LEVEL II SCOUR ANALYSIS FOR BRIDGE 12 (NEWFVT00300012) on STATE ROUTE 30, crossing SMITH BROOK, NEWFANE, VERMONT

U.S. Geological Survey
Open-File Report 97-424

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

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By MICHAEL A. IVANOFF & LAURA MEDALIE

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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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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 12 (NEWFVT00300012) ON STATE ROUTE 30, CROSSING SMITH BROOK, NEWFANE, VERMONT

By **Michael A. Ivanoff and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NEWFVT00300012 on State Route 30 crossing Smith Brook, Newfane, 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 New England Upland and Green Mountain sections of the New England physiographic province in southeastern Vermont. The 9.55-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is primarily pasture with the exception of the downstream right bank which is forested. The immediate banks have dense woody vegetation except for the downstream right bank which has cut grass.

In the study area, Smith Brook has a sinuous channel with a slope of approximately 0.01 ft/ft, an average channel top width of 63 ft and an average bank height of 10 ft. The predominant channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 75.4 mm (0.247 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 21, 1996, indicated that the reach was stable.

The State Route 30 crossing of Smith Brook is a 43-ft-long, two-lane bridge consisting of a 40-foot concrete T-beam span (Vermont Agency of Transportation, written communication, March 30, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 35 degrees to the opening while the measured opening-skew-to-roadway is 30 degrees.

The scour protection measure at the site included type-2 stone fill (less than 36 inches diameter) from the upstream end of the left abutment to 35 ft. upstream, along the downstream end of the downstream left wingwall, along the right bank from 7 ft. to 90 ft. downstream, and along the left bank from 15 ft. to 40 ft. downstream. Also, there was type-1 stone fill (less than 24 inches diameter) at the left abutment and downstream left wingwall. 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.

Contraction scour for modelled flows ranged from 1.2 to 1.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 7.6 to 14.1 ft. The worst-case abutment scour also 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.

Newfane, VT. Quadrangle, 1:25,000, 1984

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 NEWFVT00300012 ***Stream*** Smith Brook

County Windham ***Road*** VT 30 ***District*** 2

Description of Bridge

Bridge length 43 ***ft*** ***Bridge width*** 32 ***ft*** ***Max span length*** 40 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 08/21/96

Description of stone fill Type-2, at the upstream end of the left abutment, to 35 ft. upstream, along the downstream end of the downstream left wingwall, and both downstream banks. Type-1, at the left abutment and along the downstream left wingwall.

Abutments and wingwalls are concrete. The left abutment footing is exposed one foot vertically at the downstream left wingwall. The upstream half of the upstream left wingwall is “laid-up” stones with concrete cap.

Yes 30

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

The waterway makes a moderate bend in the upstream and downstream reach with the majority of the flow along the left abutment side of the channel.

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	08/21/96	0	0
Level II	08/21/96	0	0

Potential for debris Moderate. There is some debris caught on boulders and trees leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) There was a side bar along the right bank from approximately 50 ft. upstream to 34 ft. downstream of the bridge as of 08/21/96.

Description of the Geomorphic Setting

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

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

Date of inspection 08/21/96

DS left: Moderately sloped channel bank to a narrow flood plain.

DS right: Narrow terrace to the valley wall.

US left: Moderately sloped channel bank to a narrow flood plain.

US right: Moderately sloped channel bank to a narrow flood plain.

Description of the Channel

Average top width 63 *ft* ***Average depth*** 10 *ft*

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

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

08/21/96

Vegetative co Trees and brush.

DS left: Cut grass on the terrace with trees and brush on valley wall.

DS right: Trees and brush.

US left: Trees and brush.

US right:

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

The assessment of 08/21/96 noted a side bar along the right bank through the bridge.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 9.55 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/ New England Upland	80
New England/ Green Mountain	20

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,490 ***ft³/s*** ***Q500*** 3,700 ***ft³/s***

The 100- and 500- year discharges are based on the flood frequency results of the Johnson and Tasker empirical equation. This included a drainage area relationship [(9.55/12.6)exp 0.67] with the 100 year flood discharge at the mouth of Smith Brook. The mouth of Smith Brook has a flood frequency estimate based on the Johnson and Tasker equation available in the Flood Insurance Study for Newfane, VT (Federal Emergency Management Agency, 1989). The drainage area at the mouth of Smith Brook is 12.6 square miles. These values are within a range defined by several empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans Subtract 3.1 feet from the USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the left abutment (elev. 498.54 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 498.84 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	-42	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	82	2	Modelled Approach section (Templated from APTEM)
APTEM	86	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.055, and overbank "n" values ranged from 0.040 to 0.055.

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 0.0115 ft/ft. This slope was estimated from the 100-year discharge water surface profile downstream of the site presented in the Flood Insurance Study for the town of Newfane, VT (Federal Emergency Management Agency, 1989).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0025 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

For the 100-year discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles for this discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.7 *ft*
Average low steel elevation 495.4 *ft*

100-year discharge 2,490 *ft^3/s*
Water-surface elevation in bridge opening 491.8 *ft*
Road overtopping? No *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 193 *ft^2*
Average velocity in bridge opening 12.9 *ft/s*
Maximum WSPRO tube velocity at bridge 15.6 *ft/s*

Water-surface elevation at Approach section with bridge 494.7
Water-surface elevation at Approach section without bridge 494.1
Amount of backwater caused by bridge 0.6 *ft*

500-year discharge 3,700 *ft^3/s*
Water-surface elevation in bridge opening 495.5 *ft*
Road overtopping? No *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 329 *ft^2*
Average velocity in bridge opening 11.3 *ft/s*
Maximum WSPRO tube velocity at bridge 13.1 */s*

Water-surface elevation at Approach section with bridge 499.4
Water-surface elevation at Approach section without bridge 495.0
Amount of backwater caused by bridge 4.4

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 discharge was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 500-year discharge resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for the 500-year discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). In this case, the 500-year discharge resulted in the worst case contraction scour with a scour depth of 1.8 ft. 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	1.2	1.8	--
Depth to armoring	29.2	6.9	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	10.4	14.1	--
Right abutment	7.6	9.6	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	2.2	2.8	--
Right abutment	2.2	2.8	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

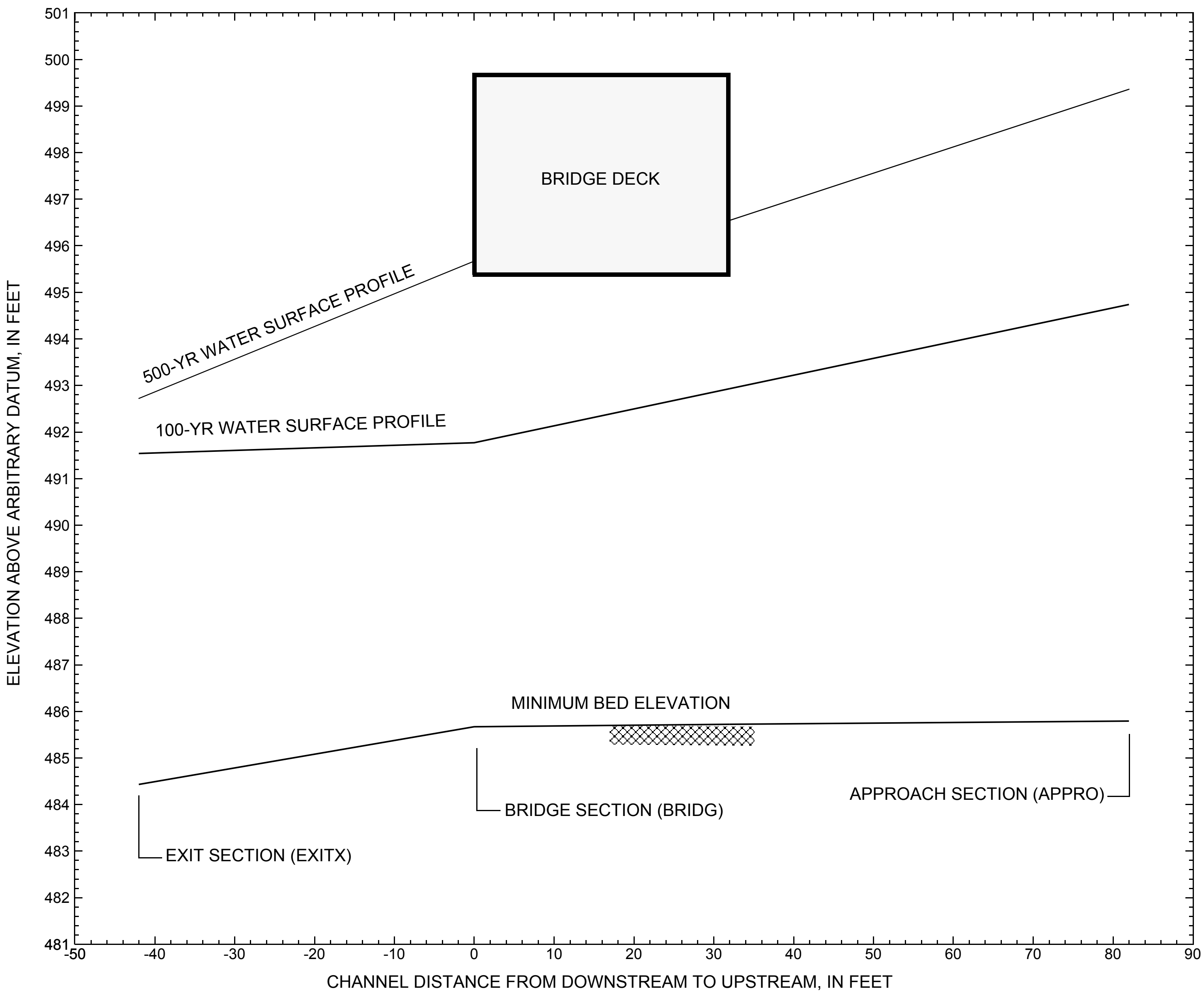

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NEWFVT00300012 on State Route 30, crossing Smith Brook, Newfane, Vermont.

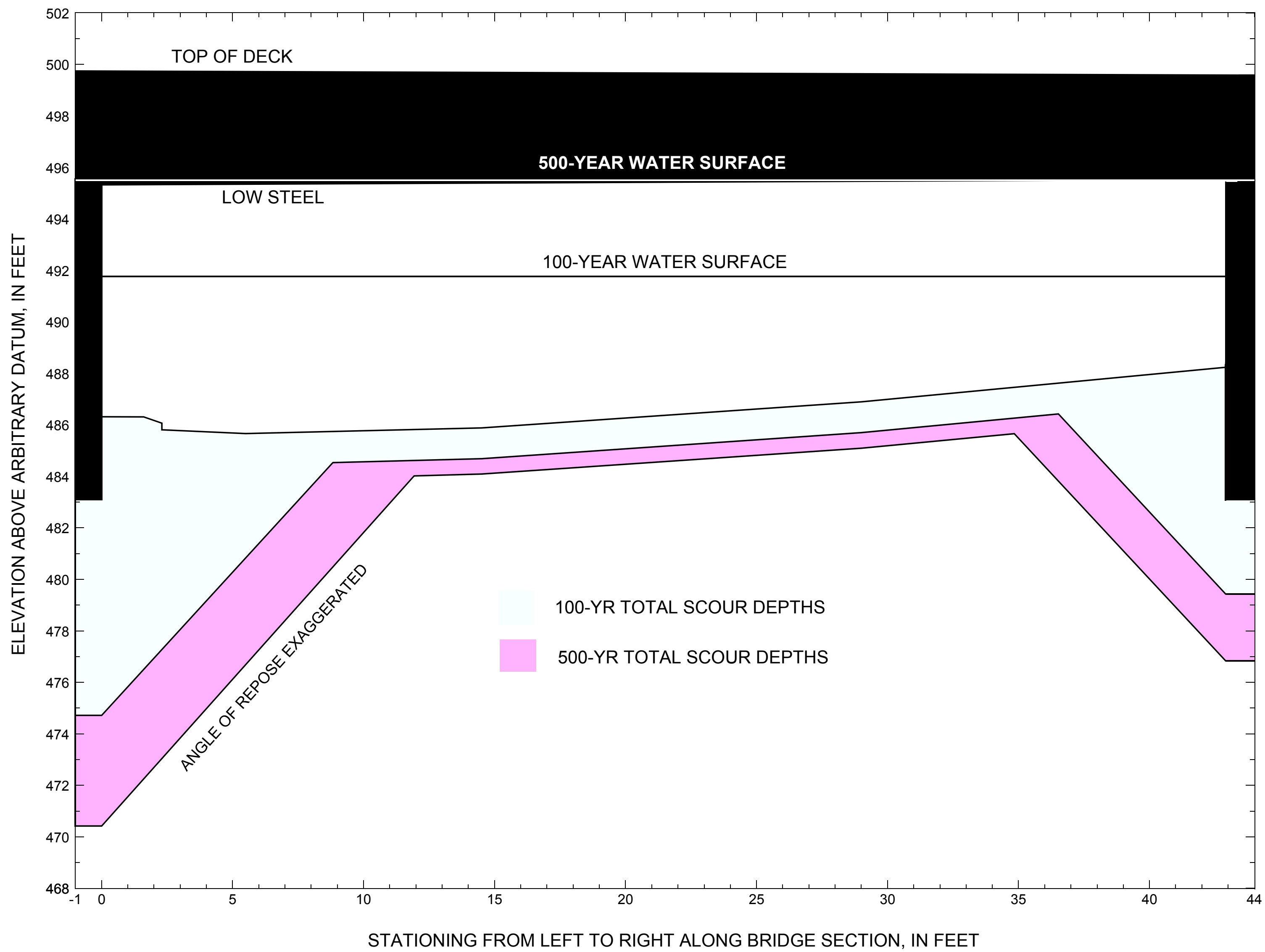

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure NEWFVT00300012 on State Route 30, crossing Smith Brook, Newfane, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure NEWFVT00300012 on State Route 30, crossing Smith Brook, Newfane, 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 2,490 cubic-feet per second											
Left abutment	0.0	492.0	495.3	483.1	486.3	1.2	10.4	--	11.6	474.7	-8.4
Right abutment	43.4	492.0	495.5	483.1	488.2	1.2	7.6	--	8.8	479.4	-3.7

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 NEWFVT00300012 on State Route 30, crossing Smith Brook, Newfane, 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 3,700 cubic-feet per second											
Left abutment	0.0	492.0	495.3	483.1	486.3	1.8	14.1	--	15.9	470.4	-12.7
Right abutment	43.4	492.0	495.5	483.1	488.2	1.8	9.6	--	11.4	476.8	-6.3

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, 1984, Newfane, Vermont 7.5 X 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File newf012.wsp
T2        Hydraulic analysis for structure NEWFVT00300012   Date: 28-JAN-97
T3        Bridge # 12 on VT 30 over Smith Brook in Newfane, VT  by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2490.0   3700.0
SK          0.0115   0.0115
*
XS   EXITX    -42
GR         -235.2, 511.68   -205.0, 498.65    -73.6, 499.43    -22.1, 497.67
GR            0.0, 487.84     10.8, 485.12     12.8, 484.43     17.8, 484.44
GR           23.8, 484.77     28.3, 485.15     34.5, 486.65     40.8, 490.41
GR           77.0, 490.74     90.5, 497.13    110.6, 506.76
N           0.050        0.046      0.055
SA                 -22.1       40.8
*
XS   FULLV      0  * * *   0.0308
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.40      30.0
GR            0.0, 495.30      0.0, 486.32      1.6, 486.31      2.3, 486.07
GR            2.3, 485.81      5.5, 485.67     10.0, 485.77     14.5, 485.89
GR           17.9, 486.14     29.0, 486.90     42.9, 488.24     43.4, 495.51
GR            0.0, 495.30
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      50.4 * *     74.0      3.2
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     22      32.0     1
GR         -181.8, 511.54   -155.8, 499.32    -68.6, 499.95    -17.8, 499.97
GR            0.0, 499.75     40.3, 499.59    155.0, 500.75    174.3, 501.39
GR          182.7, 508.02
*
XT   APTEM     86
GR         -145.6, 511.27   -118.1, 499.64     -9.5, 500.00      0.0, 489.11
GR            4.7, 486.98      8.1, 486.30      9.9, 485.80     13.5, 485.98
GR           17.5, 485.97     20.4, 486.36     38.2, 489.57     45.2, 493.57
GR           54.0, 498.77     65.7, 499.40    147.1, 500.81    179.6, 500.92
GR          199.1, 510.63
*
AS   APPRO     82  * * *  0.0025
GT
N           0.040        0.055        0.040
SA                  -9.5         54.0
*
HP 1 BRIDG   491.77 1 491.77
HP 2 BRIDG   491.77 * * 2490
HP 1 APPRO   494.74 1 494.74
HP 2 APPRO   494.74 * * 2490
*
HP 1 BRIDG   495.51 1 495.51
HP 2 BRIDG   495.51 * * 3700
HP 1 APPRO   499.36 1 499.36
HP 2 APPRO   499.36 * * 3700
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File newf012.wsp
        Hydraulic analysis for structure NEWFVT00300012   Date: 28-JAN-97
        Bridge # 12 on VT 30 over Smith Brook in Newfane, VT  by MAI
           *** RUN DATE & TIME: 02-28-97  17:05
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     193.   18505.    37.    47.                        2484.
   491.77          193.   18505.    37.    47.  1.00     0.    43.   2484.


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

         WSEL     LEW     REW    AREA       K       Q    VEL
       491.77     0.0    43.1   192.7  18505.   2490.  12.92

X STA.        0.0        3.5        5.4        7.1        8.7       10.4
  A(I)           16.9       10.1        9.1        8.6        8.5
  V(I)           7.36      12.32      13.66      14.56      14.73

X STA.       10.4       11.9       13.5       15.1       16.7       18.4
  A(I)            8.1        8.0        8.2        8.0        8.3
  V(I)          15.33      15.47      15.19      15.59      14.96

X STA.       18.4       20.1       21.9       23.8       25.8       27.8
  A(I)            8.2        8.3        8.7        8.7        8.9
  V(I)          15.09      14.95      14.34      14.29      13.93

X STA.       27.8       30.0       32.4       35.0       38.1       43.1
  A(I)            9.1        9.7       10.2       11.0       15.9
  V(I)          13.61      12.85      12.22      11.28       7.81


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      82.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     325.   28068.    52.    57.                        4600.
   494.74          325.   28068.    52.    57.  1.00    -5.    47.   4600.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      82.

         WSEL     LEW     REW    AREA       K       Q    VEL
       494.74    -4.9    47.2   324.7  28068.   2490.   7.67

X STA.       -4.9        2.2        4.7        6.7        8.4       10.0
  A(I)           27.3       18.1       15.6       14.5       14.0
  V(I)           4.57       6.87       8.00       8.58       8.86

X STA.       10.0       11.5       13.0       14.5       16.0       17.5
  A(I)           13.6       13.2       13.0       13.3       13.3
  V(I)           9.14       9.40       9.61       9.39       9.39

X STA.       17.5       19.0       20.7       22.4       24.2       26.1
  A(I)           13.2       13.7       13.9       14.3       14.7
  V(I)           9.44       9.09       8.93       8.68       8.47

X STA.       26.1       28.3       30.8       33.6       37.1       47.2
  A(I)           15.7       16.8       17.3       20.0       29.2
  V(I)           7.92       7.41       7.20       6.21       4.27
```

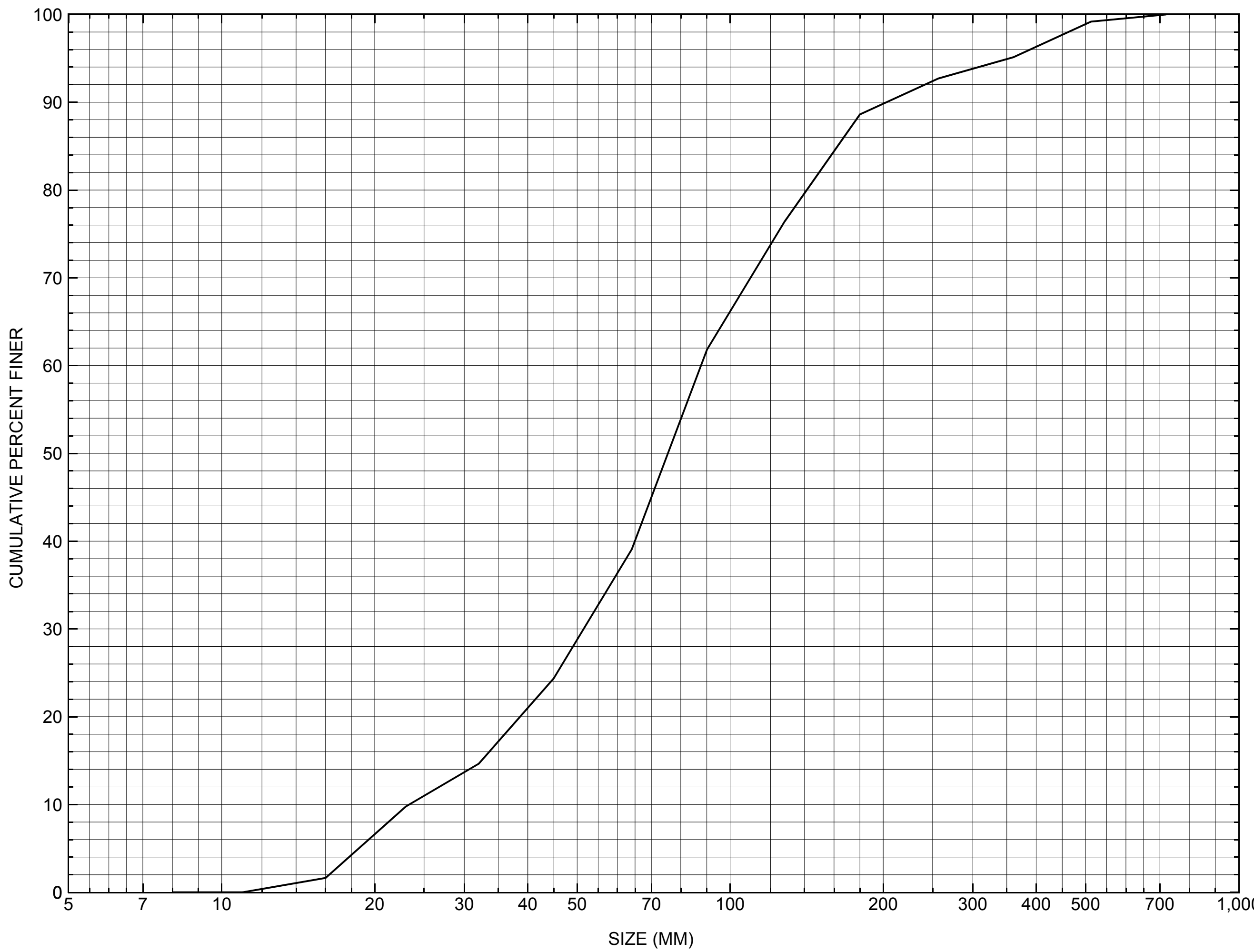
```
      U.S. Geological Survey WSPRO Input File newf012.wsp
      Hydraulic analysis for structure NEWFVT00300012   Date: 28-JAN-97
      Bridge # 12 on VT 30 over Smith Brook in Newfane, VT  by MAI
         *** RUN DATE & TIME: 02-28-97  17:05
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     329.  28768.     0.    91.                            0.
 495.51          329.  28768.     0.    91.  1.00     0.    43.      0.


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

       WSEL     LEW     REW    AREA        K        Q    VEL
     495.51     0.0    43.4   328.9   28768.    3700.  11.25

X STA.        0.0        3.4        5.5        7.4        9.2       10.9
  A(I)           27.0       17.5       15.8       14.8       14.7
  V(I)           6.86      10.57      11.74      12.48      12.59

X STA.       10.9       12.6       14.4       16.1       17.9       19.7
  A(I)           14.2       14.5       14.2       14.3       14.2
  V(I)          13.07      12.74      13.04      12.90      13.07

X STA.       19.7       21.6       23.4       25.4       27.4       29.5
  A(I)           14.6       14.5       14.9       15.2       15.3
  V(I)          12.63      12.80      12.39      12.18      12.11

X STA.       29.5       31.6       33.9       36.3       39.1       43.4
  A(I)           15.5       16.1       17.1       18.2       26.4
  V(I)          11.90      11.49      10.85      10.14       7.01


  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      82.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
           2     593.  66044.    63.    71.                        10317.
           3       3.     56.    11.    11.                           10.
 499.36          596.  66100.    74.    82.  1.01    -9.    65.   9548.


  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      82.

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.36    -9.0    65.1   595.9   66100.    3700.   6.21

X STA.       -9.0        0.7        3.7        6.1        8.2       10.1
  A(I)           52.9       33.9       29.7       26.7       25.5
  V(I)           3.49       5.45       6.23       6.92       7.24

X STA.       10.1       11.9       13.7       15.5       17.2       19.1
  A(I)           24.6       24.0       24.1       23.5       24.1
  V(I)           7.51       7.71       7.67       7.88       7.69

X STA.       19.1       20.9       22.8       24.8       26.9       29.2
  A(I)           23.7       24.7       25.2       25.2       26.8
  V(I)           7.79       7.50       7.34       7.35       6.90

X STA.       29.2       31.7       34.5       37.5       41.6       65.1
  A(I)           27.7       29.7       30.9       36.5       56.4
  V(I)           6.68       6.22       5.99       5.07       3.28
```

```
        U.S. Geological Survey WSPRO Input File newf012.wsp
        Hydraulic analysis for structure NEWFVT00300012   Date: 28-JAN-97
        Bridge # 12 on VT 30 over Smith Brook in Newfane, VT  by MAI
           *** RUN DATE & TIME: 02-28-97  17:05

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

EXITX:XS   ******    -8.     280.  1.44 *****  492.98  491.20   2490.  491.54
      -42. ******    79.   23206.  1.17 ***** *******    0.95    8.90

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.17     491.62     492.49

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   491.04     512.97    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   491.04     512.97     492.49

 ===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 =   492.49     512.97     492.49

FULLV:FV      42.    -8.     250.  1.75 *****  494.24  492.49   2490.  492.49
        0.    42.    78.   20475.  1.13 ***** *******    1.09    9.95
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      82.    -4.     294.  1.12  1.02  495.25 *******   2490.  494.14
       82.    82.    46.   24312.  1.00  0.00    0.00    0.62    8.48
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    2490.      491.77

             <<<<<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      42.     0.     193.  2.59 *****  494.37  491.77   2490.  491.77
        0.    42.    43.   18527.  1.00 ***** *******    1.00   12.91

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  495.40 ****** ****** ******

    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      32.    -5.     325.  0.91  0.38  495.66  492.33   2490.  494.74
       82.    32.    47.   28078.  1.00  0.91    0.01    0.54    7.67

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.146  0.000   30018.    -2.    42.   494.35


  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -42.    -8.    79.   2490.   23206.     280.    8.90  491.54
   FULLV:FV       0.    -8.    78.   2490.   20475.     250.    9.95  492.49
   BRIDG:BR       0.     0.    43.   2490.   18527.     193.   12.91  491.77
   RDWAY:RG      22.**************      0.******************    1.00********
   APPRO:AS      82.    -5.    47.   2490.   28078.     325.    7.67  494.74

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -2.    42.   30018.


 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    491.20    0.95  484.43  511.68************  1.44  492.98  491.54
   FULLV:FV    492.49    1.09  485.72  512.97************  1.75  494.24  492.49
   BRIDG:BR    491.77    1.00  485.67  495.51************  2.59  494.37  491.77
   RDWAY:RG  ***************  499.32  511.54**********************************
   APPRO:AS    492.33    0.54  485.79  511.26  0.38  0.91  0.91  495.66  494.74
```

```
       U.S. Geological Survey WSPRO Input File newf012.wsp
       Hydraulic analysis for structure NEWFVT00300012   Date: 28-JAN-97
       Bridge # 12 on VT 30 over Smith Brook in Newfane, VT  by MAI
          *** RUN DATE & TIME: 02-28-97  17:05

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

EXITX:XS   ******   -11.     386.  1.70 *****  494.42  492.45   3700.  492.72
      -42. ******    81.   34487.  1.19 ***** *******    0.90    9.59

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.82     492.22     493.74

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.22     512.97    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.22     512.97     493.74

 ===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 =   493.74     512.97     493.74

FULLV:FV      42.   -10.     361.  1.95 *****  495.69  493.74   3700.  493.74
        0.    42.    81.   31640.  1.19 ***** *******    0.99   10.26
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      82.    -5.     341.  1.84  1.18  496.88 *******   3700.  495.04
       82.    82.    48.   30037.  1.00  0.00    0.01    0.75   10.86
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   493.36     496.51     496.88     495.40

 ===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      42.     0.     329.  1.99 *****  497.50  493.38   3720.  495.51
        0. ******    43.   28768.  1.00 ***** *******    0.72   11.31

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.495 ******  495.40 ****** ****** ******

    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      32.    -9.     596.  0.60  0.23  499.97  493.79   3700.  499.36
       82.    32.    65.   66156.  1.01  0.90    0.01    0.39    6.21


  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -42.   -11.    81.   3700.   34487.     386.    9.59  492.72
   FULLV:FV       0.   -10.    81.   3700.   31640.     361.   10.26  493.74
   BRIDG:BR       0.     0.    43.   3720.   28768.     329.   11.31  495.51
   RDWAY:RG      22.**************      0.       0.       0.    1.00********
   APPRO:AS      82.    -9.    65.   3700.   66156.     596.    6.21  499.36


 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
   EXITX:XS    492.45    0.90  484.43  511.68************  1.70  494.42  492.72
   FULLV:FV    493.74    0.99  485.72  512.97************  1.95  495.69  493.74
   BRIDG:BR    493.38    0.72  485.67  495.51************  1.99  497.50  495.51
   RDWAY:RG  ****************  499.32  511.54************  0.60  499.81********
   APPRO:AS    493.79    0.39  485.79  511.26  0.23  0.90  0.60  499.97  499.36
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NEWFVT00300012, in Newfane, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NEWFVT00300012

General Location Descriptive

Data collected by *(First Initial, Full last name)* E. BOEHMLER

Date *(MM/DD/YY)* 03 / 30 / 95

Highway District Number *(I - 2; nn)* 02

County *(FIPS county code; I - 3; nnn)* 025

Town *(FIPS place code; I - 4; nnnnn)* 48400

Mile marker *(I - 11; nnn.nnn)* 002240

Waterway *(I - 6)* SMITH BROOK

Road Name *(I - 7):* -

Route Number VT030

Vicinity *(I - 9)* 5.6 MI S JCT. VT.35

Topographic Map Newfane

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 42585

Longitude *(i - 17; nnnnn.n)* 72395

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20001500121312

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

Maximum span length *(I - 48; nnnn)* 0040

Year built *(I - 27; YYYY)* 1945

Structure length *(I - 49; nnnnnn)* 000043

Average daily traffic, ADT *(I - 29; nnnnnn)* 005050

Deck Width *(I - 52; nn.n)* 320

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

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

Opening skew to Roadway *(I - 34; nn)* 25

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

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

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

Structure type *(I - 43; nnn)* 104

Year Reconstructed *(I - 106)* 1971

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 009.0

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

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

Comments:

The structural inspection report of 10/28/93 indicates the structure is a concrete T-beam type bridge. The abutment walls and wingwalls are concrete. Both abutment walls have newer concrete sections on the downstream ends and steel-beam span from bridge widening construction in 1971. The older sections of concrete reportedly have some minor rust stains. There is a laid-up stone wingwall on the upstream end of the left abutment which has a few stones reportedly falling out of place. The left abutment footing is exposed at the downstream end (newer section) about 0.5 feet. There is good stone fill coverage reported at all four corners of the bridge. The streambed consists of stone, **(Continued, page 31)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

Comments:

coarse gravel and boulders. There are some noticeable areas of minor bank erosion reported both upstream and downstream. The waterway makes a moderate bend into the crossing with the majority of the flow along the left abutment side of the channel. There is a gravel point bar reported along the right abutment. Debris accumulation is reported as minor at this site.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **9.55** mi^2 Lake and pond area **0** mi^2

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

Bridge site elevation **505** ft Headwater elevation **1476** ft

Main channel length **3.63** mi

10% channel length elevation **512** ft 85% channel length elevation **984** ft

Main channel slope *(S)* **173.77** 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)*: 02 / 1970

Project Number BMA 6919 Minimum channel bed elevation: 481.0

Low superstructure elevation: USLAB 493.3 DSLAB 492.03 USRAB 493.39 DSRAB 492.03

Benchmark location description:

There are no specific benchmarks shown on the plans. A couple of points shown on the plans with elevations are: 1) the point on the top streamward edge of the concrete downstream left wingwall where the concrete slope changes from horizontal to downward, elevation 495.47; and 2) the point at the same location but on the downstream right wingwall, elevation 495.47.

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

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

If 1: Footing Thickness 2.5 Footing bottom elevation: 480.0

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

-

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 10/31/96
Computerized by: EW Date: 11/13/96
Reviewd by: MAL Date: 03/21/97

Structure Number NEWFVT00300012

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* L. MEDALIE Date *(MM/DD/YY)* 08 / 21 / 1996
2. Highway District Number 02 Mile marker 002240
   County WINDHAM (025) Town NEWFANE (48400)
   Waterway *(I - 6)* SMITH BROOK Road Name ROUTE 30
   Route Number VT 30 Hydrologic Unit Code: 01080107
3. Descriptive comments:

Located 5.6 miles south of junction with Vermont 35.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 4 LBDS 4 RBDS 6 Overall 4
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 1 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 43 *(feet)* Span length 40 *(feet)* Bridge width 32 *(feet)*

Road approach to bridge:

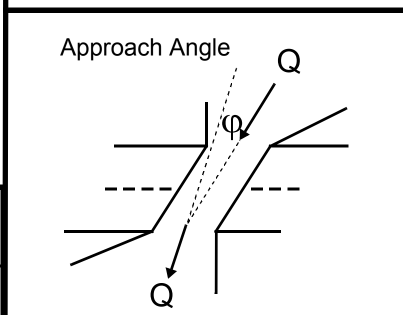
8. LB 0 RB 2 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

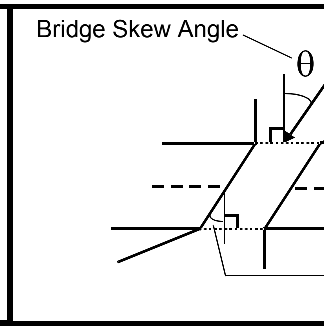
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

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





α= 30.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 115 feet US *(US, UB, DS)* to 34 feet US
Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 20 feet DS *(US, UB, DS)* to 112 feet DS

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

18. Bridge Type: **1a**

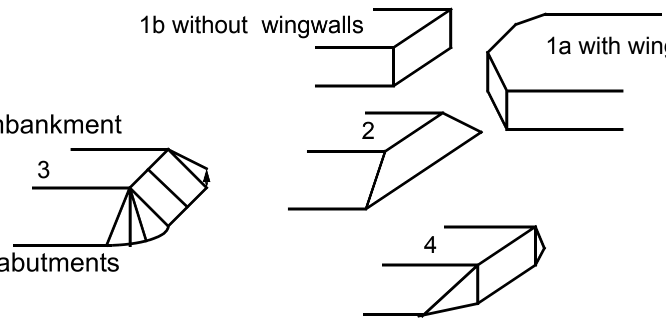
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4: The right bank downstream surface cover is grass on the immediate bank with forest beyond. The left bank downstream is a flat grass covered area. Along the right bank upstream, a paved road extends parallel to the stream, with grass and small brush beyond it. A gravel driveway runs parallel to the upstream left bank with a grass on the flood plain and shrubs on the hillside above it.

7: Values are from the VTAOT database. On site measurements were: bridge length of 46 feet; bridge span of 40 feet; and bridge width was 33 feet between road edges (35 feet between bridge faces).

8: The left bank road approach is even for the first 80 feet, then the road drops.

18: The bridge type is 1a upstream and type 4 downstream.

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
37.5	**13.0**			**9.0**	**4**	**3**	**4532**	**32**	**3**	**1**

23. Bank width **40.0** 24. Channel width **30.0** 25. Thalweg depth **63.5** 29. Bed Material **435**

30 .Bank protection type: LB **2** RB **0** 31. Bank protection condition: LB **1** RB **-**

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

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

The left bank protection extends from 35 feet upstream to the upstream bridge face.

The right bank vegetation cover is less than 25% for the first 80 feet.

33. Point/Side bar present? Y (*Y or N. if N type ctrl-n pb*) 34. Mid-bar distance: 0 DS 35. Mid-bar width: 20
36. Point bar extent: 50 feet US (*US, UB*) to 34 feet US (*US, UB, DS*) positioned 40 %LB to 100 %RB
37. Material: 34
38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):

39. Is a cut-bank present? Y (*Y or if N type ctrl-n cb*) 40. Where? LB (*LB or RB*)
41. Mid-bank distance: 74 42. Cut bank extent: 120 feet US (*US, UB*) to 35 feet US (*US, UB, DS*)
43. Bank damage: 3 (***1***- *eroded and/or creep;* ***2***- *slip failure;* ***3***- *block failure*)
44. Cut bank comments (eg. additional cut banks, protection condition, etc.):

45. Is channel scour present? N (*Y or if N type ctrl-n cs*) 46. Mid-scour distance: -
47. Scour dimensions: Length - Width - Depth : - Position - %LB to - %RB
48. Scour comments (eg. additional scour areas, local scouring process, etc.):
NO CHANNEL SCOUR

49. Are there major confluences? 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
33.5		0.5		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.):
435

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

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

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

70. Debris and Ice Comments:

1

Moderate. There is some debris caught on boulders and trees leaning over the channel upstream.

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		10	90	2	2	0	1	90.0
RABUT	1	0	90			2	0	37.5

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.):

-

-

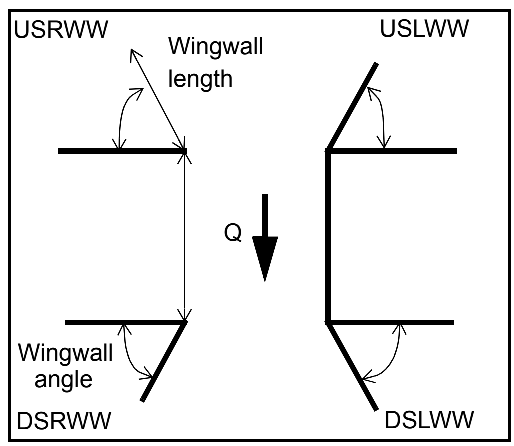
1

The left abutment footing is exposed along the downstream end below the newer section of the abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						37.5	
USRWW:	Y		1		0	0.5	
DSLWW:	-		-		Y	48.0	
DSRWW:	1		0		-	41.0	

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	-	2	Y	-	1	-	2	-
Condition	Y	-	1	-	1	-	2	-
Extent	1	0.25	0	2	0	2	0	-

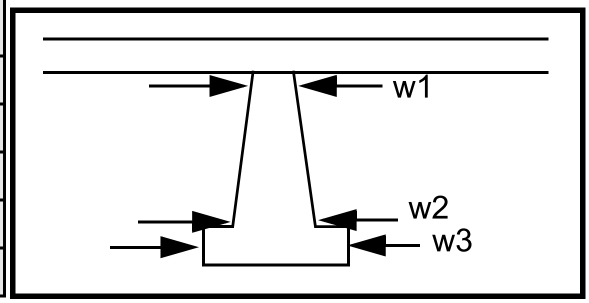
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
2
3
0
-
-

Piers:

84. Are there piers? **80:** (*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**		**120.0**	**25.0**	**12.0**
Pier 2				**25.0**	**10.5**	**110.0**
Pier 3		**-**	**-**	**11.0**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**The**	**for 5**	**is**	**the**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**DSL**	**feet**	**“laid**	**wing**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**WW**	**hori-**	**-up”**	**wall**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**foot-**	**zon-**	**stone**	**is**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**ing is**	**tally.**	**with**	**con-**	*Y- yes; N- no*
91. Attack ∠ (BF)	**expo**	**The**	**a**	**crete**	
92. Pushed	**sed**	**upst**	**con-**	**.**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**alon**	**ream**	**crete**		
95. Cross-members	**g the**	**half**	**cap;**	**82:**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**upst**	**of**	**the**	**The**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**ream**	**USL**	**rest**	**left**	
98. Exposure depth	**end**	**WW**	**of**	**abut**	

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

ment protection is along the upstream end. There are some scattered boulders along downstream end of the left abutment.

N

-

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width (Amb) - Thalweg depth (Amb) - Bed Material -

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

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

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

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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

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

105. Drop structure comments (eg. downstream scour depth):

-
-
-
-
-
-

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

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

Material: -

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

-
-
-
NO PIERS

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.):

1
1
354

Is channel scour present? **23** (Y or if N type ctrl-n cs) Mid-scour distance: **0**

Scour dimensions: Length **2** Width **345** Depth: **2** Positioned **2** %LB to **2** %RB

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

1
Along both banks, the vegetation cover is 0 to 25% to 90 feet downstream, then it is 26 to 50%.

Protection along the right bank consists of a few stones (diameter of 1-2 feet) from end of wingwall to 7 feet

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

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

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

Confluence comments (eg. confluence name):

protection extends from 15 feet downstream (along base of wingwall) to 40 feet downstream.

F. Geomorphic Channel Assessment

107. Stage of reach evolution **Th**

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)*:

ere is a 90 degree turn in the stream to the left at approximately 250 feet downstream of bridge. A few large trees have fallen into channel where cut-bank (right bank) and point bar (left bank) are present.

N

-

NO DROP STRUCTURE

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: NEWFVT00300012 Town: Newfane
Road Number: VT 30 County: Windham
Stream: Smith Brook

Initials MAI Date: 02/28/97 Checked: RHF

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	2490	3700	0
Main Channel Area, ft2	325	593	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	3	0
Top width main channel, ft	52	63	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	11	0
D50 of channel, ft	0.247	0.247	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.3	9.4	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	0.3	ERR
Total conveyance, approach	28068	66100	0
Conveyance, main channel	28068	66044	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	56	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	2490.0	3696.9	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	3.1	ERR
Vm, mean velocity MC, ft/s	7.7	6.2	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	1.0	ERR
Vc-m, crit. velocity, MC, ft/s	9.5	10.2	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

ARMORING

D90	0.666	0.666	0
D95	1.161	1.161	0
Critical grain size,Dc, ft	0.8131	0.4952	ERR
Decimal-percent coarser than Dc	0.077	0.177	0
Depth to armoring,ft	29.24	6.91	ERR

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	325	593	0
Main channel width, ft	52	63	0
y1, main channel depth, ft	6.25	9.41	ERR

Bridge Section			
(Q) total discharge, cfs	2490	3700	0
(Q) discharge thru bridge, cfs	2490	3700	0
Main channel conveyance	18505	28768	0
Total conveyance	18505	28768	0
Q2, bridge MC discharge,cfs	2490	3700	ERR
Main channel area, ft2	193	329	0
Main channel width (skewed), ft	37.3	37.6	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.3	37.6	0
y_bridge (avg. depth at br.), ft	5.17	8.75	ERR
Dm, median (1.25*D50), ft	0.309	0.309	0
y2, depth in contraction,ft	6.34	8.85	ERR
ys, scour depth (y2-ybridge), ft	1.18	0.10	N/A

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	2490	3700	0
Q, thru bridge, cfs	2490	3700	0
Total Conveyance, bridge	18505	28768	0
Main channel(MC) conveyance, bridge	18505	28768	0
Q, thru bridge MC, cfs	2490	3700	ERR
Vc, critical velocity, ft/s	9.55	10.22	N/A
Vc, critical velocity, m/s	2.91	3.11	N/A
Main channel width (skewed), ft	37.3	37.6	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.3	37.6	0.0
qbr, unit discharge, ft2/s	66.8	98.4	ERR
qbr, unit discharge, m2/s	6.2	9.1	N/A
Area of full opening, ft2	192.7	328.9	0.0
Hb, depth of full opening, ft	5.17	8.75	ERR
Hb, depth of full opening, m	1.57	2.67	N/A
Fr, Froude number, bridge MC	0	0.72	0

Cf, Fr correction factor (<=1.0)	0.00	1.00	0.00
Elevation of Low Steel, ft	0	495.4	0
Elevation of Bed, ft	-5.17	486.65	N/A
Elevation of Approach, ft	0	499.36	0
Friction loss, approach, ft	0	0.23	0
Elevation of WS immediately US, ft	0.00	499.13	0.00
ya, depth immediately US, ft	5.17	12.48	N/A
ya, depth immediately US, m	1.57	3.80	N/A
Mean elevation of deck, ft	0	499.67	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.91	ERR
Ys, depth of scour, ft	N/A	1.85	N/A

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

y2, from Laursen's equation, ft	6.342692	8.85	0
Full valley WSEL, ft	0	493.74	0
Full valley depth, ft	5.16622	7.09	N/A
Ys, depth of scour (y2-yfullv), ft	N/A	1.76	N/A

Abutment Scour

Froehlich's Abutment Scour

$Ys/Y1 = 2.27*K1*K2*(a'/Y1)^{0.43}*Fr1^{0.61}+1$

(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	2490	3700	0	2490	3700	0
a', abut.length blocking flow, ft	7.8	11.9	0	7	24.6	0
Ae, area of blocked flow ft2	32.4	77.8	0	20.2	66.2	0
Qe, discharge blocked abut.,cfs	159.4	320.7	0	89.3	234.6	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.92	4.12	ERR	4.42	3.54	ERR
ya, depth of f/p flow, ft	4.15	6.54	ERR	2.89	2.69	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	115	115	115	65	65	65
K2	1.03	1.03	1.03	0.96	0.96	0.96
Fr, froude number f/p flow	0.425	0.284	ERR	0.459	0.381	ERR
ys, scour depth, ft	10.37	14.08	N/A	7.57	9.59	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)	7.8	11.9	0	7	24.6	0
y1 (depth f/p flow, ft)	4.15	6.54	ERR	2.89	2.69	ERR
a'/y1	1.88	1.82	ERR	2.43	9.14	ERR
Skew correction (p. 49, fig. 16)	1.06	1.06	1.06	0.92	0.92	0.92
Froude no. f/p flow	0.43	0.28	N/A	0.46	0.38	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)

Characteristic	Q100	Q500	Qother	Q100	Q500	Qother
Fr, Froude Number	1	0.72	0	1	0.72	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.17	8.75	0.00	5.17	8.75	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	2.80	0.00	ERR	2.80	0.00
Fr>0.8 (vertical abut.)	2.16	ERR	ERR	2.16	ERR	ERR