LEVEL II SCOUR ANALYSIS FOR BRIDGE 52 (STOWTH00230052) on TOWN HIGHWAY 23, crossing the WEST BRANCH LITTLE RIVER, STOWE, VERMONT

Open-File Report 98-061

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

U.S. Department of the Interior
U.S. Geological Survey

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By LORA K. STRIKER AND LAURA MEDALIE

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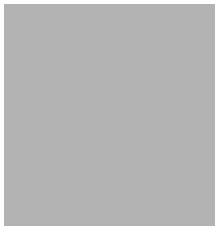

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VERMONT AGENCY OF TRANSPORTATION
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Pembroke, New Hampshire

1998

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

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

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

OTHER ABBREVIATIONS

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

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 52 (STOWTH00230052) ON TOWN HIGHWAY 23, CROSSING THE WEST BRANCH LITTLE RIVER, STOWE, VERMONT

By **Lora K. Striker and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure STOWTH00230052 on Town Highway 23 crossing the West Branch Little River also referred to as the West Branch Waterbury River, Stowe, 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 (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in north central Vermont. The 26.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is predominantly pasture while the left bank upstream and downstream of the site is shrub and brushland.

In the study area, the West Branch Little River has a sinuous channel with irregular point and lateral bars and a slope of approximately 0.01 ft/ft, an average channel top width of 110 ft and an average bank height of 11 ft. The channel bed material ranges from gravel to cobble with a median grain size (D_{50}) of 25.8 mm (0.085 ft). The geomorphic assessment at the time of the Level I and Level II site visit on
July 10, 1996, indicated that the reach was stable.

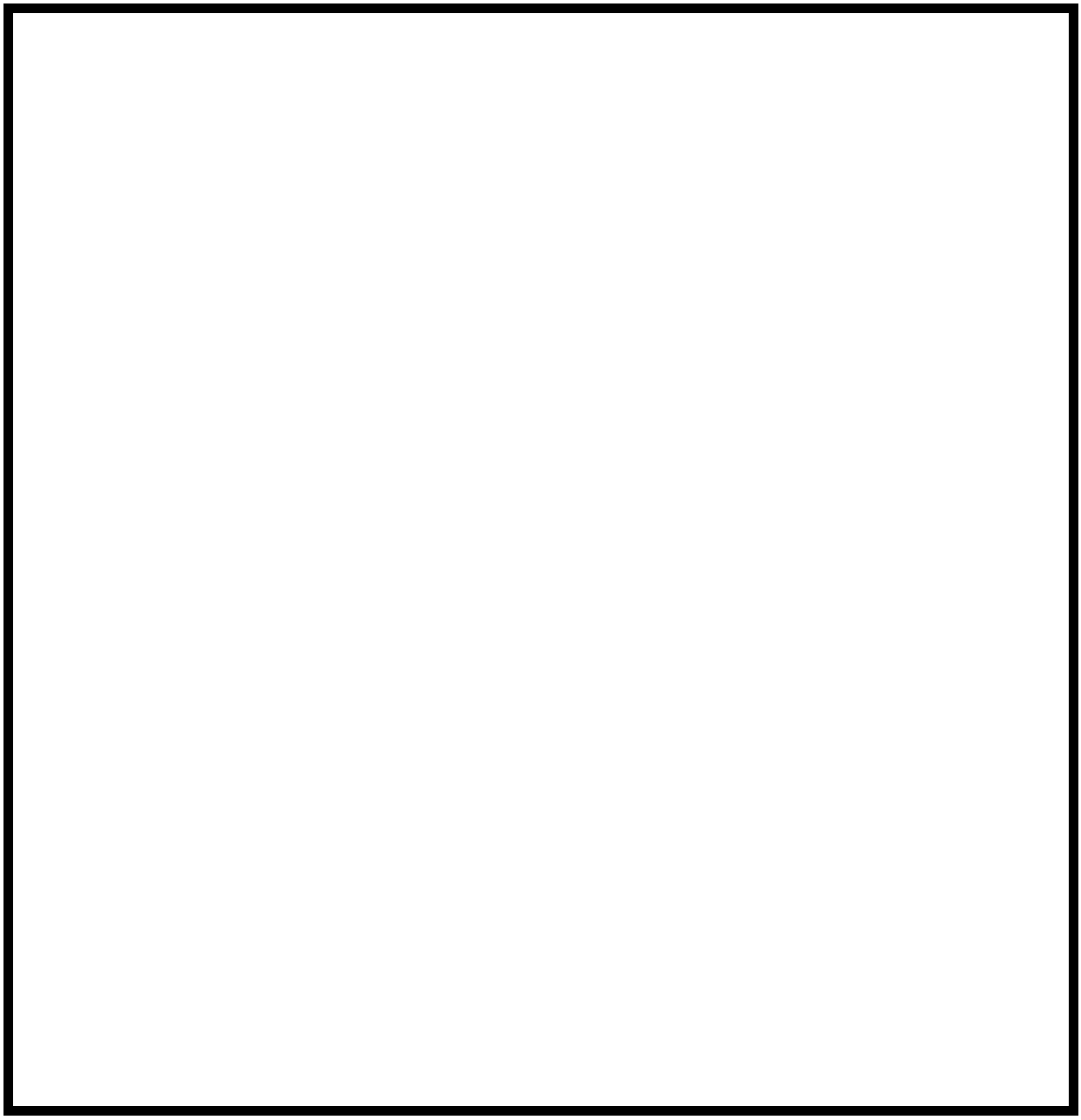
The Town Highway 23 crossing of the West Branch Little River is a 64-ft-long, two-lane bridge consisting of one 61-foot concrete span (Vermont Agency of Transportation, written communication, October 13, 1995). The opening length of the structure parallel to the bridge face is 59 ft. The bridge is supported by a vertical, mortared stone abutment on the left and a vertical, concrete abutment with wingwalls on the right. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is 0 degrees.

A scour hole 3.0 ft deeper than the mean thalweg depth was observed along the right bank upstream at a bend in the channel during the Level I assessment. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the left and right banks upstream, along the left abutment, upstream end of the right abutment, upstream end of the downstream right wingwall, and along the left and right banks downstream; and type-3 stone fill (less than 48 inches diameter) along the base of the upstream right wingwall. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was determined and analyzed as another potential worst-case scour scenario. 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 2.7 to 3.9 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 11.4 to 13.1 ft and right abutment scour ranged from 7.0 to 11.0 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 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.

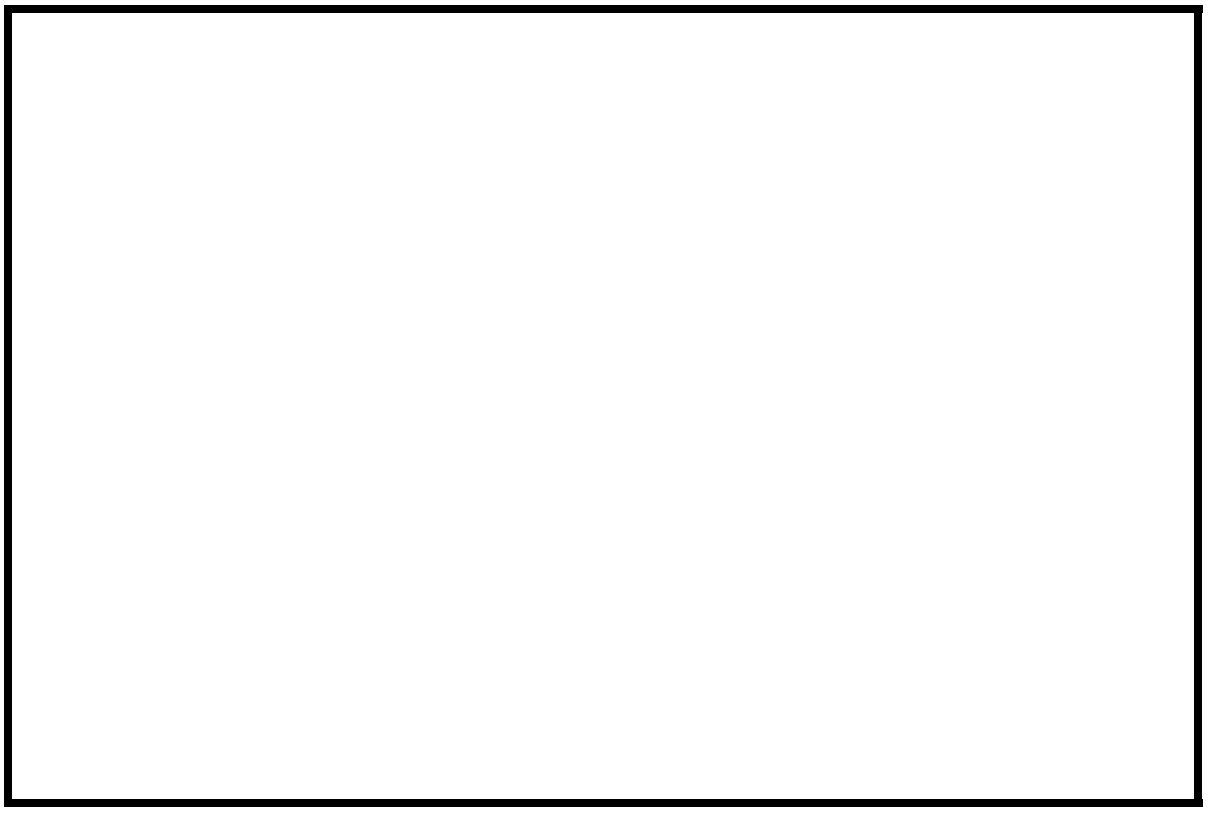


Stowe, VT. Quadrangle, 1:24,000, 1968

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 STOWTH00230052 ***Stream*** West Branch Little River

County Lamoille ***Road*** TH23 ***District*** 6

Description of Bridge

Bridge length 64 ***ft*** ***Bridge width*** 25.6 ***ft*** ***Max span length*** 61 ***ft***

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

Abutment type Vertical ***Embankment type*** Sloping; near vertical

Stone fill on abutment? Yes ***Date of inspection*** 07/10/96

Description of stone fill Type-2, along the base of the left abutment, upstream end of the right abutment, and upstream end of the DS RWW. Type-3, along the base of the US RWW.

LABUT is mortared stone. The RABUT, US RWW, and DS RWW are concrete. The RABUT concrete footing is exposed, and has wooden sheeting along the base of the footing. The sheeting is undermined at the US end.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 15

There is a mild channel bend in the upstream reach. A scour hole has developed in the location where the bend impacts the right bank upstream.

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	07/10/96	0	0
Level II	07/10/96	0	0

Potential for debris Low.

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

None, 07/10/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley, with a wide flood plain.

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

Date of inspection 07/10/96

DS left: Steep channel bank to moderately sloped overbank

DS right: Steep channel bank to a wide flood plain

US left: Steep channel bank to a wide flood plain

US right: Steep channel bank to a wide flood plain

Description of the Channel

Average top width 110 ft ***Average depth*** 11 ft

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

Sinuous but stable with alluvial channel boundaries and a wide flood plain.

07/10/96

Vegetative co Brush, shrubs, and a few trees

DS left: Brush and trees with a pasture overbank

DS right: Brush and a few trees

US left: Brush and a few trees with a pasture overbank

US right: Yes

Do banks appear stable? Banks appear stable, however, a cut-bank has developed along the right bank upstream.

If not, describe location with type of instability and date of observation.

None, 07/10/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 26.7 ***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? Yes

USGS gage description Little River near Waterbury, VT

USGS gage number 04289000

Gage drainage area 111 ***mi²***

Is there a lake/p No

Records are available from 1935 to present. Flow has been regulated by Waterbury Reservoir since 1937. The bridge is upstream of any regulation.

Calculated Discharges

Q100 5,400 ***ft³/s*** ***Q500*** 8,000 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(26.7/23.8)exp 0.67] with bridge number 3 in Stowe. Bridge number 3 crosses the West Branch Little River upstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 3 is 23.8 square miles. The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None.

Description of reference marks used to determine USGS datum. RM1 is center of chiseled square at DS end of the right abutment (elev. 500.67 ft, arbitrary survey datum). RM2 is a chiseled X on US end of the left abutment (elev. 500.29 ft, arbitrary survey datum). RM3 is a spike in pole 2.5 ft high on DS left bank 20 ft DS and 20 ft LB from DS end of the left abutment (elev. 497.45 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	-58	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	85	1	Approach section (as surveyed)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.045 to 0.062, and overbank "n" values ranged from 0.030 to 0.040.

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 0.0014 ft/ft, which was taken from the 100-year water surface profile below this site in the Flood Insurance Study (FIS) for the town of Stowe, VT (FEMA, 1980).

The approach section (APPRO) was surveyed one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.6 *ft*
Average low steel elevation 497.4 *ft*

100-year discharge 5,400 *ft³/s*
Water-surface elevation in bridge opening 491.8 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 512 *ft²*
Average velocity in bridge opening 10.6 *ft/s*
Maximum WSPRO tube velocity at bridge 13.7 *ft/s*

Water-surface elevation at Approach section with bridge 494.2
Water-surface elevation at Approach section without bridge 492.2
Amount of backwater caused by bridge 2.0 *ft*

500-year discharge 8,000 *ft³/s*
Water-surface elevation in bridge opening 493.0 *ft*
Road overtopping? Yes *Discharge over road* 1,310 *ft³/s*
Area of flow in bridge opening 579 *ft²*
Average velocity in bridge opening 11.6 *ft/s*
Maximum WSPRO tube velocity at bridge 15.2 *ft/s*

Water-surface elevation at Approach section with bridge 496.0
Water-surface elevation at Approach section without bridge 493.3
Amount of backwater caused by bridge 2.7 *ft*

Incipient overtopping discharge 6,040 *ft³/s*
Water-surface elevation in bridge opening 491.9 *ft*
Area of flow in bridge opening 518 *ft²*
Average velocity in bridge opening 11.7 *ft/s*
Maximum WSPRO tube velocity at bridge 15.2 *ft/s*

Water-surface elevation at Approach section with bridge 494.8
Water-surface elevation at Approach section without bridge 492.4
Amount of backwater caused by bridge 2.4 *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 Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour was computed by the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). Variables for the Laursen clear-water contraction scour equation include the discharge through the bridge, the width of the channel at the bridge, and the median grain size of the channel bed material.

Left abutment scour was computed by use of the Froehlich equation (Richardson and Davis, 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 at the right abutment was computed by use of the HIRE equation (Richardson and Davis, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

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	2.7	3.9	3.8
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	11.4	13.1	11.8
Left abutment	7.0	11.0	8.9
Right abutment	--	--	--
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	2.5	3.3	3.1
Left abutment	2.5	3.3	3.1
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

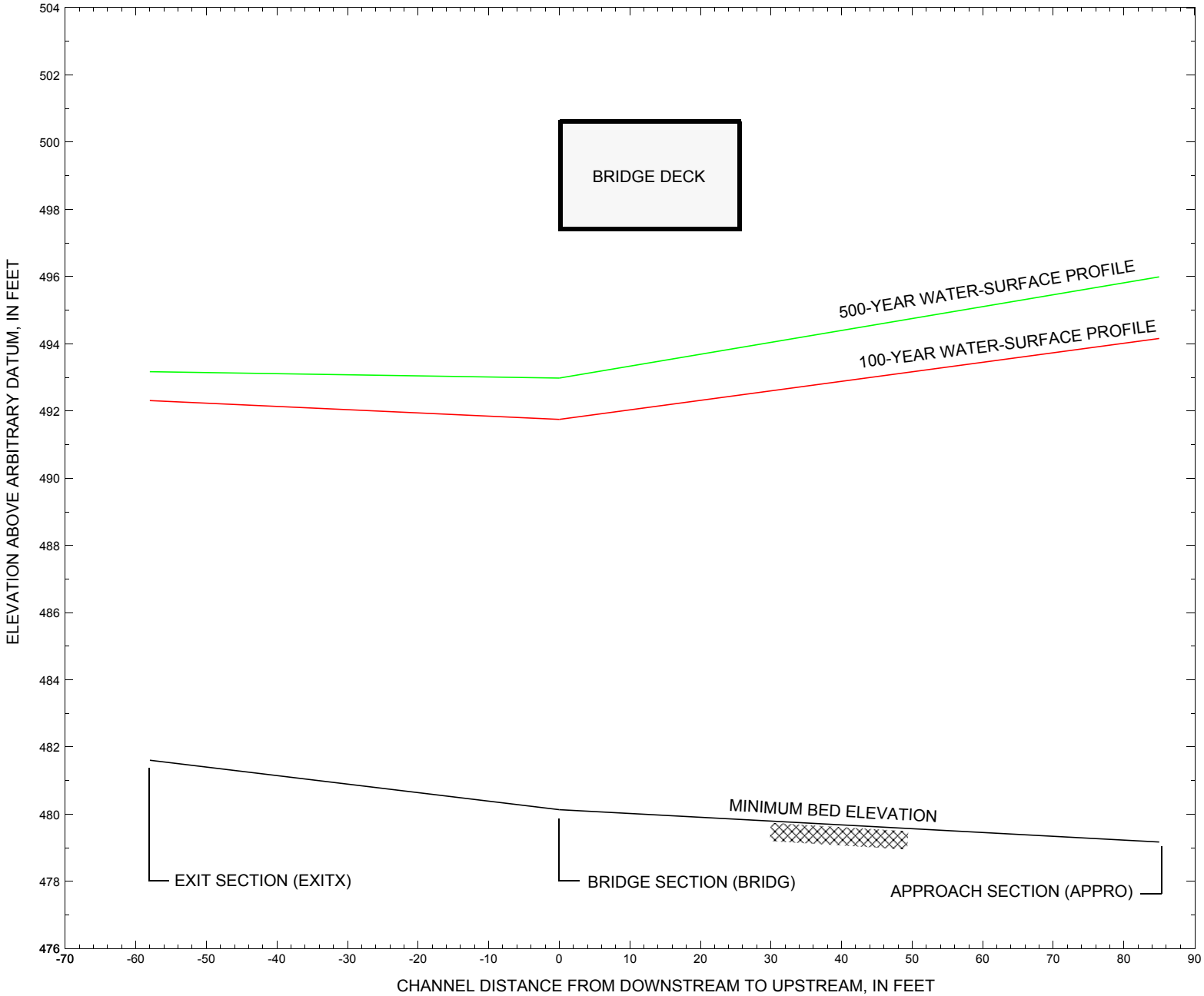


Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure STOWTH00230052 on Town Highway 23, crossing the West Branch Little River, Stowe, Vermont.

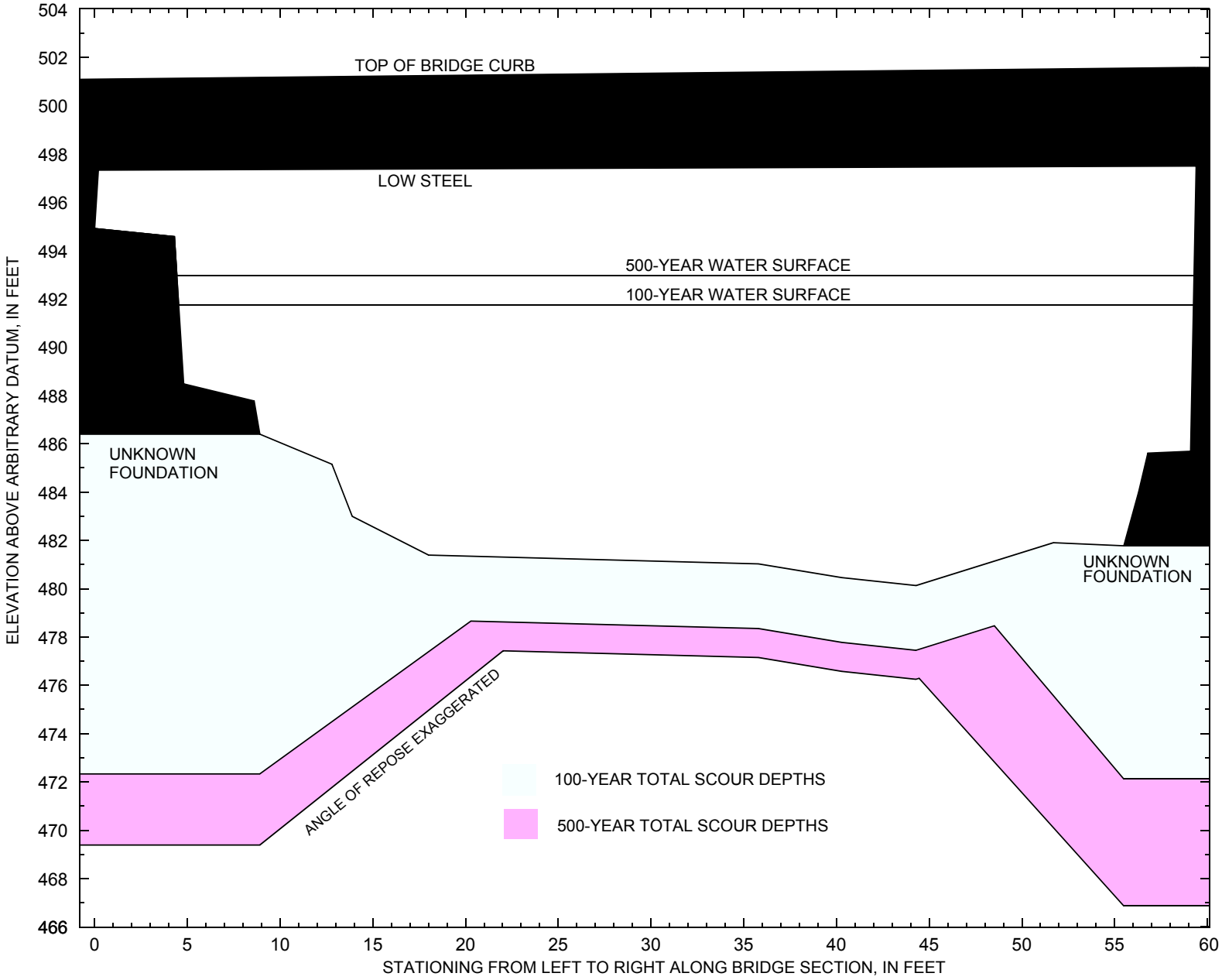


Figure 8. Scour elevations for the 100- and 500-year discharges at structure STOWTH00230052 on Town Highway 23, crossing the West Branch Little River, Stowe, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure STOWTH00230052 on Town Highway 23, crossing the West Branch Little River, Stowe, 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/pile 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-year discharge is 5,400 cubic-feet per second											
Left abutment	0.0	--	497.3	--	486.4	2.7	11.4	--	14.1	472.3	--
Right abutment	59.4	--	497.5	--	481.8	2.7	7.0	--	9.7	472.1	--

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 STOWTH00230052 on Town Highway 23, crossing the West Branch Little River, Stowe, 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/pile 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-year discharge is 8,000 cubic-feet per second											
Left abutment	0.0	--	497.3	--	486.4	3.9	13.1	--	17.0	469.4	--
Right abutment	59.4	--	497.5	--	481.8	3.9	11.0	--	14.9	466.9	--

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, 1968, Stowe, 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

```
T1        U.S. Geological Survey WSPRO Input File stow052.wsp
T2        Hydraulic analysis for structure STOWTH00230052   Date: 30-JUN-97
T3        The bridge is located 0.25 miles from the Junction of VT 108
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           5400.0   8000.0   6040.0
SK          0.0014   0.0014   0.0014
*
XS   EXITX    -58           0.
GR         -729.2, 503.76   -432.0, 499.27   -176.5, 497.77   -102.4, 498.97
GR          -84.4, 499.83    -66.4, 498.86    -50.5, 495.35      0.0, 482.78
GR            0.3, 482.80      1.2, 481.60     15.4, 482.31     36.6, 481.91
GR           40.5, 482.91     44.5, 483.22     49.5, 488.23     58.3, 492.40
GR          609.4, 488.34    690.8, 491.22    779.4, 492.54   1001.8, 492.74
GR         1070.6, 493.97   1216.7, 507.70
*
N           0.040        0.062        0.035
SA                 -50.5        58.3
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.41       0.0
GR            0.0, 497.33      0.1, 497.12      0.2, 494.91      4.3, 494.58
GR            4.8, 488.48      8.6, 487.77      8.9, 486.40     12.8, 485.15
GR           13.9, 482.99     18.0, 481.39     35.8, 481.03     40.3, 480.46
GR           44.3, 480.13     51.7, 481.91     55.5, 481.78     56.3, 484.01
GR           56.7, 483.03     56.8, 485.61     59.1, 485.69     59.2, 497.28
GR           59.4, 497.50      0.0, 497.33
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      31.7 * *     47.7     10.9
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      25.6     1
GR         -790.4, 514.17   -711.6, 505.51   -410.9, 501.99   -153.1, 499.98
GR          -75.2, 500.25     -2.1, 500.22     -1.8, 501.13      0.0, 501.10
GR           59.4, 501.58     61.8, 501.58     61.9, 500.90    140.1, 498.63
GR          328.3, 496.82    681.7, 494.74    889.6, 494.95   1050.3, 497.08
GR         1216.7, 507.70
*
AS   APPRO     85           0.
GR         -665.3, 504.76   -406.5, 504.44   -257.6, 498.84    -21.2, 496.31
GR          -10.0, 493.85     11.0, 484.59     32.0, 482.91     42.5, 479.84
GR           48.5, 479.17     51.3, 479.61     56.5, 482.90     65.9, 492.93
GR           89.6, 493.21    638.7, 491.26    652.7, 490.43    769.4, 492.54
GR          991.8, 492.74   1060.6, 493.97   1139.3, 506.14
*
N           0.040        0.050        0.030
SA               -21.2          89.6
*
HP 1 BRIDG   491.75 1 491.75
HP 2 BRIDG   491.75 * * 5400
HP 1 APPRO   494.16 1 494.16
HP 2 APPRO   494.16 * * 5400
*
HP 1 BRIDG   492.98 1 492.98
HP 2 BRIDG   492.98 * * 6694
HP 2 RDWAY   495.83 * * 1306
HP 1 APPRO   495.99 1 495.99
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File stow052.wsp
        Hydraulic analysis for structure STOWTH00230052   Date: 30-JUN-97
        The bridge is located 0.25 miles from the Junction of VT 108
           *** RUN DATE & TIME: 03-03-98  09:49

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

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1      512.   62891.    55.    72.                       8892.
   491.75            512.   62891.    55.    72.  1.00     5.    59.   8892.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.75     4.5    59.2   511.9   62891.    5400.  10.55

X STA.          4.5       16.2       18.3       20.3       22.2       24.2
  A(I)             68.2       21.0       21.1       20.1       20.7
  V(I)             3.96      12.84      12.79      13.41      13.01

X STA.         24.2       26.2       28.1       30.1       32.0       34.0
  A(I)             20.6       20.7       20.5       21.0       21.1
  V(I)            13.14      13.02      13.18      12.83      12.78

X STA.         34.0       35.9       37.9       39.7       41.5       43.2
  A(I)             20.6       20.9       20.1       20.4       19.7
  V(I)            13.13      12.94      13.44      13.22      13.69

X STA.         43.2       44.9       46.7       48.6       50.6       59.2
  A(I)             19.7       20.0       20.3       20.7       74.3
  V(I)            13.73      13.47      13.32      13.02       3.64

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      85.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              2      738.   78723.   101.   109.                      11314.
              3     1809.  135933.   972.   972.                      14004.
   494.16            2547.  214656.  1073.  1081.  1.09   -11.  1062.  21313.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      85.

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.16   -11.4  1061.8  2546.9  214656.    5400.   2.12

X STA.        -11.4       14.5       22.4       29.8       36.8       42.8
  A(I)            137.6       80.8       80.0       81.0       82.4
  V(I)             1.96       3.34       3.37       3.34       3.28

X STA.         42.8       48.8       57.6      222.7      323.9      393.1
  A(I)             87.9      115.0      231.0      162.1      131.9
  V(I)             3.07       2.35       1.17       1.67       2.05

X STA.        393.1      452.7      508.6      557.4      601.3      642.2
  A(I)            127.1      130.8      123.1      118.1      116.4
  V(I)             2.12       2.06       2.19       2.29       2.32

X STA.        642.2      672.8      708.5      768.6      873.8     1061.8
  A(I)            107.2      108.7      130.9      165.4      229.4
  V(I)             2.52       2.48       2.06       1.63       1.18
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File stow052.wsp
        Hydraulic analysis for structure STOWTH00230052   Date: 30-JUN-97
        The bridge is located 0.25 miles from the Junction of VT 108
           *** RUN DATE & TIME: 03-03-98  09:49

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     579.   75535.    55.    74.                      10689.
   492.98          579.   75535.    55.    74.  1.00     4.    59.  10689.

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      492.98     4.4    59.2   579.1   75535.    6694.  11.56

X STA.         4.4       15.7       17.9       19.8       21.8       23.8
  A(I)            77.5       24.2       23.0       23.3       22.7
  V(I)            4.32      13.81      14.58      14.36      14.74

X STA.        23.8       25.8       27.8       29.7       31.7       33.7
  A(I)            23.6       23.2       22.9       23.6       23.6
  V(I)           14.19      14.42      14.60      14.21      14.16

X STA.        33.7       35.6       37.6       39.4       41.2       43.0
  A(I)            23.3       23.5       22.6       22.5       22.6
  V(I)           14.38      14.23      14.81      14.89      14.81

X STA.        43.0       44.7       46.5       48.4       50.4       59.2
  A(I)            22.1       22.6       22.2       23.5       86.6
  V(I)           15.15      14.78      15.08      14.23       3.86

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.83   496.5   956.0   334.9   11548.    1306.   3.90

X STA.       496.5      628.2      647.1      662.2      675.5      688.1
  A(I)            51.0       15.7       14.1       13.5       13.5
  V(I)            1.28       4.17       4.63       4.83       4.83

X STA.       688.1      700.3      712.8      725.6      738.8      751.9
  A(I)            13.2       13.3       13.5       13.7       13.5
  V(I)            4.96       4.90       4.83       4.78       4.84

X STA.       751.9      765.6      780.2      794.4      809.2      824.5
  A(I)            13.8       14.5       14.0       14.3       14.6
  V(I)            4.72       4.50       4.65       4.57       4.47

X STA.       824.5      840.0      855.8      871.7      888.2      956.0
  A(I)            14.5       14.6       14.4       14.7       30.4
  V(I)            4.50       4.47       4.53       4.45       2.15

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      85.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     930.  110169.   109.   117.                      15396.
             3    3599.  424282.   984.   984.                      39059.
   495.99         4529.  534451.  1093.  1102.  1.00   -20.  1074.  52311.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      85.

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.99   -19.7  1073.7  4529.4  534451.    8000.   1.77

X STA.       -19.7       21.2       35.2       46.7       70.7      171.1
  A(I)           273.0      180.7      177.8      244.0      293.1
  V(I)            1.47       2.21       2.25       1.64       1.36

X STA.       171.1      249.6      317.8      378.0      434.2      485.3
  A(I)           252.1      236.3      222.6      219.3      209.4
  V(I)            1.59       1.69       1.80       1.82       1.91

X STA.       485.3      534.0      579.7      622.6      661.0      697.5
  A(I)           207.8      202.9      197.2      193.4      185.2
  V(I)            1.92       1.97       2.03       2.07       2.16

X STA.       697.5      745.2      811.4      882.8      956.5     1073.7
  A(I)           206.1      233.0      241.4      244.0      309.9
  V(I)            1.94       1.72       1.66       1.64       1.29
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File stow052.wsp
        Hydraulic analysis for structure STOWTH00230052   Date: 30-JUN-97
        The bridge is located 0.25 miles from the Junction of VT 108
           *** RUN DATE & TIME: 03-03-98  09:49

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     518.   63995.    55.    72.                       9048.
   491.86          518.   63995.    55.    72.  1.00     5.    59.   9048.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.86     4.5    59.2   517.9   63995.    6040.  11.66

X STA.          4.5       16.1       18.2       20.2       22.2       24.2
  A(I)             69.3       21.2       20.6       21.0       20.9
  V(I)             4.36      14.24      14.63      14.40      14.43

X STA.         24.2       26.1       28.1       30.1       32.0       34.0
  A(I)             20.7       20.9       21.2       21.0       21.1
  V(I)            14.57      14.44      14.28      14.39      14.34

X STA.         34.0       35.9       37.8       39.7       41.4       43.2
  A(I)             20.9       21.2       20.4       20.3       20.0
  V(I)            14.43      14.23      14.78      14.85      15.14

X STA.         43.2       44.9       46.7       48.5       50.5       59.2
  A(I)             19.9       20.3       20.5       21.0       75.4
  V(I)            15.18      14.88      14.71      14.37       4.01

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      85.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     803.   89108.   104.   112.                      12674.
             3    2433.  222041.   976.   976.                      21790.
   494.80         3236.  311148.  1080.  1088.  1.02   -14.  1066.   31404.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      85.

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.80   -14.3  1066.0  3236.0  311148.    6040.   1.87

X STA.        -14.3       17.1       27.1       36.3       44.3       52.5
  A(I)            182.8      111.3      111.0      114.0      125.9
  V(I)             1.65       2.71       2.72       2.65       2.40

X STA.         52.5      132.3      242.2      323.1      388.9      445.1
  A(I)            229.4      213.0      183.9      166.8      154.8
  V(I)             1.32       1.42       1.64       1.81       1.95

X STA.        445.1      497.3      546.4      590.8      632.5      666.2
  A(I)            153.8      153.3      146.0      143.7      134.5
  V(I)             1.96       1.97       2.07       2.10       2.25

X STA.        666.2      702.3      751.4      831.3      920.5     1066.0
  A(I)            137.4      148.6      181.9      192.9      250.9
  V(I)             2.20       2.03       1.66       1.57       1.20
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File stow052.wsp
       Hydraulic analysis for structure STOWTH00230052   Date: 30-JUN-97
       The bridge is located 0.25 miles from the Junction of VT 108
          *** RUN DATE & TIME: 03-03-98  09:49

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

EXITX:XS   ******   -38.    1996.  0.12 *****  492.43  490.14   5400.  492.31
      -58. ******   764.  144227.  1.06 ***** *******    0.31    2.71

FULLV:FV      58.   -39.    2069.  0.11  0.08  492.51 *******   5400.  492.40
        0.    58.   770.  150743.  1.05  0.00    0.01    0.29    2.61
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.07     492.16     489.52

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   491.90     506.14    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   491.90     506.14     489.52

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  0.47

APPRO:AS      85.    -6.     786.  1.01  0.23  493.19  489.52   5400.  492.18
       85.    85.   749.   70488.  1.38  0.45    0.00    1.06    6.87
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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      58.     5.      512.  2.06  0.19  493.82  489.09   5400.  491.75
        0.    58.    59.   62941.  1.19  1.21    0.00    0.66   10.54

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.915 ******  497.41 ****** ****** ******

    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

APPRO:AS      53.   -11.    2550.  0.08  0.19  494.24  489.52   5400.  494.16
       85.    87.  1062.  215074.  1.09  0.23    0.01    0.25    2.12

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.928  0.607   84079.    11.    66.   494.13

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -58.   -38.   764.   5400.  144227.    1996.    2.71  492.31
   FULLV:FV       0.   -39.   770.   5400.  150743.    2069.    2.61  492.40
   BRIDG:BR       0.     5.    59.   5400.   62941.     512.   10.54  491.75
   RDWAY:RG      13.**************     0.******************    1.00********
   APPRO:AS      85.   -11.  1062.   5400.  215074.    2550.    2.12  494.16

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      11.    66.   84079.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    490.14    0.31  481.60  507.70************  0.12  492.43  492.31
   FULLV:FV  ********    0.29  481.60  507.70  0.08  0.00  0.11  492.51  492.40
   BRIDG:BR    489.09    0.66  480.13  497.50  0.19  1.21  2.06  493.82  491.75
   RDWAY:RG  ***************  494.74  514.17**********************************
   APPRO:AS    489.52    0.25  479.17  506.14  0.19  0.23  0.08  494.24  494.16
```

WSPRO OUTPUT FILE (continued)

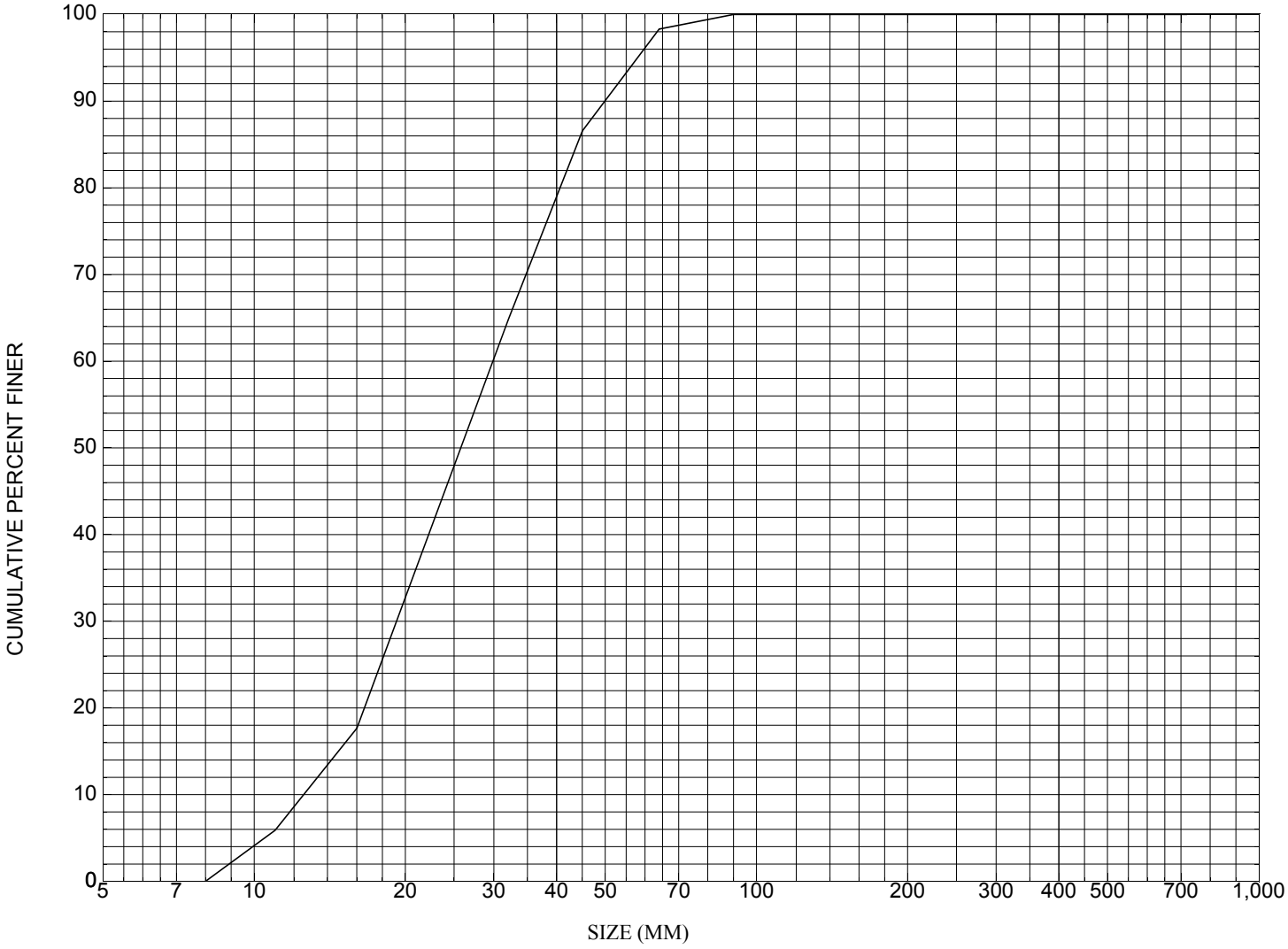
```
       U.S. Geological Survey WSPRO Input File stow052.wsp
       Hydraulic analysis for structure STOWTH00230052   Date: 30-JUN-97
       The bridge is located 0.25 miles from the Junction of VT 108
          *** RUN DATE & TIME: 03-03-98  09:49

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

EXITX:XS   ******   -42.    2820.  0.13 *****  493.30  490.88   8000.  493.17
      -58. ******  1026.  213729.  1.04 ***** *******    0.31    2.84

FULLV:FV      58.   -42.    2916.  0.12  0.08  493.38 *******   8000.  493.26
        0.    58.  1031.  224736.  1.04  0.00    0.00    0.30    2.74
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.84     493.25     493.22

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   492.76     506.14    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   492.76     506.14     493.22

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.50

APPRO:AS      85.    -9.    1597.  0.54  0.22  493.80  493.22   8000.  493.26
       85.    85.  1021.  112290.  1.37  0.21    0.00    0.83    5.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   496.64       0.00     492.30     494.74

 ===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      58.     4.     579.  2.67  0.19  495.64  490.13   6694.  492.98
        0.    58.    59.   75487.  1.28  2.15    0.00    0.71   11.56

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.883 ******  497.41 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    59.  0.01  0.05  496.04    0.00   1306.  495.83

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****
   RT:   1306.   459.   497.   956.   1.1   0.7   4.5   3.9   0.9   3.1

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

APPRO:AS      53.   -20.    4534.  0.05  0.15  496.04  493.22   8000.  495.99
       85.   112.  1074.  535246.  1.00  0.25    0.01    0.15    1.76

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.947  0.829   91152.    19.    74. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -58.   -42.  1026.   8000.  213729.    2820.    2.84  493.17
   FULLV:FV       0.   -42.  1031.   8000.  224736.    2916.    2.74  493.26
   BRIDG:BR       0.     4.    59.   6694.   75487.     579.   11.56  492.98
   RDWAY:RG      13.*******     0.   1306.       0.*********    1.00  495.83
   APPRO:AS      85.   -20.  1074.   8000.  535246.    4534.    1.76  495.99

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      19.    74.   91152.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    490.88    0.31  481.60  507.70***********  0.13  493.30  493.17
   FULLV:FV  ********    0.30  481.60  507.70  0.08  0.00  0.12  493.38  493.26
   BRIDG:BR    490.13    0.71  480.13  497.50  0.19  2.15  2.67  495.64  492.98
   RDWAY:RG  ***************  494.74  514.17  0.01******  0.05  496.04  495.83
   APPRO:AS    493.22    0.15  479.17  506.14  0.15  0.25  0.05  496.04  495.99
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File stow052.wsp
       Hydraulic analysis for structure STOWTH00230052   Date: 30-JUN-97
       The bridge is located 0.25 miles from the Junction of VT 108
          *** RUN DATE & TIME: 03-03-98  09:49

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

EXITX:XS   ******   -39.    2169.  0.13 *****  492.65  490.37   6040.  492.52
      -58. ******   778.  161365.  1.04 ***** *******    0.31    2.78

FULLV:FV      58.   -40.    2248.  0.12  0.08  492.73 *******   6040.  492.61
        0.    58.   861.  163024.  1.06  0.00    0.01    0.31    2.69
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.10     492.38     490.03

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.11     506.14    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.11     506.14     490.03

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  0.48

APPRO:AS      85.    -7.     893.  1.03  0.25  493.43  490.03   6040.  492.40
       85.    85.   762.   77444.  1.44  0.45   -0.01    1.09    6.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   494.80       0.00     491.86     494.74

 ===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      58.     5.      518.  2.54  0.20  494.40  489.62   6040.  491.86
        0.    58.    59.   64033.  1.20  1.55    0.00    0.73   11.66

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.913 ******  497.41 ****** ****** ******

    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

APPRO:AS      53.   -14.    3235.  0.06  0.17  494.85  490.03   6040.  494.80
       85.    94.  1066.  310928.  1.02  0.28    0.01    0.19    1.87

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.929  0.710   89937.    12.    67. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -58.   -39.   778.   6040.  161365.    2169.    2.78  492.52
   FULLV:FV       0.   -40.   861.   6040.  163024.    2248.    2.69  492.61
   BRIDG:BR       0.     5.    59.   6040.   64033.     518.   11.66  491.86
   RDWAY:RG      13.**************      0.       0.       0.    1.00********
   APPRO:AS      85.   -14.  1066.   6040.  310928.    3235.    1.87  494.80

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      12.    67.   89937.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    490.37    0.31  481.60  507.70************  0.13  492.65  492.52
   FULLV:FV  ********    0.31  481.60  507.70  0.08  0.00  0.12  492.73  492.61
   BRIDG:BR    489.62    0.73  480.13  497.50  0.20  1.55  2.54  494.40  491.86
   RDWAY:RG  ***************  494.74  514.17  0.02******  0.06  494.82********
   APPRO:AS    490.03    0.19  479.17  506.14  0.17  0.28  0.06  494.85  494.80
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure STOWTH00230052, in Stowe, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number STOWTH00230052

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)* 70525

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

Waterway *(I - 6)* West Branch Little (Waterbury) River

Road Name *(I - 7):* Weeks Hill Road

Route Number C3023

Vicinity *(I - 9)* 0.25 MI TO JCT W VT 108

Topographic Map Stowe

Hydrologic Unit Code: 02010003

Latitude *(I - 16; nnnn.n)* 44286

Longitude *(i - 17; nnnnn.n)* 72413

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10080800520808

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

Maximum span length *(I - 48; nnnn)* 0061

Year built *(I - 27; YYYY)* 1958

Structure length *(I - 49; nnnnnn)* 000064

Average daily traffic, ADT *(I - 29; nnnnnn)* 001500

Deck Width *(I - 52; nn.n)* 256

Year of ADT *(I - 30; YY)* 93

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

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

Waterway adequacy *(I - 71; n)* 7

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span *(nnn.n ft)* 53

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

Vertical clearance from streambed *(nnn.n ft)* 13.1

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

Waterway of full opening *(nnn.n ft^2)* 694

Comments:

According to the structural inspection report dated 6/7/95, the deck of the structure consists of concrete with asphalt overlay. The bridge guide rail consists of concrete posts with a 2-cable rail. There are minor cracks and spalls on the RABUT; the LABUT is grouted stone. There are also minor cracks on the wing-walls of the RABUT. Past erosion and undermining problems at both abutments have been corrected. There is a fairly new footing on the LABUT. Past channel scour problems at both abutments have been corrected. There is some stone fill and areas of erosion on the embankments. There is a large gravel bar US of the LABUT. Minor debris is noted.

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} (ft^3/ *sec*): -

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **26.7** mi^2 Lake/pond/swamp area **0** mi^2

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

Bridge site elevation **700** ft Headwater elevation **3900** ft

Main channel length **9.95** mi

10% channel length elevation **720** ft 85% channel length elevation **1610** ft

Main channel slope *(S)* **119.26** 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:

There is no benchmark information available.

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:

There is no foundation material information available.

Comments:

-

Cross-sectional Data

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

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

Comments: **There is no cross-section information available.**

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

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

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

Comments: -

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 10/23/96
Computerized by: RB Date: 10/24/96
Reviewd by: LKS Date: 07/08/97

Structure Number STOWTH00230052

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* L. MEDALIE Date *(MM/DD/YY)* 07 / 10 / 1996

2. Highway District Number 06
Mile marker 0000
County Lamoille (015)
Town Stowe (70525)
Waterway *(I - 6)* West Branch Little (Waterbury) River
Road Name Weeks Hill Road
Route Number C3023
Hydrologic Unit Code: 02010003

3. Descriptive comments:
The bridge is located 1/4 of a mile from the junction with VT 108. The bridge has an asphalt deck.

B. Bridge Deck Observations

4. Surface cover... LBUS 5 RBUS 4 LBDS 5 RBDS 4 Overall 4
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

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

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

7. Bridge length 64 *(feet)* Span length 61 *(feet)* Bridge width 25.6 *(feet)*

Road approach to bridge:

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

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

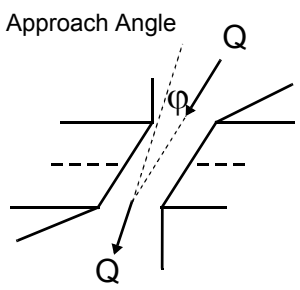
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

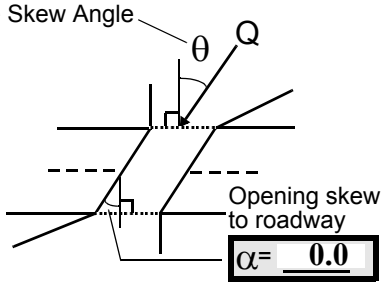
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	0	-
RBDS	0	-	2	1
LBDS	0	-	2	1

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

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 126 feet US *(US, UB, DS)* to 35 feet US
Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 0 feet US *(US, UB, DS)* to 20 feet DS

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

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

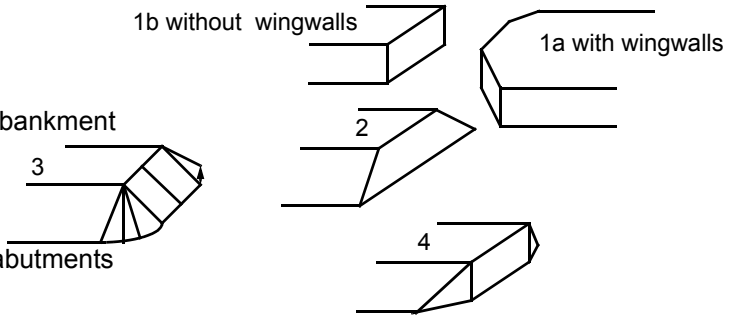
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. The left bank US has shrubs close to the bridge then lawn after 100 ft. Moving bankward, there is a gravel road and more shrubs and pasture beyond the road. The right banks US and DS are pasture that has been recently cut. The vegetation on the left bank DS is shrubs for 100 ft and then row crops.
7. Bridge measurement values are from the VT AOT files. The measured bridge length is 64 ft, bridge span is 58 ft, and the deck width is 25.5 ft.
11. The road approach erosion on the right and left banks DS and the left bank US is very slight consisting of minor erosion around the end of the wingwalls.
18. The left abutment is vertical without wingwalls and the right abutment is vertical with wingwalls.

C. Upstream Channel Assessment

	21. Bank height (BF)		22. Bank angle (BF)		26. % Veg. cover (BF)		27. Bank material (BF)		28. Bank erosion (BF)	
20. SRD	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
60.0	**11.5**			**10.5**	**1**	**2**	**2**	**2**	**1**	**2**

23. Bank width **20.0** 24. Channel width **15.0** 25. Thalweg depth **111.0** 29. Bed Material **3**

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

26. From the bridge to 60 ft US the left bank vegetation cover is between 0% and 25%, the vegetation cover then increases to between 51% to 75%, consisting mainly of shrubs and brush.
30. On the right bank the protection extends from the bridge to 93 ft. From 73 ft US to 79 ft US there are also 3 large type-3 boulders on the right bank. On the left bank, the protection is from the bridge to 59 ft US.
31. The left bank protection is well above the annual flood line, while the right bank protection extends to the bottom of the channel. The average US thalweg depth is 1.25 ft.

33. Point/Side bar present? Y *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: 100 35. Mid-bar width: 27

36. Point bar extent: 20 feet US *(US, UB)* to 155 feet US *(US, UB, DS)* positioned 0 %LB to 60 %RB

37. Material: 34

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

The point bar is mostly gravel with some cobbles and sparse vegetation at the upstream end.

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

41. Mid-bank distance: 120 42. Cut bank extent: 185 feet US *(US, UB)* to 20 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. Is channel scour present? Y *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: 69

47. Scour dimensions: Length 110 Width 8 Depth : 3 Position 75 %LB to 90 %RB

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

Channel scour has occurred where the flow bends at the impact zone. The width and depth were measured at the mid-scour distance from the bridge. The depth at the upstream and downstream ends of the scour is 1 ft.

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

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

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

54. Confluence comments (eg. confluence name):

There are no major confluences upstream at this site.

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
46.0		1.0		2	7	7	-

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

34

-

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

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

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

70. Debris and Ice Comments:

1

The debris accumulation is minimal.

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**	**85**	**2**	**2**	**0**	**1**	**90.0**
RABUT	**2**	**0**	**90**			**2**	**3**	**59.5**

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

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

2

4

1

71. At low flow the attack is on the left abutment, but the main channel runs along the right abutment.

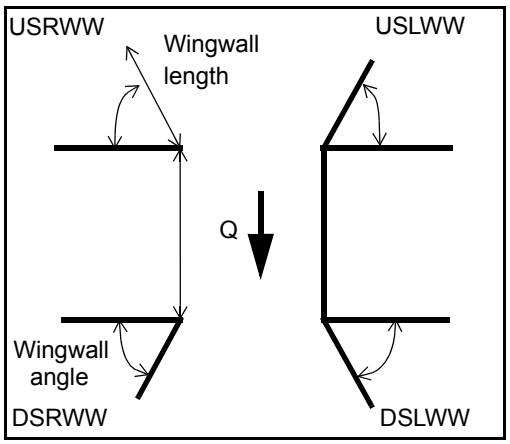
74. On the right abutment, the concrete footing is exposed 2 ft at the DS end and 4 ft at the US end. There is a fence of vertical 2 in. x 4 in. boards jointed together in front of the footing. At the DS end, 2 ft of the fence is exposed and 3 ft is exposed on the US end. The wood fence in undermined up to 6 in. in areas at the US end and is leaning into the stream at a 25 degree angle. At the DS end, the fence is not undermined and is vertical. The concrete behind the wooden fence at the US end is undermined up to 6 in.

75. The US scour hole extends under the bridge and is 2 ft deep 6 ft into the channel from the footing fence.

77. The left abutment is a 6 ft high wall of "laid-up" stone wall with a concrete footing and a 2 ft concrete bridge seat set back 5 ft from the face of the stone abutment. Below the footing and sloping at a 45 degree angle is stone fill protection, which acts similar to

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:	**a spill**		**throu**		**gh**	**59.5**	
USRWW:	**type**		**abut-**		**ment.**	**2.0**	
DSLWW:	**The**		**top of**		**the**	**27.5**	
DSRWW:	**left**		**abut-**		**ment**	**24.0**	



*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	**foot-**	**abov**	**rent**	**level.**	**N**	**-**	**1**	**0.5**
Condition	**ing is**	**e the**	**wate**		**-**	**-**	**2**	**N**
Extent	**5 ft**	**cur-**	**r**		**-**	**Y**	**0**	**-**

*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

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

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

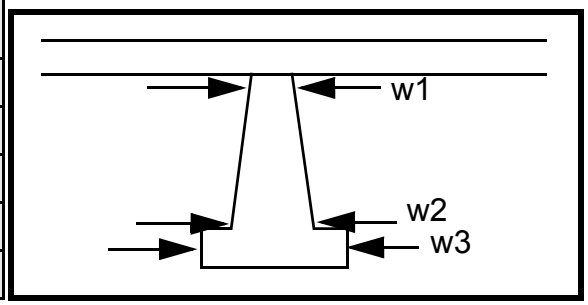
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
Y
1
0
-
-
-
-
-

Piers:

84. Are there piers? **3** *(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	-			-	**50.0**	**16.0**
Pier 2	-			-	**55.0**	**16.5**
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4
86. Location (BF)	**1**	-	**pro-**	
87. Type	**1**	-	**tec-**	
88. Material	**2**	-	**tion**	
89. Shape	**1**	-	**is set**	
90. Inclined?	**1**	-	**in**	
91. Attack ∠ (BF)	**2**	**2**	**the**	
92. Pushed	**1**	**1**	**chan**	**N**
93. Length (feet)	-	-	-	-
94. # of piles	**2**	**2**	**nel.**	-
95. Cross-members	-	**The**		-
96. Scour Condition	-	**right**		-
97. Scour depth	-	**abut**		-
98. Exposure depth	-	**ment**		-

LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP

***1**- Solid pier, **2**- column, **3**- bent*

***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*

***1**- Round; **2**- Square; **3**- Pointed*

Y- yes; N- no

LB or RB

***0**- none; **1**- laterals; **2**- diagonals; **3**- both*

***0**- not evident; **1**- evident (comment);*
***2**- footing exposed; **3**- piling exposed;*
***4**- undermined footing; **5**- settled; **6**- failed*

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

-

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width - Thalweg depth - 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):

-

There are no piers.

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: **1**

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

1
2
2
1

Is a cut-bank present? **1** *(Y or if N type ctrl-n cb)* Where? **3** *(LB or RB)* Mid-bank distance: **2**

Cut bank extent: **2** feet **1** *(US, UB, DS)* to **1** feet **Th** *(US, UB, DS)*

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

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

vegetation cover on the left bank is weeds and shrubs to 64 ft DS. Beyond 64 ft DS, there is one tree and more brush. On the right bank the vegetation cover is large shrubs, but there are no trees until 95 ft DS. The downstream bank protection extends to 32 ft DS on the right bank and 53 ft DS on the left bank. The left bank protection is type-2 stone fill located on the lower part of the embankment and type-1 stone fill located higher on

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

Scour dimensions: Length **nkm** Width **ent.** Depth: **The** Positioned **re** %LB to **is a** %RB

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

short stretch of erosion on the left bank with block failure at 115 ft DS where the bank is vertical.

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

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

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

Confluence comments (eg. confluence name):

There is no drop structure at this site.

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

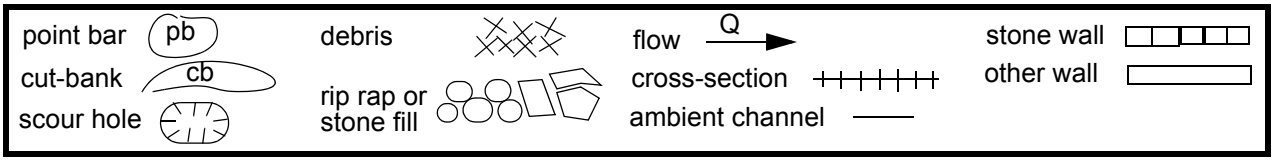
__1__- Constructed
__2__- Stable
__3__- Aggraded
__4__- Degraded
__5__- Laterally unstable
__6__- Vertically and laterally unstable

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

N

-
-
-
-
-
-
-
-
-

109. G. Plan View Sketch - T



APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: STOWTH00230052 Town: STOWE
Road Number: TH 23 County: LAMOILLE
Stream: W. BRANCH LITTLE (WATERBURY) RIVER

Initials LKS Date: 07/02/97 Checked: MAI

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	5400	8000	6040
Main Channel Area, ft2	738	930	803
Left overbank area, ft2	0	0	0
Right overbank area, ft2	1809	3599	2433
Top width main channel, ft	101	109	104
Top width L overbank, ft	0	0	0
Top width R overbank, ft	972	984	976
D50 of channel, ft	0.0848	0.0848	0.0848
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.3	8.5	7.7
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	1.9	3.7	2.5
Total conveyance, approach	214656	534451	311148
Conveyance, main channel	78723	110169	89108
Conveyance, LOB	0	0	0
Conveyance, ROB	135933	424282	222041
Percent discrepancy, conveyance	0.0000	0.0000	-0.0003
Qm, discharge, MC, cfs	1980.4	1649.1	1729.8
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	3419.6	6350.9	4310.3
Vm, mean velocity MC, ft/s	2.7	1.8	2.2
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	1.9	1.8	1.8
Vc-m, crit. velocity, MC, ft/s	6.9	7.0	6.9
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	5400	8000	6040
(Q) discharge thru bridge, cfs	5400	6694	6040
Main channel conveyance	62891	75535	63995
Total conveyance	62891	75535	63995
Q2, bridge MC discharge,cfs	5400	6694	6040
Main channel area, ft2	512	579	518
Main channel width (normal), ft	54.7	54.8	54.7
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	54.7	54.8	54.7
y_bridge (avg. depth at br.), ft	9.36	10.57	9.47
Dm, median (1.25*D50), ft	0.106	0.106	0.106
y2, depth in contraction,ft	12.04	14.45	13.25
ys, scour depth (y2-ybridge), ft	**2.68**	**3.88**	**3.78**

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	5400	6694	6040
Main channel area (DS), ft2	512	579	518
Main channel width (normal), ft	54.7	54.8	54.7
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	54.7	54.8	54.7
D90, ft	0.1637	0.1637	0.1637
D95, ft	0.1901	0.1901	0.1901
Dc, critical grain size, ft	0.2618	0.3033	0.3188
Pc, Decimal percent coarser than Dc	0.006	0.000	0.000
Depth to armoring, ft	**N/A**	**N/A**	**N/A**

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	5400	8000	6040	5400	8000	6040
a', abut.length blocking flow, ft	15.9	24.1	18.8	1002.6	1014.5	1006.8
Ae, area of blocked flow ft2	84.47	160.86	109.45	1879.86	3435.82	2571.64
Qe, discharge blocked abut.,cfs	165.75	235.7	180.82	3507.38	--	4504.64
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.96	1.47	1.65	1.87	1.75	1.75
ya, depth of f/p flow, ft	5.31	6.67	5.82	1.87	3.39	2.55
--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	0.150	0.100	0.121	0.240	0.160	0.193
ys, scour depth, ft	**11.39**	**13.13**	**11.84**	23.65	27.32	25.34
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)	15.9	24.1	18.8	1002.6	1014.5	1006.8
y1 (depth f/p flow, ft)	5.31	6.67	5.82	1.87	3.39	2.55
a'/y1	2.99	3.61	3.23	534.72	299.55	394.16
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.15	0.10	0.12	0.24	0.16	0.19
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	8.52	13.45	10.80
vertical w/ ww's	ERR	ERR	ERR	**6.98**	**11.03**	**8.85**
spill-through	ERR	ERR	ERR	4.68	7.40	5.94

Abutment riprap Sizing

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

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.66	0.71	0.73	0.66	0.71	0.73
y, depth of flow in bridge, ft	9.36	10.57	9.47	9.36	10.57	9.47
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	**2.52**	**3.29**	**3.12**	**2.52**	**3.29**	**3.12**
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR