LEVEL II SCOUR ANALYSIS FOR BRIDGE 30 (HUNTTH00220030) on TOWN HIGHWAY 22, crossing BRUSH BROOK, HUNTINGTON, VERMONT

Open-File Report 97-816

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and

U.S. Department of the Interior
U.S. Geological Survey

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 30 (HUNTTH00220030) on TOWN HIGHWAY 22, crossing BRUSH BROOK, HUNTINGTON, VERMONT

By RONDA L. BURNS

U.S. Geological Survey
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VERMONT AGENCY OF TRANSPORTATION
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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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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 30 (HUNTTH00220030) ON TOWN HIGHWAY 22, CROSSING BRUSH BROOK, HUNTINGTON, VERMONT

By Ronda L. Burns

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure HUNTTH00220030 on Town Highway 22 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 4.98-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 0.06 ft/ft, an average channel top width of 49 ft and an average bank height of 9 ft. The channel bed material ranges from sand to boulders with a median grain size (D_{50}) of 206 mm (0.675 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 25, 1996, indicated that the reach was stable.

The Town Highway 22 crossing of Brush Brook is a 30-ft-long, one-lane bridge consisting of one 27-foot steel-beam span (Vermont Agency of Transportation, written communication, December 12, 1995). The opening length of the structure parallel to the bridge face is 25.6 ft. The bridge is supported by vertical, concrete abutments. The channel is skewed approximately zero degrees to the opening while the computed opening-skew-to-roadway is 15 degrees.

A scour hole 1 ft deeper than the mean thalweg was observed along the left abutment during the Level I assessment. The left abutment footing is exposed and undermined. The only scour countermeasure noted at the site was type-2 stone fill (less than 36 inches diameter) along the downstream left road approach embankment. 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). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows was zero. Abutment scour ranged from 7.8 to 10.1 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled "Scour Results". Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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 HUNTTH00220030 ***Stream*** Brush Brook

County Chittenden ***Road*** TH 22 ***District*** 5

Description of Bridge

Bridge length 30 ***ft*** ***Bridge width*** 16.1 ***ft*** ***Max span length*** 27 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** None

Stone fill on abutment? No ***Date of inspection*** 6/25/96

Description of stone fill Type-2, along the downstream left road approach embankment.

Abutments are concrete. There is a one foot deep scour hole along the left abutment. The left abutment footing is exposed and undermined 0.1 ft.

No

Is bridge skewed to flood flow according to There ***survey?*** ***Angle*** 0 No

is a mild 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	6/25/96	0	0
Level II	6/25/96	0	0

Potential for debris High. There is some debris caught on boulders in the channel and along the banks upstream and downstream.

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

The right abutment was constructed on a large boulder that extends into the channel under the bridge as of 6/25/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with steep valley walls on both sides.

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

Date of inspection 6/25/96

DS left: Steep channel bank to a moderately sloped overbank

DS right: Steep valley wall

US left: Steep valley wall

US right: Steep channel bank to a moderately sloped overbank

Description of the Channel

Average top width 49 ***ft*** ***Average depth*** 9 ***ft***

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

Straight and stable with non-alluvial channel boundaries.

6/25/96

Vegetative co Trees

DS left: Trees

DS right: Trees

US left: Trees

US right: Yes

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

The assessment of 6/25/96 noted that low flow is influenced by two large boulders in the channel at the upstream bridge face which constrict the bridge opening. There is also a bedrock outcrop on the right bank downstream.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 4.98 ***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***: None.

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 1,500 ***ft³/s*** ***Q500*** 1,960 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(4.98/5.01)exp 0.55] with bridge number 31 in Huntington. Bridge number 31 crosses Brush Brook downstream of this site and has flood frequency estimates available from the VTAOT database (Vermont Agency of Transportation, written communication, May, 1995). The drainage area above bridge number is 5.01 square miles. 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 None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream left retaining wall (elev. 497.93 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream right retaining wall (elev. 498.54 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-31	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	43	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.060 to 0.065, and overbank "n" values ranged from 0.070 to 0.080.

Critical depth at the exit section (EXITX) was assumed as the starting water surface. Normal depth was computed below critical depth approximately 0.4 ft by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0571 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1948).

The modelled approach section (APPRO) was surveyed one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

For the 100-year and 500-year discharge, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.0 *ft*
Average low steel elevation 497.45 *ft*

100-year discharge 1,500 *ft³/s*
Water-surface elevation in bridge opening 493.3 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 119 *ft²*
Average velocity in bridge opening 12.6 *ft/s*
Maximum WSPRO tube velocity at bridge 16.5 *ft/s*

Water-surface elevation at Approach section with bridge 496.3
Water-surface elevation at Approach section without bridge 494.9
Amount of backwater caused by bridge 1.4 *ft*

500-year discharge 1,960 *ft³/s*
Water-surface elevation in bridge opening 494.3 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 143 *ft²*
Average velocity in bridge opening 13.8 *ft/s*
Maximum WSPRO tube velocity at bridge 18.1 *ft/s*

Water-surface elevation at Approach section with bridge 497.6
Water-surface elevation at Approach section without bridge 495.8
Amount of backwater caused by bridge 1.8 *ft*

Incipient overtopping discharge - *ft³/s*
Water-surface elevation in bridge opening - *ft*
Area of flow in bridge opening - *ft²*
Average velocity in bridge opening - *ft/s*
Maximum WSPRO tube velocity at bridge - *ft/s*

Water-surface elevation at Approach section with bridge -
Water-surface elevation at Approach section without bridge -
Amount of backwater caused by bridge - *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 100-year and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). 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	0.0	--
Depth to armoring	16.5	21.5	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	7.8	10.1	--
Right abutment	7.8	8.7	--
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	2.1	2.5	--
Right abutment	2.1	2.5	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

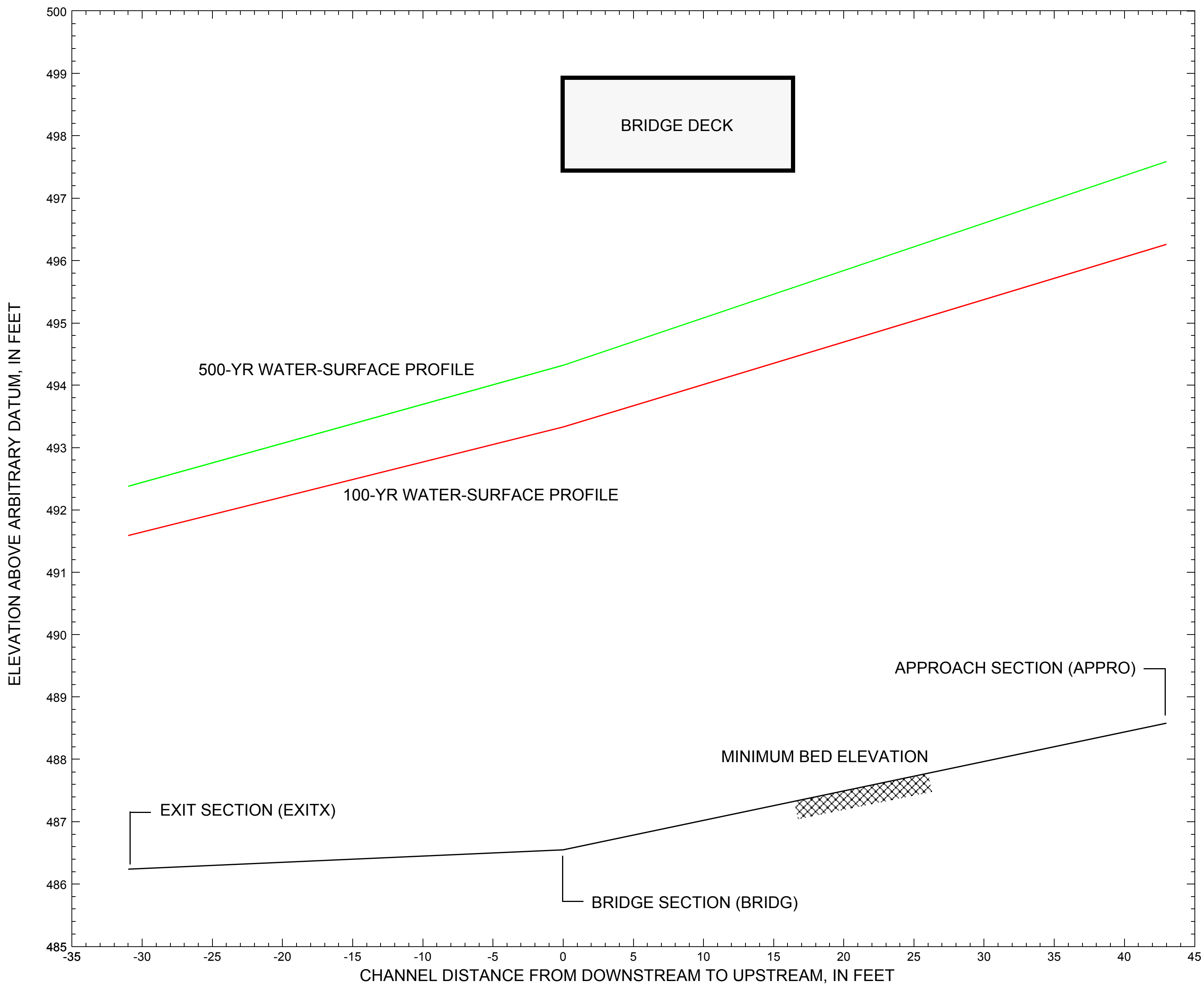

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure HUNTTH00220030 on Town Highway 22, crossing Brush Brook, Huntington, Vermont.

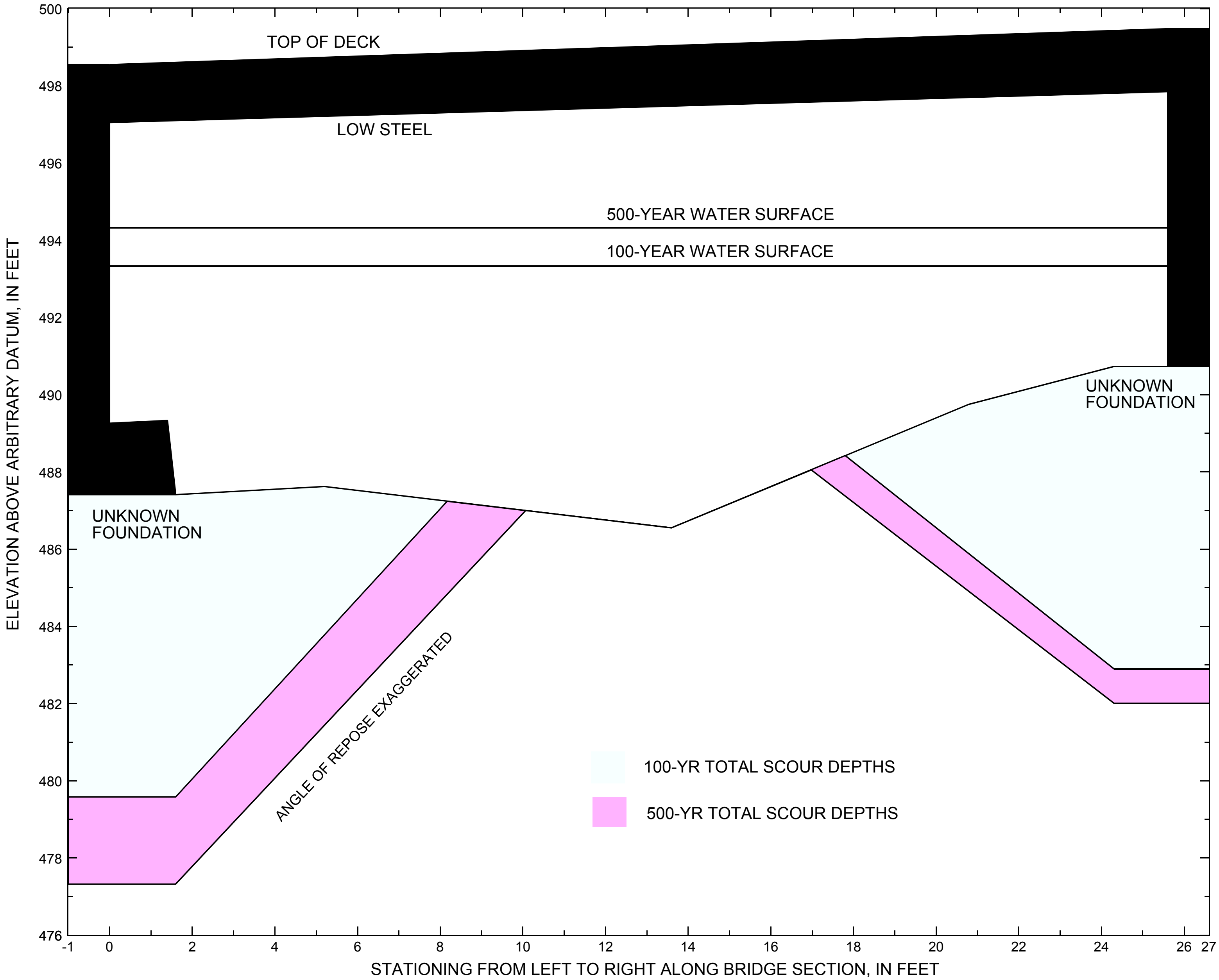

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure HUNTTH00220030 on Town Highway 22, crossing Brush Brook, Huntington, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HUNTTH00220030 on Town Highway 22, 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 1,500 cubic-feet per second											
Left abutment	0.0	--	497.1	--	487.4	0.0	7.8	--	7.8	479.6	--
Right abutment	25.6	--	497.9	--	490.7	0.0	7.8	--	7.8	482.9	--

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 HUNTTH00220030 on Town Highway 22, 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 1,960 cubic-feet per second											
Left abutment	0.0	--	497.1	--	487.4	0.0	10.1	--	10.1	477.3	--
Right abutment	25.6	--	497.9	--	490.7	0.0	8.7	--	8.7	482.0	--

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 hunt030.wsp
T2        Hydraulic analysis for structure HUNTTH00220030   Date: 05-JUN-97
T3        TH022 crossing Brush Brook, in Huntington, Vermont
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1500.0   1960.0
SK          0.0571   0.0571
*
XS   EXITX    -31           0.
GR          -97.6, 508.82    -81.7, 501.56    -65.5, 499.55    -31.0, 497.14
GR          -16.0, 494.49     -7.4, 491.38      0.0, 487.22      2.6, 486.55
GR            5.8, 486.24      8.9, 486.73     18.3, 487.02     22.4, 487.66
GR           31.9, 492.33     37.3, 501.18     60.7, 499.23     76.8, 505.92
GR           87.1, 512.97
*
N           0.080        0.065        0.070
SA                 -16.0         37.3
*
XS   FULLV      0  * * *   0.0063
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.45      15.0
GR            0.0, 497.05      0.0, 489.26      1.4, 489.33      1.5, 488.14
GR            1.6, 487.41      5.2, 487.62     13.6, 486.55     14.1, 488.41
GR           20.8, 489.75     24.3, 490.73     25.6, 497.85      0.0, 497.05
*
*         BRTYPE  BRWDTH
CD           1      16.8
N           0.060
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      8      16.1     2
GR          -69.9, 510.70    -58.0, 502.22    -36.3, 499.35    -14.6, 498.39
GR            0.0, 498.55     26.8, 499.48     43.8, 500.20     88.3, 505.24
GR          123.7, 509.13    198.2, 512.43
*
*
AS   APPRO     43           0.
GR          -49.5, 512.09    -34.2, 502.27    -20.4, 499.89    -11.3, 496.73
GR           -3.5, 495.33      0.0, 491.46      4.1, 490.53      6.0, 489.98
GR            8.6, 489.45     11.9, 488.58     15.4, 489.30     18.1, 490.16
GR           23.5, 490.98     29.6, 496.93     39.0, 503.00    100.5, 506.11
GR          137.3, 512.49
*
N           0.080        0.065        0.080
SA                  -3.5        39.0
*
HP 1 BRIDG   493.33 1 493.33
HP 2 BRIDG   493.33 * * 1500
HP 1 APPRO   496.26 1 496.26
HP 2 APPRO   496.26 * * 1500
*
HP 1 BRIDG   494.32 1 494.32
HP 2 BRIDG   494.32 * * 1960
HP 1 APPRO   497.59 1 497.59
HP 2 APPRO   497.59 * * 1960
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File hunt030.wsp
        Hydraulic analysis for structure HUNTTH00220030   Date: 05-JUN-97
        TH022 crossing Brush Brook, in Huntington, Vermont
           *** RUN DATE & TIME: 09-30-97  09:29

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      119      6822     24     34                         1500
   493.33           119      6822     24     34  1.00      0     25     1500

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.33     0.0    24.8   118.7    6822.    1500.  12.64

X STA.        0.0        2.5        3.7        4.7        5.7        6.6
  A(I)           11.7        6.6        5.9        5.5        5.2
  V(I)           6.40      11.40      12.78      13.76      14.55

X STA.        6.6        7.5        8.3        9.1        9.9       10.6
  A(I)            4.8        4.9        4.7        4.6        4.6
  V(I)          15.62      15.45      15.98      16.48      16.23

X STA.       10.6       11.3       12.1       12.8       13.5       15.0
  A(I)            4.5        4.6        4.7        4.8        7.5
  V(I)          16.54      16.30      15.89      15.79       9.97

X STA.       15.0       16.2       17.6       19.2       21.1       24.8
  A(I)            5.5        5.8        6.3        6.8        9.9
  V(I)          13.64      13.03      11.84      11.10       7.54

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1        2        27      5      5                            9
             2      172     11026     32     37                         2253
   496.26           175     11052     38     42  1.02     -8     29     2114

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.26    -8.7    28.9   174.6   11052.    1500.   8.59

X STA.       -8.7        0.7        2.6        4.2        5.6        6.8
  A(I)           16.1        9.7        8.7        8.3        7.8
  V(I)           4.67       7.70       8.60       9.04       9.57

X STA.        6.8        8.0        9.0       10.1       11.0       11.9
  A(I)            7.5        7.4        7.2        7.1        6.9
  V(I)          10.03      10.15      10.46      10.60      10.92

X STA.       11.9       12.9       13.8       14.8       15.9       17.1
  A(I)            7.0        7.0        7.3        7.3        8.0
  V(I)          10.76      10.70      10.30      10.33       9.43

X STA.       17.1       18.4       19.8       21.4       23.2       28.9
  A(I)            8.1        8.4        9.1       10.1       15.8
  V(I)           9.22       8.94       8.27       7.42       4.74
```

```
     U.S. Geological Survey WSPRO Input File hunt030.wsp
     Hydraulic analysis for structure HUNTTH00220030   Date: 05-JUN-97
     TH022 crossing Brush Brook, in Huntington, Vermont
        *** RUN DATE & TIME: 09-30-97  09:29

 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      142      8901     24     36                         1966
494.32           142      8901     24     36  1.00      0     25     1966

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

     WSEL     LEW     REW    AREA        K        Q    VEL
   494.32     0.0    25.0   142.5    8901.    1960.  13.76

X STA.        0.0        2.6        3.8        4.9        5.9        6.8
  A(I)           14.3        8.2        7.2        6.4        6.2
  V(I)           6.85      12.02      13.54      15.33      15.78

X STA.        6.8        7.7        8.5        9.3       10.1       10.9
  A(I)            5.9        5.7        5.6        5.4        5.5
  V(I)          16.66      17.15      17.43      18.01      17.77

X STA.       10.9       11.6       12.4       13.2       14.4       15.6
  A(I)            5.4        5.5        5.6        8.5        6.2
  V(I)          18.07      17.84      17.42      11.57      15.68

X STA.       15.6       16.8       18.1       19.6       21.4       25.0
  A(I)            6.5        6.7        7.4        8.1       12.2
  V(I)          15.17      14.64      13.33      12.13       8.06

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1       13       287     10     11                           85
          2      216     15522     34     39                         3091
497.59           230     15808     44     50  1.07    -13     31     2867

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

     WSEL     LEW     REW    AREA        K        Q    VEL
   497.59   -13.8    30.6   229.6   15808.    1960.   8.54

X STA.      -13.8       -0.5        1.6        3.2        4.7        6.0
  A(I)           25.0       12.9       11.0       10.1       10.0
  V(I)           3.92       7.61       8.94       9.69       9.76

X STA.        6.0        7.2        8.4        9.5       10.6       11.6
  A(I)            9.4        9.4        9.2        8.9        8.9
  V(I)          10.38      10.46      10.63      10.97      10.97

X STA.       11.6       12.6       13.6       14.7       15.8       17.1
  A(I)            8.9        9.0        9.4        9.4        9.9
  V(I)          10.98      10.87      10.44      10.44       9.89

X STA.       17.1       18.5       20.0       21.7       23.6       30.6
  A(I)           10.6       11.0       11.6       13.3       21.6
  V(I)           9.27       8.93       8.46       7.36       4.53
```

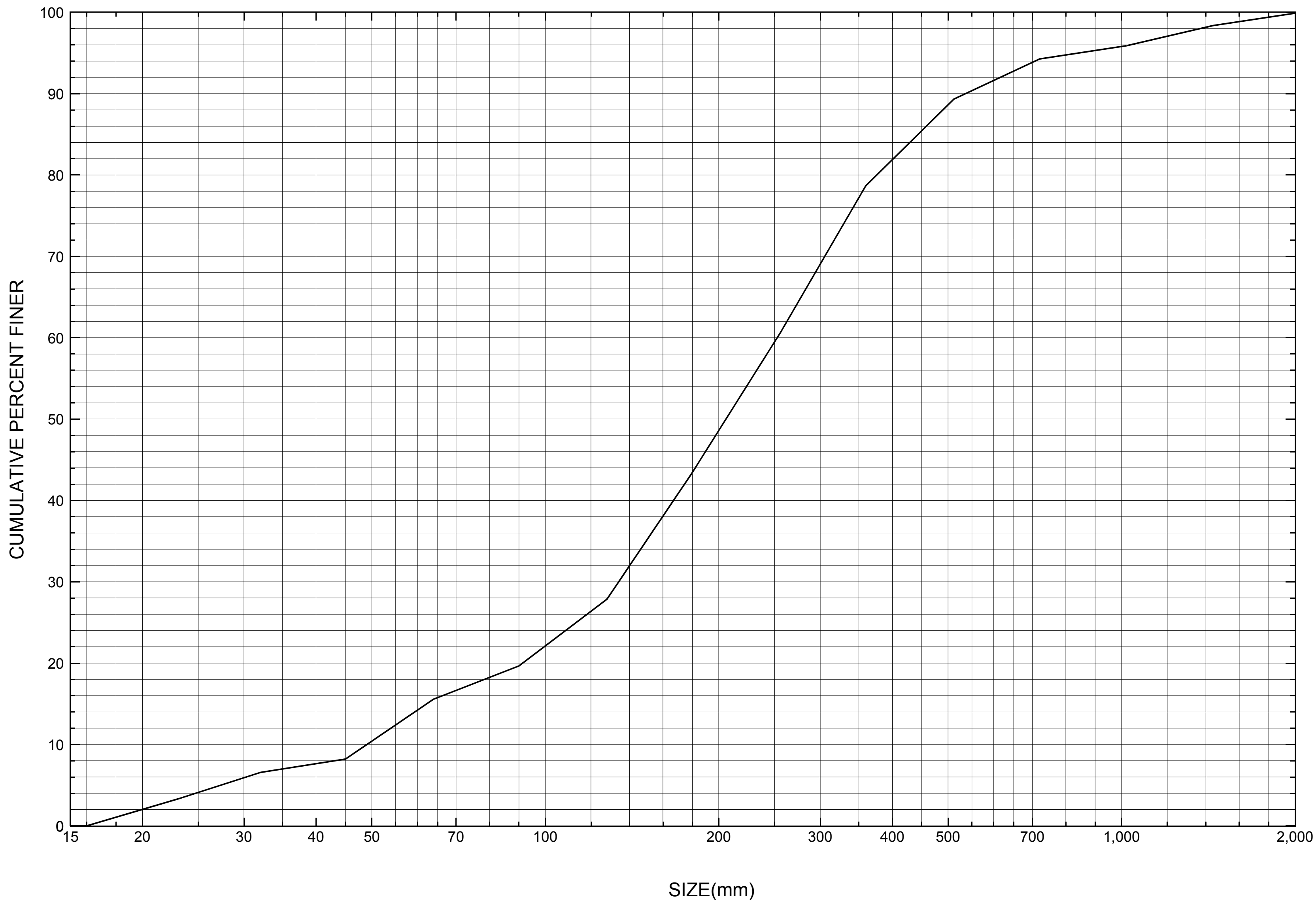
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File hunt030.wsp
        Hydraulic analysis for structure HUNTTH00220030   Date: 05-JUN-97
        TH022 crossing Brush Brook, in Huntington, Vermont
           *** RUN DATE & TIME: 09-30-97  09:29

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                             WSI,CRWS =   491.22     491.59

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

EXITX:XS   ******     -7      139  1.80 *****  493.40  491.59    1500  491.59
       -30 ******     30     7260  1.00 ***** *******    1.00   10.77

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.69

FULLV:FV       31    -11      204  0.84  0.78  494.17 *******    1500  493.33
         0     31     32    12270  1.00  0.00   -0.01    0.61    7.37
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.89     493.25     494.91

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   492.83     512.49    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   492.83     512.49     494.91

 ===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 =   494.91     512.49     494.91

APPRO:AS       43     -2      130  2.09 *****  497.00  494.91    1500  494.91
        43     43     28     7186  1.00 ***** *******    0.99   11.58
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    1500.     493.33

            <<<<<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       31      0      119  2.49 *****  495.81  493.33    1500  493.33
         0     31     25     6813  1.00 ***** *******    1.00   12.65

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.45 ****** ****** ******

    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       26     -8      175  1.17  0.81  497.43  494.91    1500  496.26
        43     27     29    11063  1.02  0.81    0.01    0.71    8.58

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.192  0.000   11088.     2.    26.   495.77
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -31.    -8.    30.   1500.    7260.     139.   10.77  491.59
   FULLV:FV       0.   -12.    32.   1500.   12270.     204.    7.37  493.33
   BRIDG:BR       0.     0.    25.   1500.    6813.     119.   12.65  493.33
   RDWAY:RG       8.***************       0.******************    2.00********
   APPRO:AS      43.    -9.    29.   1500.   11063.     175.    8.58  496.26

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    26.   11088.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    491.59    1.00  486.24  512.97************  1.80  493.40  491.59
   FULLV:FV  ********    0.61  486.44  513.17  0.78  0.00  0.84  494.17  493.33
   BRIDG:BR    493.33    1.00  486.55  497.85************  2.49  495.81  493.33
   RDWAY:RG  ****************  498.39  512.43**********************************
   APPRO:AS    494.91    0.71  488.58  512.49  0.81  0.81  1.17  497.43  496.26
```

```
        U.S. Geological Survey WSPRO Input File hunt030.wsp
        Hydraulic analysis for structure HUNTTH00220030   Date: 05-JUN-97
        TH022 crossing Brush Brook, in Huntington, Vermont
           *** RUN DATE & TIME: 09-30-97  09:29

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   491.93     492.38

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

EXITX:XS   ******     -9      171  2.04 *****  494.42  492.38    1960  492.38
       -30 ******     32     9598  1.00 ***** *******    1.00   11.46

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  1.64

FULLV:FV       31    -14      243  1.01  0.79  495.20 *******    1960  494.19
         0     31     33    15747  1.00  0.00   -0.01    0.63    8.05
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   493.69     512.49    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   493.69     512.49     495.80

 ===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 =   495.80     512.49     495.80

APPRO:AS       43     -5      158  2.41 *****  498.21  495.80    1960  495.80
        43     43     28     9605  1.01 ***** *******    1.03   12.41
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                 SECID "BRIDG"     Q,CRWS =    1960.     494.32

            <<<<<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       31      0      143  2.94 *****  497.26  494.32    1960  494.32
         0     31     25     8905  1.00 ***** *******    1.00   13.75

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.45 ****** ****** ******

    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       26    -13      230  1.21  0.73  498.80  495.80    1960  497.59
        43     27     31    15821  1.07  0.81    0.01    0.68    8.53

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.278  0.015   15532.     1.    26.   497.18

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -31.   -10.    32.   1960.    9598.     171.   11.46  492.38
   FULLV:FV       0.   -15.    33.   1960.   15747.     243.    8.05  494.19
   BRIDG:BR       0.     0.    25.   1960.    8905.     143.   13.75  494.32
   RDWAY:RG       8.**************       0.*****************    2.00********
   APPRO:AS      43.   -14.    31.   1960.   15821.     230.    8.53  497.59

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       1.    26.   15532.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    492.38    1.00  486.24  512.97************  2.04  494.42  492.38
   FULLV:FV  ********    0.63  486.44  513.17  0.79  0.00  1.01  495.20  494.19
   BRIDG:BR    494.32    1.00  486.55  497.85************  2.94  497.26  494.32
   RDWAY:RG  ****************  498.39  512.43**********************************
   APPRO:AS    495.80    0.68  488.58  512.49  0.73  0.81  1.21  498.80  497.59
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count at the approach cross-section for structure HUNTTH00220030, in Huntington, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HUNTTH00220030

General Location Descriptive

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

Date *(MM/DD/YY)* 12 / 12 / 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 C3022

Vicinity *(I - 9)* 1.2 MI TO JCT W CL3 TH21

Topographic Map Huntington

Hydrologic Unit Code: 02010003

Latitude *(I - 16; nnnn.n)* 44178

Longitude *(i - 17; nnnnn.n)* 72559

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10040800300408

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

Maximum span length *(I - 48; nnnn)* 0027

Year built *(I - 27; YYYY)* 1925

Structure length *(I - 49; nnnnnn)* 000030

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)* 10

Waterway adequacy *(I - 71; n)* 6

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 22

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

Vertical clearance from streambed (*nnn.n ft*) 9.4

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

Waterway of full opening (*nnn.n* ft^2) 207

Comments:

According to the structural inspection report dated 7-17-95, the structure is a steel stringer with a wooden deck. The abutments and backwalls have a few fine cracks, small leaks and small spalls overall. A concrete footing was originally poured on the LABUT but it has separated, broken into pieces, and slid away from the abutment bottom. The abutment bottom has some spalling, with undermining along its entire length. The voids are up to 18 inches horizontal by 2-3 inches deep. The downstream half of the RABUT has several fine vertical and diagonal cracks with small leaks. A massive 10 ft boulder has been encased in the lower half of the RABUT. The upstream half of the RABUT is undermined **(Continued p. 31)**

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: **ledge and boulders**

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:

5-6 ft horizontally by up to 18 inches deep. The voided area extends in behind the boulder. Massive boulders and ledge are in the US and DS channel and along the banks.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **4.98** mi^2 Lake/pond/swamp area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **1060** ft Headwater elevation **4290** ft

Main channel length **2.91** mi

10% channel length elevation **1170** ft 85% channel length elevation **2900** ft

Main channel slope *(S)* **792.1** 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:

-

Cross-sectional Data

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

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

Comments: **This is a cross-section of the upstream face. The low chord elevation is from the survey log done for this report on 06/25/96. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 07/17/95. The sketch was done on 11/02/93.**

Station	0	5	11	16	22	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low chord elevation	497.0	-	-	-	497.8	-	-	-	-	-	-
Bed elevation	498.5	-	-	-	490.4	-	-	-	-	-	-
Low chord to bed	7.5	9.9	10.5	9.7	7.4	-	-	-	-	-	-

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: **JD** Date: **6/5/97**
Computerized by: **JD** Date: **6/5/97**
Reviewd by: **RB** Date: **11/5/97**

Structure Number **HUNTTH00220030**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R**. **BURNS** Date *(MM/DD/YY)* **06** / **25** / 19**96**

2. Highway District Number **05** Mile marker **0**

County **CHITTENDEN (007)** Town **HUNTINGTON (34600)**

Waterway *(I - 6)* **BRUSH BROOK** Road Name **-**

Route Number **C3022** Hydrologic Unit Code: **02010003**

3. Descriptive comments:

This structure is located 1.2 miles from the junction with CL3 Town Highway 21.

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 **30** *(feet)* Span length **27** *(feet)* Bridge width **16.1** *(feet)*

Road approach to bridge:

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

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

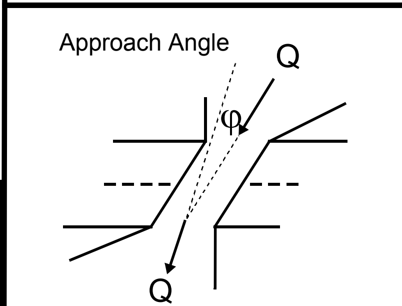
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

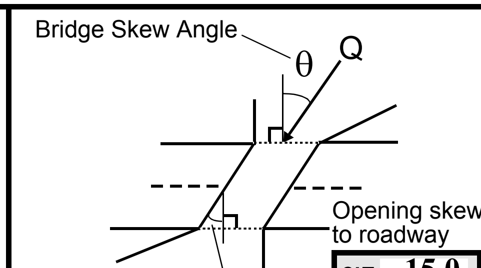
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	**0**	**-**	**2**	**1**
RBUS	**0**	**-**	**2**	**1**
RBDS	**0**	**-**	**0**	**-**
LBDS	**2**	**1**	**3**	**1**

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





α= **15.0**

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

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: **1b**

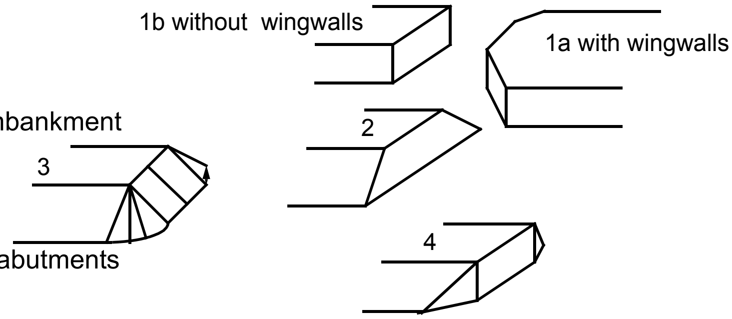
1a- Vertical abutments with wingwalls

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 VTAOT database. The measured bridge length is 29 feet. The measured span length is 26 feet. The measured bridge width is 17.1 feet.

11. The downstream side of the left road embankment has stone protection that was plowed into a ridge.

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
28.5	**4.0**			**12.0**	**4**	**4**	**542**	**542**	**1**	**0**

23. Bank width **25.0** 24. Channel width **40.0** 25. Thalweg depth **43.5** 29. Bed Material **54**

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

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

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

28. Upstream of the point bar, the left bank is less steep and tree roots are exposed.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 14 35. Mid-bar width: 5

36. Point bar extent: 10 feet US (US, UB) to 30 feet US (US, UB, DS) positioned 0 %LB to 10 %RB

37. Material: 42

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

The point bar is between boulders.

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

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

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

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

NO CUT BANKS

45. Is channel scour present? 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

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
23.5		2.0		2	7	7	-

58. Bank width (BF) - 59. Channel width (Amb) - 60. Thalweg depth (Amb) 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.):

542

63. The bed material becomes finer going downstream under the bridge.

Two large boulders constrict the upstream bridge opening to about 3 feet during low flows.

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

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

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

70. Debris and Ice Comments:

2

65. There is an abundance of trees and branches caught on boulders in the channel and on the banks.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**90**	**2**	**3**	**1**	**2**	**90.0**
RABUT	**1**	**-**	**90**			**2**	**0**	**24.5**

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.):

-

-

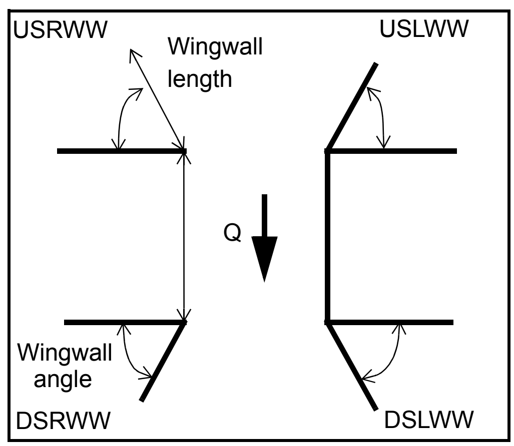
1

The left abutment has a freshly poured concrete footing. The remains of the old, disconnected footing can be seen in the channel. The height of the new footing is 2 feet and is already undermined with a 0.1 foot vertical opening that can be penetrated horizontally 1 foot. The right abutment was poured over a boulder that is at least 10 feet in diameter. Upstream and downstream of the boulder the abutment is poured directly on smaller boulder bed material. The large boulder protrudes approximately 7 feet into the channel from the abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**24.5**	
USRWW:	**N**		**-**		**-**	**1.5**	
DSLWW:	**-**		**-**		**N**	**14.0**	
DSRWW:	**-**		**-**		**-**	**19.5**	

*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**	**-**	**-**	**-**	**-**	**-**
Condition	**N**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Extent	**-**	**-**	**-**	**-**	**-**	**0**	**0**	**-**

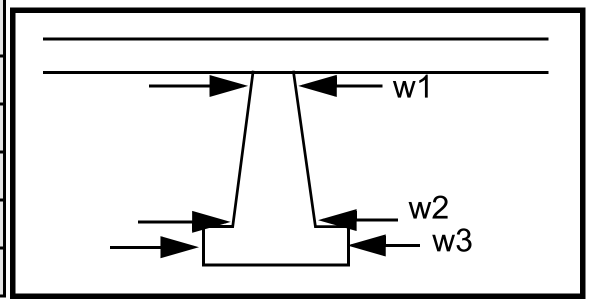
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

-
-
-
-
-
-
-
-
-
-

E. Downstream Channel Assessment

100.

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

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

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

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

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

4
4
543
543
0
1
542
0
0
-
-

Roots are exposed on the right bank in the confluence region. At 42 feet downstream there is bedrock outcropping on the right bank.

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):

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

Point bar extent: ______ feet ____ *(US, UB, DS)* to **N** ____ feet **-** ___ *(US, UB, DS)* positioned **NO** %LB to **DR** %RB

Material: **OP**

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

STRUCTURE

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

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.):

-
-
-
-

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

Scour dimensions: Length **T** Width **BAR** Depth: **S** Positioned ____ %LB to ____ %RB

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

N
-
-

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

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

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

Confluence comments (eg. confluence name):

BANKS

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

1- *Constructed*
2- *Stable*
3- *Aggraded*
4- *Degraded*
5- *Laterally unstable*
6- *Vertically and laterally unstable*

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

N
-
-
-
-
-
-
NO CHANNEL SCOUR

N

109. G. Plan View Sketch

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: HUNTTH00220030 Town: HUNTINGTON
Road Number: TH 22 County: CHITTENDEN
Stream: BRUSH BROOK

Initials RLB Date: 9/29/97 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	1500	1960	0
Main Channel Area, ft2	172	216	0
Left overbank area, ft2	2	13	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	32	34	0
Top width L overbank, ft	5	10	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.6754	0.6754	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.4	6.4	ERR
y1, average depth, LOB, ft	0.4	1.3	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	11052	15808	0
Conveyance, main channel	11026	15522	0
Conveyance, LOB	27	287	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	-0.0090	-0.0063	ERR
Qm, discharge, MC, cfs	1496.5	1924.5	ERR
Ql, discharge, LOB, cfs	3.7	35.6	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	8.7	8.9	ERR
Vl, mean velocity, LOB, ft/s	1.8	2.7	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	13.0	13.4	N/A
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	N/A
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	1500	1960	0
(Q) discharge thru bridge, cfs	1500	1960	0
Main channel conveyance	6822	8901	0
Total conveyance	6822	8901	0
Q2, bridge MC discharge,cfs	1500	1960	ERR
Main channel area, ft2	119	142	0
Main channel width (normal), ft	24.0	24.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24	24.1	0
y_bridge (avg. depth at br.), ft	4.96	5.89	ERR
Dm, median (1.25*D50), ft	0.84425	0.84425	0
y2, depth in contraction,ft	4.50	5.64	ERR
ys, scour depth (y2-ybridge), ft	-0.46	-0.26	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	1500	1960	N/A
Main channel area (DS), ft2	119	142	0
Main channel width (normal), ft	24.0	24.1	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	24.0	24.1	0.0
D90, ft	1.7579	1.7579	0.0000
D95, ft	2.7630	2.7630	0.0000
Dc, critical grain size, ft	1.2785	1.3940	ERR
Pc, Decimal percent coarser than Dc	0.189	0.163	0.000
Depth to armoring, ft	16.46	21.47	ERR

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	1500	1960	0	1500	1960	0
a', abut.length blocking flow, ft	9.1	14.3	0	4.5	6	0
Ae, area of blocked flow ft2	15.59	31.14	0	12.47	18.51	0
Qe, discharge blocked abut.,cfs	72.61	144.67	0	59.21	84	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.66	4.65	ERR	4.75	4.54	ERR
ya, depth of f/p flow, ft	1.71	2.18	ERR	2.77	3.09	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	105	105	105	75	75	75
K2	1.02	1.02	1.02	0.98	0.98	0.98
Fr, froude number f/p flow	0.627	0.555	ERR	0.503	0.455	ERR
ys, scour depth, ft	7.83	10.09	N/A	7.75	8.72	N/A

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)	9.1	14.3	0	4.5	6	0
y1 (depth f/p flow, ft)	1.71	2.18	ERR	2.77	3.09	ERR
a'/y1	5.31	6.57	ERR	1.62	1.94	ERR
Skew correction (p. 49, fig. 16)	1.03	1.03	1.03	0.95	0.95	0.95
Froude no. f/p flow	0.63	0.55	N/A	0.50	0.46	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	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	1	1	0	1	1	0
y, depth of flow in bridge, ft	4.96	5.89	0.00	4.96	5.89	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	2.07	2.46	ERR	2.07	2.46	ERR