LEVEL II SCOUR ANALYSIS FOR BRIDGE 34 (HUNTTH00210034) on TOWN HIGHWAY 21, crossing BRUSH BROOK, HUNTINGTON, VERMONT

Open-File Report 97-663

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 RONDA L. BURNS & MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
Mark Schaefer, Acting Director

For additional information write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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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 34 (HUNTTH00210034) ON TOWN HIGHWAY 21, CROSSING BRUSH BROOK, HUNTINGTON, VERMONT

By **Ronda L. Burns 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 HUNTTH00210034 on Town Highway 21 crossing Brush Brook, Huntington, 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 in central Vermont. The 6.23-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest.

In the study area, Brush Brook has an incised, straight channel with a slope of approximately 0.03 ft/ft, an average channel top width of 43 ft and an average bank height of 4 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 90.0 mm (0.295 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 26, 1996, indicated that the reach was stable.

The Town Highway 21 crossing of Brush Brook is a 28-ft-long, one-lane bridge consisting of one 26-foot steel-beam span with a timber deck (Vermont Agency of Transportation, written communication November 30, 1995). The opening length of the structure parallel to the bridge face is 25.4 ft. The bridge is supported by vertical, concrete abutments with a wingwall on the upstream right. The channel is skewed approximately 5 degrees to the opening and the computed opening-skew-to-roadway is 5 degrees.

A tributary enters Brush Brook on the right bank immediately downstream of the bridge. At the confluence, the left bank of Brush Brook is eroded and there is a small void under the downstream end of the left abutment footing which is completely exposed. The right abutment footing is also exposed. The scour countermeasures at the site include type-2 stone fill (less than 36 inches diameter) along the upstream banks and in front of the right abutment and type-3 stone fill (less than 48 inches diameter) along the entire base length of the upstream right wingwall and along the downstream 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 is 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 0.7 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge, which was less than the 100-year discharge. Abutment scour ranged from 6.9 to 10.9 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.

Plymouth, VT. Quadrangle, 1:24,000, 1966
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 HUNTTH00210034 ***Stream*** Brush Brook

County Chittenden ***Road*** TH 21 ***District*** 5

Description of Bridge

Bridge length 28 ***ft*** ***Bridge width*** 16.1 ***ft*** ***Max span length*** 26 ***ft***

Alignment of bridge to road (on curve or straight) Curve

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

Stone fill on abutment? Yes ***Date of inspection*** 06/26/96

Description of stone fill Type-2, along the right abutment and type-3, along the upstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. The footings are exposed on both abutments and there is a small void under the downstream end of the left abutment.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 5

There is a moderate channel bend in the downstream reach.

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	06/26/96	0	0
Level II	06/26/96	0	0

Potential for debris Moderate. Trees along the left and right banks have exposed roots.

Describe any features near or at the bridge that may affect flow (include observation date) A tributary enters on the right bank immediately downstream of the bridge. At the confluence, the left bank of Brush Brook is eroded where flow from the tributary impacts the bank. 06/26/96

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a steep valley wall on the right.

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

Date of inspection 06/26/96

DS left: Steep channel bank to a moderately sloped overbank

DS right: Steep channel bank to a narrow terrace and steep valley wall

US left: Steep channel bank to a moderately sloped overbank

US right: Steep channel bank to a narrow terrace and steep valley wall

Description of the Channel

Average top width 43 ***ft*** ***Average depth*** 4 ***ft***

Predominant bed material Cobbles/Boulders ***Bank material*** Cobbles/Boulders

Straight and stable with semi-alluvial to non-alluvial channel boundaries.

06/26/96

Vegetative co

DS left: Trees and brush

DS right: Trees and brush

US left: Trees and brush

US right: Trees and brush

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

None. 06/26/96

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.23 ***mi²***

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***: -

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

-

-

Calculated Discharges

Q100 1,700 ***ft³/s*** ***Q500*** 2,220 ***ft³/s***

The discharges are interpolated between flood frequency estimates for drainage areas of 9.19 square miles and 5.01 square miles available from the VTAOT database (Vermont Agency of Transportation, written communication, May, 1995) and graphically extrapolated to the 500-year event. The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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 Add 328.0 to the USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a metal tablet stamped "State of Vermont survey mark" on top of the downstream end of the right abutment of HUNTTH00220033 (elev. 497.14 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the left abutment footing (elev. 495.25 ft, arbitrary survey datum). RM3 is a nail in a telephone pole 4 ft above the ground, 100 ft from the left end of the bridge on the bankward side of TH 22 (elev. 499.74 ft, arbitrary survey datum).

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXTEM	-196	1	Approach section from HUNTTH00220033
EXIT1	-196	2	Modelled additional Exit section (Templated from EXTEM)
EXITX	-28	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APTEM	32	1	Approach section as surveyed (Used as a template)
APPRO	42	2	Modelled Approach section (Templated from APTEM)

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 0.050 to 0.060, and overbank "n" values ranged from 0.045 to 0.090.

Huntington bridge 33, on Town Highway 22, is located 400 ft downstream of this site. The water surface elevation computed for the approach section of bridge 33 was used as the starting water surface for this model. The surveyed approach section (EXTEM) from bridge 33 was adjusted to account for the difference between the arbitrary datums for the two bridges to establish the modelled exit section (EXIT1). Also because of a tributary entering Brush Brook between the bridge and exit sections of this site, a change in discharge was included. However, it was necessary to reduce the discharge at the exit cross section instead of at the downstream face of the bridge because of the limitations of the WSPRO model.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0401 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 location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 502.5 ***ft***
Average low steel elevation 500.0 ***ft***

100-year discharge 1,700 ***ft³/s***
Water-surface elevation in bridge opening 500.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 442 ***ft³/s***
Area of flow in bridge opening 176 ***ft²***
Average velocity in bridge opening 7.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.0 ***ft/s***

Water-surface elevation at Approach section with bridge 501.0
Water-surface elevation at Approach section without bridge 499.1
Amount of backwater caused by bridge 1.9 ***ft***

500-year discharge 2,220 ***ft³/s***
Water-surface elevation in bridge opening 500.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 747 ***ft³/s***
Area of flow in bridge opening 176 ***ft²***
Average velocity in bridge opening 8.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.3 ***ft/s***

Water-surface elevation at Approach section with bridge 501.3
Water-surface elevation at Approach section without bridge 500.0
Amount of backwater caused by bridge 1.3 ***ft***

Incipient overtopping discharge 1,460 ***ft³/s***
Water-surface elevation in bridge opening 497.6 ***ft***
Area of flow in bridge opening 118 ***ft²***
Average velocity in bridge opening 12.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 15.1 ***ft/s***

Water-surface elevation at Approach section with bridge 500.3
Water-surface elevation at Approach section without bridge 498.8
Amount of backwater caused by bridge 1.5 ***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 for the incipient roadway-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 100-year and 500-year discharges resulted in unsubmerged 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 these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting 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 is presented in Appendix F. Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

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	0.0	0.7
Depth to armoring	7.5	5.0	17.8
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	9.7	10.9	10.8
Right abutment	8.0	9.2	6.9
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	2.0	2.0
Right abutment	1.9	2.0	2.0
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

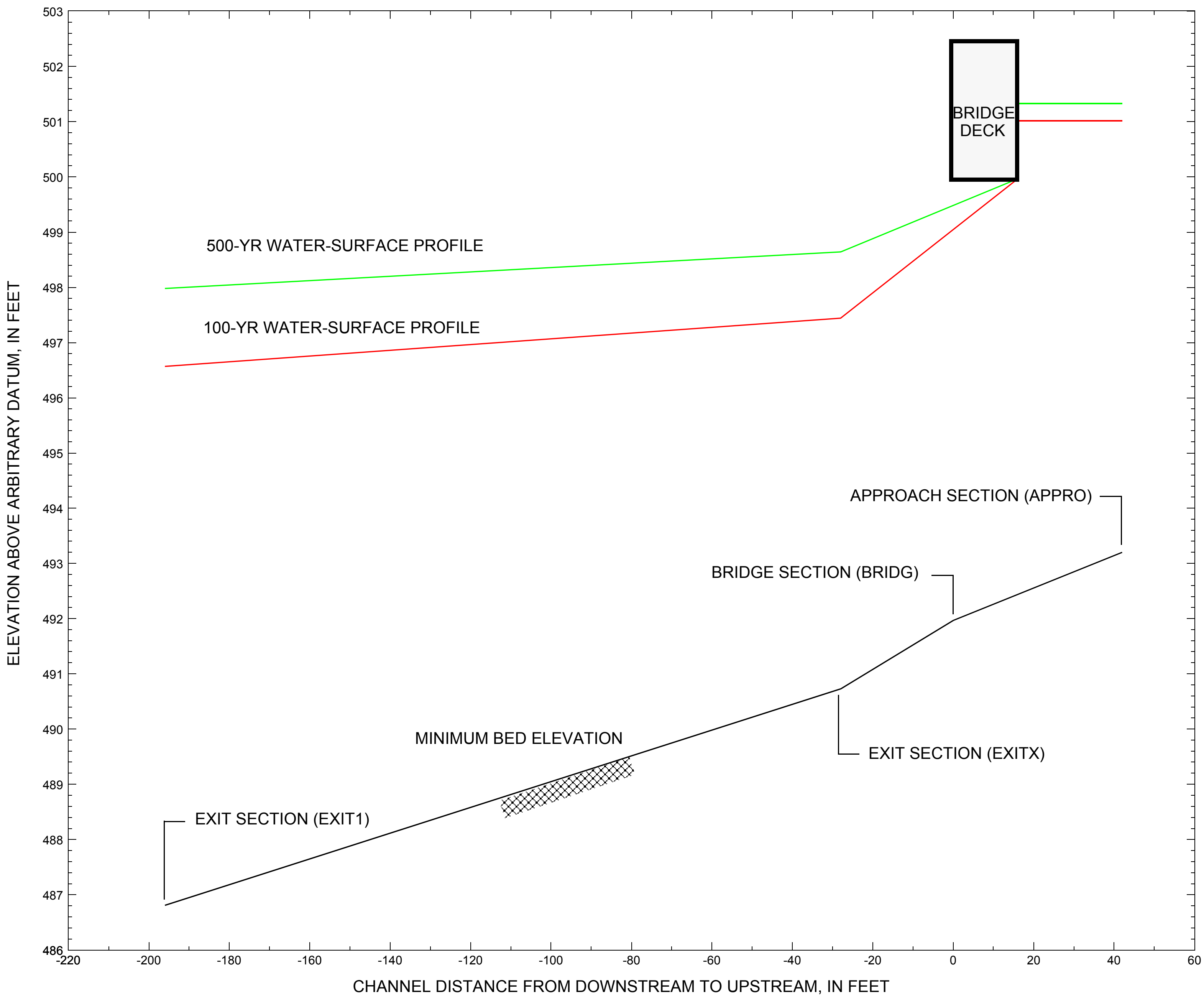

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure HUNTTH00210034 on Town Highway 21, crossing Brush Brook, Huntington, Vermont.

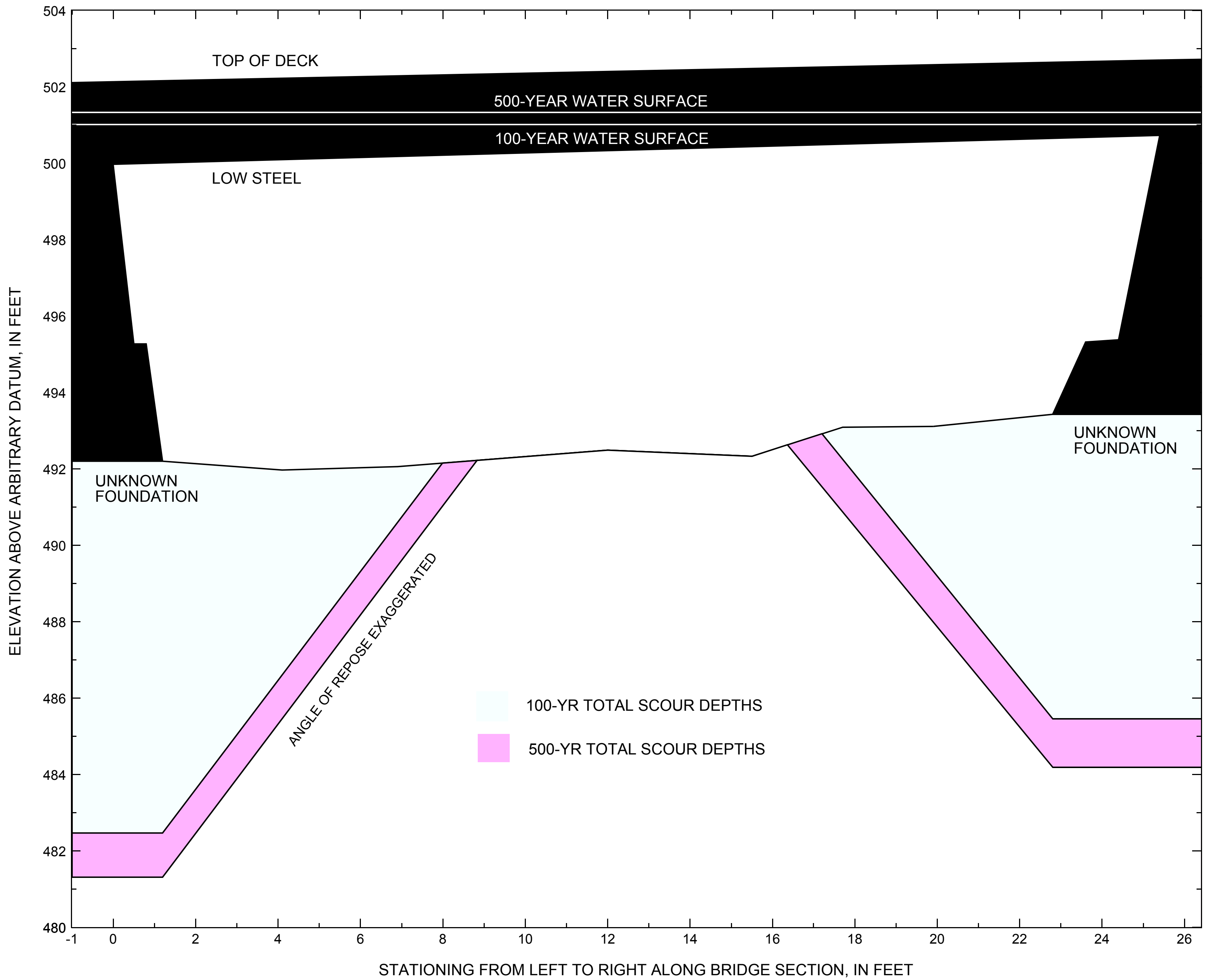

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure HUNTTH00210034 on Town Highway 21, crossing Brush Brook, Huntington, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HUNTTH00210034 on Town Highway 21, crossing Brush Brook, Huntington, 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 1,700 cubic-feet per second											
Left abutment	0.0	828.4	499.97	--	492.2	0.0	9.7	--	9.7	482.5	--
Right abutment	25.4	828.4	500.73	--	493.4	0.0	8.0	--	8.0	485.4	--

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 HUNTTH00210034 on Town Highway 21, crossing Brush Brook, Huntington, 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 2,220 cubic-feet per second											
Left abutment	0.0	828.4	499.97	--	492.2	0.0	10.9	--	10.9	481.3	--
Right abutment	25.4	828.4	500.73	--	493.4	0.0	9.2	--	9.2	484.2	--

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, 1948, Huntington, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1980, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File hunt034.wsp
T2        Hydraulic analysis for structure HUNTTH00210034   Date: 17-JUN-97
T3        TH 21 CROSSING BRUSH BROOK IN HUNTINGTON, VT                     RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2030.0   2660.0   1740.0
WS          496.57   497.98   494.43
*
XT   EXTEM     -196          0.
GR          -345.7, 509.49   -212.1, 503.93   -161.7, 502.14   -137.2, 501.39
GR           -70.3, 500.19    -41.2, 500.06     -8.1, 493.17      0.0, 491.09
GR             4.0, 490.59      8.6, 489.90     13.0, 489.32     20.2, 489.85
GR            23.0, 490.65     31.7, 494.27     35.2, 496.50     50.8, 503.79
*
XS   EXIT1     -196
GT             -2.51
N           0.090       0.055
SA                 -41.2
*
*    The cross section EXTEM is the approach cross section from bridge
*    HUNTTH00220033,downstream of this bridge.  EXIT1 is templated from EXTEM
*    to adjust for the differences in the arbitrary datums between the two bridges.
*
XS   EXITX    -28           0.
GR          -291.9, 506.78
GR           -83.3, 498.91    -74.5, 498.66    -29.9, 498.39    -16.1, 498.27
GR           -11.3, 497.46     -4.7, 493.08     -3.7, 492.54      0.0, 492.05
GR             6.9, 491.28      9.8, 490.73     16.3, 491.20     20.5, 492.19
GR            21.0, 492.45     28.8, 494.43     33.2, 496.51     39.2, 497.19
GR            53.7, 497.54     73.6, 498.68     79.2, 500.86     87.2, 501.17
*
N           0.075       0.060       0.050
SA                 -11.3         33.2
*
Q           1700.0   2220.0   1460.0
*
XS   FULLV      0  * * *   0.0478
*
*            SRD     LSEL    XSSKEW
BR   BRIDG     0    499.97      5.0
GR             0.0, 499.97      0.5, 495.27      0.8, 495.27      1.1, 492.97
GR             1.2, 492.20      4.1, 491.97      6.9, 492.06     12.0, 492.49
GR            15.5, 492.33     17.7, 493.09     19.9, 493.11     22.8, 493.43
GR            23.6, 495.32     24.4, 495.38     25.4, 500.73      0.0, 499.97
*
*       BRTYPE  BRWDTH
CD          1      20.3
N           0.050
*
*            SRD    EMBWID   IPAVE
XR   RDWAY      8      16.1     2
GR          -257.3, 506.78
GR           -73.3, 499.63    -60.6, 499.06    -18.8, 501.64     -2.4, 502.37
GR            -2.2, 503.18     13.1, 503.24     28.1, 503.21     28.3, 502.69
GR            90.4, 501.41    139.4, 501.18    200.6, 502.44    219.0, 506.24
*
*
XT   APTEM     32           0.
GR          -188.4, 506.78
GR           -59.1, 501.38    -44.8, 500.48    -20.8, 500.41     -7.6, 498.50
GR             0.0, 493.93      1.9, 493.31      4.0, 492.80     17.4, 493.35
GR            18.9, 494.04     19.6, 494.69     27.0, 496.75     33.0, 499.05
GR            46.6, 500.92    139.4, 501.18    200.6, 502.44    219.0, 506.24
GR           230.0, 512.96
```

```
*
AS   APPRO     42  * * *   0.0401
GT
N           0.075        0.060        0.045
SA                 -7.6         33.0



HP 1 BRIDG 499.97 1 499.97
HP 2 BRIDG 499.97 * * 1266
HP 1 BRIDG 497.72 1 497.72
HP 2 RDWAY 501.02 * * 442
HP 1 APPRO 501.02 1 501.02
HP 2 APPRO 501.02 * * 1700
*
HP 1 BRIDG 499.97 1 499.97
HP 2 BRIDG 499.97 * * 1445
HP 1 BRIDG 498.66 1 498.66
HP 2 RDWAY 501.33 * * 747
HP 1 APPRO 501.33 1 501.33
HP 2 APPRO 501.33 * * 2220
*
HP 1 BRIDG 497.62 1 497.62
HP 2 BRIDG 497.62 * * 1460
HP 1 APPRO 500.26 1 500.26
HP 2 APPRO 500.26 * * 1460
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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      U.S. Geological Survey WSPRO Input File hunt034.wsp
      Hydraulic analysis for structure HUNTTH00210034   Date: 17-JUN-97
      TH 21 CROSSING BRUSH BROOK IN HUNTINGTON, VT                     RLB
         *** RUN DATE & TIME: 07-07-97  14:42

  CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      176     14732     25     37                          2639
 499.97           176     14732     25     37  1.00      0     25      2639

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.97     0.0    25.3   175.9   14732.    1266.   7.20

X STA.        0.0         2.8         4.1         5.2         6.2         7.2
  A(I)            17.8        10.1         8.9         8.0         7.6
  V(I)            3.56        6.29        7.09        7.90        8.30

X STA.        7.2         8.1         9.1        10.0        10.9        11.9
  A(I)             7.4         7.2         7.0         7.1         7.0
  V(I)            8.55        8.81        9.04        8.92        9.01

X STA.       11.9        12.8        13.8        14.7        15.7        16.7
  A(I)             7.1         7.1         7.2         7.2         7.7
  V(I)            8.98        8.93        8.77        8.80        8.27

X STA.       16.7        17.8        19.0        20.3        21.8        25.3
  A(I)             7.8         8.2         8.8        10.2        16.6
  V(I)            8.10        7.71        7.22        6.23        3.80

  CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      120      8497     25     33                          1508
 497.72           120      8497     25     33  1.00      0     25      1508

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =       8.

       WSEL     LEW     REW    AREA        K        Q    VEL
     501.02  -109.1   -28.8    77.3    1495.     442.   5.72

X STA.     -109.1       -89.3       -83.4       -79.4       -76.1       -73.3
  A(I)             7.6         5.2         4.4         4.0         3.7
  V(I)            2.91        4.28        5.06        5.50        5.99

X STA.      -73.3       -70.9       -68.8       -66.9       -65.1       -63.4
  A(I)             3.5         3.2         3.2         3.1         3.0
  V(I)            6.41        6.80        7.00        7.24        7.38

X STA.      -63.4       -61.9       -60.4       -58.8       -57.2       -55.3
  A(I)             2.9         2.9         2.9         3.0         3.1
  V(I)            7.51        7.72        7.53        7.38        7.12

X STA.      -55.3       -53.3       -50.9       -47.8       -43.4       -28.8
  A(I)             3.2         3.4         3.9         4.5         6.6
  V(I)            6.81        6.41        5.73        4.88        3.36

  CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      42.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1       20       246     39     40                            79
           2      231     17563     41     43                          3128
           3        9       251     11     12                            45
 501.02           260     18060     91     94  1.16    -46     44      2302

  VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      42.

       WSEL     LEW     REW    AREA        K        Q    VEL
     501.02   -47.0    44.4   259.7   18060.    1700.   6.55

X STA.      -47.0        -3.6        -0.9         0.9         2.4         3.8
  A(I)            32.9        14.4        12.1        10.8        10.5
  V(I)            2.59        5.90        7.01        7.88        8.12

X STA.        3.8         5.1         6.4         7.6         8.9        10.2
  A(I)            10.0        10.0         9.8        10.0         9.9
  V(I)            8.48        8.49        8.68        8.54        8.60

X STA.       10.2        11.6        12.9        14.3        15.7        17.2
  A(I)             9.9        10.2        10.4        10.4        10.7
  V(I)            8.57        8.37        8.18        8.15        7.93

X STA.       17.2        18.9        21.1        23.7        27.3        44.4
  A(I)            11.8        13.0        13.6        15.4        24.0
  V(I)            7.22        6.54        6.27        5.51        3.54
```

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       U.S. Geological Survey WSPRO Input File hunt034.wsp
       Hydraulic analysis for structure HUNTTH00210034   Date: 17-JUN-97
       TH 21 CROSSING BRUSH BROOK IN HUNTINGTON, VT                     RLB
          *** RUN DATE & TIME: 07-07-97  14:42

   CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      176     14732     25     37                         2639
  499.97           176     14732     25     37  1.00      0     25     2639

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

        WSEL     LEW     REW    AREA        K        Q    VEL
      499.97     0.0    25.3   175.9   14732.    1445.   8.21

X STA.        0.0        2.8        4.1        5.2        6.2        7.2
  A(I)            17.8       10.1        8.9        8.0        7.6
  V(I)            4.07       7.18       8.09       9.02       9.47

X STA.        7.2        8.1        9.1       10.0       10.9       11.9
  A(I)             7.4        7.2        7.0        7.1        7.0
  V(I)            9.76      10.05      10.31      10.18      10.28

X STA.       11.9       12.8       13.8       14.7       15.7       16.7
  A(I)             7.1        7.1        7.2        7.2        7.7
  V(I)           10.25      10.19      10.01      10.04       9.44

X STA.       16.7       17.8       19.0       20.3       21.8       25.3
  A(I)             7.8        8.2        8.8       10.2       16.6
  V(I)            9.25       8.79       8.24       7.11       4.34

   CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      143     10982     25     35                         1953
  498.66           143     10982     25     35  1.00      0     25     1953

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =       8.

        WSEL     LEW     REW    AREA        K        Q    VEL
      501.33  -117.0   146.7   107.1    2241.     747.   6.98

X STA.     -117.0      -94.0      -87.2      -82.4      -78.7      -75.4
  A(I)            10.3        7.0        5.9        5.3        5.0
  V(I)            3.62       5.32       6.30       6.98       7.42

X STA.      -75.4      -72.6      -70.2      -67.9      -65.8      -63.9
  A(I)             4.7        4.4        4.3        4.1        4.1
  V(I)            7.98       8.49       8.73       9.03       9.19

X STA.      -63.9      -62.0      -60.3      -58.5      -56.5      -54.3
  A(I)             4.0        3.9        4.0        4.1        4.2
  V(I)            9.37       9.63       9.42       9.05       8.88

X STA.      -54.3      -51.9      -49.0      -45.2      -40.0      146.7
  A(I)             4.4        4.8        5.4        6.1       11.0
  V(I)            8.51       7.83       6.86       6.17       3.39

   CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      42.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1       33       528     44     44                          159
            2      244     19187     41     43                         3387
            3       13       354     17     17                           64
  501.33           289     20069    102    105  1.24    -51     50     2490

   VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      42.

        WSEL     LEW     REW    AREA        K        Q    VEL
      501.33   -51.9    49.8   289.2   20069.    2220.   7.68

X STA.      -51.9       -4.6       -1.6        0.4        2.0        3.5
  A(I)            42.7       15.5       13.5       11.9       11.5
  V(I)            2.60       7.18       8.24       9.35       9.66

X STA.        3.5        4.8        6.2        7.5        8.9       10.2
  A(I)            10.8       10.8       10.6       10.8       10.7
  V(I)           10.27      10.26      10.49      10.32      10.39

X STA.       10.2       11.6       13.0       14.4       15.9       17.4
  A(I)            10.8       10.7       11.2       11.2       11.5
  V(I)           10.27      10.34       9.95       9.92       9.64

X STA.       17.4       19.2       21.5       24.2       28.0       49.8
  A(I)            13.1       13.9       14.6       16.5       27.1
  V(I)            8.49       8.00       7.60       6.71       4.10
```

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        U.S. Geological Survey WSPRO Input File hunt034.wsp
        Hydraulic analysis for structure HUNTTH00210034   Date: 17-JUN-97
        TH 21 CROSSING BRUSH BROOK IN HUNTINGTON, VT                     RLB
           *** RUN DATE & TIME: 07-07-97  14:42

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      118      8244     24     33                         1462
   497.62           118      8244     24     33  1.00      0     25     1462

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.62     0.3    24.8   117.6    8244.    1460.  12.42

X STA.        0.3        2.8        3.9        4.9        5.9        6.8
  A(I)           11.2        6.4        5.7        5.4        5.1
  V(I)           6.54      11.44      12.71      13.63      14.22

X STA.        6.8        7.7        8.6        9.6       10.5       11.4
  A(I)            5.0        4.9        4.9        4.9        4.8
  V(I)          14.54      14.90      15.04      14.90      15.13

X STA.       11.4       12.4       13.3       14.3       15.2       16.2
  A(I)            4.9        5.0        4.9        5.0        5.3
  V(I)          14.79      14.73      14.96      14.60      13.82

X STA.       16.2       17.4       18.6       20.0       21.5       24.8
  A(I)            5.5        5.6        6.0        6.6       10.5
  V(I)          13.23      12.99      12.13      11.10       6.93

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      42.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1        6        97      9      9                           30
             2      200     13831     41     43                         2523
             3        2        43      6      6                            9
   500.26           209     13972     56     59  1.06    -16     39     2230

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      42.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.26   -17.0    38.9   209.0   13972.    1460.   6.99

X STA.      -17.0       -2.7       -0.4        1.2        2.7        3.9
  A(I)           20.3       11.6        9.8        9.3        8.8
  V(I)           3.59       6.29       7.48       7.81       8.29

X STA.        3.9        5.1        6.3        7.5        8.7        9.9
  A(I)            8.2        8.4        8.2        8.4        8.3
  V(I)           8.87       8.67       8.87       8.72       8.79

X STA.        9.9       11.2       12.4       13.7       15.1       16.4
  A(I)            8.4        8.4        8.7        8.9        9.0
  V(I)           8.64       8.71       8.38       8.19       8.08

X STA.       16.4       17.9       19.8       22.2       25.5       38.9
  A(I)            9.5       10.8       11.7       13.1       19.0
  V(I)           7.70       6.73       6.24       5.58       3.85
```

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        U.S. Geological Survey WSPRO Input File hunt034.wsp
        Hydraulic analysis for structure HUNTTH00210034   Date: 17-JUN-97
        TH 21 CROSSING BRUSH BROOK IN HUNTINGTON, VT                     RLB
           *** RUN DATE & TIME: 07-07-97  14:42

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXIT1:XS   ******    -35      426  0.35 ***** 496.92  492.88    2030  496.57
      -195 ******     41    35137  1.00 ***** *******    0.36    4.76

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "EXITX"     KRATIO =  0.39
EXITX:XS      168    -10      210  1.05  1.22  498.49 *******    1700  497.44
       -27    168     50    13675  1.03  0.35    0.00    0.78    8.10

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.98     497.72     497.66
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.94     508.12    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.94     508.12     497.66
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  0.67
FULLV:FV       28     -9      159  1.78  0.64  499.50  497.66    1700  497.72
         0     28     33     9178  1.00  0.36    0.00    0.98   10.71
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.01     499.11     499.09
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.22     513.36    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.22     513.36     499.09
APPRO:AS       42     -8      155  1.88  1.45  501.01  499.09    1700  499.13
        42     42     32     9105  1.00  0.05    0.01    1.00   10.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.03       0.00     498.13     499.06
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   502.56         0.      1700.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING 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       28      0      176  0.81 ***** 500.78  497.17    1266  499.97
         0 ******     25    14732  1.00 ***** *******    0.48    7.20

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.396  0.000  499.97 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG        8.    26.  0.23  0.78  501.56    0.00    442.  501.02

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    442.    80.  -109.   -29.   2.0   1.0   5.5   5.7   1.5   3.0
   RT:      0.    74.    83.   158.   0.4   0.2   3.5   7.6   0.7   2.8

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
APPRO:AS       22    -46      259  0.78  0.18  501.79  499.09    1700  501.02
        42     22     44    18036  1.16  0.00    0.00    0.74    6.55
                  <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -196.   -36.    41.   2030.   35137.     426.    4.76  496.57
   EXITX:XS      -28.   -11.    50.   1700.   13675.     210.    8.10  497.44
   FULLV:FV        0.   -10.    33.   1700.    9178.     159.   10.71  497.72
   BRIDG:BR        0.     0.    25.   1266.   14732.     176.    7.20  499.97
   RDWAY:RG        8.*******   442.    442.*********       0.    2.00  501.02
   APPRO:AS       42.   -47.    44.   1700.   18036.     259.    6.55  501.02

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS    492.88    0.36  486.81  506.98************  0.35  496.92  496.57
   EXITX:XS  ********    0.78  490.73  506.78  1.22  0.35  1.05  498.49  497.44
   FULLV:FV    497.66    0.98  492.07  508.12  0.64  0.36  1.78  499.50  497.72
   BRIDG:BR    497.17    0.48  491.97  500.73************  0.81  500.78  499.97
   RDWAY:RG  ****************  499.06  506.78  0.23******  0.78  501.56  501.02
   APPRO:AS    499.09    0.74  493.20  513.36  0.18  0.00  0.78  501.79  501.02
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        U.S. Geological Survey WSPRO Input File hunt034.wsp
        Hydraulic analysis for structure HUNTTH00210034   Date: 17-JUN-97
        TH 21 CROSSING BRUSH BROOK IN HUNTINGTON, VT                     RLB
           *** RUN DATE & TIME: 07-07-97  14:42

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXIT1:XS   ******    -86      555  0.37 *****  498.35  493.70    2660  497.98
      -195 ******     44    49203  1.04 ***** *******    0.42    4.80

 ===125 FR# EXCEEDS FNTEST AT SECID "EXITX":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.94     498.64     497.14
 ===110 WSEL NOT FOUND AT SECID "EXITX":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   497.48     506.78    0.50
 ===115 WSEL NOT FOUND AT SECID "EXITX":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   497.48     506.78     497.14
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "EXITX"     KRATIO =  0.43
EXITX:XS      168    -71      312  0.96  0.95  499.60  497.14    2220  498.64
       -27    168     73    21317  1.22  0.29    0.00    0.94    7.12

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    1.02     498.64     498.48
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   498.14     508.12    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   498.14     508.12     498.48
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  0.62
FULLV:FV       28    -10      203  1.90  0.49  500.56  498.48    2220  498.66
         0     28     45    13137  1.02  0.47    0.00    1.02   10.92
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    1.11     499.78     499.97
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   498.16     513.36    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   498.16     513.36     499.97
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
            ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                 WSBEG,WSEND,CRWS =   499.97     513.36     499.97
APPRO:AS       42    -14      193  2.13 *****  502.10  499.97    2220  499.97
        42     42     37    12555  1.04 ***** *******    1.07   11.49
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   502.87       0.00     499.20     499.06
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                 WS,QBO,QRD =   502.79         0.       2220.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING 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       28      0      176  1.05 *****  501.02  497.58    1445  499.97
         0 ******     25    14732  1.00 ***** *******    0.55    8.21

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.428  0.000  499.97 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    26.  0.32  1.13  502.15   -0.01    747.  501.33

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    747.    93.  -117.   -24.   2.3   1.1   6.2   7.2   1.9   3.0
   RT:      0.    49.    90.   139.   0.5   0.3   4.4   8.7   1.0   2.8

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
APPRO:AS       22    -51      289  1.13  0.26  502.46  499.97    2220  501.33
        42     22     50    20069  1.24  0.00   -0.01    0.89    7.68
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS    -196.   -87.    44.   2660.   49203.     555.    4.80  497.98
   EXITX:XS     -28.   -72.    73.   2220.   21317.     312.    7.12  498.64
   FULLV:FV       0.   -11.    45.   2220.   13137.     203.   10.92  498.66
   BRIDG:BR       0.     0.    25.   1445.   14732.     176.    8.21  499.97
   RDWAY:RG       8.*******   747.    747.*********       0.    2.00  501.33
   APPRO:AS      42.   -52.    50.   2220.   20069.     289.    7.68  501.33
```

```
 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    493.70    0.42  486.81  506.98************  0.37  498.35  497.98
   EXITX:XS    497.14    0.94  490.73  506.78  0.95  0.29  0.96  499.60  498.64
   FULLV:FV    498.48    1.02  492.07  508.12  0.49  0.47  1.90  500.56  498.66
   BRIDG:BR    497.58    0.55  491.97  500.73************  1.05  501.02  499.97
   RDWAY:RG  ****************  499.06  506.78  0.32******  1.13  502.15  501.33
   APPRO:AS    499.97    0.89  493.20  513.36  0.26  0.00  1.13  502.46  501.33

        U.S. Geological Survey WSPRO Input File hunt034.wsp
        Hydraulic analysis for structure HUNTTH00210034   Date: 17-JUN-97
        TH 21 CROSSING BRUSH BROOK IN HUNTINGTON, VT                     RLB
           *** RUN DATE & TIME: 07-07-97  14:42

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXIT1:XS   ******    -25      277  0.61 *****  495.04  492.46    1740  494.43
      -195 ******     36    19764  1.00 ***** *******    0.53    6.2

 ===125 FR# EXCEEDS FNTEST AT SECID "EXITX":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.83     496.43     495.92
 ===110 WSEL NOT FOUND AT SECID "EXITX":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   493.93     506.78    0.50
 ===115 WSEL NOT FOUND AT SECID "EXITX":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   493.93     506.78     495.92
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "EXITX"     KRATIO =  0.47
EXITX:XS      168     -9      161  1.29  2.33  497.71  495.92    1460  496.42
       -27    168     33     9321  1.00  0.34   -0.01    0.83    9.10

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    1.10     497.01     497.26
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   495.92     508.12    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   495.92     508.12     497.26
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
            ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                 WSBEG,WSEND,CRWS =   497.26     508.12     497.26
FULLV:FV       28     -8      140  1.70 *****  498.96  497.26    1460  497.26
         0     28     32     7623  1.00 ***** *******    1.00   10.46
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.97     498.76     498.67
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   496.76     513.36    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   496.76     513.36     498.67
APPRO:AS       42     -6      140  1.69  1.49  500.45  498.67    1460  498.76
        42     42     31     7896  1.00  0.00    0.01    0.96   10.42
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   500.27       0.00     497.62     499.06
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                 WS,QBO,QRD =   502.43         0.      1460.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                      YU/Z,WSIU,WS = 1.10     500.66     500.81
 ===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       28      0      118  2.40  0.78  500.02  492.17    1460  497.62
         0     28     25     8237  1.00  0.17    0.00    1.00   12.42

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  499.97 ****** ****** ******

    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       22    -16      209  0.80  0.41  501.07  498.67    1460  500.26
        42     22     39    13996  1.06  0.64    0.00    0.65    6.98

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.366  0.088   12781.    -1.    23.   499.98
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>
```

FIRST USER DEFINED TABLE.

XSID:CODE	SRD	LEW	REW	Q	K	AREA	VEL	WSEL
EXIT1:XS	-196.	-26.	36.	1740.	19764.	277.	6.28	494.43
EXITX:XS	-28.	-10.	33.	1460.	9321.	161.	9.10	496.42
FULLV:FV	0.	-9.	32.	1460.	7623.	140.	10.46	497.26
BRIDG:BR	0.	0.	25.	1460.	8237.	118.	12.42	497.62
RDWAY:RG	8.	*******	*******	0.	*********	0.	2.00	********
APPRO:AS	42.	-17.	39.	1460.	13996.	209.	6.98	500.26

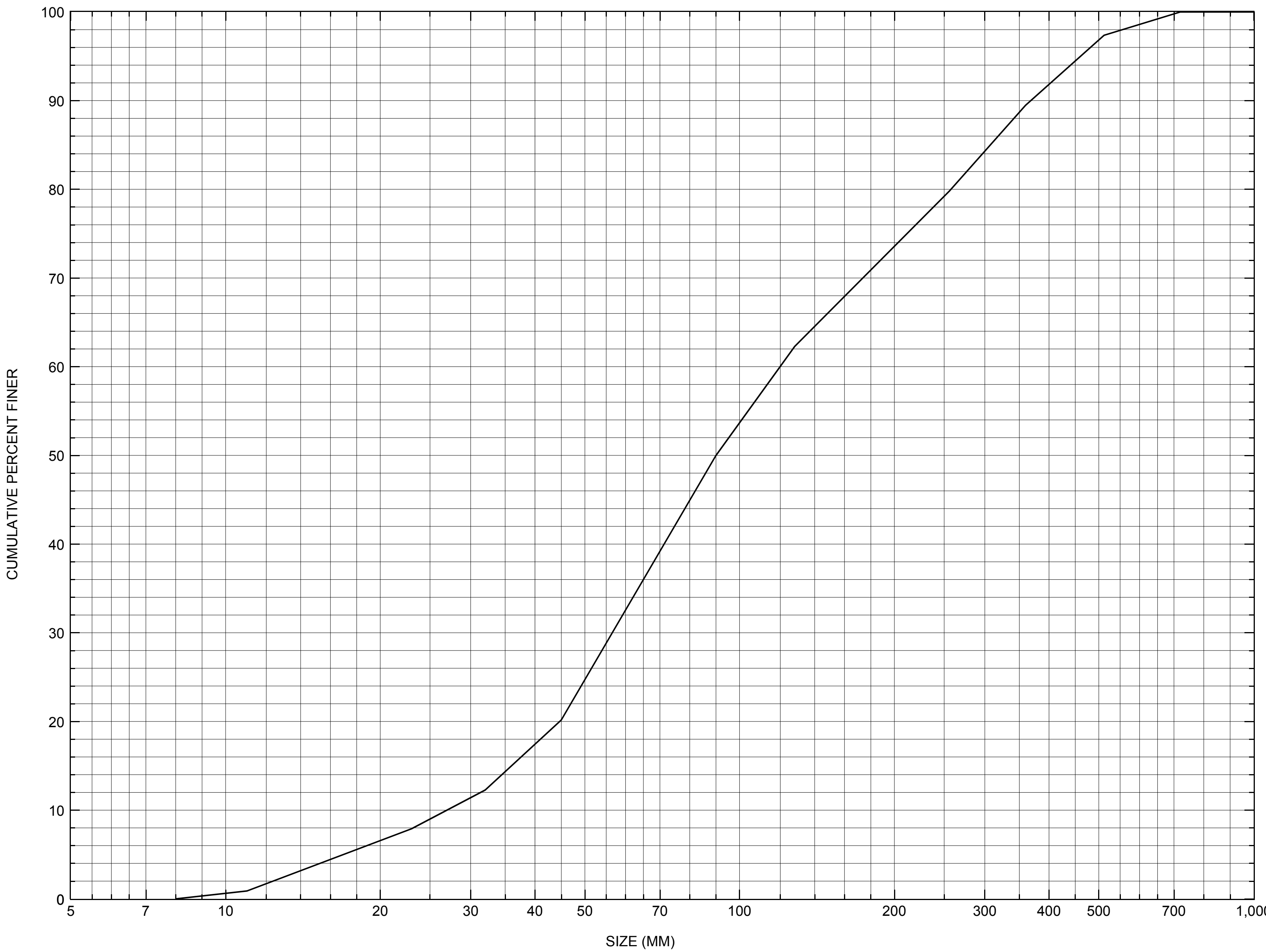
XSID:CODE	XLKQ	XRKQ	KQ
APPRO:AS	-1.	23.	12781.

SECOND USER DEFINED TABLE.

XSID:CODE	CRWS	FR#	YMIN	YMAX	HF	HO	VHD	EGL	WSEL
EXIT1:XS	492.46	0.53	486.81	506.98	******	******	0.61	495.04	494.43
EXITX:XS	495.92	0.83	490.73	506.78	2.33	0.34	1.29	497.71	496.42
FULLV:FV	497.26	1.00	492.07	508.12	******	******	1.70	498.96	497.26
BRIDG:BR	492.17	1.00	491.97	500.73	0.78	0.17	2.40	500.02	497.62
RDWAY:RG	********	********	499.06	506.78	******	******	0.62	501.24	********
APPRO:AS	498.67	0.65	493.20	513.36	0.41	0.64	0.80	501.07	500.26

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure HUNTTH00210034, in Huntington, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HUNTTH00210034

General Location Descriptive

Data collected by (First Initial, Full last name) L. Medalie

Date (MM/DD/YY) 11 / 30 / 95

Highway District Number (I - 2; nn) 05

County (FIPS county code; I - 3; nnn) 007

Town (FIPS place code; I - 4; nnnnn) 34600

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

Waterway (I - 6) BRUSH BROOK

Road Name (I - 7): -

Route Number C3021

Vicinity (I - 9) 0.01 MI TO JCT W C3 TH22

Topographic Map Huntington

Hydrologic Unit Code: 0201003

Latitude (I - 16; nnnn.n) 44179

Longitude (i - 17; nnnnn.n) 72569

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10040800340408

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0026

Year built (I - 27; YYYY) 1950

Structure length (I - 49; nnnnnn) 000028

Average daily traffic, ADT (I - 29; nnnnnn) 000010

Deck Width (I - 52; nn.n) 161

Year of ADT (I - 30; YY) 93

Channel & Protection (I - 61; n) 5

Opening skew to Roadway (I - 34; nn) 02

Waterway adequacy (I - 71; n) 6

Operational status (I - 41; X) P

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) 23

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 7

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

Waterway of full opening (nnn.n ft^2) 161

Comments:

According to the structural inspection report dated 11/1/93, this structure is a steel beam stringer with a wood deck. The abutments and footings are concrete. The DS right wingwall has sheet metal backwalls, which are rusted. A 1 ft void is present along the bottom of the LABUT footing at the DS end, and is possibly the result of an encased boulder slipping out. A concrete footing has recently been poured along the bottom of the RABUT to correct the spalling problem. Large boulders have been placed on the embankments at the US end of both abutments. The DS end of the LABUT has eroded some, with a few boulders showing. An additional small stream flows in near the DS end of the RABUT.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **6.1**

Terrain character: **Hilly to mountainous, mostly forested**

Stream character & type: **-**

Streambed material: **Stone and gravel**

Discharge Data *(cfs)*: $Q_{2.33}$ **400** Q_{10} **900** Q_{25} **1200**

Q_{50} **1500** Q_{100} **1800** 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: **Interagency memo in hydraulics report dated 12/13/94, states that the existing bridge constricts the channel and has a history of scour problems. The scour problems at this bridge are caused, in part, by the location of the bridge in relation to the confluence with the small brook to the east.**

Watershed storage area (*in percent*): **1** %

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*)	**251.27**	**251.85**	**252.16**	**252.46**	**252.81**
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: **Elevations are in meters.**

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

Relief Elevation (*ft*): **-** Discharge over roadway at Q_{100} (*ft³/ sec*): **-**

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

Upstream distance (*miles*): **-** Town: **Huntington** Year Built: **1925**

Highway No. : **TH22** Structure No. : **32** Structure Type: **I-beam**

Clear span (*ft*): **35** Clear Height (*ft*): **10** Full Waterway (*ft²*): **350**

Downstream distance (*miles*): .05 Town: Huntington Year Built: 1990
Highway No. : TH22 Structure No. : 33 Structure Type: Clear span bridge
Clear span (*ft*): 30 Clear Height (*ft*): 8 Full Waterway (ft^2): 240

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 6.23 mi^2 Lake/pond/swamp area 0 mi^2
Watershed storage *(ST)* 0 %
Bridge site elevation 820 ft Headwater elevation 4290 ft
Main channel length 4.03 mi
10% channel length elevation 880 ft 85% channel length elevation 2660 ft
Main channel slope *(S)* 601.00 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 BENCKMARK 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 DRILL BORING INFORMATION

Comments:

Note on hydraulics report dated 12/94, bot. bms=252.50 meters; chan. bot. @approach=250.39 meters. The average low superstructure elevation is 252.5 meters.

Cross-sectional Data

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

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

Comments: **This cross section is the upstream face. The low cord to bed length data is from the sketch attached to a bridge inspection report dated 11/01/93. The sketch was done on 11/02/93. There is no accurate low cord elevation data of the upstream face available.**

Station	0	1	9	16	22	23	-	-	-	-	-
Feature	LAB	-	-	-	-	RAB	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	4.5	7.1	8.1	7.6	7.6	5.2	-	-	-	-	-

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

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

Comments:

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: **EW** Date: **7/10/96**
Computerized by: **EW** Date: **8/2/96**
Reviewd by: **RB** Date: **7/16/97**

Structure Number **HUNTTH00210034**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. IVANOFF** Date *(MM/DD/YY)* **06** / **26** / 19**96**

2. Highway District Number **05** Mile marker **000000**
County **CHITTENDEN (007)** Town **HUNTINGTON (34600)**
Waterway *(I - 6)* **BRUSH BROOK** Road Name **SALVAS ROAD**
Route Number **TH 21** Hydrologic Unit Code: **02010003**

3. Descriptive comments:
Located 0.01 miles to the junction with town highway 22.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **6** LBDS **6** RBDS **6** Overall **6**
*(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 **2** DS **2** *(**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 **28** *(feet)* Span length **26** *(feet)* Bridge width **16.1** *(feet)*

Road approach to bridge:

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

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

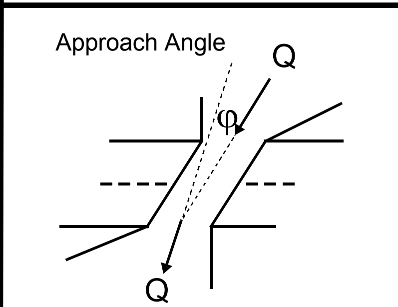
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

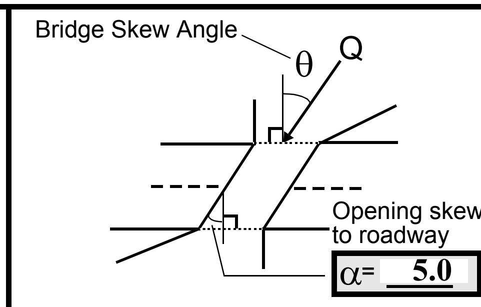
	Protection 11.Type	Protection 12.Cond.	13.Erosion	14.Severity
LBUS	0	-	0	-
RBUS	2	1	0	-
RBDS	0	-	0	-
LBDS	2	1	2	1

*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: **0** 16. Bridge skew: **5**





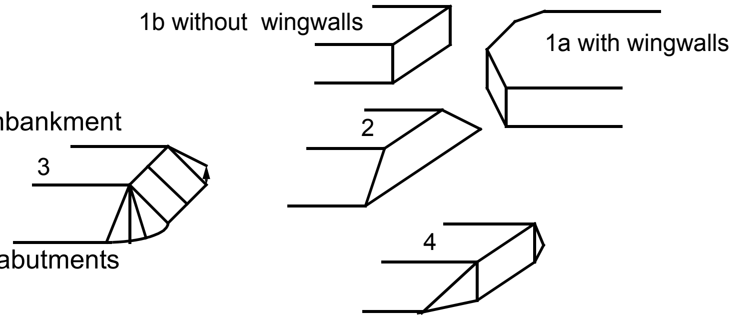
17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **0**
Range? **10** feet **US** *(US, UB, DS)* to **10** feet **US**

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**

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.)

#4: The RBUS is forested with a small pasture near the roadway and a swampy zone with a line of debris near the hill slope.
#7: Values are from VTAOT, measured values during site visit: bridge length = 30 feet; bridge span = 26 feet; bridge width = 14 feet.
#11: The road approach protection on the RBUS and LBDS is sparse with only a few stones visible.
#18: Only one wingwall exists, the USRWW.

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
17.0	**4.5**			**5.0**	**4**	**4**	**54**	**54**	**1**	**1**

23. Bank width **30.0** 24. Channel width **20.0** 25. Thalweg depth **41.0** 29. Bed Material **543**

30 .Bank protection type: LB **2** RB **2** 31. Bank protection condition: LB **1** RB **2**

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: The LB material is boulders and bedrock.
#29: The bed material consists of boulders, cobble and gravel.
#30: The LB protection extends 30 feet US from the abutment.
The RB protection extends along the USRWW to 20 feet US.

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

36. Point bar extent: **-** feet **-** (US, UB) to **-** feet **-** (US, UB, DS) positioned **-** %LB to **-** %RB

37. Material: **-**

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

NO POINT BARS

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: **60** 42. Cut bank extent: **25** feet **US** (US, UB) to **140** 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.):

-

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

47. Scour dimensions: Length **-** Width **-** Depth : **-** Position **-** %LB to **-** %RB

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

NO CHANNEL SCOUR

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

A culvert enters on the LB at 212 feet US. It is two feet in diameter.

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB **2** RB ____ (**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
19.0		**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.):

543

#63: The bed material consists of boulders, cobbles and gravel.

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 2____ *(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

There are trees along both banks with exposed roots.

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		10	86	2	2	0	3.0	90.0
RABUT	1	0	76			2	2	25.5

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.):

0

1.6

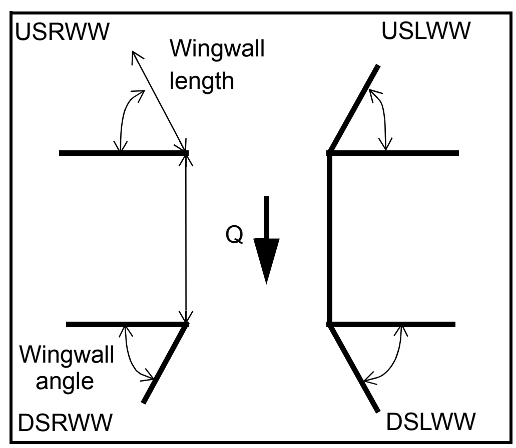
1

#74: In addition to the exposure of the left abutment footing, 0.8 feet of penetration exists three feet from the DS end of the abutment. This penetration void is one foot long (horizontally) and 0.3 feet deep (vertically) with respect to the footing.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						25.5	
USRWW:	N		-		-	1.0	
DSLWW:	-		-		Y	15.5	
DSRWW:	1		0		-	17.0	

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	-	3
Condition	N	-	-	-	-	1	-	1
Extent	-	-	-	-	3	0	2	-

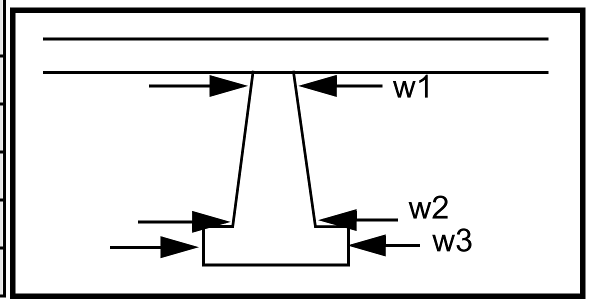
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? #82 (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	-			-	55.0	10.5
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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.):
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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

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

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

PIERS

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

Point bar extent: ______ feet **4** (US, UB, DS) to **4** feet **54** (US, UB, DS) positioned **54** %LB to **1** %RB

Material: **1**

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

543
0
3
-

Is a cut-bank present? **1** *(Y or if N type ctrl-n cb)* Where? **The** *(LB or RB)* Mid-bank distance: **ban**

Cut bank extent: **k** feet **ma** *(US, UB, DS)* to **teria** feet **l** *(US, UB, DS)*

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

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

sists of boulders and cobbles.
The bed material consists of boulders, cobbles and gravel.
The RB protection consists of large broken concrete blocks and boulders leaning against the end of the RABUT extending to 6 feet DS and along the left bank of the confluence and right road approach.

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to ____ %RB

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

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

Confluence 1: Distance **NO** Enters on **DR** *(LB or RB)* Type **OP** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

RE

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)*:

Y
43
8
23
DS
60
DS
92
100
32

109. G. Plan View Sketch

- T

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: HUNTTH00210034 Town: HUNTINGTON
Road Number: TH 21 County: ADDISON
Stream: BRUSH BROOK

Initials RLB Date: 7/3/97 Checked: SAO

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	1700	2220	1460
Main Channel Area, ft2	231	244	200
Left overbank area, ft2	20	33	6
Right overbank area, ft2	9	13	2
Top width main channel, ft	41	41	41
Top width L overbank, ft	39	44	9
Top width R overbank, ft	11	17	6
D50 of channel, ft	0.2953	0.2953	0.2953
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.6	6.0	4.9
y1, average depth, LOB, ft	0.5	0.8	0.7
y1, average depth, ROB, ft	0.8	0.8	0.3
Total conveyance, approach	18060	20069	13972
Conveyance, main channel	17563	19187	13831
Conveyance, LOB	246	528	97
Conveyance, ROB	251	354	43
Percent discrepancy, conveyance	0.0000	0.0000	0.0072
Qm, discharge, MC, cfs	1653.2	2122.4	1445.3
Ql, discharge, LOB, cfs	23.2	58.4	10.1
Qr, discharge, ROB, cfs	23.6	39.2	4.5
Vm, mean velocity MC, ft/s	7.2	8.7	7.2
Vl, mean velocity, LOB, ft/s	1.2	1.8	1.7
Vr, mean velocity, ROB, ft/s	2.6	3.0	2.2
Vc-m, crit. velocity, MC, ft/s	10.0	10.0	9.7
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)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1700	2220	1460
(Q) discharge thru bridge, cfs	1266	1445	1460
Main channel conveyance	14732	14732	8244
Total conveyance	14732	14732	8244
Q2, bridge MC discharge,cfs	1266	1445	1460
Main channel area, ft2	176	176	118
Main channel width (normal), ft	25.2	25.2	24.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.2	25.2	24.4
y_bridge (avg. depth at br.), ft	6.98	6.98	4.84
Dm, median (1.25*D50), ft	0.369125	0.369125	0.369125
y2, depth in contraction,ft	4.72	5.29	5.49
ys, scour depth (y2-ybridge), ft	-2.26	-1.69	0.65

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	OtherQ
Q, total, cfs	1700	2220	1460
Q, thru bridge MC, cfs	1266	1445	1460
Vc, critical velocity, ft/s	9.96	10.05	9.72
Va, velocity MC approach, ft/s	7.16	8.70	7.23
Main channel width (normal), ft	25.2	25.2	24.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.2	25.2	24.4
qbr, unit discharge, ft2/s	50.2	57.3	59.8
Area of full opening, ft2	176.0	176.0	118.0
Hb, depth of full opening, ft	6.98	6.98	4.84
Fr, Froude number, bridge MC	0.48	0.55	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	120	143	N/A
**Hb, depth at downstream face, ft	4.76	5.67	N/A
**Fr, Froude number at DS face	0.85	0.75	ERR
**Cf, for downstream face (<=1.0)	1.00	1.00	N/A
Elevation of Low Steel, ft	499.97	499.97	0

Elevation of Bed, ft	492.99	492.99	-4.84
Elevation of Approach, ft	501.02	501.33	0
Friction loss, approach, ft	0.18	0.26	0
Elevation of WS immediately US, ft	500.84	501.07	0.00
ya, depth immediately US, ft	7.85	8.08	4.84
Mean elevation of deck, ft	503.21	503.21	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.97	0.96	1.00
**Cc, for downstream face (<=1.0)	0.858039	0.90914	ERR
Ys, scour w/Chang equation, ft	-1.79	-1.07	N/A
Ys, scour w/Umbrell equation, ft	0.11	1.18	N/A

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	1.12	0.60	N/A
**Ys, scour w/Umbrell equation, ft	2.33	2.49	ERR

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	4.72	5.29	5.49
WSEL at downstream face, ft	497.72	498.66	--
Depth at downstream face, ft	4.76	5.67	N/A
Ys, depth of scour (Laursen), ft	-0.04	-0.38	N/A

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	Other Q
Q, discharge thru bridge MC, cfs	1266	1445	1460
Main channel area (DS), ft2	120	143	118
Main channel width (normal), ft	25.2	25.2	24.4
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	25.2	25.2	24.4
D90, ft	1.2092	1.2092	1.2092
D95, ft	1.5113	1.5113	1.5113
Dc, critical grain size, ft	0.7481	0.6282	1.0208
Pc, Decimal percent coarser than Dc	0.231	0.274	0.147
Depth to armoring, ft	7.47	4.99	17.77

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)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1700	2220	1460	1700	2220	1460
a', abut.length blocking flow, ft	47.1	52	17.4	19.1	24.5	14.1
Ae, area of blocked flow ft2	43.7	52.4	36.8	32.6	38.8	21.8

Qe, discharge blocked abut.,cfs	--	--	182.5	132.2	189.9	88.5

(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)

Ve, (Qe/Ae), ft/s	4.02	4.54	4.96	4.06	4.89	4.06
ya, depth of f/p flow, ft	0.93	1.01	2.11	1.71	1.58	1.55

--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	85	85	85	95	95	95
K2	0.99	0.99	0.99	1.01	1.01	1.01
Fr, froude number f/p flow	0.662	0.691	0.601	0.548	0.685	0.575
ys, scour depth, ft	9.73	10.89	10.76	7.97	9.24	6.90

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)	47.1	52	17.4	19.1	24.5	14.1
y1 (depth f/p flow, ft)	0.93	1.01	2.11	1.71	1.58	1.55
a'/y1	50.76	51.60	8.23	11.19	15.47	9.12
Skew correction (p. 49, fig. 16)	0.98	0.98	0.98	1.01	1.01	1.01
Froude no. f/p flow	0.66	0.69	0.60	0.55	0.69	0.58
Ys w/ corr. factor K1/0.55:						
vertical	5.79	6.38	ERR	ERR	ERR	ERR
vertical w/ ww's	4.75	5.23	ERR	ERR	ERR	ERR
spill-through	3.18	3.51	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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.85	0.75	1	0.85	0.75	1
y, depth of flow in bridge, ft	4.76	5.67	4.84	4.76	5.67	4.84
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	1.97	ERR	ERR	1.97	ERR
Fr>0.8 (vertical abut.)	1.90	ERR	2.02	1.90	ERR	2.02