LEVEL II SCOUR ANALYSIS FOR BRIDGE 10 (HANCTH00010010) on TOWN HIGHWAY 1, crossing the WHITE RIVER, HANCOCK, VERMONT

U.S. Geological Survey
Open-File Report 96-570

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

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By SCOTT A. OLSON and MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1996

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Velocity and Flow	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	MC	main channel
D_{50}	median diameter of bed material	RAB	right abutment
DS	downstream	RABUT	face of right abutment
elev.	elevation	RB	right bank
f/p	flood plain	ROB	right overbank
ft^2	square feet	RWW	right wingwall
ft/ft	feet per foot	TH	town highway
JCT	junction	UB	under bridge
LAB	left abutment	US	upstream
LABUT	face of left abutment	USGS	United States Geological Survey
LB	left bank	VTAOT	Vermont Agency of Transportation
LOB	left overbank	WSPRO	water-surface profile model

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

In the appendices, the above abbreviations may be combined. For example, USLB would represent upstream left bank.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 10 (HANCTH00010010) ON TOWN HIGHWAY 1, CROSSING THE WHITE RIVER, HANCOCK, VERMONT

_By_ Scott A. Olson and Michael A. Ivanoff

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure HANCTH00010010 on town highway 1 crossing the White River, Hancock, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province of central Vermont. The 59.8-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is primarily grass with trees and brush on the immediate channel banks.

In the study area, the White River has a sinuous channel with a slope of approximately 0.005 ft/ft, an average channel top width of 104 ft and an average channel depth of 6 ft. The predominant channel bed materials are gravel and cobble with a median grain size (D_{50}) of 98.9 mm (0.325 ft). The geomorphic assessment at the time of the Level I and Level II site visit on November 15, 1994, indicated that the reach was stable.

The town highway 1 crossing of the White River is a 91-ft-long, two-lane bridge consisting of one 89-foot steel-beam span (Vermont Agency of Transportation, written communication, August 26, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is 0 degrees. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows was 0.0 feet. Abutment scour ranged from 13.1 to 17.1 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled "Scour Results". Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives "excessively conservative estimates of scour depths" (Richardson and others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Hancock, VT. Quadrangle, 1:24,000, 1970

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number HANCTH00010010 **Stream** White River

County Addison **Road** TH1 **District** 4

Description of Bridge

Bridge length 91 **ft** **Bridge width** 19.3 **ft** **Max span length** 89 **ft**

Alignment of bridge to road (on curve or straight) Slight curve on left road approach.

Abutment type Vertical, concrete **Embankment type** Sloping

Stone fill on abutment? Yes, left **Date of inspection** 11/15/94

Description of stone fill Type-2 stone fill (less than 36 inches diameter) along the toe of the left abutment and upstream left wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. The left abutment has an exposed footing.

Y 15

Is bridge skewed to flood flow according to Y **survey?** **Angle**

The bridge is located on a mild channel bend. The bend will cause higher flows to impact the right abutment.

Debris accumulation on bridge at time of Level I or Level II site visit:

	Date of inspection	Percent of channel blocked horizontally	Percent of channel blocked vertically
	11/15/94	0	0
Level I	11/15/94	0	0
Level II			

Potential for debris Low.

Describe any features near or at the bridge that may affect flow (include observation date) --

Description of the Geomorphic Setting

General topography The channel is located in an approximately 1,000-foot-wide upland valley with flat to slightly irregular flood plain and steep valley walls on both sides.

Geomorphic conditions at bridge site: downstream (DS), upstream (US)

Date of inspection 11/15/94

DS left: Flood plain to steep valley wall.

DS right: Flood plain to steep valley wall.

US left: Flood plain to steep valley wall.

US right: Flood plain to steep valley wall.

Description of the Channel

Average top width 104 *ft*

Average depth 6 *ft*

Predominant bed material Gravel / Cobbles

Bank material Gravel/Cobbles

Sinuous but stable with alluvial channel boundaries.

11/15/94

Vegetative co Grass with trees and brush on immediate channel bank.

DS left: Grass and paved roadway with trees and brush on immediate bank.

DS right: Grass with trees and brush on immediate channel bank.

US left: Grass and paved roadway with trees and brush on immediate bank.

US right: Y

Do banks appear stable? -- ***If not, describe location and type of instability and date of observation.***

--

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 59.8 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None.

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi***^{2}

Is there a lake/p -- No

Calculated Discharges

Q100 13,000 ***ft***^{3}***/s*** ***Q500*** 19,000 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on a drainage area relationship [(59.8/56.7)exp 0.7] with a river location having flood frequency estimates in the Flood Insurance Study for the Town of Hancock (Federal Emergency Management Agency, 1991). According to the Flood Insurance Study, a site with a drainage area of 56.7 square miles on the White River has 100- and 500-year discharges of 12,500 and 18,300 cfs, respectively.

Description of the Water-Surface Profile Model (WSPRO) Analysis

Datum for WSPRO analysis (USGS survey, sea level, VTAOT plans) USGS survey

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the right abutment (elev. 500.39 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment (elev. 501.36 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-93	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	102	2	Modelled Approach section (Templated from APTEM)
APTEM	144	1	Approach section as surveyed (Used as a template)

[1] For location of cross-sections see plan-view sketch included with Level I field form, Appendix E.
For more detail on how cross-sections were developed see WSPRO input file.

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Shearman and others, 1986, and Shearman, 1990). The analyses reported herein reflect conditions existing at the site at the time of the study. Furthermore, in the development of the model it was necessary to assume no accumulation of debris or ice at the site. Results of the hydraulic model are presented in the Bridge Hydraulic Summary, Appendix B, and figure 7.

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.045 to 0.050, and overbank "n" values ranged from 0.035 to 0.085.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0050 ft/ft which was measured from the 100-year water-surface profile downstream of the bridge in the Flood Insurance Study for the Town of Hancock (Federal Emergency Management Agency, 1991).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0069 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.1 *ft*
Average low steel elevation 497.7 *ft*

100-year discharge 13,000 *ft³/s*
Water-surface elevation in bridge opening 498.3 *ft*
Road overtopping? Y *Discharge over road* 4,980 *ft³/s*
Area of flow in bridge opening 811 *ft²*
Average velocity in bridge opening 9.7 *ft/s*
Maximum WSPRO tube velocity at bridge 11.1 *ft/s*

Water-surface elevation at Approach section with bridge 500.8
Water-surface elevation at Approach section without bridge 499.1
Amount of backwater caused by bridge 1.7 *ft*

500-year discharge 19,000 *ft³/s*
Water-surface elevation in bridge opening 498.3 *ft*
Road overtopping? Y *Discharge over road* 11,000 *ft³/s*
Area of flow in bridge opening 811 *ft²*
Average velocity in bridge opening 9.5 *ft/s*
Maximum WSPRO tube velocity at bridge 10.7 *ft/s*

Water-surface elevation at Approach section with bridge 502.1
Water-surface elevation at Approach section without bridge 500.5
Amount of backwater caused by bridge 1.6

Incipient overtopping discharge 7,880 *ft³/s*
Water-surface elevation in bridge opening 496.1 *ft*
Area of flow in bridge opening 681 *ft²*
Average velocity in bridge opening 11.6 *ft/s*
Maximum WSPRO tube velocity at bridge 13.4 *ft/s*

Water-surface elevation at Approach section with bridge 498.2
Water-surface elevation at Approach section without bridge 497.3
Amount of backwater caused by bridge 0.9 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour was computed by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146) for the 100-year and 500-year discharges, where orifice flow was present at the bridge. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). The results of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) were also computed for the 100-year and 500-year discharges and can be found in appendix F. Contraction scour was computed by use of the Laursen's clear-water contraction scour equation for the incipient overtopping discharge. For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour.

Abutment scour for the right abutment was computed by use of the Froehlich equation (Richardson and others, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour at the left abutment was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.0
Depth to armoring	1.6	1.2	7.2
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	13.3	13.1	10.1
Right abutment	15.9	17.1	13.2
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.9	1.7	2.6
Right abutment	1.9	1.7	2.6
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--
	--	--	--

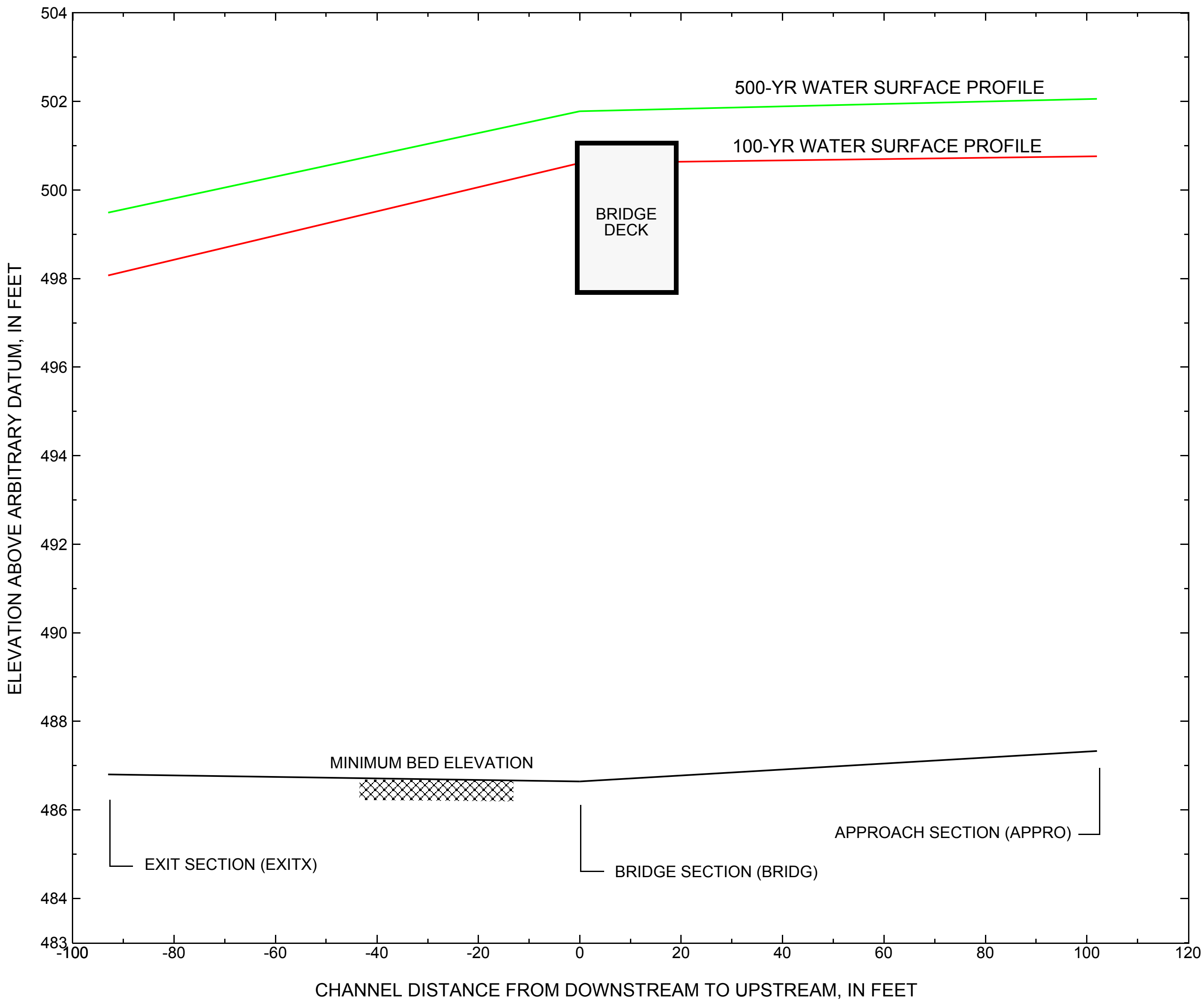

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure HANCTH00010010 on town highway 1, crossing the White River, Hancock, Vermont.

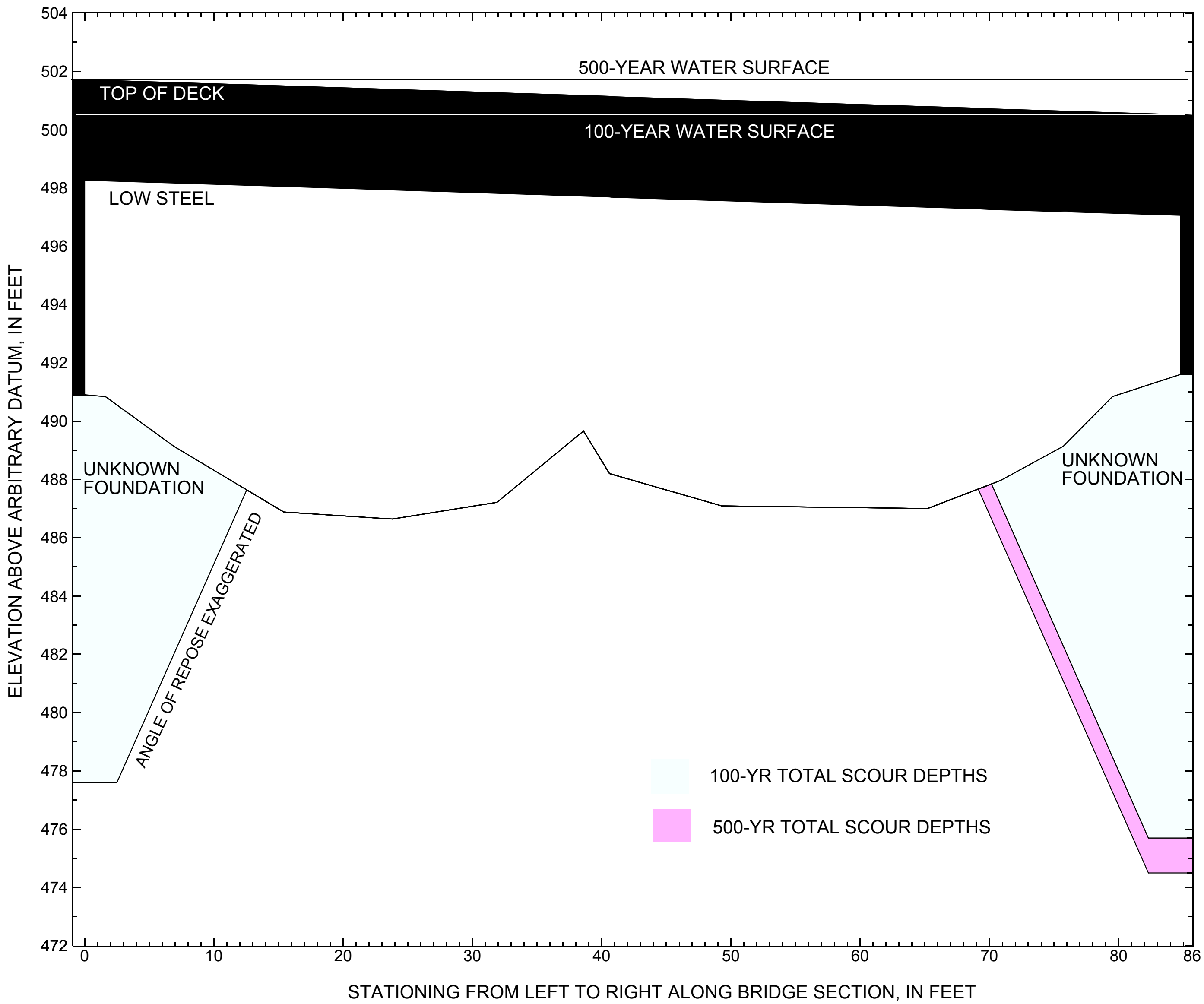

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure HANCTH00010010 on town highway 1, crossing the White River, Hancock, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HANCTH00010010 on Town Highway 1, crossing the White River, Hancock, Vermont.

