LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (RIPTTH00180017) on TOWN HIGHWAY 18, crossing the SOUTH BRANCH MIDDLEBURY RIVER, RIPTON, VERMONT

Open-File Report 97-658

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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LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (RIPTTH00180017) on TOWN HIGHWAY 18, crossing the SOUTH BRANCH MIDDLEBURY RIVER, RIPTON, VERMONT

By RONDA L. BURNS AND LAURA MEDALIE

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Pembroke, New Hampshire

1997

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

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

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (RIPTTH00180017) ON TOWN HIGHWAY 18, CROSSING THE SOUTH BRANCH MIDDLEBURY RIVER, RIPTON, VERMONT

By **Ronda L. Burns and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure RIPTTH00180017 on Town Highway 18 crossing the South Branch Middlebury River, Ripton, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in west-central Vermont. The 15.5-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest except on the upstream left bank where it is shrubs and brush.

In the study area, the South Branch Middlebury River has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 86 ft and an average bank height of 10 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 111 mm (0.364 ft). In addition, there is a bedrock outcrop across the channel downstream of the bridge. The geomorphic assessment at the time of the Level I and Level II site visit on June 10, 1996, indicated that the reach was stable.

The Town Highway 18 crossing of the South Branch Middlebury River is a 61-ft-long, one-lane bridge consisting of one 58-foot steel-beam span (Vermont Agency of Transportation, written communication, November 30, 1995). The opening length of the structure parallel to the bridge face is 56.8 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 40 degrees to the opening while the computed opening-skew-to-roadway is 30.

A scour hole 1.25 ft deeper than the mean thalweg depth was observed along the right abutment and the downstream right wingwall during the Level I assessment. The scour protection measures at the site include type-2 stone fill (less than 36 inches diameter) along the left abutment and it's wingwalls and at the upstream end of the right abutment. Also, type-3 stone fill (less than 48 inches diameter) is along 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 others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is 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 0.1 to 1.1 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 5.6 to 9.0 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 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 RIPTTH00180017 ***Stream*** South Branch Middlebury River

County Addison ***Road*** TH 18 ***District*** 5

Description of Bridge

Bridge length 61 ***ft*** ***Bridge width*** 15 ***ft*** ***Max span length*** 58 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 06/10/96

Description of stone fill Type-2, along the upstream end of the right abutment, along the left abutment and it's wingwalls, and type-3 along the upstream right wingwall.

Abutments and wingwalls are concrete. There is a one and one quarter foot deep scour hole in front of the right abutment and the downstream right wingwall.

Yes 40

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

The channel makes a moderate bend through the bridge. The scour hole has developed in the location where the flow impacts the right abutment.

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	06/10/96	0	0
Level II	06/10/96	0	0

Potential for debris Moderate. There is a fallen tree in the upstream reach.

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

None. 06/10/96

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley setting with steep valley walls on both sides.

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

Date of inspection 06/10/96

DS left: Steep channel bank to a moderately sloped overbank

DS right: Steep channel bank to a narrow terrace and a steep valley wall

US left: Steep channel bank to a moderately sloped overbank

US right: Steep valley wall

Description of the Channel

Average top width 86 *ft* ***Average depth*** 10 *ft*

Predominant bed material Cobble/Boulder ***Bank material*** Cobble/Boulder

Sinuous but stable with non-alluvial channel boundaries.

06/10/96

Vegetative co

DS left: Trees

DS right: Trees

US left: Shrubs and brush

US right: Trees

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

Describe any obstructions in channel and date of observation. A bedrock outcrop downstream of the bridge crosses the channel with one foot of channel scour downstream of the outcrop as of 06/10/96.

Hydrology

Drainage area 15.5 ***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***: None

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 3,100 ***ft³/s*** ***Q500*** 4,450 ***ft³/s***

The 100-year discharge is from flood frequency estimates available from the VTAOT database which were extended graphically to the 500-year discharge. 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 a chiseled X on top of the downstream end of the right abutment (elev. 500.10 ft, arbitrary survey datum). RM2 is a metal U.S. Department of Agriculture benchmark on top of the upstream end of the left abutment (elev. 500.02 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXIT1	-52	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	11	1	Road Grade section
APTEM	64	1	Approach section as surveyed (Used as a template)
APPR1	71	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 0.060 to 0.075, and overbank "n" values ranged from 0.065 to 0.085.

Normal depth at the exit section (EXIT1) 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 0.0258 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1944).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0119 ft/ft) to establish the modelled approach section (APPR1), 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.

For the 500-year discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles for this discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.4 *ft*
Average low steel elevation 495.5 *ft*

100-year discharge 3,100 *ft³/s*
Water-surface elevation in bridge opening 490.9 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 263 *ft²*
Average velocity in bridge opening 11.8 *ft/s*
Maximum WSPRO tube velocity at bridge 14.4 *ft/s*

Water-surface elevation at Approach section with bridge 493.6
Water-surface elevation at Approach section without bridge 492.7
Amount of backwater caused by bridge 0.9 *ft*

500-year discharge 4,450 *ft³/s*
Water-surface elevation in bridge opening 491.9 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 311 *ft²*
Average velocity in bridge opening 14.3 *ft/s*
Maximum WSPRO tube velocity at bridge 17.6 *ft/s*

Water-surface elevation at Approach section with bridge 495.8
Water-surface elevation at Approach section without bridge 494.1
Amount of backwater caused by bridge 1.7 *ft*

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

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.1	1.1	--
Depth to armoring	12.9	26.5	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	5.6	8.4	--
Left abutment	6.1	9.0	--
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:	2.2	2.7	--
Left abutment	2.2	2.7	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

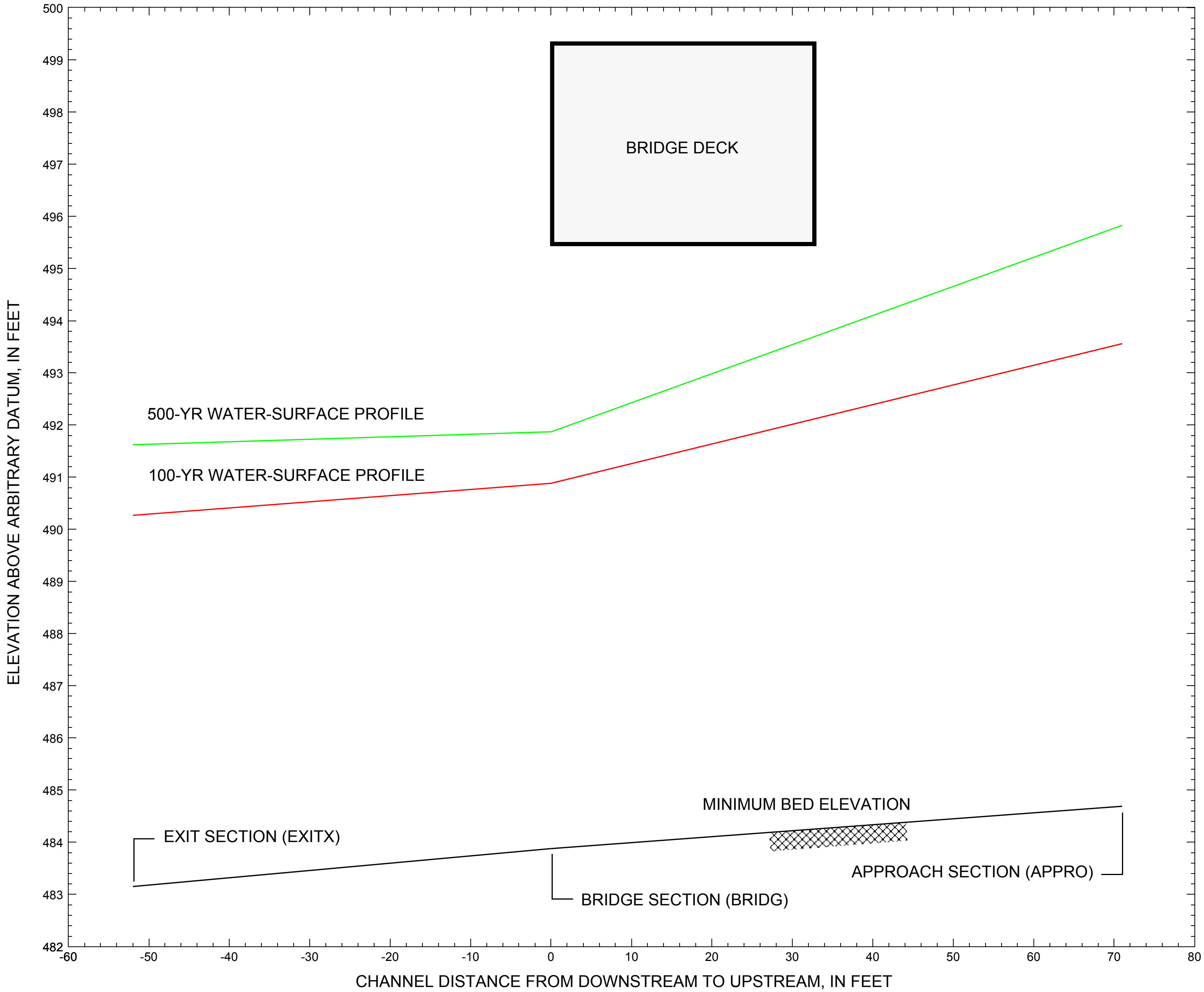

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure RIPTTH00180017 on Town Highway 18, crossing the South Branch Middlebury River, Ripton, Vermont.

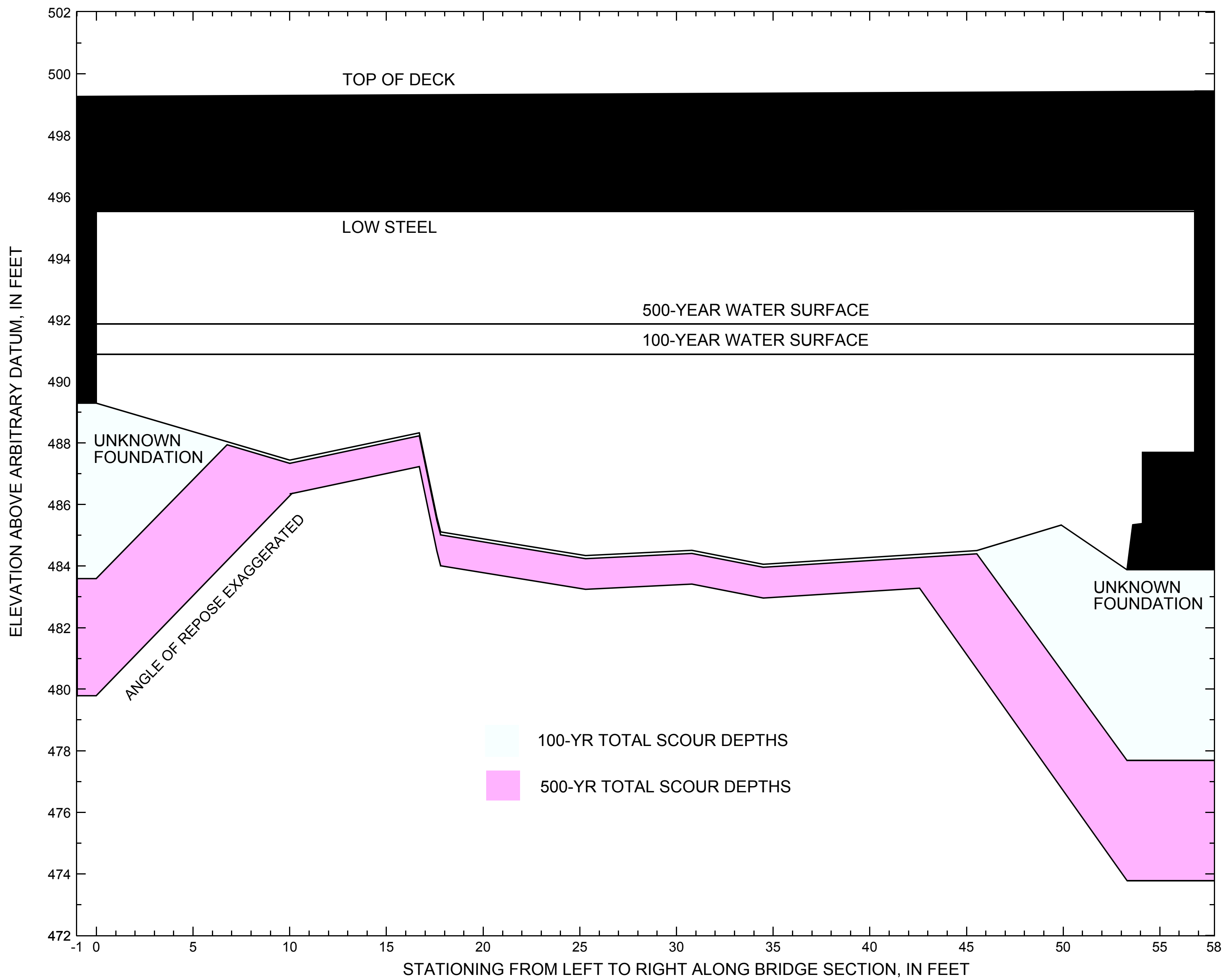

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure RIPTTH00180017 on Town Highway 18, crossing the South Branch Middlebury River, Ripton, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure RIPTTH00180017 on Town Highway 18, crossing the South Branch Middlebury River, Ripton, 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-yr. discharge is 3,100 cubic-feet per second											
Left abutment	0.0	--	495.5	--	489.3	0.1	5.6	--	5.7	483.6	--
Right abutment	56.8	--	495.6	--	483.9	0.1	6.1	--	6.2	477.7	--

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 RIPTTH00180017 on Town Highway 18, crossing the South Branch Middlebury River, Ripton, 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-yr. discharge is 4,450 cubic-feet per second											
Left abutment	0.0	--	495.5	--	489.3	1.1	8.4	--	9.5	479.8	--
Right abutment	56.8	--	495.6	--	483.9	1.1	9.0	--	10.1	473.8	--

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, 1944, East Middlebury, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1972, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File ript017.wsp
T2        Hydraulic analysis for structure RIPTTH00180017   Date: 30-JUN-97
T3        TH 18 CROSSING THE SOUTH BRANCH MIDDLEBURY RIVER IN RIPTON, VT    RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3100.0   4450.0
SK          0.0258   0.0258
*
XS   EXIT1    -52           0.
GR         -127.1, 508.37   -118.6, 503.34   -107.5, 502.43    -83.3, 494.97
GR          -55.0, 492.94     -4.6, 491.58      0.0, 490.97      4.8, 487.38
GR           15.1, 484.78     18.9, 484.46     28.9, 484.59     36.4, 486.49
GR           42.0, 486.42     49.6, 483.80     54.2, 483.15     59.0, 483.38
GR           60.8, 485.09     69.5, 485.70     77.0, 491.11    100.4, 499.80
GR          135.4, 500.88    193.2, 510.43
* GR         -20.0, 491.21    -18.2, 487.80    -11.4, 490.85
*
N           0.085        0.075        0.085
SA                  -4.6        100.4
*
XS   FULLV      0  * * *   0.0132
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.54      30.0
GR            0.0, 495.52      0.0, 489.29     10.0, 487.44
GR           17.6, 485.60     17.8, 485.11     25.3, 484.34     30.8, 484.51
GR           34.5, 484.06     44.2, 484.44     53.3, 483.88
GR           53.6, 485.34     54.0, 485.38     54.1, 487.71     56.5, 487.69
GR           56.8, 495.56      0.0, 495.52
* GR          16.7, 488.33     49.9, 485.33
*
*         BRTYPE  BRWDTH        WWANGL  WWWID
CD           1      34.0  *  *    67.3    6.4
N           0.060
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     11      15.0     2
GR         -279.3, 505.91   -248.2, 504.33   -155.8, 501.06   -105.7, 499.17
GR          -44.7, 498.77     -4.5, 499.24     -4.3, 500.00
GR           54.9, 500.07     55.4, 499.46     60.0, 499.43     94.2, 500.19
GR          118.5, 500.89    142.4, 503.76    186.7, 512.71
* GR           0.0, 499.26
*
XT   APTEM     64           0.
GR          -38.1, 498.78    -15.9, 496.88     -7.8, 494.27      0.0, 489.51
GR            4.4, 486.26      7.6, 485.13     18.1, 485.03     23.8, 484.61
GR           29.2, 485.77     33.2, 486.39     37.4, 486.59     42.6, 492.41
GR           52.7, 496.93     68.1, 509.85    114.7, 515.29
*
AS   APPR1     71  * * *  0.0119
GT
N           0.065        0.070
SA                 -15.9
*
HP 1 BRIDG  490.88 1 490.88
HP 2 BRIDG  490.88 * * 3100
HP 1 APPR1  493.56 1 493.56
HP 2 APPR1  493.56 * * 3100
*
HP 1 BRIDG  491.87 1 491.87
HP 2 BRIDG  491.87 * * 4450
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File ript017.wsp
        Hydraulic analysis for structure RIPTTH00180017   Date: 30-JUN-97
        TH 18 CROSSING THE SOUTH BRANCH MIDDLEBURY RIVER IN RIPTON, VT    RLB
           *** RUN DATE & TIME: 07-11-97  13:45

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      263     17834     49     58                         3449
   490.88           263     17834     49     58  1.00      0     57     3449

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       490.88     0.0    56.6   262.6   17834.    3100.  11.80

X STA.         0.0        10.3        15.0        18.3        20.8        23.0
  A(I)            22.8        16.3        14.8        12.8        12.1
  V(I)            6.79        9.49       10.51       12.10       12.78

X STA.        23.0        25.2        27.1        29.1        31.1        33.1
  A(I)            11.8        11.2        11.2        11.1        11.0
  V(I)           13.15       13.85       13.88       13.95       14.09

X STA.        33.1        34.9        36.8        38.6        40.5        42.5
  A(I)            10.8        10.8        10.8        10.8        11.3
  V(I)           14.39       14.36       14.34       14.32       13.76

X STA.        42.5        44.6        46.6        48.9        51.2        56.6
  A(I)            11.6        11.7        12.8        13.7        23.3
  V(I)           13.40       13.28       12.12       11.28        6.65

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      71.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      326     22169     51     57                         4645
   493.56           326     22169     51     57  1.00     -6     45     4645

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      71.

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.56    -6.5    45.0   325.5   22169.    3100.   9.52

X STA.        -6.5         3.3         5.9         7.9         9.7        11.4
  A(I)            29.7        18.7        16.4        15.2        14.4
  V(I)            5.21        8.29        9.46       10.21       10.73

X STA.        11.4        13.1        14.8        16.4        17.9        19.5
  A(I)            14.1        13.9        13.5        13.3        13.4
  V(I)           11.03       11.15       11.51       11.62       11.55

X STA.        19.5        21.1        22.6        24.1        25.7        27.4
  A(I)            13.3        13.5        13.3        13.8        14.0
  V(I)           11.64       11.49       11.63       11.24       11.04

X STA.        27.4        29.3        31.4        33.7        36.3        45.0
  A(I)            15.1        15.3        16.7        18.4        29.4
  V(I)           10.25       10.10        9.26        8.43        5.28
```

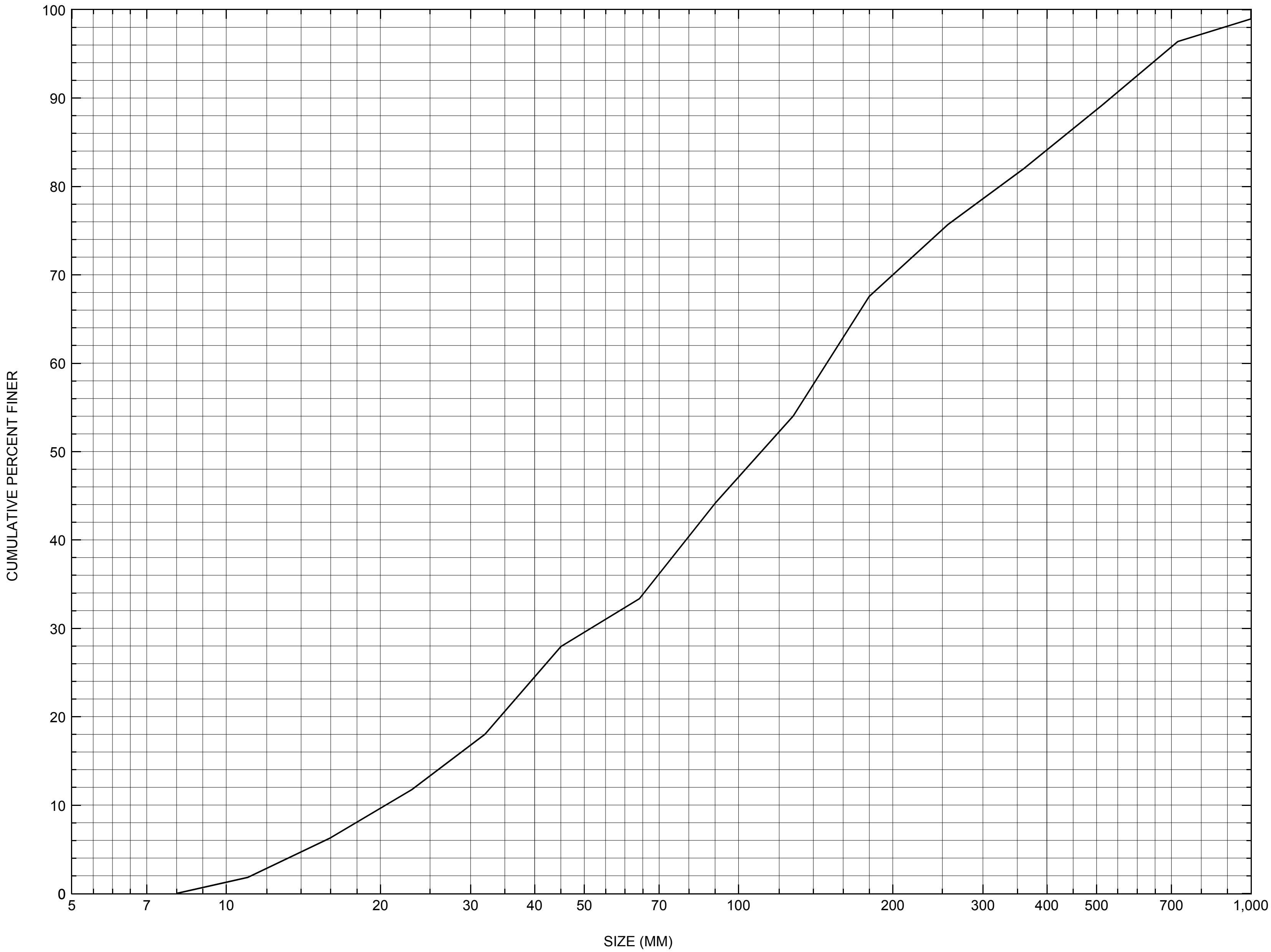
```
        U.S. Geological Survey WSPRO Input File ript017.wsp
        Hydraulic analysis for structure RIPTTH00180017   Date: 30-JUN-97
        TH 18 CROSSING THE SOUTH BRANCH MIDDLEBURY RIVER IN RIPTON, VT    RLB
           *** RUN DATE & TIME: 07-11-97  13:45

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      311     23139     49     60                         4447
   491.87           311     23139     49     60  1.00      0     57     4447

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.87     0.0    56.7   311.2   23139.    4450.  14.30

X STA.        0.0        8.8       13.5       16.9       19.7       22.1
  A(I)            26.0       19.2       16.7       16.0       14.5
  V(I)            8.55      11.62      13.35      13.90      15.30

X STA.       22.1       24.2       26.3       28.3       30.3       32.3
  A(I)            13.7       13.2       13.2       13.0       13.0
  V(I)           16.20      16.89      16.82      17.16      17.10

X STA.       32.3       34.3       36.2       38.1       40.1       42.1
  A(I)            12.8       12.6       12.9       13.2       13.2
  V(I)           17.33      17.62      17.30      16.90      16.86

X STA.       42.1       44.2       46.4       48.7       51.1       56.7
  A(I)            13.8       14.3       14.7       16.8       28.3
  V(I)           16.11      15.57      15.09      13.22       7.86

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      71.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      454     34001     62     69                         6946
   495.83           454     34001     62     69  1.00    -11     50     6946

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      71.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.83   -12.4    50.1   454.0   34001.    4450.   9.80

X STA.      -12.4        1.5        4.7        7.0        9.0       10.9
  A(I)            43.4       27.7       23.2       21.3       20.1
  V(I)            5.12       8.03       9.58      10.47      11.06

X STA.       10.9       12.7       14.5       16.2       17.9       19.6
  A(I)            18.7       18.9       18.3       18.1       18.2
  V(I)           11.91      11.76      12.14      12.26      12.20

X STA.       19.6       21.2       22.9       24.5       26.2       28.1
  A(I)            17.9       18.1       18.4       18.6       19.4
  V(I)           12.44      12.31      12.08      11.99      11.45

X STA.       28.1       30.1       32.3       34.7       37.6       50.1
  A(I)            20.2       21.2       22.7       25.9       43.6
  V(I)           11.01      10.51       9.78       8.60       5.11
```

```
        U.S. Geological Survey WSPRO Input File ript017.wsp
        Hydraulic analysis for structure RIPTTH00180017   Date: 30-JUN-97
        TH 18 CROSSING THE SOUTH BRANCH MIDDLEBURY RIVER IN RIPTON, VT    RLB
           *** RUN DATE & TIME: 07-11-97  13:45

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

EXIT1:XS   ******      1      356  1.18 *****  491.45  489.20    3100  490.27
       -51 ******     76    19286  1.00 ***** *******    0.70    8.71

FULLV:FV       52      0      409  0.89  1.09  492.54 *******    3100  491.65
         0     52     77    23803  1.00  0.00    0.01    0.58    7.58
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       71     -4      284  1.86  1.56  494.58 *******    3100  492.72
        71     71     43    18434  1.00  0.48    0.00    0.79   10.92
          <<<<<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       52      0      263  2.17  1.45  493.05  490.51    3100  490.88
         0     52     57    17837  1.00  0.15    0.00    0.90   11.80

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  495.54 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS       37     -6      326  1.41  0.90  494.97  491.76    3100  493.56
        71     37     45    22171  1.00  1.03    0.01    0.67    9.52

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000   22435.   -13.    44.   492.46

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

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K      AREA     VEL    WSEL
   EXIT1:XS     -52.     1.    76.   3100.   19286.     356.    8.71  490.27
   FULLV:FV       0.     0.    77.   3100.   23803.     409.    7.58  491.65
   BRIDG:BR       0.     0.    57.   3100.   17837.     263.   11.80  490.88
   RDWAY:RG      11.**************       0.******************    2.00********
   APPR1:AS      71.    -7.    45.   3100.   22171.     326.    9.52  493.56

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS     -13.    44.   22435.

  SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXIT1:XS    489.20    0.70  483.15  510.43************  1.18  491.45  490.27
   FULLV:FV  ********    0.58  483.84  511.12  1.09  0.00  0.89  492.54  491.65
   BRIDG:BR    490.51    0.90  483.88  495.56  1.45  0.15  2.17  493.05  490.88
   RDWAY:RG  ****************  498.77  512.71**********************************
   APPR1:AS    491.76    0.67  484.69  515.37  0.90  1.03  1.41  494.97  493.56
```

```
        U.S. Geological Survey WSPRO Input File ript017.wsp
        Hydraulic analysis for structure RIPTTH00180017   Date: 30-JUN-97
        TH 18 CROSSING THE SOUTH BRANCH MIDDLEBURY RIVER IN RIPTON, VT    RLB
           *** RUN DATE & TIME: 07-11-97  13:45

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

EXIT1:XS   ******     -5      461  1.45 *****  493.07  490.30    4450  491.62
       -51 ******     78    27686  1.00 ***** *******    0.73    9.65

FULLV:FV       52    -33      536  1.11  1.10  494.17 *******    4450  493.06
         0     52     80    33845  1.03  0.00    0.00    0.69    8.30
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPR1":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.87     494.05     493.35

 ===110 WSEL NOT FOUND AT SECID "APPR1":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   492.56     515.37    0.50

 ===115 WSEL NOT FOUND AT SECID "APPR1":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   492.56     515.37     493.35

APPR1:AS       71     -6      351  2.49  1.69  496.55  493.35    4450  494.05
        71     71     46    24564  1.00  0.69    0.00    0.87   12.66
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    4450.     491.87

            <<<<<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       52      0      311  3.18 *****  495.05  491.87    4450  491.87
         0     52     57    23136  1.00 ***** *******    1.00   14.30

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  495.54 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
   RDWAY:RG      11.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS       37    -11      454  1.50  1.02  497.32  493.35    4450  495.83
        71     40     50    33974  1.00  1.26    0.01    0.64    9.81

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000   35239.   -12.    44.   494.86

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -52.    -6.    78.   4450.   27686.     461.    9.65  491.62
   FULLV:FV       0.   -34.    80.   4450.   33845.     536.    8.30  493.06
   BRIDG:BR       0.     0.    57.   4450.   23136.     311.   14.30  491.87
   RDWAY:RG      11.**************      0.******************    2.00********
   APPR1:AS      71.   -12.    50.   4450.   33974.     454.    9.81  495.83

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS     -12.    44.   35239.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXIT1:XS    490.30    0.73  483.15  510.43************  1.45  493.07  491.62
   FULLV:FV  ********    0.69  483.84  511.12  1.10  0.00  1.11  494.17  493.06
   BRIDG:BR    491.87    1.00  483.88  495.56************  3.18  495.05  491.87
   RDWAY:RG  ****************  498.77  512.71**********************************
   APPR1:AS    493.35    0.64  484.69  515.37  1.02  1.26  1.50  497.32  495.83
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure RIPTTH00180017, in Ripton, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number RIPTTH00180017

General Location Descriptive

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

Date *(MM/DD/YY)* 11 / 30 / 95

Highway District Number *(I - 2; nn)* 05

County *(FIPS county code; I - 3; nnn)* 001

Town *(FIPS place code; I - 4; nnnnn)* 59650

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

Waterway *(I - 6)* SO. BR. MIDDLEBURY RIVER

Road Name *(I - 7)*: -

Route Number C3018

Vicinity *(I - 9)* 0.1 MI TO JCT W VT125

Topographic Map East Middlebury

Hydrologic Unit Code: 2010002

Latitude *(I - 16; nnnn.n)* 43577

Longitude *(i - 17; nnnnn.n)* 73017

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10011600170116

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

Maximum span length *(I - 48; nnnn)* 0058

Year built *(I - 27; YYYY)* 1940

Structure length *(I - 49; nnnnnn)* 000061

Average daily traffic, ADT *(I - 29; nnnnnn)* 000150

Deck Width *(I - 52; nn.n)* 150

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

Channel & Protection *(I - 61; n)* 5

Opening skew to Roadway *(I - 34; nn)* 20

Waterway adequacy *(I - 71; n)* 6

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 56

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

Vertical clearance from streambed (*nnn.n ft*) 10

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

Waterway of full opening (*nnn.n* ft^2) 560

Comments:

According to the structural inspection report dated 12/8/94, the abutments, wingwalls, backwalls, and footings are concrete. They have minor fine cracks, small leaks, and small spalls overall. The channel flow is mostly against the RABUT and its DS wingwall, and the channel is scoured down approximately 1.5 ft. Boulders are present in front of the LABUT and it's wingwalls, and the US wingwall on the RABUT. Bedrock outcrops appear downstream. Riprap is mostly washed away at the RABUT and it's DS wing-wall. There is 4 ft of exposed footing at the RABUT.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **15.6**

Terrain character: **Hilly and forested**

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ **800** Q_{10} **1600** Q_{25} **2100**
Q_{50} **2600** Q_{100} **3100** 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*)	3.3	5.1	6	6.9	7.7
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

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

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

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

Upstream distance (*miles*): **2.7** Town: **Ripton** Year Built: **1975**

Highway No. : **TH21** Structure No. : **11** Structure Type: **Concrete slab**

Clear span (*ft*): **18** Clear Height (*ft*): **10** Full Waterway (*ft²*): **180**

Downstream distance (*miles*): 1 Town: Ripton Year Built: 1978

Highway No. : VT125 Structure No. : 14 Structure Type: Twin call R.C. box

Clear span (*ft*): 40 Clear Height (*ft*): 12 Full Waterway (ft^2): 480

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 15.51 mi^2 Lake/pond/swamp area 0 mi^2

Watershed storage *(ST)* 0 %

Bridge site elevation 1170 ft Headwater elevation 3234 ft

Main channel length 6.73 mi

10% channel length elevation 1250 ft 85% channel length elevation 1920 ft

Main channel slope *(S)* 132.73 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? N *If no, type ctrl-n xs*

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

Comments: **NO CROSS SECTIONAL INFORMATION**

Station		-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord 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: **JD** Date: **5/6/97**
Computerized by: **JD** Date: **5/6/97**
Reviewd by: **RB** Date: **7/23/97**

Structure Number **RIPTTH00180017**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **L**. **MEDALIE** Date *(MM/DD/YY)* **06** / **10** / 19**96**
2. Highway District Number **05** Mile marker **0**
County **ADDISON (001)** Town **RIPTON (59650)**
Waterway *(I - 6)* **SO. BR. MIDDLEBURY RIVER** Road Name **-**
Route Number **C3018** Hydrologic Unit Code: **02010002**
3. Descriptive comments:
This structure is located 0.1 mile from the intersection of Town Highway 18 with State Route 125.

B. Bridge Deck Observations

4. Surface cover... LBUS **5** RBUS **6** LBDS **6** RBDS **6** Overall **6**
*(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 **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 **61** *(feet)* Span length **58** *(feet)* Bridge width **15** *(feet)*

Road approach to bridge:

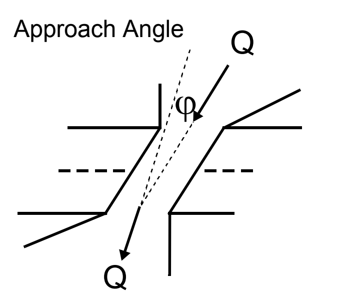
8. LB **0** RB **2** *(**0** even, **1**- lower, **2**- higher)*
9. LB **2** RB **2** *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left **2.4:1** US right **2.7:1**

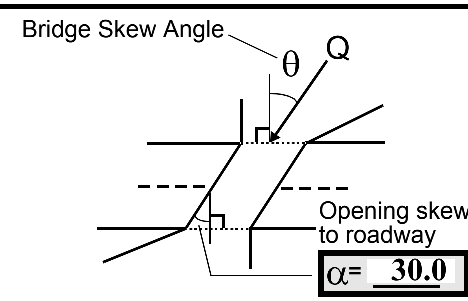
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	2	1
RBDS	0	-	2	2
LBDS	0	-	2	1

*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: **30** 16. Bridge skew: **40**



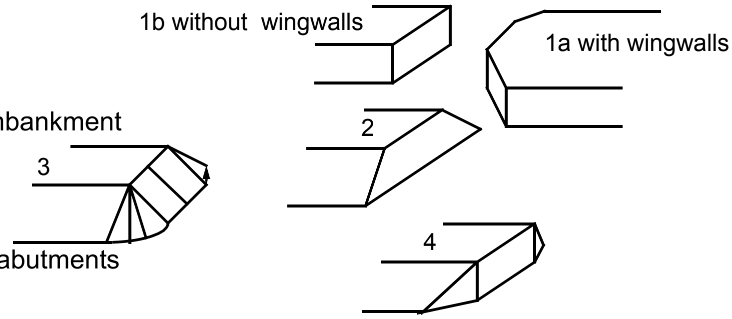


17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **50** feet **US** *(US, UB, DS)* to **0** feet **UB**
Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **0**
Range? **75** feet **DS** *(US, UB, DS)* to **120** feet **DS**

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

18. Bridge Type: 4

1a- Vertical abutments with wingwalls
1b- Vertical abutments without wingwalls
2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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 road approach bisects the forest cover on the LBUS and RBDS.
7. Values are from the VT AOT database. The measured bridge length is 61 ft, span is 55 ft and width is 14.9 ft.
11. The DS right road embankment has four 36 inch boulders near its top, spaced 6-8 feet apart. There is a 1-1.5 foot wide path 20 feet down the road from the structure that channels road wash. The DS right road approach also has moderate road wash erosion just behind the wingwall. The US right road approach erosion starts 8 feet from the right side of the bridge. Grass at the top of the US right road approach helps slow down erosion in the 2 foot wide channel. The left road approach has road wash erosion behind the upstream and downstream wingwalls.
17. The channel makes a moderate bend through the bridge, but the banks are naturally protected with boulders and bedrock.

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
48.5	10.5			10.5	2	3	54	5	0	1

23. Bank width 25.0 24. Channel width 35.0 25. Thalweg depth 68.5 29. Bed Material 453

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

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

32. Comments (bank material variation, minor inflows, protection extent, etc.):
The banks are steep and lined with large boulders.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **70** 35. Mid-bar width: **6**

36. Point bar extent: **40** feet **US** (US, UB) to **90** feet **US** (US, UB, DS) positioned **0** %LB to **20** %RB

37. Material: **345**

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

The side bar is just DS of a birch tree that has fallen off the left bank.

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

41. Mid-bank distance: **130** 42. Cut bank extent: **110** feet **US** (US, UB) to **180** feet **US** (US, UB, DS)

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

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

-

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

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

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

NO CHANNEL SCOUR

There is some localized scour around boulders, reaching 0.75 feet in depth.

49. Are there major confluences? **Y** (Y or if N type ctrl-n mc) 50. How many? **1**

51. Confluence 1: Distance **65** 52. Enters on **RB** (LB or RB) 53. Type **2** (**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 many large boulders at the mouth of the confluence.

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		1.5		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.):

453

-

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

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

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

70. Debris and Ice Comments:

2

There is a fallen birch tree in the channel 70 feet US of the bridge.

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**	**0**	**2**	**-**	**1**	**90.0**
RABUT	**1**	**10**	**90**			**2**	**3**	**49.0**

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.):

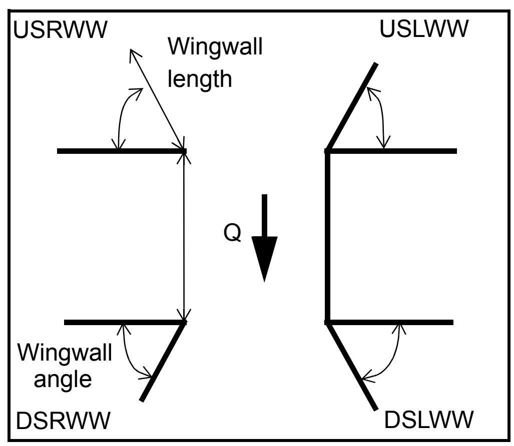
1.25
5
1

74. The right abutment footing is undermined. A range pole can penetrate 1 ft horizontally under the footing. The undermined section is 1.5 ft long, and 3 in. high. The bed material around the opening is loose gravel that can be easily penetrated with a range pole to 3 in.
75. Scour depth based on an average thalweg depth of 1.25 ft.
76. The right abutment has 2.5 feet of exposure on the upper footing and 2.5 feet of exposure on the lower footing. The left abutment is exposed 1 foot above the bed material but is covered by boulders.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**49.0**	
USRWW:	**Y**		**1**		**0**	**1.5**	
DSLWW:	**-**		**-**		**Y**	**22.0**	
DSRWW:	**1**		**2**		**-**	**21.5**	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**2**	**0**	**Y**	**0.75**	**1**	**1**	**1**	**1**
Condition	**Y**	**-**	**1**	**2**	**1**	**1**	**1**	**2**
Extent	**1**	**-**	**2**	**2**	**3**	**2**	**2**	**-**

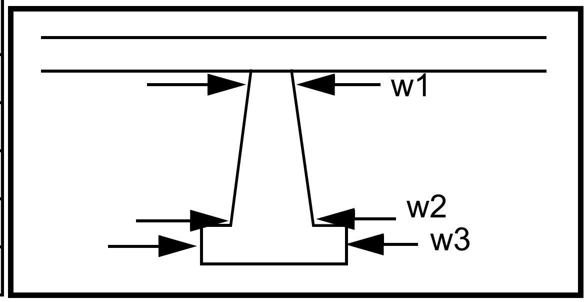
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
1
1
0
-
-

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				45.0	17.5	90.0
Pier 2				12.5	90.0	10.5
Pier 3			-	45.0	18.0	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e DS	and 0.5	wall	end.	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	right	ft of	uppe	The	1- Solid pier, 2- column, 3- bent
88. Material	wing	expo	r	lowe	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	wall	sure	foot-	r	1- Round; 2- Square; 3- Pointed
90. Inclined?	has 2	on	ing is	foot-	Y- yes; N- no
91. Attack ∠ (BF)	ft of	the	expo	ing is	
92. Pushed	expo	DS	sed 2	also	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	sure	end.	ft for	expo	
95. Cross-members	on	The	5 ft	sed 2	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	the	US	from	ft at	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	US	right	the	the	
98. Exposure depth	end	wing	DS	cor-	

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

ner with the right abutment, but is covered with boulders US of this point.
There is a 5 ft boulder at the corner of the left abutment and US left wingwall.

N

E. Downstream Channel Assessment

100.

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

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

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? **N**____ *(Y or if N type ctrl-n cb)* Where? **O**____ *(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: **4**_____

Scour dimensions: Length **3**_____ Width **542**_____ Depth: **54**_____ Positioned **1**____ %LB to **1**____ %RB

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

654
0
0
-

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

Confluence 1: Distance **e are**____ Enters on **man**____ *(LB or RB)* Type **y**____ *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

g the left bank. A large boulder sits at the DS end of the DS left wingwall, measuring 12 feet long and 2.5 feet high.

F. Geomorphic Channel Assessment

107. Stage of reach evolution **Be**____

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)*:

drock outcrops are across the channel from 53 feet DS to 65 feet DS. The bedrock is on both sides of the channel and flow is over the middle.

109. G. Plan View Sketch

\- N

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: RIPTTH00180017 Town: RIPTON
Road Number: TH 18 County: ADDISON
Stream: SOUTH BRANCH MIDDLEBURY RIVER

Initials RLB Date: 7/11/97 Checked: EB

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	3100	4450	0
Main Channel Area, ft2	326	454	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	51	62	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.3636	0.3636	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.4	7.3	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	22169	34001	0
Conveyance, main channel	22169	34001	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	3100.0	4450.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	9.5	9.8	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	10.9	11.1	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?

Main Channel	0	0	N/A
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	3100	4450	0
(Q) discharge thru bridge, cfs	3100	4450	0
Main channel conveyance	17834	23139	0
Total conveyance	17834	23139	0
Q2, bridge MC discharge,cfs	3100	4450	ERR
Main channel area, ft2	263	311	0
Main channel width (normal), ft	49.0	49.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	49	49.1	0
y_bridge (avg. depth at br.), ft	5.37	6.33	ERR
Dm, median (1.25*D50), ft	0.4545	0.4545	0
y2, depth in contraction,ft	5.42	7.38	ERR
ys, scour depth (y2-ybridge), ft	0.06	1.05	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	3100	4450	N/A
Main channel area (DS), ft2	263	311	0
Main channel width (normal), ft	49.0	49.1	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	49.0	49.1	0.0
D90, ft	1.7455	1.7455	0.0000
D95, ft	2.2112	2.2112	0.0000
Dc, critical grain size, ft	1.0654	1.4360	ERR
Pc, Decimal percent coarser than Dc	0.199	0.140	0.000
Depth to armoring, ft	12.87	26.46	ERR

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)

Characteristic	Left Abutment 100 yr Q	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
(Qt), total discharge, cfs	3100	4450	0	3100	4450	0
a', abut.length blocking flow, ft	1.3	7.2	0	1.2	6.2	0
Ae, area of blocked flow ft2	3.94	22.48	0	4.06	21.63	0
Qe, discharge blocked abut.,cfs	20.56	115.25	0	21.38	110.36	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	5.22	5.13	ERR	5.27	5.10	ERR
ya, depth of f/p flow, ft	3.03	3.12	ERR	3.38	3.49	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	60	60	60	120	120	120
K2	0.95	0.95	0.95	1.04	1.04	1.04
Fr, froude number f/p flow	0.528	0.511	ERR	0.505	0.481	ERR
ys, scour depth, ft	5.55	8.37	N/A	6.14	9.02	N/A

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

Characteristic	Left Abutment 100 yr Q	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
a'(abut length blocked, ft)	1.3	7.2	0	1.2	6.2	0
y1 (depth f/p flow, ft)	3.03	3.12	ERR	3.38	3.49	ERR
a'/y1	0.43	2.31	ERR	0.35	1.78	ERR
Skew correction (p. 49, fig. 16)	0.90	0.90	0.00	1.07	1.07	0.00
Froude no. f/p flow	0.53	0.51	N/A	0.50	0.48	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.9	1	0	0.9	1	0
y, depth of flow in bridge, ft	5.37	6.33	0.00	5.37	6.33	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	2.18	2.65	ERR	2.18	2.65	ERR