LEVEL II SCOUR ANALYSIS FOR BRIDGE 12 (HUNTTH00010012) on TOWN HIGHWAY 1, crossing BRUSH BROOK, HUNTINGTON, VERMONT

U.S. Geological Survey
Open-File Report 97-226

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

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By Ronda L. Burns and Emily C. Wild

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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 12 (HUNTTH00010012) ON TOWN HIGHWAY 1, CROSSING BRUSH BROOK, HUNTINGTON, VERMONT

By **Ronda L. Burns and Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure HUNTTH00010012 on Town Highway 1 crossing Brush Brook, Huntington, Vermont (figures 1–9). 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.

In August 1976, Hurricane Belle caused flooding at this site which resulted in road and bridge damage (figures 7-8). This was approximately a 25-year flood event based on flood-frequency data contained in the Flood Insurance Study for the Town of Huntington (U.S. Department of Housing and Urban Development, 1978).

The site is in the Green Mountain section of the New England physiographic province in central Vermont. The 9.19-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture while the immediate banks have some woody vegetation.

In the study area, the Brush Brook has a sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 62 ft and an average bank height of 5 ft. The channel bed material ranges from gravel to cobble with a median grain size (D_{50}) of 100.0 mm (0.328 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 1 crossing of Brush Brook is a 64-ft-long, two-lane bridge consisting of one 62-foot steel-stringer span (Vermont Agency of Transportation, written communication, November 30, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 6 degrees.

Channel scour 2.2 ft deeper than the mean thalweg depth was observed along the upstream right bank and along the base of the spill-through protection for the right abutment during the Level I assessment. Scour protection measured at the site was type-2 stone fill (less than 36 inches diameter) along the upstream left and right banks and in front of all four wingwalls. In front of the abutments, there was type-3 stone fill (less than 48 inches diameter) forming a spill-through slope. 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.

There was no computed contraction scour for any modelled flow. Abutment scour ranged from 1.4 to 2.8 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 9. 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.

Huntington, VT. Quadrangle, 1:24,000, 1948
Photoinspected 1980

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.

Figure 7. Right road approach viewed after the August 1976 flood which destroyed the bridge (U.S. Department of Housing and Urban Development, 1978).

LEVEL II SUMMARY

Structure Number HUNTTH00010012 ***Stream*** Brush Brook

County Chittenden ***Road*** TH1 ***District*** 5

Description of Bridge

Bridge length 64 ***ft*** ***Bridge width*** 31.4 ***ft*** ***Max span length*** 62 ***ft***

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

Abutment type Spill-through ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 06/25/96

Description of stone fill Type-3, along the entire baselengths of both abutments forming spill-through slopes at the faces of the abutments.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a one to two foot deep scour hole in front of the right abutment protection that is the extension of a channel scour hole from upstream.

Is bridge skewed to flood flow according to Level I survey? N ***Angle***

Is bridge located on a bend in channel? If so, describe (mild, moderate, severe) Y 10

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	06/25/96	0	0
Level II	06/25/96	0	0

Potential for debris Moderate. There is debris accumulated on the side bars between the bushes and trees and on the point bar downstream.

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

None. (June 25, 1996)

Description of the Geomorphic Setting

General topography The channel is located within the wide, flat to slightly irregular flood plain of the Huntington River and has steep valley walls on both sides upstream.

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

Date of inspection 06/25/96

DS left: Wide flood plain.

DS right: Wide flood plain.

US left: Wide flood plain.

US right: Wide flood plain.

Description of the Channel

Average top width 62 ***ft*** ***Average depth*** 5 ***ft***

Predominant bed material Gravel / Cobbles ***Bank material*** Gravel/Cobbles

Sinuous but stable with semi-alluvial channel boundaries and a wide flood plain.

06/25/96

Vegetative co Short grass on the overbank with brush with a few trees on the immediate bank.

DS left: Short grass on the overbank with brush with a few trees on the immediate bank.

DS right: Short grass on the overbank with brush with a few trees on the immediate bank.

US left: Short grass on the overbank with brush with a few trees on the immediate bank.

US right:

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

None. (June 25, 1996)

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 9.19 ***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 2100 ***ft³/s*** ***Q500*** 2750 ***ft³/s***

The discharges are from flood frequency estimates available from the VTAOT database (written communication, VTAOT, May 1995) 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 0.6 ft. to USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a brass tablet on top of the upstream end of the left abutment (elev. 500.89 ft., arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 500.39 ft., arbitrary survey datum). RM3 is a spike 6 ft. above the ground in a telephone pole 50 ft. from the left bank and 20 ft. downstream from the road (elev. 504.39 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	-52	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	17	1	Road Grade section
APPRO	93	2	Modelled Approach section (Templated from APTEM)
APTEM	86	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Shearman and others, 1986, and Shearman, 1990). The analyses reported herein reflect conditions existing at the site at the time of the study. Furthermore, in the development of the model it was necessary to assume no accumulation of debris or ice at the site. Results of the hydraulic model are presented in the Bridge Hydraulic Summary, Appendix B, and figure 8.

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 0.040 to 0.055, and overbank "n" values ranged from 0.035 to 0.040.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0162 ft/ft which was calculated from surveyed thalweg points downstream. Brush Brook flows into the Huntington River 0.1 mile downstream. There is a possibility of backwater from the Huntington River if peaks at the confluence occur simultaneously. Assuming normal depth as the starting water surface will provide the worst-case scenario.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0055 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

The 100-year flow in this case is also the incipient road-overflow discharge.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.6 *ft*
Average low steel elevation 496.4 *ft*

100-year discharge 2,100 *ft³/s*
Water-surface elevation in bridge opening 495.3 *ft*
Road overtopping? N *Discharge over road* 0 *ft³/s*
Area of flow in bridge opening 266 *ft²*
Average velocity in bridge opening 7.9 *ft/s*
Maximum WSPRO tube velocity at bridge 9.5 *ft/s*

Water-surface elevation at Approach section with bridge 496.5
Water-surface elevation at Approach section without bridge 496.3
Amount of backwater caused by bridge 0.2 *ft*

500-year discharge 2,750 *ft³/s*
Water-surface elevation in bridge opening 495.6 *ft*
Road overtopping? Y *Discharge over road* 765 *ft³/s*
Area of flow in bridge opening 287 *ft²*
Average velocity in bridge opening 6.92 *ft/s*
Maximum WSPRO tube velocity at bridge 8.1 *ft/s*

Water-surface elevation at Approach section with bridge 496.9
Water-surface elevation at Approach section without bridge 496.7
Amount of backwater caused by bridge 0.2

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 9.

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). There was no computed contraction scour for any modelled flows. Streambed armoring computations indicate that contraction scour will not be limited by armoring.

Scour at the abutments for the 100- and 500-year discharges was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation 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. The 500-year flow resulted in the worst case total scour.

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	1.0	0.5	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	1.7	2.8	--
Right abutment	1.4	2.8	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.3	1.1	--
Right abutment	1.3	1.1	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

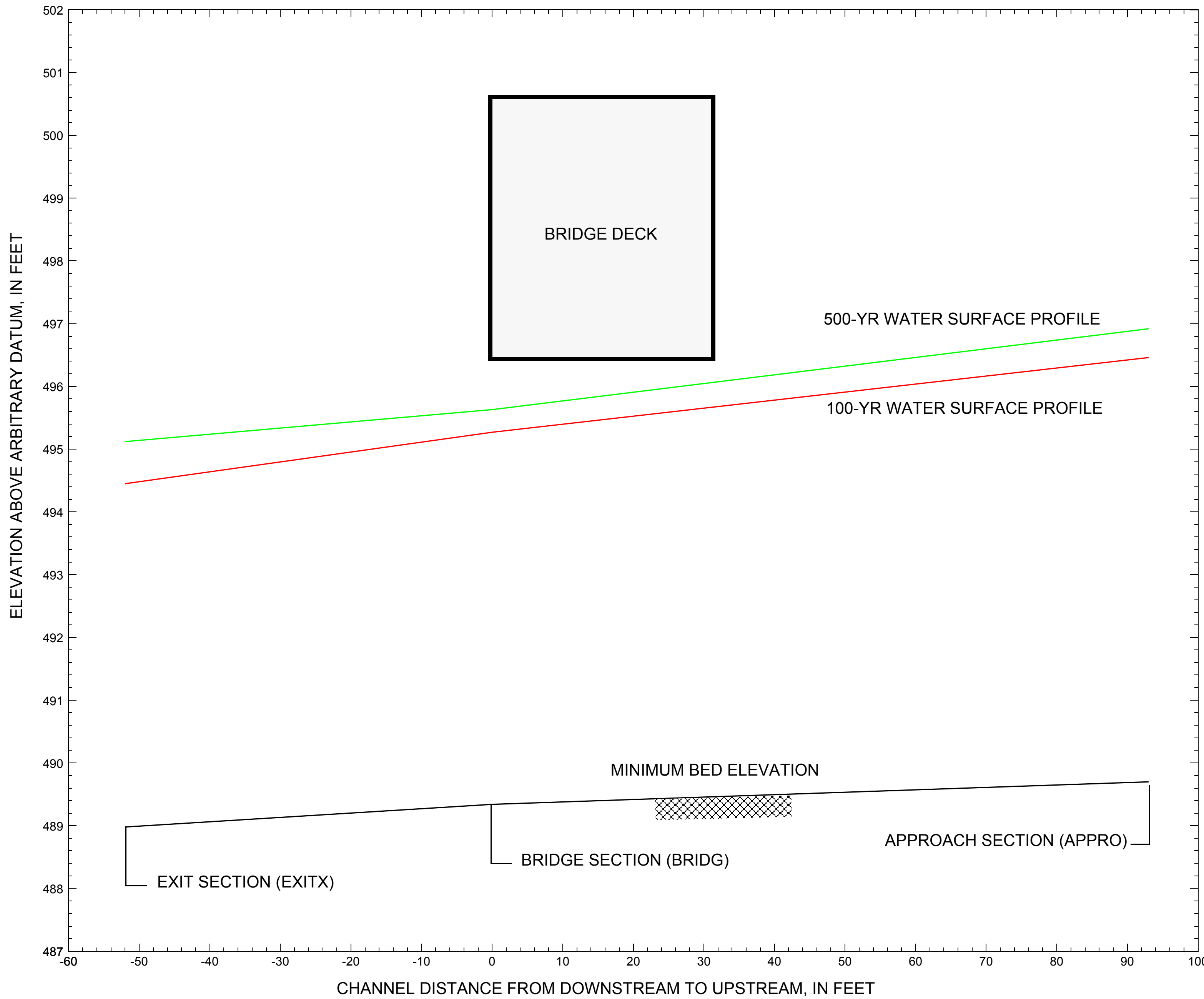

Figure 8. Water-surface profiles for the 100- and 500-yr discharges at structure HUNTTH00010012 on Town Highway 01, crossing Brush Brook, Huntington, Vermont.

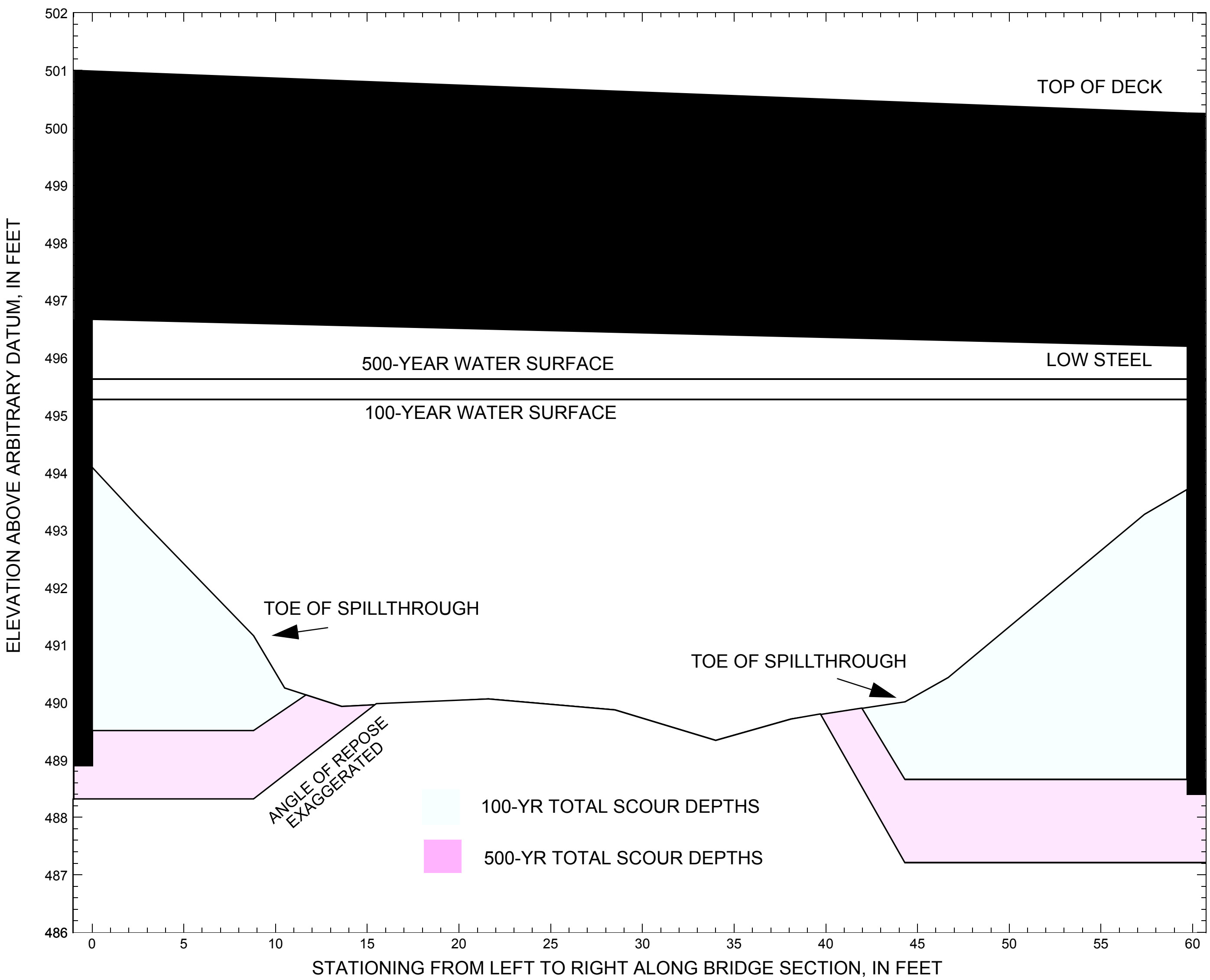

Figure 9. Scour elevations for the 100-yr and 500-yr discharges at structure HUNTTH00010012 on Town Highway 01, crossing Brush Brook, Huntington, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HUNTTH00010012 on Town Highway 01, crossing Brush Brook, Huntington, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 2100 cubic-feet per second											
Left abutment	0.0	497.2	496.7	488.9	494.1	0.0	--	--	--	--	0.6
LABUT toe	8.8	--	--	--	491.2	0.0	1.7	--	1.7	489.5	--
RABUT toe	44.3	--	--	--	490.0	0.0	1.4	--	1.4	488.6	--
Right abutment	59.7	496.6	496.2	488.4	493.7	0.0	--	--	--	--	0.2

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 HUNTTH00010012 on Town Highway 01, crossing Brush Brook, Huntington, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2750 cubic-feet per second											
Left abutment	0.0	497.2	496.7	488.9	494.1	0.0	--	--	--	--	-0.5
LABUT toe	8.8	--	--	--	491.2	0.0	2.8	--	2.8	488.4	--
RABUT toe	44.3	--	--	--	490.0	0.0	2.8	--	2.8	487.2	--
Right abutment	59.7	496.6	496.2	488.4	493.7	0.0	--	--	--	--	-1.2

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, Photoinspected 1980, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File hunt012.wsp
T2        Hydraulic analysis for structure HUNTTH00010012   Date: 28-OCT-96
T3        TH001 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           2100.0   2750.0
SK          0.0162   0.0162
*
XS   EXITX    -52           0.
GR         -456.9, 503.59   -386.8, 499.02   -319.4, 498.21   -220.4, 497.18
GR         -162.4, 496.39    -76.1, 495.21     -5.9, 493.81      0.0, 492.31
GR           14.7, 489.82     18.9, 489.45     24.3, 489.53     32.1, 489.27
GR           37.1, 488.98     45.2, 489.46     48.2, 489.92     58.0, 495.87
GR          124.3, 495.85    124.3, 505.11
*
*           For the 500-year model, the following additional points were used:
*           361.5, 493.75    433.4, 495.35    516.7, 497.95    516.7, 505.11
*           in place of point 124.3, 505.11.
*
N           0.040        0.055        0.035
SA                  -5.9         58.0
*
XS   FULLV      0  * * *   0.0069
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.43       6.0
GR            0.0, 496.67      0.0, 494.09      2.4, 493.27      8.8, 491.16
GR           10.5, 490.25     13.6, 489.93     21.6, 490.06     28.5, 489.87
GR           34.0, 489.34     38.1, 489.71     44.3, 490.01     46.7, 490.44
GR           57.4, 493.28     59.7, 493.71     59.7, 496.20      0.0, 496.67
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           3      33.9      3.8    501.3
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     17      31.4     1
GR         -462.5, 503.50   -391.6, 500.14   -279.1, 499.05   -195.7, 498.68
GR          -70.8, 500.47     -1.6, 500.99      0.0, 501.53     60.1, 500.99
GR           61.6, 500.95     61.7, 500.26    136.6, 498.61    243.2, 496.44
GR          243.2, 505.11
*
XT   APTEM    86
GR         -484.3, 508.43   -432.9, 500.41   -356.9, 499.52   -260.6, 499.03
GR         -175.0, 497.92   -136.6, 498.18   -115.7, 495.98    -16.4, 496.18
GR            0.0, 495.39      5.8, 492.55     31.2, 490.75     35.7, 489.90
GR           41.1, 489.70     45.6, 490.32     48.0, 490.55     54.0, 493.56
GR           60.4, 495.94    170.8, 496.44    170.8, 505.11
*
*           For the 500-year model, the following additional points were used:
*           356.9, 495.01    387.1, 498.41    401.4, 505.11
*           in place of point 170.8, 505.11.
*
AS   APPRO    93  * * *  0.0055
GT
N           0.035        0.055        0.035
SA                  0.0         60.4
*
HP 1 BRIDG    495.27 1 495.27
HP 2 BRIDG    495.27 * * 2100
HP 1 APPRO    496.46 1 496.46
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
         U.S. Geological Survey WSPRO Input File hunt012.100.wsp
         Hydraulic analysis for structure HUNTTH00010012   Date: 28-OCT-96
         TH001 CROSSING BRUSH BROOK IN HUNTINGTON VT                        RLB
            *** RUN DATE & TIME: 02-19-97  11:36

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

      WSEL  SA#     AREA         K  TOPW  WETP  ALPH    LEW    REW      QCR
              1      265     25704    59    63                          3185
    495.27           265     25704    59    63  1.00      0     60     3185

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        495.27     0.0    59.7   265.5   25704.    2100.   7.91

X STA.         0.0        8.3       11.6       14.1       16.4       18.7
  A(I)             21.2       15.2       13.1       12.4       12.1
  V(I)             4.96       6.92       8.04       8.48       8.66
X STA.        18.7       21.0       23.3       25.5       27.7       29.9
  A(I)             11.8       11.9       11.9       11.5       11.7
  V(I)             8.91       8.83       8.82       9.14       8.99

X STA.        29.9       31.9       33.8       35.7       37.8       40.0
  A(I)             11.4       11.1       11.3       11.6       11.9
  V(I)             9.18       9.45       9.31       9.07       8.79

X STA.        40.0       42.2       44.6       47.4       51.1       59.7
  A(I)             11.9       12.8       13.8       15.1       21.9
  V(I)             8.79       8.23       7.59       6.97       4.80

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      93.

      WSEL  SA#     AREA         K  TOPW  WETP  ALPH    LEW    REW      QCR
              1       45      1007   120   120                           158
              2      279     20479    60    62                          3398
              3       26       422   106   106                            71
    496.46           350     21908   287   289  1.29   -119    167     1927

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      93.

          WSEL     LEW     REW    AREA        K        Q    VEL
        496.46  -119.9   166.7   349.6   21908.    2100.   6.01

X STA.      -119.9        1.7        8.1       12.1       15.7       18.8
  A(I)             47.7       20.8       16.7       15.9       14.9
  V(I)             2.20       5.06       6.27       6.62       7.05

X STA.        18.8       21.8       24.6       27.2       29.6       31.9
  A(I)             14.6       14.2       13.7       13.3       13.3
  V(I)             7.21       7.42       7.66       7.91       7.90

X STA.        31.9       34.1       36.0       37.9       39.8       41.6
  A(I)             12.7       12.7       12.2       12.4       12.4
  V(I)             8.28       8.29       8.60       8.50       8.48

X STA.        41.6       43.6       45.8       48.3       52.2      166.7
  A(I)             13.1       13.8       14.9       18.4       42.2
  V(I)             8.04       7.58       7.07       5.72       2.49
```

```
       U.S. Geological Survey WSPRO Input File hunt012.500.wsp
       Hydraulic analysis for structure HUNTTH00010012   Date: 28-OCT-96
       TH001 CROSSING BRUSH BROOK IN HUNTINGTON VT                       RLB
          *** RUN DATE & TIME: 02-19-97  11:41

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      287     29026     59     64                          3578
  495.63           287     29026     59     64  1.00      0     60      3578

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.63     0.0    59.7   286.8   29026.    1985.   6.92

X STA.        0.0        7.9       11.4       13.8       16.2       18.5
  A(I)           22.6       16.7       13.7       13.4       13.2
  V(I)           4.38       5.95       7.26       7.38       7.54

X STA.       18.5       20.9       23.2       25.5       27.7       29.9
  A(I)           13.3       12.8       12.5       12.7       12.5
  V(I)           7.47       7.76       7.94       7.83       7.95

X STA.       29.9       31.9       33.9       35.9       38.0       40.1
  A(I)           12.2       12.3       12.2       12.5       12.7
  V(I)           8.10       8.10       8.13       7.91       7.83

X STA.       40.1       42.5       44.9       47.6       51.5       59.7
  A(I)           13.3       13.5       14.5       17.1       23.1
  V(I)           7.48       7.36       6.83       5.79       4.29

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      17.

        WSEL     LEW     REW    AREA        K        Q    VEL
      496.69   219.8   468.6   185.1    6467.     765.   4.13

X STA.      219.8      257.8      276.5      292.9      307.1      319.8
  A(I)           14.5       11.5       10.9       10.1        9.5
  V(I)           2.63       3.34       3.50       3.78       4.01

X STA.      319.8      331.8      342.8      353.0      362.8      371.9
  A(I)            9.5        9.1        8.8        8.7        8.4
  V(I)           4.03       4.22       4.35       4.42       4.56

X STA.      371.9      380.4      388.2      395.3      402.0      408.2
  A(I)            8.1        7.8        7.6        7.5        7.3
  V(I)           4.73       4.88       5.01       5.07       5.21

X STA.      408.2      414.2      420.0      426.9      436.1      468.6
  A(I)            7.3        7.4        8.1        9.0       13.8
  V(I)           5.25       5.17       4.70       4.23       2.77

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      93.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      101      3770    124    124                           520
            2      307     23994     60     62                          3918
            3      307     12904    313    313                          1726
  496.92           715     40668    498    500  1.33   -123    374      4216

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      93.

        WSEL     LEW     REW    AREA        K        Q    VEL
      496.92  -124.3   373.5   715.1   40668.    2750.   3.85

X STA.     -124.3      -52.6        3.2       10.5       16.2       21.1
  A(I)           56.7       51.9       31.1       27.5       25.8
  V(I)           2.42       2.65       4.43       4.99       5.34

X STA.       21.1       25.5       29.5       33.2       36.4       39.5
  A(I)           24.4       23.8       22.7       22.1       21.6
  V(I)           5.63       5.79       6.06       6.22       6.38

X STA.       39.5       42.6       46.0       50.3       80.7      209.8
  A(I)           22.0       22.9       26.1       47.6       81.2
  V(I)           6.25       6.00       5.27       2.89       1.69

X STA.      209.8      266.5      298.9      323.3      343.5      373.5
  A(I)           54.4       42.2       37.1       34.1       39.9
  V(I)           2.53       3.26       3.71       4.03       3.44
```

WSPRO OUTPUT FILE (continued)

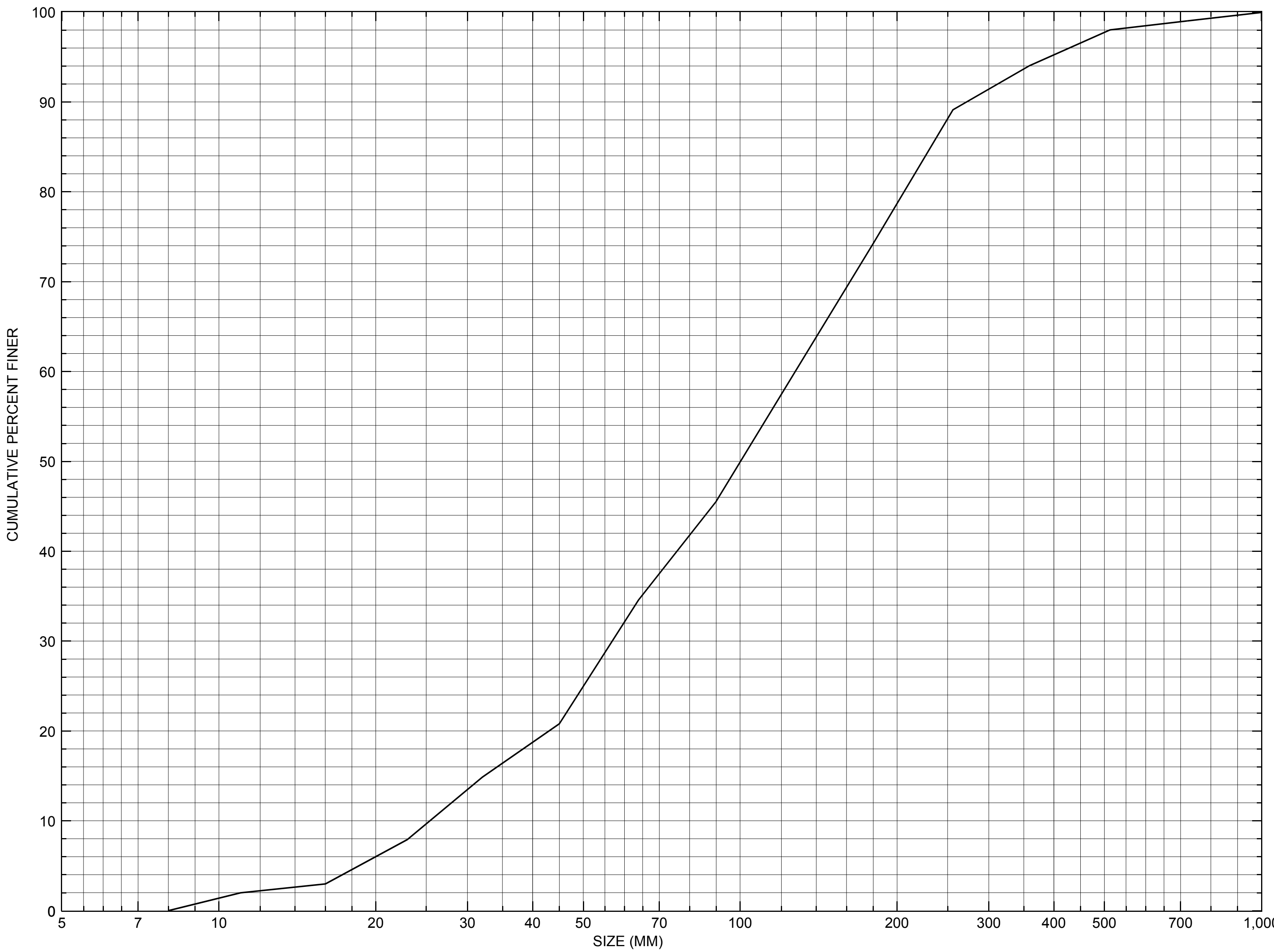
```
        U.S. Geological Survey WSPRO Input File hunt012.100.wsp
        Hydraulic analysis for structure HUNTTH00010012   Date: 28-OCT-96
        TH001 CROSSING BRUSH BROOK IN HUNTINGTON VT                        RLB
           *** RUN DATE & TIME: 02-19-97  11:36

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

EXITX:XS   ******    -37      255  1.11 *****  495.56  493.75    2100  494.45
       -51 ******     56    16490  1.05 ***** *******    0.90    8.24

FULLV:FV       52    -70      329  0.72  0.63  496.19 *******    2100  495.47
         0     52     57    22070  1.13  0.00    0.00    0.75    6.39
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.17     496.33     495.13

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.97     508.47    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =    494.97     508.47     495.13

APPRO:AS       93   -118      314  0.84  0.92  497.17  495.13    2100  496.33
        93     93    138    20210  1.22  0.06    0.00    1.17    6.68
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   496.46       0.00     495.27     496.44

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

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

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

BRIDG:BR       52      0      266  0.97  0.68  496.24  494.18    2100  495.27
         0     52     60    25721  1.00  0.00   -0.02    0.66    7.91

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   4.  1.000 ******  496.43 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.        <<<<<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       59   -119      350  0.73  0.61  497.19  495.13    2100  496.46
        93     62    167    21905  1.29  0.34    0.01    1.09    6.01

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.767  0.057   20563.     2.    62. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -52.   -38.    56.   2100.   16490.     255.    8.24  494.45
   FULLV:FV       0.   -71.    57.   2100.   22070.     329.    6.39  495.47
   BRIDG:BR       0.     0.    60.   2100.   25721.     266.    7.91  495.27
   RDWAY:RG      17.**************      0.       0.       0.    1.00********
   APPRO:AS      93.  -120.   167.   2100.   21905.     350.    6.01  496.46

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    62.   20563.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    493.75    0.90  488.98  505.11************  1.11  495.56  494.45
   FULLV:FV  ********    0.75  489.34  505.47  0.63  0.00  0.72  496.19  495.47
   BRIDG:BR    494.18    0.66  489.34  496.67  0.68  0.00  0.97  496.24  495.27
   RDWAY:RG  ****************  496.44  505.11  0.56******  0.72  496.62********
   APPRO:AS    495.13    1.09  489.74  508.47  0.61  0.34  0.73  497.19  496.46
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File hunt012.500.wsp
       Hydraulic analysis for structure HUNTTH00010012   Date: 28-OCT-96
       TH001 CROSSING BRUSH BROOK IN HUNTINGTON VT                        RLB
          *** RUN DATE & TIME: 02-19-97  11:41

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                     WSI,CRWS =   494.80     495.12

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

EXITX:XS   ******    -70      477  0.71 *****  495.82  495.12    2750  495.12
       -51 ******    423    26977  1.36 ***** *******    1.01    5.77

FULLV:FV       52    -92      599  0.45  0.43  496.25 *******    2750  495.80
         0     52    436    33964  1.36  0.00   -0.01    0.79    4.59
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.26     496.43     496.66

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.30     508.47    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.30     508.47     496.66

 ===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 =   496.66     508.47     496.66

APPRO:AS       93   -121      588  0.50 *****  497.16  496.66    2750  496.66
        93     93    371    31897  1.46 ***** *******    0.91    4.68
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   498.50       0.00     494.86     495.40

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

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

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

BRIDG:BR       52      0      287  0.84  0.47  496.47  494.06    1985  495.63
         0     52     60    29045  1.13  0.18   -0.01    0.59    6.92

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   4.  0.940 ******  496.43 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.    62.  0.28  0.31  496.94    0.00    765.  496.69

              Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.   386.  -407.   -20.   2.2   1.2   7.1   8.9   2.3   3.1
   RT:    765.   248.   220.   468.   1.3   0.7   4.6   4.2   1.0   3.1

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

APPRO:AS       59   -123      717  0.30  0.52  497.23  496.66    2750  496.92
        93     88    374    40780  1.33  0.23    0.00    0.65    3.84

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.879  0.430   23215.     8.    67. ********

                    <<<<<END OF BRIDGE COMPUTATION>>>>>

 FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA      VEL    WSEL
   EXITX:XS     -52.    -71.   423.   2750.   26977.      477.     5.77  495.12
   FULLV:FV       0.    -93.   436.   2750.   33964.      599.     4.59  495.80
   BRIDG:BR       0.      0.    60.   1985.   29045.      287.     6.92  495.63
   RDWAY:RG      17.*******     0.    765.       0.        0.     1.00  496.69
   APPRO:AS      93.   -124.   374.   2750.   40780.      717.     3.84  496.92

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    495.12    1.01  488.98  505.11************  0.71  495.82  495.12
   FULLV:FV  ********    0.79  489.34  505.47  0.43  0.00  0.45  496.25  495.80
   BRIDG:BR    494.06    0.59  489.34  496.67  0.47  0.18  0.84  496.47  495.63
   RDWAY:RG  ****************  495.40  505.11  0.28******  0.31  496.94  496.69
   APPRO:AS    496.66    0.65  489.74  508.47  0.52  0.23  0.30  497.23  496.92
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count at the approach cross-section for structure HUNTTH00010012, in Huntington, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HUNTTH00010012

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)* 005020

Waterway *(I - 6)* BRUSH BROOK

Road Name *(I - 7)*: TR 01 FAS 211

Route Number -

Vicinity *(I - 9)* 6.5 MI N JCT VT.17

Topographic Map Huntington

Hydrologic Unit Code: 02010003

Latitude *(I - 16; nnnn.n)* 44179

Longitude *(i - 17; nnnnn.n)* 72581

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20021100120408

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

Maximum span length *(I - 48; nnnn)* 0062

Year built *(I - 27; YYYY)* 1976

Structure length *(I - 49; nnnnnn)* 000064

Average daily traffic, ADT *(I - 29; nnnnnn)* 001070

Deck Width *(I - 52; nn.n)* 314

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

Channel & Protection *(I - 61; n)* 8

Opening skew to Roadway *(I - 34; nn)* 06

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

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

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

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

Comments:
Structural inspection folder was missing from the regular 4th floor location at VT AOT.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **9.2**

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ **750** Q_{10} **1200** Q_{25} **1550**

Q_{50} **1850** Q_{100} **2100** 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} (*ft³/ sec*): -

Are there other structures nearby? (*Yes, No, Unknown*): ____ *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 (*ft²*): -

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **9.19** mi^2

Lake and pond area **0** mi^2

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

Bridge site elevation **690** ft

Headwater elevation **4290** ft

Main channel length **4.98** mi

10% channel length elevation **750** ft

85% channel length elevation **2500** ft

Main channel slope *(S)* **469** 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? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: ___ / ______

Project Number ________________________ Minimum channel bed elevation: 488.5

Low superstructure elevation: USLAB 497.23 DSLAB 497.23 USRAB 496.66 DSRAB 496.61

Benchmark location description:

BM #1, S.I.R., 60" M assumed elev. 500', upstream edge of road, 200' left of bridge (next to gravel drive)
BM #2, S.I.R., 4" M assumed elev. 496', upstream edge of road, 220' right of bridge

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

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

If 1: Footing Thickness 1.5 Footing bottom elevation: 489

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? Y *If no, type ctrl-n bi* Number of borings taken: 2

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

Briefly describe material at foundation bottom elevation or around piles:

Bottom of the footing of the Labut is in sandy gravel at 489.5'.
Bottom of the footing of the Rabut is in silt at 489.0'.

Comments:

The low superstructure elevations are the bridge seat elevations from the bridge plans.
The elevation of the top wingwall-abutment corner is 501.5' on the left abutment US and DS, and 501.0' on the right abutment US and DS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTIONAL INFORMATION**

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

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

Comments: -
-

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

Qa/Qc Check by: **RB** Date: **10/28/96**

Computerized by: **RB** Date: **10/29/96**

Reviewd by: **SAO** Date: **03/13/97**

Structure Number **HUNTTH00010012**

A. General Location Descriptive

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

2. Highway District Number **05** Mile marker **005020**

County **007** Town **34600**

Waterway *(I - 6)* **BRUSH BROOK** Road Name **TR01 FAS 211**

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

3. Descriptive comments:

Located 6.5 miles north of the junction with VT 17.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **4** RBDS **4** Overall **4**

*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US **2** UB **1** DS **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 **64** *(feet)* Span length **62** *(feet)* Bridge width **31.4** *(feet)*

Road approach to bridge:

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

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

10. Embankment slope (*run / rise in feet / foot*):
US left **2.9:1** US right **4.7:1**

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

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

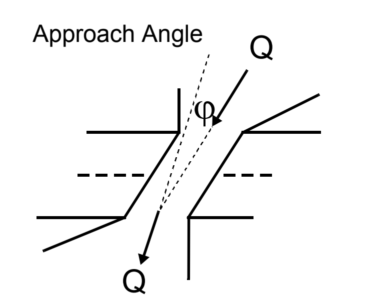
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

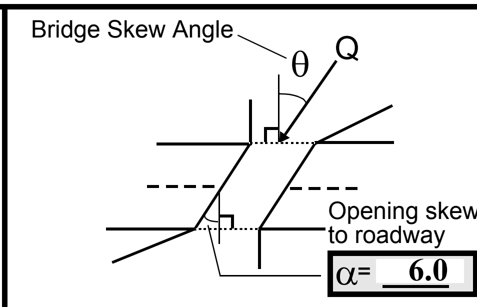
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **10**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*

Where? **LB** *(LB, RB)* Severity **1**

Range? **86** feet **DS** *(US, UB, DS)* to **360** feet **DS**

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/3**

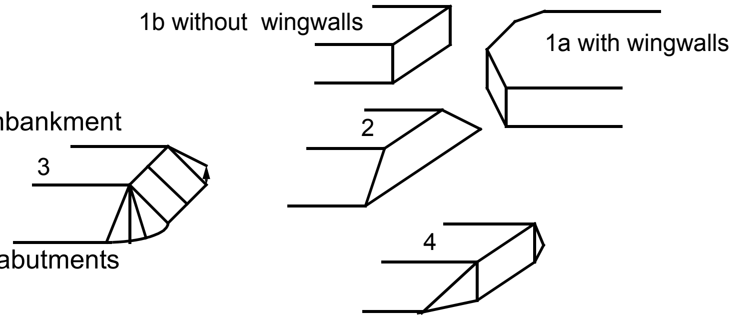
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. The left bank US is vegetated with brush and a few trees along the channel and a field with 3 houses and a swing set on the overbank. The right bank US has brush along the channel and a field on the overbank with one large and one small barn. The right bank DS is a field with one house about 200 ft. from the bridge and brush along the bank. The left bank DS has brush and a few trees along the channel and a barn across from the US left bank houses.

18. The wingwalls are parallel to the abutments, but do not go below low chord. Also, the protection around the abutments act like a spill through type abutment.

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
85.5	3.0			2.5	2	2	234	234	1	1

23. Bank width **25.0** 24. Channel width **25.0** 25. Thalweg depth **60.4** 29. Bed Material **432**

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

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

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

From 175 ft. US to 130 ft. US the left bank point bar is slightly eroded where two 0.3 ft. diameter birch trees now exist horizontally in the channel.

30. The bank protection extends from the end of the wingwalls to about 200 ft. US. The banks are well protected and constrict the channel.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **86** 35. Mid-bar width: **40**

36. Point bar extent: **175** feet **US** (US, UB) to **156** feet **DS** (US, UB, DS) positioned **0** %LB to **60** %RB

37. Material: **243**

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

This side bar is vegetated with clumps of grass along the channel and trees along the banks on both the US and DS ends, however, under the bridge the bar is only comprised of sand. Another side bar comprised of cobble, gravel, and sand exists from 170 ft. US to 125 ft. US. It is positioned from 50% LB to 100% RB with a mid-bar width of 40.5 ft. at 133 ft. US. This bar is vegetated with grass clumps on the streamward side and trees and bushes on the bankward side.

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

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

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

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

NO CUT BANKS

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **74**

47. Scour dimensions: Length **95** Width **4.2** Depth : **2.2** Position **85** %LB to **95** %RB

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

Scour is from 80 ft. US to 15 ft. under the bridge. Thalweg depth is assumed to be 0.5 ft. An additional scour hole is from 128 ft. US to 121 ft. US. It is 7 ft. in length and 4.5 ft. wide and has a depth of 0.6 ft. It is positioned from 30% LB to 50% RB with mid-scour at 124 ft. US.

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
43.0		1.0		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.):

432

Channel scour exists along the bottom of the spill-through on the right side.

63. The stream bed is uniform, tightly packed cobbles.

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

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

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

70. Debris and Ice Comments:

1

66. Debris has accumulated on the side bars between bushes and trees as well as on the DS point bar.

67. Debris potential is low due to the surface area being pasture and the only vegetation being along the channel.

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		5	90	0	0	-	-	90.0
RABUT	1	0	90			0	0	59.5

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.):

-

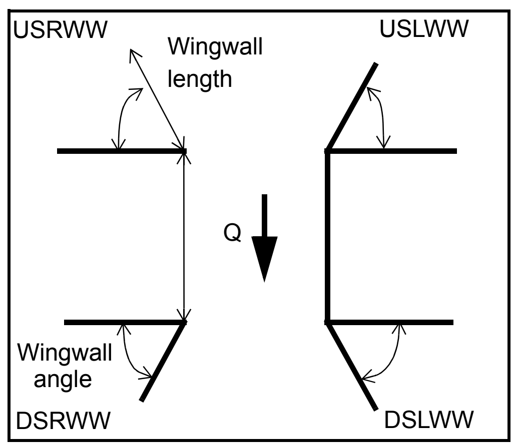
-

1

The abutments are in good condition. The water level only reaches the abutments at bankfull because of the protection. There are high water marks on both banks US and DS.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						59.5	
USRWW:	Y		1		0	1.0	
DSLWW:	-		-		Y	34.0	
DSRWW:	1		0		-	34.0	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	0	Y	-	1	1	1	1
Condition	Y	-	1	-	1	1	1	1
Extent	1	-	0	2	2	3	3	-

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

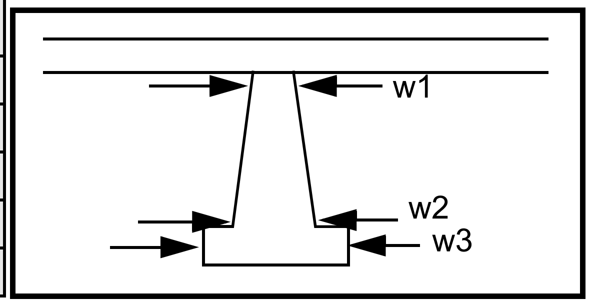
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
1
2
1
1

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1	**95.0**	**85.0**	**85.0**	**8.0**	**8.0**	**8.0**
Pier 2	**95.0**	-	-	**8.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**ere**	**both**	**82.**	**s.**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**are**	**the**	**All**	**The**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**Ver-**	**US**	**four**	**pro-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**mont**	**left**	**wing**	**tec-**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**sur-**	**wing**	**walls**	**tion**	*Y- yes; N- no*
91. Attack ∠ (BF)	**vey**	**wall**	**are**	**acts**	
92. Pushed	**mar**	**and**	**par-**	**like**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**ks,**	**the**	**allel**	**a**	
95. Cross-members	**meta**	**DS**	**to**	**spill**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**l**	**right**	**the**	**thro**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**disks**	**wing**	**abut**	**ugh**	
98. Exposure depth	**, on**	**wall.**	**ment**	**type**	

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

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
-	-			-	N	-	-	-	-	-

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

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 - feet - (US, UB, DS) positioned - %LB to - %RB

Material: -

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

-
-
-
-

Is a cut-bank present? - (Y or if N type ctrl-n cb) Where? NO (LB or RB) Mid-bank distance: PIE

Cut bank extent: RS 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? _____ (Y or if N type ctrl-n cs) Mid-scour distance: 2

Scour dimensions: Length 1 Width 234 Depth: 234 Positioned 2 %LB to 1 %RB

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

43
0
0
-

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

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

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

Confluence comments (eg. confluence name):

crushed stone and boulders placed in front of the concrete blocks surrounding a dry hydrant. The DS cross section was surveyed a few feet DS of the dry hydrant blocks.

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

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: HUNTTH00010012 Town: Huntington
Road Number: 1 County: Chittenden
Stream: Brush Brook

Initials RLB Date: 2/19/97 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	2100	2750	0
Main Channel Area, ft2	279	307	0
Left overbank area, ft2	45	101	0
Right overbank area, ft2	26	307	0
Top width main channel, ft	60	60	0
Top width L overbank, ft	120	124	0
Top width R overbank, ft	106	313	0
D50 of channel, ft	0.328	0.328	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.7	5.1	ERR
y1, average depth, LOB, ft	0.4	0.8	ERR
y1, average depth, ROB, ft	0.2	1.0	ERR
Total conveyance, approach	21908	40668	0
Conveyance, main channel	20479	23994	0
Conveyance, LOB	1007	3770	0
Conveyance, ROB	422	12904	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1963.0	1622.5	ERR
Ql, discharge, LOB, cfs	96.5	254.9	ERR
Qr, discharge, ROB, cfs	40.5	872.6	ERR
Vm, mean velocity MC, ft/s	7.0	5.3	ERR
Vl, mean velocity, LOB, ft/s	2.1	2.5	ERR
Vr, mean velocity, ROB, ft/s	1.6	2.8	ERR
Vc-m, crit. velocity, MC, ft/s	10.0	10.1	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)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	279	307	0
Main channel width, ft	60	60	0
y1, main channel depth, ft	4.65	5.12	ERR

Bridge Section			
(Q) total discharge, cfs	2100	2750	0
(Q) discharge thru bridge, cfs	2100	1985	0
Main channel conveyance	25704	29026	0
Total conveyance	25704	29026	0
Q2, bridge MC discharge,cfs	2100	1985	ERR
Main channel area, ft2	265	287	0
Main channel width (skewed), ft	47.3	47.3	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	47.3	47.3	0
y_bridge (avg. depth at br.), ft	5.60	6.07	ERR
Dm, median (1.25*D50), ft	0.41	0.41	0
y2, depth in contraction,ft	4.12	3.93	ERR
ys, scour depth (y2-ybridge), ft	-1.48	-2.14	N/A

ARMORING			
D90	0.893	0.893	0
D95	1.284	1.284	0
Critical grain size,Dc, ft	0.3364	0.2471	ERR
Decimal-percent coarser than Dc	0.4896	0.6015	0
Depth to armoring,ft	1.05	0.49	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	2100	2750	0	2100	2750	0
a', abut.length blocking flow, ft	124.5	128.9	0	114.8	85.6	0
Ae, area of blocked flow ft2	57.13	114.56	0	43.62	80.8	0
Qe, discharge blocked abut.,cfs	152.58	301.37	0	113.08	--	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.67	2.63	ERR	2.59	2.36	ERR
ya, depth of f/p flow, ft	0.46	0.89	ERR	0.38	0.94	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0	0.55	0.55	0
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	95	95	0	85	85	0
K2	1.01	1.01	0.00	0.99	0.99	0.00
Fr, froude number f/p flow	0.695	0.492	ERR	0.741	0.428	ERR
ys, scour depth, ft	5.60	7.05	N/A	4.95	5.79	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)	124.5	128.9	0	114.8	85.6	0
y1 (depth f/p flow, ft)	0.46	0.89	ERR	0.38	0.94	ERR
a'/y1	271.32	145.04	ERR	302.13	90.69	ERR
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.69	0.49	N/A	0.74	0.43	N/A
Ys w/ corr. factor K1/0.55:						
vertical	2.99	5.17	ERR	2.46	5.10	ERR
vertical w/ ww's	2.45	4.24	ERR	2.02	4.18	ERR
spill-through	1.65	2.84	ERR	1.35	2.80	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	Qother			
Fr, Froude Number	0.66	0.59	0	0.66	0.59	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.60	6.07	0.00	5.60	6.07	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.51	1.31	0.00	1.51	1.31	0.00
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	1.32	1.14	0.00	1.32	1.14	0.00
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR