LEVEL II SCOUR ANALYSIS FOR BRIDGE 81 (JAMAVT01000081) on STATE ROUTE 100, crossing the WINHALL RIVER, JAMAICA, VERMONT

U.S. Geological Survey
Open-File Report 97-409

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

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By MICHAEL A. IVANOFF & ROBERT E. HAMMOND

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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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 81 (JAMAVT01000081) ON STATE ROUTE 100, CROSSING THE WINHALL RIVER, JAMAICA, VERMONT

By **Michael A. Ivanoff and Robert E. Hammond**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JAMAVT01000081 on State Route 100 crossing the Winhall River, Jamaica, 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 30.6-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture with trees on the immediate banks. The upstream left bank of the bridge is forested.

In the study area, the Winhall River has an incised, straight channel with a slope of approximately 0.01 ft/ft, an average channel top width of 124 ft and an average bank height of 9 ft. The channel bed material ranges from gravel to bedrock with a median grain size (D_{50}) of 86.7 mm (0.284 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 8, 1996, indicated that the reach was stable.

The State Route 100 crossing of the Winhall River is an 84-ft-long, two-lane bridge consisting of one 82-foot steel-beam span (Vermont Agency of Transportation, written communication, March 30, 1995). The bridge is supported by vertical, concrete abutments with no wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 15 degrees.

The scour protection measures at the site included type-2 stone fill (less than 36 inches diameter) along the base of the left abutment. There was also type-4 stone fill (less than 60 inches diameter) along both downstream banks. In addition, there are stone walls placed on both upstream banks. Additional details describing conditions at the site are included in the Level II Summary and Appendices D
and E.

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

The contraction scour ranged from 0.0 to 2.6 ft. The worst-case contraction scour occurred at the incipient road-overtopping discharge. Abutment scour ranged from 7.9 to 21.9 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.

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.

Londonderry, 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 JAMAVT01000081 ***Stream*** Winhall River

County Windham ***Road*** VT 100 ***District*** 2

Description of Bridge

Bridge length 84 ***ft*** ***Bridge width*** 32.5 ***ft*** ***Max span length*** 82 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** sloping right

Stone fill on abutment? None left, ***Date of inspection***

Yes, left

8/8/96

Type-2, along the base of the left abutment. Stone walls were along both upstream banks.

Abutments are concrete. The right abutment footing is exposed vertically one foot.

Is bridge skewed to flood flow according to No ***survey?*** Yes ***Angle*** 10

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	8/8/96	0	0
Level II	8/8/96	0	0

Potential for debris Low. There is some debris caught on boulders in the channel upstream.

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

There was a side bar along the downstream left bank beginning at the bridge face as of 8/8/96.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley, with narrow overbank areas and steep valley walls on both sides.

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

Date of inspection 8/8/96

DS left: Mildly sloping channel bank to the valley wall.

DS right: Moderately sloped channel bank to a narrow overbank.

US left: Steep channel bank to a narrow overbank.

US right: Moderately sloped channel bank to a narrow flood plain.

Description of the Channel

Average top width 124 ***ft*** ***Average depth*** 9 ***ft***

Predominant bed material Gravel to Bedrock ***Bank material*** Cobbles to Bedrock

Straight and stable with non-alluvial channel boundaries.

8/8/96

Vegetative co Trees and brush

DS left: Trees and brush

DS right: Trees and brush

US left: Trees and brush

US right:

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

The assessment of 8/8/96 noted a side bar on the left bank side of the channel downstream. In addition, some debris is caught on boulders in the channel upstream.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 30.6 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 10,900 ***ft³/s*** ***Q500*** 16,000 ***ft³/s***

The 100- and 500-year discharges are based on the VTAOT values for bridge number 40 in Jamaica. Bridge number 40 crosses the Winhall River upstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 40 is 30.5 square miles. (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 Subtract 395.0 feet from the USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the left end of the downstream bridge face curb (elev. 500.56 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 499.89 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	-90	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	111	2	Modelled Approach section (Templated from APTEM)
APTEM	117	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 0.045 to 0.055, and overbank "n" values ranged from 0.035 to 0.055.

Critical depth at the exit section (EXITX) was allowed for each discharge as the starting water surface. Normal depth was computed below critical depth 0.8 ft by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0159 ft/ft which was estimated from the 100-year discharge slope downstream of the bridge in the Flood Insurance Study for Jamaica, VT (Federal Emergency Management Agency, 1988).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0052 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

For the incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. Analyzing both the supercritical and subcritical profiles for the discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.7 ***ft***
Average low steel elevation 495.9 ***ft***

100-year discharge 10,900 ***ft³/s***
Water-surface elevation in bridge opening 495.9 ***ft***
Road overtopping? Yes ***Discharge over road*** 2,505 ***ft³/s***
Area of flow in bridge opening 844 ***ft²***
Average velocity in bridge opening 10.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.5 ***ft/s***

Water-surface elevation at Approach section with bridge 498.4
Water-surface elevation at Approach section without bridge 496.0
Amount of backwater caused by bridge 2.4 ***ft***

500-year discharge 16,000 ***ft³/s***
Water-surface elevation in bridge opening 495.9 ***ft***
Road overtopping? Yes ***Discharge over road*** 6,420 ***ft³/s***
Area of flow in bridge opening 845 ***ft²***
Average velocity in bridge opening 11.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.7 ***ft/s***

Water-surface elevation at Approach section with bridge 499.8
Water-surface elevation at Approach section without bridge 497.8
Amount of backwater caused by bridge 2.0 ***ft***

Incipient overtopping discharge 8,920 ***ft³/s***
Water-surface elevation in bridge opening 492.0 ***ft***
Area of flow in bridge opening 561 ***ft²***
Average velocity in bridge opening 15.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 19.0 ***ft/s***

Water-surface elevation at Approach section with bridge 496.1
Water-surface elevation at Approach section without bridge 494.6
Amount of backwater caused by bridge 1.5 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the incipient road overtopping model was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 100-year and 500-year discharges resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for the 100-year and 500-year discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146).

For the discharges resulting in orifice flow, estimates of contraction scour were also computed by use of the Laursen clear-water contraction scour equation and the Umbrel pressure-flow equation (Richardson and others, 1995, p. 144) and are presented in Appendix F. Furthermore, since the discharges resulted in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

Abutment scour 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 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	0.0	0.4	2.6
Depth to armoring	5.0	4.4	N/A
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour	16.2	21.9	7.9
Left abutment	16.0	19.7	9.5
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:	2.6	2.7	3.3
Left abutment	2.6	2.7	3.3
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

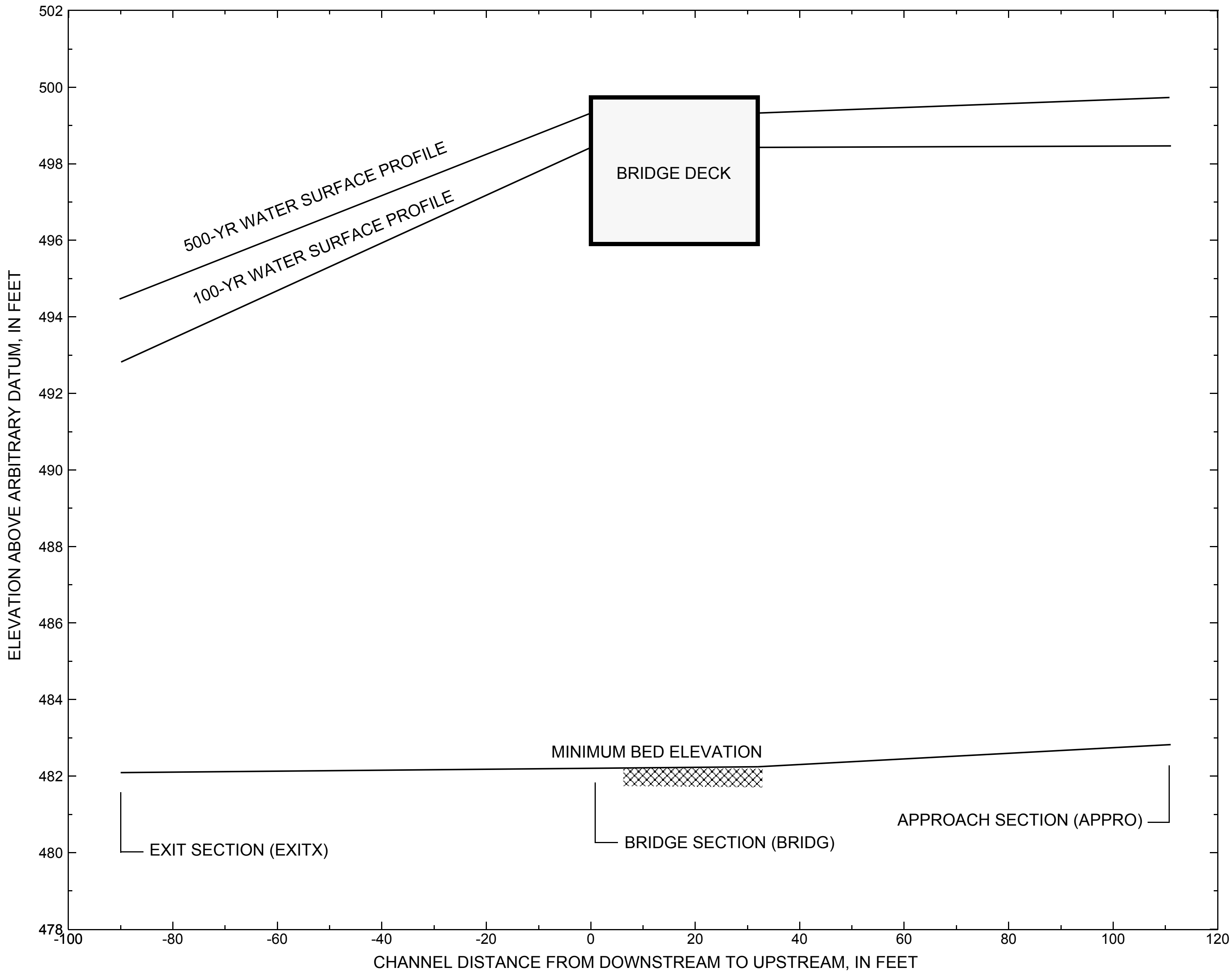

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JAMAVT01000081 on State Route 100, crossing Winhall River, Jamaica, Vermont.

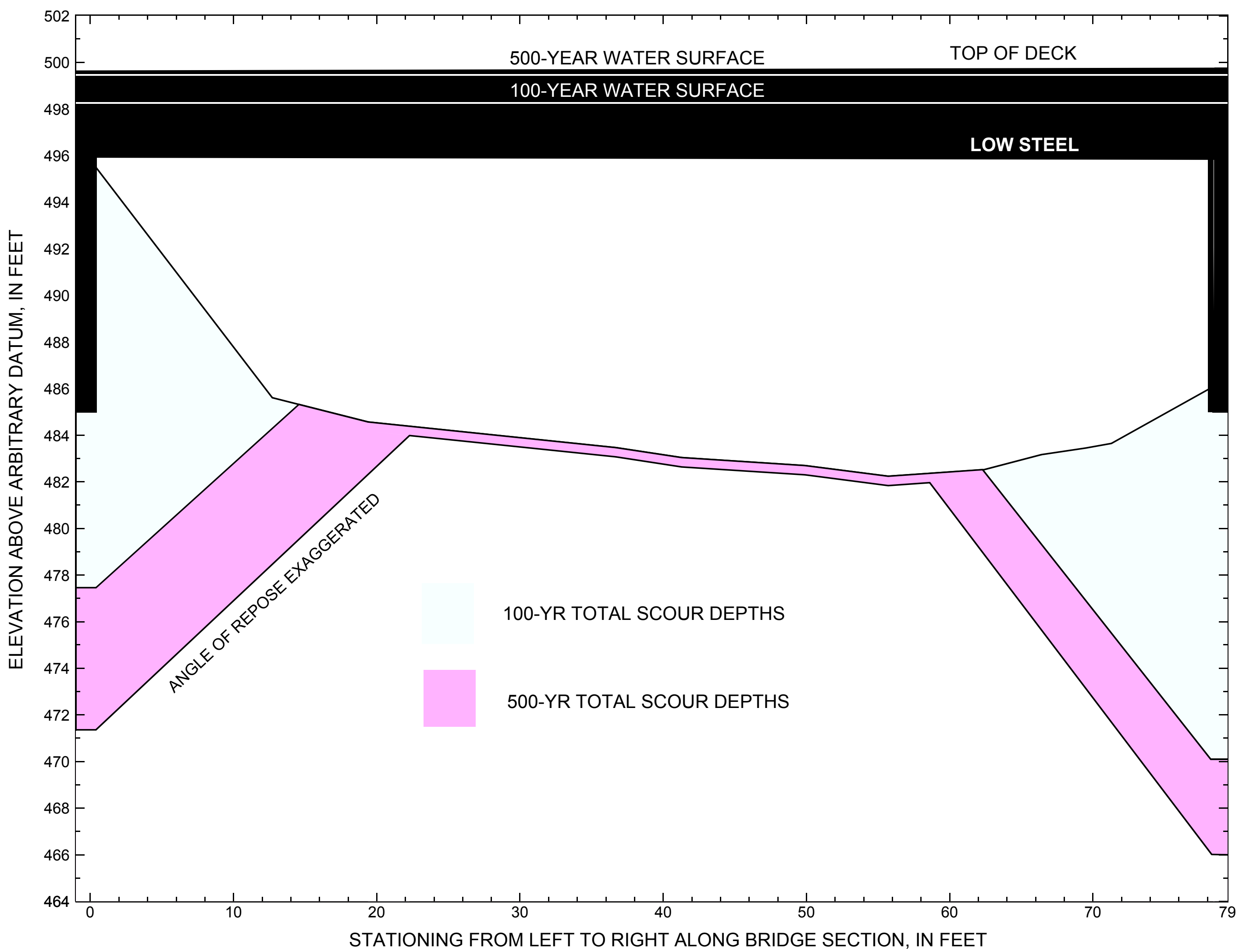

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure JAMAVT01000081 on State Route 100, crossing Winhall River, Jamaica, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JAMAVT01000081 on State Route 100, crossing Winhall River, Jamaica, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat 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 10,900 cubic-feet per second											
Left abutment	0.0	100.9	495.9	485.0	493.7	0.0	16.2	--	16.2	477.5	-7.5
Right abutment	78.5	100.9	495.9	485.0	486.1	0.0	16.0	--	16.0	470.1	-14.9

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure JAMAVT01000081 on State Route 100, crossing Winhall River, Jamaica, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat 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 16,000 cubic-feet per second											
Left abutment	0.0	100.9	495.9	485.0	493.7	0.4	21.9	--	22.3	471.4	-13.6
Right abutment	78.5	100.9	495.9	485.0	486.1	0.4	19.7	--	20.1	466.0	-19.0

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, Londonderry, 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 jama081.wsp
T2        Hydraulic analysis for structure JAMAVT01000081   Date: 03-FEB-97
T3        Bridge #81 on VT 100 over Winhall River in Jamaica, VT  by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          10900.0  16000.0  8920.0
SK          0.0159   0.0159  0.0159
*
*  The exit section left overbank points are from the Flood Insur. Study(FEMA 1988)
XS   EXITX    -90
GR         -271.0, 506.14   -206.0, 498.04   -177.0, 496.24    -98.0, 489.34
GR            0.0, 491.14      3.9, 486.92     19.5, 483.81
GR           26.4, 483.29     32.5, 482.85     45.7, 482.51     51.4, 482.10
GR           58.1, 482.09     62.0, 482.50     66.1, 483.34     77.3, 486.96
GR           82.6, 490.72    107.2, 492.18    211.7, 495.63    416.6, 496.77
GR          451.7, 497.28    611.0, 508.18
N           0.040       0.050        0.035
SA                   0.0         82.6
*
XS   FULLV      0  * * *   0.0015
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.89      15.0
GR            0.0, 495.94      0.4, 493.66      0.5, 495.49     12.7, 485.61
GR           19.4, 484.57     36.7, 483.47     41.3, 483.04     49.9, 482.70
GR           55.7, 482.24     62.4, 482.52     66.4, 483.17     69.5, 483.45
GR           71.3, 483.65     78.5, 486.08     78.5, 495.85      0.0, 495.94
*
*         BRTYPE  BRWDTH
CD           1      35.3
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     18      32.5     1
GR         -127.0, 503.88   -118.2, 498.81    -62.9, 498.39     -2.1, 499.62
GR           -1.9, 500.56      0.0, 500.57     79.7, 500.62     81.0, 500.62
GR           81.2, 499.74     86.8, 499.81    110.4, 499.63    234.4, 496.55
GR          300.7, 496.06    367.3, 496.19    433.9, 497.15    601.4, 509.07
*
XT   APTEM    117
GR         -134.5, 503.88    -94.6, 495.45      0.0, 494.55      3.1, 490.97
GR           14.1, 485.98     21.9, 484.19     23.9, 483.74     29.7, 482.85
GR           33.7, 483.45     38.1, 484.01     42.6, 486.08     45.3, 484.46
GR           49.6, 485.03     71.7, 488.75     84.5, 493.38    171.0, 494.44
GR          245.4, 496.50    299.8, 496.06    366.4, 496.19    432.9, 497.15
GR          601.1, 509.07
*
* In the incipient road-overtopping model the approach section was truncated at 245.4 this
* prevents excessive flow along the right overbank.
AS   APPRO    111  * * *  0.0052
GT
N           0.055        0.055        0.055
SA                   0.0         84.5
*
HP 1 BRIDG   495.89 1 495.89
HP 2 BRIDG   495.89 * * 8496
```

```
HP 1 BRIDG   494.38 1 494.38
HP 2 RDWAY   498.25 * * 2505
HP 1 APPRO   498.36 1 498.36
HP 2 APPRO   498.36 * * 10900
*
HP 1 BRIDG   495.94 1 495.94
HP 2 BRIDG   495.94 * * 9836
HP 1 BRIDG   495.81 1 495.81
HP 2 RDWAY   499.47 * * 6420
HP 1 APPRO   499.79 1 499.79
HP 2 APPRO   499.79 * * 16000
*
HP 1 BRIDG   492.03 1 492.03
HP 2 BRIDG   492.03 * * 8920
HP 1 APPRO   496.06 1 496.06
HP 2 APPRO   496.06 * * 8920
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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      U.S. Geological Survey WSPRO Input File jama081.wsp
      Hydraulic analysis for structure JAMAVT01000081   Date: 03-FEB-97
      Bridge #81 on VT 100 over Winhall River in Jamaica, VT  by MAI
         *** RUN DATE & TIME: 06-30-97  10:16
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     844.   98725.    42.   127.                        21448.
 495.89          844.   98725.    42.   127.  1.00     0.    79.  21448.

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     495.89     0.0    78.5   844.2   98725.    8496. 10.06

X STA.         0.0       13.1       17.2       20.6       23.7       26.7
  A(I)            67.0       42.6       37.1       34.1       33.6
  V(I)            6.34       9.96      11.45      12.47      12.64

X STA.        26.7       29.5       32.3       35.0       37.6       40.3
  A(I)            32.9       32.2       31.6       31.6       32.2
  V(I)           12.92      13.20      13.46      13.43      13.18

X STA.        40.3       42.8       46.2       49.7       53.1       56.5
  A(I)            32.1       41.7       45.0       44.0       44.1
  V(I)           13.22      10.18       9.45       9.65       9.63

X STA.        56.5       59.9       63.5       67.3       71.6       78.5
  A(I)            44.1       46.9       47.3       51.4       72.6
  V(I)            9.63       9.05       8.98       8.27       5.85

  CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRIDG; SRD =       0.
   WSEL SA#     AREA        K   TOPW    WETP ALPH    LEW    REW     QCR
           1     751. 103267.    75.    89.                       13536.
 494.65          751. 103267.    75.    89. 1.00     0.    79. 13536.

  VELOCITY DISTRIBUTION: ISEQ = 4; SECID = RDWAY; SRD =      18.

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.25   166.0   449.4   442.4   11825.    2505.   5.66

X STA.       166.0      222.5      238.8      252.1      263.7      274.7
  A(I)            39.6       26.1       23.7       21.8       21.4
  V(I)            3.16       4.80       5.29       5.74       5.84

X STA.       274.7      284.6      293.9      302.6      311.2      319.8
  A(I)            20.1       19.7       18.9       18.7       18.6
  V(I)            6.24       6.35       6.63       6.69       6.74

X STA.       319.8      328.7      337.5      346.4      355.5      364.8
  A(I)            18.9       18.8       18.8       18.9       19.3
  V(I)            6.62       6.67       6.65       6.62       6.49

X STA.       364.8      374.6      385.7      398.6      415.0      449.4
  A(I)            19.9       20.7       22.0       24.4       31.9
  V(I)            6.29       6.04       5.69       5.14       3.92

  CROSS-SECTION PROPERTIES: ISEQ = 5; SECID = APPRO; SRD =     111.

   WSEL SA#     AREA        K   TOPW    WETP ALPH    LEW    REW     QCR
           1     341.   19807.   109.   109.                        3434.
           2     974. 129480.    85.    90.                       18774.
           3     996.   52599.   366.   366.                        9325.
 498.36         2312. 201887.   559.   565. 1.62 -109.   450. 20936.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     111.

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.36  -108.5   450.4  2311.7  201887.   10900.   4.72

X STA.      -108.5      -43.0        1.8       12.5       18.4       23.5
  A(I)           184.8      165.5       98.6       74.5       71.1
  V(I)            2.95       3.29       5.53       7.32       7.67

X STA.        23.5       27.8       32.0       36.3       41.2       46.7
  A(I)            65.0       63.5       65.2       67.8       72.6
  V(I)            8.39       8.59       8.36       8.03       7.51

X STA.        46.7       51.8       57.6       64.1       72.3       90.4
  A(I)            68.3       72.3       74.9       83.9      117.3
  V(I)            7.98       7.54       7.28       6.50       4.64

X STA.        90.4      121.3      157.8      208.3      308.5      450.4
  A(I)           146.8      158.1      181.3      224.3      256.1
  V(I)            3.71       3.45       3.01       2.43       2.13
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        U.S. Geological Survey WSPRO Input File jama081.wsp
        Hydraulic analysis for structure JAMAVT01000081   Date: 03-FEB-97
        Bridge #81 on VT 100 over Winhall River in Jamaica, VT  by MAI
           *** RUN DATE & TIME: 06-30-97  14:29

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     845.   81737.     0.   169.                           0.
   495.94          845.   81737.     0.   169.  1.00     0.    79.       0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.94     0.0    78.5   845.2   81737.    9836.  11.64

X STA.         0.0       13.9       18.7       22.7       26.5       30.0
  A(I)            76.5       49.6       44.4       42.7       40.7
  V(I)            6.43       9.92      11.08      11.52      12.08

X STA.        30.0       33.5       36.7       39.8       42.8       45.8
  A(I)            40.3       38.9       37.7       37.3       36.6
  V(I)           12.20      12.64      13.04      13.17      13.45

X STA.        45.8       48.7       51.5       54.3       57.1       59.8
  A(I)            36.9       36.1       36.4       35.9       35.8
  V(I)           13.32      13.61      13.50      13.68      13.73

X STA.        59.8       62.6       65.7       68.9       72.5       78.5
  A(I)            36.7       38.3       39.7       41.9       62.6
  V(I)           13.40      12.85      12.38      11.73       7.85

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     839.  120041.    76.    93.                       15833.
   495.81          839.  120041.    76.    93.  1.00     0.    79.  15833.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      18.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.47  -119.3   466.5   905.9   64954.    6420.   7.09

X STA.      -119.3      170.1      206.1      227.2      242.5      256.4
  A(I)           112.6       63.7       52.3       44.2       42.4
  V(I)            2.85       5.04       6.14       7.27       7.57

X STA.       256.4      269.3      281.2      292.5      303.2      314.0
  A(I)            40.1       38.3       37.4       36.5       36.6
  V(I)            8.00       8.38       8.59       8.79       8.77

X STA.       314.0      324.7      335.3      346.0      356.9      367.8
  A(I)            35.8       35.6       35.8       36.0       35.9
  V(I)            8.96       9.02       8.97       8.91       8.93

X STA.       367.8      379.6      392.5      407.0      424.2      466.5
  A(I)            37.6       38.7       40.9       44.5       61.0
  V(I)            8.55       8.29       7.86       7.22       5.27

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     111.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     501.   36084.   115.   116.                        5932.
             2    1095.  157336.    85.    90.                       22373.
             3    1534.  104196.   386.   386.                       17347.
   499.79         3130.  297616.   586.   592.  1.46  -115.   471.  34034.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     111.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.79  -115.3   470.6  3130.2  297616.   16000.   5.11

X STA.      -115.3      -54.7      -15.9        9.3       17.4       23.6
  A(I)           227.3      191.6      167.7      108.0       94.6
  V(I)            3.52       4.17       4.77       7.41       8.46

X STA.        23.6       29.1       34.4       40.2       47.0       53.4
  A(I)            91.9       88.2       90.9       99.2       93.5
  V(I)            8.70       9.07       8.80       8.06       8.56

X STA.        53.4       60.7       69.6       84.3      111.6      142.2
  A(I)            99.4      107.9      135.0      171.5      180.8
  V(I)            8.04       7.41       5.93       4.67       4.43

X STA.       142.2      176.9      223.4      292.6      356.5      470.6
  A(I)           191.6      212.7      245.3      237.2      295.9
  V(I)            4.18       3.76       3.26       3.37       2.70
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       U.S. Geological Survey WSPRO Input File jama081.wsp
       Hydraulic analysis for structure JAMAVT01000081   Date: 03-FEB-97
       Bridge #81 on VT 100 over Winhall River in Jamaica, VT  by MAI
          *** RUN DATE & TIME: 06-30-97  13:39

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

    WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
            1      561     67882    71     80                         8925
  492.03           561     67882    71     80  1.00      5     79     8925


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

        WSEL     LEW     REW    AREA        K        Q    VEL
      492.03     4.8    78.5   560.6   67882.    8920.  15.91

X STA.        4.8       16.0       20.5       24.6       28.2       31.6
  A(I)           45.9       31.7       30.0       27.4       26.9
  V(I)           9.71      14.05      14.88      16.27      16.57

X STA.       31.6       34.9       37.9       40.9       43.7       46.5
  A(I)           26.2       25.5       25.5       24.1       24.4
  V(I)          17.03      17.52      17.47      18.50      18.28

X STA.       46.5       49.2       51.8       54.4       56.9       59.5
  A(I)           24.0       24.4       23.5       23.8       24.3
  V(I)          18.55      18.28      18.99      18.71      18.33

X STA.       59.5       62.1       65.1       68.2       71.9       78.5
  A(I)           24.4       26.1       26.9       30.2       45.3
  V(I)          18.30      17.06      16.59      14.78       9.85


   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     111.

    WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
            1      104      2947    98     98                          611
            2      780     89365    85     90                        13447
            3      238      8918   146    146                         1723
  496.06          1122    101229   328    334  1.44    -97    231     9803


   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     111.

        WSEL     LEW     REW    AREA        K        Q    VEL
      496.06   -97.6   230.6  1122.1  101229.    8920.   7.95

X STA.      -97.6        7.1       13.4       17.7       21.3       24.5
  A(I)          138.7       52.4       45.2       40.9       38.9
  V(I)           3.22       8.52       9.87      10.90      11.46

X STA.       24.5       27.5       30.3       33.1       36.0       39.2
  A(I)           37.7       36.4       36.0       37.1       38.1
  V(I)          11.82      12.24      12.40      12.01      11.71

X STA.       39.2       43.0       46.7       50.2       54.1       58.4
  A(I)           41.6       40.7       39.7       40.9       43.4
  V(I)          10.73      10.95      11.23      10.92      10.28

X STA.       58.4       63.4       69.5       78.8      118.4      230.6
  A(I)           45.0       50.7       59.5      106.3      152.9
  V(I)           9.91       8.79       7.50       4.20       2.92
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File jama081.wsp
        Hydraulic analysis for structure JAMAVT01000081   Date: 03-FEB-97
        Bridge #81 on VT 100 over Winhall River in Jamaica, VT  by MAI
           *** RUN DATE & TIME: 06-30-97  14:29

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   492.09     492.79

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

EXITX:XS   ******  -137.    1063.  1.98 *****  494.77  492.79  10900.  492.79
      -90. ******   126.  107448.  1.21 ***** *******    0.99   10.26

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

FULLV:FV      90.  -154.    1491.  0.99  0.61  495.37 *******  10900.  494.38
        0.    90.   170.  163429.  1.19  0.00   -0.01    0.66    7.31
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.88     509.04    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.88     509.04     496.00
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   496.00     509.04     496.00

APPRO:AS     111.   -97.    1103.  2.18 *****  498.18  496.00  10900.  496.00
      111.   111.   228.   99564.  1.43 ***** *******    1.13    9.89
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   498.28       0.00     493.21     496.06
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   501.18         0.     10900.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR      90.     0.     844.  1.58 *****  497.47  491.77   8496.  495.89
        0. ******    79.   98725.  1.00 ***** *******    0.54   10.06

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.443  0.000  495.89 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.    79.  0.23  0.56  498.69    0.01   2505.  498.25

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.    78.  -118.   -41.   0.5   0.2   4.0   9.0   0.8   3.0
   RT:   2505.   283.   166.   449.   2.2   1.6   6.6   5.7   2.0   3.1

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

APPRO:AS      76.  -108.    2309.  0.56  0.37  498.92  496.00  10900.  498.36
      111.    80.   450.  201615.  1.62  0.00    0.01    0.52    4.72

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -90.  -137.   126.  10900.  107448.    1063.   10.26  492.79
   FULLV:FV       0.  -154.   170.  10900.  163429.    1491.    7.31  494.38
   BRIDG:BR       0.     0.    79.   8496.   98725.     844.   10.06  495.89
   RDWAY:RG      18.*******     0.   2505.       0.*********    1.00  498.25
   APPRO:AS     111.  -108.   450.  10900.  201615.    2309.    4.72  498.36

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    492.79    0.99  482.09  508.18************  1.98  494.77  492.79
   FULLV:FV  ********    0.66  482.23  508.32  0.61  0.00  0.99  495.37  494.38
   BRIDG:BR    491.77    0.54  482.24  495.94************  1.58  497.47  495.89
   RDWAY:RG  ****************  496.06  509.07  0.23******  0.56  498.69  498.25
   APPRO:AS    496.00    0.52  482.82  509.04  0.37  0.00  0.56  498.92  498.36
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        U.S. Geological Survey WSPRO Input File jama081.wsp
        Hydraulic analysis for structure JAMAVT01000081   Date: 03-FEB-97
        Bridge #81 on VT 100 over Winhall River in Jamaica, VT  by MAI
           *** RUN DATE & TIME: 06-30-97  14:29

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                            WSI,CRWS =   493.35     494.17

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

EXITX:XS   ******  -153.    1466.  2.21 *****  496.38  494.17  16000.  494.17
      -90. ******   168.  159987.  1.19 ***** *******    0.98   10.91

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "FULLV"     KRATIO =  1.47

FULLV:FV      90.  -171.    1997.  1.17  0.61  496.99 *******  16000.  495.81
        0.    90.   220.  235700.  1.17  0.00   -0.01    0.68    8.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   495.31     509.04    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   495.31     509.04     497.82

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
            ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                 WSBEG,WSEND,CRWS =   497.82     509.04     497.82

APPRO:AS     111.  -106.    2014.  1.66 *****  499.48  497.82  16000.  497.82
      111.   111.   443.  171469.  1.69 ***** *******    0.95    7.95
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   503.61       0.00     495.84     496.06

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.87     498.51     499.12     495.89

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

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

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

BRIDG:BR      90.     0.     845.  2.11 *****  498.05  492.58   9836.  495.94
        0. ******    79.   81737.  1.00 ***** *******    0.63   11.64

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.476  0.000  495.89 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.    79.  0.23  0.59  500.16    0.02   6420.  499.47

            Q    WLEN    LEW     REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    551.   110.  -119.     -9.   1.1   0.7   5.4   7.1   1.4   3.1
   RT:   5869.   350.   117.    467.   3.4   2.4   8.2   7.1   3.1   3.1

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

APPRO:AS      76.  -115.    3132.  0.59  0.59  500.38  497.82  16000.  499.79
      111.    88.   471.  297881.  1.45  0.40    0.02    0.47    5.11

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -90.  -153.   168.  16000.  159987.    1466.   10.91  494.17
   FULLV:FV       0.  -171.   220.  16000.  235700.    1997.    8.01  495.81
   BRIDG:BR       0.     0.    79.   9836.   81737.     845.   11.64  495.94
   RDWAY:RG      18.*******   551.   6420.       0.*********    1.00  499.47
   APPRO:AS     111.  -115.   471.  16000.  297881.    3132.    5.11  499.79

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    494.17    0.98  482.09  508.18************  2.21  496.38  494.17
   FULLV:FV  ********    0.68  482.23  508.32  0.61  0.00  1.17  496.99  495.81
   BRIDG:BR    492.58    0.63  482.24  495.94************  2.11  498.05  495.94
   RDWAY:RG  ****************  496.06  509.07  0.23******  0.59  500.16  499.47
   APPRO:AS    497.82    0.47  482.82  509.04  0.59  0.40  0.59  500.38  499.79
```
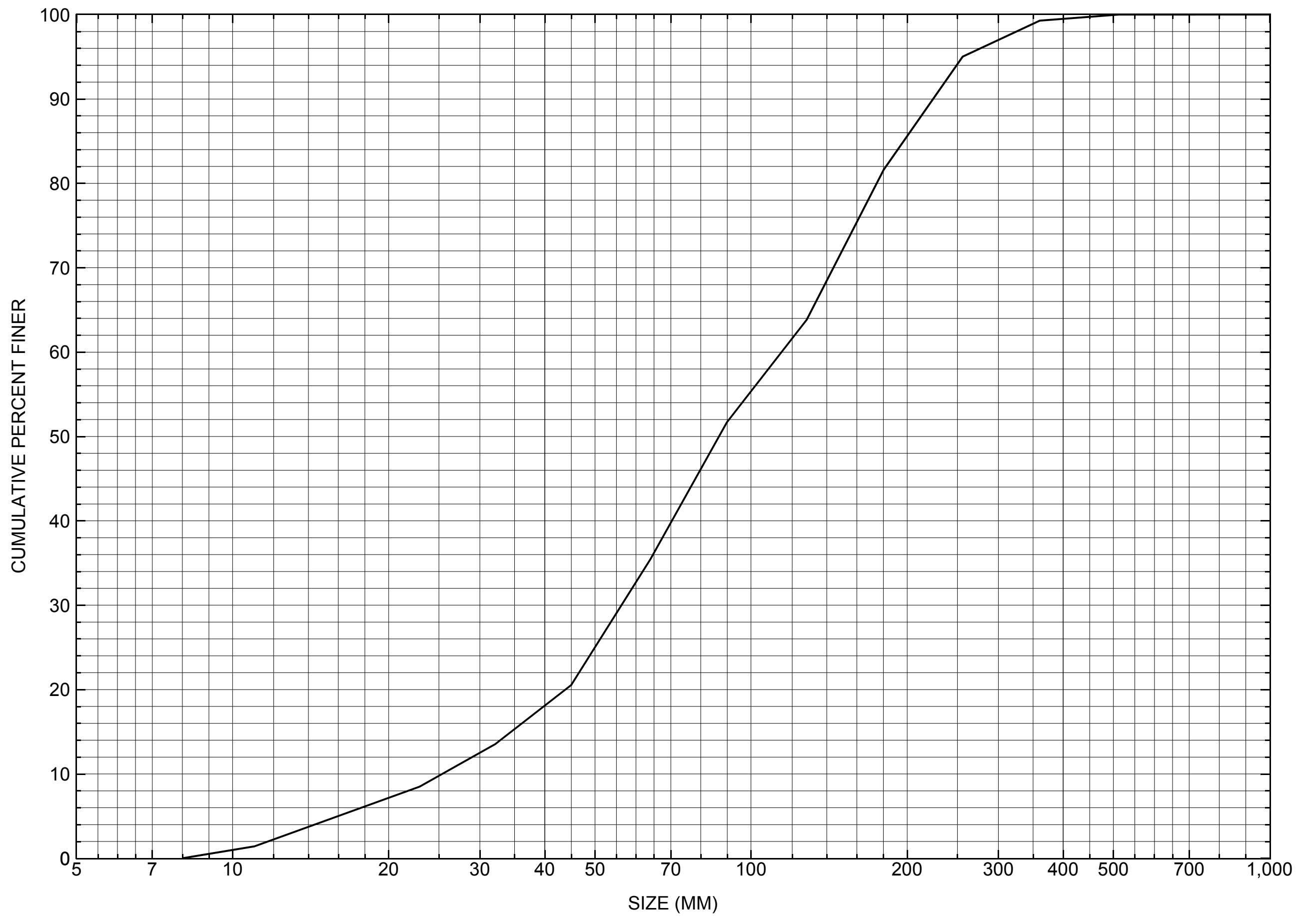

```
        U.S. Geological Survey WSPRO Input File jama081.wsp
        Hydraulic analysis for structure JAMAVT01000081   Date: 03-FEB-97
        Bridge #81 on VT 100 over Winhall River in Jamaica, VT  by MAI
           *** RUN DATE & TIME: 06-30-97  13:39

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                          WSI,CRWS =   491.47     492.10

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

EXITX:XS   ******   -129      891  1.89 *****  493.99  492.10    8920  492.10
       -89 ******    106    86793  1.22 ***** *******    1.00   10.01

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "FULLV"     KRATIO =  1.55

FULLV:FV       90   -145     1275  0.92  0.61  494.60 *******    8920  493.69
         0     90    149   134442  1.20  0.00   -0.01    0.65    7.00
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.13     493.41     494.64
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.19     509.04    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.19     509.04     494.64
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   494.64     509.04     494.64

APPRO:AS      111    -12      728  2.67 *****  497.31  494.64    8920  494.64
       111    111    179    69145  1.14 ***** *******    1.19   12.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    8920.     492.03

            <<<<<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       90      5      561  3.94 *****  495.97  492.03    8920  492.03
         0     90     79    67908  1.00 ***** *******    1.00   15.91

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  495.89 ****** ****** ******

    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
   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       76    -97     1122  1.42  0.91  497.48  494.64    8920  496.06
       111     78    231   101191  1.44  0.61    0.01    0.91    7.95

       M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
      0.594  0.156   85147.    -4.    70.   495.44

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW        Q         K     AREA     VEL    WSEL
   EXITX:XS     -90.  -130.   106.   8920.   86793.     891.   10.01  492.10
   FULLV:FV       0.  -146.   149.   8920.  134442.    1275.    7.00  493.69
   BRIDG:BR       0.     5.    79.   8920.   67908.     561.   15.91  492.03
   RDWAY:RG      18.**************       0.*****************    1.00********
   APPRO:AS     111.   -98.   231.   8920.  101191.    1122.    7.95  496.06

    XSID:CODE   XLKQ   XRKQ        KQ
   APPRO:AS      -4.    70.   85147.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    492.10    1.00  482.09  508.18************  1.89  493.99  492.10
   FULLV:FV  ********    0.65  482.23  508.32  0.61  0.00  0.92  494.60  493.69
   BRIDG:BR    492.03    1.00  482.24  495.94************  3.94  495.97  492.03
   RDWAY:RG  ***************  496.06  509.07********************************
   APPRO:AS    494.64    0.91  482.82  509.04  0.91  0.61  1.42  497.48  496.06
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JAMAVT01000081, in Jamaica, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JAMAVT01000081

General Location Descriptive

Data collected by *(First Initial, Full last name)* M. IVANOFF

Date *(MM/DD/YY)* 03 / 30 / 95

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

County *(FIPS county code; I - 3; nnn)* 025

Town *(FIPS place code; I - 4; nnnnn)* 36175

Mile marker *(I - 11; nnn.nnn)* 003660

Waterway *(I - 6)* WINHALL RIVER

Road Name *(I - 7):* -

Route Number VT100

Vicinity *(I - 9)* 0.1 MI N JCT. VT.30 N

Topographic Map Londonderry

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43088

Longitude *(i - 17; nnnnn.n)* 72505

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20001300811309

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

Maximum span length *(I - 48; nnnn)* 0082

Year built *(I - 27; YYYY)* 1936

Structure length *(I - 49; nnnnnn)* 000084

Average daily traffic, ADT *(I - 29; nnnnnn)* 002450

Deck Width *(I - 52; nn.n)* 325

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

Channel & Protection *(I - 61; n)* 7

Opening skew to Roadway *(I - 34; nn)* 15

Waterway adequacy *(I - 71; n)* 5

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

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

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

Year Reconstructed *(I - 106)* 1972

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 12.5

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

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

Comments:

The structural inspection report of 11/04/93 indicates the structure is a single span, steel beam type bridge with an asphalt road surface. Both abutment walls are concrete, and the wingwalls consist of newer cantilevered concrete sections extending off the main abutment walls. Overall, the concrete has very minor cracks and stains. The footing is exposed along the right abutment, but is not undermined. There are some random boulders placed along both abutments. The waterway has a fairly straight alignment through the structure. There is bedrock outcropping on the left abutment side of the channel, below the upstream bridge face. The streambed consists of stone and gravel with random boulders.

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: -

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft^3/ sec*): -

Are there other structures nearby? (*Yes, No, Unknown*): 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 (*ft^2*): -

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 30.61 mi^2 Lake and pond area 0.17 mi^2

Watershed storage *(ST)* 0.5 %

Bridge site elevation 1135 ft Headwater elevation 3878 ft

Main channel length 13.78 mi

10% channel length elevation 1240 ft 85% channel length elevation 2638 ft

Main channel slope *(S)* 135.24 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)*: 02 / 1972

Project Number BMA 6208 Minimum channel bed elevation: 88.4

Low superstructure elevation: USLAB 101.0 DSLAB 100.94 USRAB 100.91 DSRAB 100.88

Benchmark location description:
None

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: 90.0

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? 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 FOUNDATION MATERIAL INFORMATION.

Comments:
Other points with elevations shown are: 1) at the downstream right wingwall where the slope begins to decline, elevation 104.79, and 2) at the downstream left wingwall where the slope begins to decline, elevation 104.76. The plan are for widening the existing structure and approaches.

Cross-sectional Data

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

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

Comments: **The stations and elevations are in feet.**

Station	209	217	235	245	254	273	279	284	289	-	-
Feature	LAB	-	-	-	-	-	-	-	RAB	-	-
Low cord elevation	1132.8	1132.8	1132.7	1132.7	1132.7	1132.8	1132.8	1132.7	1132.7	-	-
Bed elevation	1127.3	1123	1120.3	1119.7	1119.1	1120.6	1122.6	1126.3	1130.0	-	-
Low cord to bed length	5.5	9.8	12.4	13	12.4	12.2	10	6.4	2.7	-	-

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

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

Comments: -
-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **09/26/96**
Computerized by: **RB** Date: **09/26/96**
Reviewd by: **MAI** Date: **05/06/97**

Structure Number **JAMAVT 01000081**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R. HAMMOND** Date *(MM/DD/YY)* **08** / **08** / 19**96**

2. Highway District Number **02** Mile marker **003660**

County **WINDHAM (025)** Town **JAMAICA (36175)**

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

Route Number **VT100** Hydrologic Unit Code: **01080107**

3. Descriptive comments:

Located 0.1 miles north on VT 100 from the junction of VT 100 and VT 30. A Vermont brass survey marker is on top the US left abutment. It is stamped 'ST' bridge number '239L'.

B. Bridge Deck Observations

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

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

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

7. Bridge length **84** *(feet)* Span length **82** *(feet)* Bridge width **32.5** *(feet)*

Road approach to bridge:

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

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

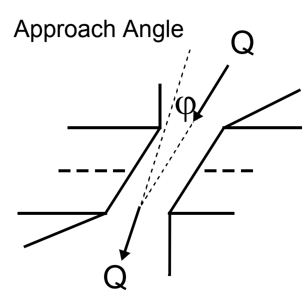
10. Embankment slope (*run / rise in feet / foot*):
US left **0.0:1** US right **0.0:1**

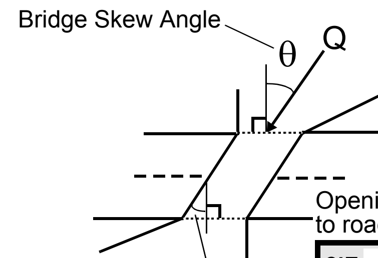
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	2	2
RBDS	0	-	2	2
LBDS	0	-	2	1

*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: **10** 16. Bridge skew: **10**





α= **15.0**

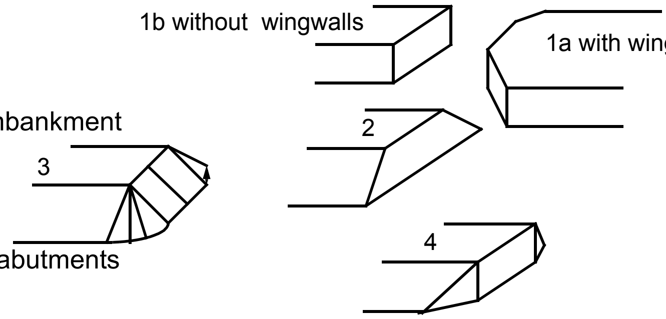
17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **200** feet **US** *(US, UB, DS)* to **150** feet **US**

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

*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.)

On the left bank US there is a house and lawn with forest beyond. On the right bank US there is also a house and lawn near VT 100 and then a large mowed area. The DS banks are predominantly lawn with a car wash on the right bank and a house on the left bank.
The values in #7 are from the VT AOT files. Measured bridge length between the backs of the abutments is 84 ft., bridge span is 80 ft. and bridge width is 32.6 ft. between the outside edges of the deck.
The preexisting abutments were extended to allow for the widening of the road. The bridge steel rests on the old abutment and the rail and curb are on the extensions to the abutment. The lowest part of the extensions are below low chord.

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
85.0	**3.5**			**4.5**	**2**	**2**	**6**	**6**	**1**	**1**

23. Bank width **50.0** 24. Channel width **20.0** 25. Thalweg depth **84.0** 29. Bed Material **6**

30 .Bank protection type: LB **5** RB **5** 31. Bank protection condition: LB **1** RB **2**

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.):

There is bedrock in the channel and along the lower banks to 200+ ft. US.
Some large rocks and cobbles have been placed or dumped on top of the bedrock to extend the lawns closer to the stream.
There is some scattered slumping of the old protection on both banks and light fluvial erosion. It is more evident on the right than the left.

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

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

37. Material: **-**

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

NO POINT BARS

All features US are controlled by bedrock.

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: **100** 42. Cut bank extent: **200+** feet **US** (US, UB) to **10** 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.):

Large trees, greater than 3.5 feet in diameter, have exposed roots on the right bank at 20 ft. US.

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
68.5		1.5		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.):

654

Bedrock extends to 10 ft. under the bridge on the left side of the channel. There are also boulders and cobbles in the streambed.

There is moderate fluvial erosion along the right abutment.

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 1____ (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 is some debris caught on boulders in the upstream channel.

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	0	-	-	90.0
RABUT	1	10	90			0	2	76.0

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

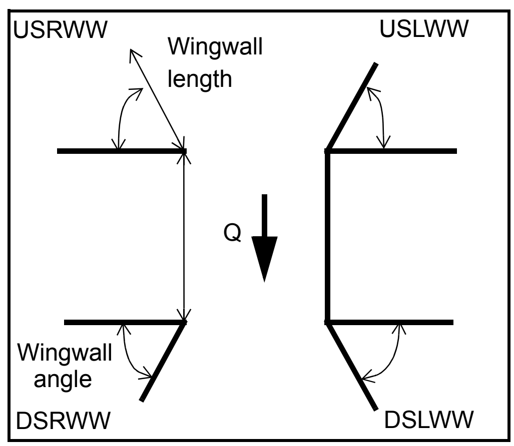
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
1
1
On the right abutment, the extensions are undermined 4.5 ft. on both ends.
The left abutment protection is above the bottom of the extensions.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						76.0	
USRWW:	N		-		-	1.0	
DSLWW:	-		-		N	35.0	
DSRWW:	-		-		-	35.5	

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	-	-	N	-	-	-	1	-
Condition	N	-	-	-	-	-	1	-
Extent	-	-	-	-	-	2	0	-

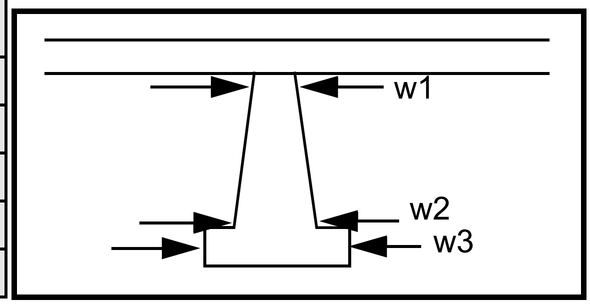
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? _-_ *(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)		-	-	-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		-	-	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		-	-	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		-	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		-	-	-	*Y- yes; N- no*
91. Attack ∠ (BF)		-	-	-	
92. Pushed		-	-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		-	-	-	
95. Cross-members		-	-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		-	-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	N	-	-	-	
98. Exposure depth	-	-	-	-	

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
-	-			-	-	NO	PIE	RS		

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.):

3
2
45
45
1
2
453
4
4
3
2
On the left bank the erosion is light fluvial, but on the right bank there is moderate undercutting and some block failure.

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

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

105. Drop structure comments (eg. downstream scour depth):
bank protection is placed, dumped cobbles and boulders along both banks to extend lawns towards the stream channel.

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 **N** %LB to **-** %RB

Material: **NO**

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

DROP STRUCTURE

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

Cut bank extent: **0** feet **30** *(US, UB, DS)* to **10** feet **UB** *(US, UB, DS)*

Bank damage: **120** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
0
40
435

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

Scour dimensions: Length **vege-** Width **tated** Depth: **side** Positioned **bar.** %LB to ____ %RB

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

Y
RB

Are there major confluences? **50** *(Y or if N type ctrl-n mc)* How many? **5**

Confluence 1: Distance **DS** Enters on **200** *(LB or RB)* Type **DS** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

are some areas where block failure of the right bank material is evident.

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 CHANNEL SCOUR

N

109. G. Plan View Sketch

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: JAMAVT01000081 Town: Jamaica
Road Number: VT 100 County: Windham
Stream: Winhall River

Initials MAI Date: 05/06/97 Checked: SAO

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	10900	16000	8920
Main Channel Area, ft2	974	1095	780
Left overbank area, ft2	341	501	104
Right overbank area, ft2	996	1534	238
Top width main channel, ft	85	85	85
Top width L overbank, ft	109	115	98
Top width R overbank, ft	366	386	146
D50 of channel, ft	0.285	0.285	0.285
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	11.5	12.9	9.2
y1, average depth, LOB, ft	3.1	4.4	1.1
y1, average depth, ROB, ft	2.7	4.0	1.6
Total conveyance, approach	201887	297616	101229
Conveyance, main channel	129480	157336	89365
Conveyance, LOB	19807	36084	2947
Conveyance, ROB	52599	104196	8918
Percent discrepancy, conveyance	0.0005	0.0000	-0.0010
Qm, discharge, MC, cfs	6990.7	8458.5	7874.6
Ql, discharge, LOB, cfs	1069.4	1939.9	259.7
Qr, discharge, ROB, cfs	2839.9	5601.6	785.8
Vm, mean velocity MC, ft/s	7.2	7.7	10.1
Vl, mean velocity, LOB, ft/s	3.1	3.9	2.5
Vr, mean velocity, ROB, ft/s	2.9	3.7	3.3
Vc-m, crit. velocity, MC, ft/s	11.1	11.3	10.7
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	10900	16000	8920
(Q) discharge thru bridge, cfs	8496	9836	8920
Main channel conveyance	98725	81737	67882
Total conveyance	98725	81737	67882
Q2, bridge MC discharge,cfs	8496	9836	8920
Main channel area, ft2	844	845	561
Main channel width (normal), ft	75.8	75.8	71.2
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	75.8	75.8	71.2
y_bridge (avg. depth at br.), ft	11.14	11.15	7.87
Dm, median (1.25*D50), ft	0.35625	0.35625	0.35625
y2, depth in contraction,ft	9.49	10.76	10.44
ys, scour depth (y2-ybridge), ft	-1.64	-0.39	2.57

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	10900	16000	8920
Q, thru bridge MC, cfs	8496	9836	8920
Vc, critical velocity, ft/s	11.08	11.30	10.67
Va, velocity MC approach, ft/s	7.18	7.72	10.10
Main channel width (normal), ft	75.8	75.8	71.2
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	75.8	75.8	71.2
qbr, unit discharge, ft2/s	112.1	129.8	125.1
Area of full opening, ft2	844.2	845.2	560.6
Hb, depth of full opening, ft	11.14	11.15	7.87
Fr, Froude number, bridge MC	0.54	0.63	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	731	839	N/A
**Hb, depth at downstream face, ft	9.64	11.07	N/A
**Fr, Froude number at DS face	0.66	0.62	ERR
**Cf, for downstream face (<=1.0)	1.00	1.00	N/A
Elevation of Low Steel, ft	495.89	498.89	0

Elevation of Bed, ft	484.75	487.74	-7.86
Elevation of Approach, ft	498.36	499.79	0
Friction loss, approach, ft	0.37	0.59	0
Elevation of WS immediately US, ft	497.99	499.20	0.00
ya, depth immediately US, ft	13.24	11.46	7.86
Mean elevation of deck, ft	500.6	500.6	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.96	0.99	1.00
**Cc, for downstream face (<=1.0)	0.92	0.99	ERR
Ys, scour w/Chang equation, ft	-0.57	0.42	N/A
Ys, scour w/Umbrell equation, ft	0.09	-1.11	N/A

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	1.36	0.52	N/A
**Ys, scour w/Umbrell equation, ft	1.59	-1.02	ERR

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	9.49	10.76	10.44
WSEL at downstream face, ft	494.38	495.81	--
Depth at downstream face, ft	9.64	11.07	N/A
Ys, depth of scour (Laursen), ft	-0.15	-0.31	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	8496	9836	8920
Main channel area (DS), ft2	731	839	560.6
Main channel width (normal), ft	75.8	75.8	71.2
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	75.8	75.8	71.2
D90, ft	0.7363	0.7363	0.7363
D95, ft	0.8391	0.8391	0.8391
Dc, critical grain size, ft	0.5291	0.5103	1.0759
Pc, Decimal percent coarser than Dc	0.242	0.260	0.019
Depth to armoring, ft	4.99	4.35	N/A

Abutment Scour

Froehlich's Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1

(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	10900	16000	8920	10900	16000	8920
a', abut.length blocking flow, ft	109.8	116.6	103.5	168.2	168.2	153.4
Ae, area of blocked flow ft2	348.4	489.3	137.1	577.3	696.1	269.4
Qe, discharge blocked abut.,cfs	1083.9	--	440.9	--	--	968.7

(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)

Ve, (Qe/Ae), ft/s	3.11	4.02	3.22	3.41	4.27	3.60
ya, depth of f/p flow, ft	3.17	4.20	1.32	3.43	4.14	1.76

--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)

K1	1	1	1	1	1	1

--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)

theta	105	105	105	75	75	75
K2	1.02	1.02	1.02	0.98	0.98	0.98
Fr, froude number f/p flow	0.308	0.332	0.492	0.305	0.325	0.478
ys, scour depth, ft	19.61	24.91	14.30	23.09	26.87	18.72

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

a'(abut length blocked, ft)	109.8	116.6	103.5	168.2	168.2	153.4
y1 (depth f/p flow, ft)	3.17	4.20	1.32	3.43	4.14	1.76
a'/y1	34.60	27.79	78.13	49.01	40.64	87.35
Skew correction (p. 49, fig. 16)	1.03	1.03	1.03	0.95	0.95	0.95
Froude no. f/p flow	0.31	0.33	0.49	0.31	0.33	0.48
Ys w/ corr. factor K1/0.55:						
vertical	16.16	21.91	7.88	16.03	19.73	9.51
vertical w/ ww's	13.25	17.97	6.46	13.14	16.18	7.80
spill-through	8.89	12.05	4.33	8.81	10.85	5.23

Abutment riprap Sizing

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

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.66	0.63	1	0.66	0.63	1
y, depth of flow in bridge, ft	9.64	11.15	7.87	9.64	11.15	7.87
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.60	2.74	ERR	2.60	2.74	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	3.29	ERR	ERR	3.29