LEVEL II SCOUR ANALYSIS FOR BRIDGE 23 (WOLCTH00130023) on TOWN HIGHWAY 13, crossing the WILD BRANCH LAMOILLE RIVER, WOLCOTT, VERMONT

U.S. Geological Survey
Open-File Report 97-394

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

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By EMILY C. WILD AND JAMES R. DEGNAN

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U.S. DEPARTMENT OF THE INTERIOR
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Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 23 (WOLCTH00130023) ON TOWN HIGHWAY 13, CROSSING THE WILD BRANCH LAMOILLE RIVER, WOLCOTT, VERMONT

By **Emily C. Wild 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 WOLCTH00130023 on Town Highway 13 crossing the Wild Branch Lamoille River, Wolcott, 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, collected from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in north-central Vermont. The 27.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture on the upstream right overbank. The upstream left overbank is brushland. Downstream of the bridge, the surface cover is forested on the right overbank. The downstream left overbank is pasture while the immediate bank has dense woody vegetation.

In the study area, the Wild Branch Lamoille River has an incised, straight channel with a slope of approximately 0.009 ft/ft, an average channel top width of 65 ft and an average bank height of 7 ft. The channel bed material ranges from sand to boulders with a median grain size (D_{50}) of 85.3 mm (0.280 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 17, 1996 indicated that the reach was laterally unstable.

The Town Highway 13 crossing of the Wild Branch Lamoille River is a 41-ft-long, one-lane bridge consisting of a 39-foot steel girder span (Vermont Agency of Transportation, written communication, October 13, 1995). The opening length of the structure parallel to the bridge face is 38 ft. The bridge is supported by vertical, concrete abutments. The right abutment has concrete wingwalls. The channel is skewed approximately 45 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 3.5 ft deeper than the mean thalweg depth was observed in the channel during the Level I assessment. Scour countermeasures at the site includes type-2 stone fill (less than 3 feet diameter) along the banks, the right wingwalls, the right abutment and the road embankments. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 1.0 to 2.1 ft. The worst-case contraction scour occurred at the 100-year discharge. Left abutment scour ranged from 9.1 to 13.2 ft. Right abutment scour ranged from 15.7 to 22.3 ft. The worst-case abutment scour occurred at the 500-year discharge for both abutments. 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.

During the August 1995 flood, the Wild Branch Lamoille River overtopped the bridge deck at structure WOLCTH00130023. Debris also was caught in the upstream I-beam of the structure.

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

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

NORTH

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

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

LEVEL II SUMMARY

Structure Number WOLCTH00130023 ***Stream*** Wild Branch Lamoille River

County Lamoille ***Road*** TH13 ***District*** 6

Description of Bridge

Bridge length 41 ***ft*** ***Bridge width*** 12.5 ***ft*** ***Max span length*** 39 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 7/17/96

Description of stone fill Type-2, around the right wingwalls and right abutment. Type-2, along the upstream and downstream left road embankments.

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

Is bridge skewed to flood flow according to Yes ***survey?*** ***Angle*** 45

Yes

Is there a channel bend in the bridge reach? If so, describe (mild, moderate, severe)

There is a moderate channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	7/17/96	0	0
Level II	7/17/96	0	0

Potential for debris Moderate. There is some debris caught in the upstream I-beam of the structure.

Describe any features near or at the bridge that may affect flow (include observation date)

None. 7/17/96

Description of the Geomorphic Setting

General topography The channel is located within a narrow irregular flood plain with steep valley walls along the right side.

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

Date of inspection 7/17/96

DS left: Narrow flood plain to a moderately sloped overbank.

DS right: Steep valley wall.

US left: Narrow flood plain to a moderately sloped overbank.

US right: Narrow flood plain to a steep valley wall.

Description of the Channel

Average top width 65 *ft* ***Average depth*** 7 *ft*

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

Sinuous and laterally unstable with alluvial channel boundaries and a narrow flood plain.

7/17/96

Vegetative co Pasture with trees and brush along immediate banks.

DS left: Some brush with Town Highway 1 parallel to channel.

DS right: Brushland with trees along immediate banks.

US left: Short grass and brush with Town Highway 1 parallel to channel.

US right:

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

During the 7/17/96 site inspection, moderate fluvial erosion and slip failure was noted along the upstream left bank.

Describe any obstructions in channel and date of observation.

Stone fill along RABUT blocks part of the right channel. 7/17/96

Hydrology

Drainage area 27.7 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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 4,930 ***ft³/s*** ***Q500*** 7,180 ***ft³/s***

The 100- and 500-year discharges are from the Flood Insurance Study for the Town of Wolcott (Federal Emergency Management Agency, 1982).

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 left abutment (elev. 495.61 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the upstream right wingwall (elev. 499.27 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-38	1	Exit section
FULLV	0	3, 5	Downstream Full-valley section (EXITX overbank and BRIDG channel)
BRIDG	0	1	Bridge section
RDWAY	6	1	Road Grade section
APTEM	43	1	Approach section as surveyed (Used as a template)
APPRO	50	2	Modelled Approach section (Templated from APTEM

[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 0.055 to 0.057, and overbank "n" values ranged from 0.040 to 0.080.

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 0.0092 ft/ft, which was estimated from the 100-year water surface slope downstream of the bridge in the Flood Insurance Study for Wolcott, VT (Federal Emergency Management Agency, February 2, 1982).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0652 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.8 *ft*
Average low steel elevation 497.2 *ft*

100-year discharge 4,930 *ft³/s*
Water-surface elevation in bridge opening 497.3 *ft*
Road overtopping? Y *Discharge over road* 791 *ft³/s*
Area of flow in bridge opening 329 *ft²*
Average velocity in bridge opening 12.6 *ft/s*
Maximum WSPRO tube velocity at bridge 15.6 *ft/s*

Water-surface elevation at Approach section with bridge 501.4
Water-surface elevation at Approach section without bridge 498.7
Amount of backwater caused by bridge 2.7 *ft*

500-year discharge 7,180 *ft³/s*
Water-surface elevation in bridge opening 497.3 *ft*
Road overtopping? Y *Discharge over road* 3,012 *ft³/s*
Area of flow in bridge opening 329 *ft²*
Average velocity in bridge opening 12.7 *ft/s*
Maximum WSPRO tube velocity at bridge 15.7 */s*

Water-surface elevation at Approach section with bridge 503.4
Water-surface elevation at Approach section without bridge 500.3
Amount of backwater caused by bridge 3.1 *ft*

Incipient overtopping discharge 3,350 *ft³/s*
Water-surface elevation in bridge opening 495.3 *ft*
Area of flow in bridge opening 259 *ft²*
Average velocity in bridge opening 13.0 *ft/s*
Maximum WSPRO tube velocity at bridge 16.7 *ft/s*

Water-surface elevation at Approach section with bridge 497.8
Water-surface elevation at Approach section without bridge 497.1
Amount of backwater caused by bridge 0.7 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the incipient discharge was computed by use of the Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 100-year and 500-year discharges resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Results of this analysis are presented in figure 8 and tables 1 and 2. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour. Additional estimates of contraction scour for the 100-year and 500-year discharges were computed by use of Laursen's clear-water scour equation (Richardson and others, 1995, p. 32, equation 20) and the results are presented in Appendix F.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	2.1	1.9	1.0
Depth to armoring	15.0	15.7	25.2
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	11.2	13.2 9.1	20.0
Left abutment	22.3–	15.7-	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	3.1
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	3.1	2.8	3.1
Left abutment	3.1	2.8	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	
Pier 2			

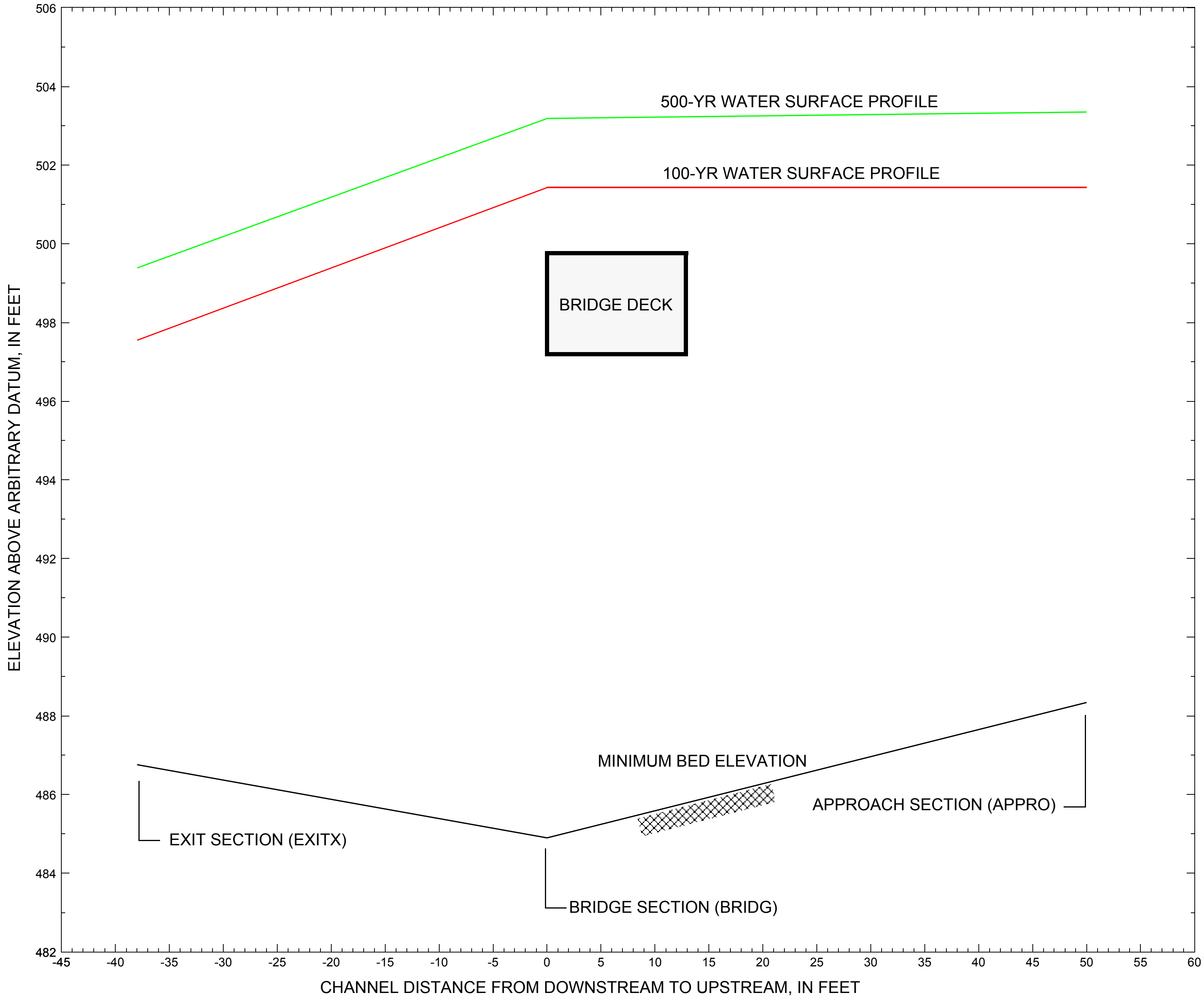

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure WOLCTH00130023 on Town Highway 13, crossing the Wild Branch of the Lamoille River, Wolcott, Vermont.

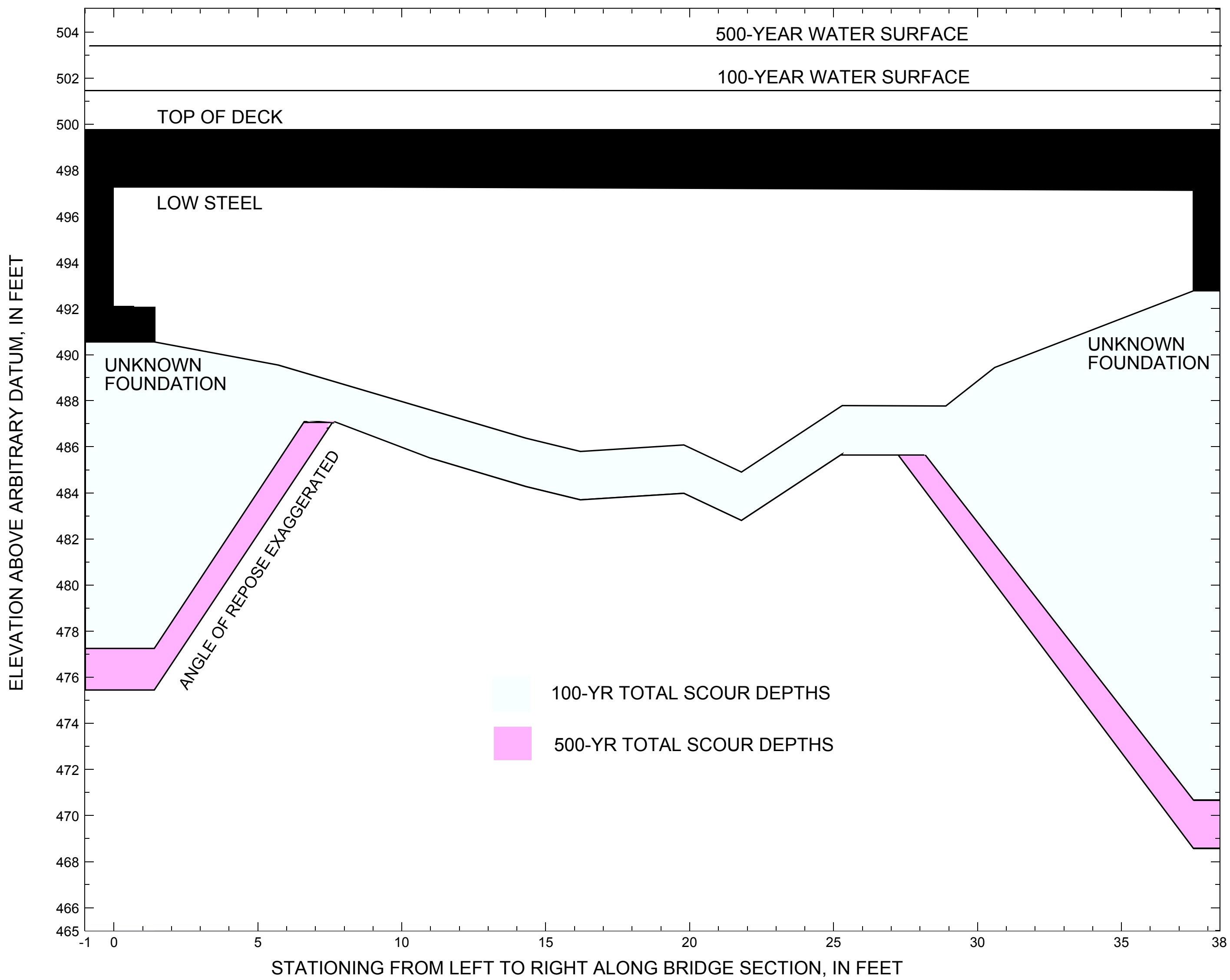

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure WOLCTH00130023 on Town Highway 13, crossing the Wild Branch of the Lamoille River, Wolcott, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WOLCTH00130023 on Town Highway 13, crossing the Wild Branch Lamoille River, Wolcott, 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 4,930 cubic-feet per second											
Left abutment	0.0	--	497.3	--	490.6	2.1	11.2	--	13.3	477.3	--
Right abutment	37.5	--	497.1	--	492.8	2.1	20.0	--	22.1	470.7	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure WOLCTH00130023 on Town Highway 13, crossing the Wild Branch Lamoille River, Wolcott, 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 7,180 cubic-feet per second											
Left abutment	0.0	--	497.3	--	490.6	1.9	13.2	--	15.1	475.5	--
Right abutment	37.5	--	497.1	--	492.8	1.9	22.3	--	24.2	468.6	--

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

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U.S. Geological Survey, 1986, Wolcott, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

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T1        U.S. Geological Survey WSPRO Input File wolc023.wsp
T2        Hydraulic analysis for structure WOLCTH00130023   Date: 14-MAY-97
T3        Town Highway 13, Wild Branch Lamoille River, Wolcott, Vermont  by ECW
*
J1         * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           4930.0   7180.0   3350.0
SK          0.0092   0.0092   0.0092
*
XS   EXITX    -38           0.
GR         -251.3, 507.84   -195.0, 506.31   -147.1, 505.27    -58.7, 499.91
GR          -14.3, 497.21      0.0, 493.88      6.9, 493.46     16.8, 490.37
GR           21.2, 489.33     23.6, 488.70     31.7, 488.59     39.2, 487.64
GR           43.6, 486.76     47.1, 487.37     51.9, 487.36     52.4, 488.63
GR           58.0, 489.32     65.8, 494.01     72.4, 497.86     85.3, 502.04
GR          111.5, 502.82    137.5, 515.06
*
N           0.040        0.057        0.040
SA                   6.9         85.3
*
XS   FULLV      0
GR         -251.3, 507.84   -195.0, 506.31   -147.1, 505.27    -58.7, 499.91
GR          -14.3, 497.21      0.0, 493.88      5.7, 489.55     11.0, 487.61
GR           16.2, 485.80     19.8, 486.08     21.8, 484.90     25.3, 487.79
GR           28.9, 487.77     30.6, 489.45     37.5, 492.77     72.4, 497.86
GR           72.4, 497.86     85.3, 502.04    111.5, 502.82    137.5, 515.06
*            31.7, 488.59     39.2, 487.64     43.6, 486.76
*            47.1, 487.37     51.9, 487.36     52.4, 488.63     58.0, 489.32
*            65.8, 494.01
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.19       0.0
GR            0.0, 497.29      0.7, 491.95      1.3, 491.93      1.3, 490.55
GR            5.7, 489.55     11.0, 487.61     16.2, 485.80     19.8, 486.08
GR           21.8, 484.90     25.3, 487.79     28.9, 487.77     30.6, 489.45
GR           37.5, 492.77     37.5, 497.10      0.0, 497.29
*
*        BRTYPE  BRWDTH       WWANGL    WWWID
CD          1      19.1 * *     55.9      8.5
N           0.055
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      6      12.5     2
GR         -273.6, 509.92   -138.3, 506.43    -32.4, 500.33      0.0, 499.76
GR           37.7, 499.76     71.8, 501.32     93.5, 502.53     98.8, 501.33
GR          125.8, 516.34
*
XT   APTEM     43           0.
GR         -119.7, 506.48    -60.1, 499.72    -20.4, 497.71      0.0, 495.40
GR            6.2, 489.52      8.6, 488.37     12.5, 487.88     18.6, 488.47
GR           23.9, 489.02     26.7, 489.40     34.1, 489.87     39.1, 490.42
GR           53.1, 494.90     83.2, 495.86     96.3, 500.12    121.0, 501.70
GR          157.6, 515.31
*
AS   APPRO     50 * * * 0.0652
GT
N           0.080        0.055        0.045
SA                   0.0         53.1
*
HP 1 BRIDG 497.29 1 497.29
HP 2 BRIDG 497.29 * * 4137
HP 2 RDWAY 501.43 * * 791
HP 1 APPRO 501.43 1 501.43
HP 2 APPRO 501.43 * * 4930
*
HP 1 BRIDG 497.29 1 497.29
HP 2 BRIDG 497.29 * * 4166
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File wolc023.wsp
        Hydraulic analysis for structure WOLCTH00130023   Date: 14-MAY-97
        Town Highway 13, Wild Branch Lamoille River, Wolcott, Vermont  by ECW
           *** RUN DATE & TIME: 05-27-97  14:39
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      329     21310      0     89                              0
   497.29           329     21310      0     89  1.00      0     38          0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.29     0.0    37.5   329.0   21310.    4137.  12.58

X STA.        0.0        4.5        6.9        8.9       10.6       12.2
  A(I)            27.6       18.7       17.0       15.8       15.3
  V(I)            7.49      11.08      12.20      13.06      13.49

X STA.       12.2       13.6       14.9       16.1       17.3       18.5
  A(I)            14.7       13.9       13.8       13.4       13.3
  V(I)           14.07      14.85      15.01      15.47      15.60

X STA.       18.5       19.7       20.9       22.1       23.3       24.7
  A(I)            13.5       13.8       13.7       14.3       15.0
  V(I)           15.31      14.99      15.05      14.48      13.79

X STA.       24.7       26.4       28.1       30.0       32.6       37.5
  A(I)            15.7       15.8       17.1       19.6       27.1
  V(I)           13.13      13.10      12.12      10.57       7.65

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       6.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.43   -51.5    99.0   148.8    5177.     791.   5.32

X STA.      -51.5      -32.2      -25.8      -20.4      -15.8      -11.5
  A(I)            10.7        7.5        6.7        6.2        6.1
  V(I)            3.69       5.29       5.87       6.34       6.46

X STA.      -11.5       -7.7       -4.2       -0.9        2.2        5.3
  A(I)             5.7        5.6        5.3        5.2        5.2
  V(I)            6.93       7.11       7.50       7.66       7.65

X STA.        5.3        8.9       13.2       17.6       22.1       26.6
  A(I)             6.0        7.2        7.4        7.5        7.5
  V(I)            6.59       5.46       5.32       5.29       5.26

X STA.       26.6       31.2       36.0       41.3       48.8       99.0
  A(I)             7.6        8.0        8.6       10.0       14.7
  V(I)            5.20       4.93       4.58       3.96       2.68

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      187      6602     71     71                           1717
             2      562     70370     53     57                          10376
             3      213     16951     57     57                           2348
   501.43           962     93923    181    185  1.36    -70    110      10792

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.43   -71.2   109.6   961.9   93923.    4930.   5.13

X STA.      -71.2       -8.2        4.4        8.2       10.9       13.5
  A(I)           144.7       76.2       42.0       34.7       33.7
  V(I)            1.70       3.23       5.88       7.10       7.31

X STA.       13.5       16.0       18.7       21.4       24.1       27.1
  A(I)            32.8       33.7       33.1       33.2       34.4
  V(I)            7.52       7.31       7.45       7.42       7.17

X STA.       27.1       30.1       33.2       36.5       40.0       44.2
  A(I)            34.8       35.3       35.6       37.6       40.5
  V(I)            7.09       6.99       6.93       6.56       6.09

X STA.       44.2       49.9       57.9       66.5       76.1      109.6
  A(I)            45.8       49.5       49.9       52.6       81.9
  V(I)            5.39       4.98       4.94       4.69       3.01
```

```
        U.S. Geological Survey WSPRO Input File wolc023.wsp
        Hydraulic analysis for structure WOLCTH00130023   Date: 14-MAY-97
        Town Highway 13, Wild Branch Lamoille River, Wolcott, Vermont  by ECW
           *** RUN DATE & TIME: 05-27-97  14:39
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      329     21310      0     89                            0
   497.29           329     21310      0     89  1.00      0     38        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.29     0.0    37.5   329.0   21310.    4166.  12.66

 X STA.         0.0        4.5        6.9        8.9       10.6       12.2
   A(I)            27.6       18.7       17.0       15.8       15.3
   V(I)            7.55      11.16      12.29      13.15      13.59

 X STA.        12.2       13.6       14.9       16.1       17.3       18.5
   A(I)            14.7       13.9       13.8       13.4       13.3
   V(I)           14.17      14.95      15.12      15.58      15.71

 X STA.        18.5       19.7       20.9       22.1       23.3       24.7
   A(I)            13.5       13.8       13.7       14.3       15.0
   V(I)           15.42      15.10      15.16      14.58      13.89

 X STA.        24.7       26.4       28.1       30.0       32.6       37.5
   A(I)            15.7       15.8       17.1       19.6       27.1
   V(I)           13.23      13.20      12.20      10.65       7.70

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       6.

         WSEL     LEW     REW    AREA        K        Q    VEL
       503.19   -82.1   102.1   429.8   24147.    3012.   7.01

 X STA.       -82.1      -47.5      -37.3      -30.1      -23.9      -18.2
   A(I)            34.5       23.2       20.0       18.1       17.7
   V(I)            4.37       6.48       7.54       8.30       8.52

 X STA.       -18.2      -12.8       -7.9       -3.1        1.3        5.6
   A(I)            17.0       15.9       15.8       15.2       14.8
   V(I)            8.84       9.48       9.51       9.92      10.18

 X STA.         5.6       11.2       17.2       23.3       29.4       35.6
   A(I)            19.2       20.5       20.8       21.0       21.3
   V(I)            7.83       7.36       7.24       7.17       7.08

 X STA.        35.6       42.2       49.7       59.4       73.1      102.1
   A(I)            22.1       23.1       25.7       29.1       34.8
   V(I)            6.83       6.51       5.86       5.18       4.32

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      340     15510     88     88                         3784
             2      664     92908     53     57                        13323
             3      341     31871     71     72                         4243
   503.35          1345    140289    212    217  1.39    -87    124    16264

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

         WSEL     LEW     REW    AREA        K        Q    VEL
       503.35   -88.1   124.2  1344.9  140289.    7180.   5.34

 X STA.       -88.1      -25.4       -3.6        5.6        9.2       12.3
   A(I)           185.1      128.2       83.0       50.4       46.1
   V(I)            1.94       2.80       4.32       7.12       7.78

 X STA.        12.3       15.4       18.4       21.5       24.8       28.2
   A(I)            45.3       43.9       45.0       45.9       46.0
   V(I)            7.93       8.17       7.98       7.82       7.81

 X STA.        28.2       31.8       35.5       39.2       43.7       49.6
   A(I)            47.3       47.9       48.0       52.5       58.7
   V(I)            7.59       7.49       7.48       6.84       6.12

 X STA.        49.6       57.0       65.0       73.5       83.7      124.2
   A(I)            61.0       62.3       63.5       73.1      111.6
   V(I)            5.88       5.76       5.65       4.91       3.22
```

```
        U.S. Geological Survey WSPRO Input File wolc023.wsp
        Hydraulic analysis for structure WOLCTH00130023   Date: 14-MAY-97
        Town Highway 13, Wild Branch Lamoille River, Wolcott, Vermont  by ECW
           *** RUN DATE & TIME: 05-27-97  14:39
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      259     21616     37     48                         3866
   495.31           259     21616     37     48  1.00      0     38     3866

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

         WSEL     LEW     REW    AREA         K        Q    VEL
       495.31     0.3    37.5   258.5   21616.    3350.  12.96

X STA.         0.3         5.2         7.7         9.7        11.3        12.8
  A(I)            22.9        15.1        13.6        12.5        11.8
  V(I)            7.30       11.10       12.29       13.44       14.22

X STA.        12.8        14.1        15.3        16.4        17.4        18.5
  A(I)            11.1        10.6        10.5        10.1        10.0
  V(I)           15.10       15.85       15.98       16.60       16.74

X STA.        18.5        19.6        20.7        21.8        22.9        24.2
  A(I)            10.3        10.5        10.5        11.3        11.8
  V(I)           16.32       16.02       15.94       14.87       14.24

X STA.        24.2        25.8        27.4        29.1        31.8        37.5
  A(I)            12.5        12.0        13.1        16.2        22.3
  V(I)           13.42       13.94       12.77       10.34        7.50

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       17       320     18     18                           98
             2      371     35280     53     57                         5574
             3       64      3156     35     35                          491
   497.84           453     38756    105    109  1.15    -17     88     4968

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

         WSEL     LEW     REW    AREA         K        Q    VEL
       497.84   -17.5    87.9   452.6   38756.    3350.   7.40

X STA.       -17.5         5.7         8.4        10.5        12.4        14.2
  A(I)            44.4        21.9        19.0        18.0        17.3
  V(I)            3.77        7.63        8.80        9.32        9.71

X STA.        14.2        16.1        18.0        20.0        22.0        24.1
  A(I)            17.5        17.3        17.3        17.6        17.8
  V(I)            9.58        9.71        9.68        9.49        9.43

X STA.        24.1        26.4        28.7        31.1        33.7        36.4
  A(I)            18.3        18.9        18.8        19.4        19.8
  V(I)            9.17        8.88        8.92        8.65        8.44

X STA.        36.4        39.3        43.0        48.7        62.5        87.9
  A(I)            21.1        23.3        27.2        35.9        42.0
  V(I)            7.94        7.20        6.16        4.66        3.99
```

```
U.S. Geological Survey WSPRO Input File wolc023.wsp
Hydraulic analysis for structure WOLCTH00130023   Date: 14-MAY-97
Town Highway 13, Wild Branch Lamoille River, Wolcott, Vermont  by ECW
   *** RUN DATE & TIME: 05-27-97  14:39

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

EXITX:XS   ******    -19      550  1.29 *****  498.85  495.58    4930  497.55
       -37 ******     72    51369  1.04 ***** *******    0.66    8.96

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.85     497.79     496.92

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.05     515.06    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.05     515.06     496.92

FULLV:FV       38    -23      469  1.75  0.48  499.55  496.92    4930  497.80
         0     38     72    37599  1.02  0.23    0.00    0.85   10.52
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.80     498.73     497.71

 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.30     515.77    0.50

 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.30     515.77     497.71

APPRO:AS       50    -30      550  1.48  0.65  500.19  497.71    4930  498.71
        50     50     91    49469  1.18  0.00   -0.02    0.81    8.96
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   497.80     497.19

            <<<<<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       38      0      329  2.46 *****  499.75  495.64    4137  497.29
         0 ******     38    21310  1.00 ***** *******    0.75   12.57

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.19 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       6.    38.  0.10  0.56  501.89    0.00    791.  501.43

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    462.    70.   -52.    18.   1.7   1.2   5.9   5.3   1.7   3.0
   RT:    328.    53.    18.    72.   1.7   1.2   5.7   5.2   1.6   3.0

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

APPRO:AS       31    -70      963  0.56  0.35  501.99  497.71    4930  501.43
        50     34    110    94019  1.36  0.00    0.00    0.46    5.12

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -38.   -20.    72.   4930.   51369.     550.    8.96  497.55
   FULLV:FV       0.   -24.    72.   4930.   37599.     469.   10.52  497.80
   BRIDG:BR       0.     0.    38.   4137.   21310.     329.   12.57  497.29
   RDWAY:RG       6.*******   462.    791.******************    2.00  501.43
   APPRO:AS      50.   -71.   110.   4930.   94019.     963.    5.12  501.43

     SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    495.58    0.66  486.76  515.06************  1.29  498.85  497.55
   FULLV:FV    496.92    0.85  484.90  515.06  0.48  0.23  1.75  499.55  497.80
   BRIDG:BR    495.64    0.75  484.90  497.29************  2.46  499.75  497.29
   RDWAY:RG  ****************  499.76  516.34  0.10******  0.56  501.89  501.43
   APPRO:AS    497.71    0.46  488.34  515.77  0.35  0.00  0.56  501.99  501.43
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File wolc023.wsp
        Hydraulic analysis for structure WOLCTH00130023   Date: 14-MAY-97
        Town Highway 13, Wild Branch Lamoille River, Wolcott, Vermont  by ECW
           *** RUN DATE & TIME: 05-27-97  14:39

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

EXITX:XS   ******    -49      751  1.52 *****  500.91  497.19    7180  499.39
       -37 ******     77    74841  1.07 ***** *******    0.72    9.55

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.83     499.68     498.76

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   498.89     515.06    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   498.89     515.06     498.76

FULLV:FV       38    -54      686  1.77  0.43  501.46  498.76    7180  499.70
         0     38     78    60880  1.04  0.13    0.00    0.83   10.47
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.83     500.32     499.20

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   499.20     515.77    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   499.20     515.77     499.20

APPRO:AS       50    -60      778  1.70  0.57  502.03  499.20    7180  500.33
        50     50     96    74589  1.28  0.00    0.00    0.83    9.23
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                      WS3N,LSEL =   499.70     497.19

            <<<<<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       38      0      329  2.49 *****  499.78  495.67    4166  497.29
         0 ******     38    21310  1.00 ***** *******    0.75   12.66

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.19 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       6.    38.  0.10  0.62  503.87    0.00   3012.  503.19

           Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1660.   100.   -82.    18.   3.4   2.3   8.2   7.0   3.0   3.1
   RT:   1351.    84.    18.   102.   3.4   2.3   8.1   7.0   3.0   3.1

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

APPRO:AS       31    -87     1345  0.62  0.38  503.97  499.20    7180  503.35
        50     36    124   140350  1.39  0.00    0.00    0.44    5.34

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q       K     AREA     VEL   WSEL
   EXITX:XS     -38.   -50.    77.   7180.   74841.     751.    9.55  499.39
   FULLV:FV       0.   -55.    78.   7180.   60880.     686.   10.47  499.70
   BRIDG:BR       0.     0.    38.   4166.   21310.     329.   12.66  497.29
   RDWAY:RG       6.******* 1660.   3012.******************    2.00  503.19
   APPRO:AS      50.   -88.   124.   7180.  140350.    1345.    5.34  503.35

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    497.19    0.72  486.76  515.06************  1.52  500.91  499.39
   FULLV:FV    498.76    0.83  484.90  515.06  0.43  0.13  1.77  501.46  499.70
   BRIDG:BR    495.67    0.75  484.90  497.29************  2.49  499.78  497.29
   RDWAY:RG  ****************  499.76  516.34  0.10******  0.62  503.87  503.19
   APPRO:AS    499.20    0.44  488.34  515.77  0.38  0.00  0.62  503.97  503.35
```

```
       U.S. Geological Survey WSPRO Input File wolc023.wsp
       Hydraulic analysis for structure WOLCTH00130023   Date: 14-MAY-97
       Town Highway 13, Wild Branch Lamoille River, Wolcott, Vermont  by ECW
          *** RUN DATE & TIME: 05-27-97  14:39

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

EXITX:XS   ******     -8      417  1.03 *****  496.98  494.10    3350  495.95
      -37 ******     69    34908  1.03 ***** *******    0.62    8.03

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     496.15     495.27

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.45     515.06    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.45     515.06     495.27

FULLV:FV       38     -9      336  1.55  0.48  497.72  495.27    3350  496.17
         0     38     61    25462  1.01  0.26    0.00    0.81    9.97
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.85     497.06     496.06

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.67     515.77    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.67     515.77     496.06

APPRO:AS       50    -10      374  1.40  0.72  498.45  496.06    3350  497.06
        50     50     85    30406  1.12  0.00    0.01    0.85    8.96
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   495.31     497.39     497.83     497.19

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

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   499.86      3327.         0.

 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       38      0      258  2.61  0.57  497.92  494.67    3350  495.31
         0     38     38    21601  1.00  0.37    0.00    0.87   12.96

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.19 ****** ****** ******
    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       6.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

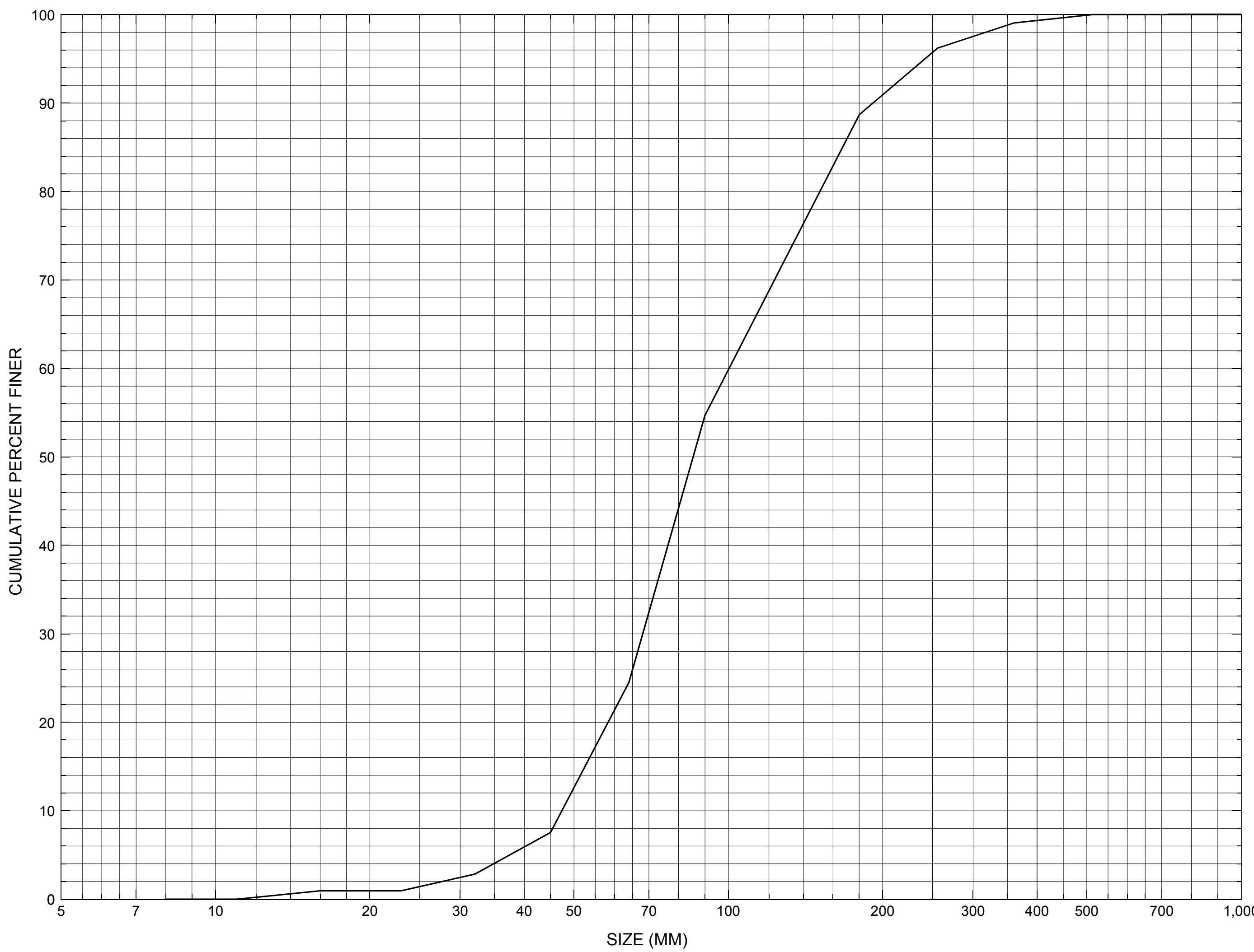
APPRO:AS       31    -16      452  0.98  0.44  498.82  496.06    3350  497.84
        50     33     88    38705  1.15  0.46    0.00    0.68    7.41

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.611  0.155   32671.     5.    42.   497.55
                   <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -38.    -9.    69.   3350.   34908.     417.    8.03  495.95
   FULLV:FV       0.   -10.    61.   3350.   25462.     336.    9.97  496.17
   BRIDG:BR       0.     0.    38.   3350.   21601.     258.   12.96  495.31
   RDWAY:RG       6.**************      0.       0.       0.    2.00********
   APPRO:AS      50.   -17.    88.   3350.   38705.     452.    7.41  497.84
 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    494.10    0.62  486.76  515.06************  1.03  496.98  495.95
   FULLV:FV    495.27    0.81  484.90  515.06  0.48  0.26  1.55  497.72  496.17
   BRIDG:BR    494.67    0.87  484.90  497.29  0.57  0.37  2.61  497.92  495.31
   RDWAY:RG  ****************  499.76  516.34************  0.44  500.20********
   APPRO:AS    496.06    0.68  488.34  515.77  0.44  0.46  0.98  498.82  497.84
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure WOLCTH00130023, in Wolcott, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WOLCTH00130023

General Location Descriptive

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

Date *(MM/DD/YY)* 10 / 13 / 95

Highway District Number *(I - 2; nn)* 06

County *(FIPS county code; I - 3; nnn)* 015

Town *(FIPS place code; I - 4; nnnnn)* 85375

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

Waterway *(I - 6)* Wild Branch Lamoille River

Road Name *(I - 7):* -

Route Number TH 13

Vicinity *(I - 9)* 0.01 MI TO JCT W CL2 TH1

Topographic Map Wolcott

Hydrologic Unit Code: 2010005

Latitude *(I - 16; nnnn.n)* 44359

Longitude *(i - 17; nnnnn.n)* 72280

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10081000230810

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

Maximum span length *(I - 48; nnnn)* 0039

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

Structure length *(I - 49; nnnnnn)* 000041

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

Deck Width *(I - 52; nn.n)* 125

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)* 5

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

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

Structure type *(I - 43; nnn)* 303

Year Reconstructed *(I - 106)* 1973

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*) ______

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

Waterway of full opening (*nnn.n ft*^{2}) ______

Comments:

According to the structural inspection report dated 6/26/95, the deck of the structure consists of wood planks with wood runners. The posts and rails are iron, which is rusted. The right abutment and its wing-walls are concrete with a small concrete footing. There is a fine vertical crack and small leak under the right side (upstream) girder. The left abument appears to be a concrete faced, laid-up stone wall with a concrete footing and laid-up stone wingwalls. Boulder riprap has been placed in front of both abutments and their wingwalls. The US channel flows toward the bridge at nearly 45 degrees. A large, coarse gravel bar in the US channel along the right abutment. Boulders and **(Continued, page 33)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (*ft²*): -

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

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

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

Comments:

possibly ledge outcrops, with small areas of erosion along the US and DS road embankments.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **27.745** mi^2 Lake/pond/swamp area **0.265** mi^2

Watershed storage *(ST)* **0.955** %

Bridge site elevation **770.8** ft Headwater elevation **2617** ft

Main channel length **11.526** mi

10% channel length elevation **816.72** ft 85% channel length elevation **1564.56** ft

Main channel slope *(S)* **86.51** 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 BENCKMARK 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 DRILL BORING INFORMATION

Comments:
-

Cross-sectional Data

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

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

Comments: **This is a cross-section of the upstream face. The low cord elevation is from the survey log done for this report on 07/17/96. The low cord to bed length data is from the sketch attached to a bridge inspection report dated 06/26/95. The sketch was done on 10/20/93.**

Station	0	12.3	19.3	28.3	37.3	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low cord elevation	497.3	-	-	-	497.1	-	-	-	-	-	-
Bed elevation	491.7	-	-	-	493.1	-	-	-	-	-	-
Low cord to bed length	5.6	10.5	11.9	9.1	4.0	-	-	-	-	-	-

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

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

Comments:

-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 8/14/96

Computerized by: EW Date: 8/14/96

Reviewd by: EW Date: 5/28/97

Structure Number WOLCTH00130023

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 07 / 17 / 1996

2. Highway District Number 06 Mile marker 000000

County Lamoille (015) Town WOLCOTT (85375)

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

Route Number C3013 Hydrologic Unit Code: 2010005

3. Descriptive comments:

This structure has a wooden deck with steel I-beams. The bridge is located 0.01 miles to the junction with Cl2 TH1.

B. Bridge Deck Observations

4. Surface cover... LBUS 5 RBUS 4 LBDS 4 RBDS 6 Overall 5

*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

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

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

7. Bridge length 41 *(feet)* Span length 39 *(feet)* Bridge width 12.5 *(feet)*

Road approach to bridge:

8. LB 2 RB 2 *(**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 -- US right --

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

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

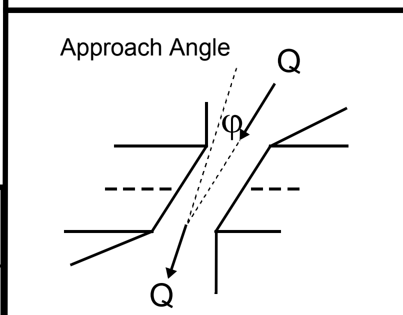
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

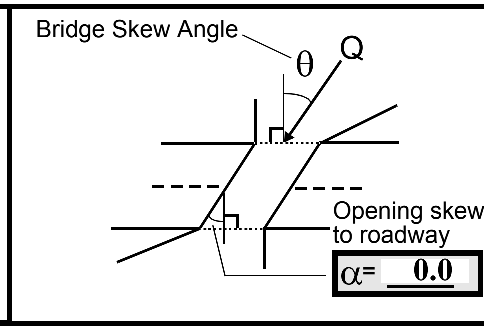
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: 45 16. Bridge skew: 45





17. Channel impact zone 1: Exist? Y *(Y or N)*

Where? LB *(LB, RB)* Severity 2

Range? 105 feet US *(US, UB, DS)* to 0 feet US

Channel impact zone 2: Exist? Y *(Y or N)*

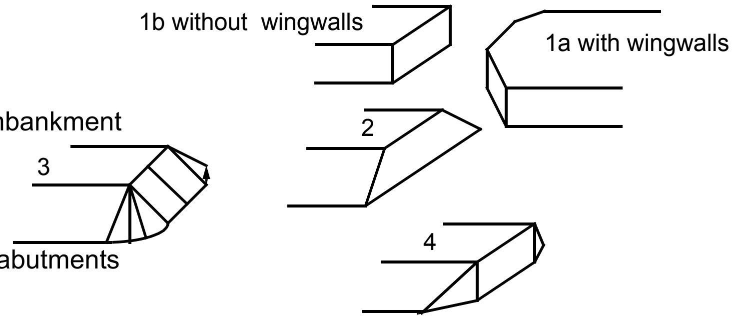
Where? RB *(LB, RB)* Severity 2

Range? 10 feet US *(US, UB, DS)* to 30 feet DS

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

18. Bridge Type: **1a/1b**

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



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

#7: The measured bridge width from rail to rail was 11.7 feet. The wooden deck excedes the boundaries of the rails.
#18: The left abutment is type 1b. The right abutment is type 1a.

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
31.5	6.0			4.5	3	1	432	234	2	1

23. Bank width **40.0** 24. Channel width **15.0** 25. Thalweg depth **52.5** 29. Bed Material **453**

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

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

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

#30: Right bank protection is dumped stone. It is continuous protection extending from 35 feet upstream and along the upstream right wingwall, right abutment, downstream right wingwall and downstream right bank.

Left bank protection is dumped stone extending from 45 feet upstream to the upstream end of the left bank.

At 70 feet US there is a road which crosses through the stream channel, perpendicular to flow.

33. <u>Point/Side bar present?</u> **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **65 US** 35. Mid-bar width: **18**

36. Point bar extent: **80** feet **US** *(US, UB)* to **25** feet **US** *(US, UB, DS)* positioned **40** %LB to **100** %RB

37. Material: **453**

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

The side bar begins where the road crosses the stream at 75 feet upstream. The material, on the left bank ramp where the road crosses the stream, consists of angular stone fill.

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

41. Mid-bank distance: **105** 42. Cut bank extent: **145** feet **US** *(US, UB)* to **75** feet **US** *(US, UB, DS)*

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

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

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

47. Scour dimensions: Length - Width - Depth : - Position - %LB to - %RB

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

Refer to downstream channel assessment for scour hole dimensions.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
33.0		**2.0**		**2**	**7**	**7**	**-**

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

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

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

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

523

#63: The bed material includes slumped bank material.

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

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

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

70. Debris and Ice Comments:

2

A decrease in the slope under the bridge, as well as the bridge location on the bend in the stream contribute to a moderate capture efficiency and ice blockage potential. Debris is presently caught in an I-beam at the upstream bridge face.

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	2	0	3 ft	90.0
RABUT	1	45	90			2	0	37.0

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.):

0

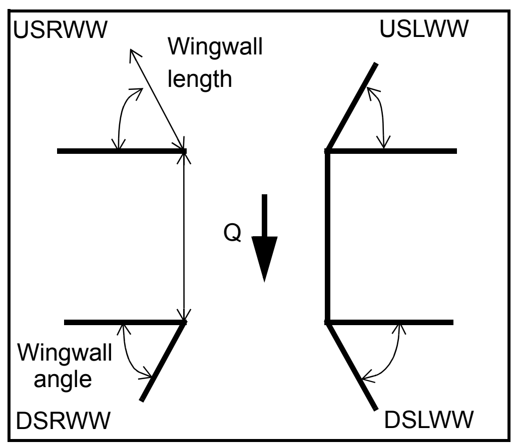
0

1

The left abutment has a sand bar along the footing base described in the downstream channel assessment.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						37.0	
USRWW:	N		-		-	4.5	
DSLWW:	-		-		Y	14.0	
DSRWW:	1		0		-	12.0	



*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	-	-	Y	-	-	1	-	1
Condition	N	-	1	-	-	1	-	1
Extent	-	-	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*

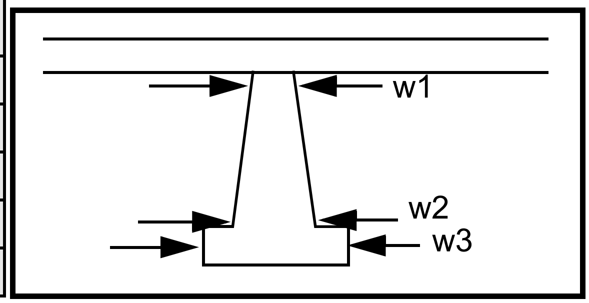
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
-
-
-
2
1
1

Piers:

84. Are there piers? **Th** *(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	-			-	**55.0**	**15.0**
Pier 2	-			-	**60.0**	**13.5**
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e bank/**	**e is**	**ends**	**Stacke**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**brid**	**dum**	**(roa**	**d**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**ge**	**ped**	**d**	**stone**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**pro-**	**stone**	**emb**	**exist**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**tec-**	**at**	**ank-**	**s at**	*Y- yes; N- no*
91. Attack ∠ (BF)	**tion**	**the**	**ment**	**the**	
92. Pushed	**is**	**upst**	**s) of**	**dow**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**dum**	**ream**	**the**	**nstre**	
95. Cross-members	**ped**	**and**	**left**	**am**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**stone**	**dow**	**abut**	**end**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**.**	**nstre**	**ment**	**of**	
98. Exposure depth	**Ther**	**am**	**.**	**the**	

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

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: 3

Scour dimensions: Length 2 Width 23 Depth: 432 Positioned 1 %LB to 1 %RB

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

345
2
2
2

Are there major confluences? 1 (Y or if N type ctrl-n mc) How many? The

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

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

Confluence comments (eg. confluence name):

extends from 35 feet upstream to 27 feet downstream. From 27 feet downstream to 68 feet downstream on the right bank, the protection type is also type 2. However, there is more vegetation between the slumping placed

F. Geomorphic Channel Assessment

107. Stage of reach evolution pro

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)*:

tection. A bedrock outcrop exists on the right bank from 68 feet downstream and beyond.

The left bank dumped stone protection ends at 17 feet downstream, and is slumped into channel.

N

109. G. Plan View Sketch

- -

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: WOLCTH00130023 Town: WOLCOTT
Road Number: TH 13 County: LAMOILLE
Stream: WILD BRANCH LAMOILLE RIVER

Initials ECW Date: 5/23/97 Checked: EB 5/27/97

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	4930	7180	3350
Main Channel Area, ft2	562	664	371
Left overbank area, ft2	187	340	17
Right overbank area, ft2	213	341	64
Top width main channel, ft	53	53	53
Top width L overbank, ft	71	88	18
Top width R overbank, ft	57	71	35
D50 of channel, ft	0.28	0.28	0.28
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.6	12.5	7.0
y1, average depth, LOB, ft	2.6	3.9	0.9
y1, average depth, ROB, ft	3.7	4.8	1.8
Total conveyance, approach	93923	140289	38756
Conveyance, main channel	70370	92908	35280
Conveyance, LOB	6602	15510	320
Conveyance, ROB	16951	31871	3156
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	3693.7	4755.0	3049.5
Ql, discharge, LOB, cfs	346.5	793.8	27.7
Qr, discharge, ROB, cfs	889.8	1631.2	272.8
Vm, mean velocity MC, ft/s	6.6	7.2	8.2
Vl, mean velocity, LOB, ft/s	1.9	2.3	1.6
Vr, mean velocity, ROB, ft/s	4.2	4.8	4.3
Vc-m, crit. velocity, MC, ft/s	10.9	11.2	10.1
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)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	4930	7180	3350
(Q) discharge thru bridge, cfs	4137	4166	3350
Main channel conveyance	21310	21310	21616
Total conveyance	21310	21310	21616
Q2, bridge MC discharge,cfs	4137	4166	3350
Main channel area, ft2	329	329	259
Main channel width (normal), ft	37.5	37.5	37.2
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.5	37.5	37.2
y_bridge (avg. depth at br.), ft	8.77	8.77	6.96
Dm, median (1.25*D50), ft	0.35	0.35	0.35
y2, depth in contraction,ft	9.41	9.47	7.91
ys, scour depth (y2-ybridge), ft	0.64	0.70	0.95

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation   Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and other, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	4930	7180	3350
Q, thru bridge MC, cfs	4137	4166	3350
Vc, critical velocity, ft/s	10.87	11.18	10.14
Va, velocity MC approach, ft/s	6.57	7.16	8.22
Main channel width (normal), ft	37.5	37.5	37.2
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.5	37.5	37.2
qbr, unit discharge, ft2/s	110.3	111.1	90.1
Area of full opening, ft2	329.0	329.0	259.0
Hb, depth of full opening, ft	8.77	8.77	6.96
Fr, Froude number, bridge MC	0.75	0.75	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	497.19	497.19	0
Elevation of Bed, ft	488.42	488.42	-6.96
Elevation of Approach, ft	501.43	503.35	0
Friction loss, approach, ft	0.35	0.38	0
Elevation of WS immediately US, ft	501.08	502.97	0.00
ya, depth immediately US, ft	12.66	14.55	6.96
Mean elevation of deck, ft	499.76	499.76	0
w, depth of overflow, ft (>=0)	1.32	3.21	0.00
Cc, vert contrac correction (<=1.0)	0.94	0.94	1.00
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	2.07	1.85	N/A
Ys, scour w/Umbrell equation, ft	0.87	1.78	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]

Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	4137	4166	3350
Main channel area (DS), ft2	329	329	259
Main channel width (normal), ft	37.5	37.5	37.2
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	37.5	37.5	37.2
D90, ft	0.6281	0.6281	0.6281
D95, ft	0.7932	0.7932	0.7932
Dc, critical grain size, ft	0.6040	0.6125	0.7006
Pc, Decimal percent coarser than Dc	0.108	0.105	0.077
Depth to armoring, ft	14.97	15.66	25.19

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	4930	7180	3350	4930	7180	3350
a', abut.length blocking flow, ft	71.2	88.1	17.5	72.1	86.7	50.4
Ae, area of blocked flow ft2	139	172.9	33.5	316.2	376.3	141.5
Qe, discharge blocked abut.,cfs	--	--	126.4	--	--	774
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.09	2.48	3.77	4.77	5.31	5.47
ya, depth of f/p flow, ft	1.95	1.96	1.91	4.39	4.34	2.81
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	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	0.264	0.312	0.481	0.401	0.449	0.575
ys, scour depth, ft	11.18	13.20	9.11	19.98	22.31	15.72

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)	71.2	88.1	17.5	72.1	86.7	50.4
y1 (depth f/p flow, ft)	1.95	1.96	1.91	4.39	4.34	2.81
a'/y1	36.47	44.89	9.14	16.44	19.98	17.95
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.26	0.31	0.48	0.40	0.45	0.58
Ys w/ corr. factor K1/0.55:						
vertical	9.14	9.72	ERR	ERR	ERR	ERR
vertical w/ ww's	7.50	7.97	ERR	ERR	ERR	ERR
spill-through	5.03	5.34	ERR	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship

D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)

(Richardson and others, 1995, p112, eq. 81,82)

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.75	0.75	0.87	0.75	0.75	0.87
y, depth of flow in bridge, ft	8.77	8.77	6.96	8.77	8.77	6.96
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	3.05	3.05	ERR	3.05	3.05	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	2.80	ERR	ERR	2.80