LEVEL II SCOUR ANALYSIS FOR BRIDGE 29 (JAMATH00300029) on TOWN HIGHWAY 30, crossing BALL MOUNTAIN BROOK, JAMAICA, VERMONT

Open-File Report 98-88

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 29 (JAMATH00300029) on TOWN HIGHWAY 30, crossing BALL MOUNTAIN BROOK, JAMAICA, VERMONT

By JAMES R. DEGNAN

U.S. Geological Survey
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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
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Box 25286
Denver, CO 80225-0286

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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 1930-- 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 1930.

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 29 (JAMATH00300029) ON TOWN HIGHWAY 30, CROSSING BALL MOUNTAIN BROOK, JAMAICA, VERMONT

By **James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JAMATH00300029 on Town Highway 30 crossing Ball Mountain Brook, 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 (Federal Highway Administration, 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 10.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest with some lawn on the upstream and downstream left bank.

In the study area, Ball Mountain Brook has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 76 ft and an average bank height of 4 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 122.0 mm (0.400 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 12, 1996, indicated that the reach was laterally unstable. There are cut-banks on the upstream and downstream banks.

The Town Highway 30 crossing of Ball Mountain Brook is a 84-ft-long, one-lane bridge consisting of one 80-foot steel-beam span (Vermont Agency of Transportation, written communication, March 30, 1995). The opening length of the structure parallel to the bridge face is 77.4 ft. The bridge is supported by vertical, laid-up stone abutments. The channel is not skewed to the opening and does not have an opening-skew-to-roadway.

A scour hole 2.5 ft deeper than the mean thalweg depth was observed in the upstream channel during the Level I assessment. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the upstream and downstream left banks, the left and right abutments, and the downstream right bank. 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). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.1 ft to 0.5 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 8.1 to 11.0 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Jamaica, 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 JAMATH00300029 ***Stream*** Ball Mountain Brook

County Windham ***Road*** TH30 ***District*** 2

Description of Bridge

Bridge length 84 ***ft*** ***Bridge width*** 14 ***ft*** ***Max span length*** 80 ***ft***

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

Abutment type Spill-through ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 8/12/96

Description of stone fill Type-2, along the upstream and downstream left banks, the left and right abutments, and the downstream right bank.

Abutments are laid-up stone walls with stone fill spill-through embankments in front of each abutment.

No 0

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

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*
	8/12/96	0	0
Level I	8/12/96	0	0
Level II			

Potential for debris High. There was debris accumulation observed both upstream and at the bridge.

Describe any features near or at the bridge that may affect flow (include observation date) There is a cobble, gravel, and boulder point bar along the right abutment that affects low flow as of 8/12/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a steep valley wall on the right side.

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

Date of inspection 8/12/96

DS left: Steep channel bank to a moderately sloped overbank

DS right: Steep channel bank and valley wall

US left: Steep channel bank to a moderately sloped overbank

US right: Steep channel bank and valley wall

Description of the Channel

Average top width 76 *ft* ***Average depth*** 4 *ft*

Predominant bed material Boulders/Cobbles ***Bank material*** Cobbles/Boulders

Sinuous with non-alluvial channel boundaries and irregular point and lateral bars.

8/12/96

Vegetative co Trees

DS left: Trees

DS right: Trees

US left: Sparse trees and grass

US right: No

Do banks appear stable? There has been a land slide on the upstream right bank, in the same area as the cut-bank. There are two cut-banks on the downstream left bank.

None as of 8/12/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 10.4 ***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 3,470 ***ft³/s*** ***Q500*** 5,200 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(10.4/10.1)exp 0.67] with flood frequency estimates available from the VTAOT database (written communication, May 1995) for bridge number 21 in Jamaica. Bridge number 21 crosses Ball Mountain Brook upstream of this site and a drainage area of 10.1 square miles. These area adjusted discharges are within a range defined by empirical flood frequency relationships (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

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the right abutment (elev. 501.13 ft, arbitrary survey datum). RM2 is a nail in a telephone pole 50 ft. from the bridge along the upstream side of the left road approach (elev. 506.37 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	-69	1	Exit section
FULLV	0	3	Full-valley section (Templated from EXITX and Modified)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	98	1	Approach section

[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 0.070 to 0.075, and the overbank "n" value was 0.075.

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 0.0236 ft/ft, which was the slope of the 100-year water surface profile downstream of the site according to the Flood Insurance Study for the town of Jamaica, Vermont (Federal Emergency Management Agency, May 17, 1988).

The surveyed approach section (APPRO) was 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.

For the 100-year and 500-year discharge, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it was 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 500.5 ***ft***
Average low steel elevation 497.3 ***ft***

100-year discharge 3,470 ***ft³/s***
Water-surface elevation in bridge opening 488.9 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 282 ***ft²***
Average velocity in bridge opening 12.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 15.6 ***ft/s***

Water-surface elevation at Approach section with bridge 493.9
Water-surface elevation at Approach section without bridge 491.8
Amount of backwater caused by bridge 2.1 ***ft***

500-year discharge 5,200 ***ft³/s***
Water-surface elevation in bridge opening 490.6 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 383 ***ft²***
Average velocity in bridge opening 13.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 17.4 ***ft/s***

Water-surface elevation at Approach section with bridge 495.8
Water-surface elevation at Approach section without bridge 493.1
Amount of backwater caused by bridge 2.7 ***ft***

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

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

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

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

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical laid-up stone abutment walls is unknown. Therefore, the total scour depth computed at the toe of the embankment was applied for the entire spill-through embankment, as shown in figure 8.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.1	0.5	--
Depth to armoring	15.0	17.2	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	8.1	10.6	--
Right abutment	9.9	11.0	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	2.1	2.7	--
Right abutment	2.1	2.7	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

