LEVEL II SCOUR ANALYSIS FOR BRIDGE 92 (WSTOVT01000092) ON STATE HIGHWAY 100, CROSSING THE WEST RIVER, WESTON, VERMONT

U.S. Geological Survey
Open-File Report 97-1

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

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By ROBERT H. FLYNN AND RONDA L. BURNS

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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CONTENTS

FIGURES

TABLES

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 92 (WSTOVT01000092) ON STATE HIGHWAY 100, CROSSING THE WEST RIVER, WESTON

By **Robert H. Flynn and Ronda L. Burns**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure WSTOVT01000092 on Vermont Highway 100 crossing the West River, Weston, 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 south-central Vermont. The 32.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover upstream of the bridge is primarily forest with pasture on the upstream left overbank. Upstream and downstream, the immediate banks have brush and dense forest cover. Downstream of the bridge is forested.

In the study area, the West River has an incised, sinuous channel with a slope of approximately 0.006 ft/ft, an average channel top width of 111 ft and an average channel depth of 3 ft. The predominant channel bed material is very coarse gravel and cobbles with a median grain size (D_{50}) of 67.7 mm (0.222 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 19, 1996 indicated that the reach was laterally unstable based on the fine bank material, sinuosity of the stream, point bars and cutbanks.

The state highway 100 crossing of the West River is a 113-ft-long, two-lane bridge consisting of one 110-foot steel-beam span (Vermont Agency of Transportation, written communication, March 31, 1995). The bridge is supported by vertical, concrete abutments without wingwalls. The channel is skewed approximately 40 degrees to the opening while the opening-skew-to-roadway is 25 degrees.

The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the entire base length of the left and right abutments. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.4 to 2.1 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 8.4 to 30.7 ft. The worst-case abutment scour occurred at the 500-year discharge along the left abutment. 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.

Weston, VT. Quadrangle, 1:24,000, 1986

NORTH

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

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

LEVEL II SUMMARY

Structure Number WSTOVT01000092 ***Stream*** West River

County Windsor ***Road*** VT 100 ***District*** 2

Description of Bridge

Bridge length 113 ***ft*** ***Bridge width*** 37.0 ***ft*** ***Max span length*** 110 ***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*** 08/19/96

Description of stone fill Type-2, along the entire base length of the left and right abutments in good condition.

Abutments are concrete.

Is bridge skewed to flood flow according to Y ***survey?*** Y ***Angle*** 40

There is a moderate channel bend in both the upstream and downstream reach.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	08/19/96	0	0
Level II	08/19/96	0	0

Potential for debris Moderate. There are some large trees caught on the upstream left bank point bar.

Describe any features near or at the bridge that may affect flow (include observation date) There are some boulders upstream and at the bridge face (observed August 19, 1996).

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with narrow irregular flood plains and steep valley walls on both sides.

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

Date of inspection 08/19/96

DS left: Moderately sloped channel bank to VT 100 and a narrow flood plain

DS right: Moderately sloped channel bank to a narrow flood plain

US left: Moderately sloped channel bank

US right: Moderately sloped channel bank to VT 100 and a narrow flood plain

Description of the Channel

Average top width 111 *ft* ***Average depth*** 3 *ft*

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

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

08/19/96

Vegetative co

DS left: Trees and brush

DS right: Trees and brush

US left: Trees and pasture

US right: Trees and brush.

Do banks appear stable? No

date of observation. Cut banks are present upstream and downstream leaving exposed stones, roots and leaning trees. In addition, point bars, composed primarily of cobbles, gravel and sand, are present both upstream and downstream.

Describe any obstructions in channel and date of observation. The assessment of 08/19/96 noted flow conditions up to bank-full level are influenced by the point bar (which blocks approximately 60% of the channel) on the left bank side of the channel upstream. In addition, some debris is caught on the left bank point bar in the channel. upstream.

Hydrology

Drainage area 32.7 ***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***: None

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

USGS gage description West River below Townshend Dam

USGS gage number 01155910

Gage drainage area 282 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 5,800 ***ft³/s*** ***Q500*** 8,750 ***ft³/s***

The 100- and 500-year discharges are the median of discharge frequency curves, which were developed from empirical relationships and extended to the 500-year discharge (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 Add 693.85 feet to USGS survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a VTAOT brass tablet on top of the downstream, right bank curb, 20 feet from the right shore end of the curb (elev. 502.82 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream left bank curb (elev. 500.04 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	-75	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	18	1	Road Grade section
APPRO	135	2	Modelled Approach section (Templated from APTEM)
APTEM	175	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Shearman and others, 1986, and Shearman, 1990). The 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 0.040 to 0.060, and overbank "n" values ranged from 0.030 to 0.070.

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 0.0038 ft/ft which was determined from the surveyed thalweg points downstream of the exit section.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0115 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

WSPRO assumes critical depth at the bridge section for the 500-year discharge model. The assumption of critical depth is based on the coefficient of discharge which is a function of the bridge geometry and flow characteristics. Supercritical models were developed for this discharge and it was determined that the surface water profile does pass through critical depth within the bridge opening (full valley section). Thus, the assumption of critical depth at the bridge is a satisfactory solution for the 500-year discharge.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.3 *ft*
Average low steel elevation 495.7 *ft*

100-year discharge 5,800 *ft³/s*
Water-surface elevation in bridge opening 488.3 *ft*
Road overtopping? N *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 533 *ft²*
Average velocity in bridge opening 10.9 *ft/s*
Maximum WSPRO tube velocity at bridge 14.3 *ft/s*

Water-surface elevation at Approach section with bridge 491.6 *ft*
Water-surface elevation at Approach section without bridge 489.8 *ft*
Amount of backwater caused by bridge 1.8 *ft*

500-year discharge 8,750 *ft³/s*
Water-surface elevation in bridge opening 489.3 *ft*
Road overtopping? N *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 621 *ft²*
Average velocity in bridge opening 14.1 *ft/s*
Maximum WSPRO tube velocity at bridge 18.5 *ft/s*

Water-surface elevation at Approach section with bridge 494.3 *ft*
Water-surface elevation at Approach section without bridge 491.1 *ft*
Amount of backwater caused by bridge 3.2 *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 -- *ft*
Water-surface elevation at Approach section without bridge -- *ft*
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. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). In this case, the 500-year discharge model resulted in the worst case contraction scour with a scour depth of 2.1 ft. Armoring will not limit the contraction scour.

Abutment scour for the right abutment was computed by use of the Froehlich equation (Richardson and others, 1995, p. 48, equation 28) for the 100- and 500-year discharges. 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 left abutment for the 100- and 500-year discharges was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation. The worst case total scour occurred along the left abutment, with a total scour depth of 32.8 ft.

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	0.4	2.1	--
Depth to armoring	9.1	58.5	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	20.7	30.7	--
Right abutment	8.4	11.7	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.4	2.7	--
Right abutment	1.4	2.7	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

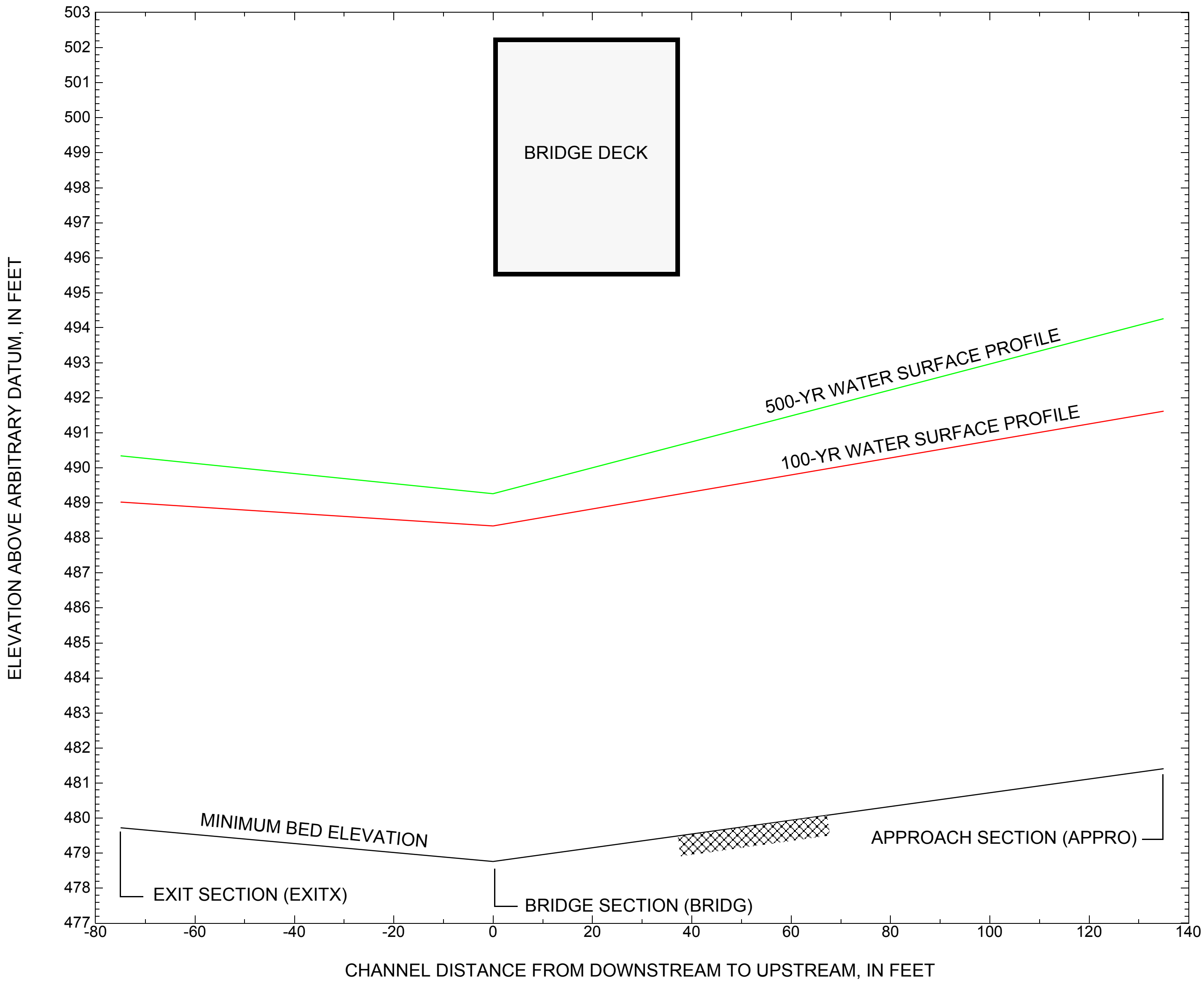

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure WSTOVT01000092 on state highway 100, crossing the West River, Weston, Vermont.

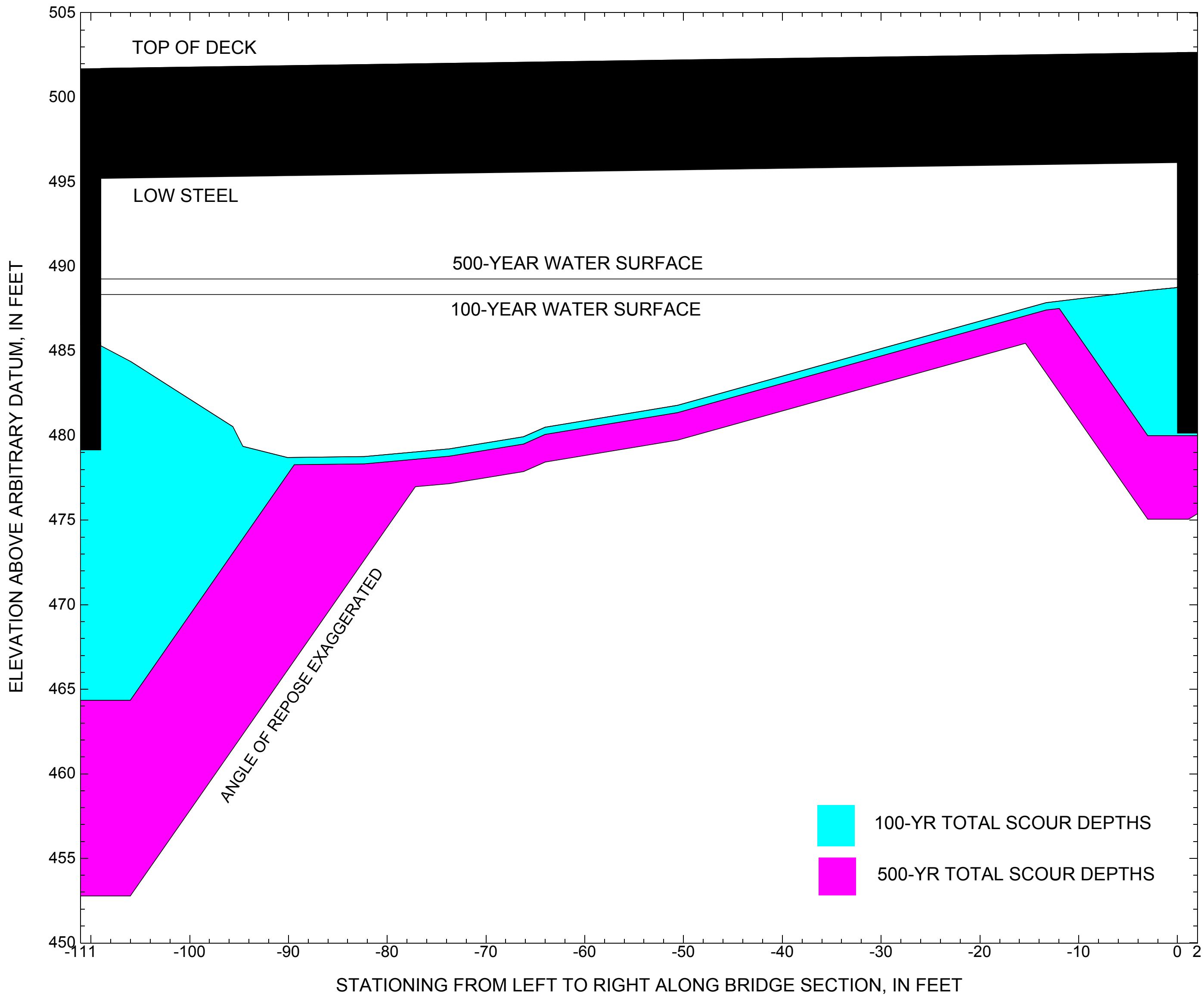

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure WSTOVT01000092 on state highway 100, crossing the West River, Weston, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WSTOVT01000092 on state highway 100, crossing the West River, Weston, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 5,800 cubic-feet per second											
Left abutment	-109.0	1189.0	495.3	479.1	485.5	0.4	20.7	--	21.1	464.4	-14.7
Right abutment	0.0	1190.1	496.1	480.1	488.8	0.4	8.4	--	8.8	480.0	-0.1

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 WSTOVT01000092 on state highway 100, crossing the West River, Weston, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 8,750 cubic-feet per second											
Left abutment	-109.0	1189.0	495.3	479.1	485.5	2.1	30.7	--	32.8	452.7	-26.4
Right abutment	0.0	1190.1	496.1	480.1	488.8	2.1	11.7	--	13.8	475.0	-5.1

1.Measured along the face of the most constricting side of the bridge.

2.Arbitrary datum for this study.

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U.S. Geological Survey, 1986, Weston, 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 wsto092.wsp
T2        Hydraulic analysis for structure WSTOVT01000092   Date: 08-OCT-96
T3        Bridge #92 over the West River. RF
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           5800.0   8750.0
SK          0.0038   0.0038
*
XS   EXITX    -75           0.
GR         -538.3, 514.18   -498.1, 507.98   -460.3, 506.42   -426.8, 504.58
GR         -408.5, 499.94   -380.1, 490.53   -130.0, 485.29   -103.5, 482.69
GR          -94.2, 480.39    -87.9, 479.75    -79.4, 479.82    -67.9, 479.72
GR          -57.5, 480.26    -53.9, 480.49    -46.1, 481.20    -31.0, 481.97
GR          -13.0, 486.61      0.0, 486.34     73.2, 487.37    187.5, 501.45
GR          381.7, 508.40
*
N           0.070        0.060        0.063
SA                -130.0       -13.0
*
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.69      25.0
GR         -109.0, 495.28   -108.7, 485.50    -95.6, 480.52    -94.6, 479.37
GR          -90.1, 478.70    -82.3, 478.76    -73.7, 479.22    -66.2, 479.93
GR          -64.0, 480.50    -50.6, 481.79    -13.3, 487.86     -1.9, 488.80
GR            0.0, 496.10   -109.0, 495.28
*
*         BRTYPE  BRWDTH
CD           1      36.2
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     18      37.0     1
GR         -591.0, 516.63   -555.1, 510.63   -488.7, 505.36   -421.6, 502.23
GR         -296.4, 499.85   -168.0, 500.08   -142.3, 500.43   -142.1, 501.31
GR         -108.5, 501.62      0.0, 502.75     23.3, 503.02     23.4, 502.00
GR           93.5, 502.94    165.4, 505.03    285.8, 508.73    331.3, 509.61
*
*
XT   APTEM    175           0.
GR         -744.0, 516.18   -680.0, 505.42   -654.4, 505.73   -543.6, 500.30
GR         -493.5, 488.19   -155.7, 488.35   -148.8, 483.29   -135.9, 482.71
GR         -129.8, 483.56   -117.0, 484.97    -75.7, 483.62    -66.2, 482.38
GR          -59.2, 481.59    -51.4, 481.41    -43.8, 481.77    -38.7, 481.61
GR          -35.8, 482.08    -31.9, 483.62    -31.7, 487.24      0.0, 487.86
GR            8.1, 492.80     35.4, 501.97     50.5, 503.66    209.5, 509.53
*
AS   APPRO    135 * * * 0.0115
GT
N           0.030        0.055
SA                -155.7
*
*
HP 1 BRIDG    488.34 1 488.34
HP 2 BRIDG    488.34 * * 5800
HP 1 APPRO    491.62 1 491.62
HP 2 APPRO    491.62 * * 5800
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

         U.S. Geological Survey WSPRO Input File wsto092.wsp
         Hydraulic analysis for structure WSTOVT01000092   Date: 08-OCT-96
         Bridge #92 over the West River. RF
            *** RUN DATE & TIME: 10-30-96  14:23
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     533.  61845.    92.    97.                         7287.
   488.34           533.  61845.    92.    97.  1.00  -109.    -7.   7287.


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

          WSEL     LEW     REW    AREA        K        Q    VEL
        488.34  -108.8    -7.5   533.0   61845.    5800.  10.88

 X STA.      -108.8      -99.4      -95.3      -92.3      -89.8      -87.5
   A(I)            38.9       26.7       24.0       21.6       20.6
   V(I)            7.46      10.85      12.06      13.44      14.08

 X STA.       -87.5      -85.1      -82.7      -80.4      -77.9      -75.4
   A(I)            20.9       20.3       20.7       20.6       20.9
   V(I)           13.89      14.30      14.01      14.08      13.84

 X STA.       -75.4      -72.9      -70.1      -67.2      -63.9      -60.3
   A(I)            21.3       22.1       23.3       24.1       25.5
   V(I)           13.63      13.13      12.45      12.02      11.36

 X STA.       -60.3      -56.2      -51.5      -46.0      -37.7       -7.5
   A(I)            26.8       29.1       31.3       38.3       56.0
   V(I)           10.82       9.97       9.28       7.56       5.18


     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     135.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1    1318.  157207.   354.   354.                       14439.
              2    1234.  125527.   163.   170.                       19285.
   491.62          2552.  282733.   517.   524.  1.02  -510.     7.  31895.

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     135.

          WSEL     LEW     REW    AREA        K        Q    VEL
        491.62  -509.6     6.9  2552.1  282733.    5800.   2.27

 X STA.      -509.6     -467.3     -437.0     -407.2     -376.8     -346.3
   A(I)           133.2      117.0      115.0      116.9      116.8
   V(I)            2.18       2.48       2.52       2.48       2.48

 X STA.      -346.3     -315.3     -284.7     -253.9     -222.3     -190.8
   A(I)           118.1      116.4      116.5      118.8      118.4
   V(I)            2.46       2.49       2.49       2.44       2.45

 X STA.      -190.8     -159.6     -139.7     -125.7     -107.0      -89.6
   A(I)           116.5      140.0      123.8      138.4      134.2
   V(I)            2.49       2.07       2.34       2.10       2.16

 X STA.       -89.6      -74.2      -61.0      -49.4      -36.7        6.9
   A(I)           128.1      125.3      122.5      131.5      204.8
   V(I)            2.26       2.31       2.37       2.21       1.42
```

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

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     621.   76420.    97.   103.                        8916.
  489.26          621.   76420.    97.   103.  1.00  -109.    -2.   8916.

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      489.26  -108.8    -1.8   621.0   76420.    8750.  14.09

X STA.      -108.8      -99.7      -95.4      -92.3      -89.6      -87.1
  A(I)           45.0       30.8       28.0       25.1       23.9
  V(I)           9.71      14.20      15.62      17.41      18.28

X STA.       -87.1      -84.6      -82.2      -79.6      -77.0      -74.4
  A(I)           23.8       23.7       24.1       24.4       24.0
  V(I)          18.40      18.48      18.14      17.96      18.21

X STA.       -74.4      -71.6      -68.6      -65.5      -61.9      -58.1
  A(I)           25.2       26.1       26.6       28.7       29.0
  V(I)          17.38      16.78      16.47      15.24      15.09

X STA.       -58.1      -53.7      -48.7      -42.5      -33.5       -1.8
  A(I)           31.5       34.1       37.6       43.9       65.5
  V(I)          13.88      12.83      11.64       9.97       6.68


   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     135.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1    2267.  380036.   365.   366.                       32068.
            2    1671.  202313.   170.   177.                       29779.
  494.26         3938.  582349.   534.   543.  1.07  -521.    14.  58611.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     135.

        WSEL     LEW     REW    AREA        K        Q    VEL
      494.26  -520.5    13.8  3938.3  582349.    8750.   2.22

X STA.      -520.5     -474.0     -447.2     -420.9     -395.1     -368.6
  A(I)          215.3      174.8      170.7      167.7      171.8
  V(I)           2.03       2.50       2.56       2.61       2.55

X STA.      -368.6     -342.9     -316.5     -289.8     -263.5     -237.2
  A(I)          165.9      170.6      171.6      169.2      168.9
  V(I)           2.64       2.57       2.55       2.59       2.59

X STA.      -237.2     -210.5     -183.9     -156.9     -135.4     -114.3
  A(I)          170.7      170.3      172.0      225.8      225.2
  V(I)           2.56       2.57       2.54       1.94       1.94

X STA.      -114.3      -91.6      -71.5      -54.4      -37.2       13.8
  A(I)          232.3      219.7      216.5      225.4      333.9
  V(I)           1.88       1.99       2.02       1.94       1.31
```

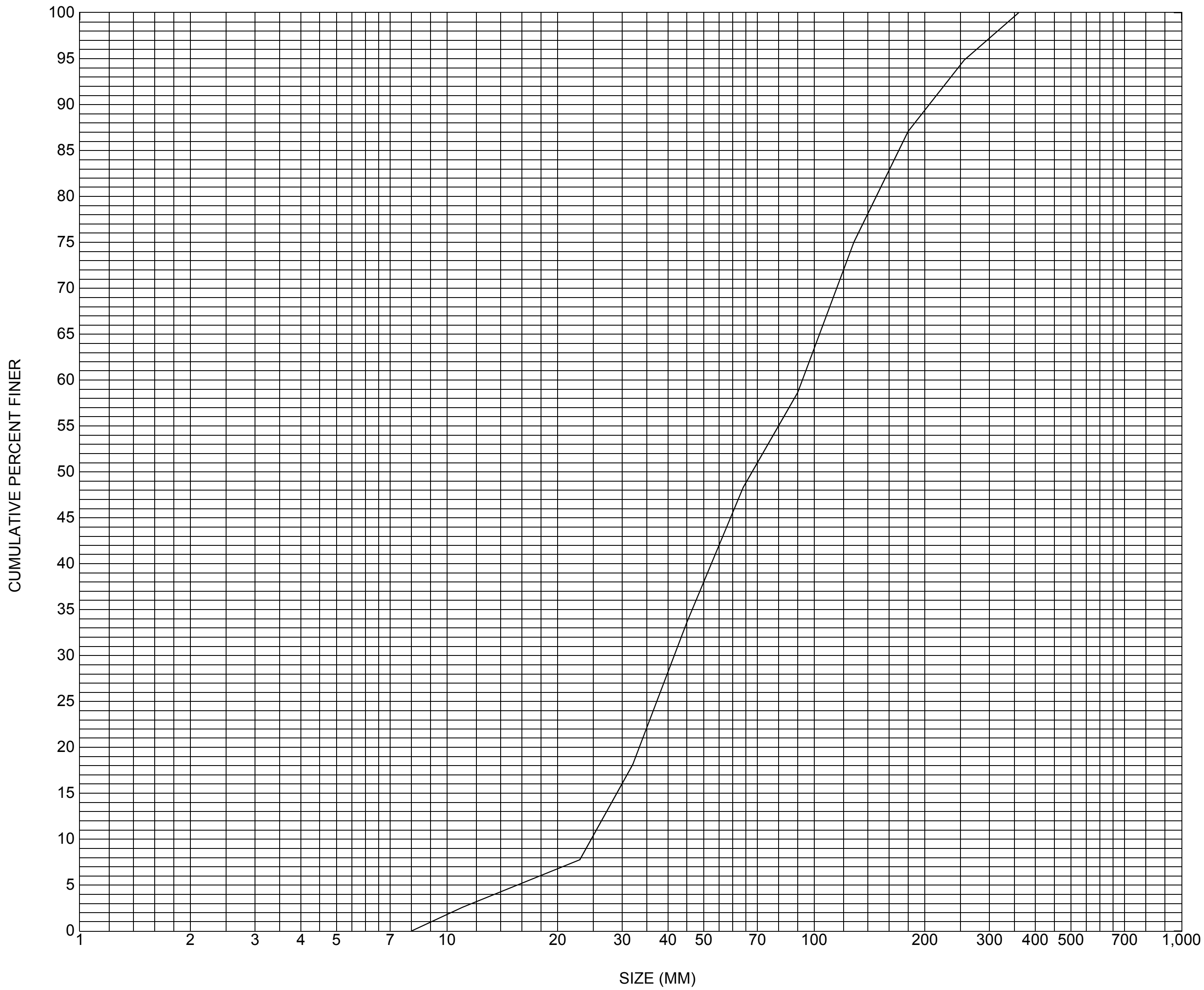
WSPRO OUTPUT FILE (continued)

```
         U.S. Geological Survey WSPRO Input File wsto092.wsp
         Hydraulic analysis for structure WSTOVT01000092   Date: 08-OCT-96
         Bridge #92 over the West River. RF
            *** RUN DATE & TIME: 10-30-96  14:23

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

 EXITX:XS   ****** -308.    1364.  0.41 *****  489.43  486.30   5800.  489.02
       -75. ******   87.   94025.  1.46 ***** *******    0.49    4.25

 FULLV:FV      75.  -324.    1497.  0.34  0.26  489.69 *******   5800.  489.35
         0.    75.   89.  104648.  1.47  0.00    0.00    0.43    3.88
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS     135.  -502.    1628.  0.20  0.32  490.01 *******   5800.  489.81
       135.   135.     4.  134861.  1.01  0.00    0.00    0.35    3.56
          <<<<<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      75.  -109.     533.  2.79  0.43  491.13  487.31   5800.  488.34
         0.    75.    -8.   61785.  1.51  1.26    0.00    0.98   10.89

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   1.  0.813 ******  495.69 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      18.        <<<<<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      99.  -510.    2552.  0.08  0.26  491.70  487.21   5800.  491.62
       135.   134.     7.  282696.  1.02  0.32    0.01    0.18    2.27

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.788  0.703   83524.  -166.   -65.   491.58

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


   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
    EXITX:XS     -75.  -308.    87.   5800.   94025.    1364.    4.25  489.02
    FULLV:FV       0.  -324.    89.   5800.  104648.    1497.    3.88  489.35
    BRIDG:BR       0.  -109.    -8.   5800.   61785.     533.   10.89  488.34
    RDWAY:RG      18.**************      0.*****************    1.00********
    APPRO:AS     135.  -510.     7.   5800.  282696.    2552.    2.27  491.62

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS    -166.   -65.   83524.

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS    486.30    0.49  479.72  514.18************  0.41  489.43  489.02
    FULLV:FV  ********    0.43  479.72  514.18  0.26  0.00  0.34  489.69  489.35
    BRIDG:BR    487.31    0.98  478.70  496.10  0.43  1.26  2.79  491.13  488.34
    RDWAY:RG  ****************  499.85  516.63**********************************
    APPRO:AS    487.21    0.18  480.95  515.72  0.26  0.32  0.08  491.70  491.62
```

```
       U.S. Geological Survey WSPRO Input File wsto092.wsp
       Hydraulic analysis for structure WSTOVT01000092   Date: 08-OCT-96
       Bridge #92 over the West River. RF
          *** RUN DATE & TIME: 10-30-96  14:23

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

EXITX:XS   ******  -371.    1936.  0.47 *****  490.82  488.02   8750.  490.34
      -75. ******    97.  141817.  1.49 ***** *******    0.48    4.52

FULLV:FV      75.  -381.    2096.  0.40  0.26  491.08 *******   8750.  490.68
        0.    75.   100.  156491.  1.48  0.00    0.01    0.43    4.17
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  1.52

APPRO:AS     135.  -508.    2300.  0.23  0.28  491.36 *******   8750.  491.13
      135.   135.     6.  237594.  1.01  0.00    0.00    0.32    3.80
         <<<<<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      75.  -109.     621.  4.35  0.53  493.61  489.17   8750.  489.26
        0.    75.    -2.   76445.  1.41  2.27    0.00    1.17   14.09

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.842 ******  495.69 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.        <<<<<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      99.  -521.    3936.  0.08  0.25  494.34  488.84   8750.  494.26
      135.   148.    14.  581894.  1.07  0.47    0.00    0.15    2.22

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.791  0.776  130166.  -210.  -103.   494.23

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -75.  -371.    97.   8750.  141817.    1936.    4.52  490.34
   FULLV:FV       0.  -381.   100.   8750.  156491.    2096.    4.17  490.68
   BRIDG:BR       0.  -109.    -2.   8750.   76445.     621.   14.09  489.26
   RDWAY:RG      18.**************      0.*****************     1.00********
   APPRO:AS     135.  -521.    14.   8750.  581894.    3936.    2.22  494.26

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS    -210.  -103.  130166.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    488.02    0.48  479.72  514.18************  0.47  490.82  490.34
   FULLV:FV  ********    0.43  479.72  514.18  0.26  0.00  0.40  491.08  490.68
   BRIDG:BR    489.17    1.17  478.70  496.10  0.53  2.27  4.35  493.61  489.26
   RDWAY:RG  ****************  499.85  516.63**********************************
   APPRO:AS    488.84    0.15  480.95  515.72  0.25  0.47  0.08  494.34  494.26
  ER
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for one pebble count transect in the channel approach of structure WSTOVT01000092, in Weston, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WSTOVT01000092

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 31 / 95

Highway District Number *(I - 2; nn)* 02

County *(FIPS county code; I - 3; nnn)* 027

Town *(FIPS place code; I - 4; nnnnn)* 82000

Mile marker *(I - 11; nnn.nnn)* 000570

Waterway *(I - 6)* WEST RIVER

Road Name *(I - 7):* -

Route Number VT100

Vicinity *(I - 9)* 2.6 MI N JCT. VT.11 W

Topographic Map Weston

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43153

Longitude *(i - 17; nnnnn.n)* 72474

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20001300921421

Maintenance responsibility *(I - 21; nn)* 01

Maximum span length *(I - 48; nnnn)* 0110

Year built *(I - 27; YYYY)* 1975

Structure length *(I - 49; nnnnnn)* 000113

Average daily traffic, ADT *(I - 29; nnnnnn)* 002270

Deck Width *(I - 52; nn.n)* 370

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

Channel & Protection *(I - 61; n)* 8

Opening skew to Roadway *(I - 34; nn)* 25

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*) 096.0

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

Vertical clearance from streambed (*nnn.n ft*) 013.0

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

Waterway of full opening (*nnn.n* ft^2) 124.8

Comments:

The structural inspection report indicates the structure is a steel stringer type bridge. Both concrete abutments are like new. The wingwalls are like new, except for a diagonal crack in the upstream left wingwall. The footings are not in view. The banks are well protected with riprap. The waterway takes a slight to moderate curve through structure. The streambed consists of stone and gravel. No settlement or channel scour is reported.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 33.3

Terrain character: rolling to mountainous

Stream character & type:

Streambed material: silt with some gravel

Discharge Data *(cfs)*: $Q_{2.33}$ ____ Q_{10} 3000 Q_{25} 4500

Q_{50} 5600 Q_{100} ____ Q_{500} ____

Record flood date *(MM / DD / YY)*: 06 / 30 / 73 Water surface elevation *(ft)*: 1186

Estimated Discharge *(cfs)*: 5000 Velocity at Q ____ *(ft/s)*: ____

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

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

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: Remains of the previous structure may affect stage at the new structure.

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 32.7 mi^2

Lake and pond area 0.09 mi^2

Watershed storage *(ST)* 0.3 %

Bridge site elevation 1194 ft

Headwater elevation 2808 ft

Main channel length 10.10 mi

10% channel length elevation 1221 ft

85% channel length elevation 1713 ft

Main channel slope *(S)* 64.99 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? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY):* 08 / 1975

Project Number ERS 0133 (4) Minimum channel bed elevation: 1174.1

Low superstructure elevation: USLAB 1187.15 DSLAB 1188.48 USRAB 1188.36 DSRAB 1189.59

Benchmark location description:

BM#1, spike in root of a 36 inch maple, elevation 1204.38, located 426 feet right bankward of the right abutment and 33 feet upstream of the roadway centerline.

Reference Point (*MSL, Arbitrary, Other*): Arbitrary Datum (*NAD27, NAD83, Other*): Arbitrary

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

If 1: Footing Thickness 2.0 Footing bottom elevation: 1174.0

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? Y *If no, type ctrl-n bi* Number of borings taken: 2

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

Briefly describe material at foundation bottom elevation or around piles:

The bottom of the footings are both set in silt. B1 is silt to gravel then silt and sand to a hard layer stopped at elevation of 1150.0. B2 is silt to sandy silt, and grey to white very hard gneiss with mica and quartz zones stopped at elevation 1135.4 in stone.

Comments:

***The footing bottom elevation of the right abutment is 1174.0 while that of the left is 1173.0. Other elevation points shown are: 1) top streamward edge of the concrete where the upstream right wingwall meets the abutment, elevation 1195.03, and 2) the point at the same location as in 1) but on the upstream left side, elevation 1193.38.**

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 11/7/96

Computerized by: EW Date: 11/7/96

Reviewd by: RF Date: 10/17/96

Structure Number WSTOVT01000092

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. BURNS Date *(MM/DD/YY)* 08 / 19 / 1996
2. Highway District Number 02 Mile marker 000570

County WINDSOR (027) Town WESTON (82000)

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

Route Number VT 100 Hydrologic Unit Code: 01080107

3. Descriptive comments:

Located 2.6 miles north of junction with Vermont 11 West.

Bridge is on a bend in the stream. Bridge deck is curved and banked so the downstream side is higher than the upstream side.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 6 LBDS 6 RBDS 5 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 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 113 *(feet)* Span length 110 *(feet)* Bridge width 37 *(feet)*

Road approach to bridge:

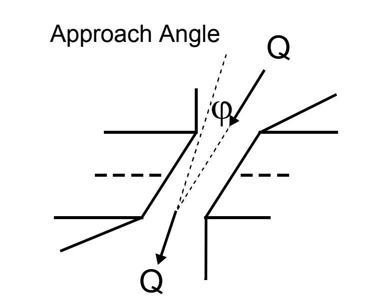
8. LB 1 RB 2 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left 0.0:1 US right 0.0:1

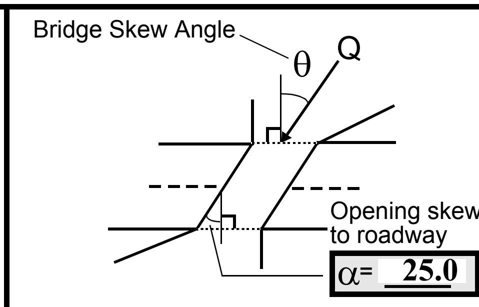
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	0	-
RBUS	2	1	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: 50 16. Bridge skew: 40





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

Where? RB *(LB, RB)* Severity 1

Range? 130 feet US *(US, UB, DS)* to 105 feet US

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

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

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

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

18. Bridge Type: **1b**

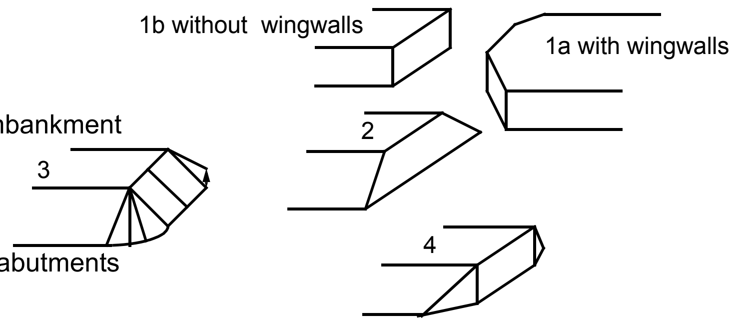
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4: There are trees all along the LBUS, beginning at 100 feet upstream with open grass field beyond. From bridge face to 100 feet upstream, the left bank and left overbank surface cover is grass only. The RBUS is just the road embankment for VT 100 from upstream bridge face to 100 feet upstream. From 100 feet upstream and further upstream, the surface cover is comprised of some trees, a house and lawn. The LBDS is forest/ thick brushland to the major bend in channel downstream. At the bend, the surface cover is soccer fields with a paved road running along the bank. The DSRB is covered by shrubs and some trees with a gravel road extending down to the water.

8: The left road approach dips down where it intersects with another paved road, then the road goes uphill.

18: Vertical concrete abutments are bridge type 1b, and boulder abutment protection acts like a type 3 spill through abutment for lower stages.

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
123.0	**5.0**			**3.5**	**1**	**1**	**432**	**432**	**1**	**0**

23. Bank width **30.0** 24. Channel width **80.0** 25. Thalweg depth **122.5** 29. Bed Material **43**

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

Upstream river is mostly pool and riffle. At 228 feet upstream, the stream levels off and there is a large pool. Thalweg in riffles is 0.5 feet and 2 feet in the pools.

Near the bridge, there are some boulders in the stream bed from the stone fill near the bridge which has slumped into channel.

Right bank protection extends from 129 feet upstream to 0 feet upstream. It also serves as road embankment protection.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **169** 35. Mid-bar width: **60**

36. Point bar extent: **284** feet **US** *(US, UB)* to **0** feet **US** *(US, UB, DS)* positioned **0** %LB to **60** %RB

37. Material: **432**

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

There are also some boulders at the bridge face. This point bar is vegetated and there is a channel along the bankward edge of the point bar. Another point bar is positioned 65% LB to 100% RB from 50 feet upstream to 47 feet downstream. Mid-bar is at the upstream bridge face where it is 30 feet wide. It is mostly gravel, cobble and sand with a few boulders from stone fill.

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: **200** 42. Cut bank extent: **300** feet **US** *(US, UB)* to **131** feet **US** *(US, UB, DS)*

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

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

Water has washed away soil covering stones along bank in cut-bank area. The bank has also been undermined with the remaining material on the top. There are exposed roots and some leaning trees.

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

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) 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
115.0		1.0		2	7	7	-

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

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

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

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

432

Water depth under bridge in pool is 2.5 feet.

Point bar extends under bridge along right side of channel, refer to #38.

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

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

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

70. Debris and Ice Comments:

1

There are large trees caught on the upstream left bank point bar.

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		15	90	2	0	-	-	90.0
RABUT	1	-	90			2	0	99.0

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.):

-

-

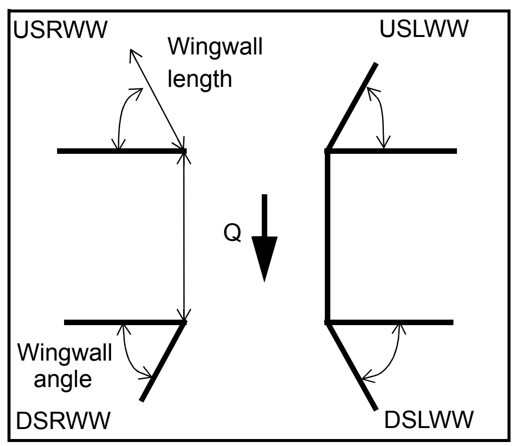
1

72: Angle refers to concrete abutments above spill-through along the base of the abutments.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						99.0	
USRWW:	N		-		-	1.5	
DSLWW:	-		-		N	35.5	
DSRWW:	-		-		-	37.0	

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	-	-	N	-	-	-	1	1
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	-	-	2	2	-

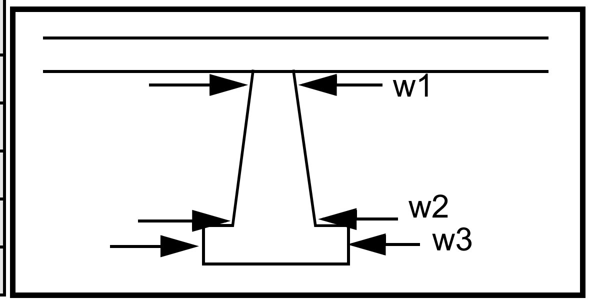
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? In (Y or if N type ctrl-n pr)

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	front	tec-	ers		LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	of	tion	some		1- Solid pier, 2- column, 3- bent
88. Material	the	at	of		1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	right	the	the		1- Round; 2- Square; 3- Pointed
90. Inclined?	abut	dow	abut		Y- yes; N- no
91. Attack ∠ (BF)	ment	nstre	ment		
92. Pushed	, a	am	pro-		LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	point	end.	tec-		
95. Cross-members	bar	The	tion	N	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	serve	point	mate	-	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	s as	bar	rial.	-	
98. Exposure depth	pro-	cov-		-	

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 (Amb) - Thalweg depth (Amb) - Bed Material -

Bank protection type (Qmax): LB - RB - Bank protection condition: LB - RB -

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

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

101. Is a drop structure present? - *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: - *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

105. Drop structure comments (eg. downstream scour depth):
-
-
-
-
-
-

106. Point/Side bar present? - (Y or N. if N type ctrl-n pb) Mid-bar distance: NO Mid-bar width: PIE

Point bar extent: RS 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.):

2

Is a cut-bank present? 2 (Y or if N type ctrl-n cb) Where? 432 (LB or RB) Mid-bank distance: 432

Cut bank extent: 2 feet 0 (US, UB, DS) to 432 feet 2 (US, UB, DS)

Bank damage: 0 (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

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

1

-

At 300 feet downstream, the stream makes a 90 degree turn.

Is channel scour present? At (Y or if N type ctrl-n cs) Mid-scour distance: 420

Scour dimensions: Length feet Width dow Depth: nstr Positioned ea %LB to m, %RB

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

stones have been piled across the stream channel.

At 340 feet downstream, there is a land slide on the left bank.

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

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

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

Confluence comments (eg. confluence name):

from 0 feet downstream to 44 feet downstream.

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

-

NO DROP STRUCTURE

109. G. Plan View Sketch

Y

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: WSTOVT01000092 Town: Weston
Road Number: VT 100 County: Windsor
Stream: West River

Initials RF Date: 10/17/96 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	5800	8750	0
Main Channel Area, ft2	1234	1671	0
Left overbank area, ft2	1318	2267	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	163	170	0
Top width L overbank, ft	354	365	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.2222	0.2222	0
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	7.6	9.8	ERR
y1, average depth, LOB, ft	3.7	6.2	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	282733	582349	0
Conveyance, main channel	125527	202313	0
Conveyance, LOB	157207	380036	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	-0.0004	0.0000	ERR
Qm, discharge, MC, cfs	2575.1	3039.8	ERR
Ql, discharge, LOB, cfs	3225.0	5710.2	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	2.1	1.8	ERR
Vl, mean velocity, LOB, ft/s	2.4	2.5	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.5	9.9	N/A
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	N/A
Vc-r, crit. velocity, ROB, ft/s	N/A	N/A	N/A

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	1234	1671	0
Main channel width, ft	163	170	0
y1, main channel depth, ft	7.57	9.83	ERR

Bridge Section			
(Q) total discharge, cfs	5800	8750	0
(Q) discharge thru bridge, cfs	5800	8750	
Main channel conveyance	61845	76420	
Total conveyance	61845	76420	
Q2, bridge MC discharge,cfs	5800	8750	ERR
Main channel area, ft2	533	621	0
Main channel width (skewed), ft	91.8	97.0	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	91.8	97	0
y_bridge (avg. depth at br.), ft	5.81	6.40	ERR
Dm, median (1.25*D50), ft	0.27775	0.27775	0
y2, depth in contraction,ft	6.24	8.46	ERR
ys, scour depth (y2-ybridge), ft	0.43	2.06	N/A

ARMORING			
D90	0.6746	0.6746	
D95	0.8495	0.8495	
Critical grain size,Dc, ft	0.5512	0.8866	ERR
Decimal-percent coarser than Dc	0.1537	0.0435	
Depth to armoring,ft	9.11	58.48	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	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	5800	8750	0	5800	8750	0
a', abut.length blocking flow, ft	363.07	372.95	0	6.25	12.51	0
Ae, area of blocked flow ft2	1691	2764.74	0	32.41	90.35	0
Qe, discharge blocked abut.,cfs	4028.98	6664.65	0	45.89	118.38	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.38	2.41	ERR	1.42	1.31	ERR
ya, depth of f/p flow, ft	4.66	7.41	ERR	5.19	7.22	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	0	1	1	0
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	115	115	0	65	65	0
K2	1.03	1.03	0.00	0.96	0.96	0.00
Fr, froude number f/p flow	0.195	0.156	ERR	0.110	0.086	ERR
ys, scour depth, ft	30.83	37.57	N/A	8.36	11.68	N/A

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

				N/A	N/A	
a'(abut length blocked, ft)	363.07	372.95	0	6.25	12.51	0
y1 (depth f/p flow, ft)	4.66	7.41	ERR	5.19	7.22	ERR
a'/y1	77.95	50.31	ERR	1.21	1.73	ERR
Skew correction (p. 49, fig. 16)	1.05	1.05	1.00	0.90	0.90	1.00
Froude no. f/p flow	0.19	0.16	N/A	0.11	0.09	N/A
Ys w/ corr. factor K1/0.55:						
vertical	20.72	30.67	ERR	ERR	ERR	ERR
vertical w/ ww's	16.99	25.15	ERR	ERR	ERR	ERR

spill-through	11.40	16.87	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother	Q100	Q500	
(V^2/gy)	0.63	0.96		0.63	0.96	
(V^2/gy from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.805	6.403		5.805	6.403	
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.42	ERR	0.00	1.42	ERR	0
Fr>0.8 (vertical abut.)	ERR	2.65	ERR	ERR	2.65	ERR
Fr<=0.8 (spillthrough abut.)	1.24	ERR	0.00	1.24	ERR	0
Fr>0.8 (spillthrough abut.)	ERR	2.34	ERR	ERR	2.34	ERR