LEVEL II SCOUR ANALYSIS FOR BRIDGE 80 (JAMAVT01000080) on STATE ROUTE 100, crossing the WEST RIVER, JAMAICA, VERMONT

U.S. Geological Survey
Open-File Report 97-214

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

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By MICHAEL A. IVANOFF & JAMES R. DEGNAN

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U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 80 (JAMAVT01000080) ON STATE ROUTE 100, CROSSING THE WEST RIVER, JAMAICA, VERMONT

By **Michael A. Ivanoff and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JAMAVT01000080 on State Route 100 crossing the West River, Jamaica, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in southern Vermont. The 227-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture on the upstream left bank and downstream of the bridge while the immediate banks have dense woody vegetation. The upstream right bank of the bridge is forested.

In the study area, the West River has an incised, straight channel with a slope of approximately 0.01 ft/ft, an average channel top width of 309 ft and an average bank height of 10 ft. The channel bed material is predominantly cobble with a median grain size (D_{50}) of 109 mm (0.359 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 13, 1996, indicated that the reach was stable.

The State Route 100 crossing of the West River is a 246-ft-long, one-lane steel thru-truss bridge consisting of three spans, the longest is 161-feet (Vermont Agency of Transportation, written communication, March 30, 1995). The bridge is supported by vertical, concrete abutments and two piers. The channel is skewed approximately 5 degrees to the opening while there is no opening-skew-to-roadway.

A scour hole 3 ft deeper than the mean thalweg depth was observed along the streamward (right) side of the left pier during the Level I assessment. A scour hole 5 ft deeper than the mean thalweg depth was observed along the streamward (left) side of the right pier 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 left and right bank below the abutments forming a “spill-through” slope at each 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 others, 1995). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

There was no computed contraction scour. Abutment scour ranged from 15.8 to 23.9 ft. The worst-case abutment scour occurred at the 500-year discharge. Pier scour ranged from 9.5 to 22.8 ft. The worst-case pier scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Townshend, VT. Quadrangle, 1:25,000, 1984

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 JAMAVT01000080 ***Stream*** West River

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

Description of Bridge

Bridge length 246 ***ft*** ***Bridge width*** 21.8 ***ft*** ***Max span length*** 161 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 08/13/96

Description of stone fill Type-2, along the left and right banks below the abutment walls forming a “spill-through” slope at each abutment.

Brief description of piers/abutments Vertical abutments and piers are concrete. There is a stone “spill-through” slope at each abutment. Under the main bridge span a 3 ft deep scour hole was observed along the left pier and a 5 ft deep scour hole along the right pier

Is bridge skewed to flood flow according to No ***survey?*** Yes ***Angle*** 5

Is bridge located on a bend in channel? If so, describe (mild, moderate, severe)

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	08/13/96	0	0
Level II	08/13/96	0	0

Potential for debris Moderate. There is some debris caught on the upstream side bar and blocking flow between the right pier and right spill-through abutment.

Describe any features near or at the bridge that may affect flow (include observation date) A large side bar along the right bank upstream extends through the bridge. Flow proceeds around the right side of the bar impacting the right pier 08/13/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a narrow flood plain and steep valley walls on both sides.

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

Date of inspection 08/13/96

DS left: Moderately sloping channel bank to a narrow flood plain.

DS right: Moderately sloping channel bank to a narrow flood plain.

US left: Moderately sloping channel bank to a narrow flood plain.

US right: Moderately sloping channel bank to the valley wall.

Description of the Channel

Average top width 309 ***ft*** ***Average depth*** 10 ***ft***

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

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

08/13/96

Vegetative co[ver] Trees and brush with pasture on the flood plain.

DS left: Trees and brush with pasture on the flood plain.

DS right: Trees and brush with pasture on the flood plain.

US left: Trees and brush.

US right: Yes

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

The assessment of 08/13/96 noted flow conditions are influenced by a side bar along the right bank side of the channel upstream. In addition, some debris is caught between the right pier and right spill-through abutment.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 227 ***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? Yes

USGS gage description West River at Jamaica, VT

USGS gage number 01155500

Gage drainage area 179 ***mi²***

Is there a lake/p Yes

Townshend Lake 3.8 miles downstream in Townshend, VT will cause backwater at the bridge. Ball Mountain Dam is upstream. Townshend Lake capacity is 1,460 million ft^3. Ball Mountain Lake capacity is 2,380 million ft^3 with a 172 square mile drainage area (U.S. Geological Survey Water-Data Report NH-VT-95-1).

Calculated Discharges

Q100 16,000 ***ft^3/s*** ***Q500*** 25,800 ***ft^3/s***

The 100- and 500-year discharges are based on the Flood Insurance Study for the West River in Jamaica, VT (Federal Emergency Management Agency, May 17, 1988). The 100-year discharge matched the same value from the VTAOT plans, see the historical form. The discharge values fell within a range of empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans Subtract 390.9 from the USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a nail 2.5 ft. high on a telephone pole at the right end of the downstream guard rail (elev. 502.80 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment bridge seat (elev. 497.53 ft, arbitrary survey datum). RM3 is a State of Vermont tablet set in a boulder on the upstream right bank near a garage off of River Rd. (elev. 507.69 ft, arbitrary survey datum).

survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-250	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	263	2	Modelled Approach section (Templated from APTEM)
APTEM	286	1	Approach section as surveyed (Used as a template)

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 0.035 to 0.045, and overbank "n" values ranged from 0.035 to 0.085.

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 0.0068 ft/ft which was estimated from the 100-year discharge water surface slope downstream of the bridge in the Flood Insurance Study for Jamaica, VT (Federal Emergency Management Agency, May 17, 1988). Downstream, Townshend Lake Dam forms backwater to the bridge up to the elevation of the spillway at 553.0 feet NGVD (493 feet USGS arbitrary survey datum). The backwater effects were not included in the analysis. During a flood event normal depth at the bridge would be the lowest potential depth.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0070 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

A two foot diameter concrete culvert was located along the base of the left road approach embankment draining water from the upstream left flood plain. The culvert was not included in the hydraulic analysis because it was assumed to have negligible effect at the modeled discharges.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.7 ***ft***
Average low steel elevation 495.6 ***ft***

100-year discharge 16,000 ***ft^3/s***
Water-surface elevation in bridge opening 489.1 ***ft***
Road overtopping? No ***Discharge over road*** -- ***s***
Area of flow in bridge opening 1,974 ***ft^2***
Average velocity in bridge opening 8.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.6 ***ft/s***

Water-surface elevation at Approach section with bridge 490.6
Water-surface elevation at Approach section without bridge 490.2
Amount of backwater caused by bridge 0.4 ***t***

500-year discharge 25,800 ***ft^3/s***
Water-surface elevation in bridge opening 490.7 ***ft***
Road overtopping? No ***Discharge over road*** --
Area of flow in bridge opening 2,320 ***ft^2***
Average velocity in bridge opening 11.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.0 ***/s***

Water-surface elevation at Approach section with bridge 492.9
Water-surface elevation at Approach section without bridge 492.2
Amount of backwater caused by bridge 0.7

Incipient overtopping discharge -- ***ft^3/s***
Water-surface elevation in bridge opening -- ***ft***
Area of flow in bridge opening -- ***ft^2***
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 -- ***t***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year discharge was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). Contraction scour for the 500-year discharge was computed by use of Laursen's live bed contraction scour equation (Richardson and others, 1995, p. 30, equations 17 and 18).

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

Pier scour was computed by use of the Colorado State University pier scour equation (Richardson and others, 1995, p. 36, equation 21). Variables for the Colorado State University pier scour equation include the Froude number of the flow approaching the pier, pier width to the depth of flow ratio, and correction factors for the pier nose shape, angle of attack of flow, bed condition, and armoring by bed material size.

