LEVEL II SCOUR ANALYSIS FOR BRIDGE 2 (STAMVT01000002) on STATE ROUTE 100, crossing ROARING BROOK, STAMFORD, VERMONT

U.S. Geological Survey
Open-File Report 97-211

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

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By ERICK M. BOEHMLER and ROBERT E. HAMMOND

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information
write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 2 (STAMVT01000002) ON STATE ROUTE 100, CROSSING ROARING BROOK, STAMFORD, VERMONT

By **Erick M. Boehmler and Robert E. Hammond**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure STAMVT01000002 on State Route 100 crossing Roaring Brook, Stamford, 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 Southwestern Vermont. The 8.26-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of houses with grass lawns, and trees on the right overbank areas upstream and downstream of the bridge. The left overbank areas upstream and downstream of the bridge are covered with trees and brush.

In the study area, Roaring Brook has a straight channel with a slope of approximately 0.02 ft/ft, an average channel top width of 56 ft and an average bank height of 5 ft. The channel bed materials range from gravel to boulders with a median grain size (D_{50}) of 53.7 mm (0.176 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 31, 1996, indicated that the reach was aggraded.

The State Route 100 crossing of Roaring Brook is a 44-ft-long, two-lane bridge consisting of one 42-foot steel-beam span (Vermont Agency of Transportation, written communication, September 28, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 5 degrees to the opening and the opening-skew-to-roadway is 5 degrees.

Scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) on the upstream banks and wingwalls, type-3 (less than 48 inches diameter) on the downstream wingwalls, and artificial levees made from a variety of materials on the downstream banks. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 0.8 feet. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 4.2 to 9.3 feet. The worst-case abutment scour occurred at the 500-year discharge at the left abutment. 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 STAMVT01000002 ***Stream*** Roaring Brook

County Bennington ***Road*** VT 100 ***District*** 1

Description of Bridge

Bridge length 44 ***ft*** ***Bridge width*** 40.0 ***ft*** ***Max span length*** 42 ***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*** 7/31/96

Description of stone fill Type-2 on the upstream wingwalls and type-3 on the downstream wingwalls.

Abutments and wingwalls are concrete.

Is bridge skewed to flood flow according to No ***survey?*** Yes ***Angle*** 5

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	7/31/96	0	0
Level II	7/31/96	0	0

Potential for debris Moderate. There are trees on the immediate banks, which are stable at this site.

Describe any features near or at the bridge that may affect flow (include observation date) Artificial levees were present on 7/31/96 on the banks through the reach to retain flow in the channel up to a foot and a half above the native bank level.

Description of the Geomorphic Setting

General topography The channel has narrow, flat to slightly irregular flood plains with no distinctive valley.

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

Date of inspection 7/31/96

DS left: Moderately sloping channel bank to a narrow, irregular flood plain.

DS right: Steep channel bank to a wide flood plain.

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

US right: Moderately sloping channel bank to a narrow, irregular flood plain.

Description of the Channel

Average top width 56 ***ft*** ***Average depth*** 5 ***ft***

Predominant bed material Gravel to Boulders ***Bank material*** Boulders

Channelized and straight with semi-alluvial channel boundaries.

Vegetative co 7/31/96

DS left: Trees and brush

DS right: Trees and brush

US left: Trees and brush

US right: Trees and brush.

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 7/31/96 noted artificial levees on the banks through the reach, which prevent flow from spilling out on the flood plain for up to 1.5 feet higher than the native bank level.

Hydrology

Drainage area 8.26 ***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***: There are a couple houses on the right overbank areas upstream and downstream of the site.

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,450 ***ft³/s*** ***Q500*** 3,400 ***ft³/s***

The 100- and 500-year discharges are based on discharge frequency curves obtained from the VTAOT database and computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Laraway, unpublished draft, 1972; Johnson and Tasker, 1974; Potter, 1957a&b; Talbot, 1887). Each curve was extrapolated to the 500-year event. Since the VTAOT database curve was central to the others, the curve was selected for the hydraulic analyses at this site.

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

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

Datum tie between USGS survey and VTAOT plans Add 634.9 feet to the USGS arbitrary survey datum to obtain the VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a metal VTAOT survey marker disk set in the top of the downstream end of the right abutment (elev. 500.26 ft, arbitrary survey datum). RM3 is a chiseled "V" in the top of the upstream end of the right abutment (elev. 500.31 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	-43	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	22	1	Road Grade section
APPRO	83	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.045 to 0.065, and overbank "n" values ranged from 0.055 to 0.075.

For the 100- and 500-year events, WSPRO assumes critical depth as the starting water surface. Normal depth at the exit section was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). For the 100- and 500- year events, normal depth was determined to be supercritical but within 0.4 feet of critical depth. Normal depth at the exit section was assumed as the starting water surface for the incipient overtopping discharge model. This depth also was computed by use of the slope-conveyance method and the same slope as used for the 100- and 500-year discharges.

The approach section (APPRO) was surveyed at 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 499.9 ***ft***
Average low steel elevation 496.3 ***ft***

100-year discharge 2,450 ***ft³/s***
Water-surface elevation in bridge opening 496.3 ***ft***
Road overtopping? Yes ***Discharge over road*** 778 ***ft³/s***
Area of flow in bridge opening 190 ***ft²***
Average velocity in bridge opening 8.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.1 ***ft/s***

Water-surface elevation at Approach section with bridge 498.4
Water-surface elevation at Approach section without bridge 498.1
Amount of backwater caused by bridge 0.3 ***ft***

500-year discharge 3,400 ***ft³/s***
Water-surface elevation in bridge opening 496.5 ***ft***
Road overtopping? Yes ***Discharge over road*** 1770 ***ft³/s***
Area of flow in bridge opening 191 ***ft²***
Average velocity in bridge opening 8.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.9 ***ft/s***

Water-surface elevation at Approach section with bridge 498.9
Water-surface elevation at Approach section without bridge 498.4
Amount of backwater caused by bridge 0.5

Incipient overtopping discharge 1,300 ***ft³/s***
Water-surface elevation in bridge opening 496.5 ***ft***
Area of flow in bridge opening 191 ***ft²***
Average velocity in bridge opening 6.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 7.9 ***ft/s***

Water-surface elevation at Approach section with bridge 497.5
Water-surface elevation at Approach section without bridge 496.4
Amount of backwater caused by bridge 1.1 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

All of the discharges modeled resulted in orifice flow conditions at the bridge. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour depths were computed by use of the Chang equation (Richardson and others, 1995, P. 145-146). Results from the Chang equation are shown in Figure 8 and tables 1 and 2. The results of Laursen's clear-water contraction scour equation (Richardson, 1995, p. 32, equation 20) also were computed and are provided in appendix F. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.8	0.6	0.0
Depth to armoring	5.3	4.4	1.0
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	8.3	9.3	7.4
Right abutment	8.0	6.1	4.2
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	1.5	1.4	0.8
Right abutment	1.5	1.4	0.8
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

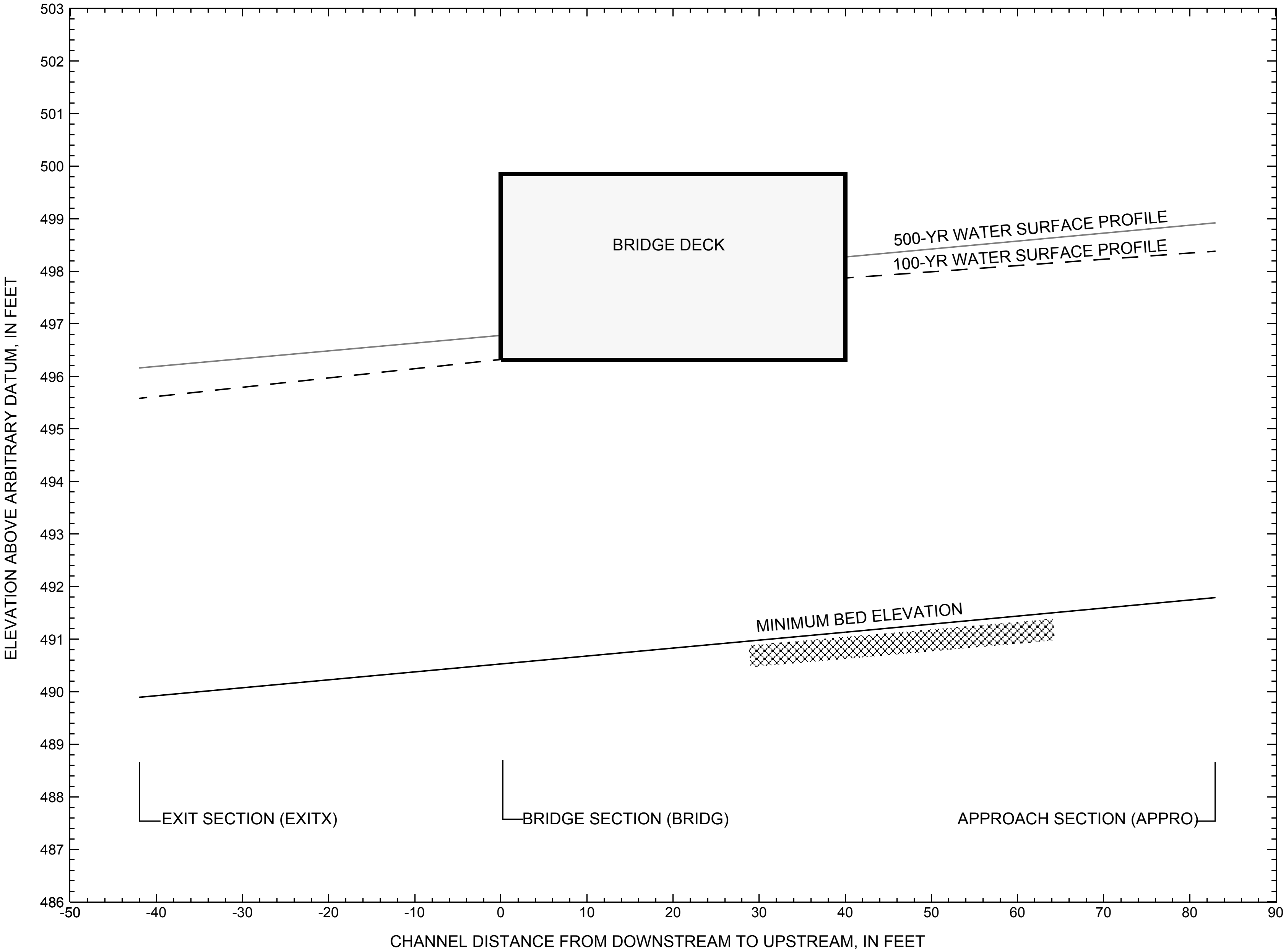

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure STAMVT01000002 on State Route 100, crossing Roaring Brook, Stamford, Vermont.

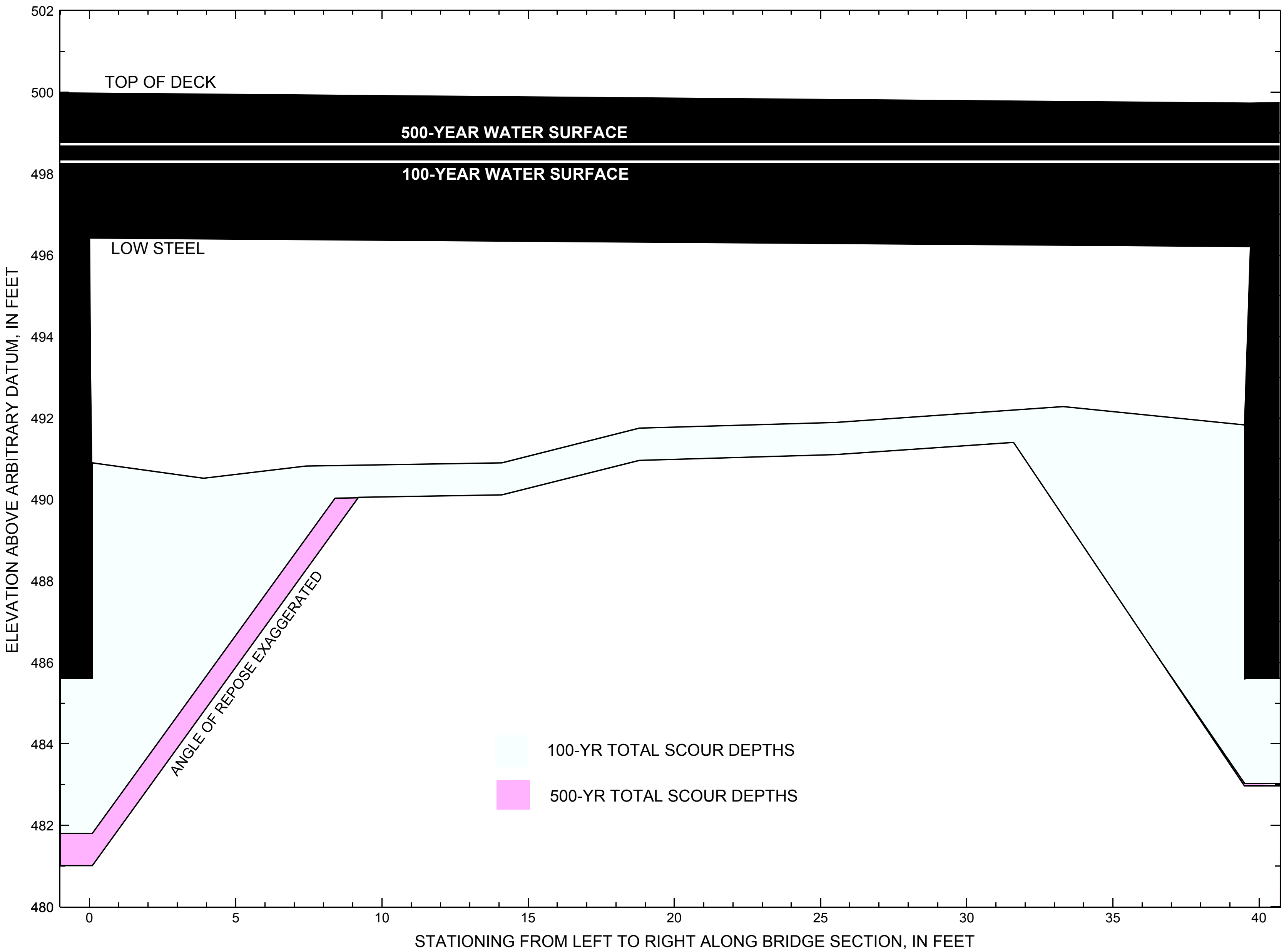

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure STAMVT01000002 on State Route 100, crossing Roaring Brook, Stamford, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure STAMVT01000002 on State Route 100, crossing Roaring Brook, Stamford, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 2,450 cubic-feet per second											
Left abutment	0.0	1131.2	496.5	485.6	490.9	0.8	8.3	--	9.1	481.8	-3.8
Right abutment	39.7	1130.8	496.2	485.6	491.8	0.8	8.0	--	8.8	483.0	-2.6

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 STAMVT01000002 on State Route 100, crossing Roaring Brook, Stamford, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 3,400 cubic-feet per second											
Left abutment	0.0	1131.2	496.5	485.6	490.9	0.6	9.3	--	9.9	481.0	-4.6
Right abutment	39.7	1130.8	496.2	485.6	491.8	0.6	6.1	--	6.7	485.1	-0.5

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, 1954, Stamford, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photography 1942 and 1951; Contour interval, 20 feet; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File stam002.wsp
T2        Hydraulic analysis for structure STAMVT01000002   Date: 06-JAN-97
T3        State Route 100 Crossing of Roaring Brook, Stamford, VT           EMB
*
J1         *  *  0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2450.0   3400.0   1300.0
SK          0.0241   0.0241   0.0241
WS          495.58   496.16   494.40
*
XS   EXITX    -43
GR         -643.0, 499.47   -414.8, 496.53   -323.9, 496.79   -264.8, 497.85
GR          -25.2, 495.23     -8.1, 495.74      0.0, 490.90      4.0, 490.12
GR            8.5, 489.89     12.1, 490.34     17.4, 490.87     21.5, 491.06
GR           32.5, 491.30     42.6, 491.28     46.4, 492.71     47.9, 495.55
GR           53.9, 494.23    150.9, 494.67    219.6, 494.49    343.6, 495.93
GR          469.7, 495.63    586.5, 497.63
*
N           0.075        0.065        0.060
SA                  -8.1         47.9
*
XS   FULLV      0  * * *   0.0145
*
BR   BRIDG     0    496.31       5.0
GR            0.0, 496.46      0.1, 490.90      3.9, 490.52      7.4, 490.82
GR           14.1, 490.90     18.8, 491.75     25.5, 491.89     33.3, 492.28
GR           39.5, 491.83     39.7, 496.21      0.0, 496.46
*
CD           1      50.0 * *     45.0      6.1
N           0.045
*
XR   RDWAY     22   40.0   1
GR            -13.5, 503.00    -13.5, 499.97      0.0, 499.97     40.0, 499.73
GR            160.9, 498.13    406.1, 497.28    461.6, 497.71    757.2, 500.00
*            -533.4, 500.26   -240.1, 498.57
*
AS   APPRO     83
GR          -13.5, 503.00    -13.5, 499.07      0.0, 492.93      6.4, 492.57
GR           13.8, 491.79     22.7, 492.17     33.7, 492.93     42.1, 498.41
GR           49.3, 497.16    372.9, 497.16    461.6, 497.71    757.2, 500.00
*
*          There is no flow left of station -13.5 with an elevation of 499.07.
*          Therefore, a vertical wall was inserted at station -13.5.
*          The highest approach water surface computed was 498.92 feet.
*
N           0.050        0.055
SA                  42.1
*
HP 1 BRIDG 496.32 1 496.32
HP 2 BRIDG 496.32 * * 1671
HP 2 RDWAY 498.30 * *  778
HP 1 APPRO 498.38 1 498.38
HP 2 APPRO 498.38 * * 2450
*
HP 1 BRIDG 496.46 1 496.46
HP 2 BRIDG 496.46 * * 1630
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File stam002.wsp
        Hydraulic analysis for structure STAMVT01000002   Date: 06-JAN-97
        State Route 100 Crossing of Roaring Brook, Stamford, VT            EMB
           *** RUN DATE & TIME: 03-24-97  08:41

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      190     12635     22     67                          3154
   496.32           190     12635     22     67  1.00      0     40      3154

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

         WSEL     LEW     REW    AREA        K        Q     VEL
       496.32     0.0    39.7   189.8  12635.    1671.   8.80

X STA.         0.0         2.5         3.9         5.2         6.5         7.8
  A(I)              13.5         8.1         7.4         7.1         7.0
  V(I)              6.18       10.31       11.34       11.74       11.93

X STA.         7.8         9.0        10.3        11.6        12.9        14.2
  A(I)               6.9         7.0         7.0         7.2         7.1
  V(I)             12.08       11.94       11.92       11.67       11.71

X STA.        14.2        15.7        17.2        19.1        21.0        23.3
  A(I)               7.6         7.9         8.5         8.6        10.5
  V(I)             11.07       10.63        9.87        9.76        7.98

X STA.        23.3        26.3        29.4        32.5        35.8        39.7
  A(I)              13.3        13.1        12.9        13.2        16.1
  V(I)              6.28        6.37        6.50        6.31        5.21

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      22.

         WSEL     LEW     REW    AREA        K        Q     VEL
       498.30   148.1   537.8   214.1   3567.     778.   3.63

X STA.       148.1       224.7       256.6       279.0       297.6       313.1
  A(I)              19.0        14.3        12.1        11.4        10.4
  V(I)              2.05        2.72        3.23        3.41        3.75

X STA.       313.1       327.1       339.4       350.7       361.1       370.9
  A(I)              10.1         9.5         9.1         8.8         8.6
  V(I)              3.85        4.11        4.25        4.42        4.52

X STA.       370.9       380.2       389.0       397.6       405.8       414.5
  A(I)               8.6         8.3         8.4         8.2         8.6
  V(I)              4.54        4.68        4.66        4.73        4.53

X STA.       414.5       424.0       435.3       449.8       470.0       537.8
  A(I)               8.8         9.5        10.7        12.1        17.8
  V(I)              4.44        4.10        3.64        3.20        2.19

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      258     21114     54     57                          3207
             2      512     13976    506    506                          2922
   498.38           770     35089    560    563  2.08    -11    548      3556

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

         WSEL     LEW     REW    AREA        K        Q     VEL
       498.38   -12.0   548.1   770.3  35089.    2450.   3.18

X STA.       -12.0         0.1         4.0         7.5        10.7        13.5
  A(I)              33.1        22.0        20.2        19.2        18.4
  V(I)              3.70        5.58        6.08        6.40        6.66

X STA.        13.5        16.3        19.1        22.0        25.0        28.1
  A(I)              17.9        18.2        18.3        18.3        18.8
  V(I)              6.83        6.74        6.71        6.68        6.50

X STA.        28.1        31.6        36.8        92.9       140.2       187.5
  A(I)              20.0        24.9        66.7        57.7        57.7
  V(I)              6.14        4.91        1.84        2.12        2.12

X STA.       187.5       236.3       284.3       334.6       389.7       548.1
  A(I)              59.5        58.6        61.3        66.3        93.2
  V(I)              2.06        2.09        2.00        1.85        1.31
```

WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File stam002.wsp
       Hydraulic analysis for structure STAMVT01000002   Date: 06-JAN-97
       State Route 100 Crossing of Roaring Brook, Stamford, VT           EMB
          *** RUN DATE & TIME: 03-24-97  08:41

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      191     10565      0     89                            0
  496.46           191     10565      0     89  1.00      0     40        0

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      496.46     0.0    39.7   191.4   10565.    1630.   8.52

X STA.        0.0         2.5         4.0         5.5         6.9         8.5
  A(I)             13.6         9.1         8.6         8.3         8.4
  V(I)             5.98        9.00        9.52        9.83        9.67

X STA.        8.5        10.0        11.5        13.0        14.5        16.2
  A(I)              8.3         8.3         8.3         8.4         8.6
  V(I)             9.77        9.84        9.87        9.67        9.48

X STA.       16.2        18.0        20.0        22.1        24.2        26.5
  A(I)              9.0         9.2         9.4         9.6         9.7
  V(I)             9.08        8.81        8.66        8.53        8.40

X STA.       26.5        28.7        31.2        33.8        36.4        39.7
  A(I)              9.6        10.2        10.5        10.6        13.7
  V(I)             8.46        7.99        7.78        7.68        5.95

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      22.

        WSEL     LEW     REW    AREA        K        Q    VEL
      498.72   116.3   592.0   395.9    8697.    1772.   4.48

X STA.      116.3       189.8       221.2       246.2       268.1       286.9
  A(I)             31.7        23.4        21.1        20.2        18.7
  V(I)             2.80        3.79        4.20        4.38        4.74

X STA.      286.9       304.2       319.6       334.1       347.8       360.6
  A(I)             18.3        17.2        16.8        16.6        16.2
  V(I)             4.85        5.16        5.27        5.32        5.46

X STA.      360.6       372.8       384.7       396.0       407.3       419.1
  A(I)             15.9        15.9        15.7        16.1        16.5
  V(I)             5.58        5.57        5.65        5.51        5.38

X STA.      419.1       432.6       448.4       468.7       496.2       592.0
  A(I)             17.4        18.5        20.9        23.4        35.5
  V(I)             5.10        4.79        4.23        3.79        2.49

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      288     24891     55     58                         3729
            2      804     27206    576    576                         5391
  498.92          1092     52097    631    634  1.83    -12    618     6024

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

        WSEL     LEW     REW    AREA        K        Q    VEL
      498.92   -13.2   617.8  1091.9   52097.    3400.   3.11

X STA.      -13.2         0.7         5.6         9.9        13.6        17.3
  A(I)             43.7        30.1        27.8        25.9        26.0
  V(I)             3.89        5.64        6.12        6.55        6.54

X STA.       17.3        20.9        24.7        28.8        33.3        63.2
  A(I)             24.8        25.6        26.8        27.8        62.2
  V(I)             6.86        6.64        6.35        6.12        2.73

X STA.       63.2       101.2       139.1       177.5       217.2       256.4
  A(I)             66.8        66.8        67.5        69.8        69.1
  V(I)             2.55        2.55        2.52        2.43        2.46

X STA.      256.4       296.5       337.1       380.5       435.8       617.8
  A(I)             70.6        71.6        76.2        85.2       127.7
  V(I)             2.41        2.38        2.23        1.99        1.33
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      U.S. Geological Survey WSPRO Input File stam002.io.wsp
      Hydraulic analysis for structure STAMVT01000002   Date: 06-JAN-97
      State Route 100 Crossing of Roaring Brook, Stamford, VT           EMB
         *** RUN DATE & TIME: 02-27-97  07:11

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      191     10565      0     89                            0
 496.46           191     10565      0     89  1.00      0     40        0

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     496.46     0.0    39.7   191.4   10565.    1300.   6.79

X STA.        0.0        2.5        4.0        5.5        6.9        8.5
  A(I)            13.6        9.1        8.6        8.3        8.4
  V(I)            4.77       7.18       7.60       7.84       7.71

X STA.        8.5       10.0       11.5       13.0       14.5       16.2
  A(I)             8.3        8.3        8.3        8.4        8.6
  V(I)            7.80       7.85       7.87       7.71       7.56

X STA.       16.2       18.0       20.0       22.1       24.2       26.5
  A(I)             9.0        9.2        9.4        9.6        9.7
  V(I)            7.25       7.03       6.91       6.80       6.70

X STA.       26.5       28.7       31.2       33.8       36.4       39.7
  A(I)             9.6       10.2       10.5       10.6       13.7
  V(I)            6.75       6.37       6.20       6.12       4.75

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      211     15756     51     53                         2440
 497.47           211     15756     51     53  1.00     -9     41     2440

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

       WSEL     LEW     REW    AREA        K        Q    VEL
     497.47   -10.0    40.7   210.8   15756.    1300.   6.17

X STA.      -10.0       -1.0        1.7        4.0        6.1        8.1
  A(I)            18.4       11.9       10.9       10.3        9.8
  V(I)            3.54       5.45       5.99       6.28       6.60

X STA.        8.1        9.9       11.7       13.3       14.9       16.5
  A(I)             9.5        9.3        9.1        8.9        8.8
  V(I)            6.87       6.99       7.12       7.30       7.38

X STA.       16.5       18.1       19.7       21.4       23.1       24.9
  A(I)             8.9        8.8        9.1        9.2        9.3
  V(I)            7.30       7.40       7.15       7.03       7.03

X STA.       24.9       26.8       28.8       30.9       33.4       40.7
  A(I)             9.6       10.0       10.3       11.4       17.3
  V(I)            6.75       6.49       6.29       5.72       3.77
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        U.S. Geological Survey WSPRO Input File stam002.wsp
        Hydraulic analysis for structure STAMVT01000002   Date: 06-JAN-97
        State Route 100 Crossing of Roaring Brook, Stamford, VT           EMB
           *** RUN DATE & TIME: 03-24-97  08:41

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                             WSI,CRWS =    495.33     495.58

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

EXITX:XS   ******    -56      476  0.66 *****  496.24  495.58    2450  495.58
       -42 ******    313    18950  1.60 ***** *******    1.00    5.15

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.96     496.33     496.20

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.08     500.09    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.08     500.09     496.20

FULLV:FV       43    -67      524  0.57  0.67  496.90  496.20    2450  496.32
         0     43    474    20370  1.69  0.00    0.00    0.96    4.67
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.13     497.12     498.09

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.82     503.00    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.82     503.00     498.09

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                   WSBEG,WSEND,CRWS =   498.09     503.00     498.09

APPRO:AS       83    -10      615  0.54 *****  498.63  498.09    2450  498.09
        83     83    511    27983  2.19 ***** *******    0.96    3.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    496.32     496.31

            <<<<<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       43      0      190  1.20 *****  497.53  495.33    1671  496.32
         0 ******     40    12562  1.00 ***** *******    0.71    8.80

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  496.31 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      22.    43.  0.21  0.32  498.50    0.00    778.  498.30

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****
   RT:    778.   377.   161.   537.   1.0   0.6   4.0   3.7   0.8   3.1

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

APPRO:AS       33    -11      773  0.32  0.51  498.71  498.09    2450  498.38
        83     53    549    35204  2.08  0.00    0.00    0.69    3.17

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS      -43.   -57.   313.   2450.   18950.     476.    5.15  495.58
   FULLV:FV        0.   -68.   474.   2450.   20370.     524.    4.67  496.32
   BRIDG:BR        0.     0.    40.   1671.   12562.     190.    8.80  496.32
   RDWAY:RG       22.*******     0.    778.       0.*********    1.00  498.30
   APPRO:AS       83.   -12.   549.   2450.   35204.     773.    3.17  498.38

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     495.58    1.00  489.89  499.47************  0.66  496.24  495.58
   FULLV:FV     496.20    0.96  490.51  500.09  0.67  0.00  0.57  496.90  496.32
   BRIDG:BR     495.33    0.71  490.52  496.46************  1.20  497.53  496.32
   RDWAY:RG   ****************  497.28  503.00  0.21******  0.32  498.50  498.30
   APPRO:AS     498.09    0.69  491.79  503.00  0.51  0.00  0.32  498.71  498.38
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        U.S. Geological Survey WSPRO Input File stam002.wsp
        Hydraulic analysis for structure STAMVT01000002   Date: 06-JAN-97
        State Route 100 Crossing of Roaring Brook, Stamford, VT          EMB
           *** RUN DATE & TIME: 03-24-97  08:41

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                          WSI,CRWS =   495.83     496.16

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

EXITX:XS   ******   -109      775  0.55 *****  496.71  496.16    3400  496.16
       -42 ******    501    28828  1.84 ***** *******    0.93    4.39

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.95     496.77     496.78
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.66     500.09    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.66     500.09     496.78
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                  WSBEG,WSEND,CRWS =   496.78     500.09     496.78

FULLV:FV       43   -109      775  0.55 *****  497.33  496.78    3400  496.78
         0     43    501    28828  1.84 ***** *******    0.93    4.39
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.62     497.02     498.40
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.28     503.00    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.28     503.00     498.40
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   498.40     503.00     498.40

APPRO:AS       83    -11      783  0.61 *****  499.01  498.40    3400  498.40
        83     83    551    35687  2.07 ***** *******    0.93    4.34
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                          WS3N,LSEL =   496.78     496.31

            <<<<<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       43      0      191  1.13 *****  497.59  495.26    1630  496.46
         0 ******     40    10565  1.00 ***** *******    0.68    8.52

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  496.31 ****** ****** ******

   XSID:CODE      SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
  RDWAY:RG      22.    43.  0.18  0.28  499.01    0.00   1772.  498.72

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****
  RT:   1772.   476.   116.   593.   1.4   0.8   5.0   4.5   1.1   3.1

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

APPRO:AS       33    -12     1092  0.28  0.65  499.20  498.40    3400  498.92
        83     57    618    52096  1.83  0.00    0.00    0.56    3.11

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD     LEW     REW       Q          K      AREA     VEL    WSEL
   EXITX:XS     -43.  -110.    501.   3400.   28828.      775.    4.39  496.16
   FULLV:FV       0.  -110.    501.   3400.   28828.      775.    4.39  496.78
   BRIDG:BR       0.      0.    40.   1630.   10565.      191.    8.52  496.46
   RDWAY:RG      22.*******     0.   1772.       0.*********    1.00  498.72
   APPRO:AS      83.   -13.    618.   3400.   52096.     1092.    3.11  498.92

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS      FR#    YMIN     YMAX     HF     HO   VHD      EGL     WSEL
   EXITX:XS    496.16     0.93  489.89  499.47************  0.55  496.71  496.16
   FULLV:FV    496.78     0.93  490.51  500.09************  0.55  497.33  496.78
   BRIDG:BR    495.26     0.68  490.52  496.46************  1.13  497.59  496.46
   RDWAY:RG  ****************  497.28  503.00   0.18******  0.28  499.01  498.72
   APPRO:AS    498.40     0.56  491.79  503.00   0.65  0.00  0.28  499.20  498.92
  ER
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File stam002.io.wsp
        Hydraulic analysis for structure STAMVT01000002   Date: 06-JAN-97
        State Route 100 Crossing of Roaring Brook, Stamford, VT           EMB
           *** RUN DATE & TIME: 02-27-97  07:11

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

EXITX:XS   ******     -5      175  0.89 *****  495.28  493.79   1300  494.40
       -42 ******     90     8370  1.03 ***** *******    0.96   7.44

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80     0.99     495.53     494.42

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.90     500.09     0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.90     500.09     494.42

FULLV:FV       43     -6      270  0.52  0.77  496.04  494.42   1300  495.51
         0     43    254    11328  1.46  0.00   -0.01    1.00   4.81
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       83     -7      161  1.02  1.17  497.46 *******   1300  496.44
        83     83     39    10628  1.00  0.25    0.01    0.77   8.08
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.86     496.72     497.17     496.31

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

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

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

BRIDG:BR       43      0      191  0.72 *****  497.18  494.72   1302  496.46
         0 ******     40    10565  1.00 ***** *******    0.55   6.80

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.434  0.000  496.31 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      22.          <<<<<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       33     -9      211  0.59  0.34  498.06  495.83   1300  497.47
        83     33     41    15772  1.00  1.07    0.00    0.53   6.16

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   497.18

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD     LEW    REW       Q         K      AREA     VEL    WSEL
   EXITX:XS     -43.     -6.    90.   1300.     8370.      175.    7.44  494.40
   FULLV:FV       0.     -7.   254.   1300.    11328.      270.    4.81  495.51
   BRIDG:BR       0.      0.    40.   1302.    10565.      191.    6.80  496.46
   RDWAY:RG      22.**************       0.        0.        0.    1.00********
   APPRO:AS      83.    -10.    41.   1300.    15772.      211.    6.16  497.47

    XSID:CODE   XLKQ   XRKQ        KQ
   APPRO:AS  ***********************

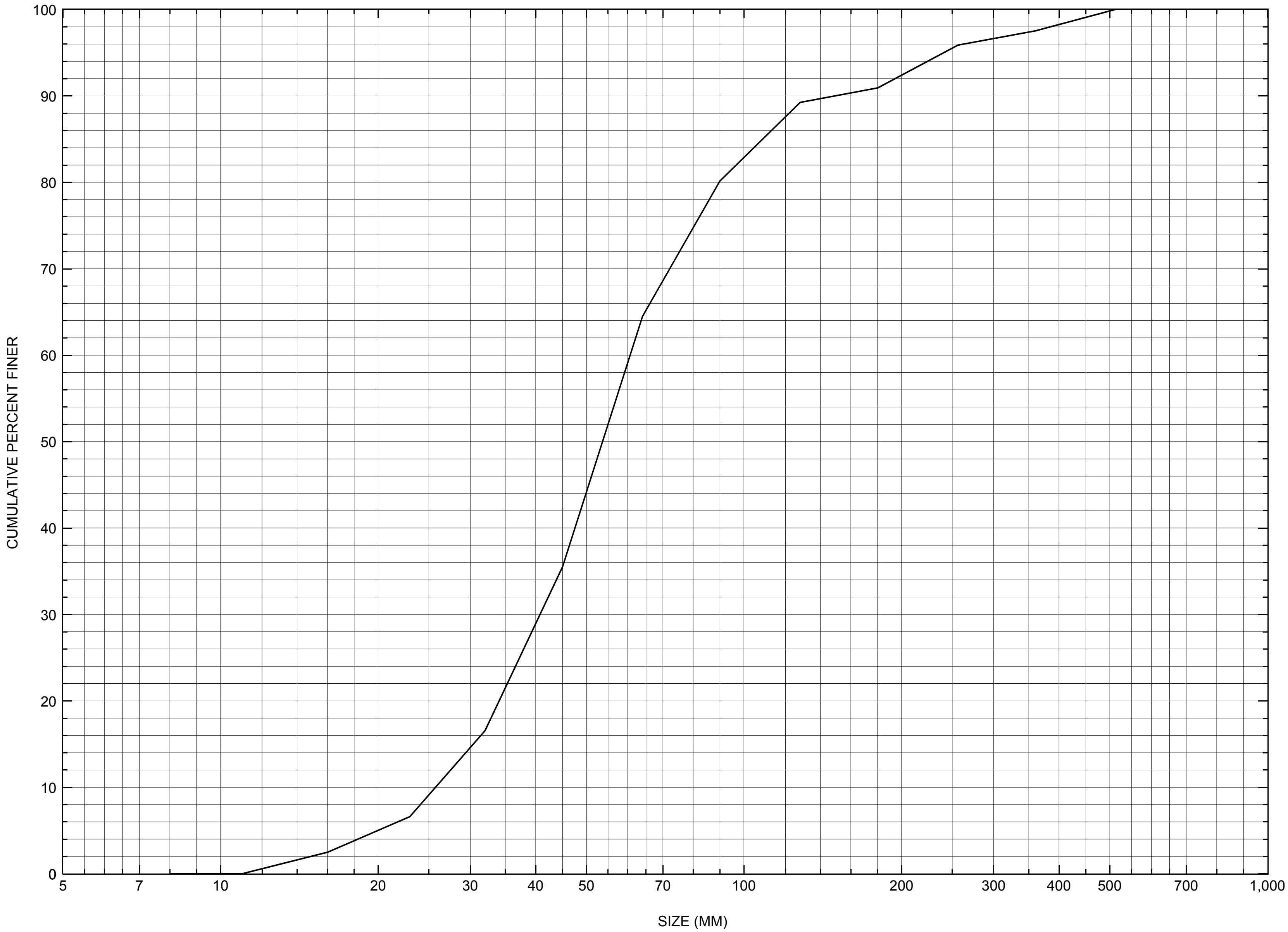
 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     493.79    0.96  489.89  499.47************  0.89  495.28  494.40
   FULLV:FV     494.42    1.00  490.51  500.09  0.77  0.00  0.52  496.04  495.51
   BRIDG:BR     494.72    0.55  490.52  496.46************  0.72  497.18  496.46
   RDWAY:RG   ****************  497.28  503.00************  0.59  497.77********
   APPRO:AS     495.83    0.53  491.79  503.00  0.34  1.07  0.59  498.06  497.47
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure STAMVT01000002, in Stamford, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number STAMVT01000002

General Location Descriptive

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

Date *(MM/DD/YY)* 09 / 28 / 95

Highway District Number *(I - 2; nn)* 01

County *(FIPS county code; I - 3; nnn)* 003

Town *(FIPS place code; I - 4; nnnnn)* 69775

Mile marker *(I - 11; nnn.nnn)* 001160

Waterway *(I - 6)* Roaring Brook

Road Name *(I - 7):* -

Route Number VT100

Vicinity *(I - 9)* 1.2 MI N MA STATE LINE

Topographic Map Stamford

Hydrologic Unit Code: 02020003

Latitude *(I - 16; nnnn.n)* 42455

Longitude *(i - 17; nnnnn.n)* 73041

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20010200020214

Maintenance responsibility *(I - 21; nn)* 01

Maximum span length *(I - 48; nnnn)* 0042

Year built *(I - 27; YYYY)* 1963

Structure length *(I - 49; nnnnnn)* 000044

Average daily traffic, ADT *(I - 29; nnnnnn)* 001670

Deck Width *(I - 52; nn.n)* 400

Year of ADT *(I - 30; YY)* 92

Channel & Protection *(I - 61; n)* 6

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

Waterway adequacy *(I - 71; n)* 5

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 31

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

Vertical clearance from streambed (*nnn.n ft*) 7

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

Waterway of full opening (*nnn.n* ft^2) 217

Comments:

According to the structural inspection report dated 8/24/93, the structure is a single span rolled beam bridge. The right abutment wall has some minor staining and cracking and the wingwalls have some minor cracking and scaling. The bridge seat of the left abutment has some debris. The left abutment concrete is in good condition, except some minor cracking and scaling along the flow line. The left abutment wingwalls are in good condition with only minor cracking and scaling. The channel is straight through structure. Currently, flow is along the left abutment side of the channel, and there is a sand, stone and cobble build-up along the right abutment side of the channel. **(Continued, page 31)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

Some minor stream bank erosion and channel scour is noted US. The abutment footings are not exposed. A note dated 3/17/92 in the hydraulic section's folder with a subject of "re: evaluation of ice impact on 3/11/92" states "ice packed in around bearing device at Beam #1, Abut #1 (Rabut) - minor scraping of paint on Beam #1 - no displacement or bending of beams - no apparent scour at abutments, but could not definitely be determined due to ice cover - no cracking or scaling in abutments or wings."

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **8.26** mi^2 Lake and pond area **0** mi^2

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

Bridge site elevation **1115** ft Headwater elevation **3095** ft

Main channel length **5.97** mi

10% channel length elevation **1125** ft 85% channel length elevation **3040** ft

Main channel slope *(S)* **427.69** ft / mi

Watershed Precipitation Data

Average site precipitation ______ in Average headwater precipitation ______ in

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

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

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

Project Number S 0102(3) Minimum channel bed elevation: 1124.5

Low superstructure elevation: USLAB 1131.07 DSLAB 1131.16 USRAB 1130.88 DSRAB 1130.81

Benchmark location description:

Disc on bridge, downstream corner of abutment and right wingwall, elev. 1135.12

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

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

If 1: Footing Thickness 2 Footing bottom elevation: 1120.5

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

If 3: Footing bottom elevation: -

Is boring information available? Y *If no, type ctrl-n bi* Number of borings taken: 4

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

Briefly describe material at foundation bottom elevation or around piles:

Refusal for the 4 drill-borings varies from 8.75 to 11.5 feet below the surface. Above that is very coarse gravel and boulders.

Comments:

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

Cross-sectional Data

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

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

Comments: **The stations and elevations are in feet (NGVD).**

Station	415.5	435	455.5								
Feature	LAB		RAB								
Low cord elevation	1131.8	1131.7	1131.6								
Bed elevation	1127.8	1128	1128.1								
Low cord to bed length	4	3.7	3.5								

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: 10/07/96
Computerized by: RB Date: 10/08/96
Reviewd by: EMB Date: 2/5/97

Structure Number STAMVT01000002

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. HAMMOND Date *(MM/DD/YY)* 07 / 31 / 1996

2. Highway District Number 01 Mile marker 001160

County Bennington (003) Town Stamford (69775)

Waterway *(I - 6)* Roaring Brook Road Name -

Route Number VT100 Hydrologic Unit Code: 02020003

3. Descriptive comments:

Bridge plate reads, "S-0102(3) 1963." Bridge is located 1.2 miles north of the Massachusetts state line and just north of the community of Stamford. Residents call the road Main Street and talked about the channel filling in over the last 10 years and the ice jam of last winter that flooded adjacent yards and basements.
4

B. Bridge Deck Observations

4. Surface cover... LBUS 2 RBUS 5 LBDS 2 RBDS 2 Overall 2
*(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 1 *(**1**- pool; **2**- riffle)*

6. Bridge structure type 44 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length 42 *(feet)* Span length 40 *(feet)* Bridge width 0 *(feet)*

Road approach to bridge:

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

9. LB 1 RB 0 *(**1**- Paved, **2**- Not paved)*

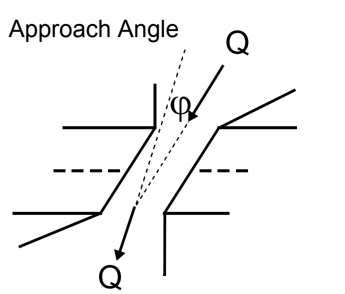
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

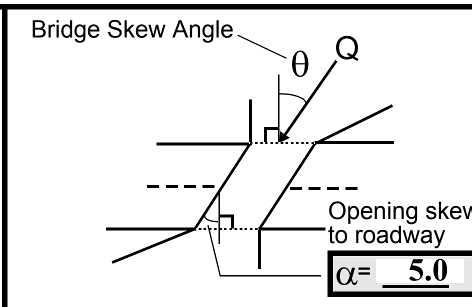
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	-	0	-	0
RBUS	-	0	-	0
RBDS	-	0	-	0
LBDS	-	0	-	5

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

Channel approach to bridge (BF):

15. Angle of approach: 5 16. Bridge skew: Y





17. Channel impact zone 1: Exist? LB *(Y or N)*
Where? 1 *(LB, RB)* Severity 0
Range? US feet 30 *(US, UB, DS)* to UB feet N

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

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

18. Bridge Type: **The**

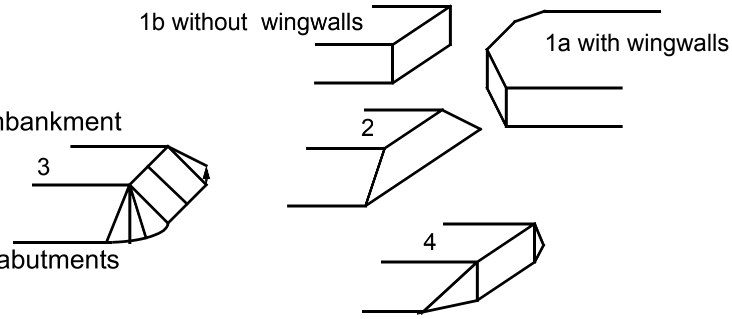
1a- Vertical abutments with wingwalls

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.)

US and DS left banks have a strip of trees one bridge length wide along the banks then a dirt road and then a hay field on the US side and a lawn with a house DS.
Bridge dimension values shown are from the VTAOT files. Measured bridge length is 43.7 ft., bridge span is 40.1 ft., the roadway width is 29.9 ft., and the bridge width including the sidewalks and rails is 40 ft.

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
40.5	**6.0**			**5.5**	**3**	**2**	**543**	**543**	**1**	**1**

23. Bank width **25.0** 24. Channel width **35.0** 25. Thalweg depth **55.5** 29. Bed Material **453**

30 .Bank protection type: LB **2** RB **2** 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. Bank protection on both banks is dumped type 3 stone near the bridge and type 2 stone beyond. On the right bank there was an old laid stone wall under the dumped stone. Large placed boulders are found at the end of the wingwalls to 35 ft. US on both the left and right bank.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **60** 35. Mid-bar width: **25**

36. Point bar extent: **10** feet **US** (US, UB) to **140** feet **DS** (US, UB, DS) positioned **30** %LB to **100** %RB

37. Material: **543**

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

By count, the point bar composition is mostly cobbles, but the boulders dominate in size.

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

41. Mid-bank distance: **130** 42. Cut bank extent: **115** feet **US** (US, UB) to **200** feet **US** (US, UB, DS)

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

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

There are roots exposed and some slumping, but the bank is still in good condition. Both banks show fluvial washing.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **0**

47. Scour dimensions: Length **15** Width **8** Depth : **0.5** Position **5** %LB to **15** %RB

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

Scour is from 5 ft. US to 10 ft. under the bridge. Average thalweg depth is 0.75 ft. Some local scour is evident immediately downstream of 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) 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
34.0		**1.0**		**2**	**7**	**7**	**-**

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

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

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

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

453

-

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

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

70. Debris and Ice Comments:

3

There is only 4 ft. of clearance between low chord and the stream bed, which suggests the capture efficiency is high. The historical form and area residents mentioned ice problems, however there is no evidence of ice damage at the bridge.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		5	90	2	0	-	-	90.0
RABUT	1	-	90			2	0	39.5

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

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

-

-

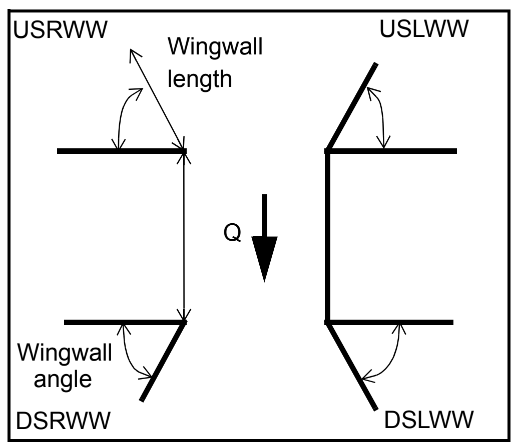
1

The left abutment toe is almost even with the left bank.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						39.5	
USRWW:	Y		1		0	1.5	
DSLWW:	-		-		Y	44.0	
DSRWW:	1		0		-	44.0	

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



82. Bank / Bridge Protection:

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

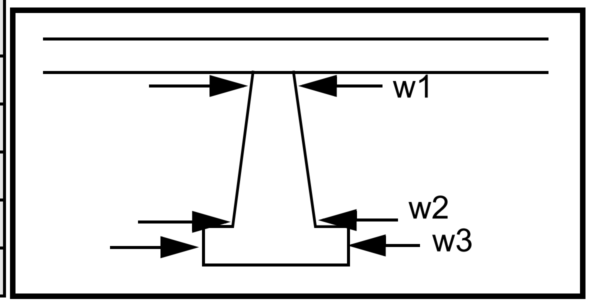
*Protection extent: **1**- entire base length; **2**- US end; **3**- DS end; **4**- other*

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		**8.0**	**9.0**	**40.0**	**50.0**	**50.0**
Pier 2				**10.0**	**40.0**	**10.0**
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

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

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

2
1
7
7
1
1
453
5
5
1
1
There are artificial levees at the top of both banks downstream, which are built of large boulders and are considered bank protection. On the left bank the levee extends to 35 feet downstream of the bridge. About 35 feet

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

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

105. Drop structure comments (eg. downstream scour depth):
stream there is a transition from levee to stone fill on the left bank. On the right bank the levee extends to 20 feet downstream. There is a transition at 20 feet downstream on the right bank from the levee boulders to a stone wall, which continues to about 150 feet downstream. The stone wall is covered by soil and large trees. The percent vegetation on the left bank is small to 100 feet DS where it abuptly increases close to 100%. On the right bank the percent vegetation cover is 50% up to 100 feet DS where it abruptly increases close to 100%. The streambed consists of more cobbles downstream than upstream.

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

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

Material: **NO**

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

DROP STRUCTURE

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

Cut bank extent: **-** feet **-** *(US, UB, DS)* to **-** feet **-** *(US, UB, DS)*

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

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

-
-
-
-

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

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

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

nt bar continues DS. See US channel assessment.

N

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

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

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

Confluence comments (eg. confluence name):

CUT BANKS

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N
-
-
-
-
-
-
NO CHANNEL SCOUR
Some local scour downstream of boulders.

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: STAMVT01000002 Town: Stamford
Road Number: VT 100 County: Bennington
Stream: Roaring Brook

Initials EMB Date: 2/5/97 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	2450	3400	1300
Main Channel Area, ft2	258	288	211
Left overbank area, ft2	0	0	0
Right overbank area, ft2	512	804	0
Top width main channel, ft	54	55	51
Top width L overbank, ft	0	0	0
Top width R overbank, ft	506	576	0
D50 of channel, ft	0.176	0.176	0.176
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.8	5.2	4.1
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	1.0	1.4	ERR
Total conveyance, approach	35089	52097	15756
Conveyance, main channel	21114	24891	15756
Conveyance, LOB	0	0	0
Conveyance, ROB	13976	27206	0
Percent discrepancy, conveyance	-0.0028	0.0000	0.0000
Qm, discharge, MC, cfs	1474.2	1624.5	1300.0
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	975.8	1775.5	0.0
Vm, mean velocity MC, ft/s	5.7	5.6	6.2
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	1.9	2.2	ERR
Vc-m, crit. velocity, MC, ft/s	8.2	8.3	8.0
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			
D90	0.4896	0.4896	0.4896
D95	0.7897	0.7897	0.7897
Critical grain size,Dc, ft	0.3413	0.3182	0.2024
Decimal-percent coarser than Dc	0.161	0.179	0.3855
Depth to armoring,ft	5.34	4.38	0.97

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	258	288	211
Main channel width, ft	54	55	51
y1, main channel depth, ft	4.78	5.24	4.14

Bridge Section			
(Q) total discharge, cfs	2450	3400	1300
(Q) discharge thru bridge, cfs	1671	1630	1300
Main channel conveyance	12635	10565	10565
Total conveyance	12635	10565	10565
Q2, bridge MC discharge,cfs	1671	1630	1300
Main channel area, ft2	190	191	191
Main channel width (skewed), ft	39.5	39.5	39.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	39.5	39.5	39.5
y_bridge (avg. depth at br.), ft	4.81	4.85	4.85
Dm, median (1.25*D50), ft	0.22	0.22	0.22
y2, depth in contraction,ft	4.73	4.63	3.81
ys, scour depth (y2-ybridge), ft	-0.08	-0.22	-1.03

Pressure Flow Scour (contraction scour for orifice flow conditions)

Hb+Ys=Cq*qbr/Vc   Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)
Chang Equation   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
(Richarson and others, 1995, p. 145-146)

	Q100	Q500	OtherQ
Q, total, cfs	2450	3400	1300
Q, thru bridge, cfs	1671	1630	1300
Total Conveyance, bridge	12635	10565	10565
Main channel(MC) conveyance, bridge	12635	10565	10565
Q, thru bridge MC, cfs	1671	1630	1300
Vc, critical velocity, ft/s	8.15	8.28	7.96
Vc, critical velocity, m/s	2.48	2.52	2.43
Main channel width (skewed), ft	39.5	39.5	39.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	39.5	39.5	39.5
qbr, unit discharge, ft2/s	42.3	41.3	32.9
qbr, unit discharge, m2/s	3.9	3.8	3.1
Area of full opening, ft2	189.8	191.4	191.4
Hb, depth of full opening, ft	4.81	4.85	4.85
Hb, depth of full opening, m	1.46	1.48	1.48
Fr, Froude number, bridge MC	0.71	0.68	0.55
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	496.31	496.31	496.31
Elevation of Bed, ft	491.50	491.46	491.46
Elevation of Approach, ft	498.38	498.92	497.47
Friction loss, approach, ft	0.51	0.65	0.34
Elevation of WS immediately US, ft	497.87	498.27	497.13
ya, depth immediately US, ft	6.37	6.81	5.67
ya, depth immediately US, m	1.94	2.07	1.73
Mean elevation of deck, ft	499.85	499.85	499.85
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.93	0.91	0.96
Ys, depth of scour, ft	0.78	0.61	-0.55

Comparison of Chang and Laursen results (for unsubmerged orifice flow)

y2, from Laursen's equation, ft	4.72625	4.626676	3.811183
Full valley WSEL, ft	0	0	495.51
Full valley depth, ft	-491.505	-491.464	4.04557
Ys, depth of scour (y2-yfullv), ft	N/A	N/A	-0.23439

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	2450	3400	1300	2450	3400	1300
a', abut.length blocking flow, ft	12.2	13.4	10.2	83.8	10.8	1
Ae, area of blocked flow ft2	33.7	42.1	23.7	100.6	22.5	2.37
Qe, discharge blocked abut.,cfs	125.6	163.9	93.9	--	--	8.9
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.73	3.89	3.96	1.94	2.73	3.76
ya, depth of f/p flow, ft	2.76	3.14	2.32	1.20	2.08	2.37
--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	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.395	0.387	0.458	0.312	0.334	0.430
ys, scour depth, ft	8.33	9.30	7.43	7.97	6.08	4.18

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)	12.2	13.4	10.2	83.8	10.8	1
y1 (depth f/p flow, ft)	2.76	3.14	2.32	1.20	2.08	2.37
a'/y1	4.42	4.27	4.39	69.81	5.18	0.42
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.40	0.39	0.46	0.31	0.33	0.43
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	5.83	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	4.78	ERR	ERR
spill-through	ERR	ERR	ERR	3.20	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.71	0.68	0.55	0.71	0.68	0.55
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	4.81	4.85	4.02	4.81	4.85	4.02
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.50	1.39	0.75	1.50	1.39	0.75
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	1.31	1.21	0.66	1.31	1.21	0.66
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR