LEVEL II SCOUR ANALYSIS FOR BRIDGE 34 (JAMATH00080034) on TOWN HIGHWAY 8, crossing the WINHALL RIVER, JAMAICA, VERMONT

Open-File Report 98-539

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

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

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By MICHAEL A. IVANOFF AND LAURA MEDALIE

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
Thomas J. Casadevall, Acting Director

For additional information
write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 34 (JAMATH00080034) ON TOWN HIGHWAY 8, CROSSING THE WINHALL RIVER, JAMAICA, VERMONT

By **Michael A. Ivanoff and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JAMATH00080034 on Town Highway 8 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 (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in southern Vermont. The 45.1-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, along the right bank, the surface cover is pasture while the immediate banks have dense woody vegetation and along the left bank the surface cover is forest.

In the study area, the Winhall River has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 109 ft and an average bank height of 4 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 105 mm (0.346 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 7, 1996, indicated that the reach was laterally unstable with moderate to heavy fluvial erosion upstream.

The Town Highway 8 crossing of the Winhall River is a 74-ft-long, one-lane bridge consisting of one 70-foot steel-beam span (Vermont Agency of Transportation, written communication, April 6, 1995). The opening length of the structure parallel to the bridge face is 65.5 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed zero degrees to the opening and the opening-skew-to-roadway is also zero degrees.

A scour hole 2 ft deeper than the mean thalweg depth was observed in the channel under the bridge during the Level I assessment. The scour protection measures at the site included type-2 stone fill (less than 36 inches diameter) along the upstream left and right wingwalls, the upstream end of the right abutment, the upstream right bank, and the downstream left bank; type-3 stone fill (less than 48 inches diameter) along the downstream left wingwall and upstream left bank; and type-4 stone fill (less than 60 inches diameter) along the left abutment. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was determined and analyzed as another potential worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.3 to 0.6 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge. Abutment scour ranged from 8.6 to 16.5 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 1995, p. 46). 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.

Andover, VT. Quadrangle, 1:24,000, 1971

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 JAMATH00080034 ***Stream*** Winhall River

County Windham ***Road*** TH 34 ***District*** 2

Description of Bridge

Bridge length 74 ***ft*** ***Bridge width*** 14 ***ft*** ***Max span length*** 70 ***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*** 8/7/96

Description of stone fill Type-2, along the upstream left and right wingwalls and at the upstream end of the right abutment. Type-4, along the entire base of the left abutment. Type-3, along the downstream left wingwall.

Abutments and wingwalls are concrete. There is a two ft deep scour hole in the channel in front of the left abutment.

No 0

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

There is a moderate channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	8/7/96	0	0
Level II	8/7/96	0	0

Potential for debris Moderate.

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

None were observed on 8/7/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley.

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

Date of inspection 8/7/96

DS left: Steep valley wall

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

US left: Steep valley wall

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

Description of the Channel

Average top width 109 ***ft*** ***Average depth*** 4 ***ft***

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

Sinuous but stable

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

8/7/96

Vegetative co Trees and brush

DS left: Trees and brush on the immediate bank with short grass on the flood plain

DS right: Trees and brush

US left: Trees and brush on the immediate bank with short grass on the flood plain

US right:

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

There is moderate to heavy fluvial erosion upstream with light fluvial erosion downstream. There are extensively damaged cut-banks upstream and downstream.

None were observed on 8/7/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 45.1 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p ... No

-

Calculated Discharges

Q100 14,100 ***ft³/s*** ***Q500*** 21,000 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(45.1/30.5)exp 0.67] with flood frequency estimates available from the VTAOT database (written communication, May 1995) for bridge number 40 in Jamaica. Bridge number 40 crosses the Winhall River upstream of this site and has a drainage area of 30.5 square miles. These area adjusted values are within a range defined by flood frequency curves derived from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year event.

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

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

Datum tie between USGS survey and VTAOT plans None. Add 562 ft to the USGS arbitrary survey datum to obtain the National Geodetic Vertical Datum of 1929.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the right abutment (elev. 498.00 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the downstream left wingwall (elev. 493.92 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	-74	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	83	2	Modelled Approach section (Templated from APTEM)
APTEM	96	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 0.050 to 0.065, and the overbank "n" value was 0.035.

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 0.0158 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1971).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.032 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 provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.5 *ft*
Average low steel elevation 497.6 *ft*

100-year discharge 14,100 *ft³/s*
Water-surface elevation in bridge opening 497.7 *ft*
Road overtopping? Yes *Discharge over road* 7,010 *ft³/s*
Area of flow in bridge opening 635 *ft²*
Average velocity in bridge opening 11.3 *ft/s*
Maximum WSPRO tube velocity at bridge 14.6 *ft/s*

Water-surface elevation at Approach section with bridge 500.9
Water-surface elevation at Approach section without bridge 498.2
Amount of backwater caused by bridge 2.7 *ft*

500-year discharge 21,000 *ft³/s*
Water-surface elevation in bridge opening 498.0 *ft*
Road overtopping? Yes *Discharge over road* 13,400 *ft³/s*
Area of flow in bridge opening 638 *ft²*
Average velocity in bridge opening 11.5 *ft/s*
Maximum WSPRO tube velocity at bridge 13.7 */s*

Water-surface elevation at Approach section with bridge 502.5
Water-surface elevation at Approach section without bridge 499.5
Amount of backwater caused by bridge 3.0 *ft*

Incipient overtopping discharge 4,740 *ft³/s*
Water-surface elevation in bridge opening 493.4 *ft*
Area of flow in bridge opening 368 *ft²*
Average velocity in bridge opening 12.9 *ft/s*
Maximum WSPRO tube velocity at bridge 17.2 *ft/s*

Water-surface elevation at Approach section with bridge 497.0
Water-surface elevation at Approach section without bridge 495.0
Amount of backwater caused by bridge 2.0 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

Contraction scour for the incipient roadway-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). At this site, the 100- and 500-year discharges resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting in orifice flow also was computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Results from these computations are presented in appendix F.

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

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

Scour Results

Contraction scour:	*100-year discharge*	*500-year discharge*	*Incipient overtopping discharge*
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.3	0.3	0.6
Depth to armoring	5.3	6.2	22.9
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-year discharge*	*500-year discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	15.4	16.5	11.0
Right abutment	12.0	12.8	8.6
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	*500-year discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	2.5	2.5	2.4
Right abutment	2.5	2.5	2.4
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

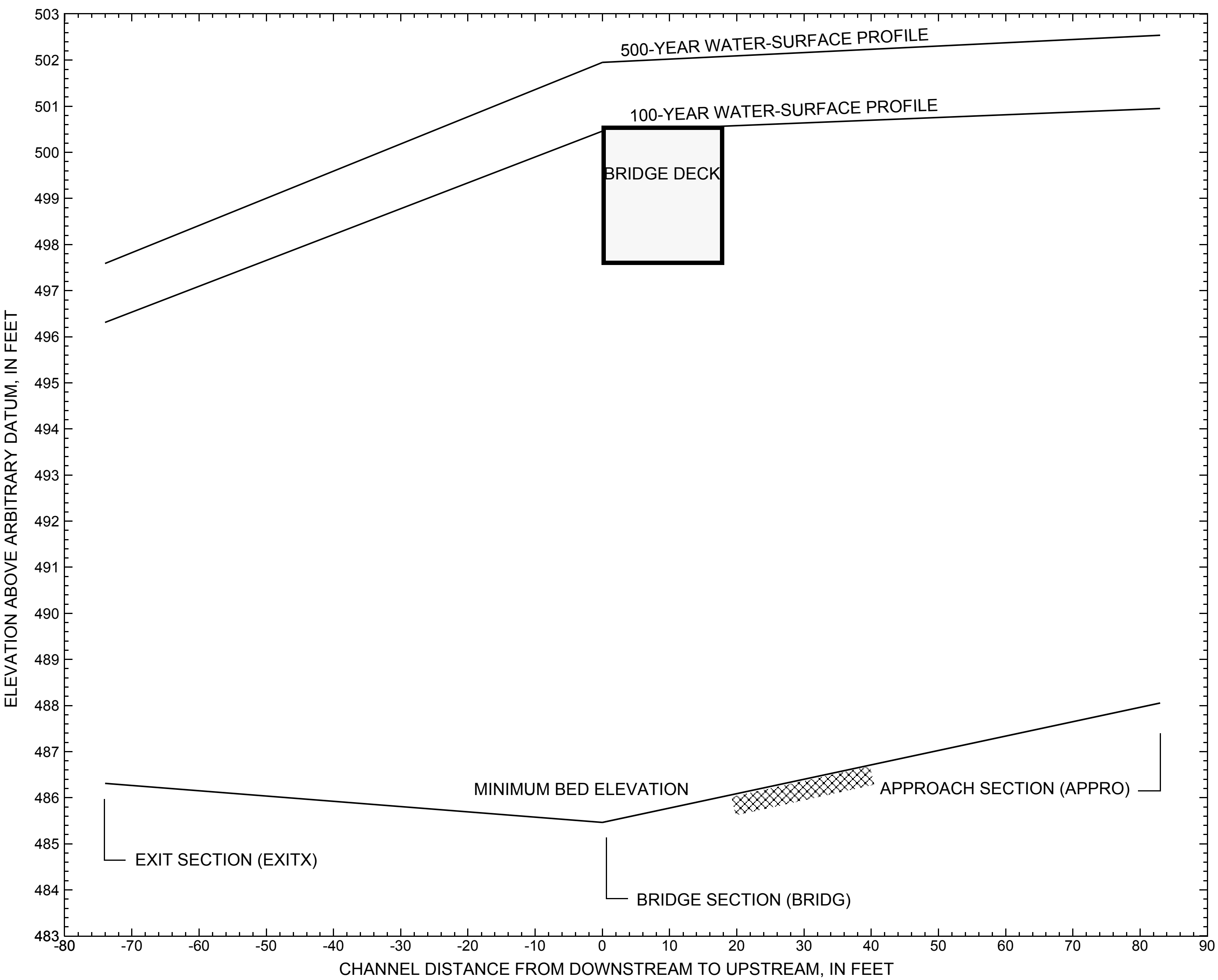

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure JAMATH00080034 on Town Highway 8, crossing the Winhall River, Jamaica, Vermont.

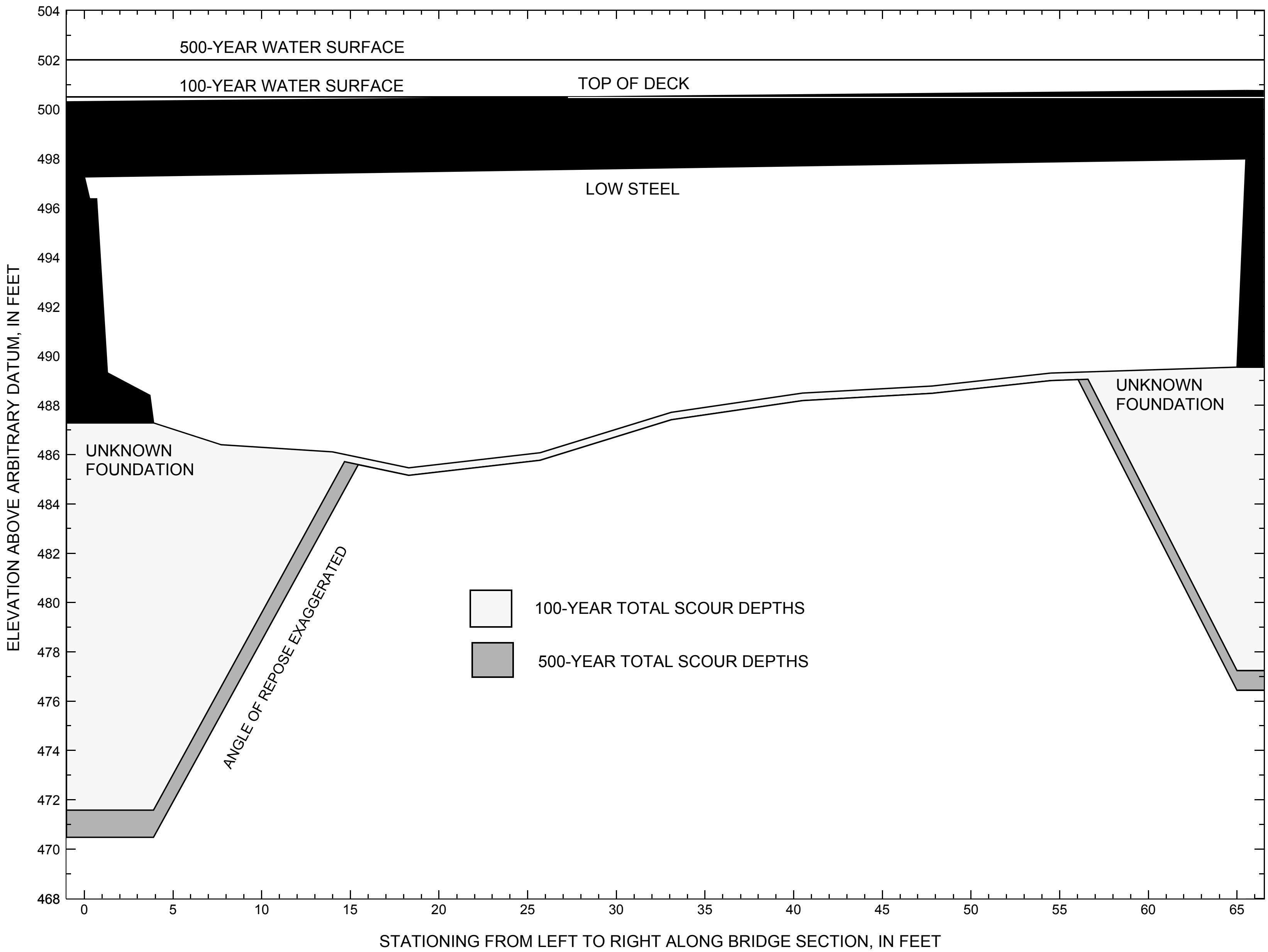

Figure 8. Scour elevations for the 100- and 500-year discharges at structure JAMATH00080034 on Town Highway 8, crossing the Winhall River, Jamaica, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JAMATH00080034 on Town Highway 8, crossing the Winhall River, Jamaica, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 14,100 cubic-feet per second											
Left abutment	0.0	--	497.3	--	487.3	0.3	15.4	--	15.7	471.6	--
Right abutment	65.5	--	498.0	--	489.5	0.3	12.0	--	12.3	477.2	--

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 JAMATH00080034 on Town Highway 8, crossing the Winhall River, Jamaica, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 21,000 cubic-feet per second											
Left abutment	0.0	--	497.3	--	487.3	0.3	16.5	--	16.8	470.5	--
Right abutment	65.5	--	498.0	--	489.5	0.3	12.8	--	13.1	476.4	--

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, 1971, Andover, 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 jama034.wsp
T2        Hydraulic analysis for structure JAMATH00080034   Date: 03-MAR-98
T3        Bridge 34 on Town Highway 8 over the Winhall River 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          14100.0  21000.0   4740.0
SK          0.0158   0.0158   0.0158
*
XS   EXITX    -74
GR         -100.4, 518.19    -84.7, 501.69    -48.1, 496.89
GR            0.0, 492.04     24.9, 487.84     35.6, 486.31     45.6, 486.78
GR           61.4, 486.95     69.6, 487.15     80.2, 487.58     84.3, 489.67
GR           93.1, 489.54    113.3, 491.39    159.1, 492.47    330.5, 497.32
GR          383.9, 502.45
N           0.065        0.035
SA                 113.3
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.62       0.0
GR            0.0, 497.26                       0.3, 496.37      0.7, 496.37
GR            1.3, 489.31      3.7, 488.40      3.9, 487.28      3.9, 487.87
GR            7.7, 486.40     14.0, 486.11     18.3, 485.46     25.7, 486.07
GR           33.1, 487.71     40.5, 488.49     47.8, 488.78     54.5, 489.30
GR           65.0, 489.54     65.5, 497.99      0.0, 497.26
*
*        BRTYPE  BRWDTH    EMBSS   EMBELV   WWANGL
CD          4      17.9      2.2    500.5     70.9
N           0.050
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      9      14.0     2
GR          -98.2, 512.24    -82.7, 504.26    -54.5, 500.68
GR            0.0, 500.31     65.2, 500.76     74.2, 500.71    113.4, 496.58
GR          292.4, 496.39    356.8, 502.45
*           -67.9, 499.89    211.0, 494.96
*
XT   APTEM     96
GR          -23.5, 504.44    -11.2, 495.42      0.0, 489.27      5.1, 488.47
GR           10.0, 489.08     17.0, 490.01     23.6, 489.44     31.1, 488.86
GR           38.3, 488.56     44.0, 488.73     50.0, 489.24     58.3, 489.15
GR           66.8, 489.71     82.5, 491.61     83.3, 494.23     92.1, 496.07
GR          306.6, 495.54    384.8, 502.40    390.0, 505.00
*
AS   APPRO     83  * * * 0.032
GT
N           0.065        0.035
SA                  92.1
*
HP 1 BRIDG   497.74 1 497.74
HP 2 BRIDG   497.74 * * 7170
HP 2 RDWAY   500.46 * * 7012
HP 1 APPRO   500.95 1 500.95
HP 2 APPRO   500.95 * * 14100
*
HP 1 BRIDG   497.99 1 497.99
HP 2 BRIDG   497.99 * * 7334
HP 2 RDWAY   501.95 * * 13415
HP 1 APPRO   502.54 1 502.54
HP 2 APPRO   502.54 * * 21000
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File jama034.wsp
        Hydraulic analysis for structure JAMATH00080034   Date: 03-MAR-98
        Bridge 34 on Town Highway 8 over the Winhall River Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-26-98  10:06
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     635.   55730.    22.   126.                       19184.
   497.74          635.   55730.    22.   126.  1.00     0.    65.  19184.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.74     0.0    65.5   635.1   55730.    7170.  11.29

X STA.         0.0        8.7       11.4       14.0       16.5       18.9
  A(I)             75.4       29.1       29.8       29.0       28.6
  V(I)             4.76      12.31      12.03      12.35      12.52

X STA.        18.9       21.4       23.9       26.4       29.1       31.9
  A(I)             28.9       29.0       29.1       30.2       29.5
  V(I)            12.39      12.38      12.33      11.86      12.14

X STA.        31.9       35.0       38.5       42.1       45.1       47.9
  A(I)             30.3       33.2       33.9       27.2       25.3
  V(I)            11.83      10.80      10.57      13.17      14.16

X STA.        47.9       50.7       53.6       56.6       59.6       65.5
  A(I)             24.6       24.8       25.1       25.3       46.7
  V(I)            14.55      14.47      14.26      14.18       7.68


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.46   -22.1   335.7   874.3   81522.    7012.   8.02

X STA.       -22.1      119.2      129.2      139.3      149.2      159.0
  A(I)             97.4       39.0       39.4       38.6       38.5
  V(I)             3.60       9.00       8.89       9.08       9.11

X STA.       159.0      168.9      178.6      188.6      198.2      207.6
  A(I)             38.8       38.2       39.5       38.4       37.3
  V(I)             9.03       9.18       8.88       9.14       9.40

X STA.       207.6      216.8      226.3      235.8      245.2      254.8
  A(I)             36.7       38.0       37.9       37.7       38.6
  V(I)             9.55       9.23       9.24       9.29       9.09

X STA.       254.8      264.1      273.3      282.7      291.9      335.7
  A(I)             37.4       37.4       38.0       37.5       90.1
  V(I)             9.38       9.39       9.22       9.36       3.89


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1172.  124481.   111.   117.                       21562.
             2    1386.  170961.   281.   281.                       17475.
   500.95         2558.  295442.   392.   399.  1.02   -19.   373.  36767.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.95   -19.3   373.0  2558.0  295442.   14100.   5.51

X STA.       -19.3        6.1       16.4       27.1       36.7       46.4
  A(I)            202.3      124.2      125.3      120.3      123.2
  V(I)             3.48       5.68       5.62       5.86       5.72

X STA.        46.4       56.6       67.4       80.3      104.3      125.5
  A(I)            124.5      128.8      139.9      148.0      113.4
  V(I)             5.66       5.47       5.04       4.76       6.22

X STA.       125.5      146.3      167.0      187.3      207.0      226.8
  A(I)            112.1      113.2      111.6      109.7      110.9
  V(I)             6.29       6.23       6.32       6.43       6.36

X STA.       226.8      246.1      265.2      283.8      302.4      373.0
  A(I)            109.2      108.9      106.6      108.1      217.7
  V(I)             6.46       6.47       6.61       6.52       3.24
```

```
        U.S. Geological Survey WSPRO Input File jama034.wsp
        Hydraulic analysis for structure JAMATH00080034   Date: 03-MAR-98
        Bridge 34 on Town Highway 8 over the Winhall River Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-26-98  10:06
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     638.  50263.     0.   148.                            0.
   497.99          638.  50263.     0.   148.  1.00     0.    66.      0.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.99     0.0    65.5   637.9   50263.    7334.  11.50

 X STA.         0.0        7.4       10.0       12.4       14.9       17.2
   A(I)            61.3       27.6       27.2       27.7       26.8
   V(I)            5.98      13.27      13.48      13.26      13.68

 X STA.        17.2       19.4       21.7       24.0       26.4       28.9
   A(I)            26.8       26.8       27.1       27.8       27.6
   V(I)           13.67      13.69      13.55      13.18      13.28

 X STA.        28.9       31.5       34.4       37.5       40.8       44.1
   A(I)            27.7       28.9       29.9       30.3       30.5
   V(I)           13.24      12.71      12.27      12.09      12.04

 X STA.        44.1       47.5       50.9       54.7       58.4       65.5
   A(I)            31.0       30.7       32.3       31.5       58.5
   V(I)           11.84      11.94      11.34      11.66       6.27


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.95   -64.5   351.5  1460.9  149063.   13415.   9.18

 X STA.       -64.5      103.0      119.5      130.0      140.6      151.2
   A(I)           268.3       82.9       56.5       57.3       57.1
   V(I)            2.50       8.09      11.87      11.70      11.75

 X STA.       151.2      161.8      172.4      183.1      193.6      203.5
   A(I)            57.6       57.5       58.2       57.4       54.0
   V(I)           11.65      11.67      11.53      11.69      12.42

 X STA.       203.5      213.3      223.6      233.8      243.9      254.2
   A(I)            53.3       56.8       55.9       55.5       56.7
   V(I)           12.59      11.80      12.01      12.08      11.82

 X STA.       254.2      264.4      274.4      284.5      294.8      351.5
   A(I)            56.5       55.2       56.1       57.2      151.0
   V(I)           11.87      12.16      11.95      11.72       4.44


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1351.  155374.   114.   120.                       26427.
             2    1846.  267296.   294.   294.                       26255.
   502.54         3196.  422670.   407.   414.  1.04   -21.   386.  49901.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.54   -21.5   385.9  3196.5  422670.   21000.   6.57

 X STA.       -21.5        7.3       19.6       31.6       42.6       54.5
   A(I)           261.4      165.7      162.9      157.2      165.8
   V(I)            4.02       6.34       6.44       6.68       6.33

 X STA.        54.5       66.7       81.3      104.9      124.9      144.2
   A(I)           167.0      179.8      179.0      138.7      135.4
   V(I)            6.29       5.84       5.87       7.57       7.76

 X STA.       144.2      163.3      182.4      201.0      219.5      237.8
   A(I)           134.2      135.1      132.9      133.0      132.0
   V(I)            7.82       7.77       7.90       7.89       7.95

 X STA.       237.8      256.2      274.5      291.8      309.9      385.9
   A(I)           133.5      134.0      127.2      133.6      287.9
   V(I)            7.86       7.84       8.25       7.86       3.65
```

```
        U.S. Geological Survey WSPRO Input File jama034.wsp
        Hydraulic analysis for structure JAMATH00080034   Date: 03-MAR-98
        Bridge 34 on Town Highway 8 over the Winhall River Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-26-98  10:06
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     368.   31877.    64.    74.                       4989.
   493.45          368.   31877.    64.    74.  1.00     1.    65.   4989.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.45     0.9    65.2   367.6   31877.    4740.  12.89

X STA.         0.9        7.7        9.7       11.8       13.9       15.9
  A(I)            36.6       14.8       15.0       14.8       15.3
  V(I)            6.48      15.98      15.76      16.05      15.51

X STA.        15.9       17.8       19.7       21.6       23.6       25.5
  A(I)            14.5       14.8       15.0       15.2       14.4
  V(I)           16.30      15.99      15.85      15.56      16.40

X STA.        25.5       27.4       29.7       32.3       35.3       38.6
  A(I)            13.8       15.6       16.2       17.0       17.5
  V(I)           17.19      15.23      14.61      13.94      13.56

X STA.        38.6       42.4       46.2       50.5       55.6       65.2
  A(I)            18.7       18.7       19.9       21.6       38.2
  V(I)           12.65      12.67      11.93      10.98       6.21


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     739.   60071.   106.   111.                      11076.
             2     359.   20193.   236.   236.                       2510.
   496.97         1098.   80264.   342.   346.  1.07   -14.   328.  10775.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      83.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.97   -13.9   327.6  1097.6   80264.    4740.   4.32

X STA.       -13.9        2.5        7.4       12.7       18.7       24.5
  A(I)            80.2       42.8       43.9       45.1       45.4
  V(I)            2.95       5.54       5.40       5.25       5.22

X STA.        24.5       29.9       34.8       39.8       44.6       49.8
  A(I)            43.9       42.8       43.1       42.4       43.5
  V(I)            5.40       5.54       5.50       5.58       5.45

X STA.        49.8       55.0       60.2       65.8       72.1       79.9
  A(I)            42.5       42.6       44.6       46.5       50.8
  V(I)            5.58       5.56       5.31       5.10       4.66

X STA.        79.9      148.4      196.6      237.7      276.6      327.6
  A(I)           116.9       72.9       66.8       67.2       73.6
  V(I)            2.03       3.25       3.55       3.53       3.22
```

WSPRO OUTPUT FILE (continued)

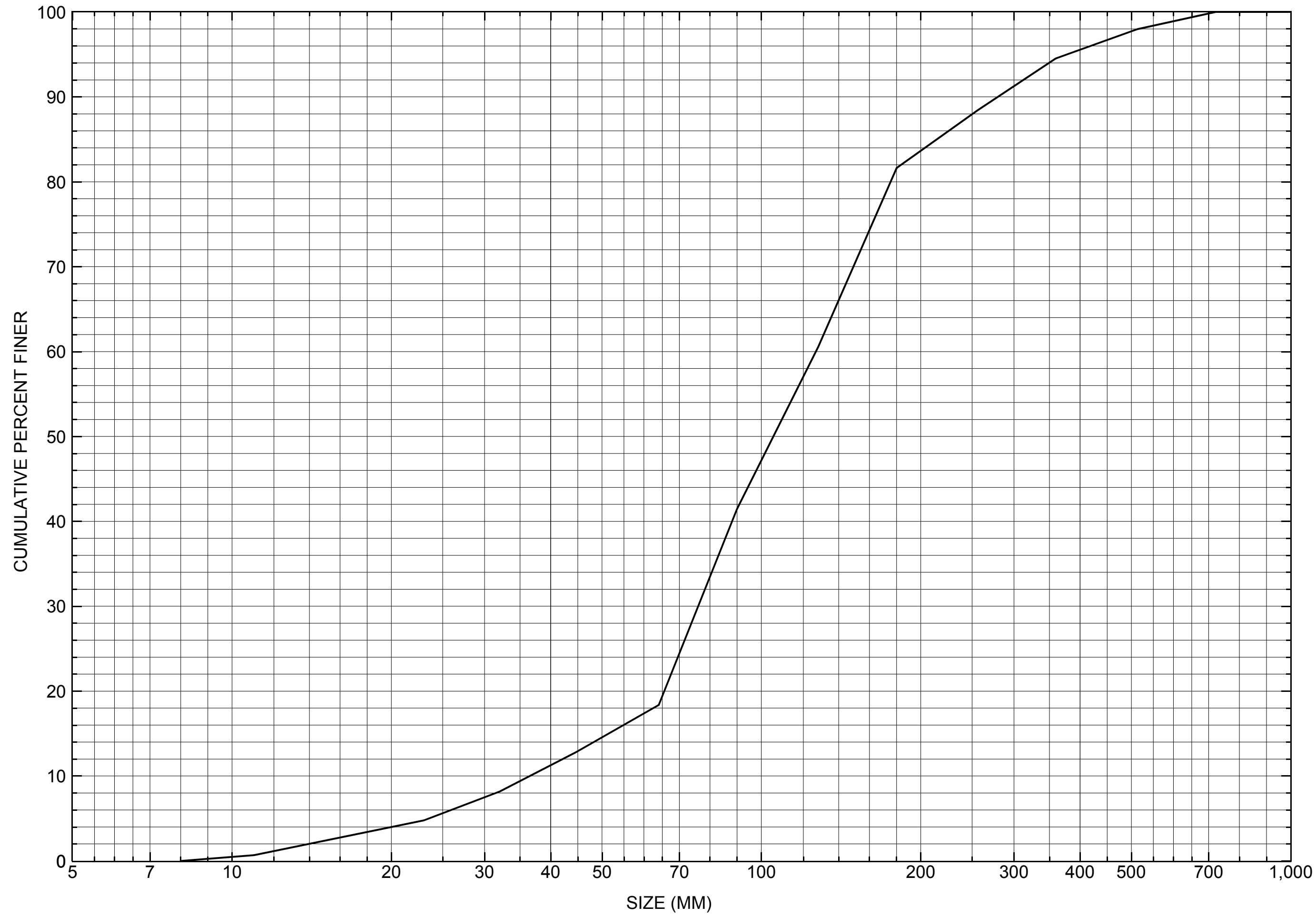
```
        U.S. Geological Survey WSPRO Input File jama034.wsp
        Hydraulic analysis for structure JAMATH00080034   Date: 03-MAR-98
        Bridge 34 on Town Highway 8 over the Winhall River Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-26-98  10:06

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

EXITX:XS   ******   -42.    1437.  1.50 *****  497.81  495.72  14100.  496.31
      -74. ******   295.  112099.  1.00 ***** *******    0.84    9.82

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             “FULLV”     KRATIO =  1.56

FULLV:FV      74.   -55.    1962.  0.81  0.75  498.56 *******  14100.  497.74
        0.    74.   335.  175314.  1.01  0.00    0.00    0.57    7.19
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      83.   -16.    1526.  1.34  0.72  499.53 *******  14100.  498.20
       83.    83.   342.  131045.  1.01  0.26    0.00    0.79    9.24
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   497.74     497.62

            <<<<<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      74.     0.     635.  1.98 *****  499.73  495.04   7170.  497.74
        0. ******    65.   55620.  1.00 ***** *******    0.64   11.29

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   6.  0.800  0.000  497.62 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG       9.    69.  0.16  0.48  501.27    0.01   7012.  500.46

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    102.    44.   -22.    22.   0.1   0.1   4.0  31.3   0.9   2.8
   RT:   6910.   259.    77.   336.   4.1   3.4   9.6   7.9   4.2   3.1

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

APPRO:AS      65.   -19.    2558.  0.48  0.60  501.43  497.68  14100.  500.95
       83.    87.   373.  295486.  1.02  0.00    0.01    0.38    5.51

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -74.   -42.   295.  14100.  112099.    1437.    9.82  496.31
   FULLV:FV       0.   -55.   335.  14100.  175314.    1962.    7.19  497.74
   BRIDG:BR       0.     0.    65.   7170.   55620.     635.   11.29  497.74
   RDWAY:RG       9.*******   102.   7012.       0.*********    2.00  500.46
   APPRO:AS      83.   -19.   373.  14100.  295486.    2558.    5.51  500.95

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.72    0.84  486.31  518.19************  1.50  497.81  496.31
   FULLV:FV  ********    0.57  486.31  518.19  0.75  0.00  0.81  498.56  497.74
   BRIDG:BR    495.04    0.64  485.46  497.99************  1.98  499.73  497.74
   RDWAY:RG  ****************  496.39  512.24  0.16******  0.48  501.27  500.46
   APPRO:AS    497.68    0.38  488.05  504.58  0.60  0.00  0.48  501.43  500.95
```

```
        U.S. Geological Survey WSPRO Input File jama034.wsp
        Hydraulic analysis for structure JAMATH00080034   Date: 03-MAR-98
        Bridge 34 on Town Highway 8 over the Winhall River Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-26-98  10:06

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

EXITX:XS   ******   -53.    1902.  1.91 *****  499.50  497.11  21000.  497.59
      -74. ******   333.  166971.  1.01 ***** *******    0.88   11.04

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

FULLV:FV      74.   -65.    2519.  1.13  0.76  500.26 *******  21000.  499.13
        0.    74.   349.  258294.  1.04  0.00    0.00    0.61    8.34
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      83.   -17.    2019.  1.69  0.70  501.23 *******  21000.  499.54
       83.    83.   357.  203157.  1.00  0.28    0.00    0.79   10.40
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =    499.13     497.62

            <<<<<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      74.     0.     638.  2.06 *****  500.05  495.14   7334.  497.99
        0. ******    66.   50263.  1.00 ***** *******    0.65   11.50

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   6.  0.800  0.000  497.62 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    69.  0.17  0.70  503.06   -0.01  13415.  501.95

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1094.    93.   -65.    29.   1.6   1.4   7.0   8.4   2.5   2.9
   RT:  12321.   323.    29.   352.   5.6   4.1  10.9   9.3   5.2   3.2

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

APPRO:AS      65.   -21.    3196.  0.70  0.90  503.23  498.72  21000.  502.54
       83.    93.   386.  422547.  1.04  0.00   -0.01    0.42    6.57

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -74.   -53.   333.  21000.  166971.    1902.   11.04  497.59
   FULLV:FV       0.   -65.   349.  21000.  258294.    2519.    8.34  499.13
   BRIDG:BR       0.     0.    66.   7334.   50263.     638.   11.50  497.99
   RDWAY:RG       9.*******  1094.  13415.******************    2.00  501.95
   APPRO:AS      83.   -21.   386.  21000.  422547.    3196.    6.57  502.54

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    497.11    0.88  486.31  518.19************  1.91  499.50  497.59
   FULLV:FV  ********    0.61  486.31  518.19  0.76  0.00  1.13  500.26  499.13
   BRIDG:BR    495.14    0.65  485.46  497.99************  2.06  500.05  497.99
   RDWAY:RG  ****************  496.39  512.24  0.17******  0.70  503.06  501.95
   APPRO:AS    498.72    0.42  488.05  504.58  0.90  0.00  0.70  503.23  502.54
```

```
        U.S. Geological Survey WSPRO Input File jama034.wsp
        Hydraulic analysis for structure JAMATH00080034   Date: 03-MAR-98
        Bridge 34 on Town Highway 8 over the Winhall River Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-26-98  10:06

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

EXITX:XS   ******   -13.     638.  0.88 *****  494.24  492.59   4740.  493.36
      -74. ******   191.   37697.  1.03 ***** *******    0.75    7.43

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.60

FULLV:FV      74.   -25.     910.  0.43  0.73  494.97 *******   4740.  494.54
        0.    74.   232.   60332.  1.01  0.00   -0.01    0.49    5.21
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.60

APPRO:AS      83.   -11.     533.  1.23  0.85  496.22 *******   4740.  494.99
       83.    83.    89.   36319.  1.00  0.40    0.00    0.68    8.89
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   496.96       0.00     493.46     496.39

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   496.77      4740.         0.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                       YU/Z,WSIU,WS = 1.05     498.13     498.27

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

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

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

BRIDG:BR      74.     1.     368.  2.67  1.38  496.12  493.27   4740.  493.45
        0.    74.    65.   31892.  1.03  0.49    0.00    0.97   12.89

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   1.  0.984 ******  497.62 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<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      65.   -14.    1099.  0.31  0.60  497.28  493.60   4740.  496.97
       83.    68.   328.   80383.  1.07  0.57    0.01    0.44    4.31

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.356  0.405   47588.    11.    75.   496.73

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -74.   -13.   191.   4740.   37697.     638.    7.43  493.36
   FULLV:FV       0.   -25.   232.   4740.   60332.     910.    5.21  494.54
   BRIDG:BR       0.     1.    65.   4740.   31892.     368.   12.89  493.45
   RDWAY:RG       9.**************      0.       0.       0.    2.00********
   APPRO:AS      83.   -14.   328.   4740.   80383.    1099.    4.31  496.97

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      11.    75.   47588.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS     492.59    0.75  486.31  518.19************  0.88  494.24  493.36
   FULLV:FV   ********    0.49  486.31  518.19  0.73  0.00  0.43  494.97  494.54
   BRIDG:BR     493.27    0.97  485.46  497.99  1.38  0.49  2.67  496.12  493.45
   RDWAY:RG   ****************  496.39  512.24************  0.15  498.33********
   APPRO:AS     493.60    0.44  488.05  504.58  0.60  0.57  0.31  497.28  496.97
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JAMATH00080034, in Jamaica, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JAMATH00080034

General Location Descriptive

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

Date *(MM/DD/YY)* 04 / 06 / 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)* 000000

Waterway *(I - 6)* Winhall Brook

Road Name *(I - 7):* -

Route Number TH08

Vicinity *(I - 9)* At the jct. of TH 8 & TH 4.

Topographic Map Londonderry

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43094

Longitude *(i - 17; nnnnn.n)* 72496

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10130900341309

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

Maximum span length *(I - 48; nnnn)* 0070

Year built *(I - 27; YYYY)* 1939

Structure length *(I - 49; nnnnnn)* 000074

Average daily traffic, ADT *(I - 29; nnnnnn)* 000050

Deck Width *(I - 52; nn.n)* 140

Year of ADT *(I - 30; YY)* 91

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

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

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) _______

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

Vertical clearance from streambed (*nnn.n ft*) 10.0

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

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

Comments:

The structural inspection report of 09/15/93 indicates the structure is a steel beam type bridge with a timber deck. The right abutment has some minor stains along the bottom. The left abutment has a new concrete facing along the lower portion of wall, and along both wingwalls. This new concrete doesn't have any cracking. There is stone fill around the left abutment. The waterway takes a slight turn through the structure. It has had previous scour problems along the left abutment which have been corrected. The streambed material consists of stone and 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)* **45.07** mi^2
Lake/pond/swamp area **0.51** mi^2

Watershed storage *(ST)* **1.1** %

Bridge site elevation **1043** ft
Headwater elevation **3281** ft

Main channel length **14.92** mi

10% channel length elevation **1161** ft
85% channel length elevation **2402** ft

Main channel slope *(S)* **110.84** ft / mi

Watershed Precipitation Data

Average site precipitation - in
Average headwater precipitation - in

Maximum 2yr-24hr precipitation event *(I24,2)* - in

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number - Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:
NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness _______ Footing bottom elevation: ______

If 2: Pile Type: ____ (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: _______

If 3: Footing bottom elevation: ______

Is boring information available? N *If no, type ctrl-n bi* Number of borings taken: -

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

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
NO PLANS

Cross-sectional Data

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

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

Comments: **The station and elevation measurements are in feet.**

Station	170	184	200	202	224	238	-	-	-	-	-
Feature	LAB	-	-	-	-	RAB	-	-	-	-	-
Low chord elevation	1060	1060	1060	1060	1060	1060	-	-	-	-	-
Bed elevation	1047.6	1048.1	1048.2	1048.9	1049.9	1052.8	-	-	-	-	-
Low chord to bed	12.4	11.9	11.8	11.1	10.1	7.2	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments: -
-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **EW** Date: **10/3/96**
Computerized by: **EW** Date: **10/4/96**
Reviewd by: **MAI** Date: **4/14/98**

Structure Number **JAMATH00080034**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **L. Medalie** Date *(MM/DD/YY)* **08** / **07** / 19**96**
2. Highway District Number **02** Mile marker **000000**
County **Windham (025)** Town **Jamaica (36175)**
Waterway *(I - 6)* **Winhall Brook** Road Name **-**
Route Number **TH08** Hydrologic Unit Code: **01080107**
3. Descriptive comments:
This site is located at the junction with TH 4.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **4** LBDS **6** RBDS **4** 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 **1** UB **1** DS **1** *(**1**- pool; **2**- riffle)*
6. Bridge structure type **1** *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length **74** *(feet)* Span length **70** *(feet)* Bridge width **14** *(feet)*

Road approach to bridge:

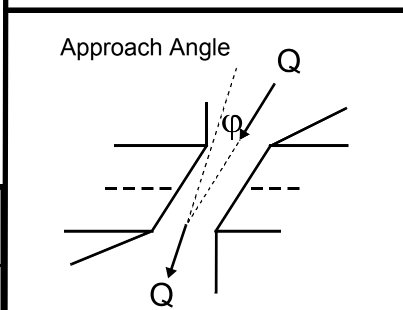
8. LB **2** RB **1** *(**0** even, **1**- lower, **2**- higher)*
9. LB **2** RB **2** *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left **2.6:1** US right **1.7:1**

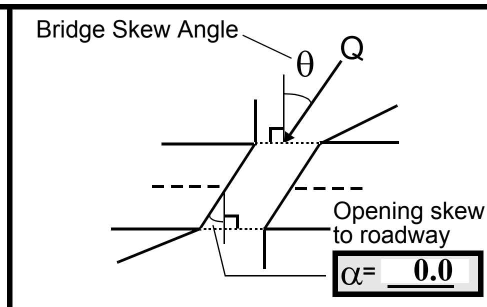
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	2	1
RBDS	0	-	2	2
LBDS	0	-	0	-

*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: **0** 16. Bridge skew: **0**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **325** feet **US** *(US, UB, DS)* to **75** feet **US**
Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **280** feet **DS** *(US, UB, DS)* to **400** feet **DS**

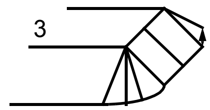
*Impact Severity: **0**- none to very slight; **1**- Slight; **2**- Moderate; **3**- Severe*

18. Bridge Type: **4**

1a- Vertical abutments with wingwalls

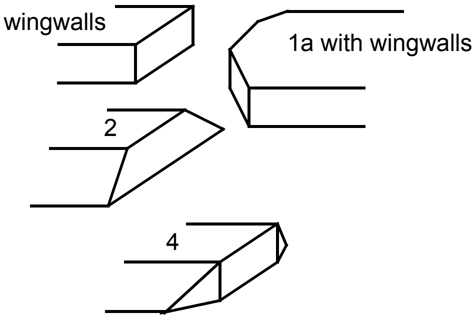
1b- Vertical abutments without wingwalls

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



3- Spill through abutments

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



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

4: Along the right bank, upstream and downstream, the surface cover is mostly lawn.

5: The stream is pooled from 35 ft upstream to the upstream bridge face.

7: The measured bridge dimensions are bridge length is 72.6 ft; span length is 65.3 ft; and bridge width is 14.1 ft.

14: The right bank road wash erosion is moderately severe. The road approach to the bridge is built up on fill and steep slopes exists on either side of it.

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
82.5	**6.0**			**4.5**	**4**	**3**	**435**	**342**	**2**	**3**

23. Bank width **30.0** 24. Channel width **25.0** 25. Thalweg depth **103.5** 29. Bed Material **45**

30 .Bank protection type: LB **3** RB **2** 31. Bank protection condition: LB **1** RB **1**

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

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

#27: The right bank protection extends from the bridge face to 48 ft upstream.
The left bank protection extends from the bridge face to 51 ft upstream.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **40** 35. Mid-bar width: **38**

36. Point bar extent: **60** feet **DS** (US, UB) to **110** feet **DS** (US, UB, DS) positioned **45** %LB to **90** %RB

37. Material: **435**

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

A larger point bar exists along the right bank at the sharp bend from 260 ft upstream to at least 500 ft upstream. It consists mostly of cobbles.

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

41. Mid-bank distance: **296** 42. Cut bank extent: **325** feet **US** (US, UB) to **60** feet **US** (US, UB, DS)

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

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

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **168**

47. Scour dimensions: Length **2** Width **2** Depth : **1** Position **0** %LB to **10** %RB

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

At 256 ft upstream, there are many local areas of scour around boulders. The area is 15 ft in length, 2 ft wide and 1 ft deep.

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
82.5		1.0		2	7	7	-

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

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

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

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

43

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

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

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

70. Debris and Ice Comments:

2

68: The island and wide point bar in front of the upstream bridge face can block movement of debris and ice.

69: There is significant scrapping of the roots exposed on the right bank cut-bank, 320 ft downstream, that suggests ice damage.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	2	-	1	90.0
RABUT	1	0	90			2	1	65.5

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

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

-

-

1

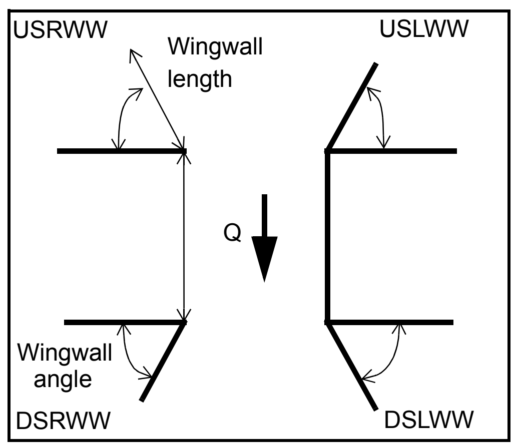
74: The RABUT has areas of spalling along the bottom, up to 4 inches of concrete has eroded from the face of the abutment.

76: The LABUT footing is exposed with some stone fill on it; the maximum exposure depth along the footing is 1 ft.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						65.5	
USRWW:	Y		1		2	2.5	
DSLWW:	-		0.5		Y	18.0	
DSRWW:	1		1		-	18.0	

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	-	0	N	-	1	1	1	1
Condition	Y	-	-	-	1	1	1	2
Extent	1	-	-	2	2	4	2	-

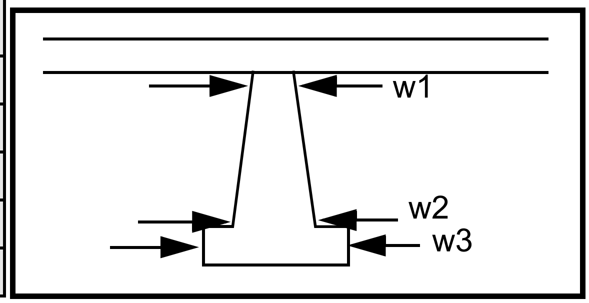
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
3
1
1
-
-
-

Piers:

84. Are there piers? **#80** *(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				**65.0**	**23.5**	**80.0**
Pier 2	**4.0**		**--**	**75.0**	**17.0**	**--**
Pier 3	**-**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**: The**	**upstre**	**the**	**barely**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**USL**	**am**	**dow**	**scou**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**WW**	**end.**	**nstre**	**red;**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**is**	**The**	**am**	**a 4**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**badl**	**USR**	**end**	**inch**	*Y- yes; N- no*
91. Attack ∠ (BF)	**y**	**WW**	**for 8**	**squa**	
92. Pushed	**spall**	**foot-**	**ft.**	**re**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**ed**	**ing is**	**The**	**area**	
95. Cross-members	**and**	**expo**	**DSL**	**at**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**erod**	**sed**	**WW**	**the**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**ed at**	**only**	**is**	**upst**	
98. Exposure depth	**the**	**at**	**just**	**ream**	

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

end.

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width - Thalweg depth - Bed Material -

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

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

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

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

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

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

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

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

Material: -

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

-
-
-
-

Is a cut-bank present? - (Y or if N type ctrl-n cb) Where? NO (LB or RB) Mid-bank distance: PIE

Cut bank extent: RS feet ____ (US, UB, DS) to ____ feet ____ (US, UB, DS)

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

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

Is channel scour present? ____ (Y or if N type ctrl-n cs) Mid-scour distance: 4

Scour dimensions: Length 2 Width 324 Depth: 23 Positioned 1 %LB to 1 %RB

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

435
2
0
1

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

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

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

Confluence comments (eg. confluence name):

extends from the downstream bridge face to 52 ft 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

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:	JAMATH00080034	Town:	Jamaica
Road Number:	TH 8	County:	Windham
Stream:	Whinhall River		

Initials MAI Date: 03/24/98 Checked: RLB

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 Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	14100	21000	4740
Main Channel Area, ft2	1172	1351	739
Left overbank area, ft2	0	0	0
Right overbank area, ft2	1386	1846	359
Top width main channel, ft	111	114	106
Top width L overbank, ft	0	0	0
Top width R overbank, ft	281	294	236
D50 of channel, ft	0.3456	0.3456	0.3456
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.6	11.9	7.0
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	4.9	6.3	1.5
Total conveyance, approach	295442	422670	80264
Conveyance, main channel	124481	155374	60071
Conveyance, LOB	0	0	0
Conveyance, ROB	170961	267296	20193
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	5940.9	7719.6	3547.5
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	8159.1	13280.4	1192.5
Vm, mean velocity MC, ft/s	5.1	5.7	4.8
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	5.9	7.2	3.3
Vc-m, crit. velocity, MC, ft/s	11.7	11.9	10.9
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	14100	21000	4740
(Q) discharge thru bridge, cfs	7170	7334	4740
Main channel conveyance	55730	50263	31877
Total conveyance	55730	50263	31877
Q2, bridge MC discharge,cfs	7170	7334	4740
Main channel area, ft2	635	638	368
Main channel width (normal), ft	65.5	65.5	64.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	65.5	65.5	64.3
y_bridge (avg. depth at br.), ft	9.70	9.74	5.72
Dm, median (1.25*D50), ft	0.432	0.432	0.432
y2, depth in contraction,ft	8.80	8.98	6.27
ys, scour depth (y2-ybridge), ft	-0.89	-0.76	**0.56**

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 Davis, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	14100	21000	4740
Q, thru bridge MC, cfs	7170	7334	4740
Vc, critical velocity, ft/s	11.65	11.88	10.87
Va, velocity MC approach, ft/s	5.07	5.71	4.80
Main channel width (normal), ft	65.5	65.5	64.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	65.5	65.5	64.3
qbr, unit discharge, ft2/s	109.5	112.0	73.7
Area of full opening, ft2	635.1	637.9	367.6
Hb, depth of full opening, ft	9.70	9.74	5.72
Fr, Froude number, bridge MC	0.64	0.65	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A

Elevation of Low Steel, ft	497.62	497.62	497.62
Elevation of Bed, ft	487.92	487.88	491.90
Elevation of Approach, ft	500.95	502.54	0
Friction loss, approach, ft	0.6	0.9	0
Elevation of WS immediately US, ft	500.35	501.64	0.00
ya, depth immediately US, ft	12.43	13.76	-491.90
Mean elevation of deck, ft	500.53	500.53	500.53
w, depth of overflow, ft (>=0)	0.00	1.11	0.00
Cc, vert contrac correction (<=1.0)	0.94	0.93	ERR
**Cc, for downstream face (<=1.0)	0.79	0.79	ERR
Ys, scour w/Chang equation, ft	**0.31**	**0.34**	N/A
Ys, scour w/Umbrell equation, ft	-1.41	-0.47	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	7170	7334	4740
Main channel area (DS), ft2	635.1	637.9	367.6
Main channel width (normal), ft	65.5	65.5	64.3
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	65.5	65.5	64.3
D90, ft	0.9164	0.9164	0.9164
D95, ft	1.2364	1.2364	1.2364
Dc, critical grain size, ft	0.5440	0.5632	0.8931
Pc, Decimal percent coarser than Dc	0.234	0.213	0.105
Depth to armoring, ft	**5.34**	**6.24**	**22.93**

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and Davis, 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	14100	21000	4740	14100	21000	4740
a', abut.length blocking flow, ft	19.3	21.5	14.8	307.5	320.4	262.4
Ae, area of blocked flow ft2	140.42	160.7	72.38	817.94	879.96	499.48
Qe, discharge blocked abut.,cfs	--	--	213.88	--	--	1684.39
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.48	4.02	2.95	5.69	6.94	3.37
ya, depth of f/p flow, ft	7.28	7.47	4.89	2.66	2.75	1.90
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82

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

theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.218	0.235	0.235	0.435	0.474	0.431
ys, scour depth, ft	**15.41**	**16.53**	**10.96**	25.64	27.84	19.53

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

a'(abut length blocked, ft)	19.3	21.5	14.8	307.5	320.4	262.4
y1 (depth f/p flow, ft)	7.28	7.47	4.89	2.66	2.75	1.90
a'/y1	2.65	2.88	3.03	115.60	116.66	137.85
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.22	0.24	0.24	0.44	0.47	0.43
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	14.70	15.61	10.48
vertical w/ ww's	ERR	ERR	ERR	**12.05**	**12.80**	**8.60**
spill-through	ERR	ERR	ERR	8.08	8.59	5.77

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.64	0.65	0.97	0.64	0.65	0.97
y, depth of flow in bridge, ft	9.70	9.74	5.72	9.70	9.74	5.72
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	**2.46**	**2.54**	ERR	**2.46**	**2.54**	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	**2.37**	ERR	ERR	**2.37**