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depths were applied for the entire spill-through embankment below the elevation at the toe of each embankment, as shown in figure 8. The right embankment scour depth was greater than the right pier scour depth and was extended under the pier.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	--
Depth to armoring	0.7	2.6	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	15.8	18.6	--
Right abutment	19.4	23.9	--
Pier scour			
Pier 1	9.5	14.4	--
Pier 2	15.0	22.8	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	1.9	3.4	--
Right abutment	1.9	3.4	--
Piers:			
Pier 1	1.0	1.8	--
Pier 2	1.0	1.8	--
	--	--	--

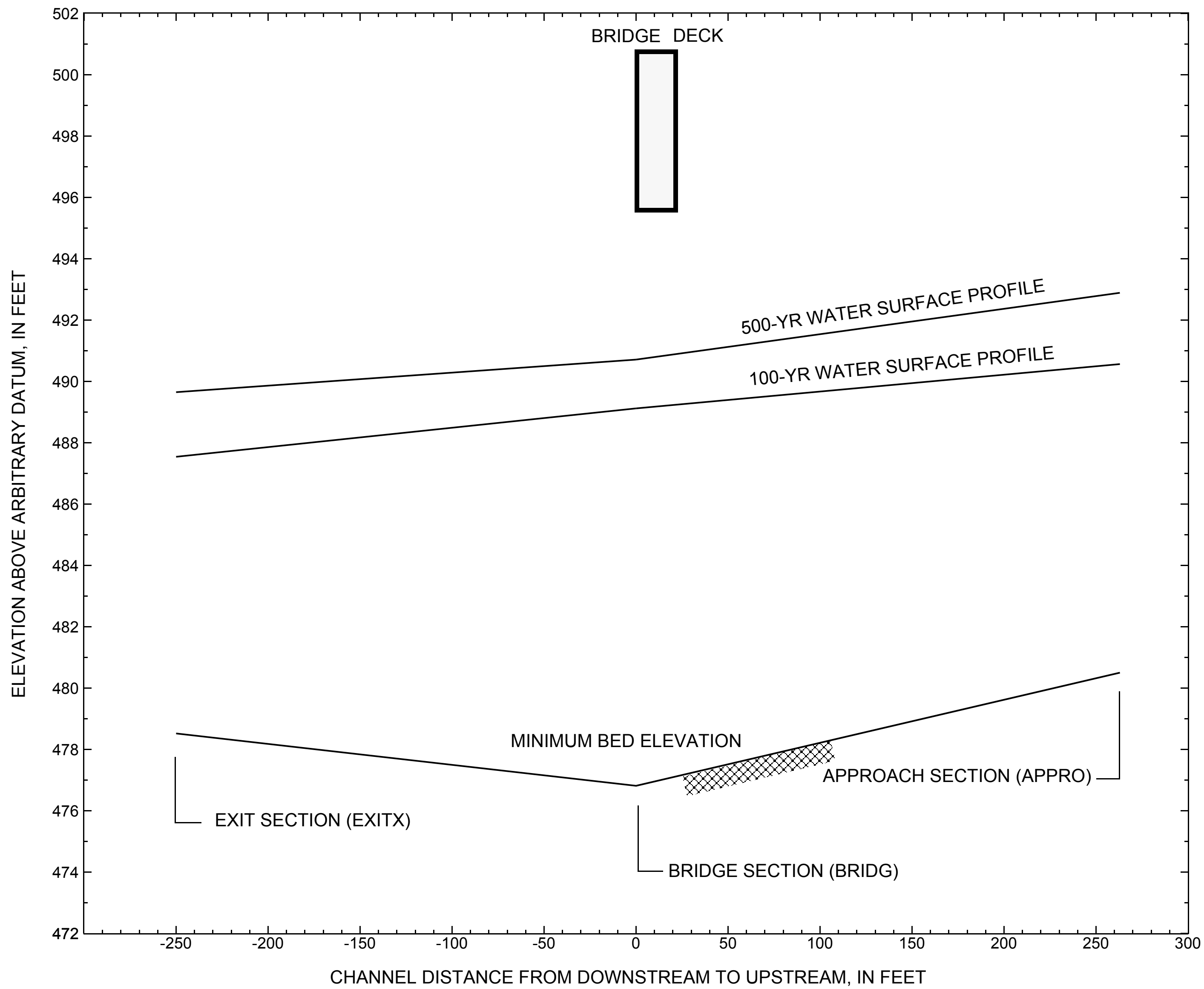

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JAMAVT01000080 on State Route 100, crossing the West River, Jamaica, Vermont.

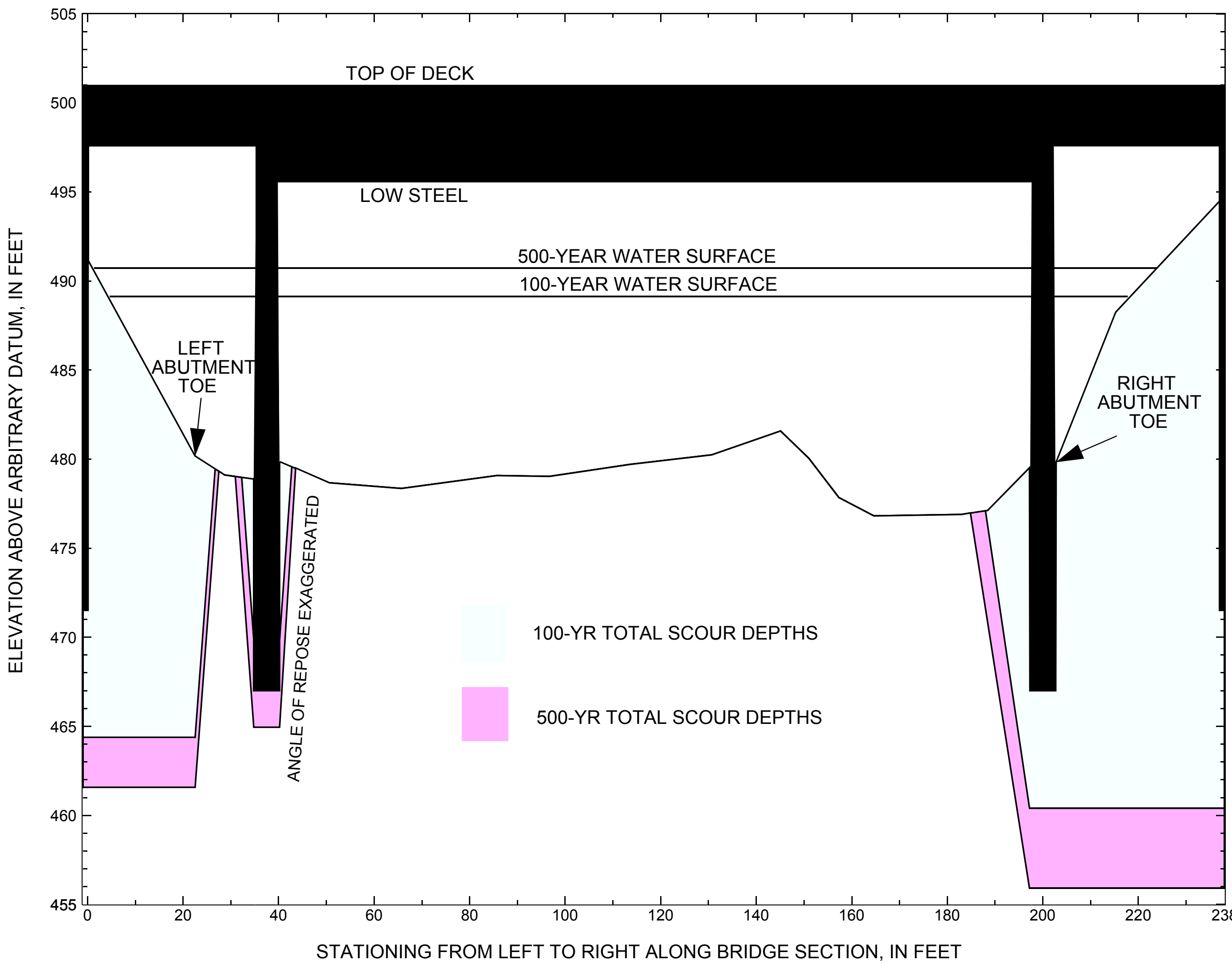

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure JAMAVT01000080 on State Route 100, crossing the West River, Jamaica, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JAMAVT01000080 on State Route 100, crossing the West River, Jamaica, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 16,000 cubic-feet per second											
Left abutment	0.0	106.6	497.6	471.5	491.2	0.0	--	--	--	--	-7.1
Toe of spill-through slope	22.5	--	--	--	480.2	0.0	15.8	--	15.8	464.4	--
Left Pier	37.5	--	495.6	467.0	479.4	0.0	--	9.5	9.5	469.9	2.9
Right Pier	200.0	--	495.6	467.0	480.0	0.0	--	15.0	15.0	465.0	-2.0
Toe of spill-through slope	202.5	--	--	--	479.8	0.0	19.4	--	19.4	460.4	--
Right abutment	237.1	106.6	497.6	471.5	494.5	0.0	--	--	--	--	-11.1

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure JAMAVT01000080 on State Route 100, crossing the West River, Jamaica, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 25,800 cubic-feet per second											
Left abutment	0.0	106.6	497.6	471.5	491.2	0.0	--	--	--	--	-9.9
Toe of spill-through slope	22.5	--	--	--	480.2	0.0	18.6	--	18.6	461.6	--
Left Pier	37.5	--	495.6	467.0	479.4	0.0	--	14.4	14.4	465.0	-2.0
Right Pier	200.0	--	495.6	467.0	480.0	0.0	--	22.8	22.8	457.2	-9.8
Toe of spill-through slope	202.5	--	--	--	479.8	0.0	23.9	--	23.9	455.9	--
Right abutment	237.1	106.6	497.6	471.5	494.5	0.0	--	--	--	--	-15.6

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, 1984, Townshend, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File jama080.wsp
T2        Hydraulic analysis for structure JAMAVT01000080   Date: 30-JAN-97
T3        Bridge # 80 on VT 100 over the West River in Jamaica, VT  by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           16000    25800
SK          0.0068   0.0068
*
*           Left overbank of EXITX assumed flat. The width of the floodplain
*           taken from FEMA model.
*
XS   EXITX   -250
GR         -941.0, 505.40   -910.0, 492.40   -882.0, 489.90    -30.3, 489.90
GR          -19.6, 488.44     -7.6, 487.84      0.0, 486.33     31.3, 482.85
GR           49.6, 479.63     62.3, 479.28     75.2, 478.52    106.0, 478.81
GR          147.5, 478.88    158.6, 479.61    164.1, 480.12    195.5, 483.30
GR          269.9, 485.41    284.5, 494.81    302.1, 494.30    307.0, 492.35
GR          581.9, 499.76    688.4, 507.77    726.5, 508.04    757.2, 523.39
N           0.035       0.040       0.085
SA                -30.3       284.5
*
XS   FULLV      0  * * *   0.0023
*
*             SRD     LSEL    XSSKEW
BR   BRIDG      0    495.60       0.0
GR            0.0, 497.60      0.0, 494.35      0.5, 491.17     22.5, 480.18
GR           28.7, 479.11     34.7, 478.88     40.4, 479.83     50.6, 478.67
GR           65.7, 478.35     85.7, 479.08     96.7, 479.03    113.7, 479.71
GR          130.8, 480.24    145.1, 481.57    151.0, 480.04    157.3, 477.83
GR          164.6, 476.81    183.0, 476.89    188.5, 477.12    197.2, 479.51
GR          197.2, 480.13    202.5, 479.82    215.3, 488.24    232.5, 494.46
GR          237.0, 497.49    237.1, 497.60    202.5, 497.60    202.5, 495.60
GR           34.7, 495.60     34.7, 497.60      0.0, 497.60
CD           1      25.8
PW          480.26, 10.8  495.80, 8.5
N           0.035
*
XR   RDWAY     13      21.8     1
GR         -575.0, 510.00   -575.0, 500.29   -470.9, 500.36   -150.2, 501.08
GR            0.0, 500.83      0.1, 500.83      0.2, 501.46    120.9, 502.05
GR          242.3, 501.49    242.4, 500.68    277.4, 500.40    447.0, 503.13
GR          606.2, 510.58    808.9, 527.34
*
*           First line of GR data below was taken from FEMA flood
*           insurance study. (From left edge to left top of bank)
*
XT   APTEM    286
GR         -641.3, 499.90   -620.3, 493.00   -522.3, 492.90    -60.3, 493.20
GR          -23.3, 493.28     -6.5, 486.34      0.0, 483.95     11.1, 482.19
GR           19.4, 481.78     41.8, 480.68     51.1, 480.66     56.8, 481.39
GR           68.7, 481.55     81.0, 481.55     84.3, 482.17     88.9, 483.03
GR          106.2, 484.30    129.0, 485.03    188.1, 486.84    207.7, 485.54
GR          229.4, 483.50    270.0, 483.95    278.1, 490.24    299.2, 491.75
GR          321.1, 498.08    459.2, 507.43
*
AS   APPRO   263
```

```
GT             -0.16  -23.3
N            0.085        0.035        0.065         0.045
SA                 -23.3        129.0        207.7
*
HP 1 BRIDG   489.12 1 489.12
HP 2 BRIDG   489.12 * * 16000
HP 2 BRIDG   489.17 * * 16000
HP 1 APPRO   490.56 1 490.56
HP 2 APPRO   490.56 * * 16000
*
HP 1 BRIDG   490.71 1 490.71
HP 2 BRIDG   490.71 * * 25800
HP 2 BRIDG   490.79 * * 25800
HP 1 APPRO   492.89 1 492.89
HP 2 APPRO   492.89 * * 25800
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File jama080.wsp
        Hydraulic analysis for structure JAMAVT01000080   Date: 30-JAN-97
        Bridge # 80 on VT 100 over the West River in Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-03-97  13:11
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1975.  363310.   213.   220.                       34114.
   489.12         1975.  363310.   213.   220.  1.00     5.   218.  34114.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       489.12     4.6   217.7  1974.9  363310.   16000.   8.10

X STA.         4.6        29.0        39.1        49.4        58.3        66.7
  A(I)            142.0       101.2       100.5        93.1        90.5
  V(I)             5.63        7.91        7.96        8.59        8.84

X STA.        66.7        75.3        84.3        93.3       102.6       112.4
  A(I)             90.6        92.2        90.6        92.7        95.2
  V(I)             8.83        8.68        8.83        8.63        8.40

X STA.       112.4       122.9       134.0       147.3       157.6       164.7
  A(I)             97.0        99.2       107.3        98.7        84.6
  V(I)             8.25        8.06        7.45        8.11        9.46

X STA.       164.7       171.5       178.5       186.0       194.3       217.7
  A(I)             83.7        85.5        91.2        95.3       143.9
  V(I)             9.55        9.36        8.77        8.39        5.56

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       489.17     4.5   217.9  1985.6  366298.   16000.   8.06

X STA.         4.5        29.0        39.1        49.4        58.3        66.7
  A(I)            142.5       101.8       101.1        93.6        91.0
  V(I)             5.61        7.86        7.91        8.54        8.79

X STA.        66.7        75.3        84.3        93.3       102.6       112.4
  A(I)             91.1        92.7        91.2        93.3        95.8
  V(I)             8.78        8.63        8.78        8.58        8.35

X STA.       112.4       122.8       133.9       147.2       157.3       164.7
  A(I)             96.9        99.2       107.4        98.0        87.1
  V(I)             8.25        8.06        7.45        8.16        9.18

X STA.       164.7       171.6       178.6       185.9       194.4       217.9
  A(I)             85.6        85.9        89.7        97.6       143.9
  V(I)             9.34        9.31        8.91        8.20        5.56

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     263.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2    1128.  186058.   146.   148.                       17779.
             3     372.   23958.    79.    79.                        4582.
             4     450.   47287.    77.    79.                        6159.
   490.56         1949.  257303.   302.   306.  1.27   -17.   285.  24951.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     263.

         WSEL     LEW     REW    AREA        K        Q    VEL
       490.56   -17.1   284.8  1948.8  257303.   16000.   8.21

X STA.       -17.1         7.3        17.0        25.3        32.9        40.2
  A(I)            113.3        82.4        75.2        71.1        71.2
  V(I)             7.06        9.71       10.64       11.25       11.24

X STA.        40.2        46.9        53.6        61.0        68.6        76.2
  A(I)             67.8        66.4        69.9        70.2        69.8
  V(I)            11.80       12.06       11.44       11.40       11.46

X STA.        76.2        84.1        94.2       106.6       121.4       147.2
  A(I)             71.4        79.1        84.4        91.5       142.6
  V(I)            11.20       10.11        9.47        8.74        5.61

X STA.       147.2       194.2       221.4       237.1       253.0       284.8
  A(I)            209.3       143.9       110.1       111.9       147.5
  V(I)             3.82        5.56        7.26        7.15        5.43
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File jama080.wsp
       Hydraulic analysis for structure JAMAVT01000080   Date: 30-JAN-97
       Bridge # 80 on VT 100 over the West River in Jamaica, VT  by MAI
          *** RUN DATE & TIME: 03-03-97  13:11
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#    AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1    2320.  463597.   221.   228.                       42677.
  490.71         2320.  463597.   221.   228.  1.00     1.   222.  42677.

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      490.71     1.4   222.1  2319.8  463597.   25800.  11.12

X STA.        1.4       27.7       38.3       48.3       57.5       66.0
  A(I)           168.6      122.4      113.5      110.8      104.3
  V(I)            7.65      10.54      11.37      11.64      12.37

X STA.       66.0       74.8       83.8       93.0      102.1      111.9
  A(I)           107.0      106.6      107.5      106.2      109.7
  V(I)           12.05      12.10      12.00      12.14      11.76

X STA.      111.9      122.0      132.8      145.3      156.0      163.7
  A(I)           110.4      113.9      121.7      114.3      101.7
  V(I)           11.69      11.33      10.60      11.28      12.69

X STA.      163.7      170.9      178.4      185.9      195.0      222.1
  A(I)            99.1      104.4      103.8      117.9      176.1
  V(I)           13.01      12.36      12.43      10.94       7.32

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      490.79     1.3   222.4  2337.5  468932.   25800.  11.04

X STA.        1.3       27.8       38.3       48.4       57.3       66.0
  A(I)           171.5      123.0      114.1      108.3      107.9
  V(I)            7.52      10.49      11.31      11.91      11.96

X STA.       66.0       74.8       83.7       93.0      102.2      111.8
  A(I)           107.5      107.1      108.0      108.5      108.6
  V(I)           12.00      12.04      11.94      11.89      11.88

X STA.      111.8      122.0      132.8      145.0      156.1      163.8
  A(I)           111.7      115.3      119.4      118.8      102.7
  V(I)           11.54      11.19      10.80      10.86      12.57

X STA.      163.8      170.9      178.2      186.0      195.1      222.4
  A(I)           100.0      101.2      108.7      118.7      176.6
  V(I)           12.90      12.75      11.87      10.87       7.31

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     263.

    WSEL  SA#    AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            2    1475.  283211.   152.   154.                       26088.
            3     555.   46751.    79.    79.                        8362.
            4     658.   77327.    96.    98.                        9780.
  492.89         2688.  407289.   326.   331.  1.27    -23.   304.  38890.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     263.

        WSEL     LEW     REW    AREA        K        Q    VEL
      492.89   -22.7   303.7  2687.9  407289.   25800.   9.60

X STA.      -22.7        5.8       16.2       25.4       33.7       41.6
  A(I)           161.4      111.0      104.4       98.3       95.7
  V(I)            7.99      11.62      12.36      13.12      13.48

X STA.       41.6       49.1       57.0       65.1       73.4       81.7
  A(I)            93.0       95.4       93.9       95.4       95.3
  V(I)           13.88      13.52      13.74      13.52      13.54

X STA.       81.7       91.4      102.8      116.0      131.5      162.5
  A(I)           102.4      107.4      113.8      127.6      231.1
  V(I)           12.59      12.01      11.34      10.11       5.58

X STA.      162.5      200.6      222.6      238.5      255.1      303.7
  A(I)           251.7      174.1      149.5      155.3      231.1
  V(I)            5.12       7.41       8.63       8.30       5.58
```

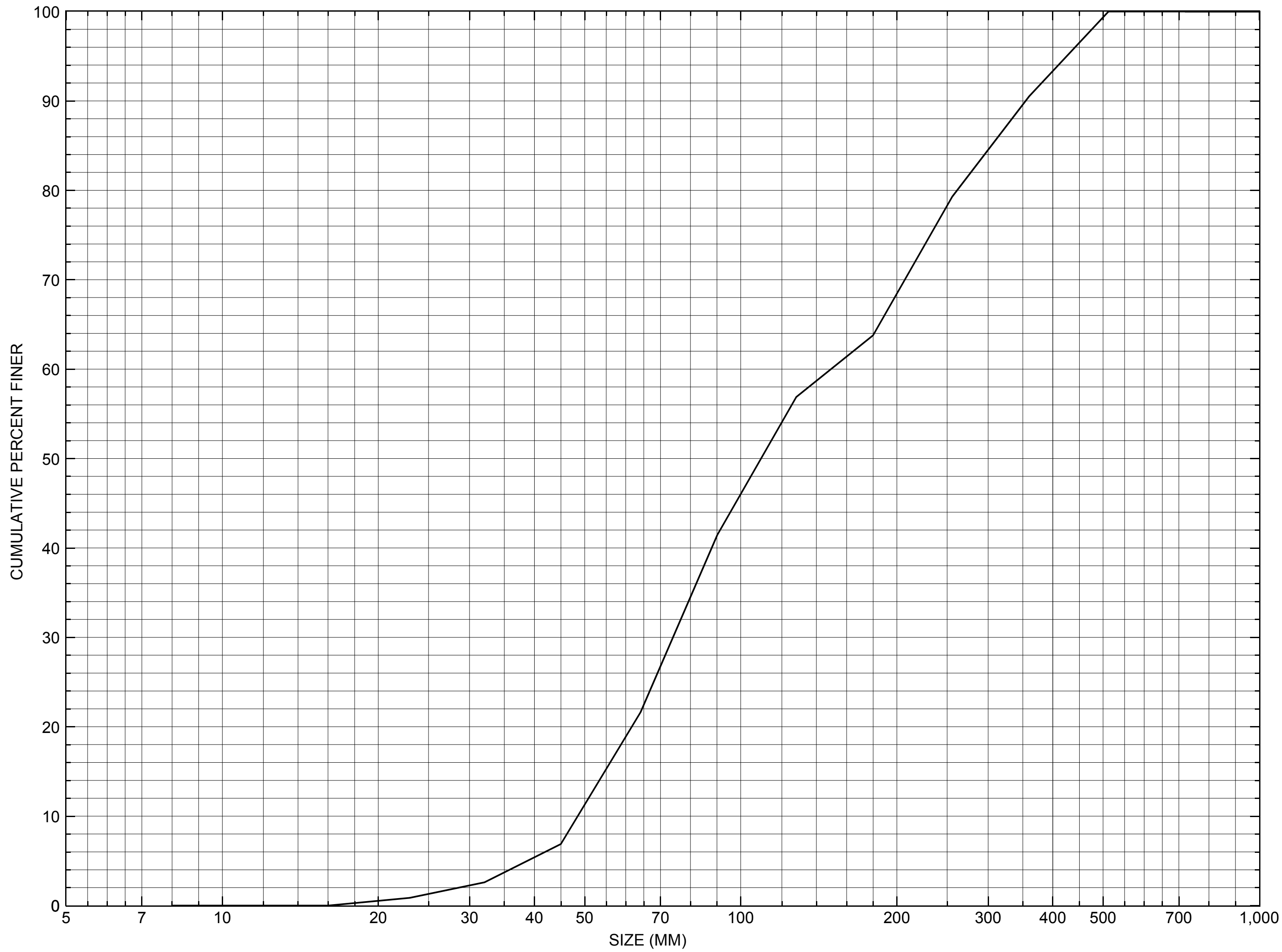
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File jama080.wsp
        Hydraulic analysis for structure JAMAVT01000080   Date: 30-JAN-97
        Bridge # 80 on VT 100 over the West River in Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-03-97  13:11

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

EXITX:XS   ******    -6.    1619.  1.52 *****  489.06  486.36  16000.  487.54
     -250. ******   273.  193841.  1.00 ***** *******    0.72    9.88

FULLV:FV     250.   -22.    1963.  1.03  1.29  490.35 *******  16000.  489.32
        0.   250.   275.  256511.  1.00  0.00    0.00    0.56    8.15
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS     263.   -16.    1839.  1.48  1.10  491.68 *******  16000.  490.19
      263.   263.   280.  237813.  1.26  0.22    0.00    0.69    8.70
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR     250.     5.    1974.  1.55  1.61  490.67  485.35  16000.  489.12
        0.   250.   218.  363191.  1.52  0.00   -0.01    0.58    8.10

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1.   0.   1.  0.811  0.046  495.60 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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     237.   -17.    1950.  1.33  1.17  491.89  488.82  16000.  490.56
      263.   242.   285.  257546.  1.27  0.05   -0.01    0.64    8.20

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.277  0.204  205675.   -23.   190.   489.64

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS    -250.    -6.   273.  16000.  193841.    1619.    9.88  487.54
   FULLV:FV       0.   -22.   275.  16000.  256511.    1963.    8.15  489.32
   BRIDG:BR       0.     5.   218.  16000.  363191.    1974.    8.10  489.12
   RDWAY:RG      13.**************       0.******************    1.00********
   APPRO:AS     263.   -17.   285.  16000.  257546.    1950.    8.20  490.56

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     -23.   190.  205675.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    486.36    0.72  478.52  523.39************  1.52  489.06  487.54
   FULLV:FV  ********    0.56  479.10  523.97  1.29  0.00  1.03  490.35  489.32
   BRIDG:BR    485.35    0.58  476.81  497.60  1.61  0.00  1.55  490.67  489.12
   RDWAY:RG  ****************  500.29  527.34**********************************
   APPRO:AS    488.82    0.64  480.50  507.27  1.17  0.05  1.33  491.89  490.56
```

```
        U.S. Geological Survey WSPRO Input File jama080.wsp
        Hydraulic analysis for structure JAMAVT01000080   Date: 30-JAN-97
        Bridge # 80 on VT 100 over the West River in Jamaica, VT  by MAI
           *** RUN DATE & TIME: 03-03-97  13:11

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

EXITX:XS   ******   -28.    2236.  2.07 *****  491.72  488.25  25800.  489.65
     -250. ******   276.  312864.  1.00 ***** *******    0.75   11.54

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  1.58

FULLV:FV     250.  -897.    3919.  0.94  1.07  492.79 *******  25800.  491.85
        0.   250.   279.  495487.  1.40  0.00    0.00    0.75    6.58
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS     263.   -21.    2470.  2.16  0.98  494.38 *******  25800.  492.22
      263.   263.   301.  359352.  1.28  0.61    0.00    0.75   10.45
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR     250.     1.    2320.  2.70  1.65  493.41  487.68  25800.  490.71
        0.   250.   222.  463764.  1.40  0.04   -0.01    0.72   11.12

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1.   0.   1.  0.844  0.045  495.60 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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     237.   -23.    2687.  1.82  1.22  494.70  490.60  25800.  492.89
      263.   241.   304.  407088.  1.27  0.08    0.01    0.66    9.60

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.303  0.205  323174.   -23.   197.   491.92

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS    -250.   -28.   276.  25800.  312864.    2236.   11.54  489.65
   FULLV:FV       0.  -897.   279.  25800.  495487.    3919.    6.58  491.85
   BRIDG:BR       0.     1.   222.  25800.  463764.    2320.   11.12  490.71
   RDWAY:RG      13.**************       0.*****************    1.00********
   APPRO:AS     263.   -23.   304.  25800.  407088.    2687.    9.60  492.89

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     -23.   197.  323174.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    488.25    0.75  478.52  523.39************  2.07  491.72  489.65
   FULLV:FV  ********    0.75  479.10  523.97  1.07  0.00  0.94  492.79  491.85
   BRIDG:BR    487.68    0.72  476.81  497.60  1.65  0.04  2.70  493.41  490.71
   RDWAY:RG  ****************  500.29  527.34**********************************
   APPRO:AS    490.60    0.66  480.50  507.27  1.22  0.08  1.82  494.70  492.89
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JAMAVT01000080, in Jamaica, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JAMAVT01000080

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)* 003440

Waterway *(I - 6)* WEST RIVER

Road Name *(I - 7):* -

Route Number VT100

Vicinity *(I - 9)* 0.2 MI S JCT. VT 30 S

Topographic Map Townshend

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43044

Longitude *(i - 17; nnnnn.n)* 72442

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20001300801309

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

Maximum span length *(I - 48; nnnn)* 0161

Year built *(I - 27; YYYY)* 1929

Structure length *(I - 49; nnnnnn)* 000246

Average daily traffic, ADT *(I - 29; nnnnnn)* 001140

Deck Width *(I - 52; nn.n)* 218

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

Channel & Protection *(I - 61; n)* 6

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

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

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

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

Structure type *(I - 43; nnn)* 310

Year Reconstructed *(I - 106)* 0000

Approach span structure type *(I - 44; nnn)* 302

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 17.0

Number of approach spans *(I - 46; nnnn)* 0002

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

Comments:

The structural inspection report of 11/04/93 indicates the structure is a steel thru-truss type bridge with steel beam approach spans and an asphalt road surface. Both abutments are concrete with skeletal type walls. The right abutment has some random minor rust stains and spalls. The left abutment has a few more cracks than the right abutment, but overall the concrete appears sound. Both solid pier stems have some random minor cracks, stains, and spalls. The footings are not in view. The waterway has a fairly straight alignment through the structure. It is diverted upstream slightly by a large gravel point bar with heavy vegetation growing along it, upstream of the right pier. **(Continued, page 32)**

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **233.8**

Terrain character: **Mountainous**

Stream character & type: **Stream flow controlled by U.S. Army Corp of Engineers dam. The dams dampen rise of flashy tributaries below Ball Mountain reservoir.**

Streambed material: **Deep, dense, sandy gravel covered by boulder layer**

Discharge Data *(cfs)*: $Q_{2.33}$ **3350** Q_{10} **7000** Q_{25} **10000**

Q_{50} **13000** Q_{100} **16000** Q_{500} ____

Record flood date *(MM / DD / YY)*: **11** / ___ / **27** Water surface elevation *(ft)*: **555.0**

Estimated Discharge *(cfs)*: **26000** Velocity at Q **25** *(ft/s)*: ____

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

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

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: **Uncontrolled tributaries below the Ball Mountain reservoir are flashy. Dam operations dampen rise.**

Watershed storage area (*in percent*): **1.2** %

The watershed storage area is: **3** (*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*)	**544.18**	**546.46**	**547.53**	**548.41**	**549.15**
Velocity (*ft / sec*)	**4.04**	**5.56**	**6.77**	**7.84**	**8.82**

Long term stream bed changes: **The above water surface elevations are in NGVD**

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

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

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

Upstream distance (*miles*): **1.35** Town: **-** Year Built: ____

Highway No. : **VT 30** Structure No. : **29** Structure Type: **-**

Clear span (*ft*): **204.0** Clear Height (*ft*): **40.0** Full Waterway (*ft²*): **-**

Downstream distance (*miles*): 3.8 Town: - Year Built: -
Highway No. : DAM Structure No. : - Structure Type: -
Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (*ft*^{2}): -

Comments:

There is minor scour at the left and right piers. The streambed consists of stone and gravel with some boulders. The downstream structure is the Townsend dam maintained and operated by the U.S. Army Corp of Engineers.
Bid let date for replacement project 11/30/96.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 227.37 mi^2 Lake and pond area 2.65 mi^2
Watershed storage *(ST)* 1.16 %
Bridge site elevation 561 ft Headwater elevation 2464 ft
Main channel length 27.79 mi
10% channel length elevation 643 ft 85% channel length elevation 1450 ft
Main channel slope *(S)* 38.72 ft / mi

Watershed Precipitation Data

Average site precipitation ______ in Average headwater precipitation ______ in

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

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

Are plans available? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: 08 / 1928

Project Number FR 63 A Minimum channel bed elevation: 85.0

Low superstructure elevation: USLAB 106.57 DSLAB 106.57 USRAB 106.58 DSRAB 106.58

Benchmark location description:
NO BENCHMARK LOCATION INFORMATION.

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

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

If 1: Footing Thickness 3.0* Footing bottom elevation: 80.57

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:
Left pier top elevation: 106.87 bottom of footing: 76.10. Right pier top elevation: 106.89, bottom of footing: 76.12. Both piers have a 3 foot thick footing.
***The footing thickness shown above is on the right abutment. The left abutment footing is about four feet thick. Other points shown with elevations are: 1) the point on the roadway at the right abutment approximately 40 feet to right of right edge of water, elevation 109.8. 2) The roadway surface at the right pier, elevation 110.11, 3) the roadway surface at left pier, elevation 110.09, and 4) the roadway surface at the left abutment approximately 40 feet to left of left edge of water, elevation 109.79.**

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.**
Lpier and Rpier are defined as the left and right bottom edges of the piers.
Elevations are in NGVD.

Station	720	742	755.7	760	792	827	873	918	922.3	933	957.5
Feature	LAB	-	Lpier1	Rpier1	-	-	-	Lpier2	Rpier2	-	RAB
Low cord elevation	558.1	558.1	558.1	558.1	558.1	558.1	558.1	558.1	558.1	558.1	558.1
Bed elevation	553.5	541.6	538.5	538	539.1	539.4	540.9	536.9	537.4	544.1	554.4
Low cord to bed length	4.6	16.5	19.6	20.1	19	18.7	17.2	21.2	20.7	14	3.7

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

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

Comments: -
-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **09/26/96**
Computerized by: **RB** Date: **09/26/96**
Reviewd by: **MAI** Date: **03/07/97**

Structure Number **JAMAVT01000080**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **J. DEGNAN** Date *(MM/DD/YY)* **08** / **13** / 19**96**

2. Highway District Number **02**
Mile marker **003440**
County **025 WINDHAM**
Town **36175 JAMAICA**
Waterway *(I - 6)* **WEST RIVER**
Road Name **-**
Route Number **VT100**
Hydrologic Unit Code: **01080107**

3. Descriptive comments:
This is a steel thru-truss type bridge located 0.2 miles south of the junction with VT 30 South.

B. Bridge Deck Observations

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

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

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

7. Bridge length **246** *(feet)* Span length **161** *(feet)* Bridge width **21.8** *(feet)*

Road approach to bridge:

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

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

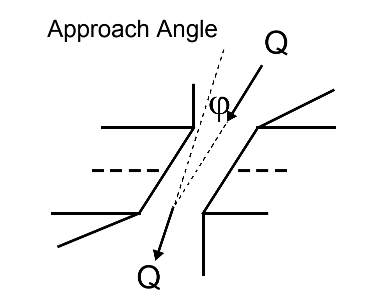
10. Embankment slope (*run / rise in feet / foot*):
US left **0.0:1** US right **0.0:1**

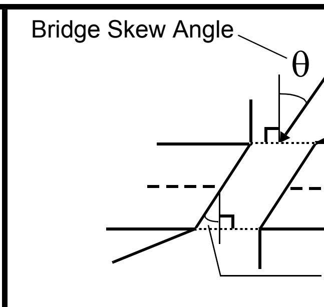
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	2	0
RBUS	0	-	2	1
RBDS	0	-	2	0
LBDS	1	2	2	1

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

Channel approach to bridge (BF):

15. Angle of approach: **0**
16. Bridge skew: **5**





α= **0.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **270** feet **US** *(US, UB, DS)* to **26** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **35** feet **US** *(US, UB, DS)* to **0** feet **US**

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

18. Bridge Type: **1b**

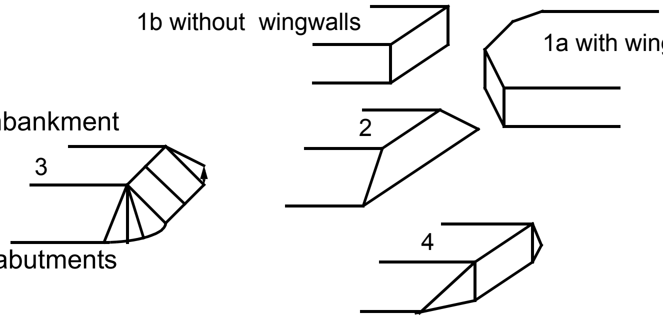
1a- Vertical abutments with wingwalls

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.)

7. Values are from the VT AOT files. Measured bridge length is 245 ft., span length is 158 ft., and bridge width is 21.8 ft.

4. All of the banks are heavily wooded but the predominant surface cover just beyond the banks is pasture except on the US right bank where there is a house and lawn surrounded by forest.

17. Both of the channel impact zones are a result of the US bar dividing the flow. The right bank is impacted at the spill-through slope of the right abutment. The spill-through protection directs the flow toward the pier.

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
281.0	**9.5**			**6.5**	**3**	**3**	**432**	**432**	**1**	**1**

23. Bank width **15.0** 24. Channel width **30.0** 25. Thalweg depth **303.0** 29. Bed Material **435**

30 .Bank protection type: LB **2** 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.):

The right and left bank protection is part of the spill-through abutment protection. It is dumped stone extending from 35 ft. US to the US bridge face on both banks.

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

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

37. Material: -

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

An island has formed upstream of the right pier. The island width is 190 feet and it is located from 390 feet US to 30 feet DS. The island grades from cobble to sand material towards the center. At high flow there is a channel around the right bank side of the island. It is heavily vegetated with grass and small trees. High water marks indicate flow overtopping the island.

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: 180 42. Cut bank extent: 240 feet US (US, UB) to 130 feet US (US, UB, DS)

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

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

-

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 0

47. Scour dimensions: Length 100 Width 40 Depth : 5 Position 60 %LB to 80 %RB

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

The scour hole is 100 ft. long and 40 ft. wide.

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
270.0		1.5		2	7	7	-

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

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

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

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

435

The point bar is sand under the bridge. The abutment walls are concrete skeletal type walls with dumped stone protection in front of them acting as a spill-through abutment slope.

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 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

There were debris caught on the US side bar. Also debris were blocking flow between the right pier and the right abutment spill-through protection.

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		5	90	0	0	-	-	90.0
RABUT	1	0	90			2	0	237.0

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

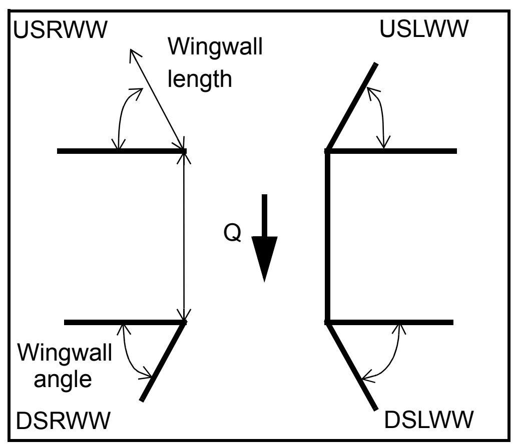
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
-
1
-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						237.0	
USRWW:	N		-		-	1.0	
DSLWW:	-		-		N	25.5	
DSRWW:	-		-		-	26.0	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	-	N	-	-	-	2	1
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	-	-	2	2	-

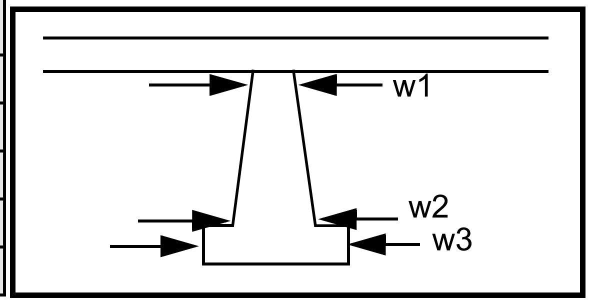
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? __-__ *(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	-	4.3	5.4	-	495.80	480.26
Pier 3	-	4.3	5.4	-	495.80	480.26
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)		L	MC	0	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		1	R	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		2	1	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		3	2	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		N	3	-	*Y- yes; N- no*
91. Attack ∠ (BF)		5	N	-	
92. Pushed		LB	20	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		UNK	LB	-	
95. Cross-members		0	UNK	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		1	0	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	Y	3	1	-	
98. Exposure depth	MC	0	5	-	

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

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width (Amb) 34.9 Thalweg depth (Amb) 35.2 Bed Material r

Bank protection type (Qmax): LB dept RB hs Bank protection condition: LB assu RB me

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.):
a 1 foot deep thalweg. Pier 1 has scour on both sides with the maximum scour depth occurring at the upstream end on the right side. The hole surrounding pier 1 is 20 ft. wide and 30 ft. long. Pier 2 has scour on the left side only with the maximum scour depth located at the upstream end.

3
3
23
234
0

101. Is a drop structure present? 0 *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: 435 *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

105. Drop structure comments (eg. downstream scour depth):
2
2
1
1
The protection on both the right and left banks is from 0 ft. DS to 20 ft. DS.

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.):

N

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

Cut bank extent: **OP** feet **ST** *(US, UB, DS)* to **RUC** feet **TU** *(US, UB, DS)*

Bank damage: **RE** *(**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: **Y**

Scour dimensions: Length **70** Width **35** Depth: **50** Positioned **DS** %LB to **115** %RB

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

DS
80
100
321

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

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

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

Confluence comments (eg. confluence name):

with gravel and cobble material extending from 460 ft. DS to 1400 ft. DS with a mid-bar distance of 500 ft. DS and a width of 40 ft. It is positioned 45% LB to 100% RB.

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)*:

Y
LB
750
675
DS
800
DS
1
This cut bank is in line with the confluence entrance on the opposite bank.

109. G. Plan View Sketch

N

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: JAMAVT01000080 Town: Jamaica
Road Number: VT 100 County: Windham
Stream: West River

Initials MAI Date: 03/03/97 Checked: SAO

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	16000	25800	0
Main Channel Area, ft2	1128	1475	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	822	1213	0
Top width main channel, ft	146	152	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	156	175	0
D50 of channel, ft	0.359	0.359	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.7	9.7	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	5.3	6.9	ERR
Total conveyance, approach	257303	407289	0
Conveyance, main channel	186058	283211	0
Conveyance, LOB	0	0	0
Conveyance, ROB	71245	124078	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	11569.7	17940.2	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	4430.3	7859.8	ERR
Vm, mean velocity MC, ft/s	10.3	12.2	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	5.4	6.5	ERR
Vc-m, crit. velocity, MC, ft/s	11.2	11.6	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	1	N/A

Live-Bed Contraction Scour

Laursen's Live Bed Contraction Scour
y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)
ys=y2-y_bridge
(Richardson and others, 1995, p. 30, eq. 17 and 18)

	Approach			Bridge		
Characteristic	100 yr	500 yr	Other Q	100 yr	500 yr	Other Q
Q1, discharge, cfs	16000	25800	0	16000	25800	0
Total conveyance	257303	407289	0	363310	463597	0
Main channel conveyance	186058	283211	0	363310	463597	0
Main channel discharge	11570	17940	ERR	16000	25800	ERR
Area - main channel, ft2	1128	1475	0	1974.9	2319.8	0
(W1) channel width, ft	146	152	0	196.1	198.9	0
(Wp) cumulative pier width, ft	0	0	0	9.7	9.7	0
W1, adjusted bottom width(ft)	146	152	0	186.4	189.2	0
D50, ft	0.359	0.359	0.359			
w, fall velocity, ft/s (p. 32)	4.9	4.9	0			
y, ave. depth flow, ft	7.73	9.70	N/A	10.59	12.26	ERR
S1, slope EGL	0.005	0.006	0			
P, wetted perimeter, MC, ft	148	154	0			
R, hydraulic Radius, ft	7.622	9.578	ERR			
V*, shear velocity, ft/s	1.108	1.360	N/A			
V*/w	0.226	0.278	ERR			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.59	0.59	0			
y2,depth in contraction, ft	8.83	11.64	ERR			
ys, scour depth, ft (y2-y_bridge)	-1.76	-0.62	N/A			

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	1128	1475	0
Main channel width, ft	146	152	0
y1, main channel depth, ft	7.73	9.70	ERR

Bridge Section			
(Q) total discharge, cfs	16000	25800	0
(Q) discharge thru bridge, cfs	16000	25800	0
Main channel conveyance	363310	463597	0
Total conveyance	363310	463597	0

Q2, bridge MC discharge,cfs	16000	25800	ERR
Main channel area, ft2	1975	2320	0
Main channel width (skewed), ft	196.1	198.9	0.0
Cum. width of piers in MC, ft	9.7	9.7	0.0
W, adjusted width, ft	186.4	189.2	0
y_bridge (avg. depth at br.), ft	10.59	12.26	ERR
Dm, median (1.25*D50), ft	0.44875	0.44875	0
y2, depth in contraction,ft	7.07	10.51	ERR
ys, scour depth (y2-ybridge), ft	-3.52	-1.75	N/A

ARMORING

D90	1.163	1.163	0
D95	1.395	1.395	0
Critical grain size,Dc, ft	0.3047	0.5398	ERR
Decimal-percent coarser than Dc	0.572	0.38	0
Depth to armoring,ft	0.68	2.64	ERR

Abutment Scour

Froehlich's Abutment Scour

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

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

	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	16000	25800	0	16000	25800	0
a', abut.length blocking flow, ft	30.6	29	0	75.2	74	0
Ae, area of blocked flow ft2	166	152.4	0	432	425.6	0
Qe, discharge blocked abut.,cfs	1311.3	1901.8	0	2747.1	4372.7	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	7.90	12.48	ERR	6.36	10.27	ERR
ya, depth of f/p flow, ft	5.42	5.26	ERR	5.74	5.75	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	0.598	0.959	ERR	0.468	0.755	ERR
ys, scour depth, ft	15.84	18.59	N/A	19.38	23.90	N/A

HIRE equation (a'/ya > 25)

$ys = 4*Fr^{0.33}*y1*K/0.55$

(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	30.6	29	0	75.2	74	0
y1 (depth f/p flow, ft)	5.42	5.26	ERR	5.74	5.75	ERR
a'/y1	5.64	5.52	ERR	13.09	12.87	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.60	0.96	N/A	0.47	0.75	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother	Q100	Q500	Qother
Fr, Froude Number	0.58	0.72	0	0.58	0.72	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	10.59	12.26	0.00	10.59	12.26	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.20	3.93	0.00	2.20	3.93	0.00
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	1.92	3.43	0.00	1.92	3.43	0.00
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR

Pier Scour (both live-bed and clear water scour)

ys/y1=2.0*K1*K2*K3*K4*(a/y1)^0.65*Fr1^0.43
(Richardson and others, 1995, p. 36, eq. 21)

K1, corr. factor for pier nose shape
Sharp nose, 0.9; round nose, cylinder, or cylinder grp., 1.0; square nose, 1.1

K2, corr. factor attack angle (see Table 3, p 37)
K2=[cos(attackangle)+L/a*sin(attackangle)]^0.65

K3, corr. factor for bed condition
Clear-water, plane bed, antidune, 1.1; med. dunes, 1.1-1.2 (see Tab.4,p37)

K4, corr. factor for armoring (the following equations are in Si units)
K4=[1-0.89*(1-Vr)^2]^0.5
Vr=(V1-Vi)/(Vc90-Vi)
V1=0.645*((D50/a)^0.053)*Vc50
Vc=6.19*(y^1/6)*(Dc^1/3)

Note for round nose piers:
ys<=2.4 times the pier width (a) for Fr<=0.8
ys<=3.0 times the pier width (a) for Fr>0.8

Pier 1	Q100	Q500	Qother
Pier stationing, ft	37.5	37.5	0
Area of WSPRO flow tube, ft2	85.6	100	0
Skewed width of flow tube, ft	6.9	7.1	0
y1, pier approach depth, ft	12.41	14.08	ERR
y1 in meters	3.781	4.293	N/A
V1, pier approach velocity, ft/s	9.34	12.9	0
a, pier width, ft	5.4	5.4	0

L, pier length, ft	34.9	34.9	0
Fr1, Froude number at pier	0.467	0.606	ERR
Pier attack angle, degrees	5	5	0
K1, shape factor	0.9	0.9	0
K2, attack factor	1.33	1.33	ERR
K3, bed condition factor	1.1	1.1	0
D50, ft	0.359	0.359	0
D50, m	0.1094	0.1094	0
D90, ft	1.163	1.163	0
D90, m	0.354	0.354	0
Vc50,critical velocity(D50),m/s	3.695	3.774	N/A
Vc90,critical velocity(D90),m/s	5.468	5.585	N/A
Vi,incipient velocity,m/s	2.065	2.109	ERR
Vr, velocity ratio	0.230	0.524	ERR
K4, armor factor	0.69	0.89	N/A
ys, scour depth (K4 applicable) ft	9.46	14.38	ERR
ys, scour depth (K4 not applied)ft	ERR	ERR	ERR

Pier Scour (both live-bed and clear water scour)

ys/y1=2.0*K1*K2*K3*K4*(a/y1)^0.65*Fr1^0.43
(Richardson and others, 1995, p. 36, eq. 21)

K1, corr. factor for pier nose shape
Sharp nose, 0.9; round nose, cylinder, or cylinder grp., 1.0; square nose, 1.1

K2, corr. factor attack angle (see Table 3, p 37)
K2=[cos(attackangle)+L/a*sin(attackangle)]^0.65

K3, corr. factor for bed condition
Clear-water, plane bed, antidune, 1.1; med. dunes, 1.1-1.2 (see Tab.4,p37)

K4, corr. factor for armoring (the following equations are in Si units)
K4=[1-0.89*(1-Vr)^2]^0.5
Vr=(V1-Vi)/(Vc90-Vi)
V1=0.645*((D50/a)^0.053)*Vc50
Vc=6.19*(y^1/6)*(Dc^1/3)

Note for round nose piers:
ys<=2.4 times the pier width (a) for Fr<=0.8
ys<=3.0 times the pier width (a) for Fr>0.8

Pier 2	Q100	Q500	Qother
Pier stationing, ft	200	200	0
Area of WSPRO flow tube, ft2	85.6	100	0
Skewed width of flow tube, ft	6.9	7.1	0
y1, pier approach depth, ft	12.41	14.08	ERR
y1 in meters	3.781	4.293	N/A
V1, pier approach velocity, ft/s	9.34	12.9	0
a, pier width, ft	5.4	5.4	0
L, pier length, ft	35.2	35.2	0
Fr1, Froude number at pier	0.467	0.606	ERR
Pier attack angle, degrees	20	20	0
K1, shape factor	0.9	0.9	0
K2, attack factor	2.12	2.12	ERR
K3, bed condition factor	1.1	1.1	0
D50, ft	0.359	0.359	0
D50, m	0.1094	0.1094	0
D90, ft	1.163	1.163	0
D90, m	0.354	0.354	0
Vc50,critical velocity(D50),m/s	3.695	3.774	N/A
Vc90,critical velocity(D90),m/s	5.468	5.585	N/A
Vi,incipient velocity,m/s	2.065	2.109	ERR
Vr, velocity ratio	0.230	0.524	ERR
K4, armor factor	0.69	0.89	N/A
ys, scour depth, (K4 applicable) ft	15.00	22.80	ERR
ys, scour depth, (K4 not applied)ft	ERR	ERR	ERR

D50=0.692(K*V)^2/(Ss-1)*2*g
(Richardson and others, 1995, p.115, eq. 83)
Pier-shape coefficient (K), round nose, 1.5; square nose, 1.7
Characteristic avg. channel velocity, V, (Q/A):
(Mult. by 0.9 for bankward piers in a straight, uniform reach,
up to 1.7 for a pier in main current of flow around a bend)

Pier 1	Q100	Q500	Qother
K, pier shape coeff.	1.5	1.5	0
V, char. aver. velocity, ft/s	8.1	11.12	0
D50, median stone diameter, ft	0.96	1.81	0.00

Pier 2			
K, pier shape coeff.	1.5	1.5	0
V, char. aver. velocity, ft/s	8.1	11.12	0
D50, median stone diameter, ft	0.96	1.81	0.00