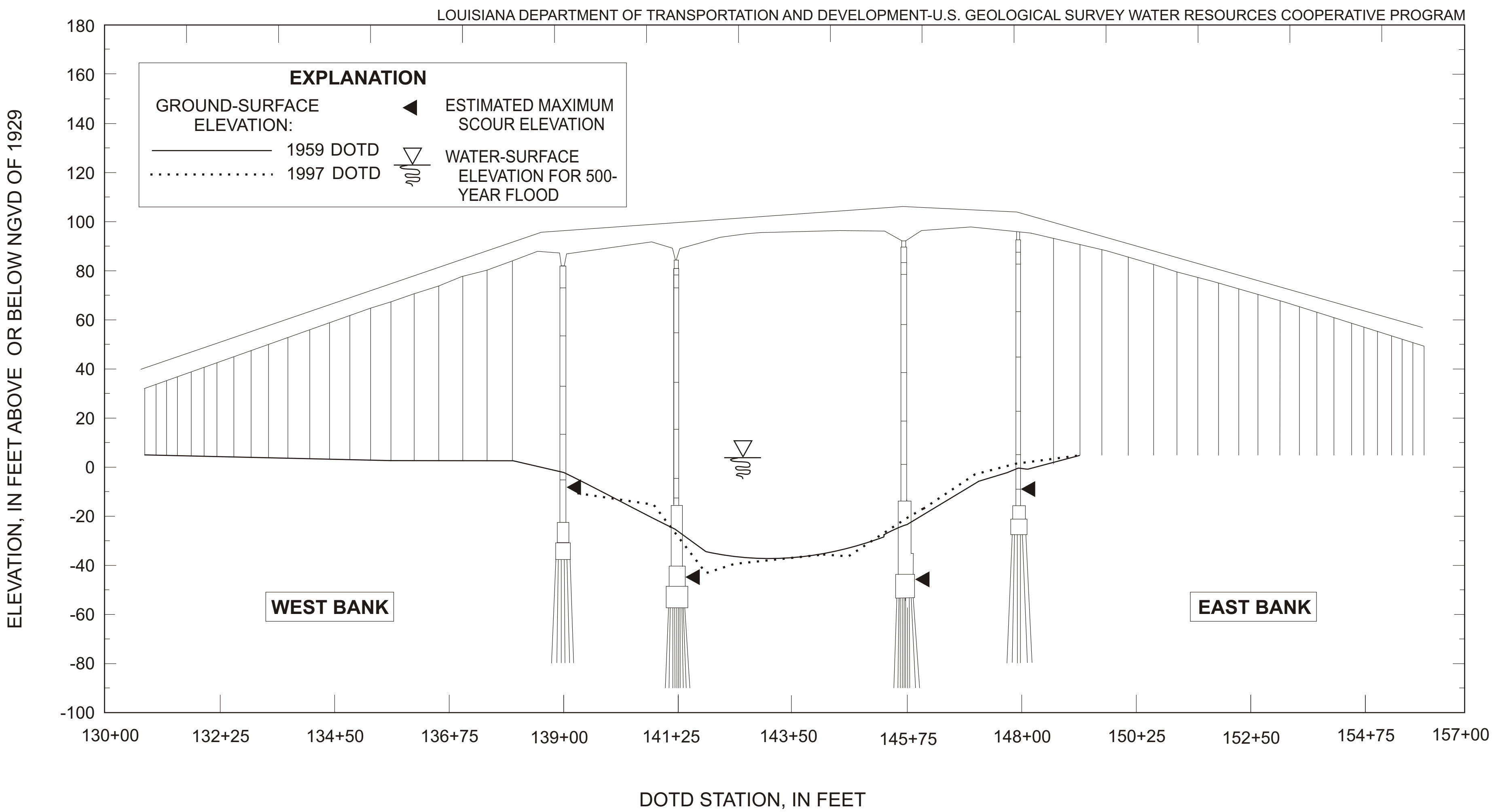


Figure 59. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 210 crossing of the Calcasieu River near Lake Charles, Louisiana.

Source: Louisiana Oil Spill Coordinator's Office (LOSCO), 19990105, Color Infrared Orthophoto, SW quadrant of Starks Quadrangle, TX, 50:1 MrSID compressed, LOSCO (1999) [c3009343_sws_50]

Figure 60. Aerial photograph of the Louisiana Highway 12 crossing of the Sabine River near Starks, Louisiana.

site is about 100 mi downstream from the Toledo Bend Reservoir. This impoundment has a significant effect on the validity of flood frequency estimates, and the confidence limits of these estimates. Based on several approaches, and their results, the 500-year flood estimate of 255,000 ft^3/s was obtained by using 1.2 * Q_{100} value (Richardson, 1991). The Q_{100} value was based on RIRM estimates (Ensminger, 1998). This estimate of the 500-year flood may result in scour being overestimated on the Sabine River sites examined. A complete analysis of the hydraulics of this multiple opening embankment crossing of the 4 mile-wide flood plain requires application of 2-dimensional flow models which is beyond the scope of this evaluation. Apportionment of the flow among the openings is based on the distribution of flow for the largest flow measurement at the site where 16 openings in the highway embankment were measured. The flow apportioned to the main channel bridge opening is 13 percent of the total measured discharge based on the flow distribution observed from the largest recorded discharges. The computed water-surface elevation resulting from hydraulic simulations of the natural conditions of the flood plain (no bridge constrictions) using the 500-year flood estimate is 26 ft above NGVD of 1929 (table 29). Simulations using WSPRO at the main bridge opening indicate velocities ranging from 2.5 to 9.6 ft/s along the cross section at the main channel bridge. Values of velocity at pier locations are listed in table 29.

Pier Scour

For the evaluation of pier scour, values for y_1 at each pier were based on the DOTD hydrographic survey of 1994. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity that was computed using WSPRO.

The maximum computed scour depth was approximately 33 ft for the pier at DOTD station 1099+50 (table 29, fig. 61). The pier at this location is 32 ft in width and is the support for the swing span of the bridge. Adjustments for wide piers, as outlined by Jones and Sheppard (1999), were applied at this pier. The channel-bed elevation of the computed scour hole is about 34 ft below NGVD of 1929. The pile tip elevation for this pier is approximately 38 ft below NGVD of 1929.

Table 29. Scour data for Louisiana Highway 12 crossing of the Sabine River near Starks, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 26.0 feet above NGVD of 1929; K_2, dimensionless correction factors; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
1098+20	22	Round	1.0	2	2.5	2	0	+20	-38
1098+69	6	Round	1.0	6	7.4	11	0	-5	-38
1099+50	-1	Round	1.0	32	9.4	33	0	-34	-38
1100+31	8	Round	1.0	6	8.7	12	0	-4	-38
1100+82	25	Round	1.0	2	3.7	2	0	23	-38

Channel Stability

Cross section information is shown in figure 61 for the years 1938 and 1994. The depth of the channel bed within the main channel has increased since the 1938 survey. These surveys indicate some decrease of the channel-bed elevations at the main channel piers. Bed elevations of the 1994 survey could reflect remnants of previous pier scour. Bed elevations based on the USGS flood discharge measurement in May 1989 represent the same general main channel shape as the 1994 DOTD survey.

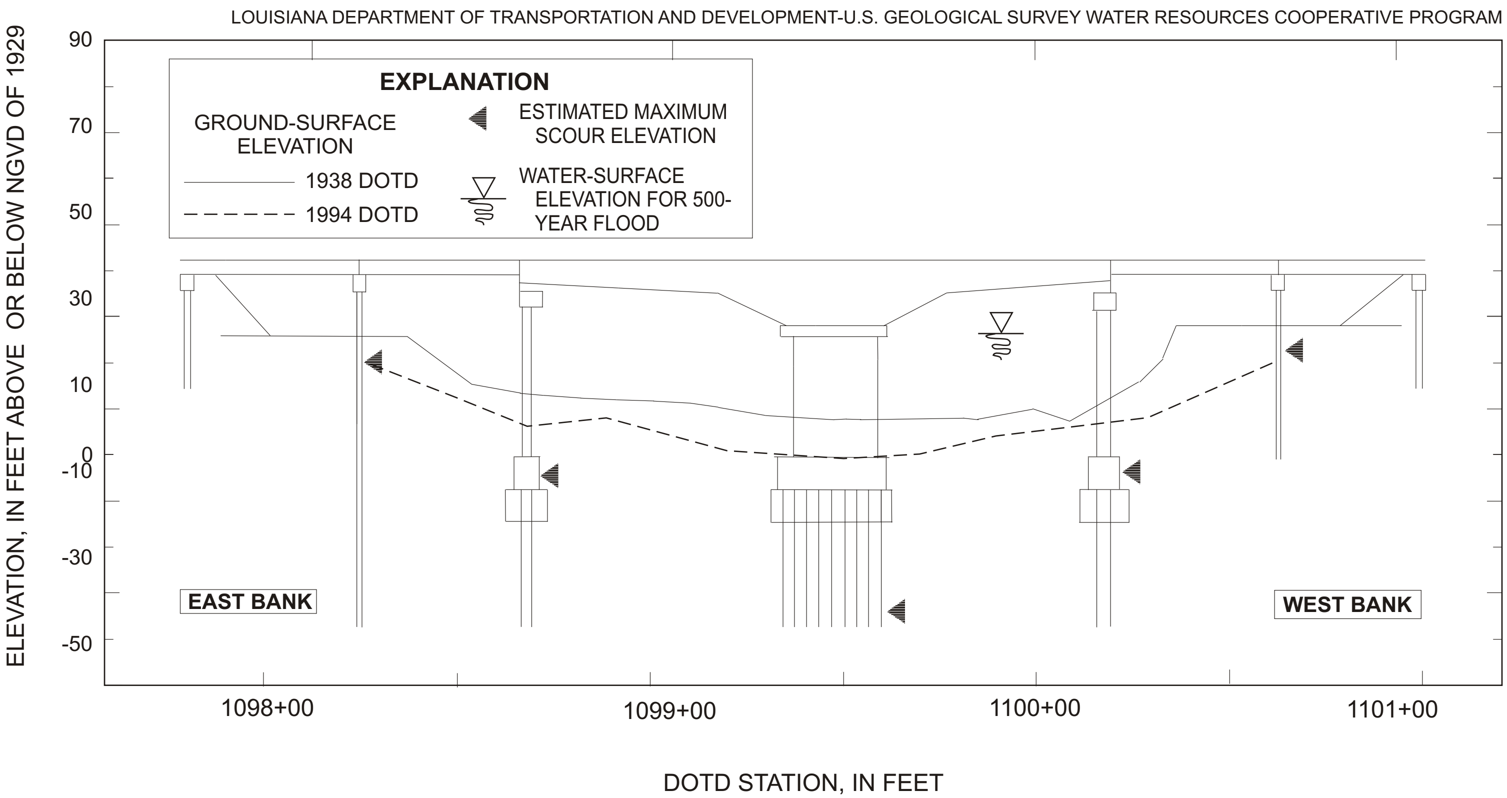


Figure 61. Bridge schematic, comparative cross sections, and scour estimates at the Louisiana Highway 12 crossing of the Sabine River near Starks, Louisiana.

Interstate Highway 10 Crossing of the Sabine River near Vinton

The Louisiana Highway 12 crossing of the Sabine River (fig. 62) consists of an earthen embankment with multiple bridge openings to convey the main channel and overbank flow. The 500-year flood estimate is 262,000 ft^3/s based on RIRM estimates (Ensminger, 1998). This estimate of the 500-year flood may result in scour being overestimated on the Sabine River sites examined. A more complete analysis of the hydraulics of this multiple opening embankment crossing of the 4-mile wide flood plain requires application of 2-dimensional flow models which is beyond the scope of this evaluation. Apportionment of the flow among the openings in the embankment is based only on the approximate area of each opening. The flow apportioned to the main channel bridge opening is 79 percent of the total discharge. The computed water-surface elevation resulting from hydraulic simulations of the main channel bridge opening using the 500-year flood estimate is 6.1 ft above NGVD of 1929 (table 30). The downstream boundary condition for the simulations was a slope of 0.00012. Simulations using WSPRO at the main bridge opening indicate velocities ranging from 2.1 to 11.6 ft/s along the cross section at the main channel bridge. Values of velocity at pier locations are listed in table 30.

Pier Scour

For evaluation of pier scour, values for y_1 at each pier were based on the DOTD hydrographic survey of 1994. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity, which was computed using WSPRO.

The maximum computed scour depth was approximately 31 ft and 30 ft for the piers at DOTD station 396+50 and 398+50, respectively (table 30, fig. 63). Contraction scour is estimated at 23 ft in the main channel and 8 to 9 ft in the overbank areas. The minimum channel-bed elevation of the computed scour holes including contraction scour is 81 ft below NGVD of 1929 at DOTD station 398+50. This estimated elevation is 8 ft below the pile tip elevation.

Channel Stability

Cross-section information is shown in figure 63 for the years 1949 and 1994. The 1994 survey indicates a lowering of the stream bed in the main channel when compared to the survey of 1949. The 1994 elevations are generally 10 ft lower than the 1949 elevations. The 1994 DOTD survey also indicates some widening of the channel. On the west bank, elevation changes greater than 10 ft are indicated in 1994 when compared to the original 1949 data.

Atchafalaya River Basin

The Atchafalaya River originates in south-central Louisiana at the confluence of the Red River and the Old River flood control structure distributary (Lower Old River) of the Mississippi River. The Old River flood control structure is the receiving water body for flow diversion from the Mississippi River. Because of this diversion, the drainage area of the Atchafalaya River is indeterminate. The basin extends in a north-south direction from its origin to the Gulf of Mexico. The Atchafalaya River is the largest of all distributaries of the Mississippi River. Flood protection works, composed primarily of levees, have been constructed for most of the length of the basin. The 500-year flood is approximated based on flow diversions at the Old River flood control structure and Morganza Spillway flood control structure and flows from the Red River and other intervening areas (U.S. Army Corps of Engineers, 2001). At Simmesport, the approximate flow is derived by combining 600,000 ft^3/s from the Old River flood control structure and 350,000 ft^3/s from the Red River for a total of 950,000 ft^3/s.

Although there is flow in the Atchafalaya River, the west Atchafalaya and Morganza floodways at Krotz Springs and Henderson, no flood statistics are applicable. The flood of record is simulated as main channel flow at those locations.

Source: Louisiana Oil Spill Coordinator's Office (LOSCO), 19990105, Color Infrared Orthophoto, SW quadrant of Echo Quadrangle, TX, 50:1 MrSID compressed, LOSCO (1999) [c3009351_sws_50]

Figure 62. Aerial photograph of the Interstate Highway 10 crossing of the Sabine River near Vinton, Louisiana.

Table 30. Scour data for Interstate Highway 10 crossing of the Sabine River near Vinton, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 6.1 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3, 1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plan; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
381+99	3.0	Round	1.0	0.0	2.2	3.8	9	-6	NA
382+80	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
383+60	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
384+40	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
385+20	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
386+00	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
386+80	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
387+60	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
388+40	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
389+20	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
390+00	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
390+80	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
391+60	2.0	Round	1.0	3.5	2.2	4.0	9	-11	NA
392+40	2.0	Round	1.0	3.5	4.0	5	9	-12	NA
393+20	2.0	Round	1.0	3.5	4.0	5	9	-12	NA
394+00	0	Round	1.0	3.5	4.0	6	9	-15	NA
395+00	-26	Round	1.0	5.0	10.1	13	23	-62	-73
396+50	-23	Round	1.0	20	9.8	31	23	-77	-73
398+50	-28	Round	1.0	20	8.9	30	23	-81	-73
400+00	-3.0	Round	1.0	5.0	4.1	7	8	-18	-73
401+00	2.0	Round	1.0	3.5	4.1	5	8	-11	NA
401+80	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
402+60	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
403+40	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
404+20	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
405+00	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
405+80	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
406+60	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
407+40	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
408+20	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
409+80	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
410+60	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
411+40	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
412+20	2.0	Round	1.0	3.5	2.1	4	8	-10	NA
413+01	2.0	Round	1.0	3.5	2.1	4	8	-10	NA

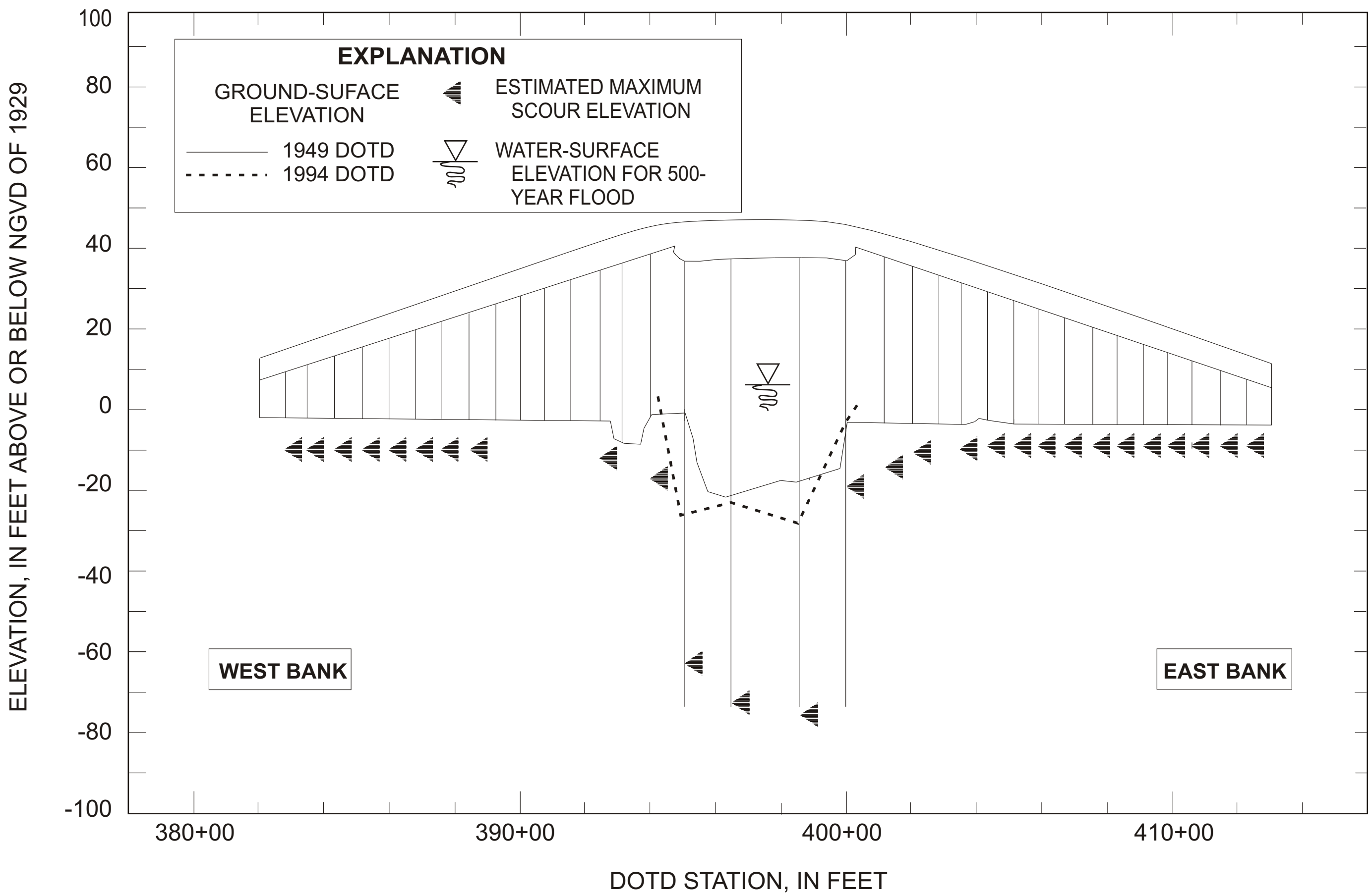


Figure 63. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 10 crossing of the Sabine River near Vinton, Louisiana.

Louisiana Highway 1 Crossing of the Atchafalaya River at Simmesport

The Louisiana Highway 1 crossing of the Atchafalaya River (fig. 64) is the first highway crossing of the river from the origin where the Red River and the Lower Old River merge. Traditional flood frequency techniques cannot be utilized along the Atchafalaya River due to the flow controls at the originating channels. The flood discharge used for calibration is the flow recorded in 1973 of 781,000 ft^3/s. The recorded water-surface elevation for this flow is 54.5 ft above NGVD of 1929 (U.S. Army Corps of Engineers, 1995). A 500-year flood estimate of 950,000 ft^3/s is based on combined flow from the Red River and Old River flood control structure diversions. The computed water-surface elevation resulting from hydraulic simulations of the 500-year flood is 59.0 ft above NGVD of 1929 (table 31). This elevation is near crown elevation shown on topographic maps of some levees in the area. Simulations using WSPRO indicate velocities at piers ranging from 4.0 to 12.0 ft/s. Values of velocity at pier locations are listed in table 31.

Pier Scour

For the evaluation of pier scour, values for y_1 at each pier were based on the DOTD hydrographic survey of 1993. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity computed using WSPRO.

The maximum computed scour depth was approximately 26 ft for the pier at DOTD station 965+70 (table 31, fig. 65). The channel-bed elevation of the computed scour hole is about 48 ft below NGVD of 1929. The lowest elevation resulting from scour computations was 63 ft below NGVD of 1929 for the pier located at DOTD station 958+50.

Table 31. Scour data for Louisiana Highway 1 crossing of the Atchafalaya River at Simmesport, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 59.0 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; footing elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Footing elevation (ft above or below NGVD of 1929)
954+56	50	Round	1.0	9	4.0	11	13	26	-75
958+50	-26	Round	1.0	15	6.0	24	13	-63	-150
965+70	-9	Round	1.0	15	8.0	26	13	-48	-150
969+10	45	Round	1.0	9	5.0	12	13	20	-75

Channel Stability

Cross section information is shown in figure 65 for the years 1965, 1991 and 1993. These surveys do not indicate substantial changes in the channel-bed elevation or alignment.

Photograph source: U.S. Department of the Interior,
U.S. Geological Survey Maintainer:
earthexplorer@edcmail.cr.usgs.gov
Last Modified: 2/5/01

Figure 64. Aerial photogragh of the Louisiana Highway 1 crossing of the Atchafalaya River at Simmesport, Louisiana.

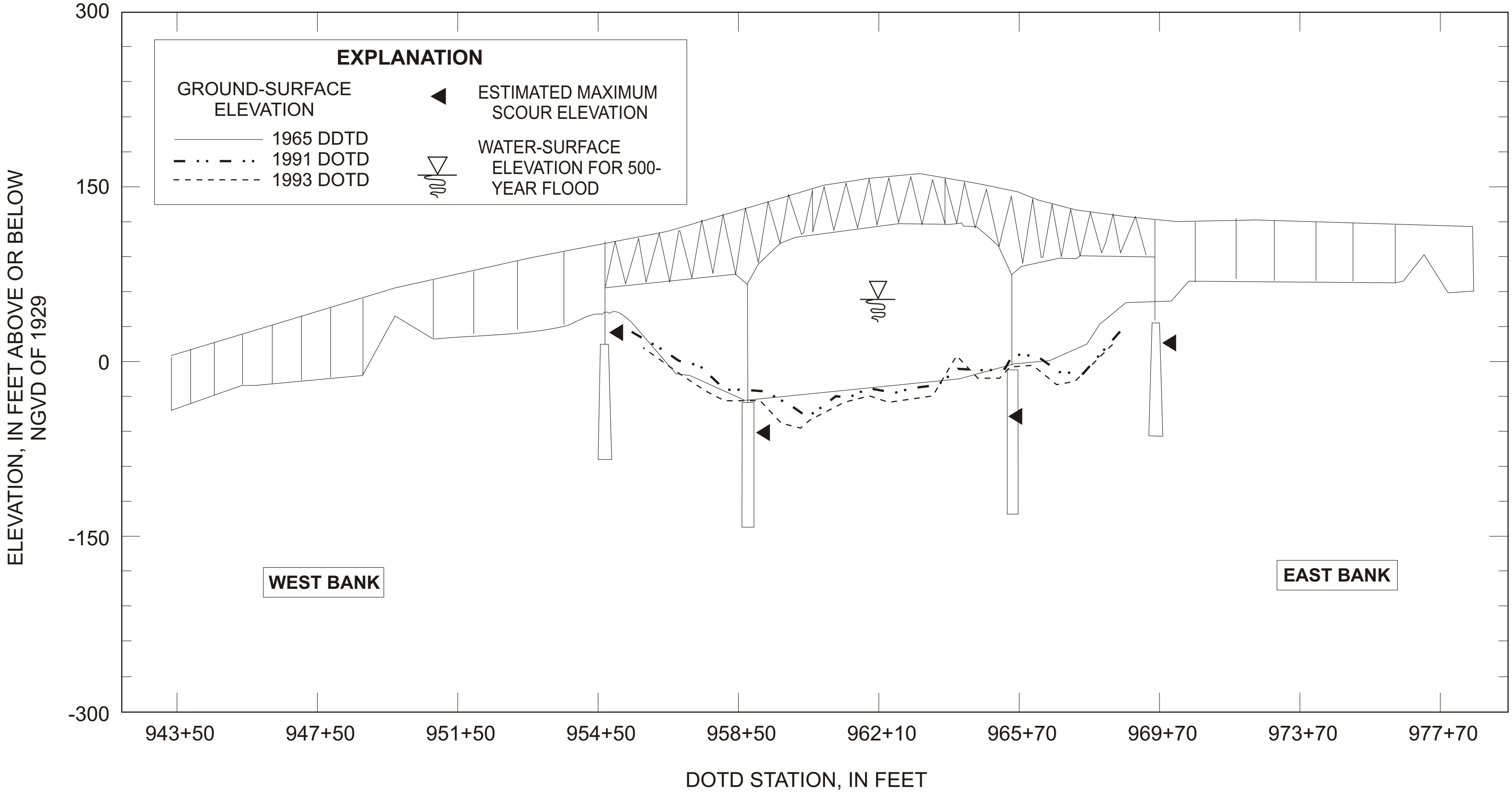


Figure 65. Bridge schematic, comparative cross sections, and scour estimates at the Louisiana Highway 1 crossing of the Atchafalaya River at Simmesport, Louisiana.

U.S. Highway 190 Crossing (eastbound and westbound) of the Atchafalaya River near Krotz Springs

There are two bridges for this highway crossing (fig. 66). The original structure is now used only for eastbound traffic; another bridge for westbound traffic was built immediately upstream of the original structure. Traditional flood frequency techniques cannot be utilized along the Atchafalaya River due to the flow controls at the originating channels. Any flow exchange between the West Atchafalaya Floodway and the Atchafalaya River is unknown, and simulation of that complex flow system is beyond the scope of this analysis. The flood discharge of 781,000 ft^3/s used in this analysis is the flow recorded in 1973. The record discharge is simulated as only in the main channel, neglecting floodway flows. Although this assumption will overestimate scour for the given discharge, it may be a reasonable indication of a 500-year flood response with flow through the floodways and main channel. Simulations using WSPRO with a downstream boundary condition of a slope of 0.000065 ft/ft produces computed water-surface elevations that are near the peak water level of 38.9 ft recorded at Krotz Springs (U.S. Army Corps of Engineers, 1995). Simulations using WSPRO indicate velocities ranging from 3.0 to 9.7 ft/s. Values of velocity at pier locations are listed in table 32.

Pier Scour

For the evaluation of pier scour, values for y_1 at each pier were based on the DOTD hydrographic survey of 1994. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity computed using WSPRO. The velocities computed at pier locations for the eastbound (downstream) bridge range from 3.8 to 9.3 ft/s with a maximum computed scour depth of 49 ft for the pier at DOTD station 86+28. The channel-bed elevation of the computed scour hole is about 97 ft below NGVD of 1929 (table 32, fig. 67). The velocities computed at pier locations for the westbound (upstream) bridge range from 8.1 to 9.7 ft/s, with a maximum computed scour depth of 52 ft for the pier at DOTD station 87+60. The channel-bed elevation of the computed scour hole is about 107 ft below NGVD of 1929 (table 32, fig. 68).

Table 32. Scour data for U.S. Highway 190 crossing (eastbound and westbound) of the Atchafalaya River near Krotz Springs, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 38.9 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
				Eastbound (downstream) bridge					
76+45	35	Round	1.0	34	3.8	22	0	13	-140
81+24	-43	Round	1.0	34	8.9	47	0	-82	-140
86+28	-48	Round	1.0	34	9.3	49	0	-97	-140
90+80	36	Round	1.0	34	4.1	22	0	14	-140
				Westbound (upstream) bridge					
80+54	-27	Round	1.0	36	8.1	46	0	-73	-140
87+60	-55	Round	1.0	36	9.7	52	0	-107	-140

Channel Stability

Cross section information for the eastbound (downstream) bridge is shown in figure 67 for the years 1968, 1991, and 1994. The 1991 and 1994 surveys indicate that the channel has become wider and deeper since the 1968 survey. There are no substantial channel changes indicated between the 1991 and 1994 surveys. Cross section information for the westbound (upstream) bridge is shown in figure 68 for the years 1973, 1991, and 1994. Both the 1991 and 1994 surveys indicate a wider channel when compared to the 1973 survey. Although there is some lateral movement of the channel, there are no substantial increases in depth near the main piers.

Photograph source: Louisiana Department of Transportation and Development, 6/19/95

Figure 66. Aerial photograph of the U.S. Highway 190 crossing (eastbound and westbound) of the Atchafalaya River near Krotz Springs, Louisiana.

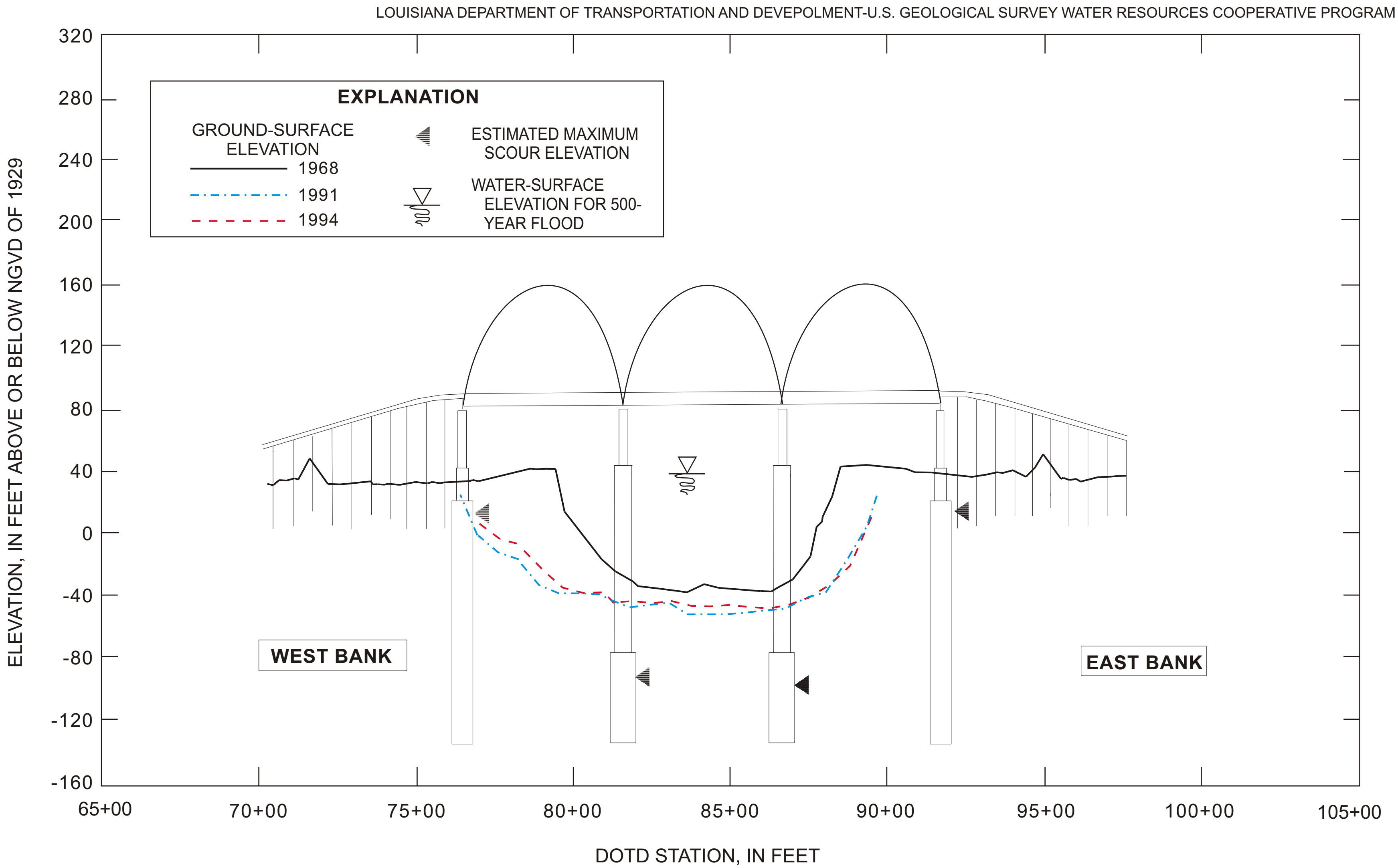


Figure 67. Bridge schematic, comparative cross sections, and scour estimates at the U.S. Highway 190 crossing (eastbound) of the Atchafalaya River near Krotz Springs, Louisiana.

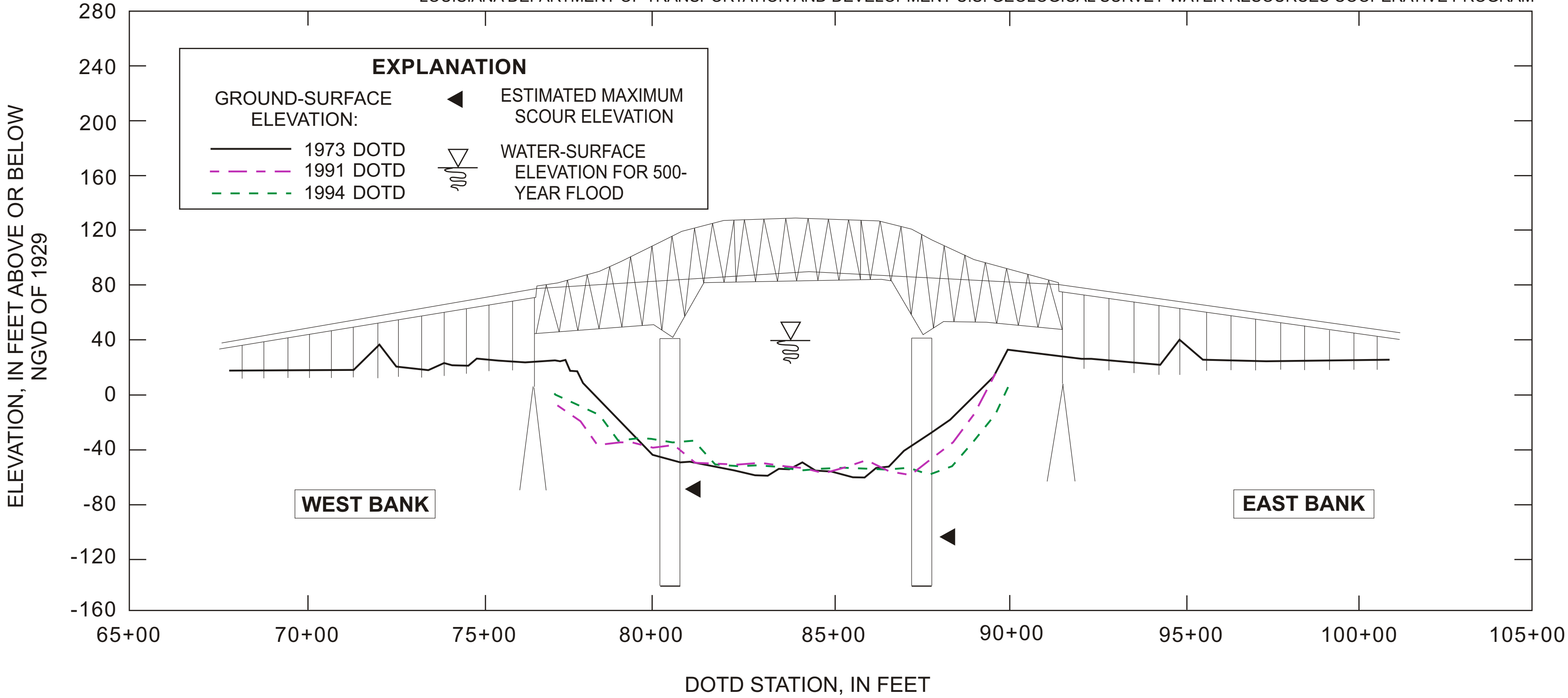


Figure 68. Bridge schematic, comparative cross sections, and scour estimates at the U.S. Highway 190 crossing (westbound) of the Atchafalaya River near Krotz Springs, Louisiana.

Interstate Highway 10 Crossing of the Atchafalaya River near Henderson

Traditional flood frequency techniques cannot be utilized along the Atchafalaya River (fig. 69), due to the flow controls at the originating channels. Any flow exchange between the West Atchafalaya River and the Morganza Floodway is unknown, and simulation of that complex flow system is beyond the scope of this analysis. The flood discharge used in this analysis is the flow of 781,000 ft^3/s recorded in 1973. The water-surface elevation used was 27.3 ft above NGVD of 1929 (table 33). The record discharge is simulated as only in the main channel neglecting floodway flows. Although this assumption will overestimate scour for the given discharge, it may be a reasonable indication of a 500-year flood response with flow through the floodways and main channel. A distributary channel, locally known as the Whiskey Bay Pilot Channel (fig. 70), forms from the main channel of the Atchafalaya River about 3 mi upstream of Interstate 10. A detailed simulation of the distribution of flows between the two channels requires hydraulic modeling that is beyond the scope of this project. For the purposes of estimating pier scour, the design discharge was apportioned to each opening based on flow area. Most of the highway crossing is elevated on piers, with relatively little earthen embankment constricting flow through the flood plain. In consideration of the small degree of encroachment and hydraulic approximations used, no contraction scour estimates were performed at this site.

Pier Scour

For the evaluation of pier scour, values for y_1 at each pier were based on the DOTD hydrographic survey of 1993. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity computed using WSPRO. The velocities used in scour computations are shown in table 33. The maximum computed scour depth was 57 ft for the pier at DOTD station 2233+71 (table 33, fig. 70). The channel-bed elevation of the computed scour hole is about 85 ft below NGVD of 1929.

Table 33. Scour data for Interstate Highway 10 crossing of the Atchafalaya River near Henderson, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 27.3 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
2233+71	-28	Round	1.0	38	12.8	57	0	-85	-150
2237+54	-8	Round	1.0	38	4.7	35	0	-43	-150

Channel Stability

Cross section information is shown in figure 71 for the years 1972, 1990, and 1993. The surveys do not indicate lowering of the channel bed at any locations in the channel parts evaluated. Some increase in the channel-bed elevation is indicated in the vicinity of DOTD station 2233+71.

Interstate Highway 10 Crossing of the Whiskey Bay Pilot Channel near Henderson-Grosse Tete

Traditional flood frequency techniques cannot be utilized along the Atchafalaya River due to the flow controls at the originating channels. The flood discharge used in this analysis is the flow recorded in 1973 of 781,000 ft^3/s. The water-surface elevation used was 27.3 ft above NGVD of 1929 (table 34). A distributary channel, locally known as the Whiskey Bay Pilot Channel, forms from the main channel of the Atchafalaya River about 3 mi upstream of Interstate 10. A detailed simulation of the distribution of flows between the two channels requires hydraulic modeling that is beyond the scope of this project. For the

Photograph source: Louisiana Department of Transportation and Development, 3/24/92

Figure 69. Aerial photograph of the Interstate Highway 10 crossing of the Atchafalaya River near Henderson, Louisiana.

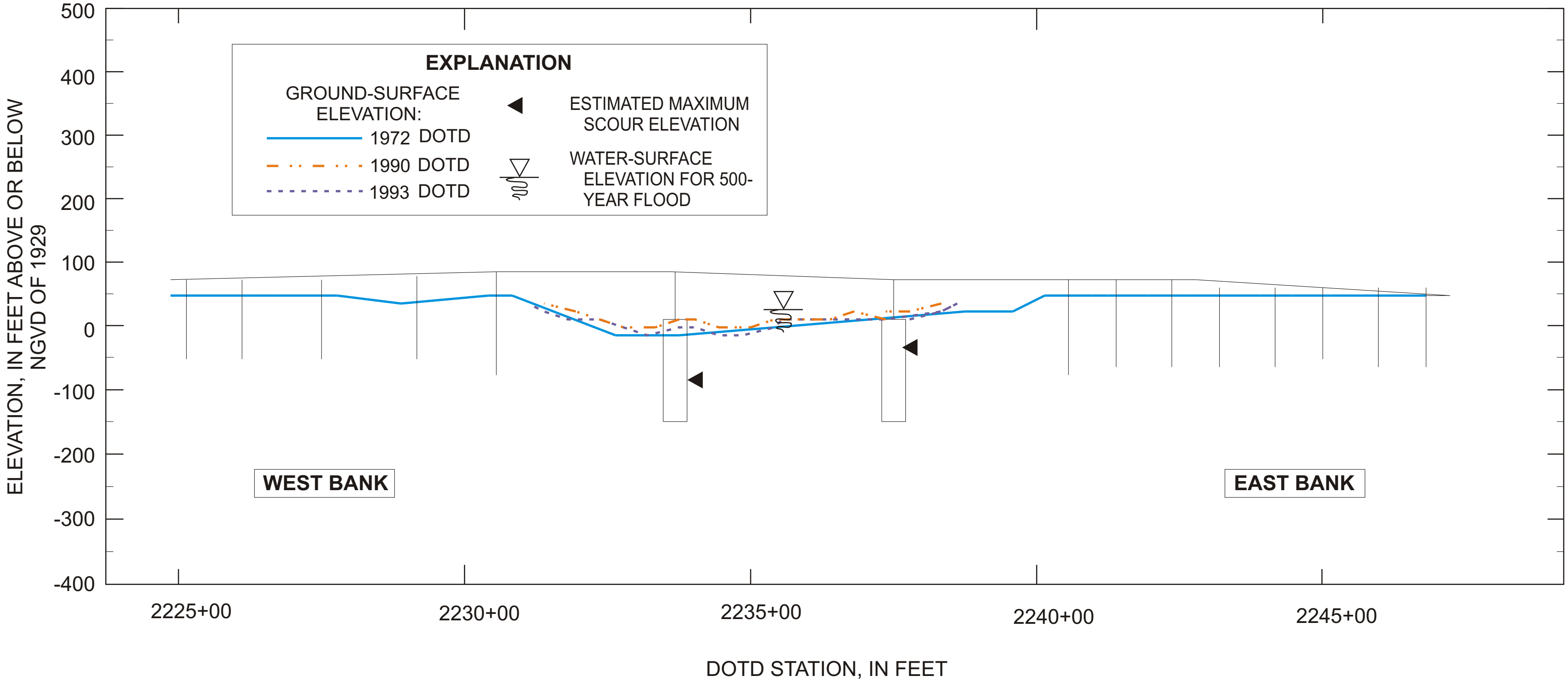


Figure 70. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 10 crossing of the Atchafalaya River near Henderson, Louisiana.

Photo source: Louisiana Department of Transportation and Development, 3/24/92

Figure 71. Aerial photograph of the Interstate Highway 10 crossing of the Whiskey Bay Pilot Channel near Henderson-Grosse Tete, Louisiana.

purposes of estimating pier scour, the design discharge was apportioned to each opening based on flow area. Most of the highway crossing is elevated on piers, with relatively little earthen embankment constricting flow through the flood plain. In consideration of the small degree of encroachment, and hydraulic approximations used, no contraction scour estimates were performed at this site.

Pier Scour

For the evaluation of pier scour, values for y_1 at each pier were based on the DOTD hydrographic survey of 1993. Values for K_1=1.0, K_2=1.0, K_3=1.1, and K_4=1.0 were based on DOTD bridge plans, site geometry, and anticipated bed conditions. The Froude number at the pier locations is based upon the value of depth and velocity computed using WSPRO. The velocities at the pier locations ranted from 1.6 to 5.7 ft/s. The maximum computed scour depth was 43 ft for the pier at DOTD station 2500+30 (table 34, fig. 72). The channel-bed elevation of the computed scour hole is about 97 ft below NGVD of 1929.

Table 34. Scour data for Interstate Highway 10 crossing of Whiskey Bay Pilot Channel near Henderson-Grosse Tete, Louisiana

[DOTD, Louisiana Department of Transportation and Development; water-surface elevation is 27.3 feet above NGVD of 1929; K_2, dimensionless correction factor for angle of flow attack; K_3=1.1; ft, feet; ft/s, foot per second; pile tip elevations scaled from DOTD bridge plans; NA, not applicable]

DOTD station	Ground elevation (ft above NGVD of 1929)	Pier shape	K_2	Pier width (ft)	Velocity (ft/s)	Local or pier scour (ft)	Contraction scour (ft)	Scour elevation (ft above or below NGVD of 1929)	Pile tip elevation (ft above or below NGVD of 1929)
2491+80	10	Round	1.0	38	1.6	20	0	-10	-140
2496+05	-41	Round	1.0	38	5.2	40	0	-81	-140
2500+30	-54	Round	1.0	38	5.7	43	0	-97	-140
2504+97	6	Round	1.0	38	1.8	22	0	-16	-140

Channel Stability

Cross section information is shown in figure 72 for the years 1967, 1989, and 1993. The surveys indicate lowering of the channel bed between stations 2500+30 and 2504+97 between the 1967 survey and the 1989 survey. This change in the geometry of the channel occurred during the construction of the highway crossing (Brice and Blodgett, 1978, p. 388). There is little change indicated between the 1989 and 1993 surveys.

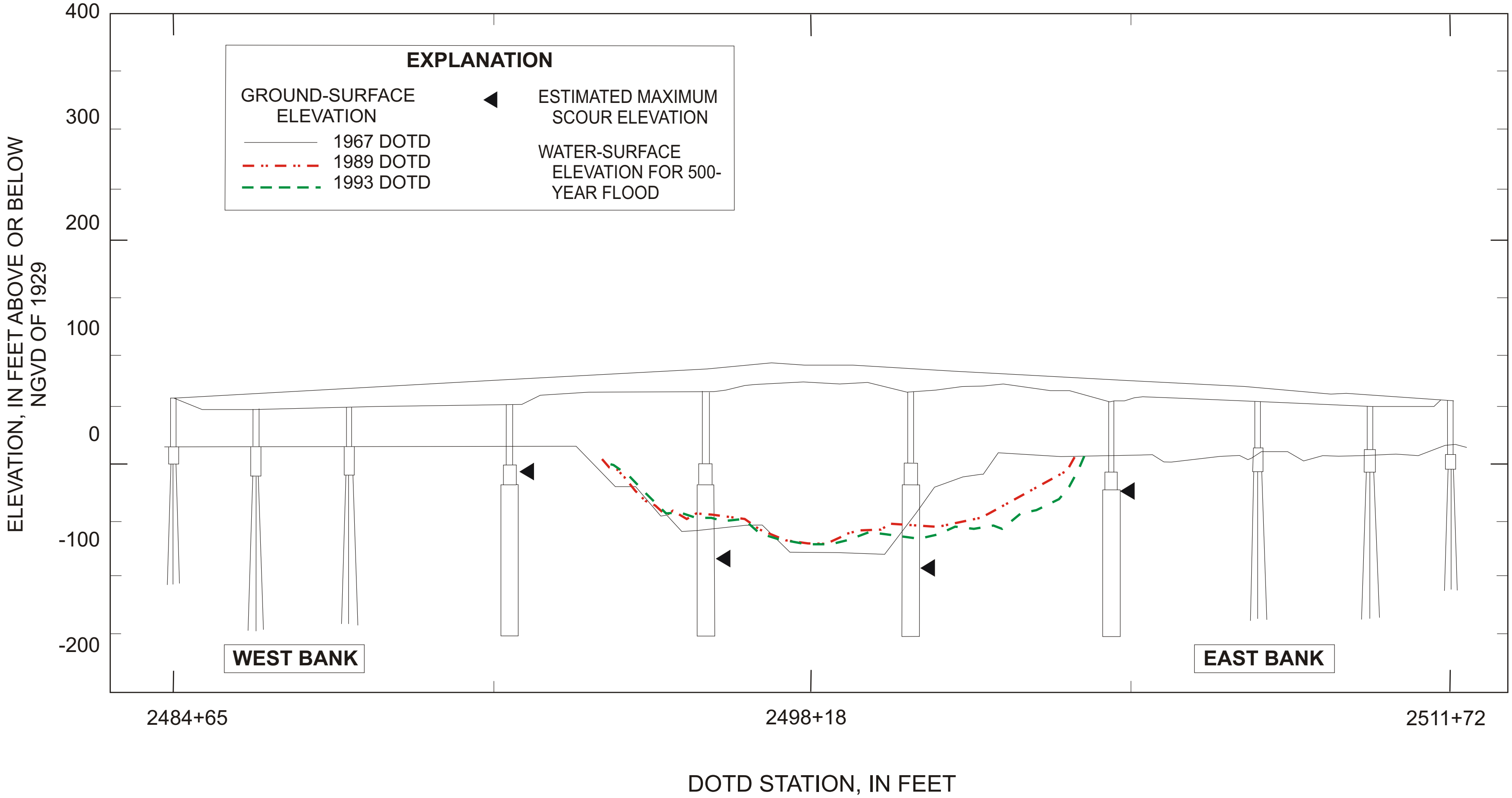


Figure 72. Bridge schematic, comparative cross sections, and scour estimates at the Interstate Highway 10 crossing of the Whiskey Bay Pilot Channel near Henderson-Grosse Tete, Louisiana.

SUMMARY

Maximum pier and contraction scour estimates at 36 bridges that cross streams in northeastern and southern (excluding the Florida Parishes area) Louisiana were computed using methodologies outlined by the Federal Highway Administration and information in Louisiana Department of Transportation and Development (DOTD) and U.S. Geological Survey files. The selected highway crossings were located over the Mississippi, Ouachita, Tensas, Black, Calcasieu, Sabine, and Atchafalaya Rivers; Inner Harbor Navigation Canal; and Whiskey Bay Pilot Channel.

Maximum estimated scour elevation was not below the known as-built pile tip elevation shown on DOTD bridge plans for all but one site. Maximum scour estimates were less than 10 feet below the pile tip elevations scaled from DOTD bridge plans at two piers of the I-10 crossing of the Sabine River near Vinton. In some instances marine traffic fenders are in place, which may reduce the potential scour at the pier. The maximum estimated pier scour among the sites ranged from 4 to 77 feet. Estimates of contraction scour generally were not substantial in magnitude or were not applicable due to site characteristics at all but four sites. For sites along the Mississippi River, the maximum estimated pier scour was 77 ft at U.S Highway 190. Contraction scour estimation is not applicable for conditions at sites along the Mississippi River where levees limit flood-plain flow. For sites along the Ouachita and Tensas Rivers, the maximum estimated pier scour was 19 ft. The Black River at U.S. Highway 84 had pier scour estimates ranging from 5 to 22 ft. For sites along the Calcasieu River, the maximum estimated pier scour was 24 ft at Interstate Highway 10. Of the two Sabine River sites, the maximum pier scour estimate was 33 ft at Louisiana Highway 12. At the Interstate Highway 10 crossing of the Atchafalaya River, the maximum pier scour estimate was 57 ft.

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