LEVEL II SCOUR ANALYSIS FOR BRIDGE 31 (BRISTH00030031) on TOWN HIGHWAY 3, crossing the NEW HAVEN RIVER, BRISTOL, VERMONT

U.S. Geological Survey
Open-File Report 97-628

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

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By JAMES R. DEGNAN

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
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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 31 (BRISTH00030031) ON TOWN HIGHWAY 3, CROSSING THE NEW HAVEN RIVER, BRISTOL, VERMONT

***By* James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRISTH00030031 on Town Highway 3 crossing the New Haven River, 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, western Vermont. The 69.1-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 left overbank which has closely spaced houses with lawns.

In the study area, the New Haven River has an incised, sinuous channel with a slope of approximately 0.01 ft/ft, an average channel top width of 136 ft and an average bank height of 13 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 233 mm (0.765 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 20, 1996, indicated that the reach was stable.

The Town Highway 3 crossing of the New Haven River is a 105-ft-long, two-lane bridge consisting of a 101-ft-long pony truss span (Vermont Agency of Transportation, written communication, November 30, 1995). The opening length of the structure parallel to the bridge face is 98 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 60 degrees to the opening, with no opening-skew-to-roadway.

A local scour hole 3 ft deeper than the mean thalweg depth was observed near the exit cross section during the Level I assessment. Scour countermeasures included a stone wall on the upstream right bank, type-3 stone fill (less than 48 inches diameter) on the upstream and downstream left banks, and type-2 stone fill (less than 36 inches diameter) on the downstream end of the right abutment and on the downstream right bank. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

There was no contraction scour for any of the modelled flows. Abutment scour ranged from 12.7 to 16.4 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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

NORTH

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

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

LEVEL II SUMMARY

Structure Number BRISTH00030031 ***Stream*** New Haven River

County Addison ***Road*** TH3 ***District*** 5

Description of Bridge

Bridge length 105 ***ft*** ***Bridge width*** 21.6 ***ft*** ***Max span length*** 101 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** none

Stone fill on abutment? Yes, Right ***Date of inspection*** 6/20/96

Description of stone fill Type-2 (<36 in.) at the downstream end of the right abutment and the upstream end of the right wing wall. Type-3 (<48 in.) along the length of the upstream and downstream left wingwalls.

Brief description of piers/abutments Abutments and wingwalls are concrete.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 60

There is a severe channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	06/20/96	0	0
Level II	06/20/96	0	0

Potential for debris Moderate. There is some debris on the banks.The bridge has a moderate capture efficiency.

Describe any features near or at the bridge that may affect flow (include observation date) A local resident reports an ice jam in the winter of 95-96. Ice scaring on trees backs this up.

Description of the Geomorphic Setting

General topography The incised channel is located within a moderate relief valley and has little to no flood plains.

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

Date of inspection 06/20/96 Steep,

DS left: high channel bank to a terrace and steep valley wall

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

US left: Steep, high channel bank to a terrace and steep valley wall

US right: Steep channel bank and steep valley wall

Description of the Channel

Average top width 136 *ft* ***Average depth*** 13 *ft*

Predominant bed material Boulder / Cobble ***Bank material*** Boulder/Cobble

Sinuous but stable with non-alluvial channel boundaries and little to no flood plains.

06/20/96

Vegetative co Forested

DS left: Forested

DS right: Forested

US left: Forested

US right:

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

The assessment of 06/20/96 noted flow conditions up to bank-full level are influenced by boulders through-out the channel upstream.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 69.1 ***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:*** Downtown Bristol is above the right valley wall. However the drainage basin is rural.

Is there a USGS gage on the stream of interest? Yes

USGS gage description New Haven River at Brooksville, VT

USGS gage number 04282525

Gage drainage area 115 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 10,160 ***ft³/s*** ***Q500*** 14,400 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(67.5/69.1)exp 0.67] with bridge number 10 in Bristol. Bridge number 10 crosses the New Haven River upstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 10 is 67.5 square miles. The 500-year discharge was extrapolated graphically. These calculated discharges fell within a range defined by empirical flood frequency relationships (Benson,1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the right abutment (elev. 496.05 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the left abutment (elev. 499.33 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	-98	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	11	1	Road Grade section
APPRO	120	2	Modelled Approach section (Templated from APTEM)
APTEM	154	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 0.050 to 0.065, and overbank "n" values ranged from 0.060 to 0.090.

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 0.014 ft/ft which was the 100-yr water-surface profile slope downstream of the bridge in the Flood Insurance Study for the Village of Bristol (Federal Emergency Management Agency, 1986). This slope matched the channel slope on the topographic map (U. S. Geological Survey, 1963).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0399 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 497.0 ***ft***
Average low steel elevation 493.4 ***ft***

100-year discharge 10,160 ***ft^3/s***
Water-surface elevation in bridge opening 487.4 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 837 ***ft^2***
Average velocity in bridge opening 12.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.5 ***ft/s***

Water-surface elevation at Approach section with bridge 489.6
Water-surface elevation at Approach section without bridge 489.3
Amount of backwater caused by bridge 0.3 ***ft***

500-year discharge 14,400 ***ft^3/s***
Water-surface elevation in bridge opening 489.2 ***ft***
Road overtopping? No ***Discharge over road*** 0 ***ft^3/s***
Area of flow in bridge opening 1,014 ***ft^2***
Average velocity in bridge opening 14.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 17.0 ***/s***

Water-surface elevation at Approach section with bridge 491.7
Water-surface elevation at Approach section without bridge 491.6
Amount of backwater caused by bridge 0.1 ***ft***

Incipient overtopping discharge - ***ft^3/s***
Water-surface elevation in bridge opening - ***ft***
Area of flow in bridge opening - ***ft^2***
Average velocity in bridge opening - ***ft/s***
Maximum WSPRO tube velocity at bridge - ***ft/s***

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year, and 500-year, discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20, 20a). Contraction scour results were zero for each modelled discharge.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	--
Depth to armoring	9.5	17.3	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	12.7	15.7	--
Left abutment	15.3	16.4	--
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	2.8	3.9	--
Left abutment	2.8	3.9	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

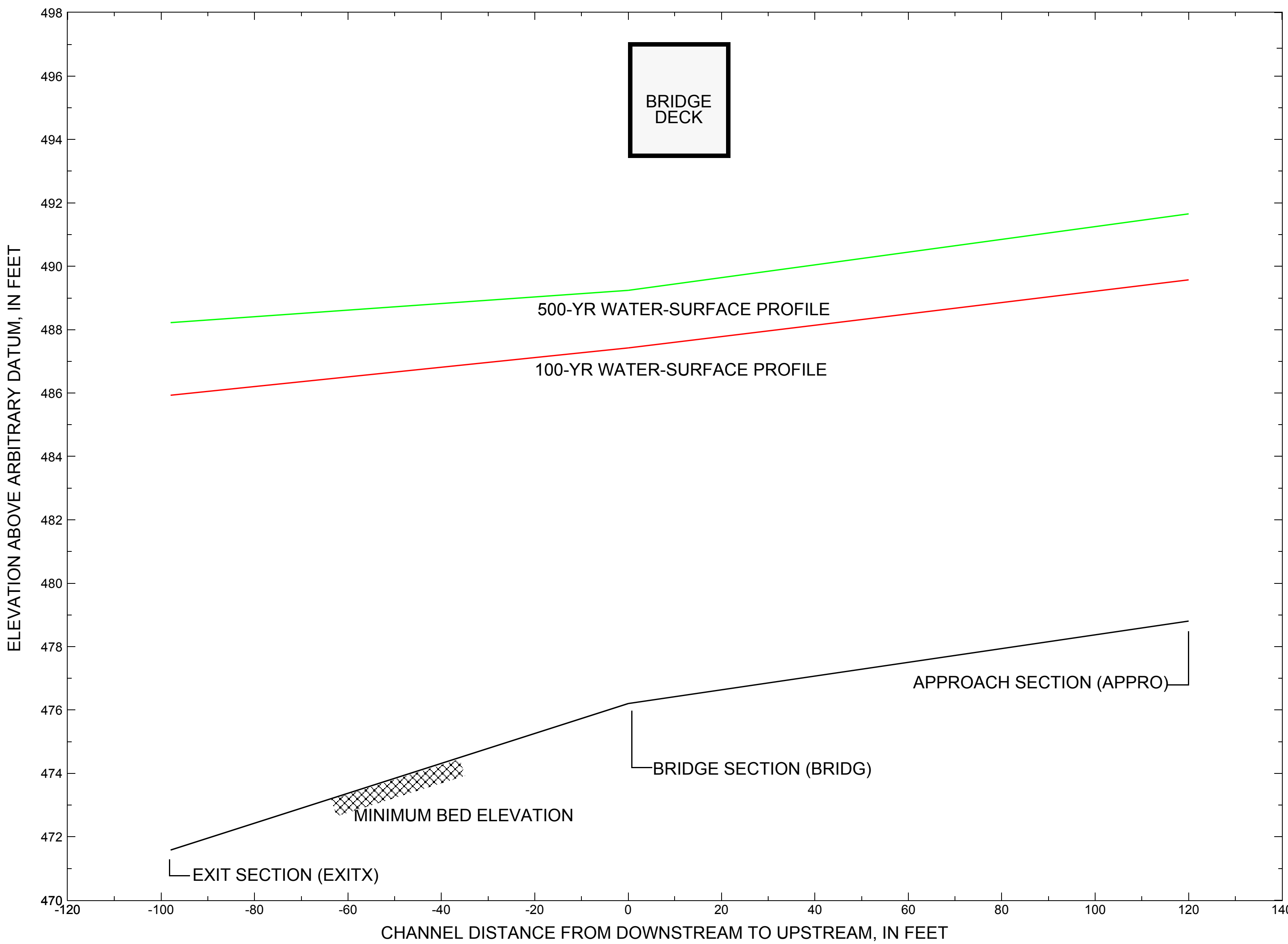

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRISTH00030031 on Town Highway 3, crossing the New Haven River, Bristol, Vermont.

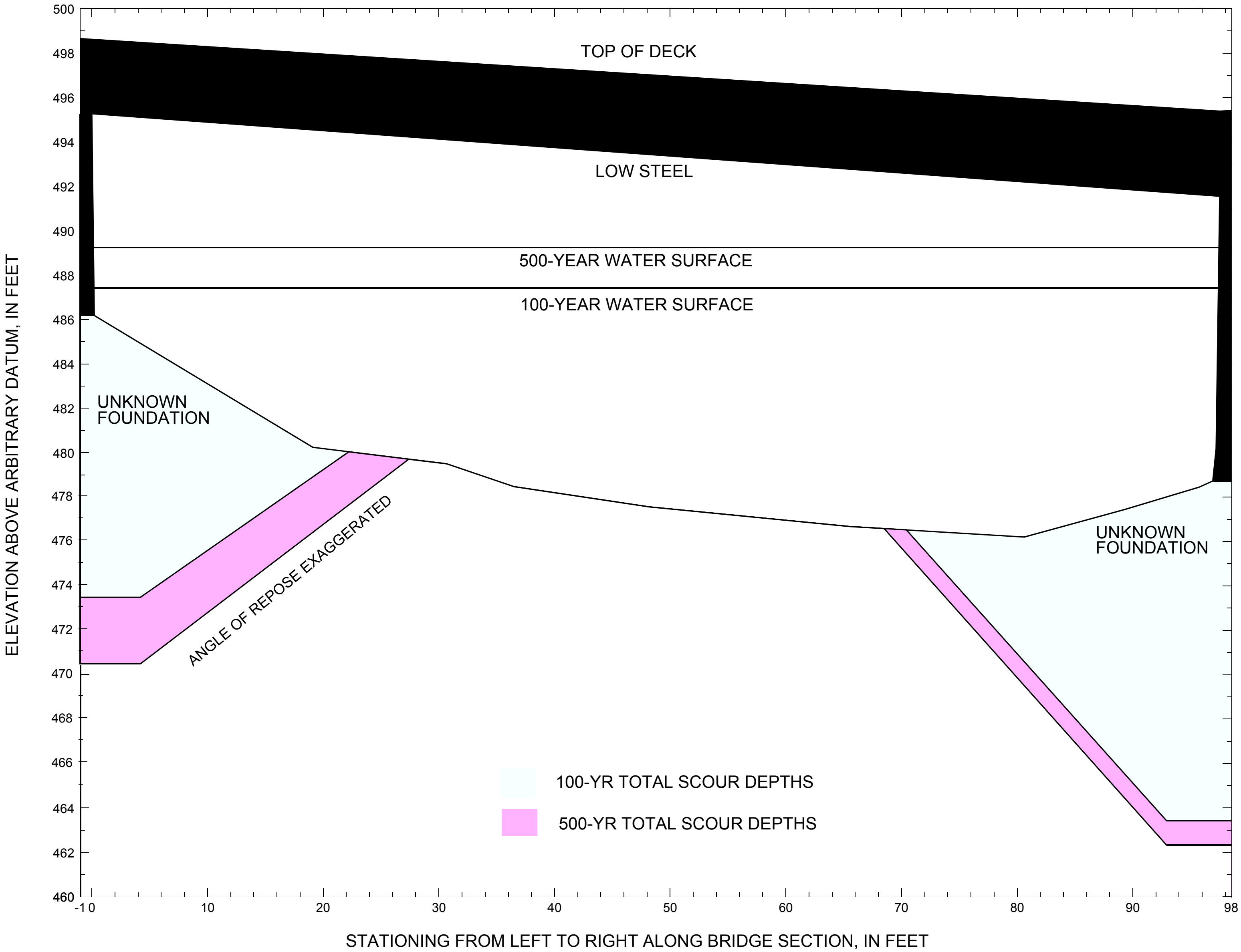

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRISTH00030031 on Town Highway 3, crossing the New Haven River, Bristol, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRISTH00030031 on Town Highway 3, crossing the New Haven River, 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 10,160 cubic-feet per second											
Left abutment	0.0	--	495.3	--	486.2	0.0	12.7	--	12.7	473.5	--
Right abutment	97.5	--	491.6	--	478.7	0.0	15.3	--	15.3	463.4	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure BRISTH00030031 on Town Highway 3, crossing the New Haven River, 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 14,400 cubic-feet per second											
Left abutment	0.0	--	495.3	--	486.2	0.0	15.7	--	15.7	470.5	--
Right abutment	97.5	--	491.6	--	478.7	0.0	16.4	--	16.4	462.3	--

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, Bristol, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File bris031.wsp
T2        Hydraulic analysis for structure BRISTH00030031   Date: 02-JUN-97
T3        TH003 crossing the New Haven River, in Bristol, Vermont            JRD
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          10160.0  14400.0
SK          0.014    0.014
*
XS   EXITX    -98           0.
GR         -140.4, 499.17    -99.0, 498.21    -57.0, 496.76     -8.9, 493.75
GR           30.0, 475.45     35.9, 474.84     40.6, 472.22     46.7, 472.23
GR           54.6, 471.58     60.3, 473.67     67.2, 475.29     71.3, 475.71
GR           94.2, 476.79     97.0, 483.89    138.1, 486.94    179.7, 488.09
GR          307.7, 501.94    430.3, 516.59    514.8, 528.16
*
N           0.070        0.065        0.090
SA                 -8.9         97.0
*
XS   FULLV      0  * * *   0.016
*
*              SRD     LSEL    XSSKEW
BR   BRIDG     0    493.41       0.0
GR            0.0, 495.27      0.2, 486.19     19.1, 480.24     30.7, 479.50
GR           36.5, 478.47     48.2, 477.56     65.5, 476.67     80.6, 476.20
GR           89.3, 477.44     95.7, 478.45     96.9, 478.73     97.2, 480.18
GR           97.5, 491.55      0.0, 495.27
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      30.8 * *     50.1      9.3
N           0.050
*
*              SRD    EMBWID   IPAVE
XR   RDWAY     11      21.6     1
GR         -106.2, 526.52    -88.8, 517.32    -71.0, 507.26    -44.0, 501.82
GR            0.0, 498.62    102.5, 495.39    150.5, 495.00    179.7, 495.81
GR          184.5, 496.01    277.7, 501.94    400.3, 516.59    484.8, 528.16
*
XT   APTEM    154           0.
GR          -82.4, 501.66    -74.7, 501.28    -40.0, 499.84    3.7, 485.20
GR            9.0, 484.79     25.0, 485.66     32.7, 484.86   40.2, 483.70
GR           52.6, 484.35     59.9, 483.22     64.8, 481.55   82.7, 480.35
GR           83.9, 480.31     95.8, 480.16     98.8, 482.96  105.2, 491.07
GR          123.5, 495.12    139.7, 495.81
*
AS   APPRO    120 * * * 0.0399
GT
BP        * * 207.26 71.43
N           0.060        0.060        0.070
SA                 -40.0        123.5
*
HP 1 BRIDG   487.42 1 487.42
HP 2 BRIDG   487.42 * * 10160
HP 1 APPRO   489.57 1 489.57
HP 2 APPRO   489.57 * * 10160
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File bris031.wsp
        Hydraulic analysis for structure BRISTH00030031   Date: 02-JUN-97
        TH003 crossing the New Haven River, in Bristol, Vermont           JRD
           *** RUN DATE & TIME: 06-09-97  13:27

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      837     97658     97    108                        13929
   487.42           837     97658     97    108  1.00      0     97    13929

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       487.42     0.2    97.4   836.7   97658.   10160.  12.14

X STA.         0.2       18.1       24.9       31.0       36.2       40.8
  A(I)            72.3       49.9       47.4       43.5       41.8
  V(I)            7.02      10.17      10.72      11.69      12.15

X STA.        40.8       44.9       48.8       52.6       56.2       59.7
  A(I)            39.1       38.3       37.3       37.4       35.8
  V(I)           12.99      13.26      13.62      13.58      14.20

X STA.        59.7       63.1       66.4       69.6       72.8       76.0
  A(I)            35.6       35.1       35.2       35.3       35.2
  V(I)           14.27      14.49      14.44      14.38      14.45

X STA.        76.0       79.2       82.4       86.1       90.3       97.4
  A(I)            35.6       35.6       39.8       42.4       64.2
  V(I)           14.25      14.28      12.78      11.98       7.92

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     120.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      816     70838    118    125                        12159
   489.57           816     70838    118    125  1.00    -12    105    12159

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     120.

         WSEL     LEW     REW    AREA        K        Q    VEL
       489.57   -13.4   105.1   816.3   70838.   10160.  12.45

X STA.       -13.4        6.8       15.2       23.9       32.5       39.1
  A(I)            67.2       50.0       48.8       48.2       43.1
  V(I)            7.56      10.15      10.41      10.54      11.79

X STA.        39.1       45.0       51.2       57.3       62.3       66.2
  A(I)            42.1       41.7       42.0       39.2       35.7
  V(I)           12.05      12.18      12.11      12.96      14.24

X STA.        66.2       69.8       73.1       76.4       79.5       82.6
  A(I)            34.3       33.0       32.8       32.1       32.2
  V(I)           14.81      15.39      15.47      15.85      15.78

X STA.        82.6       85.7       88.7       92.0       95.4      105.1
  A(I)            32.2       32.8       34.4       36.7       57.8
  V(I)           15.75      15.48      14.76      13.84       8.79
```

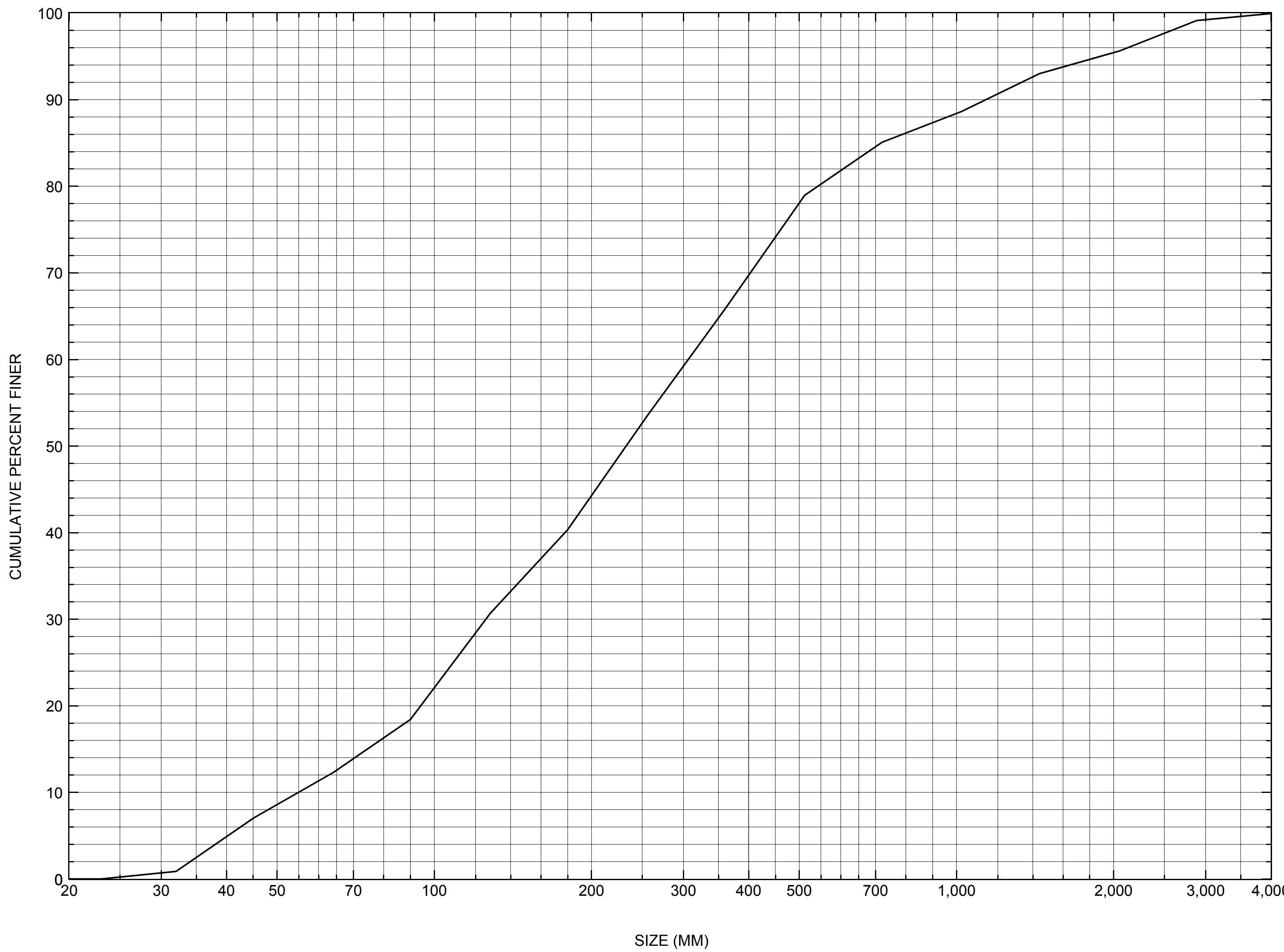
```
        U.S. Geological Survey WSPRO Input File bris031.wsp
        Hydraulic analysis for structure BRISTH00030031   Date: 02-JUN-97
        TH003 crossing the New Haven River, in Bristol, Vermont            JRD
           *** RUN DATE & TIME: 06-09-97  13:27

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1     1014    131526    97    112                         18567
   489.24          1014    131526    97    112  1.00      0     97     18567

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       489.24     0.1    97.4  1013.7  131526.   14400.  14.20

X STA.         0.1       15.7       22.6       28.4       33.7       38.3
  A(I)             85.1       60.8       54.4       52.2       49.3
  V(I)             8.46      11.84      13.23      13.79      14.62

X STA.        38.3       42.6       46.6       50.5       54.2       57.9
  A(I)             47.4       46.2       45.1       44.5       43.8
  V(I)            15.20      15.57      15.98      16.20      16.45

X STA.        57.9       61.4       64.8       68.3       71.6       74.9
  A(I)             42.9       43.5       43.0       42.2       42.7
  V(I)            16.80      16.55      16.74      17.04      16.87

X STA.        74.9       78.4       81.8       85.5       90.0       97.4
  A(I)             44.5       45.0       46.3       54.4       80.7
  V(I)            16.19      16.01      15.56      13.25       8.93

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     120.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2     1078    104046   134    141                         17377
   491.65          1078    104046   134    141  1.00    -19    114     17377

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     120.
         WSEL     LEW     REW    AREA        K        Q    VEL
       491.65   -19.6   114.0  1077.9  104046.   14400.  13.36
X STA.       -19.6        3.8       11.5       18.7       26.3       33.5
  A(I)             91.8       61.6       56.9       57.6       55.9
  V(I)             7.84      11.68      12.65      12.51      12.87

X STA.        33.5       39.6       45.0       50.8       56.4       61.4
  A(I)             53.4       50.1       51.2       50.0       48.1
  V(I)            13.49      14.37      14.06      14.40      14.97

X STA.        61.4       65.6       69.4       73.0       76.6       80.1
  A(I)             46.0       44.3       43.2       43.2       43.3
  V(I)            15.66      16.24      16.67      16.68      16.62

X STA.        80.1       83.5       87.2       90.9       95.1      114.0
  A(I)             43.6       46.1       47.0       53.9       90.6
  V(I)            16.52      15.62      15.32      13.35       7.94
```

```
        U.S. Geological Survey WSPRO Input File bris031.wsp
        Hydraulic analysis for structure BRISTH00030031   Date: 02-JUN-97
        TH003 crossing the New Haven River, in Bristol, Vermont           JRD
           *** RUN DATE & TIME: 06-09-97  13:27

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

 EXITX:XS   ******      8      896  2.10 *****  488.03  483.36   10160  485.93
        -97 ******    125    85794  1.05 ***** *******    0.74   11.34

 FULLV:FV       98      8      874  2.19  1.42  489.49 *******   10160  487.30
          0     98    122    83089  1.04  0.05    0.00    0.74   11.63

          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.88     489.33     488.74

  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   486.80     500.30    0.50

  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   486.80     500.30     488.74

 APPRO:AS      120    -12      788  2.59  2.22  491.91  488.74   10160  489.33
        120    120    105    67113  1.00  0.20    0.00    0.88   12.90

          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

             <<<<<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       98      0      837  2.29  1.69  489.71  485.76   10160  487.42
          0     98     97    97731  1.00  0.00    0.00    0.73   12.14

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   1.  1.000 ******  493.41 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL

    RDWAY:RG      11.         <<<<<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       89    -12      817  2.41  1.94  491.98  488.74   10160  489.57
        120     93    105    70911  1.00  0.33    0.01    0.84   12.44

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.173  0.013   69831.     7.   104.   487.54

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

   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
    EXITX:XS     -98.     8.   125.  10160.   85794.     896.   11.34  485.93
    FULLV:FV       0.     8.   122.  10160.   83089.     874.   11.63  487.30
    BRIDG:BR       0.     0.    97.  10160.   97731.     837.   12.14  487.42
    RDWAY:RG      11.**************       0.******************     1.00********
    APPRO:AS     120.   -13.   105.  10160.   70911.     817.   12.44  489.57

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS       7.   104.   69831.

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS    483.36    0.74  471.58  528.16************  2.10  488.03  485.93
    FULLV:FV  ********    0.75  473.15  529.73  1.42  0.05  2.19  489.49  487.30
    BRIDG:BR    485.76    0.73  476.20  495.27  1.69  0.00  2.29  489.71  487.42
    RDWAY:RG ***************  495.00  528.16**********************************
    APPRO:AS    488.74    0.84  478.80  500.30  1.94  0.33  2.41  491.98  489.57
```

```
        U.S. Geological Survey WSPRO Input File bris031.wsp
        Hydraulic analysis for structure BRISTH00030031   Date: 02-JUN-97
        TH003 crossing the New Haven River, in Bristol, Vermont            JRD
           *** RUN DATE & TIME: 06-09-97  13:27

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

EXITX:XS   ******      3     1223  2.55 *****  490.77  485.70   14400  488.22
       -97 ******    181   121584  1.18 ***** *******    0.86   11.77

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.88     489.58     487.27

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   487.72     529.73    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   487.72     529.73     487.27

FULLV:FV       98      3     1186  2.68  1.42  492.25  487.27   14400  489.58
         0     98    177   117758  1.17  0.06    0.00    0.88   12.15
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.84     491.56     490.51

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   489.08     500.30    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   489.08     500.30     490.51

APPRO:AS      120    -18     1067  2.83  2.06  494.40  490.51   14400  491.57
       120    120    114   102588  1.00  0.08    0.01    0.84   13.50
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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       98      0     1014  3.14  1.56  492.38  487.63   14400  489.24
         0     98     97   131485  1.00  0.03   -0.02    0.78   14.21

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  493.41 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<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       89    -19     1077  2.78  1.69  494.42  490.51   14400  491.65
       120     91    114   103966  1.00  0.37    0.00    0.83   13.37

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.268  0.000  106861.     4.   101.   489.75
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -98.     3.   181.  14400.  121584.    1223.   11.77  488.22
   FULLV:FV       0.     3.   177.  14400.  117758.    1186.   12.15  489.58
   BRIDG:BR       0.     0.    97.  14400.  131485.    1014.   14.21  489.24
   RDWAY:RG      11.**************      0.******************    1.00********
   APPRO:AS     120.   -20.   114.  14400.  103966.    1077.   13.37  491.65

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       4.   101.  106861.

  SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    485.70    0.86  471.58  528.16************  2.55  490.77  488.22
   FULLV:FV    487.27    0.88  473.15  529.73  1.42  0.06  2.68  492.25  489.58
   BRIDG:BR    487.63    0.78  476.20  495.27  1.56  0.03  3.14  492.38  489.24
   RDWAY:RG ***************  495.00  528.16**********************************
   APPRO:AS    490.51    0.83  478.80  500.30  1.69  0.37  2.78  494.42  491.65
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for one pebble count transect at the approach cross-section for structure BRISTH00030031, in Bristol, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number **BRISTH00030031**

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)* **08950**

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

Waterway *(I - 6)* **NEW HAVEN RIVER**

Road Name *(I - 7)*: **RIVER STREET**

Route Number **C2003**

Vicinity *(I - 9)* **0.2 MI TO JCT W CL1 TH1**

Topographic Map **Bristol**

Hydrologic Unit Code: **02010002**

Latitude *(I - 16; nnnn.n)* **44080**

Longitude *(i - 17; nnnnn.n)* **73046**

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* **20010300310103**

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

Maximum span length *(I - 48; nnnn)* **0101**

Year built *(I - 27; YYYY)* **1928**

Structure length *(I - 49; nnnnnn)* **000105**

Average daily traffic, ADT *(I - 29; nnnnnn)* **001000**

Deck Width *(I - 52; nn.n)* **216**

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*) **125.8**

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

Vertical clearance from streambed (*nnn.n ft*) **11.46**

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

Waterway of full opening (*nnn.n ft²*) **1442**

Comments:

According to the structural inspection report dated 12/8/94, the deck of the pony truss bridge is concrete with an asphalt overlay. The abutments, wingwalls, and backwalls are concrete with fine cracks and leaks and random small spalls overall. Areas of deep spalling are present on the downstream end and along the bottom of upstream right wingwall. Large spalled areas on both ends of the left abutment have been patched. Some boulder sized dumped stone protection is present in front of each abutment, around their ends, and along the channel embankments, large boulders are also in the US and DS channel. The channel flows in at a 90 degree angle near the upstream end of the right abutment.

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: -

Terrain character: -

Stream character & type: -
-

Streambed material: -

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*): - Frequency: -

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft^3/ sec*): -

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **69.12** mi^2 Lake/pond/swamp area **0.07** mi^2

Watershed storage *(ST)* **0.1** %

Bridge site elevation **480** ft Headwater elevation **3780** ft

Main channel length **14.6** mi

10% channel length elevation **570** ft 85% channel length elevation **1970** ft

Main channel slope *(S)* **127.85** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in

Maximum 2yr-24hr precipitation event *(I24,2)* **2.35** in

Average seasonal snowfall *(Sn)* **6.67** 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:

-

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? - *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:

-

Comments:

-

Cross-sectional Data

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

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

Comments: **It is not known whether this cross section is the upstream or downstream face. The low cord to bed length elevations are from the sketch attached to a bridge inspection report dated 12/8/94. The sketch was done on 10/2/92. There is no accurate low cord elevations available.**

Station	0	14.2	30.9	47.6	64.3	81	95	-	-	-	-
Feature	ABUT	-	-	-	-	-	ABUT	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	7.7	13.1	15.4	17.0	17.7	16.1	12.8	-	-	-	-

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: RB Date: 11/07/96
Computerized by: RB Date: 11/07/96
Reviewd by: JD Date: 06/16/97

Structure Number BRISTH00030031

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J . DEGNAN Date *(MM/DD/YY)* 06 / 20 / 1996

2. Highway District Number 05 Mile marker 0000

County 001 ADDISON Town BRISTOL 08950

Waterway *(I - 6)* NEW HAVEN RIVER Road Name RIVER STREET

Route Number C2003 Hydrologic Unit Code: 02010002

3. Descriptive comments:

This is a pony truss bridge with a concrete deck and an asphalt overlay located 0.2 miles from the junction with CL1 TH1.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 2 RBDS 6 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US 2 UB 2 DS 2 *(**1**- pool; **2**- riffle)*

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

7. Bridge length 101 *(feet)* Span length 105 *(feet)* Bridge width 21.6 *(feet)*

Road approach to bridge:

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

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

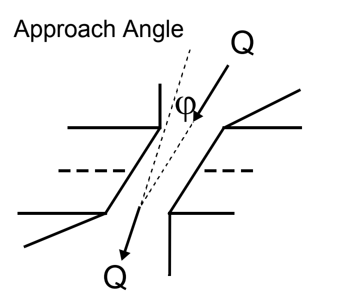
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

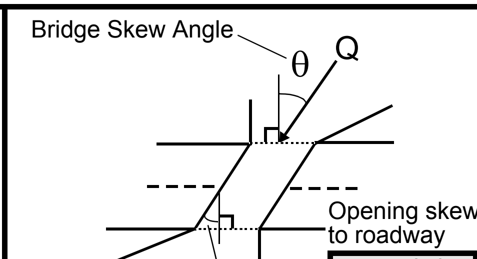
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	2	1	2	1
LBDS	2	1	2	10

*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: 60





α= 0.0

17. Channel impact zone 1: Exist? LB *(Y or N)*
Where? 3 *(LB, RB)* Severity 110
Range? US feet 20 *(US, UB, DS)* to DS feet N

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

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

18. Bridge Type: **1a**

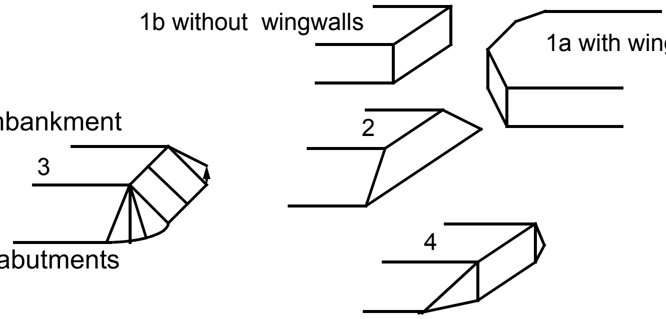
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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.)

7. The values are from the VTAOT files. The measured bridge length is 103 ft.
11. The DS right road approach protection is dumped stone close to the abutment and a stone wall further away from the structure. The DS left road approach protection is a combination of bank and road embankment protection.

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
134.5	14.5			12.0	3	3	543	542	2	1

23. Bank width **15.0** 24. Channel width **25.0** 25. Thalweg depth **165.5** 29. Bed Material **543**

30 .Bank protection type: LB **3** RB **5** 31. Bank protection condition: LB **2** 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.):

30. The right bank protection extends from 150 ft US to 0 ft US and is a stone wall. The dumped stone left bank protection extends from 100 ft US to 0 ft US and serves as the road embankment protection also. There is log cribbing on the stream bed at 200 ft US. There is a broken stone wall 15 ft high on the right bank at 220 ft. US.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **100** 35. Mid-bar width: **40**

36. Point bar extent: **40** feet **US** *(US, UB)* to **140** feet **US** *(US, UB, DS)* positioned **0** %LB to **50** %RB

37. Material: **453**

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

This point bar is on the outside corner of the stream. Beyond 2 bridge lengths US there are more alternating gravel and boulder bars on both banks.

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
There is some local scouring around boulders.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
95.0		**3.5**		**2**	**7**	**7**	**-**

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

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

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

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

543
-

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

70. Debris and Ice Comments:

2

There is ice scaring on the trees and debris on the banks upstream of the structure. A local resident reported an ice jam in the winter of 1995-1996.

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		**80**	**90**	**2**	**0**	**-**	**-**	**90.0**
RABUT	**1**	**-**	**90**			**2**	**0**	**97.5**

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

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

-

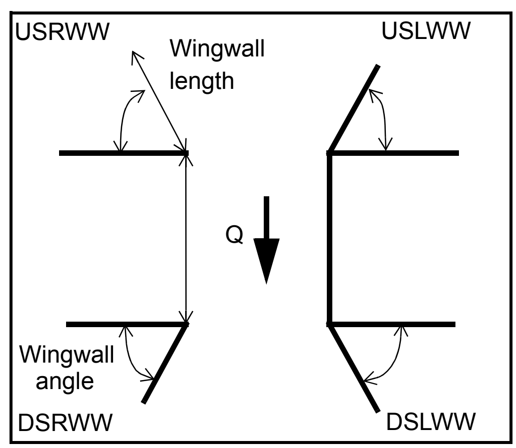
-

1

The concrete is spalling on the US right abutment corner. The water is running along the right abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**97.5**	
USRWW:	**Y**		**1**		**0**	**3.5**	
DSLWW:	**-**		**-**		**Y**	**20.0**	
DSRWW:	**1**		**0**		**-**	**25.0**	



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

82. **Bank / Bridge Protection**:

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

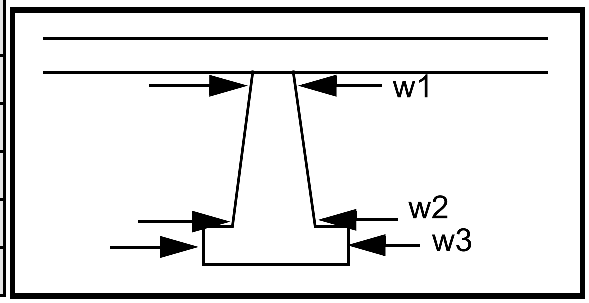
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
3
1
1
2
2
1

Piers:

84. Are there piers? **A** (*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			**5.0**	**95.0**	**15.0**	**20.0**
Pier 2				**60.0**	**17.0**	**90.0**
Pier 3	**7.0**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



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

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

E. Downstream Channel Assessment

100.

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

Bank width (BF) -_____ Channel width (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.):
-
-
-
-
-
-
NO PIERS

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

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

105. Drop structure comments (eg. downstream scour depth):
3
543
543
2
1
543

106. Point/Side bar present? **3** (Y or N. if N type ctrl-n pb) Mid-bar distance: **2** Mid-bar width: **1**

Point bar extent: **2** feet **Th** (US, UB, DS) to **e** feet **rig** (US, UB, DS) positioned **ht** %LB to **ba** %RB

Material: **nk**

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

protection is dumped stone extending from 0 ft DS to 100 ft DS, then it takes the form of a stone wall from 100 ft DS to 300 ft DS. The left bank protection is dumped stone from 0 ft DS to 100 ft DS.

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

Cut bank extent: _____ feet ____ (US, UB, DS) to _____ feet ____ (US, UB, DS)

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

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

N

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

Scour dimensions: Length **DRO** Width **P** Depth: **STR** Positioned **UC** %LB to **TU** %RB

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

RE

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

Confluence 1: Distance **Y** Enters on **100** (LB or RB) Type **40** (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance **60** Enters on **DS** (LB or RB) Type **140** (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

DS
55

F. Geomorphic Channel Assessment

107. Stage of reach evolution **100**

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)*:

543

There is an additional point bar out of the 2 bridge length range, it is large and on the inside of a corner of the stream. The mid-bar distance is 430 ft. DS and the width is 45 ft. The point bar extent is 230 ft. DS to 630 ft. DS, positioned 0% LB to 80% RB. It is composed of cobble, boulders and gravel.

N

-

-

-

-

-

-

-

109. G. Plan View Sketch

- N

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: BRISTH00030031 Town: Bristol
Road Number: 0 County: 1
Stream: New Haven River

Initials JRD Date: 6/10/97 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	10160	14400	0
Main Channel Area, ft2	816	1078	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	118	134	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.765	0.765	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.9	8.0	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	70838	104046	0
Conveyance, main channel	70838	104046	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	10160.0	14400.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	12.5	13.4	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	14.2	14.5	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	10160	14400	0
(Q) discharge thru bridge, cfs	10160	14400	0
Main channel conveyance	97658	131526	0
Total conveyance	97658	131526	0
Q2, bridge MC discharge,cfs	10160	14400	ERR
Main channel area, ft2	837	1014	0
Main channel width (normal), ft	97.2	97.3	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	97.2	97.3	0
y_bridge (avg. depth at br.), ft	8.61	10.42	ERR
Dm, median (1.25*D50), ft	0.95625	0.95625	0
y2, depth in contraction,ft	6.74	9.09	ERR
ys, scour depth (y2-ybridge), ft	-1.87	-1.34	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	10160	14400	N/A
Main channel area (DS), ft2	837	1014	0
Main channel width (normal), ft	97.2	97.3	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	97.2	97.3	0.0
D90, ft	3.7369	3.7369	0.0000
D95, ft	6.1937	6.1937	0.0000
Dc, critical grain size, ft	1.3334	1.6332	ERR
Pc, Decimal percent coarser than Dc	0.297	0.221	0.000
Depth to armoring, ft	9.47	17.27	ERR

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	10160	14400	0	10160	14400	0
a', abut.length blocking flow, ft	13.6	19.7	0	7.7	16.6	0
Ae, area of blocked flow ft2	45.2	77.3	0	45.88	79.57	0
Qe, discharge blocked abut.,cfs	342.02	606.15	0	403.26	632.38	0

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

Characteristic	Left 100 yr Q	500 yr Q	Other Q	Right 100 yr Q	500 yr Q	Other Q
Ve, (Qe/Ae), ft/s	7.57	7.84	ERR	8.79	7.95	ERR
ya, depth of f/p flow, ft	3.32	3.92	ERR	5.96	4.79	ERR
--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	0.731	0.698	ERR	0.635	0.640	ERR
ys, scour depth, ft	12.69	15.66	N/A	15.34	16.38	N/A

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	13.6	19.7	0	7.7	16.6	0
y1 (depth f/p flow, ft)	3.32	3.92	ERR	5.96	4.79	ERR
a'/y1	4.09	5.02	ERR	1.29	3.46	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.73	0.70	N/A	0.63	0.64	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.73	0.78	0	0.73	0.78	0
y, depth of flow in bridge, ft	8.61	10.42	0.00	8.61	10.42	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	2.84	3.92	0.00	2.84	3.92	0.00
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	2.47	3.42	0.00	2.47	3.42	0.00
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR