LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (BRISTH00270020) on TOWN HIGHWAY 27, crossing LITTLE NOTCH BROOK, BRISTOL, VERMONT

Open-File Report 97-756

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

U.S. Department of the Interior
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LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (BRISTH00270020) on TOWN HIGHWAY 27, crossing LITTLE NOTCH BROOK, BRISTOL, VERMONT

By ERICK M. BOEHMLER

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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 20 (BRISTH00270020) ON TOWN HIGHWAY 27, CROSSING LITTLE NOTCH BROOK, BRISTOL, VERMONT

By **Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRISTH00270020 on Town Highway 27 crossing Little Notch Brook, Bristol, 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 west-central Vermont. The 8.43-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of pasture with trees, shrubs, and brush along the road embankments and the stream banks, except for the downstream left overbank area. Surface cover on the downstream left overbank is forest with dense undergrowth consisting of vines, shrubs, and brush.

In the study area, Little Notch Brook has a sinuous channel with a slope of approximately 0.006 ft/ft, an average channel top width of 47 feet and an average bank height of 3 feet. The predominant channel bed materials are gravel and cobbles with a median grain size (D_{50}) of 66.0 mm (0.216 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 19, 1995, indicated that the reach was stable.

The Town Highway 27 crossing of Little Notch Brook is a 48-ft-long, one-lane bridge consisting of one 45-foot steel pony-truss span (Vermont Agency of Transportation, written communication, November 30, 1995). The opening length of the structure parallel to the bridge face is 42.8 feet. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 1.0 feet deeper than the mean thalweg depth was observed along the upstream left wingwall and the upstream end of the left abutment during the Level I assessment. The only scour protection measure at the site was a crude, block-cut stone wall, which extended from the upstream end of the upstream left wingwall to 45 feet upstream. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 0.2 feet. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 12.2 to 13.4 feet at the left abutment and from 3.6 to 5.0 feet at the right abutment. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number BRISTH00270020 ***Stream*** Little Notch Brook

County Addison ***Road*** TH 27 ***District*** 5

Description of Bridge

Bridge length 48 ***ft*** ***Bridge width*** 12.0 ***ft*** ***Max span length*** 45 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 6/19/96

Description of stone fill No stone fill on the abutments or wingwalls. The only protection at this site was a block-cut stone wall, which extended 45 feet upstream of the upstream left wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a 0.5 to 1 foot deep scour hole in front of the upstream left wingwall and the upstream end of the left abutment.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 15

There is a mild channel bend in the upstream reach. The scour hole has developed in the location where the flow impacts the upstream left wingwall.

Debris accumulation on bridge at time of Level I or Level II site visit:

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	6/19/96	0	0
Level II	6/19/96	0	0

Potential for debris Moderate. There is significant vegetation growth on the banks.

Describe any features near or at the bridge that may affect flow (include observation date) The downstream end of a channel anabranch is located just upstream of this bridge noted on 6/19/96.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with a narrow, irregular flood plain and steep valley walls on both sides.

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

Date of inspection 6/19/96

DS left: Mildly sloping channel bank to a narrow overbank.

DS right: Steep channel bank to a flood plain.

US left: Mildly sloping channel bank to a narrow overbank.

US right: Mildly sloping channel bank to a flood plain.

Description of the Channel

Average top width 47 ***ft*** ***Average depth*** 3 ***ft***

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

Perennial and sinuous with semi-alluvial channel boundaries and irregular point and lateral bars.

6/19/95

Vegetative co[ver] Trees, shrubs, and brush

DS left: Grass with trees and shrubs.

DS right: Trees, shrubs, and brush with grass on the overbank.

US left: Trees, shrubs, brush, and grass (swampy)

US right:

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

Describe any obstructions in channel and date of observation. The assessment of 6/19/96 noted that the upstream left wingwall and the left abutment block and divert flow to the right through the opening at all stages. The right third of the bridge opening is blocked by a partially vegetated sand and gravel bar.

Hydrology

Drainage area 8.43 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England / Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***:

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 1,690 ***ft³/s*** ***Q500*** 2,350 ***ft³/s***

The 100- and 500-year discharges are the same as those computed for the hydraulic analysis at bridge number 6 over Little Notch Brook in Bristol (BRISVT01160006, Boehmler and Burns, 1997). The difference in drainage area is small and there are no significant tributaries between this site and bridge 6. Therefore, it was assumed that there is no difference in the 100-year or 500-year peak discharge between the sites.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled "X" on top of the downstream end of the left abutment (elev. 500.31 feet, arbitrary survey datum). RM2 is the center point of a chiseled "X" on top of a rock at the upstream end of the right abutment (elev. 500.30 feet, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-40	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	58	2	Modelled Approach section (Templated from APTEM)
APTEM	66	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 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 0.045 to 0.050, and overbank "n" values ranged from 0.045 to 0.085.

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 0.0064 ft/ft, which was estimated from surveyed thalweg points downstream of the bridge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.027 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.0 ***ft***
Average low steel elevation 500.0 ***ft***

100-year discharge 1,690 ***ft³/s***
Water-surface elevation in bridge opening 493.7 ***ft***
Road overtopping? Yes ***Discharge over road*** 67 ***ft³/s***
Area of flow in bridge opening 172 ***ft²***
Average velocity in bridge opening 9.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.6 ***ft/s***

Water-surface elevation at Approach section with bridge 495.4
Water-surface elevation at Approach section without bridge 494.3
Amount of backwater caused by bridge 1.1 ***ft***

500-year discharge 2,350 ***ft³/s***
Water-surface elevation in bridge opening 494.2 ***ft***
Road overtopping? Yes ***Discharge over road*** 393 ***ft³/s***
Area of flow in bridge opening 197 ***ft²***
Average velocity in bridge opening 10.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.1 ***ft/s***

Water-surface elevation at Approach section with bridge 496.1
Water-surface elevation at Approach section without bridge 494.7
Amount of backwater caused by bridge 1.4 ***ft***

Incipient overtopping discharge 1,420 ***ft³/s***
Water-surface elevation in bridge opening 493.5 ***ft***
Area of flow in bridge opening 166 ***ft²***
Average velocity in bridge opening 8.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.5 ***ft/s***

Water-surface elevation at Approach section with bridge 495.0
Water-surface elevation at Approach section without bridge 494.1
Amount of backwater caused by bridge 0.9 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed for all of the modeled discharges by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

Abutment scour for the left abutment 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 at the right abutment 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 are defined the same as those defined for the Froehlich abutment-scour equation.

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	0.2	0.0
Depth to armoring	7.8	10.0	3.3
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	12.5	13.4	12.2
Right abutment	3.8	5.0	3.6
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.6	1.8	1.4
Right abutment	1.6	1.8	1.4
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

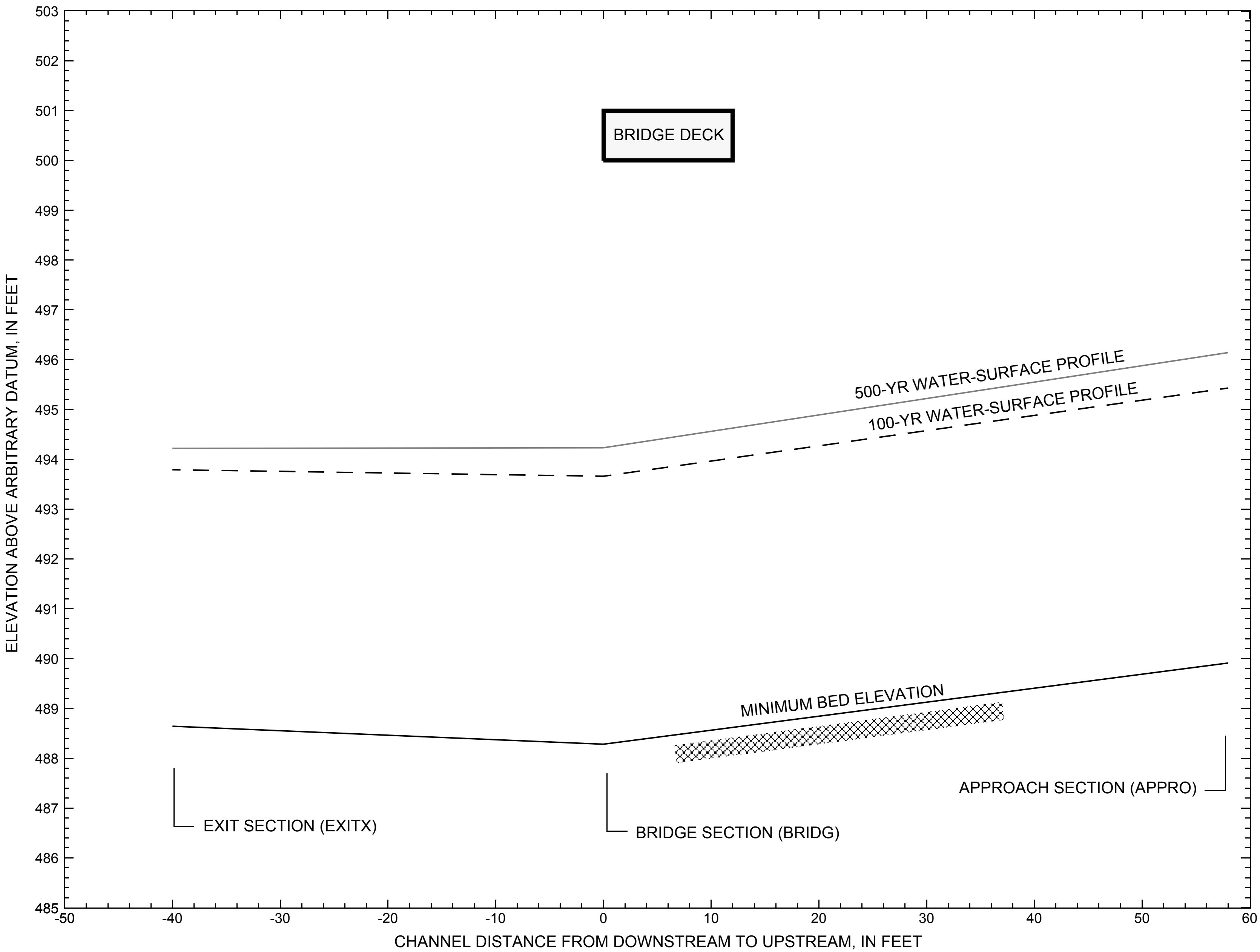

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRISTH00270020 on Town Highway 27, crossing Little Notch Brook, Bristol, Vermont.

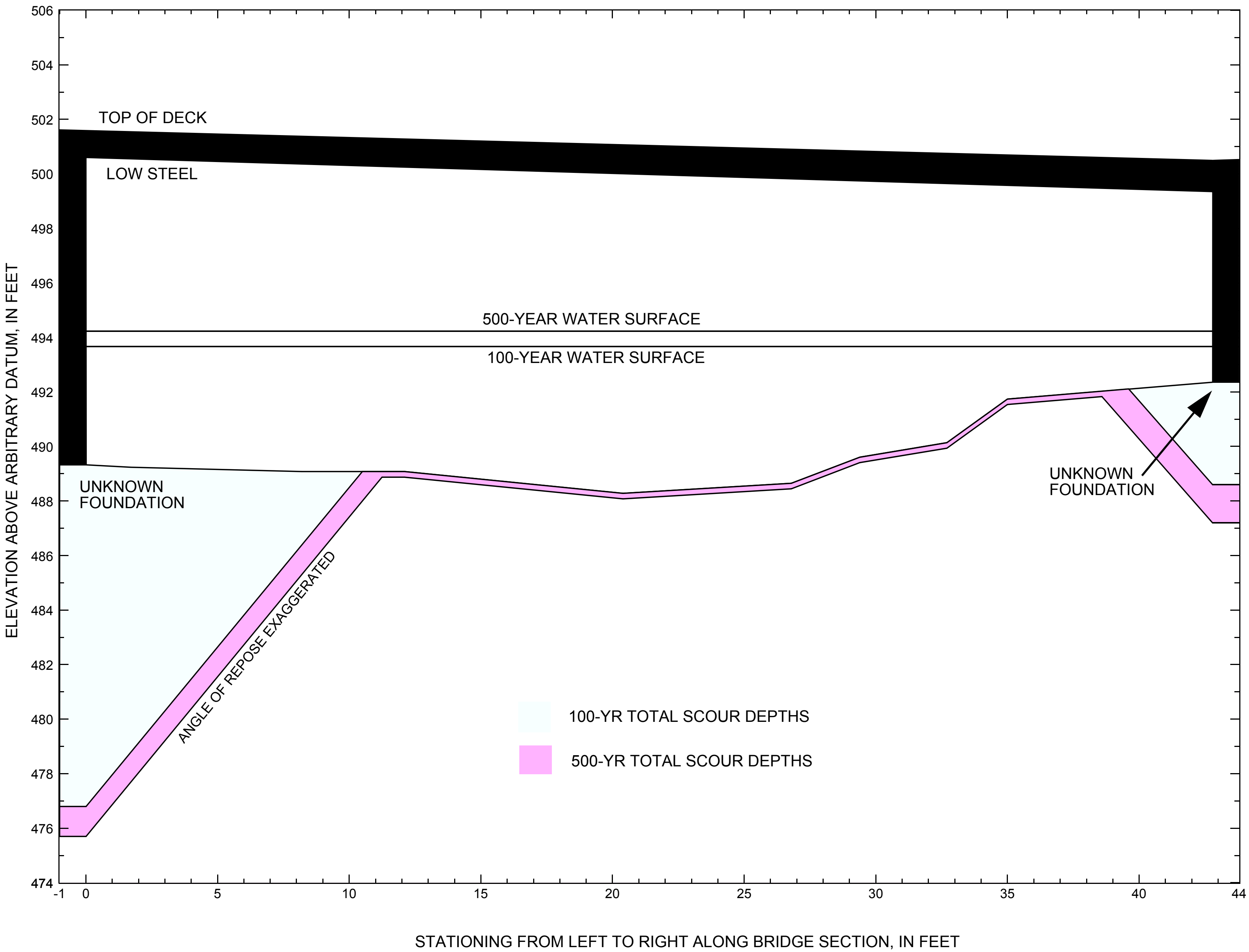

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRISTH00270020 on Town Highway 27, crossing Little Notch Brook, Bristol, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRISTH00270020 on Town Highway 27, crossing Little Notch Brook, Bristol, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,690 cubic-feet per second											
Left abutment	0.0	--	500.6	--	489.3	0.0	12.5	--	12.5	476.8	--
Right abutment	42.8	--	499.4	--	492.4	0.0	3.8	--	3.8	488.6	--

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 BRISTH00270020 on Town Highway 27, crossing Little Notch Brook, Bristol, 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 2,350 cubic-feet per second											
Left abutment	0.0	--	500.6	--	489.3	0.2	13.4	--	13.6	475.7	--
Right abutment	42.8	--	499.4	--	492.4	0.2	5.0	--	5.2	487.2	--

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, 1963, South Mountain, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps; Photoinspected, 1983; Contour interval, 20 feet; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File bris020.wsp
T2        Hydraulic analysis for structure BRISTH00270020   Date: 13-JUN-97
T3        Town Highway 27 crossing Little Notch Brook, Bristol, VT         EMB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1690.0   2350.0   1420.0
SK          0.0064   0.0064   0.0064
*
XS   EXITX    -40
GR          -98.9, 499.30    -71.0, 496.85    -50.3, 492.24    -12.0, 492.67
GR            0.0, 491.26      2.4, 489.54      5.2, 489.96     16.9, 489.36
GR           20.8, 489.02     27.9, 488.64     32.2, 489.39     33.2, 489.64
GR           34.2, 491.26     42.3, 492.46    108.3, 492.12    322.1, 494.70
GR          371.3, 495.83    443.1, 503.17
*           155.3, 494.23    176.5, 495.59
*
N           0.085        0.050        0.045
SA                 -12.0         34.2
*
XS   FULLV      0  * * *  0.0
*
*             SRD     LSEL
BR   BRIDG     0    499.97
GR            0.0, 500.60      0.0, 489.33      1.7, 489.24      8.2, 489.08
GR           12.1, 489.08     20.4, 488.28     26.8, 488.65     29.4, 489.61
GR           32.7, 490.14     35.0, 491.74     42.8, 492.36     42.8, 499.35
GR            0.0, 500.60
*
*         BRTYPE  BRWDTH         WWANGL   WWWID
CD           1      15.5   *  *    55.7     6.3
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     8      12.0     2
GR         -114.1, 512.72   -102.6, 508.73    -90.8, 508.87    -61.8, 506.51
GR          -16.1, 502.45      0.0, 501.58     44.9, 500.49     75.0, 498.85
GR          166.4, 496.38    322.1, 494.70    371.3, 495.83    443.1, 503.17
GR          465.5, 516.55
*
XT   APTEM     66
GR          -86.7, 505.30    -71.8, 499.32    -62.0, 496.28    -32.2, 495.27
GR          -21.7, 492.82     -5.7, 490.80      0.0, 490.13      7.1, 490.29
GR           12.0, 490.75     15.4, 492.44     30.4, 493.26     75.7, 492.33
GR           78.9, 491.80     81.2, 492.15     93.1, 492.82     98.5, 494.24
GR          187.7, 494.92    258.1, 495.55    301.1, 495.18    393.2, 495.83
GR          443.1, 503.17    465.5, 516.55
*
AS   APPRO     58  * * *  0.027
GT
N           0.065        0.050         0.070         0.075
SA                 -32.2         15.4          98.5
*
HP 1 EXITX 493.79 1 493.79
HP 1 BRIDG 493.66 1 493.66
HP 2 BRIDG 493.66 * * 1623
HP 2 RDWAY 495.33 * * 67
HP 1 APPRO 495.43 1 495.43
HP 2 APPRO 495.43 * * 1690
*
HP 1 EXITX 494.22 1 494.22
HP 1 BRIDG 494.23 1 494.23
HP 2 BRIDG 494.23 * * 1957
HP 2 RDWAY 495.95 * * 393
HP 1 APPRO 496.14 1 496.14
HP 2 APPRO 496.14 * * 2350
*
HP 1 EXITX 493.58 1 493.58
HP 1 BRIDG 493.51 1 493.51
HP 2 BRIDG 493.51 * * 1420
HP 1 APPRO 495.03 1 495.03
HP 2 APPRO 495.03 * * 1420
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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       U.S. Geological Survey WSPRO Input File bris020.wsp
       Hydraulic analysis for structure BRISTH00270020   Date: 13-JUN-97
       Town Highway 27 crossing Little Notch Brook, Bristol, VT          EMB
          *** RUN DATE & TIME: 07-15-97  14:10

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      172     13141     43     49                         1960
  493.66           172     13141     43     49  1.00      0     43     1960

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      493.66     0.0    42.8   172.2   13141.    1623.   9.42

X STA.        0.0        3.1        5.1        6.9        8.6       10.3
  A(I)            13.6        8.8        8.2        7.9        7.7
  V(I)            5.98       9.19       9.90      10.28      10.56

X STA.       10.3       11.9       13.5       15.0       16.5       17.9
  A(I)             7.5        7.4        7.3        7.4        7.1
  V(I)           10.77      10.95      11.16      11.00      11.39

X STA.       17.9       19.3       20.6       22.0       23.4       24.8
  A(I)             7.0        7.2        7.2        7.4        7.5
  V(I)           11.61      11.33      11.21      11.01      10.79

X STA.       24.8       26.4       28.2       30.4       33.5       42.8
  A(I)             8.1        8.5        9.3       10.9       16.3
  V(I)           10.03       9.57       8.74       7.45       4.98

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.33   263.7   349.5    27.0     414.      67.   2.48

X STA.      263.7      286.1      292.9      297.6      301.4      304.5
  A(I)             2.7        1.9        1.6        1.5        1.3
  V(I)            1.23       1.78       2.11       2.29       2.53

X STA.      304.5      307.3      309.7      311.9      314.0      315.9
  A(I)             1.3        1.2        1.1        1.1        1.1
  V(I)            2.66       2.85       2.95       3.07       3.14

X STA.      315.9      317.7      319.4      321.1      322.8      324.5
  A(I)             1.0        1.0        1.0        1.0        1.0
  V(I)            3.22       3.32       3.31       3.24       3.23

X STA.      324.5      326.5      328.8      331.6      335.6      349.5
  A(I)             1.1        1.2        1.3        1.5        2.2
  V(I)            3.07       2.88       2.68       2.29       1.51

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1        2        16     11     11                            5
            2      185     13489     48     48                         2073
            3      240     10338     83     83                         2315
            4      151      2054    269    269                          646
  495.43           579     25897    410    412  1.76    -42    367     2942

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.43   -43.3   367.1   578.8   25897.    1690.   2.92

X STA.      -43.3      -17.9      -12.2       -7.9       -4.3       -1.2
  A(I)            30.4       20.9       18.8       16.9       16.0
  V(I)            2.78       4.04       4.50       4.99       5.30

X STA.       -1.2        1.5        4.2        7.0        9.9       13.2
  A(I)            15.1       14.9       15.0       15.0       15.8
  V(I)            5.59       5.67       5.62       5.62       5.34

X STA.       13.2       20.8       33.1       45.9       56.9       66.4
  A(I)            24.9       32.0       33.0       30.8       29.0
  V(I)            3.39       2.64       2.56       2.75       2.92

X STA.       66.4       75.2       82.8       91.7      132.1      367.1
  A(I)            28.0       27.1       28.1       58.4      108.6
  V(I)            3.01       3.12       3.01       1.45       0.78
```

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        U.S. Geological Survey WSPRO Input File bris020.wsp
        Hydraulic analysis for structure BRISTH00270020   Date: 13-JUN-97
        Town Highway 27 crossing Little Notch Brook, Bristol, VT          EMB
           *** RUN DATE & TIME: 07-15-97  14:10

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      197     16140     43     50                         2391
   494.23           197     16140     43     50  1.00      0     43     2391

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.23     0.0    42.8   196.6   16140.    1957.   9.95

 X STA.        0.0        3.2        5.2        7.1        8.9       10.6
   A(I)            16.0       10.1        9.6        9.0        8.7
   V(I)            6.11       9.66      10.15      10.88      11.20

 X STA.       10.6       12.2       13.8       15.4       16.9       18.3
   A(I)             8.6        8.5        8.3        8.4        8.1
   V(I)           11.41      11.56      11.82      11.69      12.13

 X STA.       18.3       19.7       21.1       22.5       23.9       25.4
   A(I)             8.1        8.2        8.2        8.4        8.6
   V(I)           12.13      11.91      11.88      11.65      11.40

 X STA.       25.4       27.0       29.0       31.4       34.8       42.8
   A(I)             9.0       10.1       10.6       12.6       17.6
   V(I)           10.88       9.71       9.27       7.77       5.56

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.95   206.3   372.5   106.2    2607.     393.   3.70

 X STA.      206.3      251.0      264.5      274.0      281.4      287.8
   A(I)            10.8        7.5        6.5        5.7        5.4
   V(I)            1.82       2.63       3.04       3.44       3.66

 X STA.      287.8      293.3      298.1      302.5      306.6      310.5
   A(I)             5.0        4.7        4.5        4.3        4.2
   V(I)            3.93       4.21       4.36       4.54       4.64

 X STA.      310.5      314.1      317.5      320.7      323.9      327.5
   A(I)             4.1        4.0        4.0        3.9        4.2
   V(I)            4.77       4.91       4.90       5.06       4.69

 X STA.      327.5      331.4      336.0      341.7      349.7      372.5
   A(I)             4.2        4.5        5.0        5.6        8.0
   V(I)            4.63       4.36       3.96       3.48       2.45

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       17       275     30     30                           75
             2      219     17837     48     48                         2666
             3      299     14911     83     83                         3219
             4      359      8079    298    298                         2237
   496.14           895     41102    459    460  1.84    -61    397     5226

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.14   -62.2   396.8   894.6   41102.    2350.   2.63

 X STA.      -62.2      -19.3      -12.6       -7.5       -3.2        0.4
   A(I)            50.5       28.4       25.5       24.2       22.0
   V(I)            2.33       4.14       4.61       4.85       5.34

 X STA.        0.4        3.9        7.5       11.2       17.3       29.4
   A(I)            21.7       21.8       21.5       28.1       42.1
   V(I)            5.42       5.38       5.46       4.18       2.79

 X STA.       29.4       43.1       55.2       66.1       76.2       84.8
   A(I)            44.1       42.1       40.5       39.5       36.8
   V(I)            2.66       2.79       2.90       2.97       3.20

 X STA.       84.8       96.6      131.8      180.1      270.5      396.8
   A(I)            42.1       70.7       81.0      100.7      111.3
   V(I)            2.79       1.66       1.45       1.17       1.06
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       U.S. Geological Survey WSPRO Input File bris020.wsp
       Hydraulic analysis for structure BRISTH00270020   Date: 13-JUN-97
       Town Highway 27 crossing Little Notch Brook, Bristol, VT          EMB
          *** RUN DATE & TIME: 07-15-97  14:10

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      166     12385     43     49                         1852
  493.51           166     12385     43     49  1.00      0     43     1852

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      493.51     0.0    42.8   165.8   12385.    1420.   8.56

X STA.        0.0        3.1        5.0        6.8        8.5       10.2
  A(I)           13.0        8.5        7.9        7.6        7.4
  V(I)           5.46       8.38       9.03       9.36       9.62

X STA.       10.2       11.8       13.4       14.9       16.4       17.8
  A(I)            7.1        7.4        6.9        6.9        6.9
  V(I)           9.99       9.65      10.23      10.23      10.26

X STA.       17.8       19.2       20.5       21.8       23.2       24.7
  A(I)            6.8        6.8        7.0        7.1        7.3
  V(I)          10.40      10.46      10.15       9.97       9.77

X STA.       24.7       26.2       27.9       30.2       33.2       42.8
  A(I)            7.6        8.2        9.2       10.5       15.6
  V(I)           9.33       8.62       7.69       6.73       4.55

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            2      166     11275     47     48                         1764
            3      207      8064     83     83                         1851
            4       66       782    143    143                          254
  495.03           439     20121    273    274  1.52    -31    310     2560

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      58.

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.03   -32.1   310.5   438.9   20121.    1420.   3.24

X STA.      -32.1      -17.0      -11.8       -7.8       -4.5       -1.7
  A(I)           25.5       17.5       15.7       14.4       13.4
  V(I)           2.79       4.05       4.54       4.93       5.29

X STA.       -1.7        0.9        3.3        5.7        8.2       10.9
  A(I)           12.9       12.3       12.2       12.3       12.6
  V(I)           5.51       5.78       5.83       5.75       5.65

X STA.       10.9       14.3       23.0       36.7       49.3       59.5
  A(I)           14.0       23.1       29.1       28.3       25.4
  V(I)           5.06       3.07       2.44       2.51       2.79

X STA.       59.5       68.8       77.1       84.2       94.0      310.5
  A(I)           24.8       23.8       22.7       25.7       73.2
  V(I)           2.86       2.98       3.13       2.76       0.97
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File bris020.wsp
       Hydraulic analysis for structure BRISTH00270020   Date: 13-JUN-97
       Town Highway 27 crossing Little Notch Brook, Bristol, VT          EMB
          *** RUN DATE & TIME: 07-15-97  14:10

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

EXITX:XS   ******    -56      458  0.32 *****  494.11  493.37    1690  493.79
       -39 ******    247    21120  1.52 ***** *******    0.65    3.69

FULLV:FV       40    -58      556  0.21  0.20  494.31 *******    1690  494.10
         0     40    272    26797  1.47  0.00   -0.01    0.50    3.04
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.93     494.31     494.17

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.60     516.33    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.60     516.33     494.17

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.48

APPRO:AS       58    -28      285  0.75  0.49  495.06  494.17    1690  494.31
        58     58    136    12731  1.38  0.27   -0.01    0.93    5.93
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   495.60       0.00     493.56     494.70

 ===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       40      0      172  1.38  0.40  495.04  493.19    1623  493.66
         0     40     43    13129  1.00  0.52   -0.01    0.83    9.43

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  499.97 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    46.  0.20  0.24  495.46    0.00     67.  495.33

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    49.   -30.    18.   2.6   1.6   8.7  12.2   3.4   3.1
   RT:    67.    86.   264.   350.   0.6   0.3   2.6   2.5   0.4   2.7

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

APPRO:AS       43    -42      578  0.23  0.40  495.66  494.17    1690  495.43
        58     49    367    25881  1.76  0.23    0.00    0.58    2.92

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.740  0.499   12981.   -10.    32. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -40.   -57.   247.   1690.   21120.     458.    3.69  493.79
   FULLV:FV       0.   -59.   272.   1690.   26797.     556.    3.04  494.10
   BRIDG:BR       0.     0.    43.   1623.   13129.     172.    9.43  493.66
   RDWAY:RG       8.*******     0.     67.       0.*********    2.00  495.33
   APPRO:AS      58.   -43.   367.   1690.   25881.     578.    2.92  495.43

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     -10.    32.   12981.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.37    0.65  488.64  503.17************  0.32  494.11  493.79
   FULLV:FV  ********    0.50  488.64  503.17  0.20  0.00  0.21  494.31  494.10
   BRIDG:BR    493.19    0.83  488.28  500.60  0.40  0.52  1.38  495.04  493.66
   RDWAY:RG  ****************  494.70  516.55  0.20******  0.24  495.46  495.33
   APPRO:AS    494.17    0.58  489.91  516.33  0.40  0.23  0.23  495.66  495.43
```

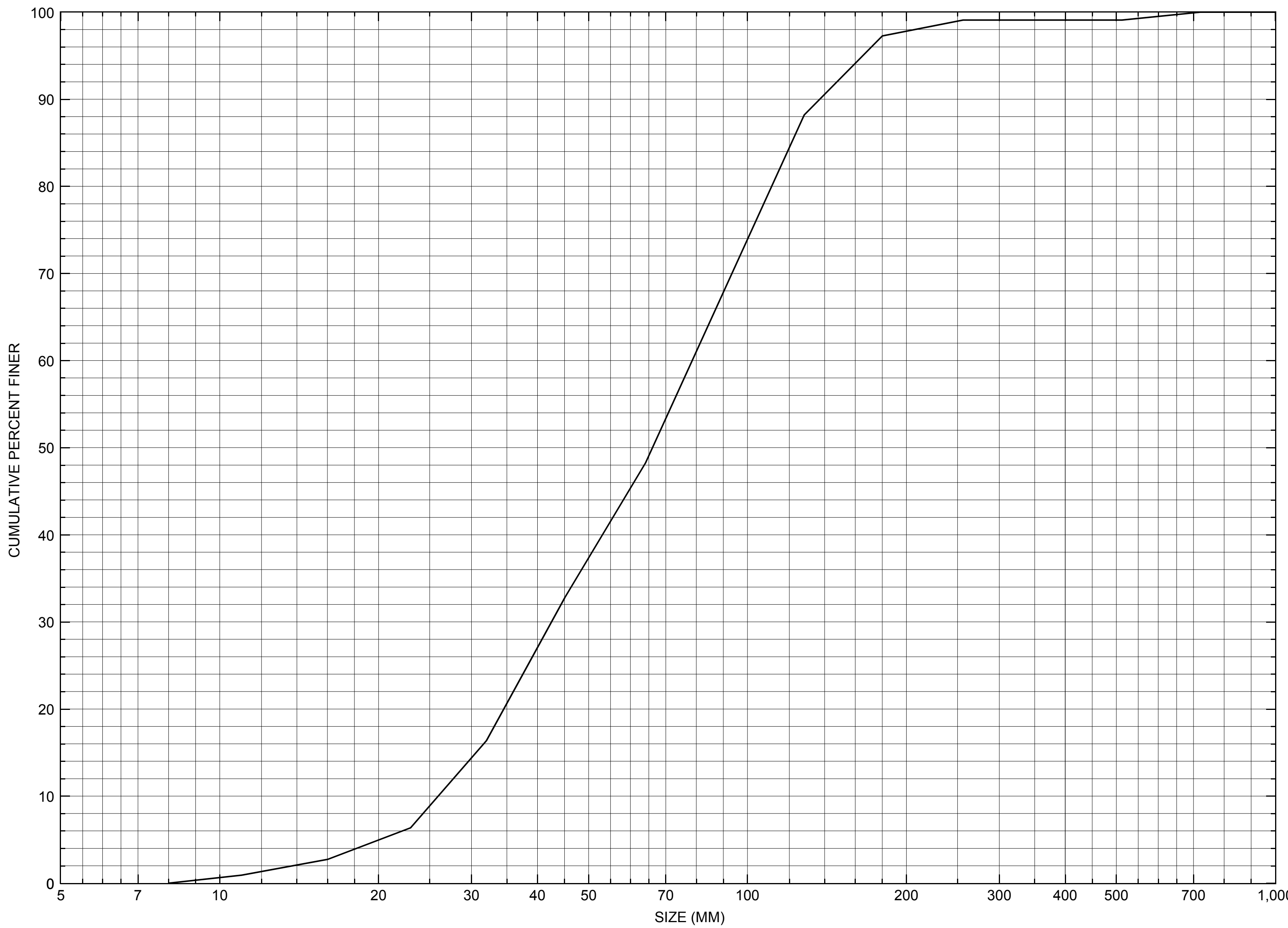
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File bris020.wsp
        Hydraulic analysis for structure BRISTH00270020   Date: 13-JUN-97
        Town Highway 27 crossing Little Notch Brook, Bristol, VT          EMB
           *** RUN DATE & TIME: 07-15-97  14:10

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

EXITX:XS   ******    -58      598  0.35 *****  494.57  493.72    2350  494.22
       -39 ******    283    29374  1.45 ***** *******    0.63    3.93

FULLV:FV       40    -60      708  0.24  0.21  494.78 *******    2350  494.54
         0     40    308    36451  1.40  0.00    0.00    0.50    3.32
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.07     494.71     494.72

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.04     516.33    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.04     516.33     494.72

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.46

APPRO:AS       58    -30      364  0.94  0.53  495.65  494.72    2350  494.72
        58     58    189    16601  1.44  0.35    0.00    1.06    6.46
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   496.96       0.00     494.18     494.70

 ===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       40      0      197  1.54  0.39  495.77  493.66    1957  494.23
         0     40     43    16135  1.00  0.81    0.00    0.82    9.95

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  499.97 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    46.  0.15  0.19  496.20    0.00    393.  495.95

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    49.   -30.    18.   2.6   1.6   8.7  12.2   3.4   3.1
   RT:   393.   167.   206.   373.   1.3   0.6   4.0   3.7   0.9   2.8

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

APPRO:AS       43    -61      896  0.20  0.34  496.34  494.72    2350  496.14
        58     49    397    41173  1.84  0.23    0.01    0.45    2.62

       M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
      0.805  0.604   16196.    -9.    34. ********

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

   FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS      -40.   -59.   283.   2350.   29374.     598.    3.93  494.22
   FULLV:FV        0.   -61.   308.   2350.   36451.     708.    3.32  494.54
   BRIDG:BR        0.     0.    43.   1957.   16135.     197.    9.95  494.23
   RDWAY:RG        8.*******     0.    393.       0.*********    2.00  495.95
   APPRO:AS       58.   -62.   397.   2350.   41173.     896.    2.62  496.14

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -9.    34.   16196.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF    HO   VHD      EGL    WSEL
   EXITX:XS    493.72    0.63  488.64  503.17************  0.35  494.57  494.22
   FULLV:FV  ********    0.50  488.64  503.17  0.21  0.00  0.24  494.78  494.54
   BRIDG:BR    493.66    0.82  488.28  500.60  0.39  0.81  1.54  495.77  494.23
   RDWAY:RG  ****************  494.70  516.55  0.15******  0.19  496.20  495.95
   APPRO:AS    494.72    0.45  489.91  516.33  0.34  0.23  0.20  496.34  496.14
```

```
      U.S. Geological Survey WSPRO Input File bris020.wsp
      Hydraulic analysis for structure BRISTH00270020   Date: 13-JUN-97
      Town Highway 27 crossing Little Notch Brook, Bristol, VT          EMB
         *** RUN DATE & TIME: 07-15-97  14:10

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

EXITX:XS   ******    -55      397  0.31 *****  493.89  493.20    1420  493.58
       -39 ******    230    17733  1.55 ***** *******    0.67    3.58

FULLV:FV       40    -57      488  0.20  0.20  494.09 *******    1420  493.89
         0     40    255    22785  1.50  0.00   -0.01    0.50    2.91
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.84     494.12     493.93

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.39     516.33    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.39     516.33     493.93

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.49

APPRO:AS       58    -27      255  0.66  0.46  494.77  493.93    1420  494.11
        58     58    110    11111  1.38  0.23   -0.01    0.85    5.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   495.03       0.00     493.51     494.70

 ===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       40      0      166  1.14  0.40  494.65  492.88    1420  493.51
         0     40     43    12364  1.00  0.34   -0.01    0.77    8.57

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  499.97 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       43    -31      440  0.25  0.43  495.28  493.93    1420  495.03
        58     49    311    20156  1.52  0.20    0.00    0.55    3.23

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.690  0.444   11239.   -11.    32. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -40.   -56.   230.   1420.   17733.     397.    3.58  493.58
   FULLV:FV       0.   -58.   255.   1420.   22785.     488.    2.91  493.89
   BRIDG:BR       0.     0.    43.   1420.   12364.     166.    8.57  493.51
   RDWAY:RG       8.**************      0.       0.       0.    2.00********
   APPRO:AS      58.   -32.   311.   1420.   20156.     440.    3.23  495.03

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     -11.    32.   11239.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.20    0.67  488.64  503.17************  0.31  493.89  493.58
   FULLV:FV  ********    0.50  488.64  503.17  0.20  0.00  0.20  494.09  493.89
   BRIDG:BR    492.88    0.77  488.28  500.60  0.40  0.34  1.14  494.65  493.51
   RDWAY:RG  ****************  494.70  516.55  0.23******  0.25  495.06********
   APPRO:AS    493.93    0.55  489.91  516.33  0.43  0.20  0.25  495.28  495.03
  ER
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure BRISTH00270020, in Bristol, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BRISTH00270020

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)* 001

Town *(FIPS place code; I - 4; nnnnn)* 09025

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

Waterway *(I - 6)* LITTLE NOTCH BROOK

Road Name *(I - 7)*: -

Route Number C4027

Vicinity *(I - 9)* 0.2 MI TO JCT W CL3 TH43

Topographic Map South.Mountain

Hydrologic Unit Code: 2010002

Latitude *(I - 16; nnnn.n)* 44054

Longitude *(i - 17; nnnnn.n)* 73053

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10010300200103

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

Maximum span length *(I - 48; nnnn)* 0045

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000048

Average daily traffic, ADT *(I - 29; nnnnnn)* 000020

Deck Width *(I - 52; nn.n)* 120

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

Channel & Protection *(I - 61; n)* 5

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

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

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

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

Structure type *(I - 43; nnn)* 310

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 40.75

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

Vertical clearance from streambed (*nnn.n ft*) 9.84

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

Waterway of full opening (*nnn.n* ft^2) 400.9

Comments:

According to the structural inspection report dated 12/8/94, this structure is a steel pony-truss bridge with a new wood plank deck. The abutments and wingwalls are concrete, with a concrete footing showing on the left abutment and its upstream wingwall. There are wood plank backwalls on each abutment. The abutment concrete has a few fine cracks, small leaks, and small spalls. There is a laid-up stone extension on the upstream end of the left wingwall. Boulders were noted as having fallen out from the wall and the wall now appears somewhat unstable. The main channel flow is against the upstream end and upstream wingwall of the left abutment. There's a vegetation covered gravel bar **(Continued, page 33)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -

Q_{50} - Q_{100} - Q_{500} -

Record flood date *(MM / DD / YY)*: - / - / - Water surface elevation *(ft)*: -

Estimated Discharge *(cfs)*: - Velocity at Q - *(ft/s)*: -

Ice conditions *(Heavy, Moderate, Light)* : - Debris *(Heavy, Moderate, Light)*: -

The stage increases to maximum highwater elevation (*Rapidly, Not rapidly*): -

The stream response is (*Flashy, Not flashy*): -

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

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

The watershed storage area is: - (*1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site*)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	-	-	-	-
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

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

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

Are there other structures nearby? (*Yes, No, Unknown*): Y *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*): **0.4** Town: **Bristol** Year Built: **1931**

Highway No. : **VT 116** Structure No. : **6** Structure Type: **Concrete slab**

Clear span (*ft*): **20** Clear Height (*ft*): **-** Full Waterway (ft^2): **-**

Comments:

in front of the right abutment, blocking at least 1/3 of the flow. A second smaller stream flows in near the upstream end of the right abutment. The channel is scoured down 1 to 2 feet at the upstream end of the left abutment and the upstream left wingwall. The streambed consists of small boulders and gravel. There is some fill and brush against the right abutment.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **8.43** mi^2

Lake/pond/swamp area **0.022** mi^2

Watershed storage *(ST)* **0.26** %

Bridge site elevation **350** ft

Headwater elevation **1840** ft

Main channel length **5.16** mi

10% channel length elevation **430** ft

85% channel length elevation **1660** ft

Main channel slope *(S)* **317.83** ft / mi

Watershed Precipitation Data

Average site precipitation **--** in

Average headwater precipitation **--** in

Maximum 2yr-24hr precipitation event *(I24,2)* **--** in

Average seasonal snowfall *(Sn)* **--** ft

Bridge Plan Data

Are plans available? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:
NO BENCKMARK INFORMATION

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

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

If 1: Footing Thickness - Footing bottom elevation: -

If 2: Pile Type: - (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: -

If 3: Footing bottom elevation: -

Is boring information available? N *If no, type ctrl-n bi* Number of borings taken: -

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

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
NO PLANS ARE AVAILABLE.

Cross-sectional Data

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

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

Comments: **This cross section is the downstream face. The low chord elevation is from the survey log done for this report on 6/19/96. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 12/8/94. The sketch was done on 9/27/92.**

Station	0	12.8	28.2	40.8	-	-	-	-	-	-	-
Feature	RAB	-	-	LAB	-	-	-	-	-	-	-
Low cord elevation	499.3	499.7	500.1	500.6	-	-	-	-	-	-	-
Bed elevation	492.0	489.3	489.3	490.4	-	-	-	-	-	-	-
Low cord to bed length	7.3	10.4	10.8	10.2	-	-	-	-	-	-	-

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

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

Comments: -

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RLB Date: 06/17/97

Computerized by: RLB Date: 06/17/97

Reviewd by: EMB Date: 6/19/97

Structure Number BRISTH00270020

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. BOEHMLER Date *(MM/DD/YY)* 06 / 19 / 1996

2. Highway District Number 05 Mile marker 0000

County ADDISON (001) Town BRISTOL (09025)

Waterway *(I - 6)* LITTLE NOTCH BROOK Road Name -

Route Number TH 27 Hydrologic Unit Code: 2010002

3. Descriptive comments:

This bridge is located about 0.2 mile from the intersection of town highway 27 with State route 116.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 4 LBDS 6 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 1 *(**1**- pool; **2**- riffle)*

6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length 48 *(feet)* Span length 45 *(feet)* Bridge width 12 *(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)*

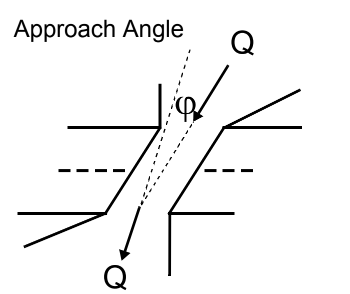
10. Embankment slope (*run / rise in feet / foot*):
US left 2.0:1 US right 1.8:1

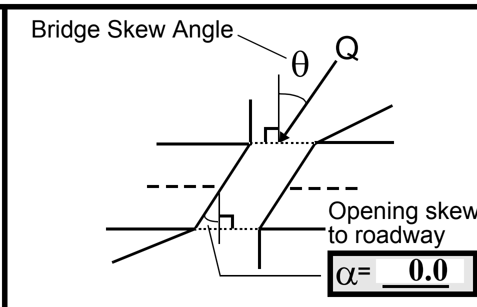
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	1	1
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	1	1	2	1

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*
*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: 20 16. Bridge skew: 15





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 0 feet US *(US, UB, DS)* to 45 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 80 feet DS

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

18. Bridge Type: **1A / 4**

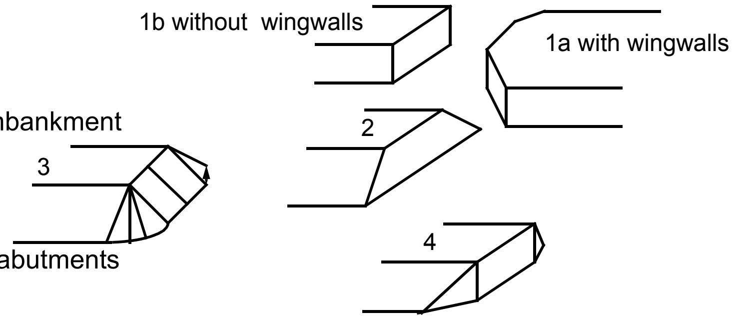
1a- Vertical abutments with wingwalls

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.)

Where pasture is indicated as the surface cover, there is also a few trees and brush on the road embankments. The DS left bank is a forest with a thick under growth of vines, shrubs and brush. The US and DS right overbanks areas are partially wetland.
The bridge dimensions shown on the previous page are the dimensions provided in the VTAOT database. During the assessment, the measured bridge length was 47 feet, span length was 45 feet, and the width was 12.5 feet.
The impact zone US is on the left bank and the upstream left wingwall.
There is a small tributary (anabranch) to this brook that enters just US of the bridge.

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
57.0	4.5			1.5	4	3	342	342	1	1

23. Bank width **10.0** 24. Channel width **25.0** 25. Thalweg depth **49.0** 29. Bed Material **243**

30 .Bank protection type: LB **5** RB **0** 31. Bank protection condition: LB **1** RB **-**

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

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

A stone-block wall protects the left bank US beginning at the US end of the US left wingwall and extending 45 feet US. The channel US is obscured by over-hanging tree branches.
The main channel of this brook impacts the US left bank with the thalweg on the left bank side.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 14 35. Mid-bar width: 12

36. Point bar extent: 36 feet US (US, UB) to 2 feet UB (US, UB, DS) positioned 20 %LB to 40 %RB

37. Material: 342

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

This point bar is an extension of the downstream end of the island between the main channel and the anabranch channel. An additional point bar is located from >200 feet to 85 feet US in the main channel with the mid-bar at 182 feet US and a width of 40 feet. It is positioned from 0% LB to 80% RB.

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

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

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

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

NO CUT BANKS

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

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

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

NO CHANNEL SCOUR

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

51. Confluence 1: Distance 0 52. Enters on RB (LB or RB) 53. Type 1 (1- perennial; 2- ephemeral)

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

54. Confluence comments (eg. confluence name):

The anabranch channel and the main channel merge at the US face of the bridge. During low flow periods the anabranch is a minor tributary stream.

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
18.0		0.5		1	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.):

324

The thalweg shifts from the left bank at the upstream face to the right bank at the downstream face of the bridge at this flow level. A small scour hole has developed under the bridge from the corner of the US left wingwall and the left abutment stretching across the channel under the bridge to the right side and ending about 10 feet DS. The scour is 22 feet long, 6 feet wide and 1 foot deep. It is positioned from 0% LB to 75% RB and centered at 6 feet under the bridge.

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? **3**___ *(Y or N)* Ice Blockage Potential **Y**____ *(**1**- Low; **2**- Moderate; **3**- High)*

70. Debris and Ice Comments:

3

During high flow, debris and ice potentially will accumulate on the point bar (island) just US of the bridge. Over-hanging tree branches US are stripped of their bark and some debris is caught among the trees. The reach in the immediate vicinity of the site is straight with small cut-banks and dense vegetation on the banks. Greater than 200 feet upstream the channel is sinuous.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		-	90	2	2	1	1	90.0
RABUT	1	15	90			2	0	43.0

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.):

-

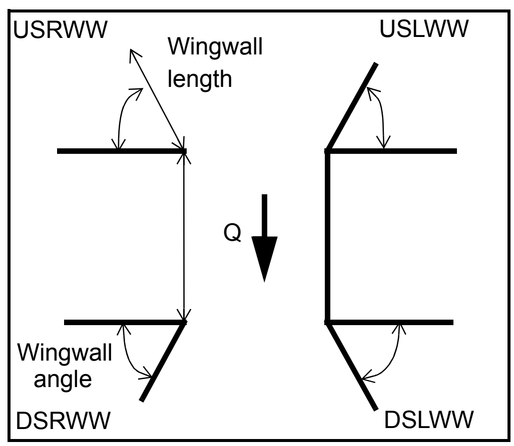
-

1

The channel is scoured from 0.5 to 1.0 foot at the US end of the left abutment.
Exposure of the left abutment footing ranges from 0.0 to 1.5 feet. The deepest exposure is at the US end of the left abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						43.0	
USRWW:	Y		1		2	1.5	
DSLWW:	0.5		1.0		Y	15.5	
DSRWW:	1		0		-	15.5	



*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	-	-	-	-	-
Condition	Y	-	1	-	-	-	-	-
Extent	1	-	0	0	0	0	0	-

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

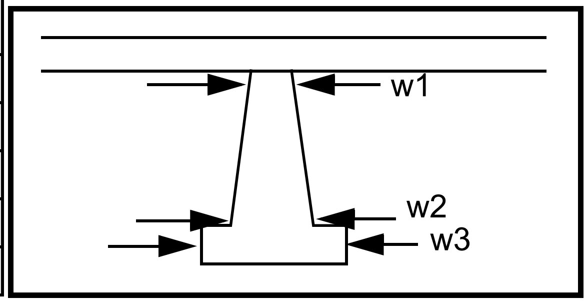
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
0
-
-
0
-
-

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				50.0	10.0	60.0
Pier 2				13.0	90.0	10.0
Pier 3		9.5	-	90.0	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e maxi-	is	the US	has a	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	mum	foun	end	depo	1- Solid pier, 2- column, 3- bent
88. Material	expo	d	of	sit of	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	sure	near	the	sand	1- Round; 2- Square; 3- Pointed
90. Inclined?	reco	the	left	and	Y- yes; N- no
91. Attack ∠ (BF)	rded	cor-	abut	grav	
92. Pushed	for	ner	ment	el	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	the	of	.	mate	
95. Cross-members	US	the	The	rial	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	left	wing	right	in	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	wing	wall	abut	front	
98. Exposure depth	wall	and	ment	of it.	

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

There is some larger stone fill buried beneath the sand and gravel. There is a pile of very loose fine gravel which now covers the DS left wingwall footing.

N

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	-	-	-	-	-

Bank width (BF) - Channel width (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.):

-
-
-
-
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-
-
-
-

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? N (Y or if N type ctrl-n cb) Where? O (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: 4

Scour dimensions: Length 2 Width 342 Depth: 342 Positioned 2 %LB to 2 %RB

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

324
0
0
-

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

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

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

Confluence comments (eg. confluence name):

and the thalweg at low flow meanders from side to side with a number of lateral bars in the reach. Some trees have fallen into the channel or are leaning toward the channel. Cut-banks are minor. There is thick tree,

F. Geomorphic Channel Assessment

107. Stage of reach evolution shr

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)*:

ub and brush growth on the left bank. On the right bank, there is a lot of brush and small trees. Large trees on the right bank are sporadic until about 100 ft DS where they dominate the bank vegetation.

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: BRISTH00270020 Town: Bristol
Road Number: TH 27 County: Addison
Stream: Little Notch Brook

Initials EMB Date: 7/15/97 Checked: RHF 7/21/97

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	1690	2350	1420
Main Channel Area, ft2	185	219	166
Left overbank area, ft2	2	17	0
Right overbank area, ft2	391	658	273
Top width main channel, ft	48	48	47
Top width L overbank, ft	11	30	0
Top width R overbank, ft	352	381	226
D50 of channel, ft	0.2166	0.2166	0.2166
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	3.9	4.6	3.5
y1, average depth, LOB, ft	0.2	0.6	ERR
y1, average depth, ROB, ft	1.1	1.7	1.2
Total conveyance, approach	25897	41102	20121
Conveyance, main channel	13489	17837	11275
Conveyance, LOB	16	275	0
Conveyance, ROB	12392	22990	8846
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	880.3	1019.8	795.7
Ql, discharge, LOB, cfs	1.0	15.7	0.0
Qr, discharge, ROB, cfs	808.7	1314.4	624.3
Vm, mean velocity MC, ft/s	4.8	4.7	4.8
Vl, mean velocity, LOB, ft/s	0.5	0.9	ERR
Vr, mean velocity, ROB, ft/s	2.1	2.0	2.3
Vc-m, crit. velocity, MC, ft/s	8.4	8.7	8.3
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

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	1623	1957	1420
Main channel area (DS), ft2	172	197	166
Main channel width (normal), ft	42.8	42.8	42.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	42.8	42.8	42.8
D90, ft	0.4496	0.4496	0.4496
D95, ft	0.5423	0.5423	0.5423
Dc, critical grain size, ft	0.4078	0.4270	0.3403
Pc, Decimal percent coarser than Dc	0.135	0.114	0.238
Depth to armoring, ft	7.84	9.98	3.28

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	1690	2350	1420
(Q) discharge thru bridge, cfs	1623	1957	1420
Main channel conveyance	13141	16140	12385
Total conveyance	13141	16140	12385
Q2, bridge MC discharge,cfs	1623	1957	1420
Main channel area, ft2	172	197	166
Main channel width (normal), ft	42.8	42.8	42.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	42.8	42.8	42.8
y_bridge (avg. depth at br.), ft	4.02	4.60	3.88
Dm, median (1.25*D50), ft	0.27075	0.27075	0.27075
y2, depth in contraction,ft	4.06	4.76	3.62
ys, scour depth (y2-ybridge), ft	**0.04**	**0.16**	**-0.26**

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	1690	2350	1420	1690	2350	1420
a', abut.length blocking flow, ft	43.3	62.2	32.1	324.3	354	267.7
Ae, area of blocked flow ft2	109.7	148.2	94.9	291	459.5	210.2
Qe, discharge blocked abut.,cfs	460.1	574.4	401.4	--	--	462.6
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.19	3.88	4.23	1.92	1.87	2.20
ya, depth of f/p flow, ft	2.53	2.38	2.96	0.90	1.30	0.79
--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	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.464	0.442	0.434	0.342	0.261	0.438
ys, scour depth, ft	**12.54**	**13.35**	**12.17**	11.82	13.17	11.62

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)	43.3	62.2	32.1	324.3	354	267.7
y1 (depth f/p flow, ft)	2.53	2.38	2.96	0.90	1.30	0.79
a'/y1	17.09	26.11	10.86	361.41	272.72	340.93
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.46	0.44	0.43	0.34	0.26	0.44
Ys w/ corr. factor K1/0.55:						
vertical	ERR	13.24	ERR	4.58	6.06	4.35
vertical w/ ww's	ERR	10.86	ERR	**3.76**	**4.97**	**3.57**
spill-through	ERR	7.28	ERR	2.52	3.33	2.39

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.83	0.82	0.77	0.83	0.82	0.77
y, depth of flow in bridge, ft	4.02	4.60	3.88	4.02	4.60	3.88
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	1.42	ERR	ERR	1.42
Fr>0.8 (vertical abut.)	1.60	1.82	ERR	1.60	1.82	ERR