[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 13,000 cubic-feet per second											
Left abutment	0.0	--	498.3	--	490.9	0.0	13.3	--	13.3	477.6	--
Right abutment	84.8	--	497.1	--	491.6	0.0	15.9	--	15.9	475.7	--

1. Measured along the face of the most constricting side of the bridge.
2. Arbitrary datum for this study.

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure HANCTH00010010 on Town Highway 1, crossing the White River, Hancock, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 19,000 cubic-feet per second											
Left abutment	0.0	--	498.3	--	490.9	0.0	13.1	--	13.1	477.8	--
Right abutment	84.8	--	497.1	--	491.6	0.0	17.1	--	17.1	474.5	--

1. Measured along the face of the most constricting side of the bridge.
2. Arbitrary datum for this study.

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U.S. Geological Survey, 1970, Hancock, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File hanc010.wsp
T2        Hydraulic analysis for structure HANC010
T3        Hydraulic analysis of HANC010 over the White River
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
Q          13000 19000 7880
SK         0.0050 0.0050 0.0050
*
XS   EXITX    -93
GR         -239.4, 507.63   -195.2, 493.99    -70.3, 494.28    -35.4, 493.47
GR          -20.9, 494.87     -6.5, 493.72      0.0, 491.83      3.4, 489.16
GR           13.8, 487.25     46.0, 487.59     54.3, 486.80     56.8, 487.14
GR           67.0, 487.39     76.5, 489.20     84.3, 491.96     94.1, 494.71
GR          107.4, 494.47    125.3, 493.28    134.6, 497.60    163.7, 498.02
GR          194.7, 496.41    464.6, 500.53    464.6, 507
N           0.070        0.045        0.050
SA                  -6.5         94.1
*
XS   FULLV     0 * * * 0.0050
*
BR   BRIDG     0 497.7
GR            0.0, 498.27      0.2, 490.85      1.6, 490.84      6.9, 489.13
GR           15.4, 486.88     23.8, 486.64     31.9, 487.21     38.6, 489.66
GR           40.6, 488.20     49.3, 487.09     65.2, 487.00     70.9, 487.97
GR           75.7, 489.13     79.5, 490.84     84.2, 491.63     84.8, 497.07
GR            0.0, 498.27
N            0.045
CD           1 28.3 * * 50 8.4
*
XR   RDWAY     8 19.3
GR         -277.7, 507.17   -201.4, 499.93   -128.9, 498.13    -62.0, 499.50
GR           -0.9, 501.61     -0.9, 503.11     85.6, 502.13     85.6, 500.63
GR          147.0, 499.01    175.4, 498.56    237.5, 497.89    464.6, 500.53
GR          464.6, 507
*
XT   APTEM    144
GR         -239.4, 507.63   -222.3, 504.44   -171.6, 501.16   -137.8, 496.94
GR          -63.4, 496.27    -23.4, 494.85     -5.6, 495.38      0.0, 492.27
GR            8.4, 489.32     15.9, 487.70     26.9, 487.62     35.5, 488.11
GR           45.1, 488.34     66.9, 489.16     74.3, 491.51     87.5, 494.12
GR          105.6, 493.45    129.6, 493.10    153.5, 498.29    185.2, 498.99
GR          235.9, 497.84    464.6, 500.53    464.6, 507
*
AS   APPRO    102
GT          -0.29
N           0.035        0.085        0.050        0.075
SA                 -63.4        -5.6          87.5
*
HP 1 BRIDG   498.27 1 498.27
HP 2 BRIDG   498.27 * * 7889
HP 2 RDWAY   500.61 * * 4976
HP 1 APPRO   500.76 1 500.76
HP 2 APPRO   500.76 * * 13000
*
HP 1 BRIDG   498.27 1 498.27
HP 2 BRIDG   498.27 * * 7657
HP 2 RDWAY   501.78 * * 11031
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File hanc010.wsp
        Hydraulic analysis for structure HANC010
        Hydraulic analysis of HANC010 over the White River
           *** RUN DATE & TIME: 07-10-96  07:07
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     811.   72136.     0.   184.                          0.
   498.27          811.   72136.     0.   184.  1.00     0.    85.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.27     0.0    84.8   810.5   72136.    7889.   9.73
X STA.         0.0        7.2       11.6       15.3       18.5       21.7
  A(I)             57.7       42.4       39.4       36.0       36.2
  V(I)             6.83       9.30      10.00      10.96      10.88

X STA.        21.7       24.9       28.2       31.5       35.3       40.2
  A(I)             35.8       35.7       35.7       38.6       42.9
  V(I)            11.01      11.03      11.06      10.23       9.20

X STA.        40.2       44.2       47.9       51.4       55.0       58.6
  A(I)             38.3       37.6       36.4       37.3       38.2
  V(I)            10.31      10.49      10.83      10.58      10.33

X STA.        58.6       62.2       66.0       70.2       75.2       84.8
  A(I)             37.5       38.4       41.3       44.7       60.4
  V(I)            10.52      10.26       9.55       8.83       6.53

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.61  -208.6   464.6   821.3   29220.    4976.   6.06
X STA.      -208.6     -153.8     -132.1     -114.5      -91.2      129.7
  A(I)             62.9       46.2       41.6       45.2       83.8
  V(I)             3.96       5.39       5.98       5.50       2.97

X STA.       129.7      157.4      175.3      190.6      203.7      216.1
  A(I)             41.2       34.1       32.6       30.1       30.0
  V(I)             6.04       7.29       7.62       8.27       8.31

X STA.       216.1      227.5      238.2      249.4      261.4      274.7
  A(I)             29.1       28.6       29.6       30.2       31.4
  V(I)             8.56       8.70       8.41       8.23       7.92

X STA.       274.7      290.4      308.4      331.4      363.6      464.6
  A(I)             34.4       36.1       40.5       46.5       67.3
  V(I)             7.23       6.90       6.15       5.35       3.70

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     102.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     398.   40591.   107.   108.                       4355.
             2     325.   18030.    58.    58.                       4378.
             3    1061.  157616.    93.    95.                      20313.
             4    1083.   43358.   377.   378.                      10409.
   500.76         2867.  259595.   635.   639.  1.89  -171.   465.  25122.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     102.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.76  -170.7   464.6  2866.8  259595.   13000.   4.53
X STA.      -170.7     -117.7      -90.3      -66.3      -25.2        2.1
  A(I)            152.1      121.1      111.4      222.5      176.0
  V(I)             4.27       5.37       5.84       2.92       3.69

X STA.         2.1       10.8       17.2       23.0       29.0       35.0
  A(I)             96.0       82.8       77.8       79.8       78.3
  V(I)             6.77       7.85       8.35       8.14       8.30

X STA.        35.0       41.3       47.6       54.2       60.9       68.2
  A(I)             81.5       80.5       82.8       82.0       86.9
  V(I)             7.98       8.08       7.85       7.93       7.48

X STA.        68.2       77.9       97.8      128.6      233.0      464.6
  A(I)             97.5      148.9      236.2      337.0      435.8
  V(I)             6.67       4.37       2.75       1.93       1.49
```

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        U.S. Geological Survey WSPRO Input File hanc010.wsp
        Hydraulic analysis for structure HANC010
        Hydraulic analysis of HANC010 over the White River
           *** RUN DATE & TIME: 07-10-96  07:07
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     811.   72136.     0.   184.                           0.
   498.27          811.   72136.     0.   184.  1.00     0.    85.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.27     0.0    84.8   810.5   72136.    7657.   9.45
X STA.         0.0         7.2        11.6        15.3        18.5        21.7
  A(I)             57.7        42.4        39.4        36.0        36.2
  V(I)             6.63        9.02        9.71       10.64       10.56

X STA.        21.7        24.9        28.2        31.5        35.3        40.2
  A(I)             35.8        35.7        35.7        38.6        42.9
  V(I)            10.69       10.71       10.74        9.93        8.93

X STA.        40.2        44.2        47.9        51.4        55.0        58.6
  A(I)             38.3        37.6        36.4        37.3        38.2
  V(I)            10.01       10.18       10.51       10.27       10.03

X STA.        58.6        62.2        66.0        70.2        75.2        84.8
  A(I)             37.5        38.4        41.3        44.7        60.4
  V(I)            10.21        9.96        9.27        8.57        6.34

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.
         WSEL     LEW     REW    AREA        K        Q    VEL
       501.78  -220.9   464.6  1500.4   75927.   11031.   7.35
X STA.      -220.9      -159.4      -132.3      -109.1       -78.6       105.7
  A(I)            117.6        87.7        80.3        89.5       144.0
  V(I)             4.69        6.29        6.87        6.17        3.83

X STA.       105.7       141.5       164.3       183.4       200.3       216.2
  A(I)             77.2        65.0        60.8        57.6        56.9
  V(I)             7.15        8.48        9.07        9.58        9.69

X STA.       216.2       231.1       245.5       260.4       277.0       295.1
  A(I)             55.6        55.5        55.0        58.6        60.5
  V(I)             9.91        9.94       10.03        9.42        9.12

X STA.       295.1       315.7       339.3       367.7       404.5       464.6
  A(I)             63.9        67.0        72.2        79.5        96.2
  V(I)             8.64        8.24        7.64        6.94        5.73

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     102.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     550.   62226.   127.   127.                        6504.
             2     400.   25494.    58.    58.                        5980.
             3    1182.  188720.    93.    95.                       23887.
             4    1573.   80618.   377.   380.                       18227.
   502.06         3705.  357058.   655.   659.  1.79  -190.   465.  37416.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     102.
         WSEL     LEW     REW    AREA        K        Q    VEL
       502.06  -190.0   464.6  3704.7  357058.   19000.   5.13
X STA.      -190.0      -123.4       -97.0       -73.9       -40.0        -3.7
  A(I)            201.5       149.3       135.9       215.4       262.5
  V(I)             4.71        6.36        6.99        4.41        3.62

X STA.        -3.7         8.5        16.4        23.3        30.3        37.4
  A(I)            132.0       109.9       101.2       101.9       102.8
  V(I)             7.20        8.64        9.39        9.32        9.24

X STA.        37.4        44.8        52.4        60.2        68.5        79.9
  A(I)            103.9       105.5       106.5       109.2       126.5
  V(I)             9.14        9.01        8.92        8.70        7.51

X STA.        79.9       103.0       131.7       212.3       297.7       464.6
  A(I)            199.8       260.0       357.2       356.4       467.5
  V(I)             4.76        3.65        2.66        2.67        2.03
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        U.S. Geological Survey WSPRO Input File hanc010.wsp
        Hydraulic analysis for structure HANC010
        Hydraulic analysis of HANC010 over the White River
           *** RUN DATE & TIME: 07-10-96  07:07
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     681.  83196.    85.    96.                       10958.
   496.14          681.  83196.    85.    96.  1.00     0.    85.  10958.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       496.14     0.1    84.7   680.9   83196.    7880.  11.57
X STA.         0.1        8.7       13.1       16.8       20.1       23.3
  A(I)            53.1       36.1       33.2       30.8       30.4
  V(I)            7.42      10.90      11.87      12.78      12.96

X STA.        23.3       26.4       29.7       33.1       37.5       42.4
  A(I)            29.5       29.8       30.9       33.2       36.3
  V(I)           13.37      13.23      12.75      11.85      10.87

X STA.        42.4       46.0       49.4       52.7       56.0       59.4
  A(I)            30.4       30.1       30.0       30.0       30.9
  V(I)           12.95      13.09      13.13      13.14      12.76

X STA.        59.4       62.8       66.2       70.1       74.8       84.7
  A(I)            30.5       31.4       33.7       36.5       54.1
  V(I)           12.93      12.56      11.70      10.80       7.28

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     102.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     146.    8764.    86.    87.                        1072.
             2     174.    6380.    58.    58.                        1719.
             3     818.  102153.    93.    95.                       13749.
             4     298.    9299.   150.   151.                        2376.
   498.15         1435.  126596.   388.   390.  1.67  -150.   287.  12130.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     102.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.15  -149.8   286.9  1435.1  126596.    7880.   5.49
X STA.      -149.8      -80.1      -24.8        3.3        9.9       14.8
  A(I)           110.5      145.3      111.9       56.3       48.8
  V(I)            3.57       2.71       3.52       7.00       8.07

X STA.        14.8       19.1       23.3       27.4       31.7       36.0
  A(I)            46.2       45.6       43.9       45.3       45.6
  V(I)            8.53       8.65       8.97       8.70       8.63

X STA.        36.0       40.5       44.9       49.6       54.5       59.5
  A(I)            45.7       45.3       46.8       48.3       47.7
  V(I)            8.61       8.70       8.42       8.15       8.26

X STA.        59.5       64.7       70.5       79.8      102.7      286.9
  A(I)            49.9       51.8       63.2      109.1      227.8
  V(I)            7.90       7.61       6.23       3.61       1.73
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        U.S. Geological Survey WSPRO Input File hanc010.wsp
        Hydraulic analysis for structure HANC010
        Hydraulic analysis of HANC010 over the White River
           *** RUN DATE & TIME: 07-10-96  07:07

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******  -208.    1977.  1.22 *****  499.29  496.80  13000.  498.07
      -93. ******   303.  183676.  1.82 ***** *******    0.80    6.58

FULLV:FV      93.  -209.    1994.  1.20  0.46  499.77 *******  13000.  498.57
        0.    93.   306.  185484.  1.82  0.00    0.02    0.79    6.52
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80     0.89     499.04     497.55

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   498.07     507.34    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   498.07     507.34     497.55

APPRO:AS     102.  -157.    1854.  1.40  0.57  500.45  497.55  13000.  499.05
      102.   102.   364.  162229.  1.83  0.10    0.01    0.89    7.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   498.57     497.70

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      93.     0.     811.  1.47 *****  499.74  494.56   7889.  498.27
        0. ******    85.   72136.  1.00 ***** *******    0.56    9.73

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.70 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    83.  0.21  0.60  501.16   -0.01   4976.  500.61

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1546.   179.  -209.   -30.   2.5   1.4   6.6   6.0   2.0   3.1
   RT:   3430.   378.    86.   465.   2.7   1.5   6.6   6.0   2.0   3.1

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

APPRO:AS      74.  -171.    2867.  0.60  0.50  501.37  497.55  13000.  500.76
      102.    85.   465.  259663.  1.89  0.00   -0.01    0.52    4.53

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -93.  -208.   303.  13000.  183676.    1977.    6.58  498.07
   FULLV:FV       0.  -209.   306.  13000.  185484.    1994.    6.52  498.57
   BRIDG:BR       0.     0.    85.   7889.   72136.     811.    9.73  498.27
   RDWAY:RG       8.******* 1546.   4976.******************    1.00  500.61
   APPRO:AS     102.  -171.   465.  13000.  259663.    2867.    4.53  500.76

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    496.80    0.80  486.80  507.63************  1.22  499.29  498.07
   FULLV:FV  ********    0.79  487.26  508.10  0.46  0.00  1.20  499.77  498.57
   BRIDG:BR    494.56    0.56  486.64  498.27************  1.47  499.74  498.27
   RDWAY:RG  ****************  497.89  507.17  0.21******  0.60  501.16  500.61
   APPRO:AS    497.55    0.52  487.33  507.34  0.50  0.00  0.60  501.37  500.76
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        U.S. Geological Survey WSPRO Input File hanc010.wsp
        Hydraulic analysis for structure HANC010
        Hydraulic analysis of HANC010 over the White River
           *** RUN DATE & TIME: 07-10-96  07:07

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******  -213.    2777.  1.33 *****  500.83  498.51  19000.  499.49
      -93. ******   397.  268478.  1.83 ***** *******    0.76    6.84

FULLV:FV      93.  -213.    2798.  1.31  0.46  501.31 *******  19000.  499.99
        0.    93.   399.  270856.  1.83  0.00    0.02    0.76    6.79
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.83     500.49     499.79

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   499.49     507.34    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   499.49     507.34     499.79

APPRO:AS     102.  -168.    2685.  1.49  0.57  501.96  499.79  19000.  500.47
      102.   102.   465.  240100.  1.91  0.09    0.00    0.84    7.08
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   499.99     497.70

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      93.     0.     811.  1.39 *****  499.66  494.43   7657.  498.27
        0. ******    85.   72136.  1.00 ***** *******    0.54    9.45

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.70 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    83.  0.23  0.73  502.56   -0.02  11031.  501.78

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   3600.   220.  -221.    -1.   3.6   2.2   8.2   7.3   3.0   3.1
   RT:   7431.   379.    86.   465.   3.9   2.7   8.5   7.4   3.4   3.1

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

APPRO:AS      74.  -190.    3705.  0.73  0.63  502.79  499.79  19000.  502.06
      102.    89.   465.  357097.  1.79  0.00   -0.02    0.51    5.13

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -93.  -213.   397.  19000.  268478.    2777.    6.84  499.49
   FULLV:FV       0.  -213.   399.  19000.  270856.    2798.    6.79  499.99
   BRIDG:BR       0.     0.    85.   7657.   72136.     811.    9.45  498.27
   RDWAY:RG       8.******* 3600.  11031.******************    1.00  501.78
   APPRO:AS     102.  -190.   465.  19000.  357097.    3705.    5.13  502.06

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    498.51    0.76  486.80  507.63************  1.33  500.83  499.49
   FULLV:FV  ********    0.76  487.26  508.10  0.46  0.00  1.31  501.31  499.99
   BRIDG:BR    494.43    0.54  486.64  498.27************  1.39  499.66  498.27
   RDWAY:RG  ****************  497.89  507.17  0.23******  0.73  502.56  501.78
   APPRO:AS    499.79    0.51  487.33  507.34  0.63  0.00  0.73  502.79  502.06
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        U.S. Geological Survey WSPRO Input File hanc010.wsp
        Hydraulic analysis for structure HANC010
        Hydraulic analysis of HANC010 over the White River
           *** RUN DATE & TIME: 07-10-96  07:07

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******  -203.    1242.  1.03 *****  497.29  495.33   7880.  496.27
      -93. ******   132.  111427.  1.64 ***** *******    0.74    6.35

FULLV:FV      93.  -203.    1245.  1.02  0.46  497.76 *******   7880.  496.74
        0.    93.   132.  111712.  1.64  0.00    0.00    0.74    6.33
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS     102.  -143.    1148.  1.08  0.56  498.35 *******   7880.  497.27
      102.   102.   150.  101884.  1.48  0.03    0.00    0.74    6.87
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   498.15       0.00     496.14     497.89

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

BRIDG:BR      93.     0.     681.  2.08  0.62  498.23  494.56   7880.  496.14
        0.    93.    85.   83269.  1.00  0.31    0.00    0.72   11.57

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  497.70 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

APPRO:AS      74.  -150.    1436.  0.78  0.46  498.93  495.63   7880.  498.15
      102.    78.   287.  126667.  1.67  0.25    0.01    0.65    5.49

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.711  0.205  100517.    -3.    81. ********

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

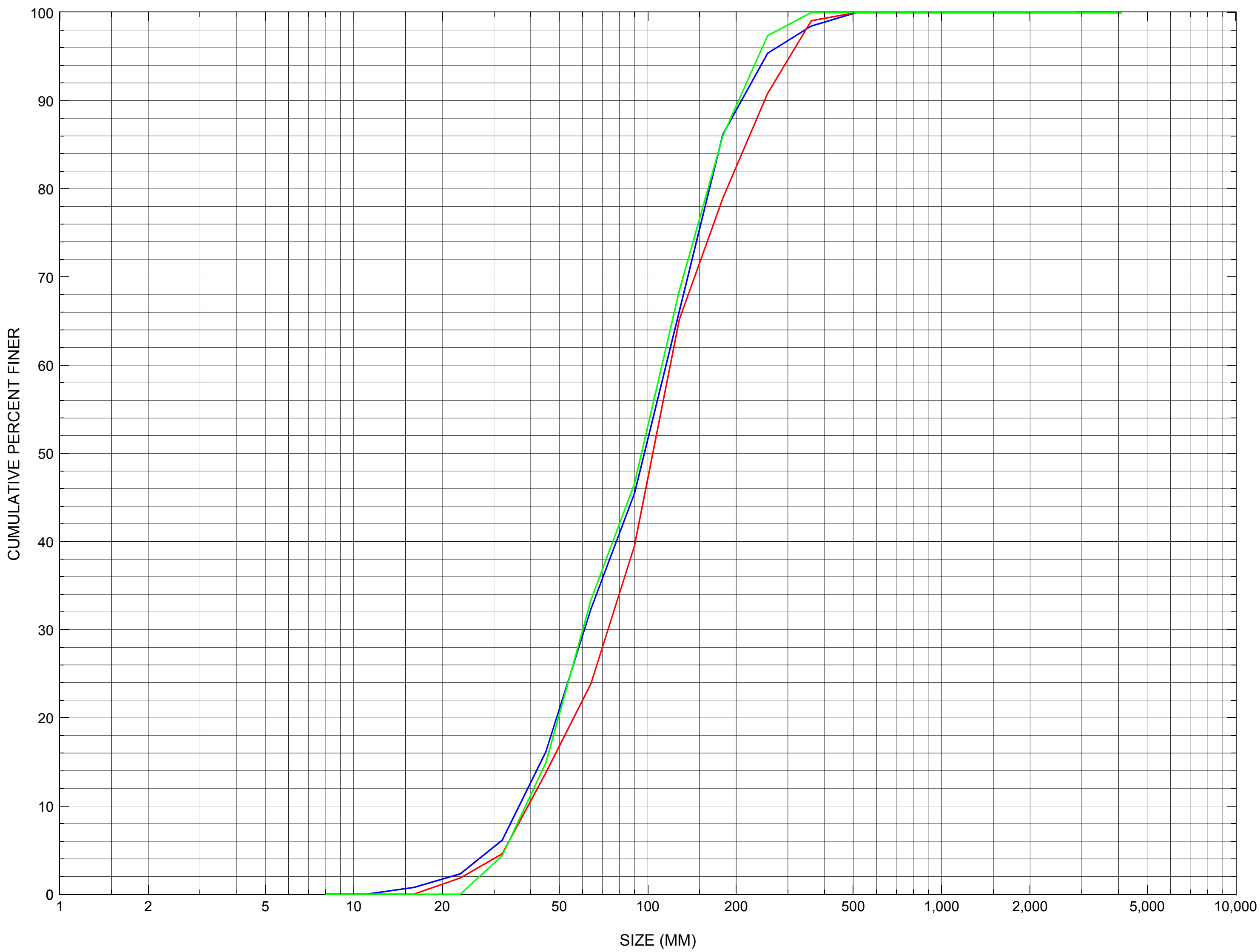
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -93.  -203.   132.   7880.  111427.    1242.    6.35  496.27
   FULLV:FV       0.  -203.   132.   7880.  111712.    1245.    6.33  496.74
   BRIDG:BR       0.     0.    85.   7880.   83269.     681.   11.57  496.14
   RDWAY:RG       8.**************      0.       0.       0.    1.00********
   APPRO:AS     102.  -150.   287.   7880.  126667.    1436.    5.49  498.15

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -3.    81.  100517.

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    495.33    0.74  486.80  507.63************  1.03  497.29  496.27
   FULLV:FV  ********    0.74  487.26  508.10  0.46  0.00  1.02  497.76  496.74
   BRIDG:BR    494.56    0.72  486.64  498.27  0.62  0.31  2.08  498.23  496.14
   RDWAY:RG  ****************  497.89  507.17  0.32******  0.78  498.61********
   APPRO:AS    495.63    0.65  487.33  507.34  0.46  0.25  0.78  498.93  498.15
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure HANCTH00010010, in Hancock, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HANCTH0010010

General Location Descriptive

Data collected by *(First Initial, Full last name)* M. IVANOFF

Date *(MM/DD/YY)* 08 / 26 / 94

Highway District Number *(I - 2; nn)* 04

County *(FIPS county code; I - 3; nnn)* 001

Town *(FIPS place code; I - 4; nnnnn)* 31525

Mile marker *(I - 11; nnn.nnn)* 000000

Waterway *(I - 6)* WHITE RIVER

Road Name *(I - 7):* -

Route Number TH010

Vicinity *(I - 9)* 0.01 MI TO JCT W VT100

Topographic Map Hancock

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43552

Longitude *(i - 17; nnnnn.n)* 72504

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10010800100108

Maintenance responsibility *(I - 21; nn)* 03

Maximum span length *(I - 48; nnnn)* 0089

Year built *(I - 27; YYYY)* 1939

Structure length *(I - 49; nnnnnn)* 000091

Average daily traffic, ADT *(I - 29; nnnnnn)* 000200

Deck Width *(I - 52; nn.n)* 193

Year of ADT *(I - 30; YY)* 90

Channel & Protection *(I - 61; n)* 7

Opening skew to Roadway *(I - 34; nn)* 00

Waterway adequacy *(I - 71; n)* 8

Operational status *(I - 41; X)* A

Underwater Inspection Frequency *(I - 92B; XYY)* N

Structure type *(I - 43; nnn)* 302

Year Reconstructed *(I - 106)* 0000

Approach span structure type *(I - 44; nnn)* 000

Clear span (*nnn.n ft*) -

Number of spans *(I - 45; nnn)* 001

Vertical clearance from streambed (*nnn.n ft*) 010.0

Number of approach spans *(I - 46; nnnn)* 0000

Waterway of full opening (*nnn.n ft*^{2}) -

Comments:

Structural report of 7/1/94 indicates that the concrete curtain walls have random stains and previous spalls have been patched. Cracks have been sealed with caulking. The downstream end of the right abutment and its downstream wingwall have a newer concrete facing. The left abutment has a newer concrete subfooting protected with stone fill. The waterway has a slight turn into the structure. Erosion not addressed. Settlement has possibly created the old cracks which now seems stabilized. No channel scour or drift/vegetation. Paved road approaches with no wash reported.

Bridge Hydrologic Data

Is there hydrologic data available? N if No, type ctrl-n h VTAOT Drainage area (mi^2): -

Terrain character: -

Stream character & type: -

-

Streambed material: STONE AND GRAVEL

Discharge Data (cfs): $Q_{2.33}$ - Q_{10} - Q_{25} -

Q_{50} - Q_{100} - Q_{500} -

Record flood date (MM / DD / YY): - / - / - Water surface elevation (ft): -

Estimated Discharge (cfs): - Velocity at Q - (ft/s): -

Ice conditions (Heavy, Moderate, Light) : - Debris (Heavy, Moderate, Light): -

The stage increases to maximum highwater elevation (Rapidly, Not rapidly): -

The stream response is (Flashy, Not flashy): -

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

-

-

-

-

-

-

Watershed storage area (in percent): -%

The watershed storage area is: - (1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (ft)	-	-	-	-	-
Velocity (ft / sec)	-	-	-	-	-

Long term stream bed changes: -

-

Is the roadway overtopped below the Q_{100}? (Yes, No, Unknown): U Frequency: -

Relief Elevation (ft): - Discharge over roadway at Q_{100} (ft^3/ sec): -

Are there other structures nearby? (Yes, No, Unknown): U If No or Unknown, type ctrl-n os

Upstream distance (miles): - Town: - Year Built: -

Highway No. : Structure No. : -- Structure Type: -

Clear span (ft): - Clear Height (ft): - Full Waterway (ft^2): -

Downstream distance (*miles*): - Town: - Year Built: -

Highway No. : - Structure No. : - Structure Type: -

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:

-
-
-
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 59.81 mi^2

Lake and pond area 0.04 mi^2

Watershed storage *(ST)* 0.1 %

Bridge site elevation 880 ft

Headwater elevation 3780 ft

Main channel length 10.54 mi

10% channel length elevation 900 ft

85% channel length elevation 1940 ft

Main channel slope *(S)* 131.56 ft / mi

Watershed Precipitation Data

Average site precipitation ______ in

Average headwater precipitation ______ in

Maximum 2yr-24hr precipitation event *(I24,2)* ______ in

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

Are plans available? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number -

Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:

NO BENCHMARK INFORMATION

Reference Point (*MSL, Arbitrary, Other*): - Datum (*NAD27, NAD83, Other*): -

Foundation Type: 4 (*1-Spreadfooting; 2-Pile; 3- Gravity; 4-Unknown*)

If 1: Footing Thickness ____ Footing bottom elevation: ____

If 2: Pile Type: ____ (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: ____

If 3: Footing bottom elevation: ____

Is boring information available? N *If no, type ctrl-n bi* Number of borings taken: -

Foundation Material Type: 3 (*1-regolith, 2-bedrock, 3-unknown*)

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS.

Cross-sectional Data

Is cross-sectional data available? N *If no, type ctrl-n xs*

Source (*FEMA, VTAOT, Other*)? -

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

Source (*FEMA, VTAOT, Other*)? -

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

U. S. Geological Survey
Bridge Field Data Collection and Processing Form

Qa/Qc Check by: **MAW** Date: **2/7/95**
Computerized by: **MAI** Date: **3/14/95**
Reviewd by: **SAO** Date: **8/12/96**

Structure Number **HANCTH00010010**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. IVANOFF** Date *(MM/DD/YY)* **11** / **15** / 19**94**

2. Highway District Number **04** Mile marker **0**

County **ADDISON (001)** Town **HANCOCK (31525)**

Waterway *(I - 6)* **WHITE RIVER** Road Name **CHURCHVILLE**

Route Number **TH001** Hydrologic Unit Code: **01080105**

3. Descriptive comments:

Located 0.01 mile from the junction of Town Highway 1 with VT 100.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **4** RBDS **4** Overall **4**
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US **2** UB **1** DS **1** *(**1**- pool; **2**- riffle)*

6. Bridge structure type **1** *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length **91** *(feet)* Span length **89** *(feet)* Bridge width **19.3** *(feet)*

Road approach to bridge:

8. LB **1** RB **1** *(**0** even, **1**- lower, **2**- higher)*

9. LB **1** RB **1** *(**1**- Paved, **2**- Not paved)*

10. Embankment slope (*run / rise in feet / foot*):
US left **2.4:1** US right **3.8:1**

	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	2	1
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	2	2	2	2

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

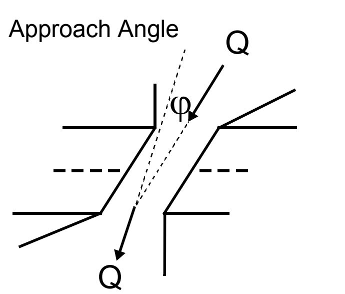
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

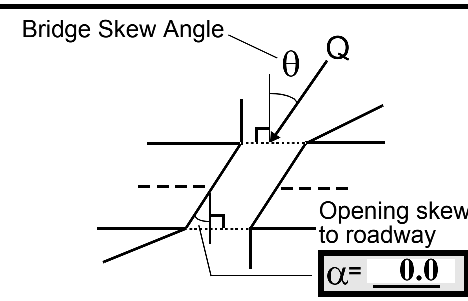
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: **10** 16. Bridge skew: **15**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **0**
Range? **15** feet **DS** *(US, UB, DS)* to **80** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **0**
Range? **250** feet **US** *(US, UB, DS)* to **200** feet **US**

*Impact Severity: **0**- none to very slight; **1**- Slight; **2**- Moderate; **3**- Severe*

18. Bridge Type: **1a**

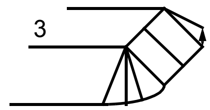
1a- Vertical abutments with wingwalls

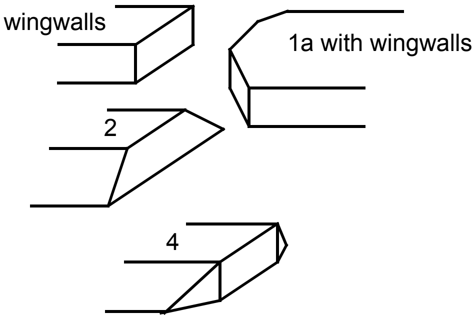
1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls perpendicular to abut. face

3- Spill through abutments

4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.





19. Bridge Deck Comments (surface cover variations, measured bridge and span lengths, bridge type variations, approach overflow width, etc.)

4. Banks are lined with trees but pasture and suburban conditions exist beyond.

7. Measured bridge length: 91, span: 89, width: 19 feet.

18. 1a type bridge to a depth of 6 ft. then a type 4 bridge above.

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
126	**6**			**5**	**4**	**4**	**432**	**432**	**0**	**0**

23. Bank width **25** 24. Channel width **15** 25. Thalweg depth **93** 29. Bed Material **435**

30 .Bank protection type: LB **0** RB **0** 31. Bank protection condition: LB **-** RB **-**

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover:* ***1****- 0 to 25%;* ***2****- 26 to 50%;* ***3****- 51 to 75%;* ***4****- 76 to 100%*
Bed and bank Material: ***0****- organics;* ***1****- silt / clay, < 1/16mm;* ***2****- sand, 1/16 - 2mm;* ***3****- gravel, 2 - 64mm;* ***4****- cobble, 64 - 256mm;* ***5****- boulder, > 256mm;* ***6****- bedrock;* ***7****- manmade*
Bank Erosion: ***0****- not evident;* ***1****- light fluvial;* ***2****- moderate fluvial;* ***3****- heavy fluvial / mass wasting*
Bank protection types: ***0****- absent;* ***1****- < 12 inches;* ***2****- < 36 inches;* ***3****- < 48 inches;* ***4****- < 60 inches;* ***5****- wall / artificial levee*
Bank protection conditions: ***1****- good;* ***2****- slumped;* ***3****- eroded;* ***4****- failed*

32. Comments (bank material variation, minor inflows, protection extent, etc.):

27. Bank material is cobble with gravel and sand.

29. Bed material is cobble with gravel and some boulders.

A silty muck overlies the banks about 2 - 3 inches deep.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 180 35. Mid-bar width: 20

36. Point bar extent: 140 feet US (US, UB) to 300 feet US (US, UB, DS) positioned 70 %LB to 100 %RB

37. Material: 432

38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):

Material is cobble with gravel and sand. Resembles a side bar within the channel.

39. Is a cut-bank present? N (Y or if N type ctrl-n cb) 40. Where? - (LB or RB)

41. Mid-bank distance: - 42. Cut bank extent: - feet - (US, UB) to - feet - (US, UB, DS)

43. Bank damage: - (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

44. Cut bank comments (eg. additional cut banks, protection condition, etc.):

NO CUT BANKS

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 0US

47. Scour dimensions: Length 40 Width 12 Depth : 1.2 Position 5 %LB to 30 %RB

48. Scour comments (eg. additional scour areas, local scouring process, etc.):

Localized scour due to bridge constriction of the channel. Stone fill is in place along the left abutment providing protection for the exposed left abutment footing.

49. Are there major confluences? N (Y or if N type ctrl-n mc) 50. How many? -

51. Confluence 1: Distance - 52. Enters on - (LB or RB) 53. Type - (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance - Enters on - (LB or RB) Type - (**1**- perennial; **2**- ephemeral)

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB 2 RB ____ (**1**- natural bank; **2**- abutment; **3**- artificial levee)

56. Height (BF) LB	RB	57 Angle (BF) LB	RB	61. Material (BF) LB	RB	62. Erosion (BF) LB	RB
59		1.5		2	7	7	0

58. Bank width (BF) - 59. Channel width (Amb) - 60. Thalweg depth (Amb) 90 63. Bed Material 0

*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*

*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*

64. Comments (bank material variation, minor inflows, protection extent, etc.):

342

Right bank has an overlying muck layer about 4 inches deep covering a sand bank with some cobble within the material leading up to the abutment.

63. Bed material is gravel with cobble and some sand.

65. Debris and Ice Is there debris accumulation? ____ (Y or N) 66. Where? **N**____ (1- Upstream; 2- At bridge; 3- Both)

67. Debris Potential **-**____ (1- Low; 2- Moderate; 3- High) 68. Capture Efficiency **1**____ (1- Low; 2- Moderate; 3- High)

69. Is there evidence of ice build-up? **1**___ (Y or N) Ice Blockage Potential **N**____ (1- Low; 2- Moderate; 3- High)

70. Debris and Ice Comments:

1

67. No debris accumulation near the bridge, upstream is laterally stable, has few cut banks, consist of cobble and boulder sized material.

68. High channel gradient and the span length is more than approximately 80% of the upstream bank width.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**90**	**2**	**2**	**0**	**1**	**90**
RABUT	**1**	**15**	**90**			**2**	**0**	**85**

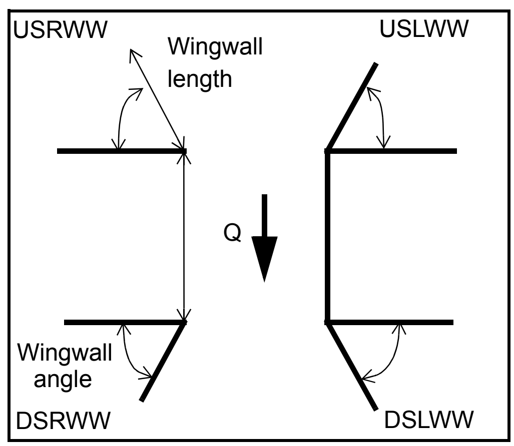
Pushed: LB or RB *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
-
1

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**69**	
USRWW:	**Y**		**1**		**0**	**2.5**	
DSLWW:	**-**		**-**		**Y**	**19.0**	
DSRWW:	**1**		**0**		**-**	**19.0**	



Wingwall materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**-**	**0**	**Y**	**-**	**1**	**-**	**1**	**-**
Condition	**Y**	**-**	**1**	**-**	**1**	**-**	**1**	**-**
Extent	**1**	**-**	**0**	**2**	**0**	**2**	**0**	**-**

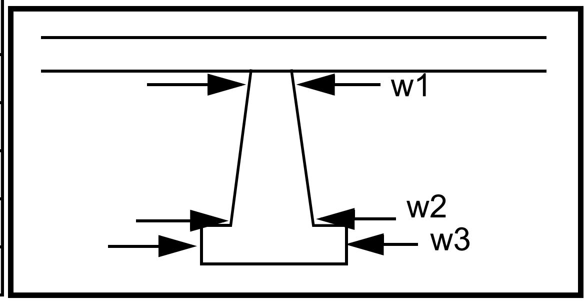
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
1
1
1
0
-
-

Piers:

84. Are there piers? _____ *(Y or if N type ctrl-n pr)*

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**30.0**	**12.5**	**70.0**
Pier 2			**9.5**	**17.5**	**45.0**	**30.0**
Pier 3	**9.5**	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)		-	-	-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		-	-	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		-	-	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		-	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		-	-	-	*Y- yes; N- no*
91. Attack ∠ (BF)		-	-	-	
92. Pushed		-	-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		-	-	-	
95. Cross-members		-	-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		-	-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**N**	-	-	-	
98. Exposure depth	-	-	-	-	

99. Pier comments (eg. undermined penetration, protection and protection extent, unusual scour processes, etc.):
-
-
-
-
-
-
-
-
-
-

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	NO	PIE	RS		

Bank width (BF) - Channel width (Amb) - Thalweg depth (Amb) - Bed Material _____

Bank protection type (Qmax): LB _____ RB _____ Bank protection condition: LB _____ RB _____

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

Comments (eg. bank material variation, minor inflows, protection extent, etc.):

3
4
342
432
0
0
342
0
0
-
-
Some remains of concrete blocks are scattered on both the left and right banks just downstream of the bridge providing very little protection.

101. Is a drop structure present? **Le** *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: **ft** *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

105. Drop structure comments (eg. downstream scour depth):
bank material is gravel with cobble and some sand.
Right bank material is cobble with gravel and some sand.
Bed material is gravel with cobbles and some sand.

106. Point/Side bar present? _____ *(Y or N. if N type ctrl-n pb)* Mid-bar distance: ______ Mid-bar width: ______

Point bar extent: ______ feet ____ *(US, UB, DS)* to ______ feet ____ *(US, UB, DS)* positioned **N** %LB to **-** %RB

Material: **NO**

Point or side bar comments (Circle Point or Side; note additional bars, material variation, status, etc.):

DROP STRUCTURE

Is a cut-bank present? _____ *(Y or if N type ctrl-n cb)* Where? _____ *(LB or RB)* Mid-bank distance: **Y**

Cut bank extent: **400** feet **150** *(US, UB, DS)* to **150** feet **DS** *(US, UB, DS)*

Bank damage: **600** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

Cut bank comments (eg. additional cut banks, protection condition, etc.):

DS
0
95
432

Is channel scour present? **Ma** *(Y or if N type ctrl-n cs)* Mid-scour distance: **terial**

Scour dimensions: Length **is** Width **pre-** Depth: **dom** Positioned **ina** %LB to **ntly** %RB

Scour comments (eg. additional scour areas, local scouring process, etc.):

cobble with gravel and some sand.

Are there major confluences? **Y** *(Y or if N type ctrl-n mc)* How many? **RB**

Confluence 1: Distance **400** Enters on **200** *(LB or RB)* Type **DS** *(**1**- perennial; **2**- ephemeral)*

Confluence 2: Distance **700** Enters on **DS** *(LB or RB)* Type **1** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

__1__- Constructed
__2__- Stable
__3__- Aggraded
__4__- Degraded
__5__- Laterally unstable
__6__- Vertically and laterally unstable

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

N
-
-
-
-
-
-
NO CHANNEL SCOUR

N

109. G. Plan View Sketch

- -

point bar (pb)	debris	flow (Q)	stone wall
cut-bank (cb)	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: HANCTH00010010 Town: Hancock
Road Number: TH1 County: Addison
Stream: White River

Initials SAO Date: 7/10/96 Checked: EMB 7/22/96

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	13000	19000	7880
Main Channel Area, ft2	1061	1182	818
Left overbank area, ft2	723	950	320
Right overbank area, ft2	1083	1573	298
Top width main channel, ft	93	93	93
Top width L overbank, ft	165	185	144
Top width R overbank, ft	377	377	150
D50 of channel, ft	0.325	0.325	0.325
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	11.4	12.7	8.8
y1, average depth, LOB, ft	4.4	5.1	2.2
y1, average depth, ROB, ft	2.9	4.2	2.0
Total conveyance, approach	259595	357058	126596
Conveyance, main channel	157616	188720	102153
Conveyance, LOB	58621	87720	15144
Conveyance, ROB	43358	80618	9299
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	7893.1	10042.3	6358.5
Ql, discharge, LOB, cfs	2935.6	4667.8	942.6
Qr, discharge, ROB, cfs	2171.3	4289.9	578.8
Vm, mean velocity MC, ft/s	7.4	8.5	7.8
Vl, mean velocity, LOB, ft/s	4.1	4.9	2.9
Vr, mean velocity, ROB, ft/s	2.0	2.7	1.9
Vc-m, crit. velocity, MC, ft/s	11.6	11.8	11.1
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and others, 1995, p. 32, eq. 20, 20a)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	1061	1182	818
Main channel width, ft	93	93	93
y1, main channel depth, ft	11.41	12.71	8.80

Bridge Section			
(Q) total discharge, cfs	13000	19000	7880
(Q) discharge thru bridge, cfs	7889	7657	7880
Main channel conveyance	72136	72136	83196
Total conveyance	72136	72136	83196
Q2, bridge MC discharge,cfs	7889	7657	7880
Main channel area, ft2	811	811	681
Main channel width (skewed), ft	84.8	84.8	84.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	84.8	84.8	84.6
y_bridge (avg. depth at br.), ft	9.56	9.56	8.05
Dm, median (1.25*D50), ft	0.40625	0.40625	0.40625
y2, depth in contraction,ft	7.79	7.60	7.80
ys, scour depth (y2-ybridge), ft	-1.77	-1.97	-0.25

ARMORING			
D90	0.7221	0.7221	0.7221
D95	0.8644	0.8644	0.8644
Critical grain size,Dc, ft	0.3690	0.3477	0.5594
Decimal-percent coarser than Dc	0.417	0.456	0.189
Depth to armoring,ft	1.55	1.24	7.20

PRESSURE FLOW SCOUR COMPUTATION

Structure Number: HANCTH00010010 Town: Hancock
Road Number: TH 1 County: Addison
Stream: White River
Intial: EMB Date: 10/10/96 Checked: MAI
Pressure Flow Scour (contraction scour for orifice flow condtions)

Hb+Ys=Cq*qbr/Vc Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1)
Chang Equation Cc=SQRT[0.10*(Hb/(ya-w)-0.56)]+0.79 (<=1)
(Richardson and others, 1995, p. 145-146)

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	7889	7657	0
Vc, critical velocity, ft/s	11.6	11.8	0
Vc, critical velocity, m/s	3.535507	3.596464	0
Main channel width (skewed), ft	84.8	84.8	0
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	84.8	84.8	0
qbr, unit discharge, ft^2/s	93.03066	90.29481	ERR
qbr, unit discharge, m^2/s	8.641988	8.387844	N/A
Area of full opening, ft^2	810.5	810.5	0
Hb, depth of full opening, ft	9.557783	9.557783	ERR
Hb, depth of full opening, m	2.91307	2.91307	N/A
Fr, Froude number MC	0.56	0.54	1
Cf, Fr correction factor (<=1.0)	1	1	1.5
Elevation of Low Steel, ft	497.67	497.67	0
Elevation of Bed, ft	488.1122	488.1122	N/A
Elevation of approach WS, ft	500.76	502.06	0
HF, bridge to approach, ft	0.5	0.63	0
Elevation of WS immediately US, ft	500.26	501.43	0
ya, depth immediately US, ft	12.14778	13.31778	N/A
ya, depth immediately US, m	3.774948	4.138528	N/A
Mean elev. of deck, ft	502.62	502.62	0
w, depth of overflow, ft (>=0)	0	0	0
Cc, vert contrac correction (<=1.0)	0.940596	0.915567	ERR
Ys, depth of scour (chang), ft	-1.0314	-1.20001	N/A

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
(Qt), total discharge, cfs	13000	19000	7880	13000	19000	7880
a', abut.length blocking flow, ft	170.7	190	149.9	100.4	100.4	202.2
Ae, area of blocked flow ft2	540.9	573.1	355	412.3	416.4	313.6
Qe, discharge blocked abut.,cfs	--	--	1137.1	--	--	703.7
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.16	5.01	3.20	2.76	3.56	2.24
ya, depth of f/p flow, ft	3.17	3.02	2.37	4.11	4.15	1.55
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.345	0.384	0.367	0.215	0.246	0.318
ys, scour depth, ft	20.28	21.61	16.60	15.94	17.07	13.19

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	170.7	190	149.9	100.4	100.4	202.2
y1 (depth f/p flow, ft)	3.17	3.02	2.37	4.11	4.15	1.55
a'/y1	53.87	62.99	63.30	24.45	24.21	130.37
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.35	0.38	0.37	0.22	0.25	0.32
Ys w/ corr. factor K1/0.55:						
vertical	16.22	16.00	12.37	ERR	ERR	7.72
vertical w/ ww's	13.30	13.12	10.14	ERR	ERR	6.33
spill-through	8.92	8.80	6.80	ERR	ERR	4.25

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.56	0.54	0.72	0.56	0.54	0.72
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	9.56	9.56	8.05	9.56	9.56	8.05
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.85	1.72	2.58	1.85	1.72	2.58
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR