LEVEL II SCOUR ANALYSIS FOR BRIDGE 28 (HARDTH00300028) on TOWN HIGHWAY 30, crossing the LAMOILLE RIVER, HARDWICK, VERMONT

U.S. Geological Survey
Open-File Report 96-569

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

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By SCOTT A. OLSON and JAMES R. DEGNAN

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Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 28 (HARDTH00300028) ON TOWN HIGHWAY 30, CROSSING THE LAMOILLE RIVER, HARDWICK, VERMONT

***By* Scott A. Olson and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure HARDTH00300028 on town highway 30 crossing the Lamoille River, Hardwick, 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 section of the New England physiographic province in north-central Vermont. The 63.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover upstream and on the downstream right is primarily pasture with some row crops. Trees line the immediate channel banks. The left bank downstream surface cover is primarily brush.

In the study area, the Lamoille River has an incised, sinuous channel with a slope of approximately 0.002 ft/ft, an average channel top width of 76 ft and an average bank height of 6 ft. The predominant channel bed materials are gravel and cobble with a median grain size (D_{50}) of 46.6 mm (0.153 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 25, 1995, indicated that the reach was laterally unstable. The site was revisited on August 21, 1995, after the August 5-6, 1995 flood on the Lamoille River. Findings from this follow-up visit are presented in Appendix G.

The town highway 30 crossing of the Lamoille River is a 54-ft-long, one-lane bridge consisting of one 52-foot steel-beam span (Vermont Agency of Transportation, written communication, April 3, 1995). The bridge is supported by vertical, stone abutments with wingwalls. Scour, about one foot below the mean thalweg, exists along the right abutment and right upstream wingwall. Sheet piling has been driven around the right abutment and wingwalls and filled with concrete. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is 0 degrees. 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 1.9 to 2.5 ft. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 11.2 to 17.8 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled "Scour Results". Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Caspian Lake, VT. Quadrangle, 1:24,000, 1986

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 HARDTH00300028 ***Stream*** Lamoille River

County Caledonia ***Road*** TH30 ***District*** 7

Description of Bridge

Bridge length 54 ***ft*** ***Bridge width*** 16.1 ***ft*** ***Max span length*** 52 ***ft***

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

Abutment type Vertical, stone ***Embankment type*** Sloping

Stone fill on abutment? Yes, right ***Date of inspection*** 7/25/95

Description of stone fill Type-2 (less than 36 inches in diameter) along the sheet piling that is around the right abutment and wingwalls.

Brief description of piers/abutments Abutments and wingwalls are stone. Sheet piling has been driven around the right abutment and filled with concrete. Both abutments have concrete caps.

Is bridge skewed to flood flow according to Y ***survey?*** Y ***Angle*** 5

Is bridge located on a bend in channel? If so, describe (mild, moderate, severe) There is a mild channel bend in the upstream and downstream reaches.

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	7/25/95	0	0
Level II	7/25/95	0	0

Potential for debris Low to moderate. Landowner says ice jamming is a frequent problem, flooding the upstream fields for about a day.

Describe any features near or at the bridge that may affect flow (include observation date) None evident on July 25 or August 21, 1995.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with flat to slightly irregular flood plains.

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

Date of inspection 7/25/95

DS left: Narrow flood plain

DS right: Flood plain

US left: Flood plain

US right: Flood plain

Description of the Channel

Average top width 76 ***ft*** ***Average depth*** 6 ***ft***

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

This perennial stream is sinuous with alluvial channel boundaries and a flood plain.

7/25/95

Vegetative co Brush and grass.

DS left: Pasture with row crops. Trees along immediate channel bank.

DS right: Pasture with row crops. Trees along immediate channel bank.

US left: Pasture with row crops. Trees along immediate channel bank.

US right:

N

Do banks appear stable? ***If not, describe location and type of instability and date of observation.*** July 25, 1995 and August 21, 1995. The cut banks into alluvial boundaries and point bars suggest that this is a laterally unstable reach. However, the structure was built in 1950 and the channel is still aligned with the abutments.

None. July 25, 1995 and August 21, 1995.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 63.7 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 8,630 ***ft³/s*** ***Q500*** 12,300 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(63.7/60.0)exp 0.67] with flood frequency estimates reported in the Flood Insurance Study for the Town of Hardwick (Federal Emergency Management Agency, 1987) for a location on the Lamoille River where the drainage area is 60.0 square miles.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the right abutment (elev. 500.35 ft, arbitrary datum). RM2 is a chiseled square on top of the upstream end of the left abutment (elev. 500.89 ft, arbitrary datum). RM3 is a chiseled X on top of the downstream end of the right abutment (elev. 500.47 ft, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-59	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPRO	76	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 0.036 to 0.038, and overbank "n" values were 0.045.

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 0.0017 ft/ft which was the stream bed profile downstream of the bridge in the Flood Insurance Study for the Town of Hardwick (Federal Emergency Management Agency, 1987). There is potential for backwater from Hardwick bridge 29 located about 1400 feet downstream. A model between the bridges was developed with the approach section of the downstream bridge. This section was used as a template and was placed along the stream-bed profile taken from the Flood Insurance Study between the two bridges. For each modelled discharge, the water surface profile converged onto normal depth downstream of bridge 28 in Hardwick.

The approach section (APPRO) was surveyed approximately 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.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.9 *ft*
Average low steel elevation 498.3 *ft*

100-year discharge 8,630 *ft^3/s*
Water-surface elevation in bridge opening 498.5 *ft*
Road overtopping? Y *Discharge over road* 2,570 *ft^3/s*
Area of flow in bridge opening 560 *ft^2*
Average velocity in bridge opening 10.7 *ft/s*
Maximum WSPRO tube velocity at bridge 12.4 *ft/s*

Water-surface elevation at Approach section with bridge 501.6
Water-surface elevation at Approach section without bridge 499.1
Amount of backwater caused by bridge 2.5 *ft*

500-year discharge 12,300 *ft^3/s*
Water-surface elevation in bridge opening 498.5 *ft*
Road overtopping? Y *Discharge over road* 6,260 *ft^3/s*
Area of flow in bridge opening 560 *ft^2*
Average velocity in bridge opening 10.7 *ft/s*
Maximum WSPRO tube velocity at bridge 12.4 *ft/s*

Water-surface elevation at Approach section with bridge 503.0
Water-surface elevation at Approach section without bridge 500.5
Amount of backwater caused by bridge 2.5

Incipient overtopping discharge 5,060 *ft^3/s*
Water-surface elevation in bridge opening 495.7 *ft*
Area of flow in bridge opening 427 *ft^2*
Average velocity in bridge opening 11.9 *ft/s*
Maximum WSPRO tube velocity at bridge 14.3 *ft/s*

Water-surface elevation at Approach section with bridge 498.3
Water-surface elevation at Approach section without bridge 496.8
Amount of backwater caused by bridge 1.5 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146) for the 100-year and 500-year discharges, where orifice flow occurred 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). Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the incipient overtopping dischange. The results of the Laursen's clear-water scour equation were also computed for the 100-year and 500-year discharges, and can be found in appendix F. For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. In this case, the 100-year model resulted in the worst-case contraction scour with a scour depth of 2.5 ft. However, it was not the worst-case total scour.

Abutment scour was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. Variables for the HIRE 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	2.5 2.4	1.9	6.2 6.3
Depth to armoring	14.6	--	--
Left overbank	--	--	--
Right overbank	--	15.9	17.8
Local scour:			
Abutment scour	12.2	14.2	16.1
Left abutment	11.2	--	--
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	2.2	2.2
Pier 3			

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:	3.3	2.2	2.2
Left abutment	3.3	--	--
Right abutment	--	--	--
Piers:			
Pier 1	--	--	--
Pier 2	--		

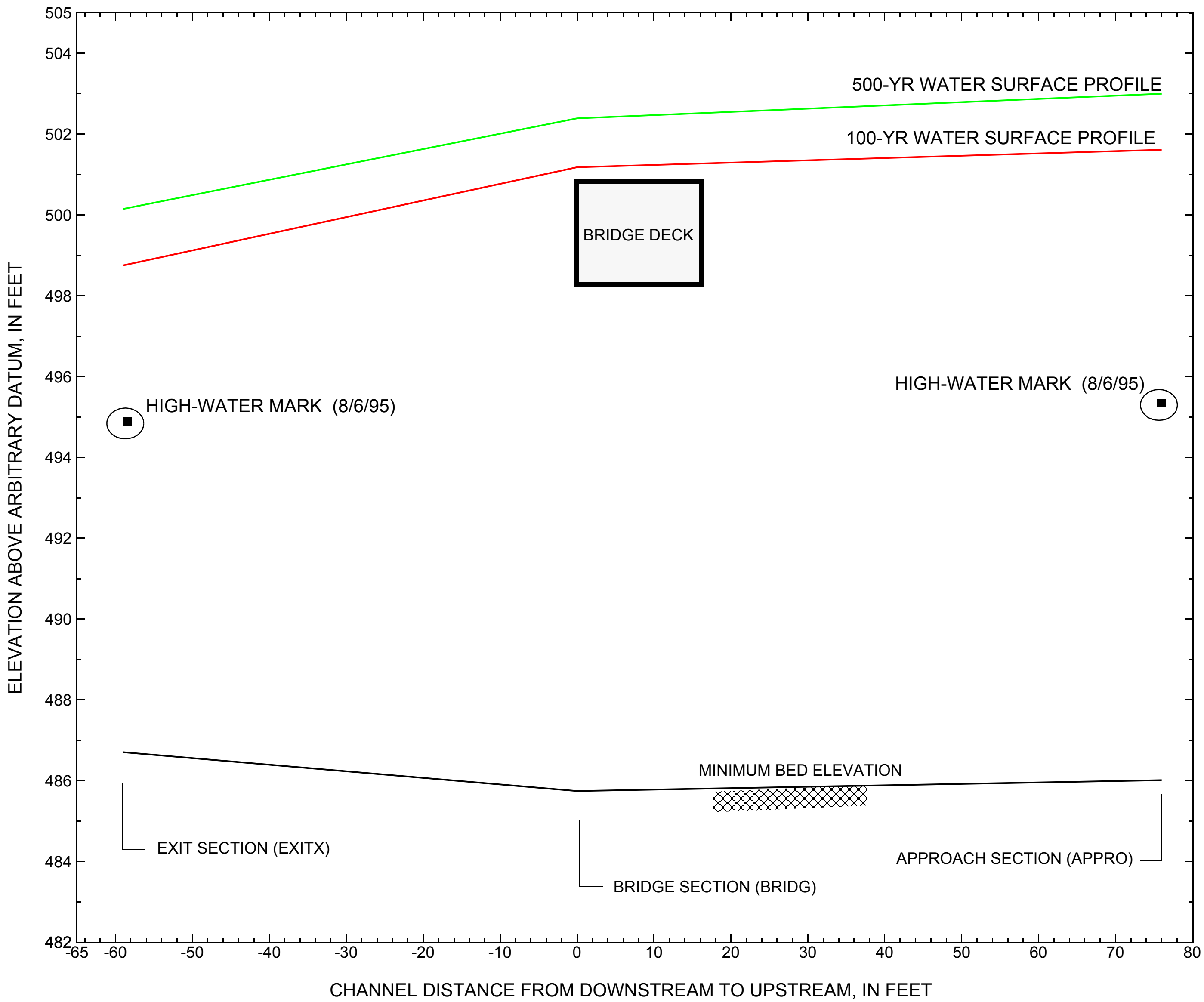

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure HARDTH00300028 on town highway 30, crossing the Lamoille River, Hardwick, Vermont.

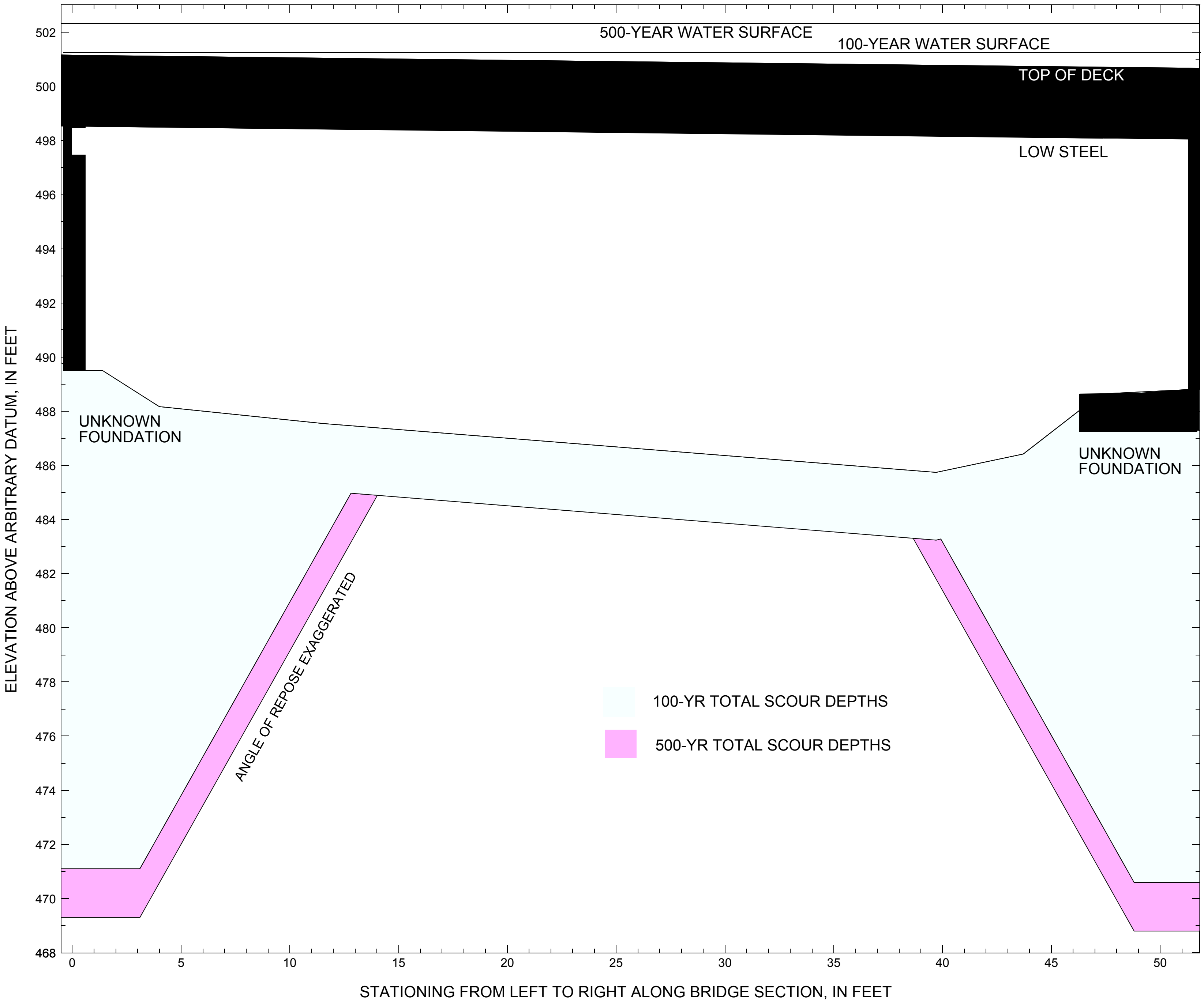

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure HARDTH00300028 on town highway 30, crossing the Lamoille River, Hardwick, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HARDTH00300028 on Town Highway 30, crossing the Lamoille River, Hardwick, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing 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 8,630 cubic-feet per second											
Left abutment	0.6	--	498.52	--	489.5	2.5	15.9	--	18.4	471.1	--
Right abutment	51.3	--	498.04	--	487.3	2.5	14.2	--	16.7	470.6	--

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 HARDTH00300028 on Town Highway 30, crossing the Lamoille River, Hardwick, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing 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 12,300 cubic-feet per second											
Left abutment	0.6	--	498.52	--	489.5	2.4	17.8	--	20.2	469.3	--
Right abutment	51.3	--	498.04	--	487.3	2.4	16.1	--	18.5	468.8	--

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

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T1        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard028.wsp
T2        CREATED ON 11-AUG-95 FOR BRIDGE HARDTH00300028 USING FILE hard028.dca
T3        HYDRAULIC ANALYSIS OF HARD028     SAO
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          8630 12300 5060
SK         0.0017 0.0017 0.0017
*
XS   EXITX   -59
GR          -90.2, 500.56    -74.2, 496.26    -59.2, 494.09    -19.4, 493.53
GR           -6.3, 492.07      0.0, 488.18      8.0, 486.70     12.5, 487.30
GR           26.2, 487.42     35.1, 487.15     39.4, 487.38     45.8, 487.18
GR           53.3, 487.64     56.8, 488.03     67.6, 491.55     79.4, 494.74
GR          166.0, 494.84    196.6, 498.26    324.0, 498.36    329.8, 506.49
N           0.045        0.038       0.045
SA                -6.3          79.4
*
XS   FULLV      0
*
BR   BRIDG   0 498.3
GR            0.0, 498.52      0.2, 497.31      0.6, 497.27      1.4, 489.49
GR            4.0, 488.17     11.5, 487.55     23.7, 486.77     33.5, 486.12
GR           39.7, 485.74     43.7, 486.42     46.4, 488.10     47.2, 487.30
GR           47.4, 488.64     51.0, 488.76     51.3, 498.04      0.0, 498.52
N             0.036
CD            4 20.5 2.2 499.3 50.0 0.0
*
XR   RDWAY     10      16.1   2
GR         -188.7, 500.80   -155.7, 501.05   -131.1, 499.05   -107.0, 498.16
GR          -53.1, 498.30      0.0, 501.11     50.3, 500.70     98.6, 500.89
GR          151.6, 501.11    203.2, 502.59    244.8, 505.12    290.8, 509.95
*
AS   APPRO   76
GR         -223.0, 501.52   -203.4, 498.50   -137.7, 495.69   -114.7, 494.41
GR            0.0, 493.05      6.4, 488.92      9.1, 488.23     16.4, 487.62
GR           25.6, 487.60     39.4, 486.46     45.2, 486.01     49.1, 486.73
GR           53.1, 487.51     53.9, 488.10     56.0, 489.61     61.6, 493.73
GR           66.5, 495.15    123.6, 496.16    153.7, 499.11    185.7, 499.59
GR          222.9, 499.88    250.1, 508.54
N            0.045    0.038     0.045
SA               0.0        66.5
*
HP 1 BRIDG  498.52 1 498.52
HP 2 BRIDG  498.52 * * 5997
HP 2 RDWAY  501.18 * * 2568
HP 1 APPRO  501.61 1 501.61
HP 2 APPRO  501.61 * * 8630
*
HP 1 BRIDG  498.52 1 498.52
HP 2 BRIDG  498.52 * * 6013
HP 2 RDWAY  502.39 * * 6256
HP 1 APPRO  503.00 1 503.00
HP 2 APPRO  503.00 * * 12300
*
HP 1 BRIDG  495.65 1 495.65
HP 2 BRIDG  495.65 * * 5060
```

APPENDIX B:

WSPRO OUTPUT FILE

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard028.wsp
        CREATED ON 11-AUG-95 FOR BRIDGE HARDTH00300028 USING FILE hard028.dca
        HYDRAULIC ANALYSIS OF HARD028     SAO
           *** RUN DATE & TIME: 06-12-96  14:42
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     560.   64063.     0.   122.                          0.
   498.52          560.   64063.     0.   122.  1.00     0.    51.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.52     0.0    51.3   560.4   64063.    5997.  10.70
X STA.         0.0         5.4         8.4        11.0        13.4        15.8
  A(I)              44.8        30.7        27.8        27.0        26.5
  V(I)              6.69        9.76       10.78       11.11       11.31

X STA.        15.8        18.1        20.4        22.5        24.7        26.8
  A(I)              25.8        25.2        24.6        25.0        24.4
  V(I)             11.61       11.91       12.18       12.01       12.27

X STA.        26.8        28.9        30.9        33.0        35.0        37.0
  A(I)              24.7        24.2        24.3        24.9        24.4
  V(I)             12.12       12.38       12.35       12.05       12.30

X STA.        37.0        39.0        41.2        43.4        46.3        51.3
  A(I)              24.7        26.2        27.1        31.7        46.2
  V(I)             12.14       11.43       11.05        9.46        6.49

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.
         WSEL     LEW     REW    AREA        K        Q    VEL
       501.18  -188.7   154.0   377.7   17226.    2568.   6.80
X STA.      -188.7      -130.1      -120.4      -113.2      -107.2      -101.9
  A(I)              38.5        22.6        19.2        17.4        16.1
  V(I)              3.34        5.67        6.70        7.38        7.98

X STA.      -101.9       -96.9       -91.9       -87.1       -82.3       -77.5
  A(I)              14.9        15.0        14.4        14.2        14.1
  V(I)              8.65        8.59        8.92        9.06        9.10

X STA.       -77.5       -72.8       -68.0       -63.2       -58.5       -53.5
  A(I)              13.9        13.8        13.9        13.8        14.3
  V(I)              9.24        9.28        9.21        9.32        8.96

X STA.       -53.5       -48.1       -41.7       -32.8       -16.0       154.0
  A(I)              14.9        15.7        18.2        22.9        49.9
  V(I)              8.63        8.16        7.06        5.61        2.57

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      76.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1383.  154326.   223.   223.                      19538.
             2     868.  181972.    67.    70.                      17804.
             3     606.   48360.   162.   162.                       6662.
   501.61         2857.  384658.   451.   456.  1.47  -223.   228.  33690.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      76.
         WSEL     LEW     REW    AREA        K        Q    VEL
       501.61  -223.0   228.3  2857.5  384658.    8630.   3.02
X STA.      -223.0      -150.3      -119.2       -96.0       -74.2       -54.5
  A(I)             256.9       190.4       168.4       164.7       153.2
  V(I)              1.68        2.27        2.56        2.62        2.82

X STA.       -54.5       -35.3       -17.4        -0.3         9.3        15.7
  A(I)             154.1       147.9       144.2       108.7        87.2
  V(I)              2.80        2.92        2.99        3.97        4.95

X STA.        15.7        21.7        27.8        33.7        39.2        44.6
  A(I)              84.6        84.9        85.3        82.1        83.3
  V(I)              5.10        5.08        5.06        5.25        5.18

X STA.        44.6        50.3        58.3        82.2       117.0       228.3
  A(I)              86.2       103.7       164.5       204.7       302.7
  V(I)              5.01        4.16        2.62        2.11        1.43
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard028.wsp
        CREATED ON 11-AUG-95 FOR BRIDGE HARDTH00300028 USING FILE hard028.dca
        HYDRAULIC ANALYSIS OF HARD028     SAO
           *** RUN DATE & TIME: 06-12-96  14:42
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     560.   64063.     0.   122.                           0.
   498.52          560.   64063.     0.   122.  1.00     0.    51.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.52     0.0    51.3   560.4   64063.    6013.  10.73
X STA.         0.0        5.4        8.4       11.0       13.4       15.8
  A(I)            44.8       30.7       27.8       27.0       26.5
  V(I)            6.71       9.78      10.81      11.14      11.34

X STA.        15.8       18.1       20.4       22.5       24.7       26.8
  A(I)            25.8       25.2       24.6       25.0       24.4
  V(I)           11.64      11.94      12.22      12.05      12.30

X STA.        26.8       28.9       30.9       33.0       35.0       37.0
  A(I)            24.7       24.2       24.3       24.9       24.4
  V(I)           12.15      12.41      12.39      12.08      12.33

X STA.        37.0       39.0       41.2       43.4       46.3       51.3
  A(I)            24.7       26.2       27.1       31.7       46.2
  V(I)           12.17      11.46      11.08       9.48       6.51

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.
         WSEL     LEW     REW    AREA        K        Q    VEL
       502.39  -188.7   196.2   817.9   49891.    6256.   7.65
X STA.      -188.7     -147.7     -131.2     -120.6     -111.5     -103.8
  A(I)            61.8       43.9       37.5       35.4       32.3
  V(I)            5.07       7.13       8.35       8.84       9.68

X STA.      -103.8      -96.2      -88.8      -81.3      -73.9      -66.5
  A(I)            31.9       31.1       31.2       30.7       30.6
  V(I)            9.82      10.06      10.03      10.19      10.24

X STA.       -66.5      -59.2      -51.5      -43.1      -32.5      -16.4
  A(I)            30.4       31.1       31.8       34.9       41.3
  V(I)           10.30      10.05       9.83       8.96       7.57

X STA.       -16.4       17.8       48.3       76.2      116.2      196.2
  A(I)            52.3       47.3       45.8       60.3       76.5
  V(I)            5.98       6.62       6.83       5.19       4.09

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      76.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1693.  215303.   223.   225.                       26463.
             2     961.  215392.    67.    70.                       20721.
             3     834.   80802.   166.   167.                       10610.
   503.00         3488.  511497.   456.   462.  1.37  -223.   233.  46786.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      76.
         WSEL     LEW     REW    AREA        K        Q    VEL
       503.00  -223.0   232.7  3487.8  511497.   12300.   3.53
X STA.      -223.0     -161.8     -128.8     -105.3      -83.4      -62.8
  A(I)           282.7      231.2      196.7      194.0      187.1
  V(I)            2.18       2.66       3.13       3.17       3.29

X STA.       -62.8      -43.5      -25.0       -7.2        6.8       14.3
  A(I)           179.6      176.7      173.7      153.0      112.0
  V(I)            3.43       3.48       3.54       4.02       5.49

X STA.        14.3       21.2       28.0       34.7       41.0       47.1
  A(I)           105.3      105.8      106.3      102.5      103.5
  V(I)            5.84       5.81       5.78       6.00       5.94

X STA.        47.1       54.3       70.9       99.5      135.4      232.7
  A(I)           114.3      163.4      215.2      244.3      340.9
  V(I)            5.38       3.76       2.86       2.52       1.80
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       U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard028.wsp
       CREATED ON 11-AUG-95 FOR BRIDGE HARDTH00300028 USING FILE hard028.dca
       HYDRAULIC ANALYSIS OF HARD028     SAO
          *** RUN DATE & TIME: 06-12-96  14:42
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     427.   61865.    50.    65.                        7043.
  495.65          427.   61865.    50.    65.  1.00     1.    51.   7043.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      495.65     0.8    51.2   426.8   61865.    5060.  11.86
X STA.         0.8        6.1        9.1       11.8       14.3       16.6
  A(I)            35.8       23.0       21.5       20.7       19.3
  V(I)            7.07      11.00      11.77      12.23      13.11

X STA.        16.6       18.8       21.0       23.1       25.1       27.2
  A(I)            18.9       19.1       18.4       17.9       18.1
  V(I)           13.38      13.24      13.71      14.15      13.95

X STA.        27.2       29.1       31.0       32.9       34.8       36.8
  A(I)            18.1       17.7       17.8       18.4       18.5
  V(I)           14.01      14.26      14.18      13.77      13.67

X STA.        36.8       38.6       40.6       42.9       45.7       51.2
  A(I)            18.5       19.7       21.1       24.9       39.3
  V(I)           13.71      12.82      11.98      10.16       6.43

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      76.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     673.   50307.   198.   198.                        7034.
            2     646.  111213.    67.    70.                       11430.
            3     172.    9591.    79.    79.                        1444.
  498.27         1491.  171111.   343.   347.  1.60  -198.   145.  13942.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      76.
        WSEL     LEW     REW    AREA        K        Q    VEL
      498.27  -198.0   145.1  1490.8  171111.    5060.   3.39
X STA.      -198.0     -110.3      -81.4      -57.1      -35.5      -15.7
  A(I)           168.8      118.3      106.6      101.1       97.2
  V(I)            1.50       2.14       2.37       2.50       2.60

X STA.       -15.7        1.7        8.7       13.4       17.8       22.1
  A(I)            90.3       59.0       47.9       46.5       45.4
  V(I)            2.80       4.29       5.28       5.44       5.57

X STA.        22.1       26.4       30.5       34.5       38.3       42.0
  A(I)            46.4       44.5       44.6       43.9       44.3
  V(I)            5.46       5.68       5.67       5.77       5.71

X STA.        42.0       45.7       49.7       54.5       72.1      145.1
  A(I)            44.8       47.1       52.2       86.8      155.0
  V(I)            5.64       5.37       4.84       2.92       1.63
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard028.wsp
        CREATED ON 11-AUG-95 FOR BRIDGE HARDTH00300028 USING FILE hard028.dca
        HYDRAULIC ANALYSIS OF HARD028      SAO
           *** RUN DATE & TIME: 06-12-96  14:42

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

EXITX:XS   ******   -83.    1670.  0.67 *****  499.42  496.07   8630.  498.75
      -59. ******   324.  209168.  1.62 ***** *******    0.57    5.17

FULLV:FV      59.   -84.    1730.  0.63  0.10  499.52 *******   8630.  498.90
        0.    59.   324.  217675.  1.62  0.00    0.00    0.54    4.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      76.  -207.    1776.  0.57  0.12  499.65 *******   8630.  499.08
       76.    76.   153.  212920.  1.55  0.00    0.00    0.48    4.86
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   498.90     498.30

            <<<<<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      59.     0.     560.  1.78 *****  500.30  494.78   5997.  498.52
        0. ******    51.   64063.  1.00 ***** *******    0.57   10.70

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   6.  0.800  0.000  498.30 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    60.  0.03  0.21  501.79   -0.01   2568.  501.18

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   2262.   216.  -189.    27.   3.0   1.6   7.2   6.6   2.2   3.2
   RT:    306.   127.    27.   154.   0.5   0.3   4.0   8.2   0.9   2.8

===140 AT SECID "APPRO":  END OF CROSS SECTION EXTENDED VERTICALLY.
                             WSEL,YLT,YRT =   501.61      501.5      508.5

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

APPRO:AS      56.  -223.    2857.  0.21  0.14  501.82  496.72   8630.  501.61
       76.    65.   228.  384492.  1.47  0.00   -0.01    0.26    3.02

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -59.   -83.   324.   8630.  209168.    1670.    5.17  498.75
   FULLV:FV       0.   -84.   324.   8630.  217675.    1730.    4.99  498.90
   BRIDG:BR       0.     0.    51.   5997.   64063.     560.   10.70  498.52
   RDWAY:RG      10.******* 2262.   2568.******************    2.00  501.18
   APPRO:AS      76.  -223.   228.   8630.  384492.    2857.    3.02  501.61

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    496.07    0.57  486.70  506.49************  0.67  499.42  498.75
   FULLV:FV  ********    0.54  486.70  506.49  0.10  0.00  0.63  499.52  498.90
   BRIDG:BR    494.78    0.57  485.74  498.52************  1.78  500.30  498.52
   RDWAY:RG  ****************  498.16  509.95  0.03******  0.21  501.79  501.18
   APPRO:AS    496.72    0.26  486.01  508.54  0.14  0.00  0.21  501.82  501.61
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        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard028.wsp
        CREATED ON 11-AUG-95 FOR BRIDGE HARDTH00300028 USING FILE hard028.dca
        HYDRAULIC ANALYSIS OF HARD028      SAO
           *** RUN DATE & TIME: 06-12-96  14:42

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

EXITX:XS   ******   -89.    2245.  0.73 *****  500.88  497.30  12300.  500.15
      -59. ******   325.  298292.  1.56 ***** *******    0.52    5.48

FULLV:FV      59.   -89.    2308.  0.68  0.10  500.99 *******  12300.  500.30
        0.    59.   325.  309217.  1.55  0.00    0.01    0.50    5.33
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      76.  -216.    2347.  0.66  0.13  501.13 *******  12300.  500.47
       76.    76.   225.  295988.  1.55  0.00    0.02    0.50    5.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   500.30     498.30

            <<<<<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      59.     0.     560.  1.79 *****  500.31  494.80   6013.  498.52
        0. ******    51.   64063.  1.00 ***** *******    0.57   10.73

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   6.  0.800  0.000  498.30 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    60.  0.03  0.26  503.23    0.00   6256.  502.39

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   4687.   216.  -189.    27.   4.2   2.8   9.0   7.8   3.6   3.1
   RT:   1569.   169.    27.   196.   1.7   1.3   6.5   7.2   2.1   3.0

===140 AT SECID "APPRO":  END OF CROSS SECTION EXTENDED VERTICALLY.
                             WSEL,YLT,YRT =   503.00      501.5      508.5

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

APPRO:AS      56.  -223.    3490.  0.26  0.17  503.27  497.89  12300.  503.00
       76.    68.   233.  511907.  1.37  0.00    0.00    0.26    3.52

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -59.   -89.   325.  12300.  298292.    2245.    5.48  500.15
   FULLV:FV       0.   -89.   325.  12300.  309217.    2308.    5.33  500.30
   BRIDG:BR       0.     0.    51.   6013.   64063.     560.   10.73  498.52
   RDWAY:RG      10.******* 4687.   6256.******************    2.00  502.39
   APPRO:AS      76.  -223.   233.  12300.  511907.    3490.    3.52  503.00

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    497.30    0.52  486.70  506.49************  0.73  500.88  500.15
   FULLV:FV  ********    0.50  486.70  506.49  0.10  0.00  0.68  500.99  500.30
   BRIDG:BR    494.80    0.57  485.74  498.52************  1.79  500.31  498.52
   RDWAY:RG  ****************  498.16  509.95  0.03******  0.26  503.23  502.39
   APPRO:AS    497.89    0.26  486.01  508.54  0.17  0.00  0.26  503.27  503.00
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WSPRO OUTPUT FILE (continued)

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       U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard028.wsp
       CREATED ON 11-AUG-95 FOR BRIDGE HARDTH00300028 USING FILE hard028.dca
       HYDRAULIC ANALYSIS OF HARD028     SAO
          *** RUN DATE & TIME: 06-12-96  14:42

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

EXITX:XS   ******   -75.    1025.  0.54 *****  497.10  493.34   5060.  496.57
      -59. ******   181.  122608.  1.42 ***** *******    0.52    4.94

FULLV:FV      59.   -76.    1062.  0.50  0.10  497.21 *******   5060.  496.71
        0.    59.   183.  127816.  1.42  0.00    0.01    0.49    4.76
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      76.  -163.    1019.  0.61  0.14  497.40 *******   5060.  496.79
       76.    76.   130.  111256.  1.58  0.05   -0.01    0.59    4.96
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   498.27       0.00     495.65     498.16

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

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

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

BRIDG:BR      59.     1.     427.  2.61  0.20  498.26  493.96   5060.  495.65
        0.    59.    51.   61893.  1.19  0.96    0.00    0.79   11.85

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   4.  0.915 ******  498.30 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<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      56.  -198.    1492.  0.29  0.15  498.56  494.94   5060.  498.27
       76.    61.   145.  171301.  1.60  0.15    0.01    0.36    3.39

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.828  0.435   96579.    -1.    49. ********

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

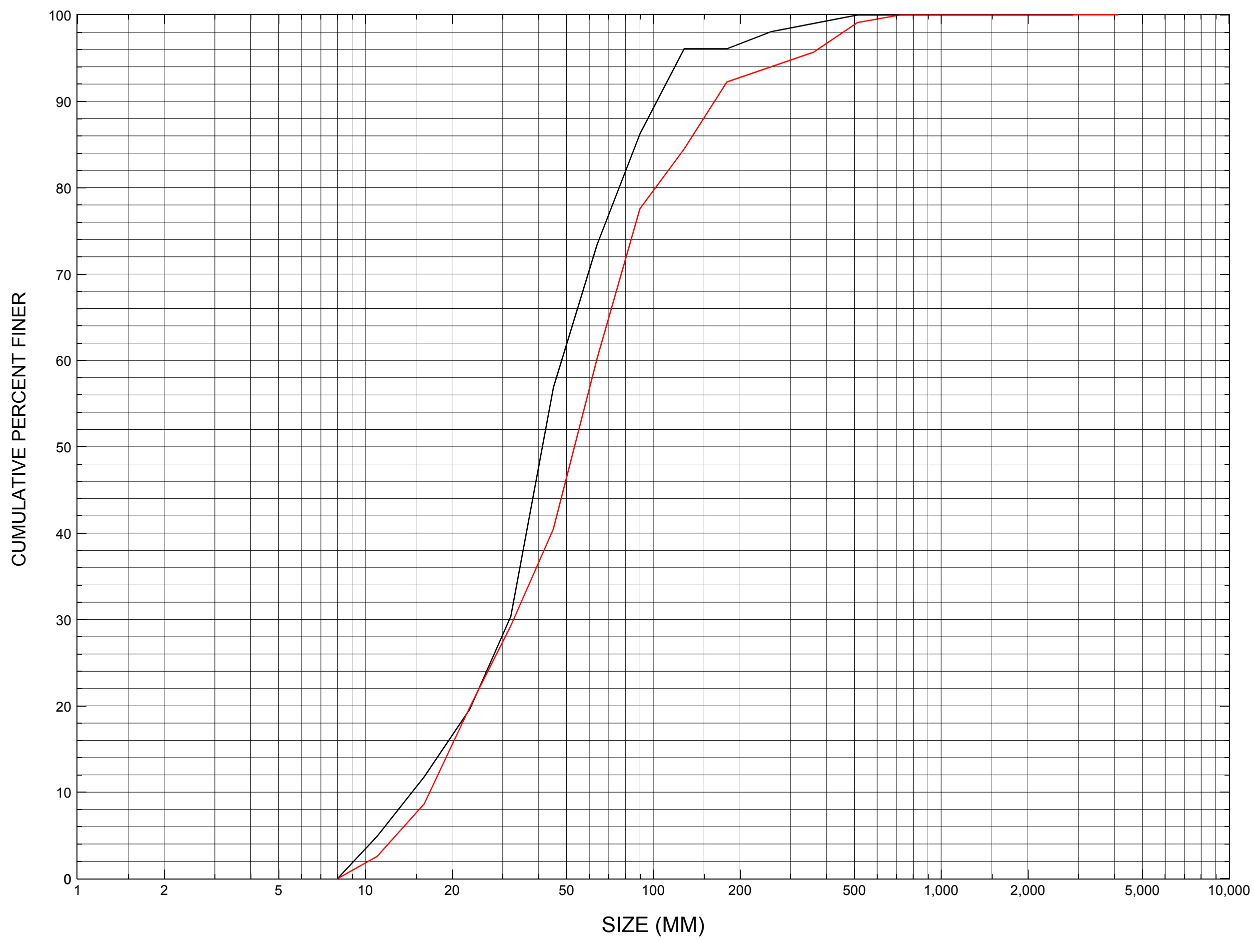
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -59.   -75.   181.   5060.  122608.    1025.    4.94  496.57
   FULLV:FV       0.   -76.   183.   5060.  127816.    1062.    4.76  496.71
   BRIDG:BR       0.     1.    51.   5060.   61893.     427.   11.85  495.65
   RDWAY:RG      10.**************      0.       0.       0.    2.00********
   APPRO:AS      76.  -198.   145.   5060.  171301.    1492.    3.39  498.27

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -1.    49.   96579.

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF     HO   VHD      EGL    WSEL
   EXITX:XS    493.34    0.52  486.70  506.49************  0.54  497.10  496.57
   FULLV:FV  ********    0.49  486.70  506.49  0.10  0.00  0.50  497.21  496.71
   BRIDG:BR    493.96    0.79  485.74  498.52  0.20  0.96  2.61  498.26  495.65
   RDWAY:RG  ****************  498.16  509.95  0.05******  0.29  498.50********
   APPRO:AS    494.94    0.36  486.01  508.54  0.15  0.15  0.29  498.56  498.27
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



SIZE (MM)

Appendix C. Bed material particle-size distributions for two pebble count transects at the approach cross-section for structure HARDTH00300028, in Hardwick, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HARDTH00300028

General Location Descriptive

Data collected by (First Initial, Full last name) M. IVANOFF

Date (MM/DD/YY) 04 / 03 / 95

Highway District Number (I - 2; nn) 07

County (FIPS county code; I - 3; nnn) 005

Town (FIPS place code; I - 4; nnnnn) 31825

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

Waterway (I - 6) LAMOILLE RIVER

Road Name (I - 7): -

Route Number TH030

Vicinity (I - 9) 0.05 MI JCT TH 30 + VT16

Topographic Map Caspian.Lake

Hydrologic Unit Code: 02010005

Latitude (I - 16; nnnn.n) 44306

Longitude (i - 17; nnnnn.n) 72190

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10030500280305

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0052

Year built (I - 27; YYYY) 1950

Structure length (I - 49; nnnnnn) 000054

Average daily traffic, ADT (I - 29; nnnnnn) 000010

Deck Width (I - 52; nn.n) 161

Year of ADT (I - 30; YY) 93

Channel & Protection (I - 61; n) 5

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

Waterway adequacy (I - 71; n) 6

Operational status (I - 41; X) 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) -

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 011.4

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

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

Comments:

The structural inspection report of 06/02/93 indicates the structure is a steel stringer type bridge with a wooden deck. The abutments and wingwalls are "laid up" stone blocks with concrete caps. A new metal sheet pile faced concrete footing has been added in front of the right abutment and its wingwalls. The stone blocks have a few small voids reported overall, as some of the stone chinking has slipped out. The concrete cap has a vertical crack 4' from the downstream end right abutment, which extends up through the backwall. There is also a 3/4" movement noted along the crack. A few random boulders are present in **(Continued, page 33)**

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:

front of the abutments and along the up- and downstream banks. Some erosion from previous flooding reportedly is evident on the upstream banks. About 1.5 -2.5 feet of contraction is reported near the right abutment. Some settlement of both abutments is noted. Debris and point bar problems are minor.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **63.65** mi^2 Lake and pond area **21.75** mi^2

Watershed storage *(ST)* **3.42** %

Bridge site elevation **968** ft Headwater elevation **1798** ft

Main channel length **13.68** mi

10% channel length elevation **1040** ft 85% channel length elevation **1358** ft

Main channel slope *(S)* **31.0** ft / mi

Watershed Precipitation Data

Average site precipitation ____ in Average headwater precipitation ____ in

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

Average seasonal snowfall *(Sn)* ____ ft

Bridge Plan Data

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

Project Number -

Minimum channel bed elevation: -

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

Benchmark location description:

NO BENCHMARK INFORMATION

Reference Point (*MSL, Arbitrary, Other*): -

Datum (*NAD27, NAD83, Other*): -

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

If 1: Footing Thickness ________ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

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: RB Date: 4/15/96
Computerized by: RB Date: 4/16/96
Reviewd by: SAO Date: 8/15/96

Structure Number HARDTH00300028

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. HAMMOND Date *(MM/DD/YY)* 7 / 25 / 1995

2. Highway District Number 07 Mile marker 000

County CALEDONIA 005 Town HARDWICK 31825

Waterway *(I - 6)* LAMOILLE RIVER Road Name -

Route Number TH30 Hydrologic Unit Code: 02010005

3. Descriptive comments:

Located 0.05 mile from the junction of TH30 and VT16.

B. Bridge Deck Observations

4. Surface cover... LBUS 4/3 RBUS 4/3 LBDS 5 RBDS 4/3 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 1 DS 1 *(**1**- pool; **2**- riffle)*

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

7. Bridge length 54 *(feet)* Span length 52 *(feet)* Bridge width 16.1 *(feet)*

Road approach to bridge:

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

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

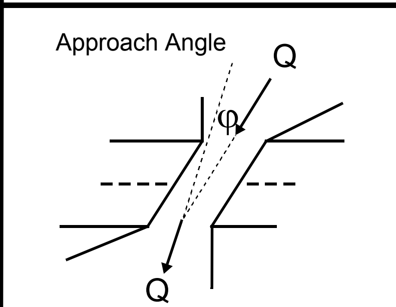
10. Embankment slope (*run / rise in feet / foot*):
US left 2.3:1 US right 2.0:1

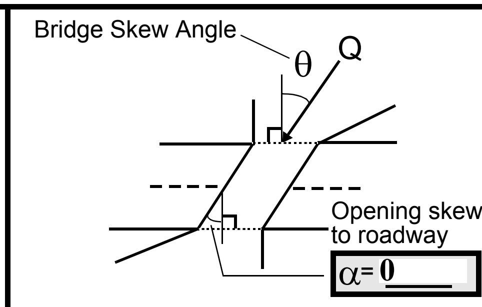
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

*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: 10 16. Bridge skew: 5





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 35 feet US *(US, UB, DS)* to 10 feet US

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

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

18. Bridge Type: **4**

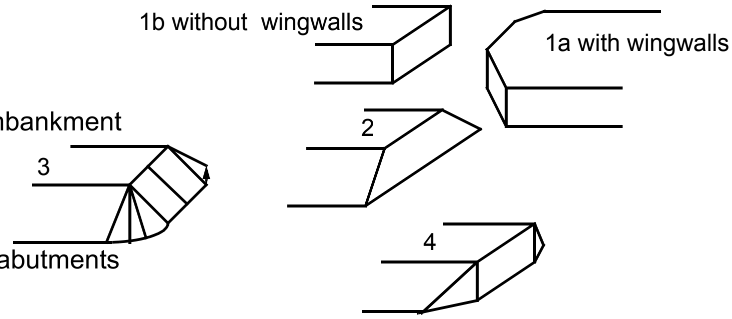
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7. Values are from the VT AOT files. Measured bridge length is 54 feet, bridge width is 16.6 feet and the span length is 52 feet.

18. Both the left and right abutment wingwalls slope down below the low chord.

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
56.0	**4.0**			**7.5**	**1**	**2**	**2**	**2**	**2**	**1**

23. Bank width **35.0** 24. Channel width **30.0** 25. Thalweg depth **66.5** 29. Bed Material **324**

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

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. Rocks and concrete debris has been dumped along the bank and some has slumped.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **100** 35. Mid-bar width: **15**

36. Point bar extent: **150** feet **US** (US, UB) to **50** feet **US** (US, UB, DS) positioned **0** %LB to **60** %RB

37. Material: **342**

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

The point bar is formed on the inside of a gradual curve.

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

41. Mid-bank distance: **150** 42. Cut bank extent: **200** feet **US** (US, UB) to **110** 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.):

The cut bank has formed along the outside of the gentle curve. There is no vegetation cover along the cut bank area. Where there are some trees, there is no loss of bank.

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

47. Scour dimensions: Length **45** Width **10** Depth : **1.5** Position **50** %LB to **80** %RB

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

The scour hole starts at 35 feet US and extends to 10 feet under the bridge. There is also some local scour around some large boulders in the stream near the right bank side.

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
46.5		**1.5**		**2**	**7**	**7**	**0**

58. Bank width (BF) **-** 59. Channel width (Amb) **-** 60. Thalweg depth (Amb) **90.0** 63. Bed Material **0**

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

63. The bed material grades from gravel on the left bank to cobble in the center and boulders on the right bank.

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 **1**____ *(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:

3

69. Landowner says that ice forms and then will jam at the bridge flooding the US fields for about a day, then it moves to the next bridge DS and will jam there causing a backwater effect on the DS fields.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	0	-	-	90.0
RABUT	2	0	90			2	2	51.3

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

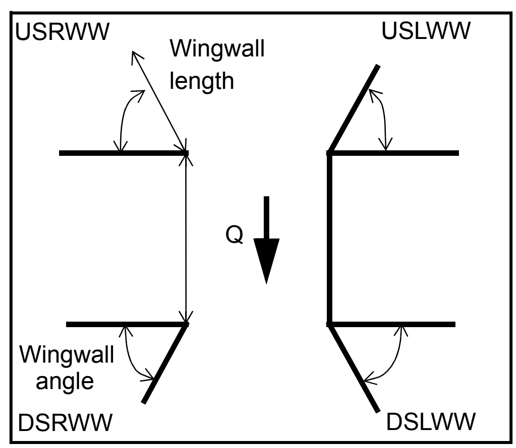
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

1
1
2
The right abutment footing is sheet piling driven into the channel about 2 to 4 feet streamward of the abutment and then concrete was poured between the sheet piling and the abutment to form a footing that is irregular along the stream.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						51.3	
USRWW:	Y		2		0	2.0	
DSLWW:	-		-		Y	20.0	
DSRWW:	2		2		1	21.0	

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

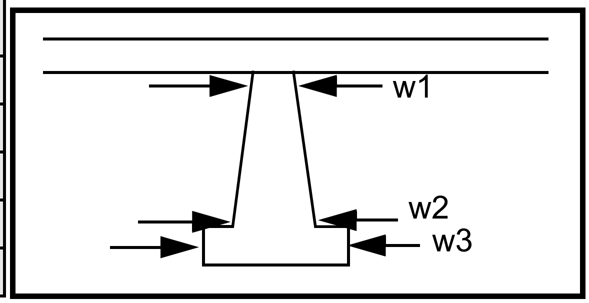
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? Alo (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	25.0	75.0	30.0	12.0	26.5	16.0
Pier 2	80.0	-	-	11.5	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	ng	dum	On	ders	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	the	ped	the	and	**1**- Solid pier, **2**- column, **3**- bent
88. Material	right	on	left	con-	**1**- Wood; **2**- concrete; **3**- metal; **4**- stone
89. Shape	abut	the	bank	crete	**1**- Round; **2**- Square; **3**- Pointed
90. Inclined?	ment	strea	there	debr	Y- yes; N- no
91. Attack ∠ (BF)	and	mwa	are	is	
92. Pushed	its	rd	some	pro-	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	wing	side	spar	tect-	
95. Cross-members	walls	of	se	ing	**0**- none; **1**- laterals; **2**- diagonals; **3**- both
96. Scour Condition	,	the	scat-	the	**0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed
97. Scour depth	rock	foot-	tered	DS	
98. Exposure depth	was	ing.	boul-	left	

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

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
-	-			-	N	-	-	-	-	-

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.):

-
-
-
-

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

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

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

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

Is channel scour present? _____ *(Y or if N type ctrl-n cs)* Mid-scour distance: __1__

Scour dimensions: Length __2__ Width __2__ Depth: __2__ Positioned __1__ %LB to __1__ %RB

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

345
0
0
-

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

Confluence 1: Distance __e is__ Enters on __pro-__ *(LB or RB)* Type __tec-__ *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

left bank beyond 2 bridge lengths, at about 150 feet DS, to protect the road embankment of State Highway 16.

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

-

109. G. Plan View Sketch

58. N

point bar pb	debris	flow Q	stone wall
cut-bank cb	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: HARDTH00300028 Town: Hardwick
Road Number: TH30 County: Caledonia
Stream: Lamoille River

Initials SAO Date: 6/12/96 Checked:

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	8630	12300	5060
Main Channel Area, ft2	868	961	646
Left overbank area, ft2	1383	1693	673
Right overbank area, ft2	606	834	172
Top width main channel, ft	67	67	67
Top width L overbank, ft	223	223	198
Top width R overbank, ft	162	166	79
D50 of channel, ft	0.153	0.153	0.153
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	13.0	14.3	9.6
y1, average depth, LOB, ft	6.2	7.6	3.4
y1, average depth, ROB, ft	3.7	5.0	2.2
Total conveyance, approach	384658	511497	171111
Conveyance, main channel	181972	215392	111213
Conveyance, LOB	154326	215303	50307
Conveyance, ROB	48360	80802	9591
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	4082.6	5179.5	3288.7
Ql, discharge, LOB, cfs	3462.4	5177.4	1487.7
Qr, discharge, ROB, cfs	1085.0	1943.1	283.6
Vm, mean velocity MC, ft/s	4.7	5.4	5.1
Vl, mean velocity, LOB, ft/s	2.5	3.1	2.2
Vr, mean velocity, ROB, ft/s	1.8	2.3	1.6
Vc-m, crit. velocity, MC, ft/s	9.2	9.3	8.7
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	868	961	646
Main channel width, ft	67	67	67
y1, main channel depth, ft	12.96	14.34	9.64

Bridge Section			
(Q) total discharge, cfs	8630	12300	5060
(Q) discharge thru bridge, cfs	5997	6013	5060
Main channel conveyance	64063	64063	61865
Total conveyance	64063	64063	61865
Q2, bridge MC discharge,cfs	5997	6013	5060
Main channel area, ft2	560	560	427
Main channel width (skewed), ft	51.3	51.3	50.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	51.3	51.3	50.4
y_bridge (avg. depth at br.), ft	10.92	10.92	8.47
Dm, median (1.25*D50), ft	0.19125	0.19125	0.19125
y2, depth in contraction,ft	11.76	11.78	10.32
ys, scour depth (y2-ybridge), ft	0.84	0.87	1.85

ARMORING			
D90	0.423	0.423	0.423
D95	0.711	0.711	0.711
Critical grain size,Dc, ft	0.3496	0.3515	0.4685
Decimal-percent coarser than Dc	0.144	0.143	0.088
Depth to armoring,ft	6.24	6.32	14.56

PRESSURE FLOW SCOUR COMPUTATION

```
 Structure Number: HARDTH00300028            Town:    Hardwick
 Road Number:      TH 30                     County:  Caledonia
 Stream:           Lamoille River
 Initial:  EMB      Date:    10/11/96 Checked: MAI
 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)
 (Richardson and others, 1995, p. 145-146)
```

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	5997	6013	0
Vc, critical velocity, ft/s	9.2	9.3	0
Vc, critical velocity, m/s	2.804023	2.834502	0
Main channel width (skewed), ft	51.3	51.3	0

Cum. width of piers, ft	0	0	0
W, adjusted width, ft	51.3	51.3	0
qbr, unit discharge, ft^2/s	116.9006	117.2125	ERR
qbr, unit discharge, m^2/s	10.85936	10.88833	N/A
Area of full opening, ft^2	560.4	560.4	0
Hb, depth of full opening, ft	10.92398	10.92398	ERR
Hb, depth of full opening, m	3.329466	3.329466	N/A
Fr, Froude number MC	0.57	0.57	1
Cf, Fr correction factor (<=1.0)	1	1	1.5
Elevation of Low Steel, ft	498.28	498.28	0
Elevation of Bed, ft	487.356	487.356	N/A
Elevation of approach WS, ft	501.61	503	0
HF, bridge to approach, ft	0.14	0.17	0
Elevation of WS immediately US, ft	501.47	502.83	0
ya, depth immediately US, ft	14.11398	15.47398	N/A
ya, depth immediately US, m	4.385947	4.808569	N/A
Mean elev. of deck, ft	500.9	500.9	0
w, depth of overflow, ft (>=0)	0.57	1.93	0
Cc, vert contrac correction (<=1.0)	0.947021	0.947021	ERR
Ys, depth of scour (chang), ft	2.49345	2.384589	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	8630	12300	5060	8630	12300	5060
a', abut.length blocking flow, ft	223	223	198.8	177	181.4	93.9
Ae, area of blocked flow ft2	1050.7	1139.4	677.6	732.4	833.7	277.7
Qe, discharge blocked abut.,cfs	--	--	1504.9	--	--	679.9
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	2.51	3.08	2.22	2.19	2.69	2.45
ya, depth of f/p flow, ft	4.71	5.11	3.41	4.14	4.60	2.96
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.177	0.197	0.212	0.186	0.200	0.251
ys, scour depth, ft	20.73	23.02	17.56	18.02	20.16	13.43

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)	223	223	198.8	177	181.4	93.9
y1 (depth f/p flow, ft)	4.71	5.11	3.41	4.14	4.60	2.96
a'/y1	47.33	43.64	58.33	42.78	39.47	31.75
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.18	0.20	0.21	0.19	0.20	0.25
Ys w/ corr. factor K1/0.55:						
vertical	19.35	21.74	14.86	17.27	19.65	13.63
vertical w/ ww's	15.87	17.83	12.18	14.17	16.11	11.18
spill-through	10.64	11.96	8.17	9.50	10.81	7.50

Abutment riprap Sizing

Isbash Relationship

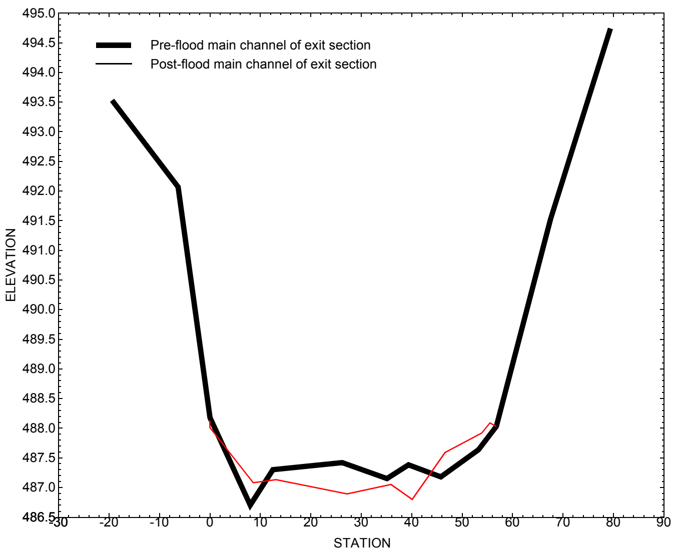
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

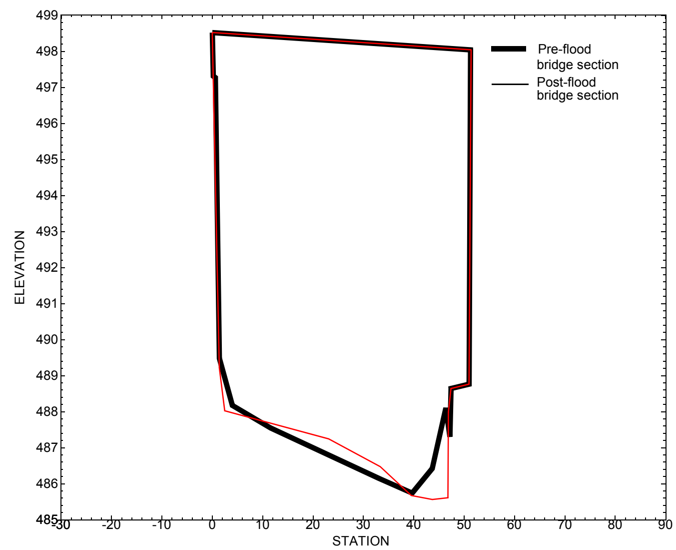
Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.57	0.57	0.79	0.57	0.57	0.79
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	10.92	10.92	8.47	10.92	10.92	8.47
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	2.19	2.19	3.27	2.19	2.19	3.27
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR

APPENDIX G:

POST AUGUST 5-6, 1995 FLOOD DATA FOR STRUCTURE HARDTH00300028

This appendix shows plots of pre- and post- flood channel surveys in the vicinity of Bridge 28 on Town Highway 30 crossing the Lamoille River, in Hardwick, Vermont. Also included are photos and a Level I form completed on August 21, 1995 (after the flood event). The photos and Level I form can be compared to the photos and Level I form of July 25, 1995 (before the flood event).





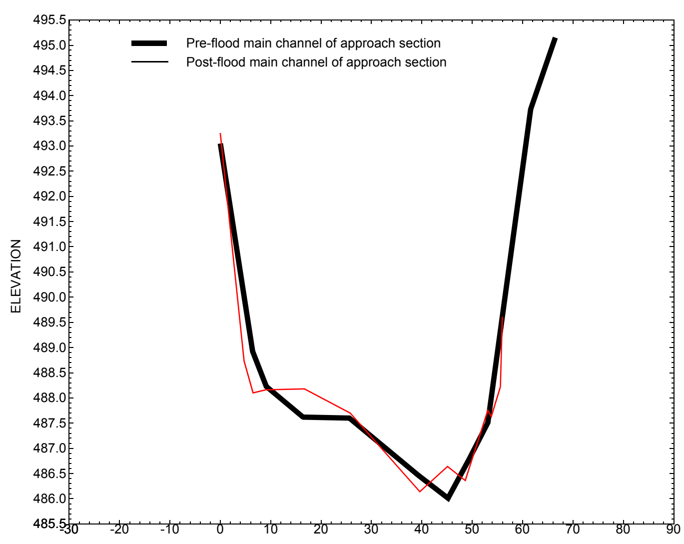


Figure G-1. Pre- and post-flood plots of channel bottom at the cross-sections identified on p. 10 of this report under the section 'Description of Water Surface Profile model (WSPRO) analysis, Cross-sections used in WSPRO analysis'.

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

Qa/Qc Check by: EW Date: 4/15/96
Computerized by: RB Date: 4/16/96
Reviewd by: SAO Date: 8/15/96

Structure Number HARDTH00300028

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 8 / 21 / 1995

2. Highway District Number 07 Mile marker 000

County 005 Town HARDWICK 31825

Waterway *(I - 6)* LAMOILLE RIVER Road Name -

Route Number TH30 Hydrologic Unit Code: 02010005

3. Descriptive comments:

This is a steel stringer type bridge with a wooden deck. Its abutments are laid up stone with concrete caps. The right abutment has a concrete footing with steel pilings in front of it. This bridge is located 0.05 miles from the junction of TH30 and VT16.

B. Bridge Deck Observations

4. Surface cover... LBUS 3 RBUS 4 LBDS 5 RBDS 3 Overall 3
*(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 1 DS 1 *(**1**- pool; **2**- riffle)*

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

7. Bridge length 54 *(feet)* Span length 52 *(feet)* Bridge width 16.1 *(feet)*

Road approach to bridge:

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

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

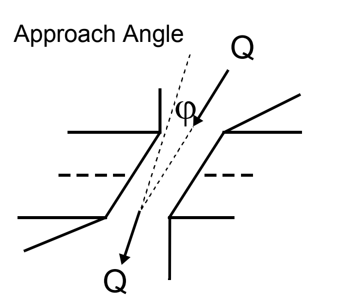
10. Embankment slope (*run / rise in feet / foot*):
US left 2.3 US right 2.0

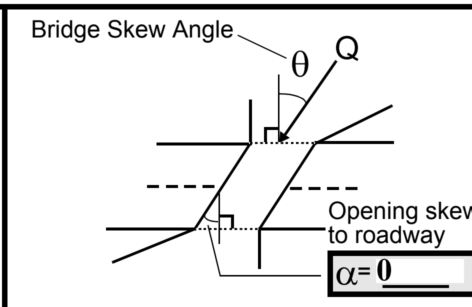
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	2	1

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

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 10





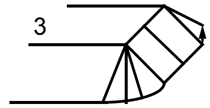
17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 0 feet US *(US, UB, DS)* to 30 feet US

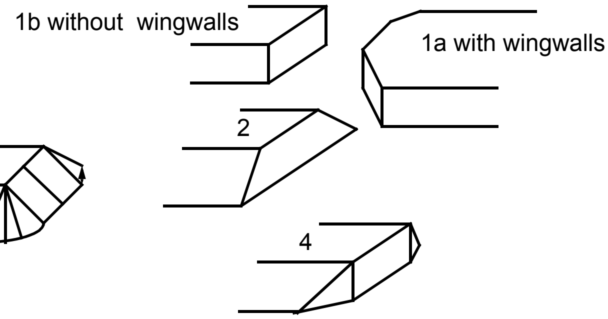
Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 115 feet US *(US, UB, DS)* to 150 feet US

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

18. Bridge Type: **4**

1a- Vertical abutments with wingwalls
1b- Vertical abutments without wingwalls
2- Vertical abutments and wingwalls, sloping embankment
Wingwalls perpendicular to abut. face
3- Spill through abutments
4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.





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

5. There is a riffle on both the US and DS sides of the bridge within the 2 bridge length range.
17. The first impact zone is on the US right wingwall. The second impact zone is a cut bank further US.
7. Values are from the VT AOT files.

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
					1	**1**	**234**	**234**	**2**	**2**

23. Bank width ______ 24. Channel width ______ 25. Thalweg depth ______ 29. Bed Material **43**

30 .Bank protection type: LB **0** RB **0** 31. 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*

32. Comments (bank material variation, minor inflows, protection extent, etc.):
There are some large pieces of broken concrete on the right bank at about 170 feet US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **80** 35. Mid-bar width: **12**

36. Point bar extent: **50** feet **US** (US, UB) to **115** feet **US** (US, UB, DS) positioned **0** %LB to **20** %RB

37. Material: **43**

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

The point bar measurements above are for the ambient flows. The same material is continuous at a depth of 0.2 feet through the DS bridge face to 5 feet DS.

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

41. Mid-bank distance: **150** 42. Cut bank extent: **115** feet **US** (US, UB) to **300** 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.):

The cut bank is just outside of the 2 bridge length range.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **4**

47. Scour dimensions: Length **45** Width **14** Depth : **1.5** Position **20** %LB to **100** %RB

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

The scour starts at 30 feet US and ends at the DS bridge face.

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
				2	7	7	-

58. Bank width (BF) ____ 59. Channel width (Amb) ____ 60. Thalweg depth (Amb) ____ 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.):

345

-

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

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

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

70. Debris and Ice Comments:

-

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT	-	90	2	0	0	-	2	20.0
RABUT	10	90	2			2	1.5	21.0

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

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

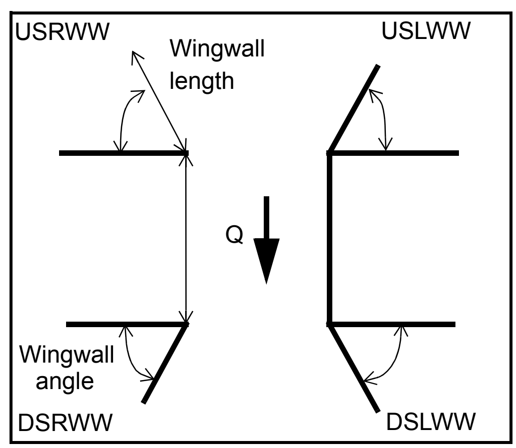
3

2

The right abutment scour is at the US end where the protection has eroded away.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:					Y	25.0	
USRWW:	2		0		-	12.0	
DSLWW:	-		Y		2	75.0	
DSRWW:	2		1.5		3	26.5	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	Y	-	2	2	-	2	-	3
Condition	2	-	2	0	2	0	2	-
Extent	0	Y	0	-	4	-	4	-

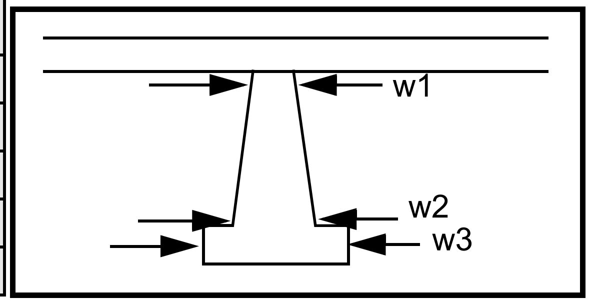
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
On the left bank there are some scattered boulders. The right bank protection is below the water surface in front of the footing.

Piers:

84. Are there piers? **N** (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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
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	-	-	-	-	
98. Exposure depth	-	-	-	-	

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

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

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

70. Debris and Ice Comments:

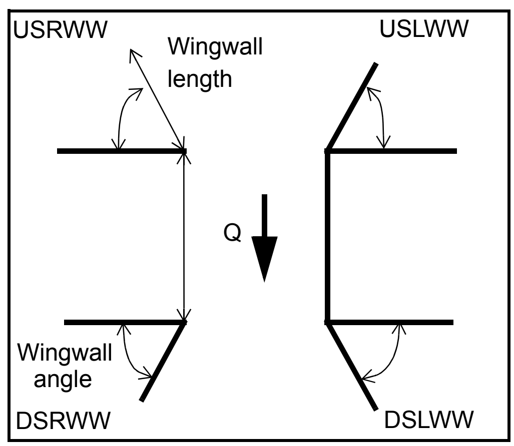
Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT								30.0
RABUT								16.0

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

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

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						80.0	
USRWW:						11.5	
DSLWW:							
DSRWW:							



*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								
Condition								
Extent								

*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*

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

NO PIERS

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
					1	1	24	243	1	1

Bank width (BF) _____ Channel width (Amb) _____ Thalweg depth (Amb) _____ Bed Material **43**

Bank protection type (Qmax): LB **0** RB **0** 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.):

There is size 3 protection on the left bank where the channel impacts the VT 16 road embankment at 145 feet DS.

101. Is a drop structure present? **N** *(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):

NO DROP STRUCTURE

106. Point/Side bar present? N (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 POINT BARS

Is a cut-bank present? N (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.):

NO CUT BANKS

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

Scour dimensions: Length - Width - Depth: - Positioned - %LB to - %RB

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

NO CHANNEL SCOUR

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

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

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

Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

F. Geomorphic Channel Assessment

107. Stage of reach evolution 5

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)*:

This is a small, perennial but flashy, stream with a gravel bed. It is set in a moderate relief valley with a narrow flood plain and little or no natural levees. The channel is probably incised with alluvial boundaries. Less than 50% of the bankline is tree covered. This is a sinuous stream that is not braided nor anabranched. It is equiwidth and has narrow point bar development.

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	