LEVEL II SCOUR ANALYSIS FOR BRIDGE 33 (TUNBTH00450033) on TOWN HIGHWAY 45, crossing the FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT

Open-File Report 97-803

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

U.S. Department of the Interior

U.S. Geological Survey

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By EMILY C. WILD and TIMOTHY SEVERANCE

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Pembroke, New Hampshire

1997

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

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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 33 (TUNBTH00450033) ON TOWN HIGHWAY 45, CROSSING THE FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT

By **Emily C. Wild and Timothy Severance**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure TUNBTH00450033 on Town Highway 45 crossing the First Branch White River, Tunbridge, 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 New England Upland section of the New England physiographic province in central Vermont. The 86.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture upstream and downstream of the bridge, while woody vegetation sparsely covers the immediate banks.

In the study area, the First Branch White River has an incised, sinuous channel with a slope of approximately 0.003 ft/ft, an average channel top width of 68 ft and an average bank height of 7 ft. The channel bed material ranges from sand to gravel with a median grain size (D_{50}) of 27.1 mm (0.089 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 18, 1995, indicated that the reach was laterally unstable due to a cut-bank present on the upstream right bank and a wide channel bar in the upstream reach.

The Town Highway 45 crossing of the First Branch White River is a 67-ft-long, one-lane bridge consisting of one 54-foot timber thru-truss span (Vermont Agency of Transportation, written communication, March 23, 1995). The opening length of the structure parallel to the bridge face is 53.5 ft. The bridge is supported on the right by a vertical, concrete abutment with an upstream wingwall, and on the left by a vertical, stone abutment. The channel is skewed approximately 20 degrees to the opening while the computed opening-skew-to-roadway is 10 degrees.

A scour hole 1.5 ft deeper than the mean thalweg depth was observed along the right abutment during the Level I assessment. Scour countermeasures at the site include type-1 stone fill (less than 12 inches diameter) along the upstream right wingwall, type-2 stone fill (less than 36 inches diameter) along the right abutment, and type-3 stone fill (less than 48 inches diameter) along the upstream right bank. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was determined and analyzed as another potential worst-case scour scenario. 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 ranged from 0.0 to 3.0 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 12.8 to 31.0 ft. Right abutment scour ranged from 9.8 to 19.0 ft. The worst-case left and right 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.

Randolph Center, VT. Quadrangle, 1:24,000, 1981
Photoinspected 1983

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 TUNBTH00450033 ***Stream*** First Branch White River

County Orange ***Road*** TH45 ***District*** 4

Description of Bridge

Bridge length 67 ***ft*** ***Bridge width*** 15.7 ***ft*** ***Max span length*** 54 ***ft***

Alignment of bridge to road (on curve or straight) Straight, left/ Curve, right

Abutment type Stone, left/ Concrete, right ***Embankment type*** None

Stone fill on abutment? Yes ***Date of inspection*** 10/18/95

Description of stone fill Type-1, along the upstream right wingwall. Type-2, along the right abutment.

Brief description of piers/abutments The left abutment is vertical, placed stone. The right abutment and upstream right wingwall are vertical, concrete. There is a one and a half ft deep scour hole in front of the right abutment.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 20

There is a mild channel bend in the upstream reach. The scour hole has developed in the location where the flow impacts 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***
Level I	10/18/95	0	0
Level II	10/18/95	0	0

Potential for debris Low. There is some debris along the high banks.

Describe any features near or at the bridge that may affect flow (include observation date) No features were observed during the 10/18/95 site visit.

Description of the Geomorphic Setting

General topography The channel is located within a narrow, flat to slightly irregular flood plain with moderately sloped valley walls on both sides.

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

Date of inspection 10/18/95

DS left: Steep channel bank and moderately sloped overbank.

DS right: Steep channel bank and steep overbank.

US left: Steep channel bank and moderately sloped overbank.

US right: Steep channel bank and steep overbank.

Description of the Channel

Average top width 68 ***ft*** ***Average depth*** 7 ***ft***

Predominant bed material Sand/ Gravel ***Bank material*** Sand

Sinuous and laterally unstable with alluvial channel boundaries and a narrow flood plain.

10/18/95

Vegetative co

DS left: Pasture with some trees along the immediate bank.

DS right: Pasture with trees and Town Highway 45 along the immediate bank.

US left: Pasture with some trees along the immediate banks.

US right: Pasture with trees and Town Highway 45 along the immediate bank.

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

The 10/18/95 site assessment noted that the banks are laterally unstable as shown by bank slip failure and bank erosion.

Describe any obstructions in channel and date of observation.

The assessment of 10/18/95 noted no obstructions.

Hydrology

Drainage area 86.4 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/ New England Upland	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 13,930 ***ft***^{3}***/s*** ***Q500*** 20,440 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on a drainage area relationship [(86.4/96)exp 0.7] with Flood Insurance Study discharge values at the Royalton/Tunbridge corporate limits (Federal Emergency Management Agency, 1989). The Royalton/Tunbridge corporate limits is downstream of this site on the First Branch White River.

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 nail in a telephone pole on the upstream left overbank, 184 feet from the left abutment (elev. 503.65 ft, arbitrary survey datum). RM2 is a nail in a telephone pole on the right overbank, 15 feet upstream (elev. 511.56 ft, arbitrary survey datum). RM3 is a chiseled X in the asphalt, on the downstream side of the road sixteen feet from the left abutment (elev. 504.16 ft, arbitrary survey datum).

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-58	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPR1	72	2	Modelled Approach section (Templated from APTEM)
APTEM	83	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.

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 0.030 to 0.040, and overbank "n" values ranged from 0.035 to 0.050.

Normal depth at the exit section (EXIT1) 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 0.0027 ft/ft which was calculated from slopes surveyed downstream.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0004 ft/ft) to establish the modelled approach section (APPR1), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 505.3 *ft*
Average low steel elevation 502.8 *ft*

100-year discharge 13,930 *ft³/s*
Water-surface elevation in bridge opening 502.9 *ft*
Road overtopping? Y *Discharge over road* 9,730 *ft³/s*
Area of flow in bridge opening 635 *ft²*
Average velocity in bridge opening 6.6 *ft/s*
Maximum WSPRO tube velocity at bridge 7.9 *ft/s*

Water-surface elevation at Approach section with bridge 504.2
Water-surface elevation at Approach section without bridge 502.5
Amount of backwater caused by bridge 1.7 *ft*

500-year discharge 20,440 *ft³/s*
Water-surface elevation in bridge opening 502.9 *ft*
Road overtopping? Y *Discharge over road* 14,780 *ft³/s*
Area of flow in bridge opening 635 *ft²*
Average velocity in bridge opening 9.2 *ft/s*
Maximum WSPRO tube velocity at bridge 11.0 *ft/s*

Water-surface elevation at Approach section with bridge 505.3
Water-surface elevation at Approach section without bridge 503.8
Amount of backwater caused by bridge 1.5 *ft*

Incipient overtopping discharge 3,740 *ft³/s*
Water-surface elevation in bridge opening 498.4 *ft*
Area of flow in bridge opening 408 *ft²*
Average velocity in bridge opening 9.2 *ft/s*
Maximum WSPRO tube velocity at bridge 11.4 *ft/s*

Water-surface elevation at Approach section with bridge 499.2
Water-surface elevation at Approach section without bridge 499.1
Amount of backwater caused by bridge 0.1 *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 100-year and 500-year scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for the 100-year and incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 500-year discharge resulted in submerged orifice flow. 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). Thus, contraction scour for the 500-year discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). For comparison, contraction scour for the 500-year discharge, which resulted in orifice flow, was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in Appendix F. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

Abutment scour 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 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	3.0	1.2
Depth to armoring	0.4 4.3	7.8	--
Left overbank	--	--	--
Right overbank	--	--	27.2
Local scour:			
Abutment scour	31.0	12.8	16.4
Left abutment	19.0	9.8	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	1.4
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	1.7	1.6	1.4
Left abutment	1.7	1.6	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	
Pier 2			

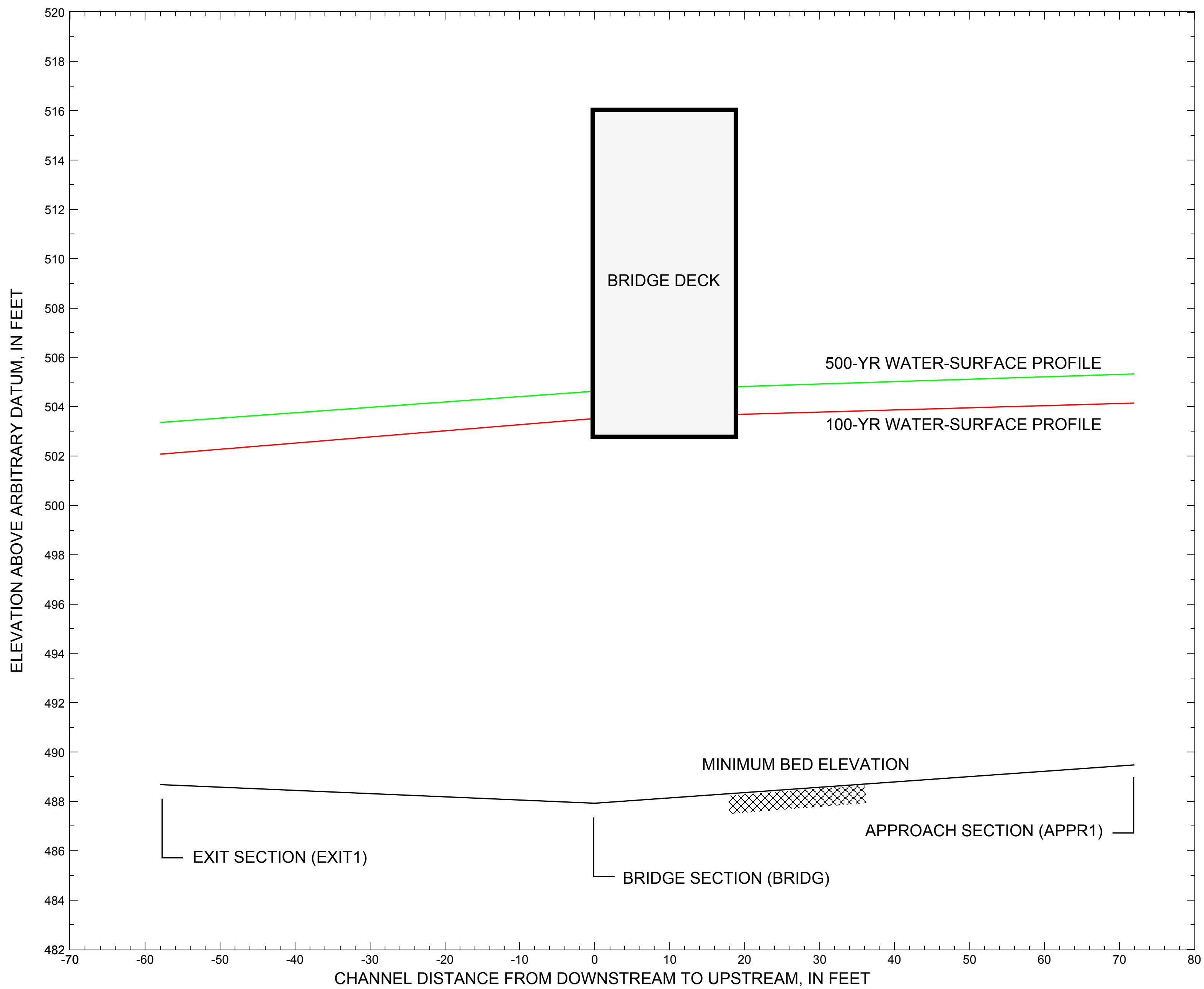

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure TUNBTH00450033 on Town Highway 45, crossing the First Branch White River, Tunbridge, Vermont.

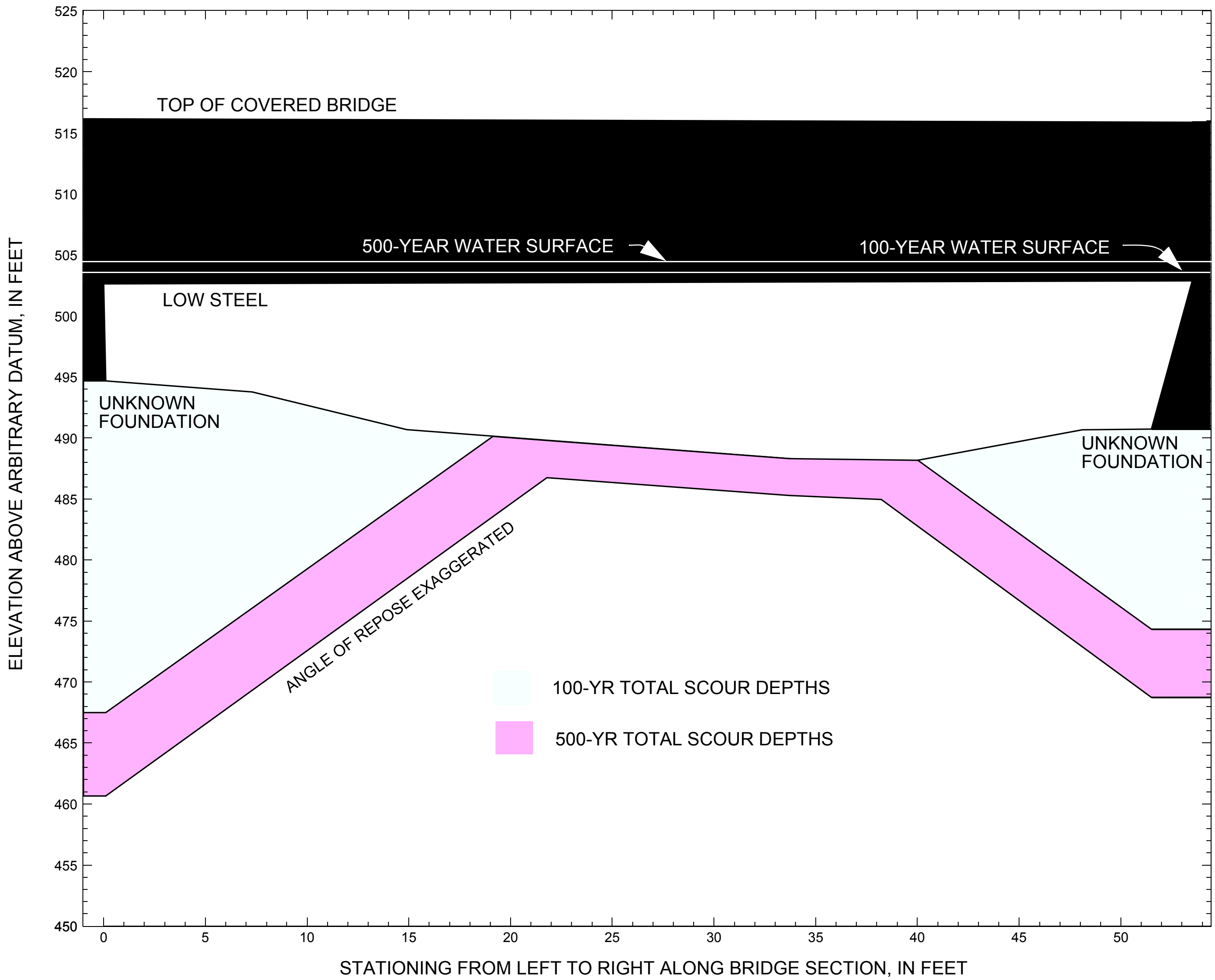

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure TUNBTH00450033 on Town Highway 45, crossing the First Branch White River, Tunbridge, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure TUNBTH00450033 on Town Highway 45, crossing the First Branch White River, Tunbridge, 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/pile 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 13,930 cubic-feet per second											
Left abutment	0.0	--	502.6	--	494.7	0.0	27.2	--	27.2	467.5	--
Right abutment	53.5	--	502.9	--	490.7	0.0	16.4	--	16.4	474.3	--

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 TUNBTH00450033 on Town Highway 45, crossing the First Branch White River, Tunbridge, 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/pile 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 20,440 cubic-feet per second											
Left abutment	0.0	--	502.6	--	494.7	3.0	31.0	--	34.0	460.7	--
Right abutment	53.5	--	502.9	--	490.7	3.0	19.0	--	22.0	468.7	--

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, 1981, Randolph Center, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File  tunb033.wsp
T2        Hydraulic analysis for structure TUNBTH00450033   Date: 09-OCT-97
T3        TH 45 CROSSING THE FIRST BRANCH WHITE RIVER
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          13930.0  20440.0    3740.0
SK          0.0027   0.0027    0.0027
*
XS   EXIT1    -58           0.
GR         -453.3, 510.61   -406.0, 500.36   -207.0, 497.26   -113.6, 499.17
GR            0.0, 498.68      7.1, 490.51     13.9, 488.68     20.8, 488.83
GR           33.1, 489.84     44.6, 489.80     52.7, 490.69     58.2, 491.19
GR           64.5, 497.40    101.1, 499.61    115.3, 507.99    142.3, 508.82
GR          166.8, 523.81
*
*   For the incipient roadway-overtopping discharge model, the points on the left overbank
*     (stationings -453.3 to -113.6) were eliminated.
*
*
N           0.035        0.040       0.050
SA                   0.0       64.5
*
*
XS   FULLV      0  * * *   0.0022
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    502.75      10.0
GR            0.0, 502.63      0.1, 494.67      7.3, 493.76     14.9, 490.68
GR           24.1, 489.48     33.7, 488.31     39.2, 487.92     48.1, 490.67
GR           51.5, 490.73     53.5, 502.88      0.0, 502.63
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD          1      23.4 * *     78.0      1.7
N           0.030
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     10      15.7     2
GR         -536.9, 511.80   -450.8, 507.28   -355.4, 501.11   -301.4, 499.22
GR         -234.6, 498.74   -155.9, 499.77    -72.1, 501.24     -6.3, 505.28
GR           -6.3, 516.14     59.5, 515.86     59.5, 505.29     98.5, 506.34
GR          127.6, 526.43
*   GR    0.0, 505.40     51.6, 505.45
*
XT   APTEM     83           0.
GR         -413.3, 513.35   -363.5, 499.07   -265.8, 497.94    -11.8, 499.19
GR            0.0, 490.71      5.8, 490.60     12.8, 491.00     17.5, 490.68
GR           24.9, 489.60     36.3, 489.57     44.4, 489.48     47.9, 490.72
GR           49.6, 491.28     59.6, 497.38     77.5, 511.85     91.1, 512.98
GR          109.3, 519.69
*
*   For the incipient roadway-overtopping discharge model, the points on the left overbank
*     (stationings -413.3 to -11.8) were eliminated.

AS   APPR1     72 * * * 0.0004
GT
N           0.035        0.040
SA                 -11.8
*
*
HP 1 BRIDG 502.88 1 502.88
HP 2 BRIDG 502.88 * * 4200
```

```
HP 2 RDWAY 503.52 * * 9730
HP 1 APPR1 504.15 1 504.15
HP 2 APPR1 504.15 * * 13930
*
HP 1 BRIDG 502.88 1 502.88
HP 2 BRIDG 502.88 * * 5813
HP 2 RDWAY 504.63 * * 14778
HP 1 APPR1 505.33 1 505.33
HP 2 APPR1 505.33 * * 20440
*
HP 1 BRIDG 498.41 1 498.41
HP 2 BRIDG 498.41 * * 3740
HP 1 APPR1 499.19 1 499.19
HP 2 APPR1 499.19 * * 3740
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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      U.S. Geological Survey WSPRO Input File  tunb033.wsp
      Hydraulic analysis for structure TUNBTH00450033   Date: 09-OCT-97
      TH 45 CROSSING THE FIRST BRANCH WHITE RIVER
         *** RUN DATE & TIME: 10-16-97  12:43
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      635     93293      0    125                            0
 502.88           635     93293      0    125  1.00      0     54        0

  VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

       WSEL     LEW     REW    AREA         K        Q    VEL
     502.88     0.0    53.5   635.0   93293.    4200.   6.61

X STA.        0.0        6.4       10.5       13.7       16.4       18.9
  A(I)           52.0       38.7       33.5       32.3       30.2
  V(I)           4.04       5.43       6.27       6.51       6.96

X STA.       18.9       21.2       23.4       25.6       27.6       29.6
  A(I)           29.4       28.5       27.7       27.4       27.1
  V(I)           7.15       7.36       7.57       7.66       7.76

X STA.       29.6       31.5       33.4       35.3       37.1       39.0
  A(I)           26.9       26.5       26.7       26.8       26.7
  V(I)           7.81       7.92       7.87       7.84       7.87

X STA.       39.0       40.9       43.0       45.3       48.1       53.5
  A(I)           28.1       29.0       30.8       34.1       52.9
  V(I)           7.48       7.24       6.82       6.16       3.97

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

       WSEL     LEW     REW    AREA         K        Q    VEL
     503.52  -392.7   -35.0  1160.0  108152.    9730.   8.39

X STA.     -392.7     -337.9     -319.0     -304.0     -291.8     -280.3
  A(I)           92.4       63.5       59.0       52.7       50.7
  V(I)           5.27       7.67       8.24       9.23       9.59

X STA.     -280.3     -269.2     -258.4     -247.9     -237.8     -227.8
  A(I)           49.8       49.6       48.9       47.4       47.7
  V(I)           9.78       9.81       9.95      10.26      10.21

X STA.     -227.8     -217.2     -206.2     -194.5     -182.0     -168.5
  A(I)           49.1       49.1       50.7       52.3       53.7
  V(I)           9.90       9.90       9.59       9.30       9.05

X STA.     -168.5     -153.8     -137.6     -117.8      -93.7      -35.0
  A(I)           56.3       57.9       64.3       69.2       95.7
  V(I)           8.64       8.40       7.56       7.04       5.08

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      72.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1     2017    265832    369    370                        26738
           2      929    167906     80     87                        18002
 504.15          2946    433737    449    457  1.07   -380     68    41309

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      72.

       WSEL     LEW     REW    AREA         K        Q    VEL
     504.15  -381.2    68.0  2946.2  433737.   13930.   4.73

X STA.     -381.2     -334.1     -305.1     -277.8     -253.2     -227.9
  A(I)          199.6      162.0      161.4      151.7      154.3
  V(I)           3.49       4.30       4.31       4.59       4.51

X STA.     -227.9     -201.4     -174.6     -146.5     -117.6      -86.9
  A(I)          157.6      156.6      160.0      160.5      166.3
  V(I)           4.42       4.45       4.35       4.34       4.19

X STA.      -86.9      -54.6      -21.2        0.7        8.5       16.6
  A(I)          169.8      169.8      164.7      105.6      107.3
  V(I)           4.10       4.10       4.23       6.60       6.49

X STA.       16.6       24.2       31.3       38.4       46.5       68.0
  A(I)          105.5      104.2      103.5      117.5      168.1
  V(I)           6.60       6.69       6.73       5.93       4.14
```

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       U.S. Geological Survey WSPRO Input File  tunb033.wsp
       Hydraulic analysis for structure TUNBTH00450033   Date: 09-OCT-97
       TH 45 CROSSING THE FIRST BRANCH WHITE RIVER
          *** RUN DATE & TIME: 10-16-97  12:43
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      635     93293      0    125                            0
  502.88           635     93293      0    125  1.00      0     54        0

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

        WSEL     LEW     REW    AREA        K        Q    VEL
      502.88     0.0    53.5   635.0   93293.    5813.   9.15

X STA.         0.0        6.4       10.5       13.7       16.4       18.9
  A(I)            52.0       38.7       33.5       32.3       30.2
  V(I)            5.59       7.52       8.68       9.01       9.63

X STA.        18.9       21.2       23.4       25.6       27.6       29.6
  A(I)            29.4       28.5       27.7       27.4       27.1
  V(I)            9.90      10.18      10.48      10.60      10.74

X STA.        29.6       31.5       33.4       35.3       37.1       39.0
  A(I)            26.9       26.5       26.7       26.8       26.7
  V(I)           10.81      10.97      10.90      10.85      10.90

X STA.        39.0       40.9       43.0       45.3       48.1       53.5
  A(I)            28.1       29.0       30.8       34.1       52.9
  V(I)           10.35      10.02       9.44       8.53       5.50

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

        WSEL     LEW     REW    AREA        K        Q    VEL
      504.63  -409.8   -16.9  1576.6  169396.   14778.   9.37

X STA.      -409.8     -346.4     -325.6     -309.1     -295.7     -283.0
  A(I)           129.0       87.4       79.9       71.7       69.6
  V(I)            5.73       8.45       9.25      10.30      10.62

X STA.      -283.0     -270.8     -259.1     -247.5     -236.4     -225.3
  A(I)            68.1       66.7       66.9       64.8       64.8
  V(I)           10.86      11.09      11.04      11.40      11.40

X STA.      -225.3     -213.6     -201.5     -188.6     -175.1     -160.8
  A(I)            66.5       66.7       69.2       70.3       72.0
  V(I)           11.11      11.07      10.68      10.52      10.26

X STA.      -160.8     -145.1     -127.6     -107.3      -82.8      -16.9
  A(I)            75.2       79.3       84.9       92.9      130.9
  V(I)            9.83       9.32       8.71       7.96       5.64

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      72.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1     2455    366136    374    374                        35715
            2     1024    194684     81     89                        20643
  505.33          3480    560820    455    463  1.04   -384     69    53514

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      72.

        WSEL     LEW     REW    AREA        K        Q    VEL
      505.33  -385.3    69.4  3479.5  560820.   20440.   5.87

X STA.      -385.3     -338.1     -309.7     -283.9     -259.3     -235.0
  A(I)           231.6      190.7      181.1      180.1      177.5
  V(I)            4.41       5.36       5.64       5.67       5.76

X STA.      -235.0     -210.4     -184.6     -158.7     -131.7     -103.8
  A(I)           176.7      182.3      179.4      183.8      185.9
  V(I)            5.78       5.61       5.70       5.56       5.50

X STA.      -103.8      -75.2      -44.8      -13.9        2.7       11.7
  A(I)           186.4      194.0      192.4      175.3      131.9
  V(I)            5.48       5.27       5.31       5.83       7.75

X STA.        11.7       20.5       28.7       37.0       45.8       69.4
  A(I)           127.6      128.9      130.0      138.3      205.7
  V(I)            8.01       7.93       7.86       7.39       4.97
```

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        U.S. Geological Survey WSPRO Input File  tunb033.wsp
        Hydraulic analysis for structure TUNBTH00450033   Date: 09-OCT-97
        TH 45 CROSSING THE FIRST BRANCH WHITE RIVER
           *** RUN DATE & TIME: 10-16-97  13:42
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      408     70067     52     63                         6487
   498.41           408     70067     52     63  1.00      0     53     6487

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.41     0.1    52.8   407.8   70067.    3740.   9.17

X STA.         0.1        8.6       12.9       15.9       18.5       20.8
  A(I)            36.4       25.6       21.9       20.4       19.1
  V(I)            5.14       7.30       8.54       9.15       9.81

X STA.        20.8       23.0       25.0       27.0       28.8       30.6
  A(I)            18.6       18.0       17.3       17.4       16.7
  V(I)           10.07      10.37      10.84      10.74      11.17

X STA.        30.6       32.3       34.0       35.6       37.3       38.9
  A(I)            16.6       16.4       16.5       16.6       16.6
  V(I)           11.27      11.39      11.32      11.25      11.28

X STA.        38.9       40.6       42.6       44.8       47.5       52.8
  A(I)            17.5       18.8       19.9       22.2       35.4
  V(I)           10.72       9.92       9.41       8.41       5.29

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      72.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      549     74373     74     79                         8505
   499.19           549     74373     74     79  1.00    -11     62     8505

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      72.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.19   -11.8    61.8   549.0   74373.    3740.   6.81

X STA.       -11.8       -0.5        3.1        6.3        9.5       12.6
  A(I)            46.1       30.2       28.0       26.4       25.7
  V(I)            4.06       6.19       6.68       7.07       7.28

X STA.        12.6       15.7       18.6       21.3       23.9       26.3
  A(I)            25.8       24.7       24.1       23.9       23.2
  V(I)            7.24       7.56       7.76       7.81       8.05

X STA.        26.3       28.7       31.1       33.6       36.0       38.5
  A(I)            23.1       23.2       23.5       23.3       23.8
  V(I)            8.08       8.07       7.97       8.03       7.86

X STA.        38.5       41.0       43.6       46.5       50.2       61.8
  A(I)            24.4       25.6       26.8       31.1       46.1
  V(I)            7.67       7.32       6.99       6.02       4.05
```

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        U.S. Geological Survey WSPRO Input File  tunb033.wsp
        Hydraulic analysis for structure TUNBTH00450033   Date: 09-OCT-97
        TH 45 CROSSING THE FIRST BRANCH WHITE RIVER
           *** RUN DATE & TIME: 10-16-97  12:43

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

EXIT1:XS   ******   -413     2240  0.82 *****  502.89  501.22   13930  502.07
       -57 ******    105   267994  1.36 ***** *******    0.62    6.22

FULLV:FV       58   -413     2280  0.78  0.15  503.06 *******   13930  502.27
         0     58    105   274739  1.35  0.00    0.02    0.60    6.11
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       72   -375     2226  0.71  0.18  503.24 *******   13930  502.53
        72     72     66   284395  1.17  0.00    0.01    0.53    6.26
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   510.78       0.00     502.68     498.74

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   502.88     503.67     504.15     502.75

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.08     503.75     503.94

 ===270 REJECTED FLOW CLASS 2 (5) 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       58      0      635  1.12  0.52  504.00  496.42    4200  502.88
         0     58     54    93293  1.65  0.75    0.00    0.43    6.61

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.778 ******  502.75 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    56.  0.06  0.37  504.47    0.00   9730.  503.52

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   9730.   358.  -393.   -35.   4.8   3.2   9.7   8.4   4.2   3.2
   RT:      0.    17.    60.    76.   0.4   0.2   5.6  27.2   1.6   2.9

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

APPR1:AS       49   -380     2944  0.37  0.47  504.52  501.18   13930  504.15
        72     85     68   433286  1.07  0.05    0.00    0.34    4.73

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.879  0.921   34377.   -66.   -12. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS      -58.  -414.   105.  13930.  267994.    2240.    6.22  502.07
   FULLV:FV        0.  -414.   105.  13930.  274739.    2280.    6.11  502.27
   BRIDG:BR        0.     0.    54.   4200.   93293.     635.    6.61  502.88
   RDWAY:RG       10.******* 9730.   9730.*********       0.    2.00  503.52
   APPR1:AS       72.  -381.    68.  13930.  433286.    2944.    4.73  504.15
```
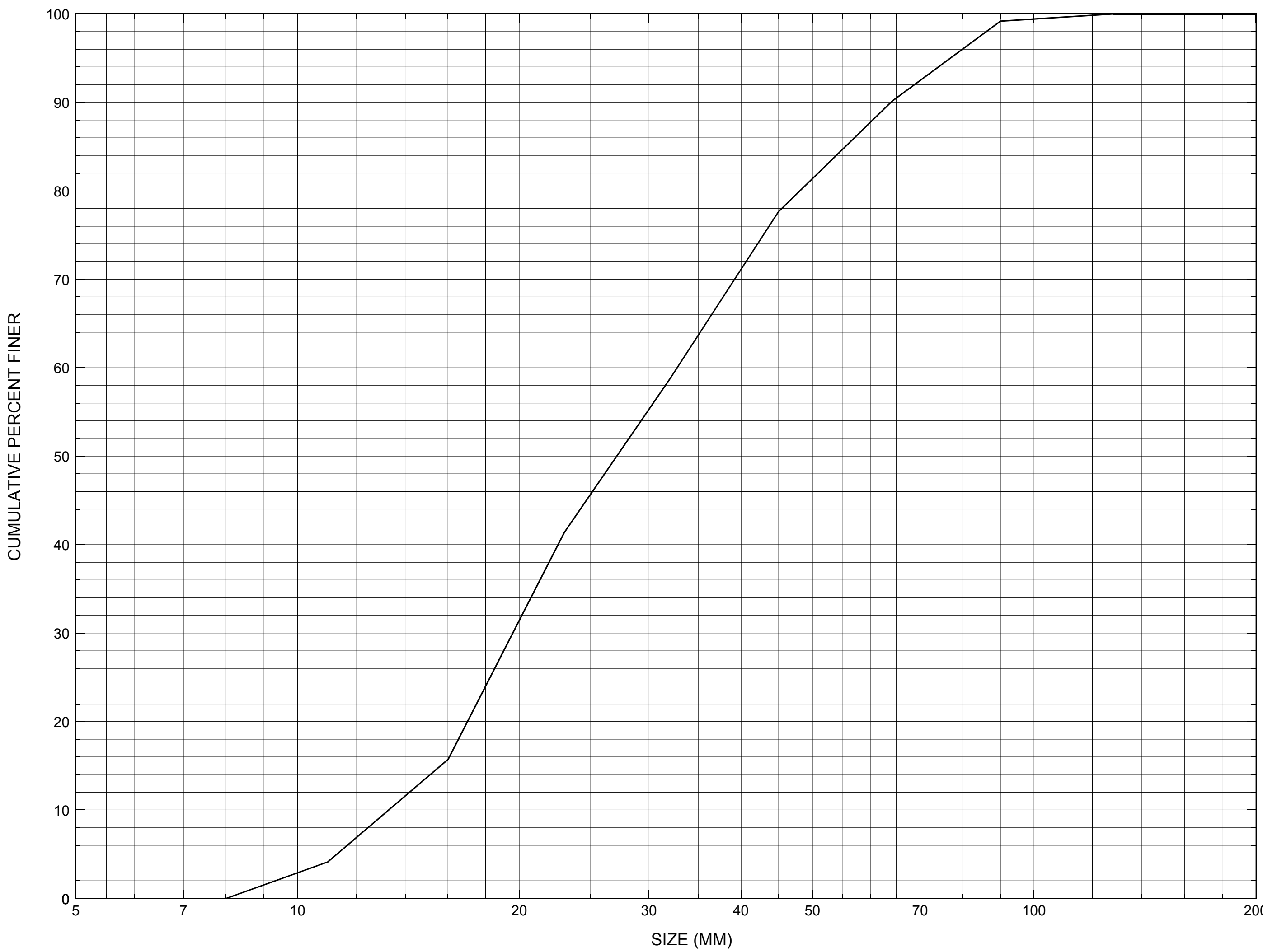

```
   XSID:CODE   XLKQ   XRKQ       KQ
  APPR1:AS     -66.   -12.   34377.

 SECOND USER DEFINED TABLE.

   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
  EXIT1:XS    501.22    0.62  488.68  523.81************  0.82  502.89  502.07
  FULLV:FV  ********    0.60  488.81  523.94  0.15  0.00  0.78  503.06  502.27
  BRIDG:BR    496.42    0.43  487.92  502.88  0.52  0.75  1.12  504.00  502.88
  RDWAY:RG  ***************  498.74  526.43  0.06******  0.37  504.47  503.52
  APPR1:AS    501.18    0.34  489.48  519.69  0.47  0.05  0.37  504.52  504.15


       U.S. Geological Survey WSPRO Input File  tunb033.wsp
       Hydraulic analysis for structure TUNBTH00450033   Date: 09-OCT-97
       TH 45 CROSSING THE FIRST BRANCH WHITE RIVER
          *** RUN DATE & TIME: 10-16-97  12:43

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

EXIT1:XS   ******   -419     2918  0.93 *****  504.29  502.07   20440  503.36
      -57 ******    107   393277  1.22 ***** *******    0.58    7.00

FULLV:FV       58   -419     2958  0.90  0.15  504.47 *******   20440  503.57
        0      58    108   401182  1.21  0.00    0.02    0.57    6.91
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       72   -379     2772  0.92  0.19  504.68 *******   20440  503.76
       72      72     68   395207  1.09  0.01    0.02    0.55    7.37
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   503.57     502.75

           <<<<<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       58      0      635  1.30 *****  504.18  497.85    5813  502.88
        0 ******     54    93293  1.00 ***** *******    0.47    9.15

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800 ******  502.75 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG      10.    56.  0.07  0.56  505.81    0.01  14778.  504.63

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:  14778.   393.  -410.   -17.   5.9   4.0  10.9   9.4   5.2   3.2
  RT:      0.    39.    60.    99.   1.1   0.5   6.4  16.3   2.1   3.0

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

APPR1:AS       49   -384     3479  0.56  0.29  505.89  502.08   20440  505.33
       72      89     69   560628  1.04  0.05    0.01    0.38    5.88

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
    ****** ****** ******** ****** ****** ********

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

  FIRST USER DEFINED TABLE.

   XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
  EXIT1:XS     -58.  -420.   107.  20440.  393277.    2918.    7.00  503.36
  FULLV:FV       0.  -420.   108.  20440.  401182.    2958.    6.91  503.57
  BRIDG:BR       0.     0.    54.   5813.   93293.     635.    9.15  502.88
  RDWAY:RG      10.******* 14778.  14778.*********       0.    2.00  504.63
  APPR1:AS      72.  -385.    69.  20440.  560628.    3479.    5.88  505.33

   XSID:CODE   XLKQ   XRKQ       KQ
  APPR1:AS  ***********************

 SECOND USER DEFINED TABLE.

   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
  EXIT1:XS    502.07    0.58  488.68  523.81************  0.93  504.29  503.36
  FULLV:FV  ********    0.57  488.81  523.94  0.15  0.00  0.90  504.47  503.57
  BRIDG:BR    497.85    0.47  487.92  502.88************  1.30  504.18  502.88
  RDWAY:RG  ***************  498.74  526.43  0.07******  0.56  505.81  504.63
  APPR1:AS    502.08    0.38  489.48  519.69  0.29  0.05  0.56  505.89  505.33
```

```
       U.S. Geological Survey WSPRO Input File  tunb033.wsp
       Hydraulic analysis for structure TUNBTH00450033   Date: 09-OCT-97
       TH 45 CROSSING THE FIRST BRANCH WHITE RIVER
          *** RUN DATE & TIME: 10-16-97  13:42

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

EXIT1:XS   ******      0      528  0.81 *****  499.49  495.16    3740  498.67
       -57 ******     86    71916  1.04 ***** *******    0.51    7.09

 ===140 AT SECID "FULLV":  END OF CROSS SECTION EXTENDED VERTICALLY.
                          WSEL,YLT,YRT =   498.86     498.81     523.94

FULLV:FV       58      0      533  0.80  0.15  499.66 *******    3740  498.86
         0     58     87    72783  1.04  0.00    0.02    0.51    7.02
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       72    -11      544  0.74  0.19  499.85 *******    3740  499.12
        72     72     62    73339  1.00  0.00    0.01    0.45    6.88
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

           <<<<<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       58      0      408  1.31  0.16  499.72  495.98    3740  498.41
         0     58     53    70039  1.00  0.06   -0.02    0.58    9.17

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  502.75 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS       49    -11      549  0.72  0.14  499.91  495.60    3740  499.19
        72     50     62    74305  1.00  0.07    0.02    0.44    6.82

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.281  0.007   73543.    -4.    49.   499.04
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD     LEW     REW       Q        K      AREA     VEL    WSEL
   EXIT1:XS     -58.      0.     86.   3740.   71916.     528.    7.09  498.67
   FULLV:FV       0.      0.     87.   3740.   72783.     533.    7.02  498.86
   BRIDG:BR       0.      0.     53.   3740.   70039.     408.    9.17  498.41
   RDWAY:RG      10.**************      0.******************    2.00********
   APPR1:AS      72.    -12.     62.   3740.   74305.     549.    6.82  499.19

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS      -4.    49.   73543.

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS     495.16    0.51  488.68  523.81************  0.81  499.49  498.67
   FULLV:FV   ********    0.51  488.81  523.94  0.15  0.00  0.80  499.66  498.86
   BRIDG:BR     495.98    0.58  487.92  502.88  0.16  0.06  1.31  499.72  498.41
   RDWAY:RG   ****************  505.28  526.43**********************************
   APPR1:AS     495.60    0.44  489.48  519.69  0.14  0.07  0.72  499.91  499.19
  ER
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure TUNBTH00450033, in Tunbridge, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number TUNBTH00450033

General Location Descriptive

Data collected by *(First Initial, Full last name)* E. BOEHMLER

Date *(MM/DD/YY)* 03 / 23 / 95

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

County *(FIPS county code; I - 3; nnn)* 017

Town *(FIPS place code; I - 4; nnnnn)* 73675

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

Waterway *(I - 6)* FIRST BRANCH WHITE RIVER

Road Name *(I - 7)*: -

Route Number TH045

Vicinity *(I - 9)* 0.1 MI JCT TH 45 + VT110

Topographic Map Randolph.Center

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43529

Longitude *(i - 17; nnnnn.n)* 72303

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10091300330913

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

Maximum span length *(I - 48; nnnn)* 0054

Year built *(I - 27; YYYY)* 1883

Structure length *(I - 49; nnnnnn)* 000067

Average daily traffic, ADT *(I - 29; nnnnnn)* 000050

Deck Width *(I - 52; nn.n)* 157

Year of ADT *(I - 30; YY)* 91

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

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

Waterway adequacy *(I - 71; n)* 7

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

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

Structure type *(I - 43; nnn)* 710

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*) 013.0

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

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

Comments:

The structural inspection report of 11/1/93 indicates that the structure is a timber, thru-truss, multiple king post type covered bridge. The right abutment is concrete while the left is constructed of stone. The right abutment has no problems. The left abutment is reported as having a cantilevered section of stone near the low superstructure. Otherwise, the stone work is in good condition. The report mentions that there is no evident channel scour or bank erosion. A minor sand bar is along the left abutment and the channel makes a sharp bend into the crossing. The riprap coverage is noted as fair. The streambed consists of stone and gravel with some sand.

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: -

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)* 86.39 mi^2
Lake/pond/swamp area 0.08 mi^2
Watershed storage *(ST)* 0.1 %
Bridge site elevation 520 ft
Headwater elevation 1700 ft
Main channel length 17.83 mi
10% channel length elevation 560 ft
85% channel length elevation 1270 ft
Main channel slope *(S)* 53.09 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? **Yes** *If no, type ctrl-n xs*

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

Comments: **The station and low chord to bed differences are from a sketch dated 11/1/93 that is attached to a bridge inspection report. The low chord elevations are from the 10/18/95 survey done for this report. This section is of the upstream face.**

Station	0	15	27	39	54	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low chord elevation	502.60	502.68	502.74	502.80	502.88	-	-	-	-	-	-
Bed elevation	494.30	490.18	488.24	486.80	489.38	-	-	-	-	-	-
Low chord to bed	8.3	12.5	14.5	16	13.5	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments: -

-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	--

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **4/10/96**
Computerized by: **RB** Date: **4/10/96**
Reviewd by: **EW** Date: **10/24/97**

Structure Number **TUNBTH00450033**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **T. SEVERANCE** Date *(MM/DD/YY)* **10** / **18** / 19**95**

2. Highway District Number **04** Mile marker **000**
County **ORANGE 017** Town **TUNBRIDGE 73675**
Waterway *(I - 6)* **FIRST BRANCH WHITE RIVER** Road Name **-**
Route Number **TH45** Hydrologic Unit Code: **01080105**

3. Descriptive comments:
Located 0.1 mile to the junction with VT 110. This is a wooden covered bridge located at the edge of the valley floor. Markings on the bridge above the left bank entrance state, "Cilley Bridge 1883."

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 **1** 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 **67** *(feet)* Span length **54** *(feet)* Bridge width **15.7** *(feet)*

Road approach to bridge:

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

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

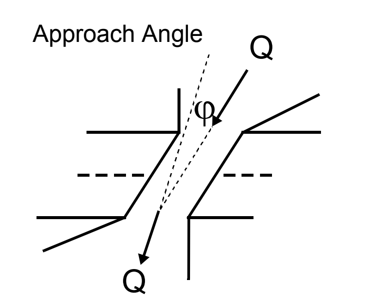
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

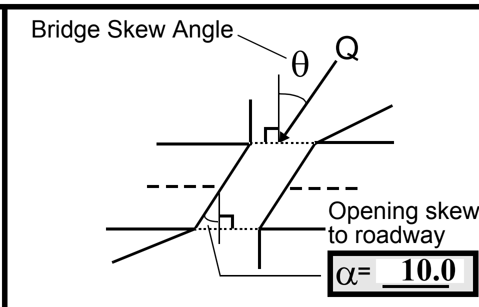
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	2	2
LBDS	0	-	0	-

*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: **20**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **0** feet **DS** *(US, UB, DS)* to **55** feet **US**

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

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

18. Bridge Type: **1a/1b**

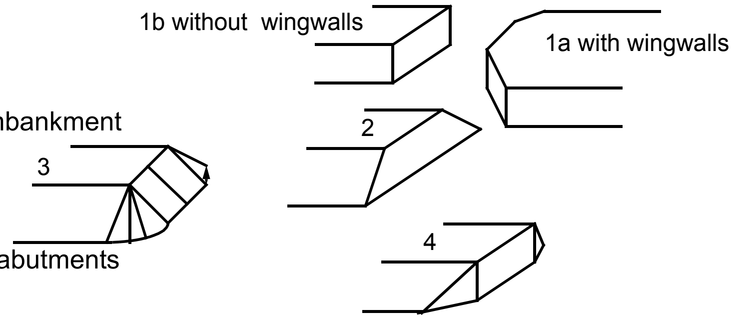
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel 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.)

7. Values are from the VT AOT files. Measured bridge length is 66 feet, span length is 56 feet and the bridge width is 15.7 feet.

9. The right road approach is paved for approximately 55 feet then it is unpaved beyond.

4. The US right bank climbs immediately within one bridge length up the valley wall where there are larger older trees. The left bank US is pasture and a corn field which slopes down slightly from the top of the left bank US where there are some small saplings. The DS right bank has thick brush within one bridge length , but the overbank is pasture. The left bank DS has thick brush and saplings along the bank but the overbank is pasture. On the left bank DS and the DS side of the left road approach there are bundled white plastic wrapped hay bails.

18. The left abutment is laid up stone and is type 1b. The right abutment is concrete and is type 1a.

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
67.5	**8.5**			**6.0**	**1**	**1**	**2**	**2**	**2**	**1**

23. Bank width **35.0** 24. Channel width **30.0** 25. Thalweg depth **71.5** 29. Bed Material **32**

30 .Bank protection type: LB **0** RB **3** 31. Bank protection condition: LB **-** RB **1**

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.):

30. The US right bank stone fill dumped along the bank starts at the right abutment and extends 53 feet US. There is dumped stone fill protection, type 2, along the left bank starting at 290 feet US and continuing US several hundred feet. Between this point and the bridge there are scattered pieces of similar stone along the base of the cut bank.

28. Most of the flow is along the right bank and there is light erosion and scour is evident. Along the left bank there is a point bar and a cut bank above it.

33. Point/Side bar present? **Y** _(Y or N. if N type ctrl-n pb)_ 34. Mid-bar distance: **218** 35. Mid-bar width: **33**

36. Point bar extent: **17** feet **US** _(US, UB)_ to **260** feet **US** _(US, UB, DS)_ positioned **0** %LB to **70** %RB

37. Material: **32**

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

The US end is primarily gravel and the DS end is mostly fines.

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

41. Mid-bank distance: **156** 42. Cut bank extent: **30** feet **US** _(US, UB)_ to **250** feet **US** _(US, UB, DS)_

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

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

The left bank above the point bar is very steep. Another cut bank is located along the right bank: mid bank distance is 195 feet, cut bank extent is 85 feet US to 300 feet US, bank damage is 3. This is out of the 2 bridge length range.

45. Is channel scour present? **Y** _(Y or if N type ctrl-n cs)_ 46. Mid-scour distance: **10**

47. Scour dimensions: Length **80** Width **8** Depth : **1.5** Position **60** %LB to **85** %RB

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

15 feet DS of the bridge face the width is 8 feet, under the bridge and US it is closer to 6 feet.

49. Are there major confluences? **Y** _(Y or if N type ctrl-n mc)_ 50. How many? **1**

51. Confluence 1: Distance **172** 52. Enters on **RB** _(LB or RB)_ 53. Type **2** _(**1**- perennial; **2**- ephemeral)_

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

54. Confluence comments (eg. confluence name):

This is a small brook currently with very little flow and much debris in the channel.

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
49.5		1.0		2	7	7	-

58. Bank width (BF) **-** 59. Channel width **-** 60. Thalweg depth **90.0** 63. Bed Material **-**

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.):

123

Along the left bank are fines and gravel along the right bank. The transition between the two is abrupt at 60% LB.

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

67. Debris Potential 1____ *(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

A little debris was left US when the higher flow subsided.

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		-	90	0	0	-	-	90.0
RABUT	2	20	90			2	0	52.5

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.):

-

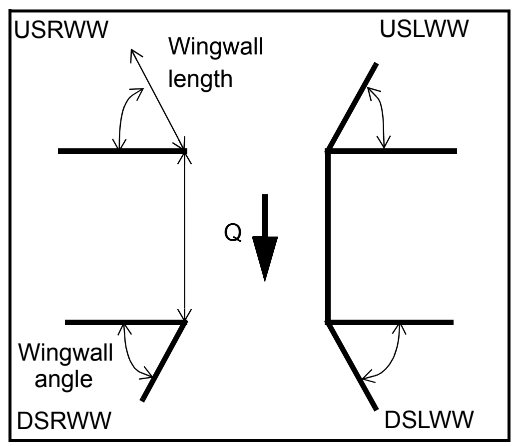
-

1

No undermining or exposure.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						52.5	
USRWW:	N		-		-	3.0	
DSLWW:	-		-		Y	19.5	
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	-	-	N	-	-	2	-	2
Condition	N	-	-	-	-	1	-	1
Extent	-	-	-	-	1	0	2	-

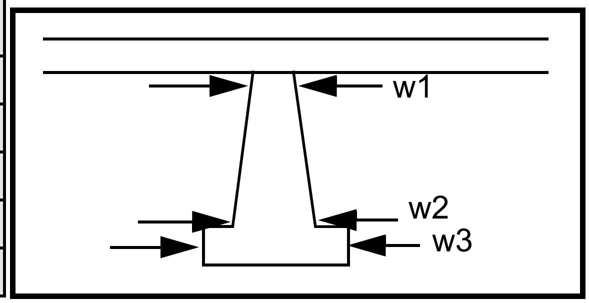
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? **Th** (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	-		**8.5**	-	**80.0**	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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
-	-			-	-	-	-	-	-	-

Bank width (BF) - Channel width - Thalweg depth - 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.):
-
-
-
-
-
-
-
-
-
NO PIERS

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

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

105. Drop structure comments (eg. downstream scour depth):

1
1
2
2

106. Point/Side bar present? 1 *(Y or N. if N type ctrl-n pb)* Mid-bar distance: 1 Mid-bar width: 32

Point bar extent: 0 feet 0 *(US, UB, DS)* to - feet - *(US, UB, DS)* positioned Bot %LB to h %RB

Material: DS

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

banks show signs of erosion and have no protection within two bridge lengths. There is stone fill placed along the DS left bank starting at 125 feet DS and extending to 150 feet DS. The bed material is loose and it is possible to penetrate as much as 1.5 feet in places along the base of the banks.

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

Cut bank extent: _____ feet ____ *(US, UB, DS)* to _____ feet ____ *(US, UB, DS)*

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

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

N

Is channel scour present? - *(Y or if N type ctrl-n cs)* Mid-scour distance: NO

Scour dimensions: Length DRO Width P Depth: STR Positioned UC %LB to TU %RB

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

RE

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

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

Confluence 2: Distance - Enters on - *(LB or RB)* Type - *(**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)*:

-

NO POINT BARS

At 300 feet DS a gravel point bar starts positioned 0% LB to 50% RB.

Y

LB

70

25

DS

125

DS

2

- A

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: TUNBTH00450033 Town: TUNBRIDGE
Road Number: TH 45 County: ORANGE
Stream: FIRST BRANCH WHITE RIVER

Initials ECW Date: 10/20/97 Checked: RLB

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	Incip. Q
Total discharge, cfs	13930	20440	3740
Main Channel Area, ft2	929	1024	549
Left overbank area, ft2	2017	2455	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	80	81	74
Top width L overbank, ft	369	374	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.089	0.089	0.089
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	11.6	12.6	7.4
y1, average depth, LOB, ft	5.5	6.6	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	433737	560820	74373
Conveyance, main channel	167906	194684	74373
Conveyance, LOB	265832	366136	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	-0.0002	0.0000	0.0000
Qm, discharge, MC, cfs	5392.5	7095.6	3740.0
Ql, discharge, LOB, cfs	8537.5	13344.4	0.0
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	5.8	6.9	6.8
Vl, mean velocity, LOB, ft/s	4.2	5.4	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	7.5	7.6	7.0
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	N/A

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Incip.Q	
(Q) total discharge, cfs	13930	20440	3740	
(Q) discharge thru bridge, cfs	4200	5813	3740	
Main channel conveyance	93293	93293	70067	
Total conveyance	93293	93293	70067	
Q2, bridge MC discharge,cfs	4200	5813	3740	
Main channel area, ft2	635	635	408	
Main channel width (normal), ft	52.7	52.7	51.9	52.7
Cum. width of piers in MC, ft	0.0	0.0	0.0	0.0
W, adjusted width, ft	52.7	52.7	51.9	52.7
y_bridge (avg. depth at br.), ft	12.05	12.05	7.86	12.05
Dm, median (1.25*D50), ft	0.11125	0.11125	0.11125	0.11125
y2, depth in contraction,ft	9.88	13.06	9.07	10.66
ys, scour depth (y2-ybridge), ft	-2.17	1.01	1.20	-1.38

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Incip.Q
Q, discharge thru bridge MC, cfs	4200	5813	3740
Main channel area (DS), ft2	635	635	408
Main channel width (normal), ft	52.7	52.7	51.9
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	52.7	52.7	51.9
D90, ft	0.2095	0.2095	0.2095
D95, ft	0.2525	0.2525	0.2525
Dc, critical grain size, ft	0.1028	0.1969	0.2259
Pc, Decimal percent coarser than Dc	0.424	0.122	0.080
Depth to armoring, ft	0.42	4.26	7.82

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1) Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and other, 1995, p. 144-146)

	Q100	Q500	Incip.Q
Q, total, cfs	13930	20440	3740
Q, thru bridge MC, cfs	4200	5813	3740
Vc, critical velocity, ft/s	7.53	7.64	6.99
Va, velocity MC approach, ft/s	5.80	6.93	6.81
Main channel width (normal), ft	52.7	52.7	51.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	52.7	52.7	51.9
qbr, unit discharge, ft2/s	79.7	110.3	72.1
Area of full opening, ft2	635.0	635.0	408.0
Hb, depth of full opening, ft	12.05	12.05	7.86
Fr, Froude number, bridge MC	0	0.47	0
Cf, Fr correction factor (<=1.0)	0.00	1.00	0.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	0	502.75	0
Elevation of Bed, ft	-12.05	490.70	-7.86
Elevation of Approach, ft	0	505.33	0
Friction loss, approach, ft	0	0.29	0
Elevation of WS immediately US, ft	0.00	505.04	0.00
ya, depth immediately US, ft	12.05	14.34	7.86
Mean elevation of deck, ft	0	516	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.96	1.00
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	N/A	3.03	N/A
Ys, scour w/Umbrell equation, ft	N/A	2.85	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 Incip.Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Incip. Q
(Qt), total discharge, cfs	13930	20440	3740	13930	20440	3740
a', abut.length blocking flow, ft	381.6	385.7	12.3	14.9	16.3	9.4
Ae, area of blocked flow ft2	991.43	1065.96	54.49	116.5	142.07	37.36
Qe, discharge blocked abut.,cfs	--	--	238.94	482.69	705.87	151.53
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.24	5.46	4.39	4.14	4.97	4.06
ya, depth of f/p flow, ft	2.60	2.76	4.43	7.82	8.72	3.97
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	80	80	80	100	100	100
K2	0.98	0.98	0.98	1.01	1.01	1.01
Fr, froude number f/p flow	0.316	0.371	0.367	0.261	0.297	0.359
ys, scour depth, ft	27.18	30.98	12.77	16.40	18.97	9.78

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)	381.6	385.7	12.3	14.9	16.3	9.4
y1 (depth f/p flow, ft)	2.60	2.76	4.43	7.82	8.72	3.97
a'/y1	146.88	139.56	2.78	1.91	1.87	2.37
Skew correction (p. 49, fig. 16)	0.97	0.97	0.97	1.02	1.02	1.02
Froude no. f/p flow	0.32	0.37	0.37	0.26	0.30	0.36
Ys w/ corr. factor K1/0.55:						
vertical	12.49	14.01	ERR	ERR	ERR	ERR
vertical w/ ww's	10.24	11.49	ERR	ERR	ERR	ERR
spill-through	6.87	7.71	ERR	ERR	ERR	ERR

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	Incip. Q	Q100	Q500	Incip. Q
Fr, Froude Number	0.43	0.47	0.58	0.43	0.47	0.58
y, depth of flow in bridge, ft	12.05	12.05	7.86	12.05	12.05	7.86
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.38	1.65	1.63	1.38	1.65	1.63
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR