LEVEL II SCOUR ANALYSIS FOR BRIDGE 33 (HUNTTH00220033) on TOWN HIGHWAY 22, crossing BRUSH BROOK, HUNTINGTON, VERMONT

Open-File Report 97-664

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 33 (HUNTTH00220033) on TOWN HIGHWAY 22, crossing BRUSH BROOK, HUNTINGTON, VERMONT

By RONDA L. BURNS & JAMES R. DEGNAN

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
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Open-File Reports Unit
Box 25286
Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 33 (HUNTTH00220033) ON TOWN HIGHWAY 22, CROSSING BRUSH BROOK, HUNTINGTON, VERMONT

By **Ronda L. Burns and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure HUNTTH00220033 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 8.65-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest except on the downstream right overbank which is pasture.

In the study area, Brush Brook has an incised, straight channel with a slope of approximately 0.04 ft/ft, an average channel top width of 42 ft and an average bank height of 3 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 76.7 mm (0.252 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 26, 1996, indicated that the reach was stable.

The Town Highway 22 crossing of Brush Brook is a 40-ft-long, two-lane bridge consisting of one 23.5-foot concrete slab span (Vermont Agency of Transportation, written communication, November 30, 1995). The opening length of the structure parallel to the bridge face is 36.9 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 35 degrees to the opening while the opening-skew-to-roadway is 30 degrees.

The scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the left and right banks upstream that extended through the bridge and along the downstream banks. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is analyzed since it has the potential of being the worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.0 to 1.1 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 6.5 to 14.9 ft. The worst-case abutment scour occurred at the incipient roadway-overtopping 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 HUNTTH00220033 ***Stream*** Brush Brook

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

Description of Bridge

Bridge length 40 ***ft*** ***Bridge width*** 23.5 ***ft*** ***Max span length*** 38 ***ft***

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

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

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

Description of stone fill Type-2, along the left and right abutments and the upstream and downstream wingwalls.

Abutments and wingwalls are concrete.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 35

There is a moderate channel bend in the upstream reach. Channel scour and a cut bank have developed in the location where the bend impacts the upstream right bank.

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*
	06/26/96	0	0
Level I	06/26/96	0	0
Level II			

Potential for debris Moderate. There is some debris caught on the upstream banks.

Describe any features near or at the bridge that may affect flow (include observation date) None. 06/26/96

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a narrow flood plain on the downstream right.

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

Date of inspection 06/26/96

DS left: Narrow flood plain to a steep valley wall

DS right: Steep channel bank to a narrow terrace

US left: Steep channel bank to a moderately sloped overbank

US right: Steep valley wall

Description of the Channel

Average top width 42 ft ***Average depth*** 3 ft

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

Straight and stable with semi-alluvial channel boundaries and a narrow flood plain on the downstream left.

06/26/96

Vegetative co Trees

DS left: Few trees with short grass on the overbank

DS right: Trees and brush

US left: Trees and brush

US right:

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

None. 06/26/96

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 8.65 ***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 2,030 ***ft³/s*** ***Q500*** 2,660 ***ft³/s***

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

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

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

Datum tie between USGS survey and VTAOT plans Subtract 4.3 ft from the USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a metal tablet stamped with "State of Vermont survey mark" on top of the downstream end of the right abutment (elev. 499.65 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment (elev. 501.15 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	-39	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	18	1	Road Grade section
APPRO	68	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 0.040 to 0.055, and overbank "n" values ranged from 0.050 to 0.090.

Critical depth at the exit section (EXITX) was allowed for each discharge as the starting water surface. Normal depth was computed below critical depth approximately 0.3 ft for each discharge by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0364 ft/ft which was estimated from surveyed thalweg points downstream.

The surveyed approach section (APPRO) was 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.

Bridge 34 on Town Highway 21 in Huntington is located 400 ft upstream of this site. A portion of the flow, approximately 25% as determined by conveyance, is diverted away from this bridge when the water surface overtops the left road approach at the upstream site. The water flows down Town Highway 22 and along the road embankment, returning to the main channel downstream of this site. Thus, the approach section may never convey the entire 100-year, 500-year, or incipient road-overtopping discharge as assumed by the model.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.0 *ft*
Average low steel elevation 497.3 *ft*

100-year discharge 2,030 *ft³/s*
Water-surface elevation in bridge opening 497.3 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 239 *ft²*
Average velocity in bridge opening 8.5 *ft/s*
Maximum WSPRO tube velocity at bridge 11.8 *ft/s*

Water-surface elevation at Approach section with bridge 499.1
Water-surface elevation at Approach section without bridge 495.4
Amount of backwater caused by bridge 3.7 *ft*

500-year discharge 2,660 *ft³/s*
Water-surface elevation in bridge opening 497.7 *ft*
Road overtopping? Yes *Discharge over road* 190 *ft³/s*
Area of flow in bridge opening 242 *ft²*
Average velocity in bridge opening 10.2 *ft/s*
Maximum WSPRO tube velocity at bridge 11.7 */s*

Water-surface elevation at Approach section with bridge 500.5
Water-surface elevation at Approach section without bridge 496.2
Amount of backwater caused by bridge 4.3 *ft*

Incipient overtopping discharge 2,300 *ft³/s*
Water-surface elevation in bridge opening 497.7 *ft*
Area of flow in bridge opening 242 *ft²*
Average velocity in bridge opening 9.5 *ft/s*
Maximum WSPRO tube velocity at bridge 10.9 *ft/s*

Water-surface elevation at Approach section with bridge 499.9
Water-surface elevation at Approach section without bridge 495.8
Amount of backwater caused by bridge 4.1 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

At this site, the 100-year, 500-year and incipient roadway-overtopping discharges resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for these discharges was also computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and are presented in Appendix F. Furthermore, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions also are provided in Appendix F.

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	1.1	0.6
Depth to armoring	33.9	39.0	36.5
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	13.9	14.4	14.9
Right abutment	6.7	6.5	7.4
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	2.4	2.3
Right abutment	2.1	2.4	2.3
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

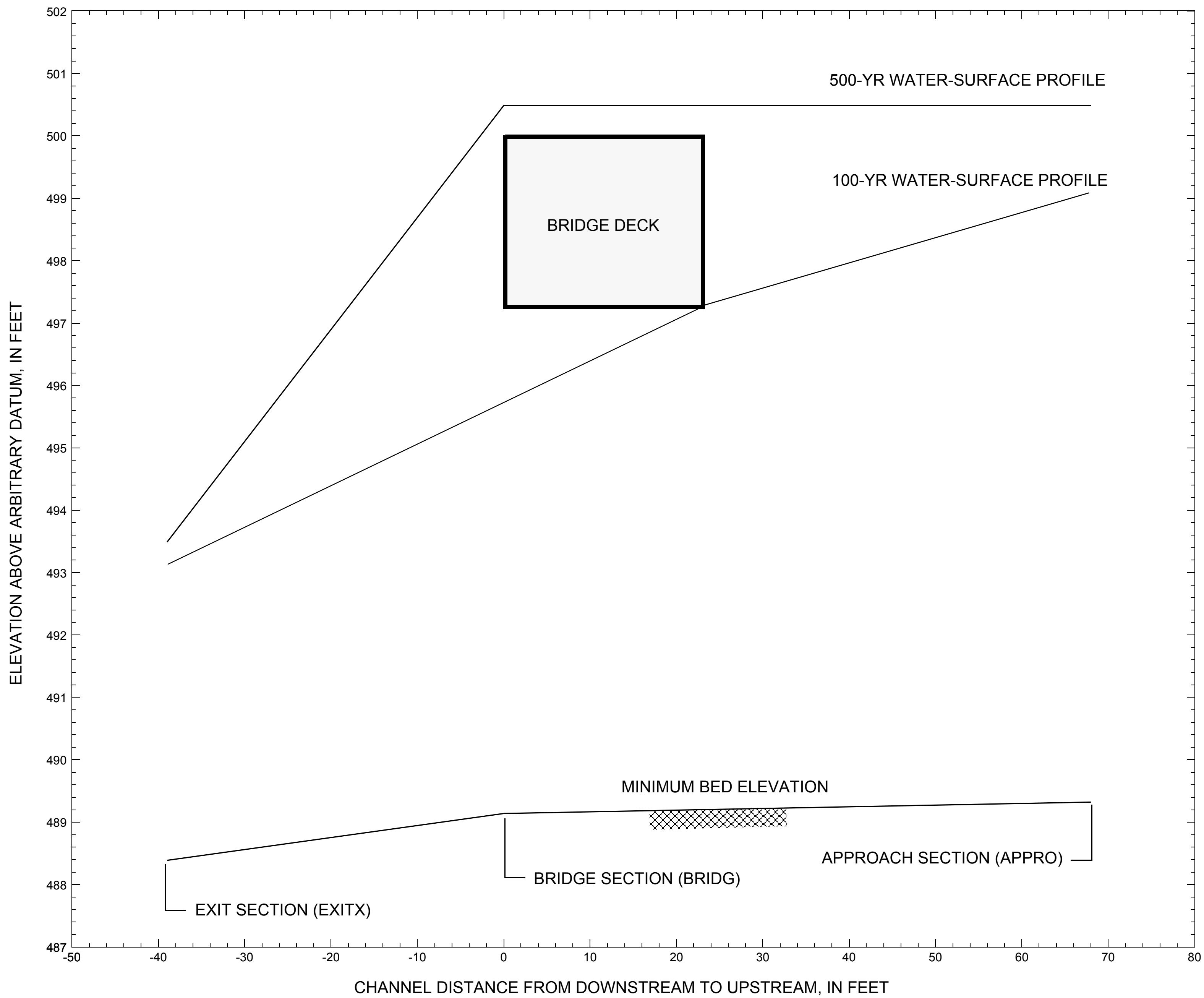

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure HUNTTH00220033 on Town Highway 22, crossing Brush Brook, Huntington, Vermont.

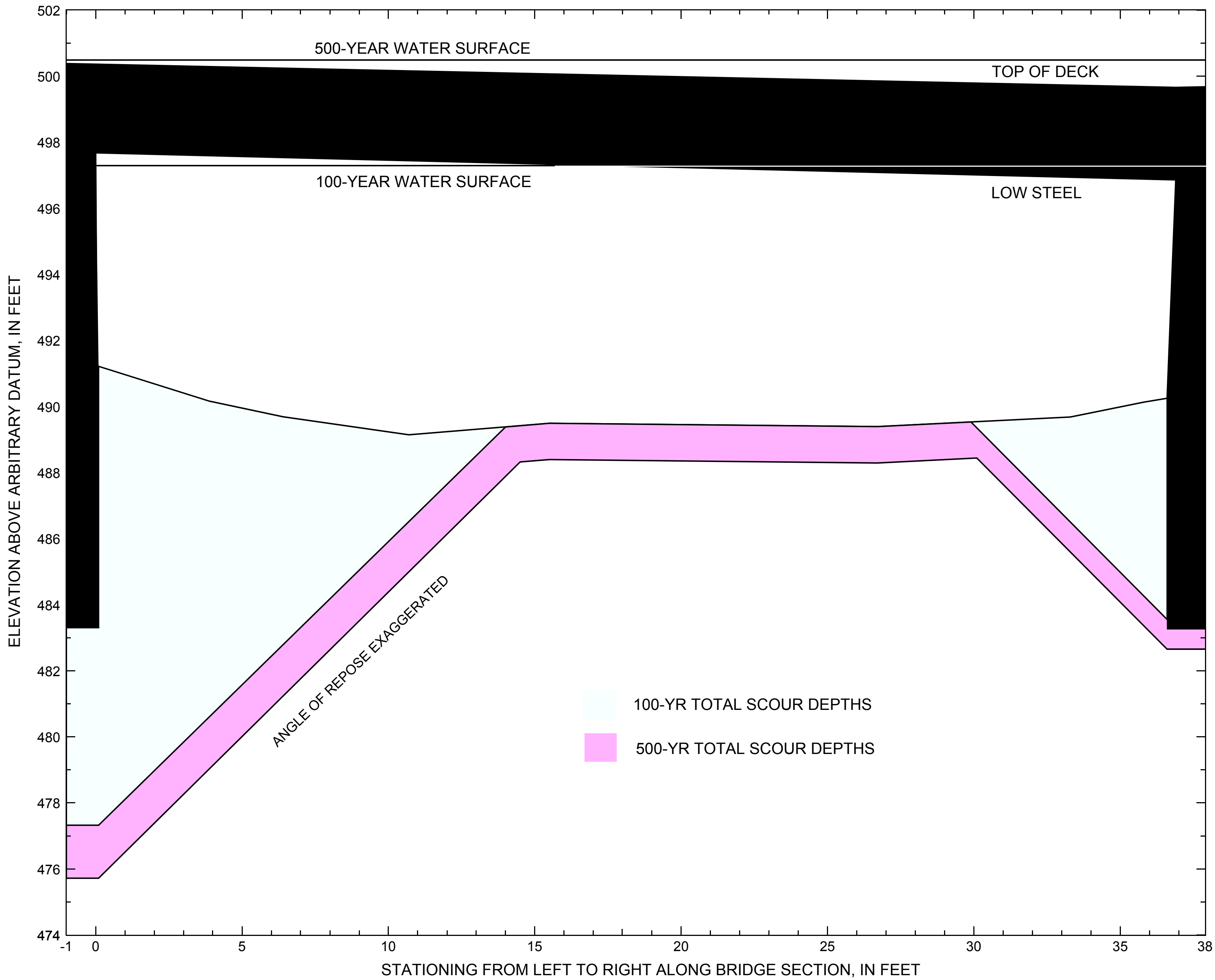

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure HUNTTH00220033 on Town Highway 22, crossing Brush Brook, Huntington, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HUNTTH00220033 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 2,030 cubic-feet per second											
Left abutment	0.0	493.4	497.7	483.3	491.2	0.0	13.9	--	13.9	477.3	-6.0
Right abutment	36.9	492.6	496.9	483.3	490.3	0.0	6.7	--	6.7	483.6	0.3

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure HUNTTH00220033 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 2,660 cubic-feet per second											
Left abutment	0.0	493.4	497.7	483.3	491.2	1.1	14.4	--	15.5	475.7	-7.6
Right abutment	36.9	492.6	496.9	483.3	490.3	1.1	6.5	--	7.6	482.7	-0.6

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 hunt033.wsp
T2        Hydraulic analysis for structure HUNTTH00220033   Date: 04-JUN-97
T3        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT          RLB
*
J1         * *  0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2030.0   2660.0   2300.0
SK          0.0364   0.0364   0.0364
*
XS   EXITX    -39            0.
GR         -250.9, 511.41   -239.6, 506.28   -195.1, 500.31   -155.6, 495.31
GR         -130.7, 490.89    -52.3, 491.95    -14.3, 491.58     -8.3, 490.40
GR            0.0, 489.92      5.0, 489.18      6.6, 488.84     10.4, 488.39
GR           20.5, 488.39     23.6, 489.34     29.9, 493.30     67.0, 496.75
GR          101.1, 496.82    115.0, 505.60
*
N           0.090        0.055        0.050
SA                 -14.3         29.9
*
*
XS   FULLV      0  * * *   0.0178
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.27      30.0
GR            0.0, 497.68      0.1, 491.22      3.9, 490.16      6.4, 489.69
GR           10.7, 489.14     15.5, 489.49     26.7, 489.39     33.3, 489.68
GR           35.8, 490.13     36.6, 490.25     36.9, 496.86      0.0, 497.68
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      38.9 * *     28.1      7.5
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     18      23.5     2
GR         -345.7, 509.49   -212.1, 503.93   -161.7, 502.14   -137.2, 501.39
GR          -70.3, 500.19
GR            0.0, 500.36     38.2, 499.66     64.8, 500.19     81.6, 509.07
*
*
AS   APPRO     68            0.
GR         -345.7, 509.49   -212.1, 503.93   -161.7, 502.14   -137.2, 501.39
GR          -70.3, 500.19    -41.2, 500.06     -8.1, 493.17      0.0, 491.09
GR            4.0, 490.59      8.6, 489.90     13.0, 489.32     20.2, 489.85
GR           23.0, 490.65     31.7, 494.27     35.2, 496.50     50.8, 503.79
*
N           0.090        0.055
SA                 -41.2
*
HP 1 BRIDG   497.29 1 497.29
HP 2 BRIDG   497.29 * * 2030
HP 1 BRIDG   494.69 1 494.69
HP 1 APPRO   499.08 1 499.08
HP 2 APPRO   499.08 * * 2030
*
HP 1 BRIDG   497.68 1 497.68
HP 2 BRIDG   497.68 * * 2470
HP 1 BRIDG   495.40 1 495.40
HP 2 RDWAY   500.49 * * 190
HP 1 APPRO   500.49 1 500.49
HP 2 APPRO   500.49 * * 2660
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File hunt033.wsp
        Hydraulic analysis for structure HUNTTH00220033   Date: 04-JUN-97
        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT          RLB
           *** RUN DATE & TIME: 07-08-97  13:11

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      239     22051     15     61                          5384
   497.29           239     22051     15     61  1.00      0     37     5384

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.29     0.0    36.9   239.1   22051.    2030.   8.49

X STA.        0.0        3.3        5.2        6.7        8.1        9.4
  A(I)            18.5       11.5        9.9        9.5        9.0
  V(I)            5.50       8.84      10.20      10.72      11.30

X STA.        9.4       10.7       11.9       13.2       14.4       15.8
  A(I)             8.6        8.7        8.8        8.8        8.9
  V(I)           11.76      11.73      11.55      11.60      11.37

X STA.       15.8       17.1       18.9       20.7       22.7       24.6
  A(I)             9.2       11.8       12.6       13.1       13.0
  V(I)           11.02       8.57       8.06       7.75       7.81

X STA.       24.6       26.6       28.6       30.7       33.1       36.9
  A(I)            13.0       13.6       13.7       15.1       21.9
  V(I)            7.82       7.44       7.42       6.72       4.63

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      160     15022     32     40                          2032
   494.69           160     15022     32     40  1.00      0     37     2032

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      426     35137     77     80                          5682
   499.08           426     35137     77     80  1.00    -35     41     5682

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.08   -36.5    40.7   426.2   35137.    2030.   4.76

X STA.      -36.5      -16.2      -10.2       -6.0       -2.7        0.0
  A(I)            42.8       29.1       24.7       22.8       20.6
  V(I)            2.37       3.49       4.11       4.46       4.93

X STA.        0.0        2.3        4.5        6.6        8.5       10.3
  A(I)            19.0       18.6       17.7       17.4       16.8
  V(I)            5.34       5.45       5.74       5.84       6.03

X STA.       10.3       12.0       13.7       15.4       17.1       18.9
  A(I)            16.2       16.5       16.0       16.8       16.7
  V(I)            6.27       6.14       6.33       6.06       6.06

X STA.       18.9       20.8       22.9       25.5       29.0       40.7
  A(I)            17.4       18.6       20.2       23.4       34.8
  V(I)            5.83       5.47       5.02       4.34       2.91
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        U.S. Geological Survey WSPRO Input File hunt033.wsp
        Hydraulic analysis for structure HUNTTH00220033   Date: 04-JUN-97
        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT         RLB
           *** RUN DATE & TIME: 07-08-97  13:11

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      242     19356      0     77                            0
   497.68           242     19356      0     77  1.00      0     37        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.68     0.0    36.9   242.1   19356.    2470.  10.20

X STA.         0.0        3.4        5.4        7.1        8.8       10.3
  A(I)            19.8       13.0       11.7       11.5       10.7
  V(I)            6.25       9.51      10.59      10.73      11.52

X STA.        10.3       11.8       13.3       14.8       16.4       18.0
  A(I)            10.8       10.6       10.7       10.8       10.7
  V(I)           11.46      11.67      11.57      11.49      11.53

X STA.        18.0       19.6       21.2       22.8       24.4       26.1
  A(I)            10.8       10.8       10.8       11.0       11.0
  V(I)           11.46      11.49      11.39      11.27      11.26

X STA.        26.1       27.7       29.5       31.4       33.5       36.9
  A(I)            11.2       11.5       12.2       13.4       19.4
  V(I)           11.07      10.74      10.16       9.19       6.36

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      182     18297     32     41                         2476
   495.40           182     18297     32     41  1.00      0     37     2476

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      18.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.49   -87.0    65.4    51.1     725.     190.   3.72

X STA.       -87.0      -57.4      -32.8        3.3       15.0       20.8
  A(I)             6.2        5.9        6.1        3.5        2.7
  V(I)            1.54       1.62       1.56       2.73       3.56

X STA.        20.8       25.0       28.4       31.0       33.2       35.2
  A(I)             2.3        2.1        1.8        1.6        1.5
  V(I)            4.17       4.48       5.33       6.12       6.39

X STA.        35.2       37.0       38.8       40.6       42.7       44.9
  A(I)             1.5        1.5        1.5        1.5        1.6
  V(I)            6.50       6.47       6.46       6.18       5.89

X STA.        44.9       47.4       50.3       53.8       58.2       65.4
  A(I)             1.7        1.8        1.9        2.1        2.5
  V(I)            5.57       5.43       4.91       4.53       3.78

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      68.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       13        94     46     46                           40
             2      542     49108     85     88                         7759
   500.49           555     49202    131    134  1.04    -86     44     6347

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.49   -87.0    43.7   554.7   49202.    2660.   4.80

X STA.       -87.0      -21.0      -14.2       -9.4       -5.5       -2.4
  A(I)            64.1       36.6       31.1       29.5       26.0
  V(I)            2.07       3.63       4.27       4.51       5.11

X STA.        -2.4        0.3        2.8        5.0        7.2        9.2
  A(I)            24.9       23.3       22.5       22.1       21.4
  V(I)            5.35       5.70       5.92       6.03       6.22

X STA.         9.2       11.2       13.1       15.0       16.9       18.9
  A(I)            21.1       21.0       20.9       20.9       21.6
  V(I)            6.29       6.35       6.37       6.35       6.16

X STA.        18.9       21.0       23.3       26.2       30.1       43.7
  A(I)            22.4       23.3       26.6       30.1       45.2
  V(I)            5.92       5.72       5.00       4.41       2.94
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      U.S. Geological Survey WSPRO Input File hunt033.wsp
      Hydraulic analysis for structure HUNTTH00220033   Date: 04-JUN-97
      TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT          RLB
         *** RUN DATE & TIME: 07-08-97  13:11

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

   WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
           1      242     19356     0     77                            0
 497.68           242     19356     0     77  1.00      0     37        0

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     497.68     0.0    36.9   242.1   19356.    2300.   9.50

X STA.       0.0        3.4        5.4        7.1        8.8       10.3
  A(I)          19.8       13.0       11.7       11.5       10.7
  V(I)          5.82       8.86       9.86      10.00      10.73

X STA.      10.3       11.8       13.3       14.8       16.4       18.0
  A(I)          10.8       10.6       10.7       10.8       10.7
  V(I)         10.67      10.86      10.77      10.69      10.74

X STA.      18.0       19.6       21.2       22.8       24.4       26.1
  A(I)          10.8       10.8       10.8       11.0       11.0
  V(I)         10.67      10.70      10.60      10.49      10.48

X STA.      26.1       27.7       29.5       31.4       33.5       36.9
  A(I)          11.2       11.5       12.2       13.4       19.4
  V(I)         10.31      10.00       9.46       8.56       5.93

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

   WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
           1      174     17031    32     41                         2304
 495.13           174     17031    32     41  1.00      0     37     2304

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

   WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
           2      488     42057    83     86                         6726
 499.85           488     42057    83     86  1.00    -39     42     6726

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.85   -40.2    42.4   487.7   42057.    2300.   4.72

X STA.     -40.2      -18.5      -12.1       -7.6       -4.1       -1.1
  A(I)          49.1       33.3       28.2       25.8       23.8
  V(I)          2.34       3.45       4.08       4.46       4.83

X STA.      -1.1        1.5        3.8        5.9        8.0        9.9
  A(I)          22.5       20.9       20.2       19.8       19.2
  V(I)          5.10       5.50       5.70       5.80       6.00

X STA.       9.9       11.7       13.5       15.3       17.1       19.0
  A(I)          18.7       18.5       18.9       18.6       19.1
  V(I)          6.16       6.22       6.07       6.20       6.01

X STA.      19.0       21.0       23.2       26.0       29.7       42.4
  A(I)          19.9       21.2       23.6       26.7       39.8
  V(I)          5.78       5.43       4.87       4.31       2.89
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        U.S. Geological Survey WSPRO Input File hunt033.wsp
        Hydraulic analysis for structure HUNTTH00220033   Date: 04-JUN-97
        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT          RLB
           *** RUN DATE & TIME: 07-08-97  13:11

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                          WSI,CRWS =   492.77     493.12

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

EXITX:XS   ******   -142      350  0.92 *****  494.04  493.12    2030  493.12
       -38 ******     30    13524  1.76 ***** *******    0.95    5.80

FULLV:FV       39   -144      395  0.70  0.75  494.78 *******    2030  494.07
         0     39     31    15915  1.71  0.00   -0.01    0.79    5.14
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     1.14     495.03     495.39
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   493.57     509.49    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   493.57     509.49     495.39
 ===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 =   495.39     509.49     495.39

APPRO:AS       68    -18      188  1.81 *****  497.20  495.39    2030  495.39
        68     68     33    11724  1.00 ***** *******    1.00   10.78
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.69     497.29     497.64     497.27
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       39      0      239  1.13 *****  498.42  494.69    2038  497.29
         0 ******     37    22030  1.00 ***** *******    0.59    8.52

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.464  0.000  497.27 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.        <<<<<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       29    -36      427  0.35  0.16  499.44  495.39    2030  499.08
        68     31     41    35170  1.00  0.71    0.00    0.36    4.76

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   498.94

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -39.  -143.    30.   2030.   13524.     350.    5.80  493.12
   FULLV:FV       0.  -145.    31.   2030.   15915.     395.    5.14  494.07
   BRIDG:BR       0.     0.    37.   2038.   22030.     239.    8.52  497.29
   RDWAY:RG      18.**************      0.*****************     2.00********
   APPRO:AS      68.   -37.    41.   2030.   35170.     427.    4.76  499.08

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.12    0.95  488.39  511.41************  0.92  494.04  493.12
   FULLV:FV  ********    0.79  489.08  512.10  0.75  0.00  0.70  494.78  494.07
   BRIDG:BR    494.69    0.59  489.14  497.68************  1.13  498.42  497.29
   RDWAY:RG  ****************  499.66  509.49************  0.23  500.47********
   APPRO:AS    495.39    0.36  489.32  509.49  0.16  0.71  0.35  499.44  499.08
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        U.S. Geological Survey WSPRO Input File hunt033.wsp
        Hydraulic analysis for structure HUNTTH00220033   Date: 04-JUN-97
        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT          RLB
           *** RUN DATE & TIME: 07-08-97  13:11

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =    493.17     493.49

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

EXITX:XS   ******   -144      415  1.08 *****  494.58  493.49    2660  493.49
       -38 ******     32    17053  1.70 ***** *******    0.96    6.41

FULLV:FV       39   -146      481  0.79  0.77  495.34 *******    2660  494.55
         0     39     36    20949  1.66  0.00   -0.01    0.77    5.53
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     1.34     495.33     496.21
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.05     509.49    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   494.05     509.49     496.21
 ===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 =   496.21     509.49     496.21

APPRO:AS       68    -22      233  2.02 *****  498.23  496.21    2660  496.21
        68     68     35    15690  1.00 ***** *******    1.00   11.41
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.67     498.81     499.12     497.27
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       39      0      242  1.62 *****  499.30  495.40    2470  497.68
         0 ******     37    19356  1.00 ***** *******    0.70   10.20

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.493  0.000  497.27 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.    45.  0.13  0.37  500.73    0.00    190.  500.49

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    90.   106.   -87.    19.   0.5   0.2   2.7   3.8   0.5   2.7
   RT:   101.    47.    19.    65.   0.8   0.6   3.8   3.6   0.8   2.8

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

APPRO:AS       29    -86      555  0.37  0.21  500.86  496.21    2660  500.49
        68     31     44    49228  1.04  0.72    0.00    0.42    4.79

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -39.  -145.    32.   2660.   17053.     415.    6.41  493.49
   FULLV:FV       0.  -147.    36.   2660.   20949.     481.    5.53  494.55
   BRIDG:BR       0.     0.    37.   2470.   19356.     242.   10.20  497.68
   RDWAY:RG      18.*******    90.    190.******************    2.00  500.49
   APPRO:AS      68.   -87.    44.   2660.   49228.     555.    4.79  500.49

   SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    493.49    0.96  488.39  511.41************  1.08  494.58  493.49
   FULLV:FV  ********    0.77  489.08  512.10  0.77  0.00  0.79  495.34  494.55
   BRIDG:BR    495.40    0.70  489.14  497.68************  1.62  499.30  497.68
   RDWAY:RG  ****************  499.66  509.49  0.13******  0.37  500.73  500.49
   APPRO:AS    496.21    0.42  489.32  509.49  0.21  0.72  0.37  500.86  500.49
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File hunt033.wsp
        Hydraulic analysis for structure HUNTTH00220033   Date: 04-JUN-97
        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT          RLB
           *** RUN DATE & TIME: 07-08-97  13:11

 ===015 WSI IN WRONG FLOW REGIME AT SECID “EXITX”:  USED WSI = CRWS.
                           WSI,CRWS =   492.95     493.29

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

EXITX:XS   ******   -143      380  0.99 *****  494.28  493.29    2300  493.29
       -38 ******     30    15068  1.73 ***** *******    0.95    6.06

FULLV:FV       39   -145      433  0.74  0.76  495.03 *******    2300  494.29
         0     39     33    18051  1.69  0.00   -0.01    0.78    5.32
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.23     495.18     495.75
 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.79     509.49    0.50
 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.79     509.49     495.75

 ===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 =   495.75     509.49     495.75

APPRO:AS       68    -19      207  1.91 *****  497.66  495.75    2300  495.75
        68     68     34    13384  1.00 ***** *******    1.00   11.09
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   495.13     497.95     498.29     497.27

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

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

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

BRIDG:BR       39      0      242  1.41 *****  499.09  495.13    2304  497.68
         0 ******     37    19356  1.00 ***** *******    0.66    9.52

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.484  0.000  497.27 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.        <<<<<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       29    -39      488  0.35  0.20  500.19  495.75    2300  499.85
        68     31     42    42034  1.00  0.71    0.00    0.34    4.72

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.71

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -39.  -144.    30.   2300.   15068.     380.    6.06  493.29
   FULLV:FV       0.  -146.    33.   2300.   18051.     433.    5.32  494.29
   BRIDG:BR       0.     0.    37.   2304.   19356.     242.    9.52  497.68
   RDWAY:RG      18.**************      0.       0.       0.    2.00********
   APPRO:AS      68.   -40.    42.   2300.   42034.     488.    4.72  499.85

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.29    0.95  488.39  511.41************  0.99  494.28  493.29
   FULLV:FV  ********    0.78  489.08  512.10  0.76  0.00  0.74  495.03  494.29
   BRIDG:BR    495.13    0.66  489.14  497.68************  1.41  499.09  497.68
   RDWAY:RG  ****************  499.66  509.49************  0.35  500.06********
   APPRO:AS    495.75    0.34  489.32  509.49  0.20  0.71  0.35  500.19  499.85
```
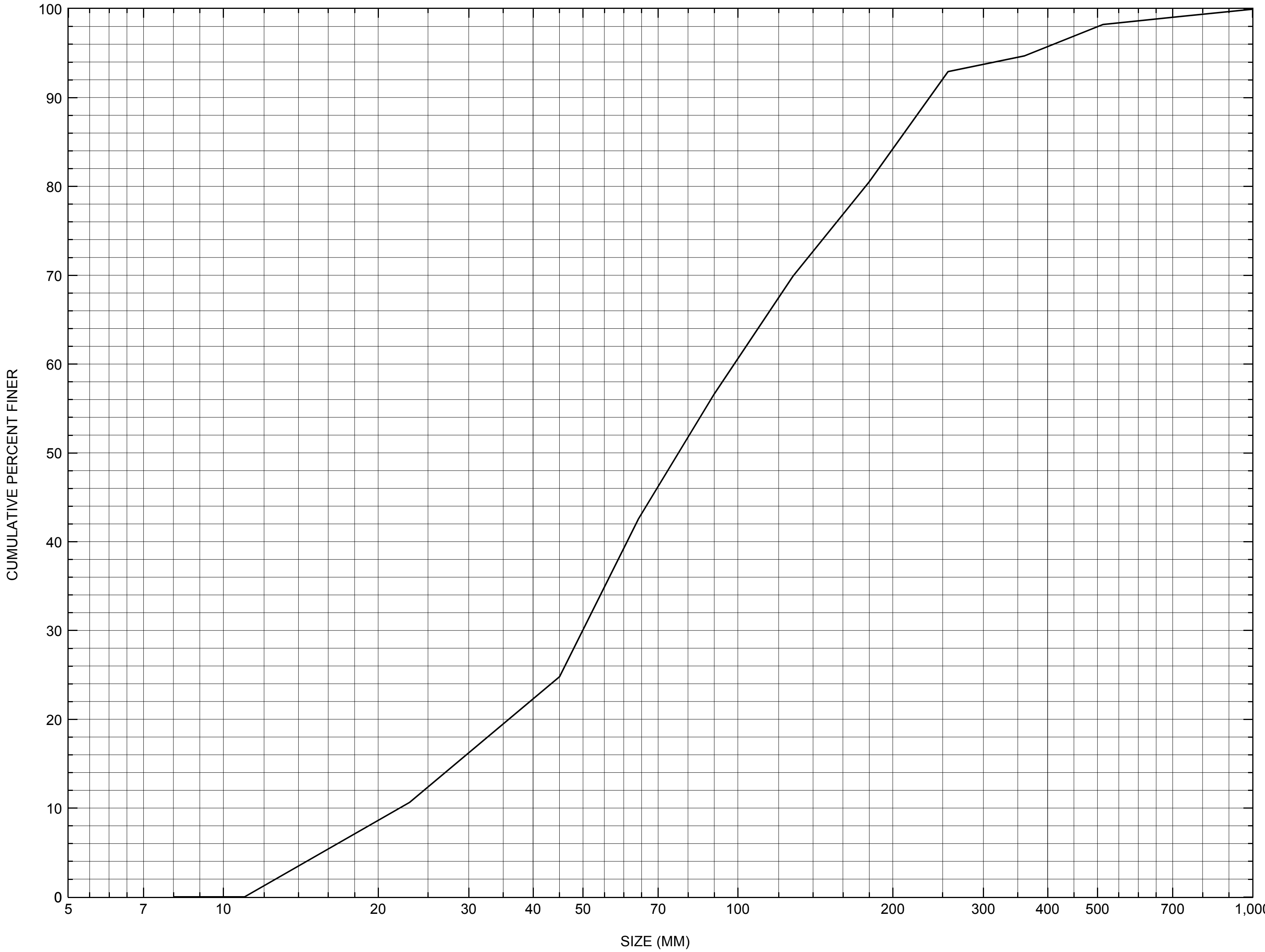

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure HUNTTH00220033, in Huntington, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HUNTTH00220033

General Location Descriptive

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

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

Highway District Number *(I - 2; nn)* 05

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

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

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

Waterway *(I - 6)* BRUSH BROOK

Road Name *(I - 7):* -

Route Number C3022

Vicinity *(I - 9)* 0.03 MI TO JCT W C3 TH21

Topographic Map Huntington

Hydrologic Unit Code: 02010003

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

Longitude *(i - 17; nnnnn.n)* 72570

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10040800330408

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

Maximum span length *(I - 48; nnnn)* 0038

Year built *(I - 27; YYYY)* 1992

Structure length *(I - 49; nnnnnn)* 000040

Average daily traffic, ADT *(I - 29; nnnnnn)* 000075

Deck Width *(I - 52; nn.n)* 235

Year of ADT *(I - 30; YY)* 93

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

Opening skew to Roadway *(I - 34; nn)* 30

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

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

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

Structure type *(I - 43; nnn)* 101

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 26.5

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

Vertical clearance from streambed (*nnn.n ft*) 7.5

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

Waterway of full opening (*nnn.n* ft^2) 198.8

Comments:

Per hydrology summary in hydraulics folder, existing clear span is 36.5 ft (26.5 ft actual). According to the structural inspection report dated 7/17/95, the bridge is an I-beam stringer with a concrete deck. The abutments and wingwalls are also concrete. Some boulder riprap is showing in front of the abutments and wingwalls, with large boulders in the US and DS channel and along the embankments. There are minor cracks in the abutments and wingwalls.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **8.65**

Terrain character: **Mountainous, forest covered with sparse population**

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ **650** Q_{10} **1200** Q_{25} **1500**
Q_{50} **1900** Q_{100} **2500** 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*)	**489.71**	**491.47**	**493.56**	**494.76**	**496.35**
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

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

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

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

Upstream distance (*miles*): **0.2** Town: **Huntington** Year Built: -

Highway No. : **TH22** Structure No. : **34** Structure Type: **I-beam stringer**

Clear span (*ft*): **27** Clear Height (*ft*): **8** Full Waterway (*ft²*): **216**

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

Highway No. : TH4 Structure No. : 41 Structure Type: I-beam stringer

Clear span (*ft*): 47 Clear Height (*ft*): 10 Full Waterway (ft^2): 470

Comments:

COE 404 Permit information: Q OHW=250 cfs and d=3 ft; Q OLW=100 cfs and d=1.5 ft; Q ave daily=175cfs.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 8.65 mi^2

Lake/pond/swamp area 0 mi^2

Watershed storage *(ST)* 0 %

Bridge site elevation 810 ft

Headwater elevation 4290 ft

Main channel length 4.01 mi

10% channel length elevation 870 ft

85% channel length elevation 2660 ft

Main channel slope *(S)* 462.75 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):* 2 / 91

Project Number - Minimum channel bed elevation: 485

Low superstructure elevation: USLAB - DSLAB - USRAB 493.47 DSRAB 492.42

Benchmark location description:

BM #1 in 36” elm, elev. 500’ (assumed), approximately 50’ US of US bridge face and 80’ up left bank.

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

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

If 1: Footing Thickness 2 Footing bottom elevation: 479

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:

A memo in the hydraulics file indicates that the low beam/girder elevation at the right abutment (DS) is 492.6 and at the left abutment (DS) is 493.4

The low superstructure elevations are bridge seat elevations from the bridge plan.

The top wingwall-abutment corner elevation is 496.50’ on the right abutment US end and 495.50 on the DS end.

Cross-sectional Data

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

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

Comments: **There is a cross section included with the plans that runs down the center line of the road.**

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

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

Qa/Qc Check by: EW Date: 7/10/96

Computerized by: EW Date: 7/11/96

Reviewd by: RB Date: 7/8/97

Structure Number HUNTTH00220033

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 06 / 26 / 1996

2. Highway District Number 05 Mile marker 000000

County 007 CHITTENDEN Town 34600 HUNTINGTON

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

Route Number C3022 Hydrologic Unit Code: 02010003

3. Descriptive comments:

Built in 1992, this bridge has a concrete deck with metal guardrails. The bridge is located 0.03 miles to junction with TH31.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 6 RBDS 4 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 40 *(feet)* Span length 38 *(feet)* Bridge width 23.5 *(feet)*

Road approach to bridge:

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

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

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

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

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

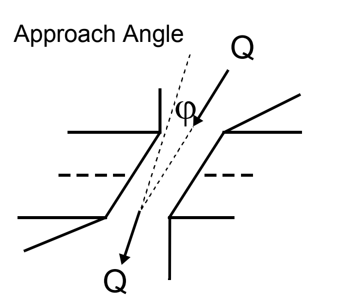
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

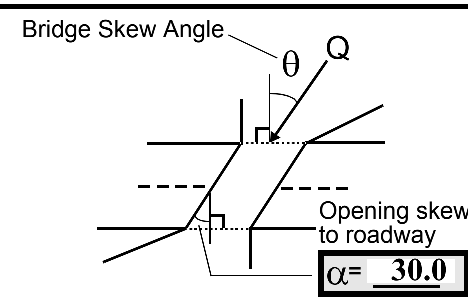
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 35



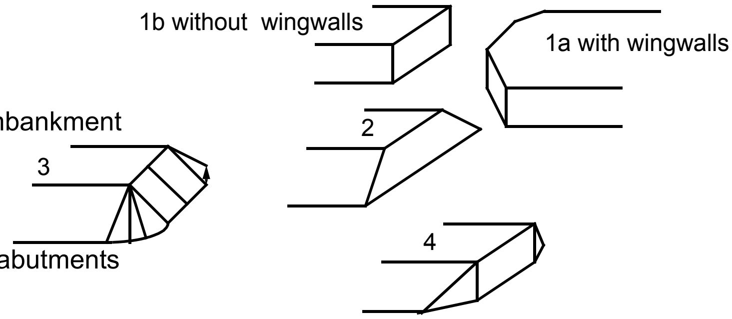


17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 110 feet US *(US, UB, DS)* to 75 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 0 feet DS *(US, UB, DS)* to 40 feet DS

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

18. Bridge Type: **1a**



1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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

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

#4: The surface cover on the RBUS is young vegetation growth over a landslide.

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
42.5	**2.5**			**3.5**	**3**	**3**	**543**	**543**	**1**	**3**

23. Bank width **10.0** 24. Channel width **20.0** 25. Thalweg depth **40.0** 29. Bed Material **435**

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.):

#28: The RB mass wasting is a landslide.

#30: The RB protection is dumped stone extending from 35 feet US to 0 feet US. The LB protection is dumped stone extending from 35 feet US to 0 feet US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **85** 35. Mid-bar width: **15**

36. Point bar extent: **130** feet **US** (US, UB) to **30** feet **US** (US, UB, DS) positioned **0** %LB to **40** %RB

37. Material: **435**

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

-

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

41. Mid-bank distance: **60** 42. Cut bank extent: **100** feet **US** (US, UB) to **45** feet **US** (US, UB, DS)

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

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

-

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **58**

47. Scour dimensions: Length **30** Width **7** Depth : **1.5** Position **60** %LB to **80** %RB

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

Scour depth based on a one foot thalweg.

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

Beyond 2 bridge lengths, a major confluence exists 6 feet DS of HUNT034 on RB.

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
19.0		1.5		2	7	7	-

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

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

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

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

435

-

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 2____ (1- Low; 2- Moderate; 3- High)

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

70. Debris and Ice Comments:

1

The bridge is on a straight reach.

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	0	-	-	90.0
RABUT	1	5	90			0	0	32.0

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

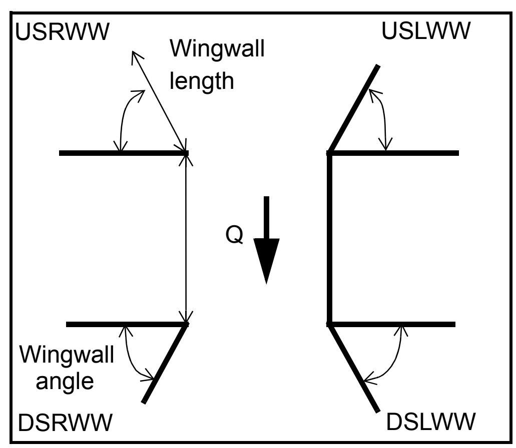
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
-
1
-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						32.0	
USRWW:	Y		1		0	1.0	
DSLWW:	-		-		Y	35.5	
DSRWW:	1		0		-	35.5	

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	-	0	Y	-	1	1	1	1
Condition	Y	-	1	-	1	1	1	1
Extent	1	-	0	2	2	2	2	-

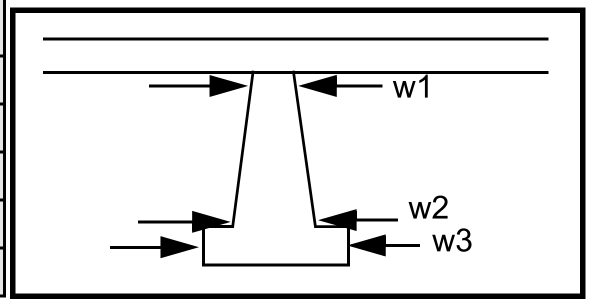
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
1
1
2
1
1

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				10.0	10.5	45.0
Pier 2	7.0	7.0	6.5	50.0	10.0	-
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 - Thalweg depth - Bed Material _____

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

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

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

2
2
543
543
1
2
543
2
2
1
3
The soil has eroded away around the RB protection. The RB protection is dumped stone extending from 0 feet DS to 45 feet DS. The LB protection extends from 0 feet DS to 24 feet DS, also comprised of dumped stone.

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

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

105. Drop structure comments (eg. downstream scour depth):
e is a dry channel on the LB in the woods that is filled with over-flow water during high flows.

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

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

Material: **NO**

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

DROP STRUCTURE

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

Cut bank extent: **73** feet **17** *(US, UB, DS)* to **27** feet **DS** *(US, UB, DS)*

Bank damage: **100** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
0
20
543

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

Scour dimensions: Length **some** Width **grass** Depth: **and** Positioned **a** %LB to **tree** %RB

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

on the point bar.

Are there major confluences? **N** *(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 **-** Enters on **-** *(LB or RB)* Type **-** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

NO CUT BANKS
The RB protection covers the cut-bank.

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: HUNTTH00220033 Town: HUNTINGTON
Road Number: TH 22 County: CHITTENDEN
Stream: BRUSH BROOK

Initials RLB Date: 6/17/97 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	2030	2660	2300
Main Channel Area, ft2	426	542	488
Left overbank area, ft2	0	13	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	77	85	83
Top width L overbank, ft	0	46	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.2517	0.2517	0.2517
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.5	6.4	5.9
y1, average depth, LOB, ft	ERR	0.3	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	35137	49202	42057
Conveyance, main channel	35137	49108	42057
Conveyance, LOB	0	94	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	2030.0	2654.9	2300.0
Ql, discharge, LOB, cfs	0.0	5.1	0.0
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	4.8	4.9	4.7
Vl, mean velocity, LOB, ft/s	ERR	0.4	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.4	9.6	9.5
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	2030	2660	2300
(Q) discharge thru bridge, cfs	2030	2470	2300
Main channel conveyance	22051	19356	19356
Total conveyance	22051	19356	19356
Q2, bridge MC discharge,cfs	2030	2470	2300
Main channel area, ft2	239	242	242
Main channel width (normal), ft	32.0	32.0	32.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	32	32	32
y_bridge (avg. depth at br.), ft	7.47	7.56	7.56
Dm, median (1.25*D50), ft	0.314625	0.314625	0.314625
y2, depth in contraction,ft	6.04	7.14	6.72
ys, scour depth (y2-ybridge), ft	-1.43	-0.42	-0.84

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	2030	2660	2300
Q, thru bridge MC, cfs	2030	2470	2300
Vc, critical velocity, ft/s	9.41	9.64	9.51
Va, velocity MC approach, ft/s	4.77	4.90	4.71
Main channel width (normal), ft	32.0	32.0	32.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	32.0	32.0	32.0
qbr, unit discharge, ft2/s	63.4	77.2	71.9
Area of full opening, ft2	239.0	242.0	242.0
Hb, depth of full opening, ft	7.47	7.56	7.56
Fr, Froude number, bridge MC	0.59	0.7	0.66
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	160	182	174
**Hb, depth at downstream face, ft	5.00	5.69	5.44
**Fr, Froude number at DS face	1.00	1.00	1.00
**Cf, for downstream face (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	497.27	497.27	497.27

Elevation of Bed, ft	489.80	489.71	489.71
Elevation of Approach, ft	499.08	500.49	499.85
Friction loss, approach, ft	0.16	0.21	0.2
Elevation of WS immediately US, ft	498.92	500.28	499.65
ya, depth immediately US, ft	9.12	10.57	9.94
Mean elevation of deck, ft	500.01	500.01	500.01
w, depth of overflow, ft (>=0)	0.00	0.27	0.00
Cc, vert contrac correction (<=1.0)	0.95	0.92	0.93
**Cc, for downstream face (<=1.0)	0.79	0.79	0.79
Ys, scour w/Chang equation, ft	-0.38	1.12	0.55
Ys, scour w/Umbrell equation, ft	-0.80	0.06	-0.39

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

**Ys, scour w/Chang equation, ft	3.53	4.45	4.13
**Ys, scour w/Umbrell equation, ft	1.67	1.94	1.74

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

y2, from Laursen's equation, ft	6.04	7.14	6.72
WSEL at downstream face, ft	494.69	495.40	495.13
Depth at downstream face, ft	5.00	5.69	5.44
Ys, depth of scour (Laursen), ft	1.04	1.46	1.28

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	2030	2470	2300
Main channel area (DS), ft2	160	182	174
Main channel width (normal), ft	32.0	32	32.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	32.0	32.0	32.0
D90, ft	0.7730	0.7730	0.7730
D95, ft	1.2181	1.2181	1.2181
Dc, critical grain size, ft	0.8504	0.9181	0.8886
Pc, Decimal percent coarser than Dc	0.070	0.066	0.068
Depth to armoring, ft	33.89	38.98	36.54

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	2030	2660	2300	2030	2660	2300
a', abut.length blocking flow, ft	39	89.5	42.7	6.2	9.2	7.9
Ae, area of blocked flow ft2	160.7	214.6	191.8	18.4	23.3	24.8

Qe, discharge blocked abut.,cfs	618.2	--	740	53.8	--	71.5

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

Ve, (Qe/Ae), ft/s	3.85	3.93	3.86	2.92	2.94	2.88
ya, depth of f/p flow, ft	4.12	2.40	4.49	2.97	2.53	3.14

--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)

K1	0.82	0.82	0.82	0.82	0.82	0.82

--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)

theta	60	60	60	120	120	120
K2	0.95	0.95	0.95	1.04	1.04	1.04
Fr, froude number f/p flow	0.334	0.430	0.321	0.299	0.284	0.287
ys, scour depth, ft	13.92	14.40	14.93	6.74	6.49	7.35

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)	39	89.5	42.7	6.2	9.2	7.9
y1 (depth f/p flow, ft)	4.12	2.40	4.49	2.97	2.53	3.14
a'/y1	9.46	37.33	9.51	2.09	3.63	2.52
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.33	0.43	0.32	0.30	0.28	0.29
Ys w/ corr. factor K1/0.55:						
vertical	ERR	13.20	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	10.82	ERR	ERR	ERR	ERR
spill-through	ERR	7.26	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)

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	1	1	1	1
y, depth of flow in bridge, ft	5.00	5.69	5.44	5.00	5.69	5.44
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	2.09	2.38	2.27	2.09	2.38	2.27