LEVEL II SCOUR ANALYSIS FOR BRIDGE 25 (HARDTH00420025) on TOWN HIGHWAY 42, crossing LAMOILLE RIVER, HARDWICK, VERMONT

U.S. Geological Survey
Open-File Report 96-231

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

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By JOSEPH D. AYOTTE

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Pembroke, New Hampshire

1996

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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 25 (HARDTH00420025) ON TOWN HIGHWAY 42, CROSSING LAMOILLE RIVER, HARDWICK, VERMONT

***By* Joseph D. Ayotte**

INTRODUCTION

This report provides the results of a detailed Level II analysis of scour potential at structure HARDTH00420025 on town highway 42 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). A Level I study is included in Appendix E of this report. A Level I study provides a qualitative geomorphic characterization of the study site. Information on the bridge available from VTAOT files was compiled prior to conducting Level I and Level II analyses and can be found in Appendix D.

The site is in the Green Mountain physiographic division of north-central Vermont in the town of Hardwick. The 119-mi^2 drainage area is in a predominantly rural basin. In the vicinity of the study site, the left banks are covered by pasture and (or) fields. The right bank of Lamoille River is adjacent to Vermont Route 15 near the north edge of the Lamoille River valley

In the study area, the Lamoille River has a sinuous channel with a slope of approximately 0.0004 ft/ft, an average channel top width of 89.0 ft and an average channel depth of 8.0 ft. The predominant channel bed material is sand and gravel (D_{50} is 22.4 mm or 0.0733 ft). In general, the banks have sparse or no woody vegetative cover and the reach was noted to be laterally unstable at the time of the Level I site visit on July 25, 1995. The Level II work was completed on 07/27/95 and the site was revisited on August 16, 1995, just 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 42 crossing of the Lamoille River is a 62-ft-long, two-lane bridge consisting of one 60-foot steel- beam span with a concrete deck, supported by vertical abutments with wingwalls on upstream and downstream sides (Vermont Agency of Transportation, written commun., August 24, 1994). The bridge is supported by vertical abutments with wingwalls on upstream and downstream sides. The channel is not skewed to the opening and the opening-skew-to-roadway is 0 degrees.

A scour hole 3.0 ft deeper than the mean thalweg depth was observed 5 feet upstream from the bridge face at mid-channel during the Level I assessment. 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, 1993).
Total scour at a highway crossing is comprised of three components: 1) long-term aggradation or degradation; 2) contraction scour (due to reduction in flow area caused by 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 scour depths for contraction and local scour and a summary of the results follows.

Contraction scour for all modelled flows was 0.0 ft. Abutment scour ranged from 6.5 ft to 15.6 ft and the worst-case abutment scour occurred at the 500-year discharge. Scour depths and depths to armoring are summarized on p. 14 in the section titled “Scour Results”. Scour elevations, based on the calculated depths are presented in tables 1 and 2; a graph of the scour elevations is presented in figure 8 Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

For all scour presented in this report, “the scour depths adopted [by VTAOT] may differ from the equation values based on engineering judgement” (Richardson and others, 1993, p. 21, 27). It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1993, p. 48). Many factors, including historical performance during flood events, the geomorphic assessment, and the results of the hydraulic analyses, must be considered to properly assess the validity of abutment scour results.

Wolcott, VT. Quadrangle, 1:24,000, 1986
Provisional Edition

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 HARDTH00420025 ***Stream*** Lamoille River

County Caledonia ***Road*** TH042 ***District*** 07

Description of Bridge

Bridge length 62 ***ft*** ***Bridge width*** 25.3 ***ft*** ***Max span length*** 60 ***ft***

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

Abutment type vertical ***Embankment type*** sloping

Stone fill on abutment? yes ***Date of inspection*** 07/25/95

Description of stone fill Type-2, in good condition; a second inspection was done on 08/16/95 after a significant (greater than 100-yr) flood event and the condition of the stone fill was unchanged

Abutments and wingwalls are concrete

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

(Opening skew to roadway is 0 degrees)

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	07/25/95	0	0
Level II	07/27/95	-	-

Potential for debris Moderate, due to woody vegetation on upstream left bank several hundred feet US of the structure

Describe any features near or at the bridge that may affect flow (include observation date) There is a strong main-channel constriction in the approach to the bridge. Additionally the is a meander several hundred feet US and a localized, vegetated point bar that was noted on 07/25/95. Relief is present as a low point in the left overbank of the roadway.

Description of the Geomorphic Setting

General topography The bridge is in a 600 ft-wide, flat valley approx. 500 ft DS of a major channel bend. Vermont Rte. 15 is adjacent to the north valley wall.

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

Date of inspection 07/25/95

DS left: wide (approx. 300 ft) flood plain

DS right: narrow terrace (VT Route 15) and steep valley wall

US left: wide (approx. 300 ft) flood plain

US right: narrow terrace (VT Route 15) and steep valley wall

Description of the Channel

Average top width 89 ***ft*** ***Average depth*** 9 ***ft***

Predominant bed material sand and gravel ***Bank material*** sand

sinuous, with large flood plains. It is alluvial and laterally unstable

07/25/95

Vegetative co

DS left: field grasses

DS right: Vt Route 15

US left: field grasses

US right: Vt Route 15

N

Do banks appear stable? 07/25/95--Both the left and right banks are reported to be eroded by means of moderate to heavy fluvial processes where there is no bank protection. The USRB is eroded heavily due to flow impact; the USLB is more stable but is eroded in places; the DSLB has light fluvial erosion beyond the stone fill protection area.

date of observation.

07/25/95--No large obstructions; 08/16/95--Some minor debris reported at the base of the left abutment from a recent flood event.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 119 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province	*Percent of drainage area*
Green Mountain Prov.	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None. Site is in an agricultural valley

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

USGS gage description Lamoille at Johnson, Vermont

USGS gage number 04292000

Gage drainage area 310 ***mi²***

Is there a lake/p No

There is a concrete dam approx. 5000 ft US of the bridge but it is considered to have little effect on the hydrology or hydraulics at the site. Hardwick lake, 6000 ft US of the bridge is also considered to have only minor effects.

Calculated Discharges

Q100 12,000 ***ft³/s*** ***Q500*** 20,400 ***ft³/s***

Q100 was taken from VTAOT files (Vermont Agency of Transportation, written commun., March, 1995) . Q500 was determined by multiplying the Q100 by 1.7

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 0.11 ft from USGS datum to get VTAOT datum which is also NGVD 1929.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on the DS end of the left abutment (arbitrary elev. 796.20). RM2 is a chiseled X on the US end of the right abutment (arbitrary elev. 796.82). RM3 is a VTAOT brass survey disk on the top of the US left wingwall (VTAOT elev. 796.10, USGS arbitrary elev. 796.21).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-62	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Upstream BRDGE face, move to downstream face (SRD is 0)
RDWAY	13	1	Road Grade section
APPRO	68	1	Modelled Approach section (Templated from SURVA)
SURVA	105	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 analysis reported herein reflects 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, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.030 to 0.040, and the overbank "n" value was 0.030.

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 0.0005 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1986).

The surveyed approach section (SURVA) was moved along the approach channel slope (0.0005 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.

The 100- and 500-year discharges significantly overtop the left road approach so the model was also run with a discharge of 3,840 ft^3/s which is at the incipient overtopping discharge elevation.

Bridge Hydraulics Summary

Average bridge embankment elevation 795.8 *ft*
Average low steel elevation 791.5 *ft*

100-year discharge 12,000 *ft³/s*
Water-surface elevation in bridge opening 791.7 *ft*
Road overtopping? Y *Discharge over road* 7299 *ft³/s*
Area of flow in bridge opening 811 *ft²*
Average velocity in bridge opening 5.8 *ft/s*
Maximum WSPRO tube velocity at bridge 6.9 *ft/s*

Water-surface elevation at Approach section with bridge 794.8
Water-surface elevation at Approach section without bridge 794.1
Amount of backwater caused by bridge 0.7 *ft*

500-year discharge 20,400 *ft³/s*
Water-surface elevation in bridge opening 791.7 *ft*
Road overtopping? Y *Discharge over road* 16343 *ft³/s*
Area of flow in bridge opening 811 *ft²*
Average velocity in bridge opening 5.4 *ft/s*
Maximum WSPRO tube velocity at bridge 6.4 *ft/s*

Water-surface elevation at Approach section with bridge 796.9
Water-surface elevation at Approach section without bridge 796.4
Amount of backwater caused by bridge 0.5

Incipient overtopping discharge 3840 *ft³/s*
Water-surface elevation in bridge opening 790 *ft*
Area of flow in bridge opening 725 *ft²*
Average velocity in bridge opening 5.30 *ft/s*
Maximum WSPRO tube velocity at bridge 6.5 *ft/s*

Water-surface elevation at Approach section with bridge 790.6
Water-surface elevation at Approach section without bridge 790.3
Amount of backwater caused by bridge .3 *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, 1993). 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.

The 100-year and 500-year discharges resulted in orifice flow and contraction scour was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). 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, 1993, p. 35, equation 18) for the incipient road-overflow discharge. 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. None of the modelled flows resulted in contraction scour.

Abutment scour at the left abutment for all flows was computed using the HIRE equation (Richardson and others, 1993, p 50) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The length to depth ratio of the embankment blocking flow for the left abutment ranged from 131 to 265. The variables used by the HIRE abutment-scour 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. For the right abutment, the length to depth ratio of the embankment blocking flow ranged from 2.2 to 3.2 and the Froehlich equation (Richardson and others, 1993, p. 49, eq. 24) was used.

Post-flood scour was also measured on August 18, 1995 (after the August 5-6, 1995 flood) at this bridge. Observed contraction scour, determined by resurveying the pre-flood channel survey at the approach (APPRO) cross section, was less than 0.5 ft. For the SURVA cross section 105 ft upstream of the bridge, approximately 1 ft of scour was detected over a distance of 10 ft near the left bank. Minor (approximately 1 ft) channel infilling was also detected near the pre-flood thalweg. Observed abutment scour, determined by resurveying the pre-flood channel survey at the bridge cross section, was less than 0.1 ft. Pre- and post-flood surveys of the above mentioned cross sections are shown in Appendix G.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.0
Depth to armoring	0.2	0.1	0.1
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	13.0	15.6	6.5
Right abutment	15.2	14.9	9.5
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Rock Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	0.6	0.5	0.8
Right abutment	0.6	0.5	0.8
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

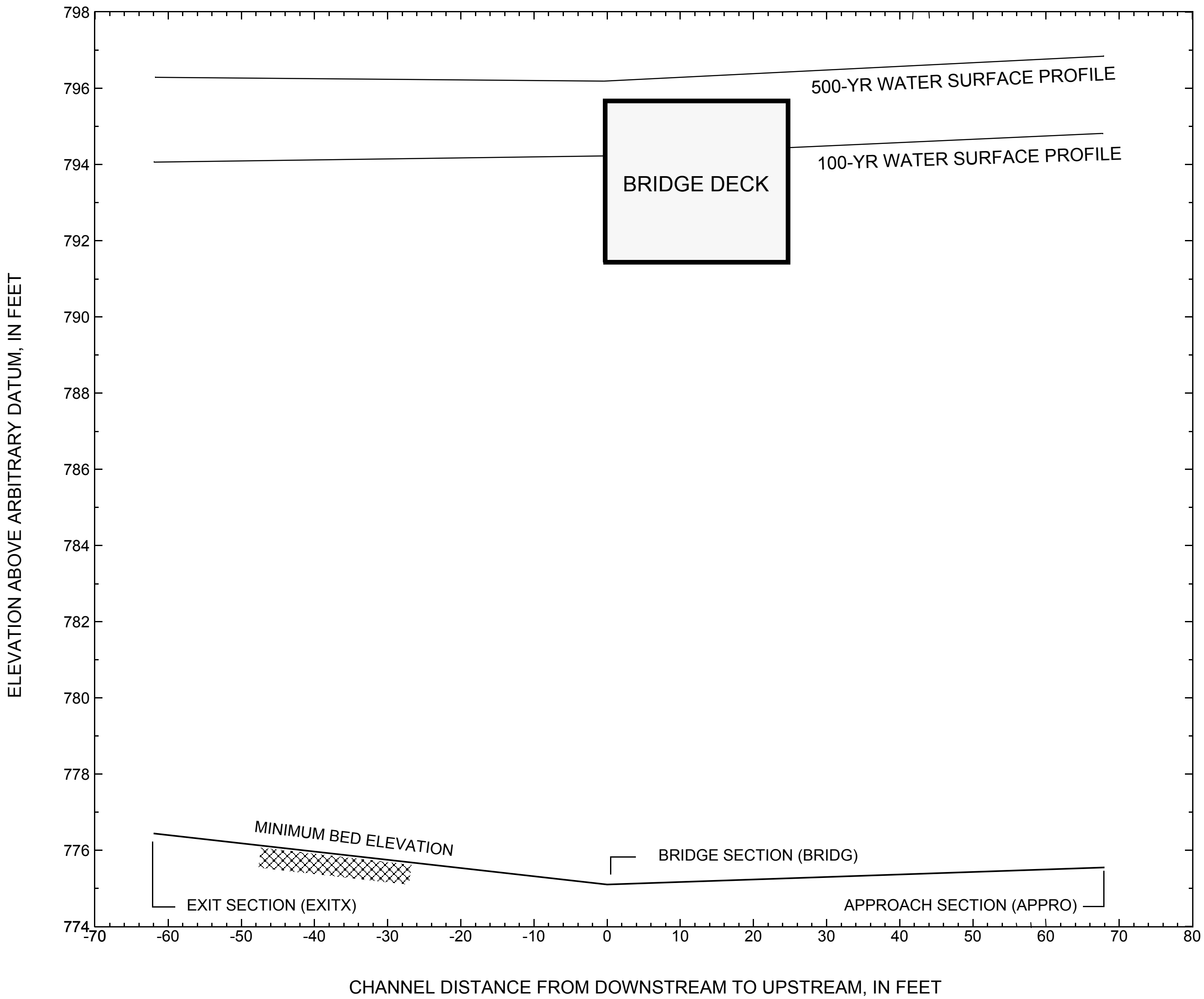

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure HARDTH00420025 on town highway 42, crossing Lamoille River, Hardwick, Vermont.

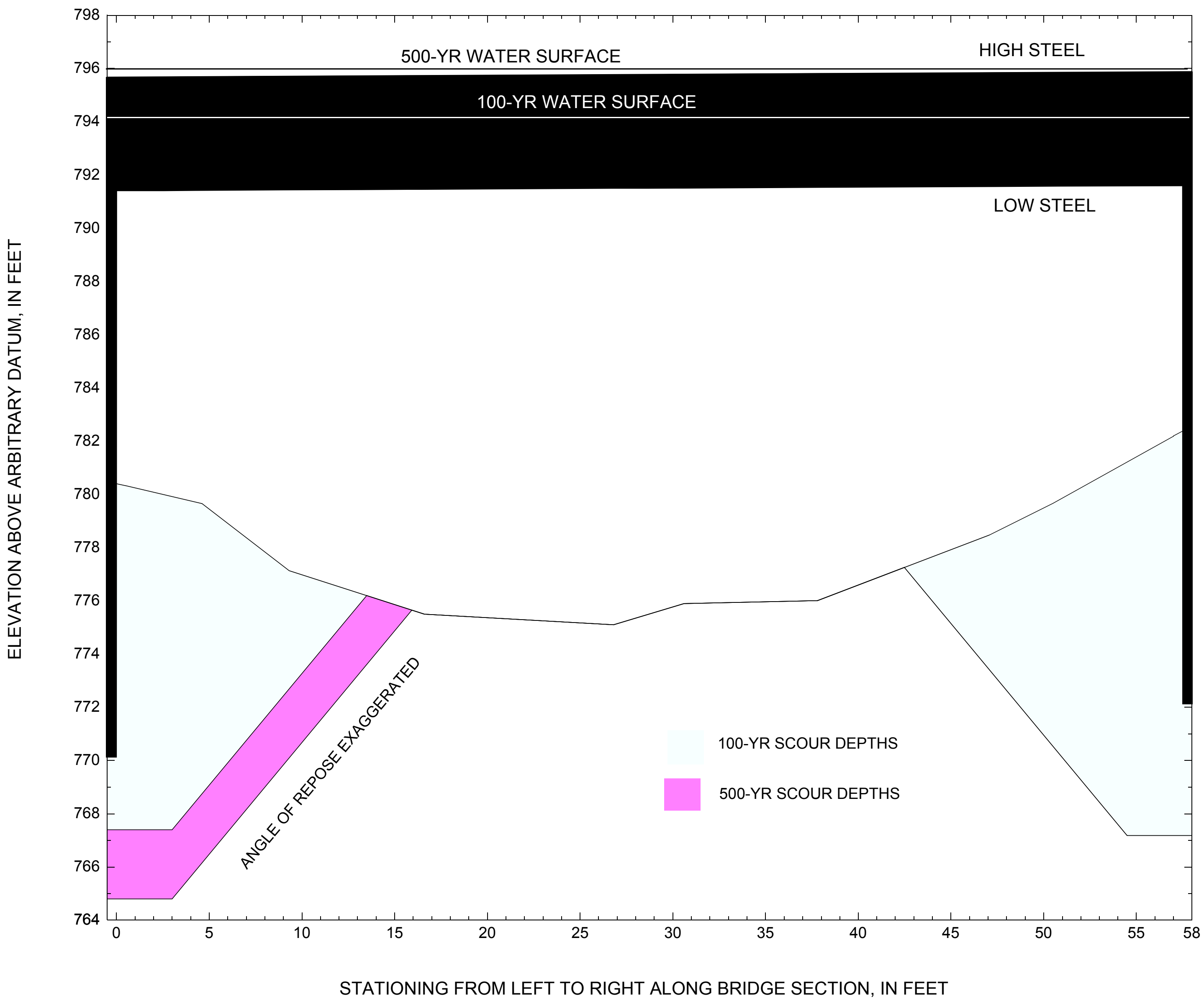

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure HARDTH00420025 on town highway 42, crossing Lamoille River, Hardwick, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HARDTH00420025 on TOWN HIGHWAY 42, crossing 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 12,000 cubic-feet per second											
Left abutment	0.0	791.1	791.3	770.1	780.4	0.0	13.0	--	13.0	767.4	-2.7
Right abutment	57.5	791.7	791.7	772.1	782.4	0.0	15.2	--	15.2	767.2	-4.9

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 HARDTH00420025 on TOWN HIGHWAY 42, crossing 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 20,400 cubic-feet per second											
Left abutment	0.0	791.1	791.3	770.1	780.4	0.0	15.6	--	15.6	764.8	-5.3
Right abutment	57.5	791.7	791.7	772.1	782.4	0.0	14.9	--	14.9	767.5	-4.6

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

```
T1        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard025.wsp
T2        CREATED ON 14-AUG-95 FOR BRIDGE HARDTH00420025 USING FILE hard025.dca
T3        Hydraulic Analysis for HARD025 over Lamoille R.    JDA
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          3840     12000      20400
SK         0.0005    0.0005     0.0005
*
XS   EXIT1    -62           0.
*
*             real survey below:
*
GR         -561.0, 797.88   -552.9, 794.90   -514.2, 794.51   -491.5, 790.39
GR         -476.9, 788.37   -459.6, 788.28   -294.9, 788.97   -195.2, 789.91
GR         -133.5, 788.26    -61.8, 788.94    -20.1, 788.82     -9.9, 785.19
GR           -0.5, 780.47      0.4, 779.23      1.6, 778.84      8.5, 777.59
GR           12.8, 777.75     34.3, 776.62     43.1, 776.44     46.2, 777.01
GR           46.2, 777.01     47.8, 779.88     54.6, 784.35     66.9, 792.16
GR           74.1, 793.77     88.2, 793.83    101.9, 793.15    108.1, 792.24
GR          112.8, 795.92    160.9, 825.90
SA               -9.9
N            0.030   0.040
*
XS   FULLV      0  * * *   0.0005
*
BR   BRIDG   0     791.50       0.0
*
*            This section was surveyed at the US face and has been adjusted
*            to the DS face using a slope of 0.010
*
GR            0.0, 791.30      0.0, 780.40      4.6, 779.65      9.3, 777.14
GR           16.6, 775.50     26.8, 775.10     30.6, 775.90     37.8, 776.01
GR           47.1, 778.48     50.5, 779.66     57.4, 782.38     57.5, 791.70
GR            0.0, 791.30
*
CD         1     31.3      0.0      0.0     52.5      0.0
N           0.030
*
*
XR   RDWAY     13      25.3   2
*
*
GR         -729.6, 812.34   -647.0, 803.24   -576.1, 798.51   -564.3, 798.28
GR         -456.6, 791.64   -395.1, 790.63   -316.6, 790.55   -229.5, 791.11
GR          -79.8, 794.50     -3.8, 795.29     -3.6, 796.21
*             0.0, 795.66     57.0, 795.92
GR           57.1, 796.82     57.8, 796.20
GR           85.6, 794.94     93.7, 796.16     96.7, 795.92    110.8, 795.98
GR          124.5, 795.30    130.8, 794.39    135.4, 798.07    183.5, 828.05
*
```

```
AS   APPRA      68          0.
*
*            overbank data from section SURVA, below; channel data from
*            constricting section immediatley us of bridge
*
GR         -553.1, 797.88   -545.0, 794.90   -506.3, 794.51   -483.6, 790.39
GR         -469.0, 788.37   -436.0, 787.99   -336.5, 789.54   -319.3, 789.52
GR         -298.1, 788.27   -276.7, 788.24   -218.0, 789.96   -184.8, 788.91
GR         -134.8, 789.68    -19.4, 787.71
GR          -12.8, 785.21
*
GR           13.0, 783.38     20.8, 779.92     23.9, 778.34     29.0, 775.81
GR           32.2, 775.55     38.3, 776.11     39.9, 777.65     43.0, 777.87
GR           45.7, 778.49     47.4, 779.92     51.3, 781.54     57.1, 784.11
*
GR           61.3, 785.70     81.5, 798.88     89.5, 800.10     92.6, 799.86
GR          106.7, 799.92    120.4, 799.24    126.6, 798.33    131.3, 802.01
GR          179.4, 831.99
*
SA                -12.8
N            0.030     0.035
*
XS   SURVA     105          0.
*
*           surveyed approach--above constriction:
*
GR         -553.1, 797.88   -545.0, 794.90   -506.3, 794.51   -483.6, 790.39
GR         -469.0, 788.37   -436.0, 787.99   -336.5, 789.54   -319.3, 789.52
GR         -298.1, 788.27   -276.7, 788.24   -218.0, 789.96   -184.8, 788.91
GR         -134.8, 789.68    -19.4, 787.71
GR          -12.8, 785.21     -4.5, 780.56
GR            0.2, 779.91     10.2, 778.11     25.5, 777.73     35.0, 776.73
GR           39.2, 777.87     51.6, 778.89     54.9, 779.92     57.0, 781.18
GR           61.3, 785.70     81.5, 798.88     89.5, 800.10     92.6, 799.86
GR          106.7, 799.92    120.4, 799.24    126.6, 798.33    131.3, 802.01
GR          179.4, 831.99
*
SA                -6.6
N            0.030     0.035
*
*
HP 1 BRIDG  790.01 1 790.01
HP 2 BRIDG  790.01 * * 3840
HP 1 APPRA  790.57 1 790.57
HP 2 APPRA  790.57 * * 3840
*
HP 1 BRIDG  791.70 1 791.70
HP 2 BRIDG  791.70 * * 4739
HP 2 RDWAY  794.20 * * 7299
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard025.wsp
        CREATED ON 14-AUG-95 FOR BRIDGE HARDTH00420025 USING FILE hard025.dca
        Hydraulic Analysis for HARD025 over Lamoille R.    JDA
           *** RUN DATE & TIME: 01-09-96  12:26
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     725.  161092.    57.    77.                      14613.
   790.01          725.  161092.    57.    77.  1.00     0.    57.  14613.
1
  HP 2 BRIDG  790.01 * * 3840
1    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       790.01     0.0    57.5   725.1  161092.    3840.   5.30

 X STA.        0.0        6.5       10.0       12.7       15.2       17.4
  A(I)            66.1       43.5       36.6       33.8       32.1
  V(I)            2.90       4.41       5.25       5.68       5.99

 X STA.       17.4       19.5       21.6       23.6       25.6       27.6
  A(I)            31.3       29.8       29.6       29.4       29.5
  V(I)            6.14       6.43       6.48       6.52       6.50

 X STA.       27.6       29.6       31.7       33.8       36.0       38.3
  A(I)            29.5       29.6       30.4       30.6       31.6
  V(I)            6.52       6.49       6.32       6.27       6.07

 X STA.       38.3       40.7       43.4       46.5       50.2       57.5
  A(I)            32.7       35.1       37.6       41.2       65.1
  V(I)            5.88       5.48       5.10       4.66       2.95
1
  HP 1 APPRA  790.57 1 790.57
1     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     810.   57634.   472.   473.                       6024.
             2     713.  123190.    82.    87.                      11962.
   790.57         1523.  180824.   553.   560.  1.56  -485.    69.  11490.
    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRA;  SRD =      68.

         WSEL     LEW     REW    AREA        K        Q    VEL
       790.57  -484.6    68.8  1523.1  180824.    3840.   2.52

 X STA.     -484.6     -429.4     -373.2     -281.1     -175.2      -65.4
  A(I)           113.0      114.6      141.1      149.3      151.4
  V(I)            1.70       1.68       1.36       1.29       1.27

 X STA.      -65.4      -21.4       -4.9        5.2       14.0       20.0
  A(I)           107.9       77.3       63.5       61.2       53.8
  V(I)            1.78       2.48       3.02       3.14       3.57

 X STA.       20.0       24.1       27.5       30.3       33.0       35.7
  A(I)            46.9       43.9       41.0       40.2       41.0
  V(I)            4.10       4.38       4.68       4.78       4.68

 X STA.       35.7       38.7       42.2       46.1       51.8       68.8
  A(I)            42.4       46.5       48.1       57.6       82.4
  V(I)            4.53       4.13       3.99       3.34       2.33
1
  *
  HP 1 BRIDG  791.70 1 791.70
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     811.  131664.     0.   137.                          0.
   791.70          811.  131664.     0.   137.  1.00     0.    58.      0.
1
  HP 2 BRIDG  791.70 * * 4739
         WSEL     LEW     REW    AREA        K        Q    VEL
       791.70     0.0    57.5   810.7  131664.    4739.   5.85

 X STA.        0.0        5.8        9.3       12.1       14.6       17.0
  A(I)            66.8       45.3       40.8       38.9       36.9
  V(I)            3.55       5.23       5.80       6.10       6.42

 X STA.       17.0       19.1       21.3       23.5       25.6       27.7
  A(I)            34.8       35.4       34.4       34.3       34.4
  V(I)            6.81       6.69       6.88       6.92       6.90

 X STA.       27.7       29.9       32.1       34.3       36.7       39.0
  A(I)            34.8       35.1       34.9       36.1       36.3
  V(I)            6.80       6.74       6.79       6.57       6.53

 X STA.       39.0       41.6       44.4       47.4       51.2       57.5
  A(I)            38.0       39.8       41.5       46.7       65.6
  V(I)            6.24       5.95       5.70       5.08       3.61
```

```
1
   HP 2 RDWAY  794.20 * * 7299


     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

          WSEL     LEW     REW    AREA        K        Q    VEL
        794.20  -498.1   -93.0  1029.4   95189.    7299.   7.09

 X STA.      -498.1     -448.5     -429.8     -414.4     -400.7     -388.4
   A(I)            74.4       53.2       48.1       46.1       43.9
   V(I)            4.91       6.86       7.59       7.91       8.32

 X STA.      -388.4     -376.3     -364.4     -352.4     -340.6     -328.8
   A(I)            43.3       42.6       43.1       42.8       42.9
   V(I)            8.42       8.56       8.46       8.53       8.50

 X STA.      -328.8     -316.9     -304.9     -291.9     -278.6     -264.5
   A(I)            43.6       43.2       45.8       46.0       47.3
   V(I)            8.37       8.44       7.96       7.93       7.72

 X STA.      -264.5     -249.3     -232.8     -213.4     -186.1      -93.0
   A(I)            49.7       52.2       57.0       66.0       98.0
   V(I)            7.34       6.99       6.40       5.53       3.73
1
   HP 1 APPRA  794.79 1 794.79
1     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRA;  SRD =      68.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1    2854.  439658.   521.   522.                      37890.
              2    1071.  229302.    88.    95.                      21193.
    794.79         3925.  668960.   609.   617.  1.08  -534.    75.  54440.
1
   HP 2 APPRA  794.79 * * 12000
     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRA;  SRD =      68.

          WSEL     LEW     REW    AREA        K        Q    VEL
        794.79  -534.1    75.2  3924.6  668960.   12000.   3.06

 X STA.      -534.1     -443.4     -410.6     -376.4     -337.6     -299.0
   A(I)           304.3      217.4      210.4      216.0      215.1
   V(I)            1.97       2.76       2.85       2.78       2.79

 X STA.      -299.0     -268.4     -232.1     -188.5     -150.8     -108.0
   A(I)           199.0      209.9      227.3      212.6      226.5
   V(I)            3.02       2.86       2.64       2.82       2.65

 X STA.      -108.0      -73.0      -42.2      -15.4        1.8       15.8
   A(I)           205.2      198.4      188.2      170.6      157.3
   V(I)            2.92       3.02       3.19       3.52       3.81

 X STA.        15.8       25.4       32.3       39.2       48.0       75.2
   A(I)           143.3      127.3      130.2      145.8      219.8
   V(I)            4.19       4.71       4.61       4.11       2.73
1
   *
   HP 1 BRIDG  791.70 1 791.70
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     811.  131664.     0.   137.                          0.
    791.70          811.  131664.     0.   137.  1.00     0.    58.      0.
1
   HP 2 BRIDG  791.70 * * 4372
     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

          WSEL     LEW     REW    AREA        K        Q    VEL
        791.70     0.0    57.5   810.7  131664.    4372.   5.39

 X STA.         0.0        5.8        9.3       12.1       14.6       17.0
   A(I)            66.8       45.3       40.8       38.9       36.9
   V(I)            3.27       4.82       5.35       5.63       5.92

 X STA.        17.0       19.1       21.3       23.5       25.6       27.7
   A(I)            34.8       35.4       34.4       34.3       34.4
   V(I)            6.29       6.18       6.35       6.38       6.36
```

```
 X STA.        27.7       29.9       32.1       34.3       36.7       39.0
   A(I)             34.8       35.1       34.9       36.1       36.3
   V(I)             6.28       6.22       6.26       6.06       6.03

 X STA.        39.0       41.6       44.4       47.4       51.2       57.5
   A(I)             38.0       39.8       41.5       46.7       65.6
   V(I)             5.76       5.49       5.26       4.68       3.33
1
   HP 2 RDWAY  796.03 * * 16343
1
     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

          WSEL     LEW     REW    AREA        K        Q    VEL
        796.03  -527.8   132.9  1939.2  225609.   16343.   8.43

 X STA.      -527.8     -460.3     -438.5     -420.5     -404.0     -389.0
   A(I)            140.3       98.0       87.1       84.7       79.9
   V(I)             5.82       8.34       9.38       9.64      10.22

 X STA.      -389.0     -374.4     -360.1     -345.7     -331.4     -317.2
   A(I)             79.0       77.7       78.5       77.8       78.1
   V(I)            10.34      10.51      10.40      10.50      10.47

 X STA.      -317.2     -302.7     -287.2     -271.6     -255.1     -237.7
   A(I)             78.8       82.4       82.1       84.7       87.4
   V(I)            10.37       9.92       9.95       9.65       9.35

 X STA.      -237.7     -218.4     -195.6     -166.8     -123.8      132.9
   A(I)             93.7      100.5      110.1      129.8      208.3
   V(I)             8.72       8.13       7.42       6.30       3.92
1
   HP 1 APPRA  796.91 1 796.91
     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRA;  SRD =      68.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1    3987.  751644.   538.   539.                       61607.
              2    1261.  293142.    91.    99.                       26592.
    796.91         5248. 1044786.   629.   638.  1.03  -550.    78.  84850.
1
   HP 2 APPRA  796.91 * * 20400
     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRA;  SRD =      68.

          WSEL     LEW     REW    AREA        K        Q    VEL
        796.91  -550.5    78.5  5247.8 1044786.   20400.   3.89

 X STA.      -550.5     -456.9     -424.7     -393.7     -359.6     -322.1
   A(I)            406.2      284.0      263.3      272.6      280.2
   V(I)             2.51       3.59       3.87       3.74       3.64

 X STA.      -322.1     -290.1     -259.7     -224.1     -186.5     -151.2
   A(I)            260.1      259.0      272.4      277.4      273.7
   V(I)             3.92       3.94       3.74       3.68       3.73

 X STA.      -151.2     -113.8      -79.7      -49.5      -21.6       -1.1
   A(I)            276.7      268.7      254.7      248.5      231.2
   V(I)             3.69       3.80       4.01       4.10       4.41

 X STA.        -1.1       15.9       27.4       36.2       46.6       78.5
   A(I)            224.5      201.3      185.5      202.7      304.9
   V(I)             4.54       5.07       5.50       5.03       3.35
 +++ BEGINNING PROFILE CALCULATIONS --   3
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

         U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE hard025.wsp
         CREATED ON 14-AUG-95 FOR BRIDGE HARDTH00420025 USING FILE hard025.dca
         Hydraulic Analysis for HARD025 over Lamoille R.    JDA
            *** RUN DATE & TIME: 01-09-96  12:26

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

 EXIT1:XS   ******  -490.    1442.  0.17 *****  790.41  783.24   3840.  790.24
       -62. ******    64.  171603.  1.59 ***** *******    0.37    2.66
```

```
 FULLV:FV      62.  -490.    1447.  0.17  0.03  790.45 *******   3840.  790.28
        0.    62.    64.  172179.  1.58  0.00    0.01    0.36    2.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRA:AS      68.  -483.    1374.  0.20  0.04  790.50 *******   3840.  790.30
       68.    68.    68.  160896.  1.62  0.01    0.00    0.40    2.79
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
            WS1,WSSD,WS3,RGMIN =   790.57       0.00     790.01     790.55

  ===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      62.     0.     725.  0.65  0.05  790.66  782.56   3840.  790.01
        0.    62.    57.  161109.  1.49  0.20    0.00    0.32    5.30


      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   4.  0.818 ******  791.50 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      13.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPRA:AS      37.  -485.    1523.  0.15  0.05  790.72  785.57   3840.  790.57
        68.    64.    69.  180805.  1.56  0.02    0.01    0.33    2.52

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.896  0.361  115121.    -4.    53. ********

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

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

 SURVA:XS      37.  -485.    1690.  0.13  0.01  790.74 *******   3840.  790.60
      105.    37.    69.  228984.  1.66  0.00    0.00    0.30    2.27
1
   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXIT1:XS     -62.  -490.    64.   3840.  171603.    1442.    2.66  790.24
    FULLV:FV       0.  -490.    64.   3840.  172179.    1447.    2.65  790.28
    BRIDG:BR       0.     0.    57.   3840.  161109.     725.    5.30  790.01
    RDWAY:RG      13.**************      0.       0.       0.    2.00********
    APPRA:AS      68.  -485.    69.   3840.  180805.    1523.    2.52  790.57

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRA:AS      -4.    53.  115121.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    SURVA:XS     105.  -485.    69.   3840.  228984.    1690.    2.27  790.60
1  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
    EXIT1:XS    783.24    0.37  776.44  825.90************  0.17  790.41  790.24
    FULLV:FV  ********    0.36  776.47  825.93  0.03  0.00  0.17  790.45  790.28
    BRIDG:BR    782.56    0.32  775.10  791.70  0.05  0.20  0.65  790.66  790.01
    RDWAY:RG  ****************  790.55  828.05  0.02******  0.15  790.70********
    APPRA:AS    785.57    0.33  775.55  831.99  0.05  0.02  0.15  790.72  790.57
    SURVA:XS  ********    0.30  776.73  831.99  0.01  0.00  0.13  790.74  790.60
  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 EXIT1:XS   ******  -511.    3615.  0.17 *****  794.19  790.63  12000.  794.02
      -62. ******   110.  536654.  1.00 ***** *******    0.24    3.32

 FULLV:FV      62.  -512.    3617.  0.17  0.03  794.22 *******  12000.  794.05
```

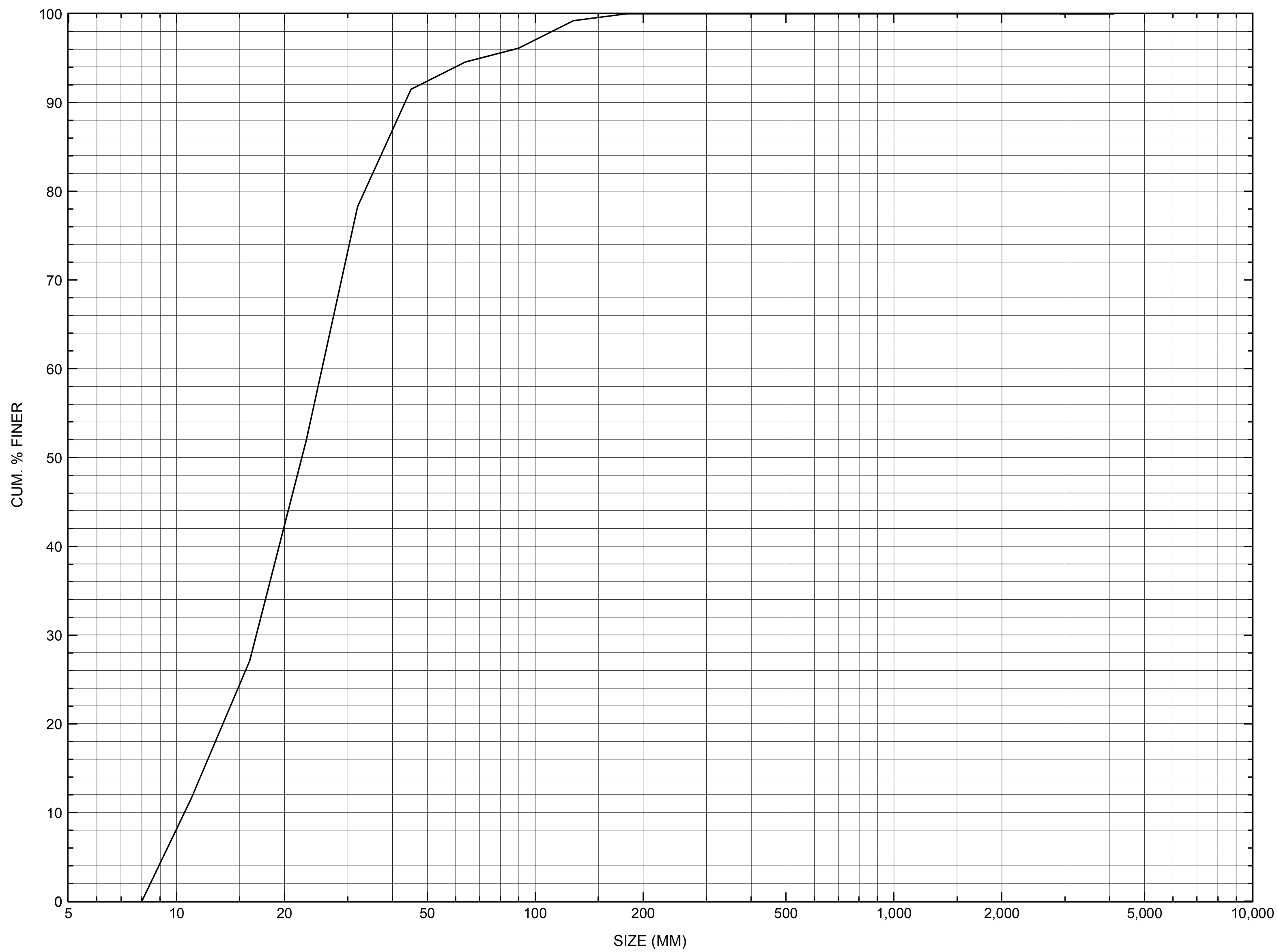
```
         0.    62.    110.  537108.  1.00  0.00     0.00    0.24    3.32
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRA:AS      68.  -504.     3502.  0.20  0.03  794.27 *******  12000.  794.07
        68.    68.     74.  574636.  1.09  0.01     0.00    0.26    3.43
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =    794.05     791.50

             <<<<<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      62.     0.      811.  0.53 *****  792.23  783.35   4739.  791.70
         0. ******    58.  131664.  1.00 ***** *******    0.27    5.85

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   6.  0.800 ******  791.50 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      13.    43.  0.01  0.16  794.94    0.00   7299.  794.20

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
    LT:   7299.   405.  -498.   -93.   3.7   2.5   8.2   7.1   3.3   3.0
    RT:      0.     1.   130.   131.   0.2   0.1   3.9  27.6   0.9   2.8

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



 APPRA:AS      37.  -534.     3926.  0.16  0.07  794.95  790.83  12000.  794.79
        68.    87.     75.  669201.  1.08  0.02     0.00    0.22    3.06

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

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

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

 SURVA:XS      37.  -536.     4087.  0.15  0.01  794.96 *******  12000.  794.81
       105.    37.     75.  728028.  1.14  0.00     0.00    0.21    2.94
   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXIT1:XS     -62.  -511.   110.  12000.  536654.    3615.    3.32  794.02
    FULLV:FV       0.  -512.   110.  12000.  537108.    3617.    3.32  794.05
    BRIDG:BR       0.     0.    58.   4739.  131664.     811.    5.85  791.70
    RDWAY:RG      13.*******  7299.   7299.*********       0.    2.00  794.20
    APPRA:AS      68.  -534.    75.  12000.  669201.    3926.    3.06  794.79

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

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    SURVA:XS     105.  -536.    75.  12000.  728028.    4087.    2.94  794.81
1  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXIT1:XS    790.63    0.24  776.44  825.90************  0.17  794.19  794.02
    FULLV:FV  ********    0.24  776.47  825.93  0.03  0.00  0.17  794.22  794.05
    BRIDG:BR    783.35    0.27  775.10  791.70************  0.53  792.23  791.70
    RDWAY:RG  ****************  790.55  828.05  0.01******  0.16  794.94  794.20
    APPRA:AS    790.83    0.22  775.55  831.99  0.07  0.02  0.16  794.95  794.79
    SURVA:XS  ********    0.21  776.73  831.99  0.01  0.00  0.15  794.96  794.81
1  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 EXIT1:XS   ******  -557.     5115.  0.25 *****  796.56  791.74  20400.  796.31
       -62. ******   113.  912066.  1.00 ***** *******    0.25    3.99

 FULLV:FV      62.  -557.     5119.  0.25  0.03  796.60 *******  20400.  796.35
```

WSPRO OUTPUT FILE (continued)

```
        0.    62.   113.  913302.  1.00  0.00    0.01    0.25    3.99
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 APPRA:AS      68.  -549.    4905.  0.28  0.03  796.64 *******  20400.  796.36
       68.    68.    78.  939113.  1.04  0.02    0.00    0.27    4.16
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

  ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   796.35     791.50

            <<<<<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      62.     0.     811.  0.45 *****  792.15  783.04   4372.  791.70
        0. ******    58.  131664.  1.00 ***** *******    0.25    5.39

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   6.  0.800 ******  791.50 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
    RDWAY:RG      13.    43.  0.02  0.24  797.13    0.02  16343.  796.03

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
    LT:  15937.   524.  -528.    -4.   5.5   3.6   9.6   8.4   4.7   2.9
    RT:    406.    69.    61.   133.   1.6   0.5   5.6  12.3   1.6   3.0

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

 APPRA:AS      37.  -550.    5245.  0.24  0.09  797.15  791.89  20400.  796.91
       68.    86.    78. 1043831.  1.03  0.02    0.02    0.24    3.89

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

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

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

 SURVA:XS      37.  -551.    5409.  0.23  0.01  797.16 *******  20400.  796.93
      105.    37.    79. 1110734.  1.06  0.00    0.00    0.23    3.77

   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
    EXIT1:XS     -62.  -557.   113.  20400.  912066.    5115.    3.99  796.31
    FULLV:FV       0.  -557.   113.  20400.  913302.    5119.    3.99  796.35
    BRIDG:BR       0.     0.    58.   4372.  131664.     811.    5.39  791.70
    RDWAY:RG      13.******* 15937.  16343.*****************    2.00  796.03
    APPRA:AS      68.  -550.    78.  20400. 1043831.    5245.    3.89  796.91

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

     XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
    SURVA:XS     105.  -551.    79.  20400. 1110734.    5409.    3.77  796.93
1  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL     WSEL
    EXIT1:XS    791.74    0.25  776.44  825.90************  0.25  796.56  796.31
    FULLV:FV  ********    0.25  776.47  825.93  0.03  0.00  0.25  796.60  796.35
    BRIDG:BR    783.04    0.25  775.10  791.70************  0.45  792.15  791.70
    RDWAY:RG  ***************  790.55  828.05  0.02******  0.24  797.13  796.03
    APPRA:AS    791.89    0.24  775.55  831.99  0.09  0.02  0.24  797.15  796.91
    SURVA:XS  ********    0.23  776.73  831.99  0.01  0.00  0.23  797.16  796.93
   ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for a pebble count transect at the approach cross-section for structure HARDTH00420025, in Hardwick, Vermont.

APPENDIX D:

HISTORICAL DATA FORM