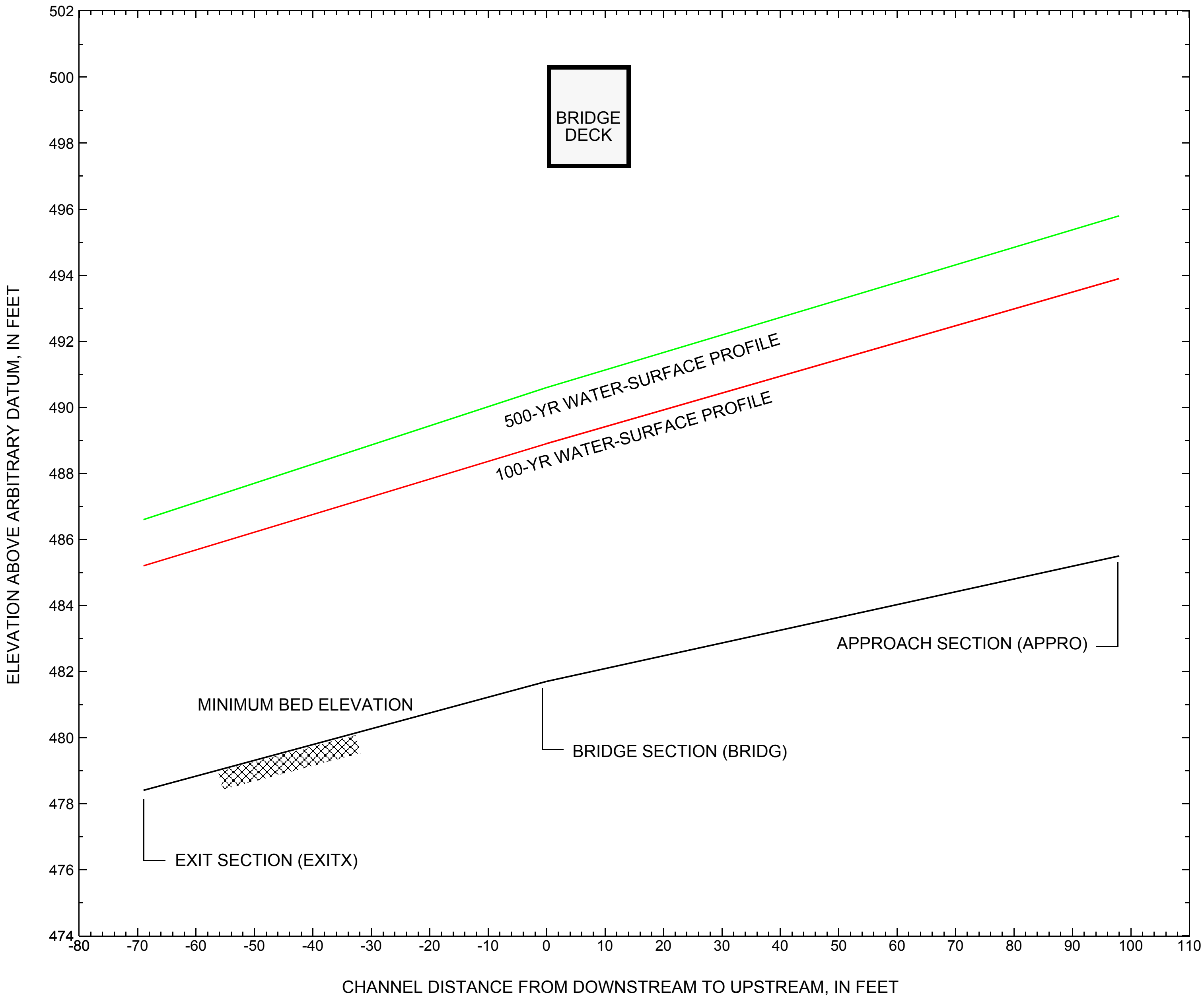

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JAMATH00300029 on Town Highway 30, crossing Ball Mountain Brook, Jamaica, Vermont.

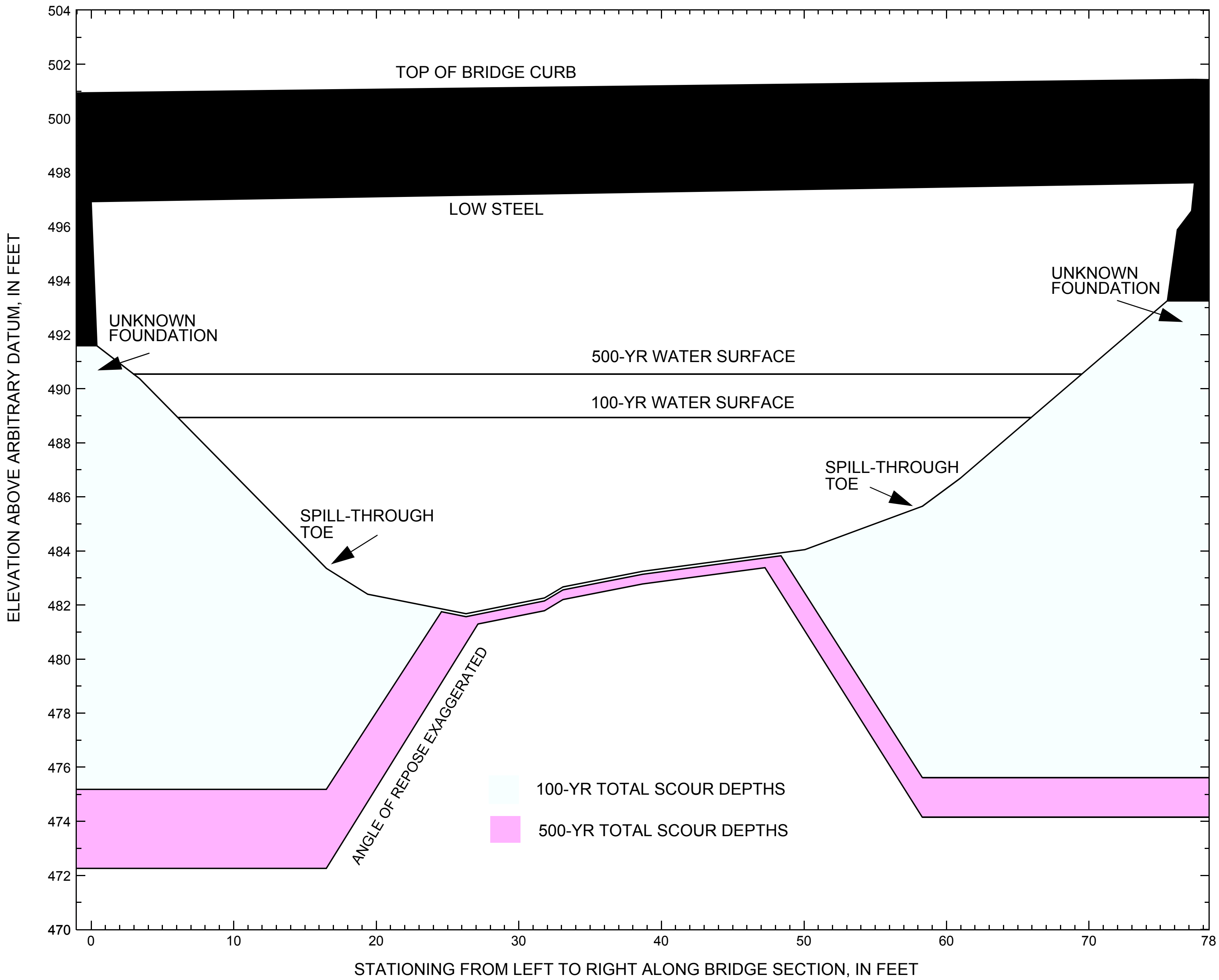

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure JAMATH00300029 on Town Highway 30, crossing Ball Mountain Brook, Jamaica, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-yr discharge at structure JAMATH00300029 on Town Highway 30, crossing Ball Mountain Brook, Jamaica, Vermont.

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

Description	Station[1]	VTAOT average bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr discharge is 3,470 cubic-feet per second											
Left abutment	0.0	--	496.9	--	491.6	--	--	--	--	--	--
LABUT toe	16.5	--	--	--	483.4	0.1	8.1	--	8.2	475.2	--
RABUT toe	58.3	--	--	--	485.7	0.1	9.9	--	10.0	475.7	--
Right abutment	77.4	--	497.6	--	493.3	--	--	--	--	--	--

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-yr discharge at structure JAMATH00300029 on Town Highway 30 crossing Ball Mountain Brook, Jamaica, Vermont.

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

Description	Station[1]	VTAOT average bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr discharge is 5,200 cubic-feet per second											
Left abutment	0.0	--	496.9	--	491.6	--	--	--	--	--	--
LABUT toe	16.5	--	--	--	483.4	0.5	10.6	--	11.1	472.3	--
RABUT toe	58.3	--	--	--	485.7	0.5	11.0	--	11.5	474.2	--
Right abutment	77.4	--	497.6	--	493.3	--	--	--	--	--	--

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, Jamaica, 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 jama029.wsp
T2        Hydraulic analysis for structure JAMATH00300029   Date: 23-JUN-97
T3     TH030 crossing Ball Mountain Brook, in Jamaica, Vermont      JRD
*
J3          6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            3470.0   5200.0
SK           0.0236   0.0236
*
XS   EXITX     -69            0.
GR          -24.8, 499.68    -13.4, 495.69      0.0, 487.14      4.6, 482.61
GR           18.0, 480.88     20.8, 480.18     30.4, 480.41     38.9, 479.80
GR           41.0, 480.89     52.2, 480.93     62.1, 479.87     72.0, 478.58
GR           84.4, 478.37     86.1, 482.11     89.7, 487.63    121.1, 498.95
GR          136.7, 497.52    159.6, 505.06
*
N            0.075
*
XS   FULLV       0
GR          -24.8, 500.89    -13.4, 496.90      0.0, 488.35      4.6, 483.82
GR           18.0, 482.09     20.8, 481.39     30.4, 481.62     38.9, 481.01
GR           41.0, 482.10     52.2, 482.14     62.1, 481.08     76.1, 483.32
GR           79.7, 488.84    111.1, 500.16    126.7, 498.73    149.6, 506.27
*
N            0.075
*
*              SRD      LSEL     XSSKEW
BR   BRIDG      0    497.27        0.0
GR            0.0, 496.92      0.4, 491.59      3.4, 490.37     16.5, 483.36
GR           19.4, 482.40     26.3, 481.68     31.8, 482.26     33.1, 482.67
GR           38.7, 483.25     50.1, 484.05     58.3, 485.65     61.0, 486.70
GR           75.5, 493.25     76.2, 495.88     77.2, 496.57     77.4, 497.62
GR            0.0, 496.92
*
*         BRTYPE  BRWDTH  EMBSS  EMBELV
CD           3      16.7    2.1   491.8
N            0.075
*
*              SRD    EMBWID   IPAVE
XR   RDWAY      8       14.0      2
GR         -328.1, 513.86   -257.0, 506.25    -81.0, 500.61      0.0, 500.24
GR            0.1, 500.44      0.1, 500.95     81.4, 501.44     81.4, 500.80
GR           81.9, 500.77    103.6, 501.41    115.8, 504.45    127.0, 515.92
*
AS   APPRO      98            0.
GR         -311.1, 513.26   -281.7, 507.33   -151.7, 503.87    -57.7, 501.93
GR          -52.6, 499.04    -17.9, 498.86      0.0, 489.52     19.3, 489.77
GR           26.4, 486.91     34.2, 486.19     37.7, 485.93     43.7, 485.78
GR           47.0, 485.50     52.6, 486.16     61.7, 486.64     71.4, 489.64
GR           87.9, 503.14
*
N            0.075         0.070
SA                 -17.9
*
HP 1 BRIDG   488.94 1 488.94
HP 2 BRIDG   488.94 * * 3470
HP 1 APPRO   493.87 1 493.87
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
         U.S. Geological Survey WSPRO Input File jama029.wsp
         Hydraulic analysis for structure JAMATH00300029   Date: 23-JUN-97
         TH030 crossing Ball Mountain Brook, in Jamaica, Vermont          JRD
            *** RUN DATE & TIME: 01-21-98  12:40

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

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     281.  15248.    60.    62.                        3461.
    488.94          281.  15248.    60.    62.  1.00     6.    66.   3461.

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        488.94     6.1    66.0   281.4   15248.    3470.  12.33

 X STA.         6.1       16.9       18.9       20.7       22.3       23.9
   A(I)            31.5       12.1       11.4       11.1       11.3
   V(I)            5.51      14.29      15.19      15.64      15.34

 X STA.        23.9       25.5       27.1       28.7       30.3       32.0
   A(I)            11.2       11.2       11.3       11.7       11.4
   V(I)           15.48      15.50      15.40      14.88      15.28

 X STA.        32.0       33.8       35.7       37.7       39.9       42.2
   A(I)            11.4       11.7       11.9       12.3       12.5
   V(I)           15.18      14.87      14.63      14.16      13.91

 X STA.        42.2       44.5       46.9       49.5       52.5       66.0
   A(I)            12.5       12.7       13.1       13.9       35.4
   V(I)           13.83      13.64      13.29      12.46       4.91

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      98.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              2     478.  31312.    85.    89.                        6438.
    493.87          478.  31312.    85.    89.  1.00    -8.    77.   6438.

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      98.

          WSEL     LEW     REW    AREA        K        Q    VEL
        493.87    -8.3    76.6   478.1   31312.    3470.   7.26

 X STA.        -8.3        8.5       16.0       22.9       26.6       29.4
   A(I)            54.5       31.5       31.1       23.1       19.7
   V(I)            3.18       5.50       5.58       7.52       8.81

 X STA.        29.4       32.1       34.6       37.0       39.4       41.7
   A(I)            19.8       19.4       19.0       19.0       18.0
   V(I)            8.74       8.92       9.15       9.12       9.63

 X STA.        41.7       44.0       46.4       48.8       51.3       53.8
   A(I)            19.1       19.4       19.8       19.8       19.8
   V(I)            9.10       8.94       8.76       8.76       8.75

 X STA.        53.8       56.4       59.2       61.9       65.1       76.6
   A(I)            19.6       20.3       20.2       21.4       43.6
   V(I)            8.84       8.55       8.60       8.12       3.98
```

```
        U.S. Geological Survey WSPRO Input File jama029.wsp
        Hydraulic analysis for structure JAMATH00300029   Date: 23-JUN-97
        TH030 crossing Ball Mountain Brook, in Jamaica, Vermont          JRD
           *** RUN DATE & TIME: 01-21-98  12:40

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     383.   23663.    67.    70.                        5215.
   490.55          383.   23663.    67.    70.  1.00     3.    70.   5215.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       490.55     3.0    69.5   383.1   23663.    5200.  13.57

X STA.         3.0      16.1       18.4       20.3       22.1       23.9
  A(I)            45.8       16.5       15.5       15.1       15.0
  V(I)            5.67      15.77      16.74      17.19      17.31

X STA.        23.9      25.6       27.3       29.1       30.9       32.8
  A(I)            15.3       14.9       15.4       15.7       15.7
  V(I)           17.03      17.40      16.93      16.57      16.57

X STA.        32.8      34.8       36.9       39.1       41.3       43.7
  A(I)            15.5       16.0       15.8       16.2       16.7
  V(I)           16.78      16.21      16.43      16.00      15.53

X STA.        43.7      46.1       48.6       51.3       54.3       69.5
  A(I)            16.4       16.9       17.3       18.0       49.2
  V(I)           15.89      15.36      15.04      14.41       5.29

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      98.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     650.   49512.    91.    96.                        9849.
   495.82          650.   49512.    91.    96.  1.00   -12.    79.   9849.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      98.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.82   -12.1    79.0   649.7   49512.    5200.   8.00

X STA.       -12.1       5.7       11.4       17.4       22.8       26.5
  A(I)            73.9       35.1       36.6       35.6       30.3
  V(I)            3.52       7.40       7.11       7.30       8.59

X STA.        26.5      29.5       32.4       35.1       37.8       40.3
  A(I)            27.3       26.3       26.2       26.3       25.1
  V(I)            9.52       9.89       9.93       9.87      10.37

X STA.        40.3      43.0       45.6       48.2       50.9       53.7
  A(I)            26.6       26.9       26.7       26.5       26.8
  V(I)            9.76       9.66       9.74       9.81       9.69

X STA.        53.7      56.5       59.4       62.3       65.8       79.0
  A(I)            27.1       27.3       26.9       29.5       62.6
  V(I)            9.59       9.53       9.65       8.83       4.15
```

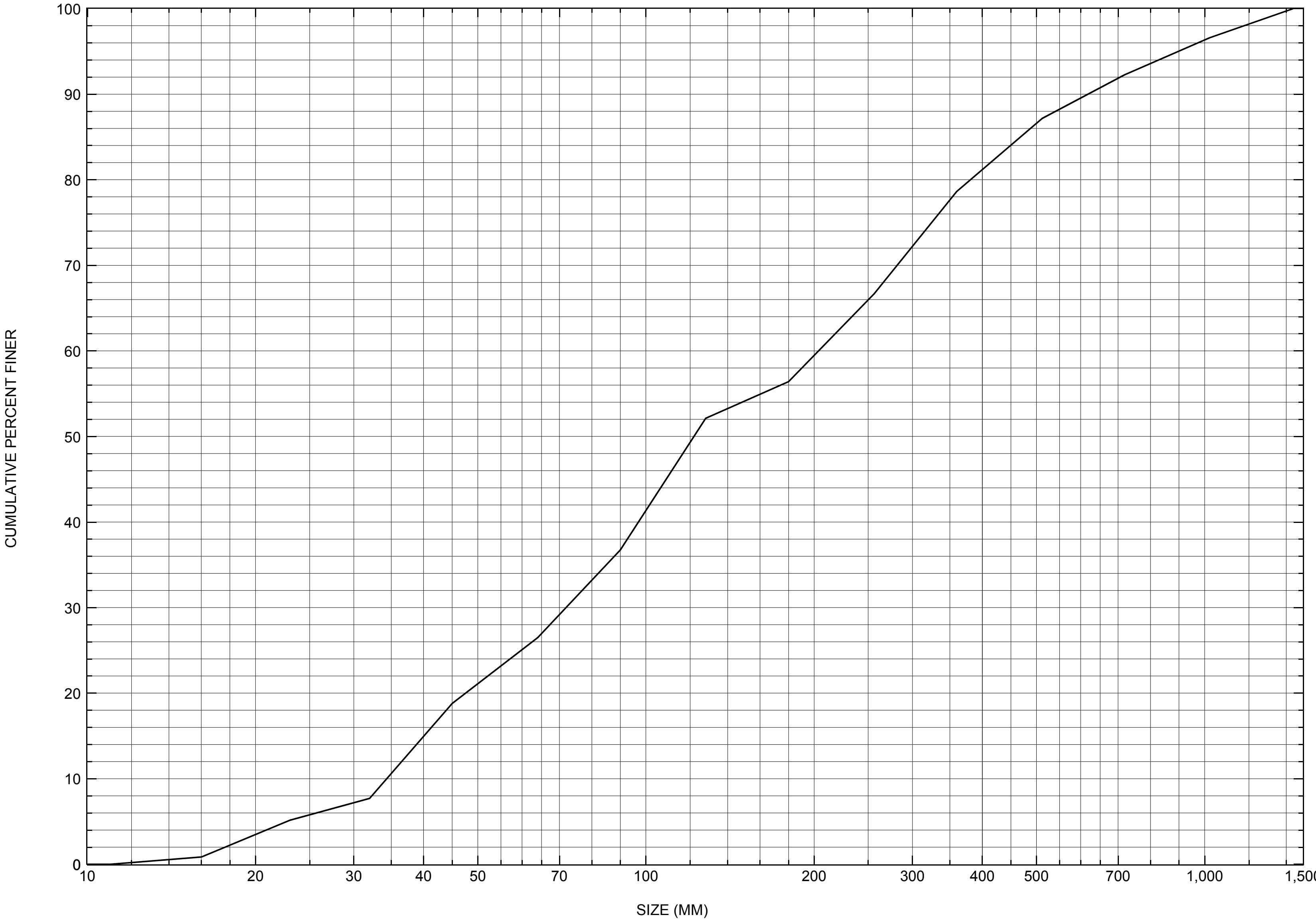
```
        U.S. Geological Survey WSPRO Input File jama029.wsp
        Hydraulic analysis for structure JAMATH00300029   Date: 23-JUN-97
        TH030 crossing Ball Mountain Brook, in Jamaica, Vermont          JRD
           *** RUN DATE & TIME: 01-21-98  12:40

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

EXITX:XS   ******     2.     416.  1.08 *****  486.31  484.07   3470.  485.23
      -69. ******    88.   22572.  1.00 ***** *******    0.67    8.35

FULLV:FV      69.     1.     363.  1.42  1.88  488.38 *******   3470.  486.96
        0.    69.    78.   19587.  1.00  0.17    0.02    0.78    9.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===120 YTOL NOT SATISFIED AT SECID "APPRO":  TRIALS CONTINUED.
                        YTOL,WSLIM1,WSLIM2 =  0.02     486.46     487.46
 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
               FNTEST,FR#,WSEL,CRWS =  0.80    1.27     491.18     491.78
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                    WSLIM1,WSLIM2,DELTAY =   486.46     513.26    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                    WSLIM1,WSLIM2,CRWS =   486.46     513.26     491.78
 ===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 =   491.78     513.26     491.78

APPRO:AS      98.    -4.     308.  1.98 *****  493.76  491.78   3470.  491.78
       98.    98.    74.   15980.  1.00 ***** *******    1.00   11.27
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                    SECID "BRIDG"     Q,CRWS =    3470.     488.94

            <<<<<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      69.     6.     282.  2.81 *****  491.75  488.94   3470.  488.94
        0.    69.    66.   15262.  1.19 ***** *******    1.09   12.32

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  0.917 ******  497.27 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<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      81.    -8.     479.  0.82  2.08  494.69  491.78   3470.  493.87
       98.    82.    77.   31353.  1.00  0.86    0.01    0.54    7.25

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.339  0.121   27503.    19.    79.   492.84

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -69.     2.    88.   3470.   22572.     416.    8.35  485.23
   FULLV:FV       0.     1.    78.   3470.   19587.     363.    9.56  486.96
   BRIDG:BR       0.     6.    66.   3470.   15262.     282.   12.32  488.94
   RDWAY:RG       8.**************      0.*****************     2.00********
   APPRO:AS      98.    -8.    77.   3470.   31353.     479.    7.25  493.87

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      19.    79.   27503.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    484.07    0.67  478.37  505.06************  1.08  486.31  485.23
   FULLV:FV  ********    0.78  481.01  506.27  1.88  0.17  1.42  488.38  486.96
   BRIDG:BR    488.94    1.09  481.68  497.62************  2.81  491.75  488.94
   RDWAY:RG  ****************  500.24  515.92**********************************
   APPRO:AS    491.78    0.54  485.50  513.26  2.08  0.86  0.82  494.69  493.87
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File jama029.wsp
        Hydraulic analysis for structure JAMATH00300029   Date: 23-JUN-97
        TH030 crossing Ball Mountain Brook, in Jamaica, Vermont          JRD
           *** RUN DATE & TIME: 01-21-98  12:40

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

EXITX:XS   ******     1.     538.  1.45 *****  488.09  485.25   5200.  486.63
      -69. ******    89.   33835.  1.00 ***** *******    0.69    9.66

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     488.30     487.47
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   486.13     506.27    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   486.13     506.27     487.47

FULLV:FV      69.     0.     468.  1.92  1.90  490.22  487.47   5200.  488.30
        0.    69.    79.   29068.  1.00  0.24    0.00    0.81   11.12
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80   11.97     487.82     493.07
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   487.80     513.26    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   487.80     513.26     493.07
 ===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 =   493.07     513.26     493.07

APPRO:AS      98.    -7.     411.  2.49 *****  495.56  493.07   5200.  493.07
       98.    98.    76.   24925.  1.00 ***** *******    1.00   12.64
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =   5200.     490.55

            <<<<<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      69.     3.     383.  3.42 *****  493.97  490.55   5200.  490.55
        0.    69.    70.   23654.  1.19 ***** *******    1.09   13.58

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  0.915 ******  497.27 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.         <<<<<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      81.   -12.     649.  1.00  2.04  496.81  493.07   5200.  495.82
       98.    88.    79.   49480.  1.00  0.81    0.01    0.53    8.01

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.305  0.119   43521.    14.    80.   494.89

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -69.     1.    89.   5200.   33835.     538.    9.66  486.63
   FULLV:FV       0.     0.    79.   5200.   29068.     468.   11.12  488.30
   BRIDG:BR       0.     3.    70.   5200.   23654.     383.   13.58  490.55
   RDWAY:RG       8.**************      0.******************     2.00********
   APPRO:AS      98.   -12.    79.   5200.   49480.     649.    8.01  495.82

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      14.    80.   43521.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    485.25    0.69  478.37  505.06************  1.45  488.09  486.63
   FULLV:FV    487.47    0.81  481.01  506.27  1.90  0.24  1.92  490.22  488.30
   BRIDG:BR    490.55    1.09  481.68  497.62************  3.42  493.97  490.55
   RDWAY:RG  ***************  500.24  515.92**********************************
   APPRO:AS    493.07    0.53  485.50  513.26  2.04  0.81  1.00  496.81  495.82
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JAMATH00300029, in Jamaica, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JAMATH00300029

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)* 000000

Waterway *(I - 6)* BALL MOUNTAIN BROOK

Road Name *(I - 7):* -

Route Number TH030

Vicinity *(I - 9)* 0.1 MI JCT TH 30 & TH 27

Topographic Map Jamaica

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43042

Longitude *(i - 17; nnnnn.n)* 72508

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10130900291309

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

Maximum span length *(I - 48; nnnn)* 0080

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

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

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)* 6

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

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

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

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*) 013.5

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 single span, steel beam type bridge with a timber deck. Both abutments are mortared stone with concrete bearing caps and backwalls. The right abutment is in generally good condition. New stone fill is in place along the left abutment wall. The waterway takes a moderate to sharp turn through the structure. The streambed consists of stone and boulders, with some gravel deposits. There is a large slope along the side of the river upstream from the right abutment.

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)* 10.42 mi^2

Lake/pond/swamp area 0.02 mi^2

Watershed storage *(ST)* 0.2 %

Bridge site elevation 1496 ft

Headwater elevation 3940 ft

Main channel length 6.65 mi

10% channel length elevation 1555 ft

85% channel length elevation 2244 ft

Main channel slope *(S)* 138.23 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:
The plan available is one page and provides no benchmark or footing information.

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	**511**	**512**	**534**	**554**	**564**	**579**	**586**	**589**	-	-	-
Feature	**LAB**	-	-	-	-	-	-	**RAB**	-	-	-
Low cord elevation	**1507.1**	**1507.1**	**1506.9**	**1506.7**	**1506.6**	**1506.4**	**1503.3**	**1506.3**	-	-	-
Bed elevation	-	**1502.5**	**1494.2**	**1493.2**	**1492.7**	**1493.2**	**1495.4**	-	-	-	-
Low cord to bed length	-	**4.6**	**12.7**	**13.5**	**13.9**	**13.2**	**10.9**	-	-	-	-

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: **11/6/96**
Computerized by: **RB** Date: **11/7/96**
Reviewd by: **JD** Date: **9/2/97**

Structure Number **JAMATH00300029**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **J**. **DEGNAN** Date *(MM/DD/YY)* **08** / **12** / 19**96**

2. Highway District Number **02** Mile marker **0000**
County **WINDHAM (025)** Town **JAMAICA (36175)**
Waterway *(I - 6)* **BALL MOUNTAIN BROOK** Road Name **-**
Route Number **TH030** Hydrologic Unit Code: **01080107**

3. Descriptive comments:
This wood decked bridge is 0.1 miles from the junction of TH 30 and TH 27.

B. Bridge Deck Observations

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

5. Ambient water surface... US **2** UB **2** DS **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 **80** *(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)*

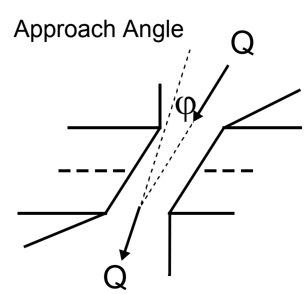
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

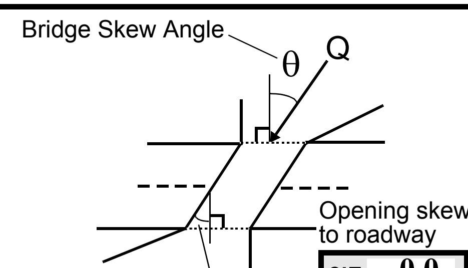
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	1	1	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	1	1	0	-

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





α= **0.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **170** feet **US** *(US, UB, DS)* to **40** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **0** feet **US** *(US, UB, DS)* to **90** feet **DS**

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

18. Bridge Type: **1b**

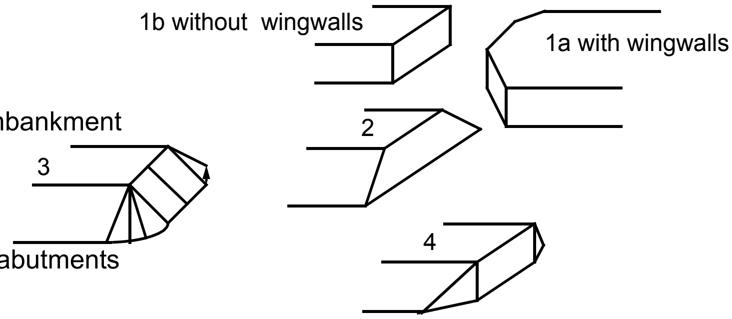
1a- Vertical abutments with wingwalls

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.)

4. The surface cover on the US left bank and the DS left bank is lawn beyond the trees that are along the bank.
7. Values are from the VTAOT files. Measured bridge dimensions match those in the historical form.
17. A third severe impact zone is on the left bank just beyond the DS confluence. The channel impacts bed-rock and switches direction by 90 degrees.

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
84.0	**3.0**			**3.0**	**3**	**3**	**543**	**543**	**2**	**3**

23. Bank width **20.0** 24. Channel width **15.0** 25. Thalweg depth **52.0** 29. Bed Material **543**

30 .Bank protection type: LB **2** RB **0** 31. Bank protection condition: LB **1** RB **-**

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

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

26. A land slide has occurred along the right bank, where the vegetation cover is between 0% and 25%. The cover noted above takes into account the undisturbed forest on the overbank. The right bank is also vegetated close to the bridge which helps to stabilize it.
30. The left bank protection extends from 25 ft US to 0 ft US. It is dumped stone.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **0** 35. Mid-bar width: **20**

36. Point bar extent: **90** feet **US** *(US, UB)* to **0** feet **DS** *(US, UB, DS)* positioned **60** %LB to **100** %RB

37. Material: **435**

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

There is an additional point bar positioned 0% LB to 40% RB with a mid-bar distance of 160 ft US extending from 175 ft US to 140 ft US. It consists of cobble, gravel and boulder and is 15 ft wide at mid-bar.

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: **110** 42. Cut bank extent: **175** feet **US** *(US, UB)* to **40** feet **US** *(US, UB, DS)*

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

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

-

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **55**

47. Scour dimensions: Length **15** Width **10** Depth : **2.5** Position **25** %LB to **80** %RB

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

This scour hole is caused by large boulders constricting flow. There are other areas of local scour around boulders. Assumed thalweg depth is 0.5 ft.

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

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

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

54. Confluence comments (eg. confluence name):

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)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
35.5		0.5		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.):

543

-

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

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

The wide opening and high deck protect this bridge from debris and ice, but the sharp channel bends US and DS could cause blockage.

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	0	-	-	90.0
RABUT	2	0	90			0	0	77.5

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

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

-

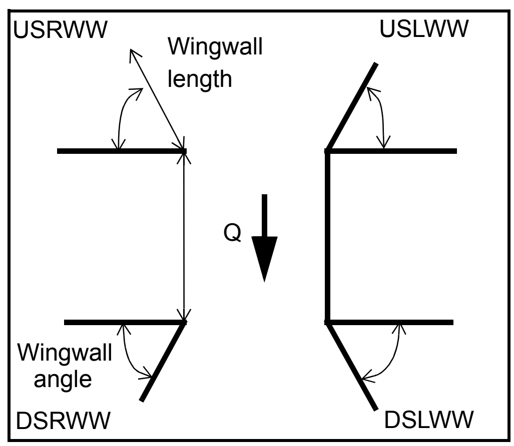
-

2

-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						77.5	
USRWW:	N		-		-	1.5	
DSLWW:	-		-		N	17.0	
DSRWW:	-		-		-	16.5	



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

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

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

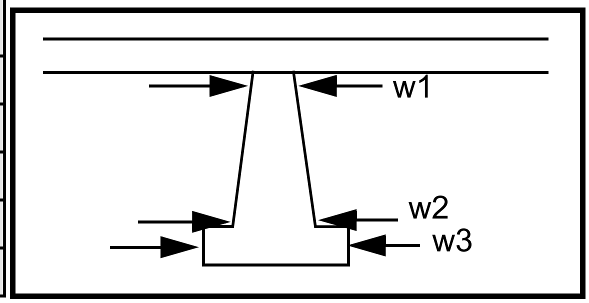
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

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



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e right	protec-	left	throug	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	abut	tion	bank	h	1- Solid pier, 2- column, 3- bent
88. Material	ment	is	pro-	slope	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	pro-	dum	tec-	s in	1- Round; 2- Square; 3- Pointed
90. Inclined?	tec-	ped	tion.	front	Y- yes; N- no
91. Attack ∠ (BF)	tion	stone	This	of	
92. Pushed	is rip	con-	pro-	each	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	rap.	tinu-	tec-	abut	
95. Cross-members	The	ing	tion	ment	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	left	from	form	.	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	abut	the	s		
98. Exposure depth	ment	US	spill-		

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

N
-
-

E. Downstream Channel Assessment

100.

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

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

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

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

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

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

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

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

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

-

-

NO PIERS

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

Cut bank extent: _____ 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.):

3

3

435

435

Is channel scour present? **2** *(Y or if N type ctrl-n cs)* Mid-scour distance: **2**

Scour dimensions: Length **543** Width **2** Depth: **2** Positioned **1** %LB to **3** %RB

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

The left bank protection is dumped stone continuing from the left abutment and extending to 20 ft DS. The right bank protection runs along the base of the road embankment and goes from the right abutment to 130 ft DS. At 70 ft DS it has been eroded and at 88 ft DS it becomes a stone wall.

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

***1**- Constructed*
***2**- Stable*
***3**- Aggraded*
***4**- Degraded*
***5**- Laterally unstable*
***6**- Vertically and laterally unstable*

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

N

-

NO DROP STRUCTURE

Y

190

45

40

DS

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: JAMATH00300029 Town: Jamaica
Road Number: TH030 County: Windham
Stream: Ball Mountain Brook

Initials JD Date: 06/30/97 Checked: EMB

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	3470	5200	0
Main Channel Area, ft2	478	650	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	85	91	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.4	0.4	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.6	7.1	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	31312	49512	0
Conveyance, main channel	31312	49512	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	3470.0	5200.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	7.3	8.0	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	11.0	11.5	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	3470	5200	0
(Q) discharge thru bridge, cfs	3470	5200	0
Main channel conveyance	15248	23663	0
Total conveyance	15248	23663	0
Q2, bridge MC discharge,cfs	3470	5200	ERR
Main channel area, ft2	281	383	0
Main channel width (normal), ft	50.9	54.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	50.9	54.1	0
y_bridge (avg. depth at br.), ft	5.52	7.08	ERR
Dm, median (1.25*D50), ft	0.5	0.5	0
y2, depth in contraction,ft	5.63	7.55	ERR
ys, scour depth (y2-ybridge), ft	0.11	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	3470	5200	N/A
Main channel area (DS), ft2	281	383	0
Main channel width (normal), ft	50.9	54.1	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	50.9	54.1	0.0
D90, ft	2.0262	2.0262	0.0000
D95, ft	2.9418	2.9418	0.0000
Dc, critical grain size, ft	1.2514	1.3191	ERR
Pc, Decimal percent coarser than Dc	0.200	0.187	0.000
Depth to armoring, ft	15.02	17.20	ERR

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)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	3470	5200	0	3470	5200	0
a', abut.length blocking flow, ft	19.6	21.9	0	14.4	15.1	0
Ae, area of blocked flow ft2	66.26	99.15	0	62.99	78.61	0
Qe, discharge blocked abut.,cfs	238.27	447.02	0	330.73	401.14	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.60	4.51	ERR	5.25	5.10	ERR
ya, depth of f/p flow, ft	3.38	4.53	ERR	4.37	5.21	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--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	0.345	0.373	ERR	0.442	0.394	ERR
ys, scour depth, ft	8.07	10.63	N/A	9.92	11.03	N/A

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)	19.6	21.9	0	14.4	15.1	0
y1 (depth f/p flow, ft)	3.38	4.53	ERR	4.37	5.21	ERR
a'/y1	5.80	4.84	ERR	3.29	2.90	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.34	0.37	N/A	0.44	0.39	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1.09	1.09	0	1.09	1.09	0
y, depth of flow in bridge, ft	5.52	7.08	0.00	5.52	7.08	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	2.36	3.03	ERR	2.36	3.03	ERR
Fr<=0.8 (spillthrough abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (spillthrough abut.)	2.09	2.68	ERR	2.09	2.68	ERR