LEVEL II SCOUR ANALYSIS FOR BRIDGE 26 (WRUTTH00050026) on TOWN HIGHWAY 5, crossing the CLARENDON RIVER, WEST RUTLAND, VERMONT

Open-File Report 98-071

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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By MICHAEL A. IVANOFF

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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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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 26 (WRUTTH00050026) ON TOWN HIGHWAY 5, CROSSING THE CLARENDON RIVER, WEST RUTLAND, VERMONT

By **Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure WRUTTH00050026 on Town Highway 5 crossing the Clarendon River, West Rutland, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Taconic section of the New England physiographic province in west-central Vermont. The 46.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture upstream and downstream of the bridge. The right bank surface cover consists of forest upstream, and shrubs, brush, and a few trees downstream.

In the study area, the Clarendon River has an incised, sinuous channel with a slope of approximately 0.003 ft/ft, an average channel top width of 52 ft and an average bank height of 6 ft. The channel bed material ranges from silt/clay to gravel with a median grain size (D_{50}) of 62.6 mm (0.205 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 26, 1995, indicated that the reach was stable.

The Town Highway 5 crossing of the Clarendon River is a 41-ft-long, two-lane bridge consisting of one 39-foot concrete slab span (Vermont Agency of Transportation, written communication, March 15, 1995). The opening length of the structure parallel to the bridge face is 37.5 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is zero degrees.

The scour protection measures at the site included type-3 stone fill (less than 48 inches diameter) along the upstream left and right banks and along the entire base length of the upstream left and right wingwalls, type-2 stone fill (less than 36 inches diameter) along the downstream left and right banks and along the entire base length of the downstream left wingwall, and type-4 stone fill (less than 60 inches diameter) along the entire base length of the downstream right wingwall. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour computed for all modelled flows was zero ft. Left abutment scour ranged from 9.2 to 13.3 ft. Right abutment scour ranged from 6.2 to 10.7 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

West Rutland, VT. Quadrangle, 1:24,000, 1964
Photorevised 1972

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 WRUTTH00050026 ***Stream*** Clarendon River

County Rutland ***Road*** TH 5 ***District*** 3

Description of Bridge

Bridge length 41.0 ***ft*** ***Bridge width*** 25.4 ***ft*** ***Max span length*** 39.0 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** Sloping

Stone fill on abutment? No ***Date of inspection*** 9/26/95

Description of stone fill Type-2 stone fill along the entire base length of the downstream left wingwall. Type-4 stone fill along the entire base length of the downstream right wingwall.

Abutments and wingwalls are concrete.

Yes

5 Yes

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

is a mild channel bend in the upstream reach, such that flow impacts the right abutment more significantly than the left.

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	9/26/95	0	0
Level II	9/26/95	0	0

Potential for debris Moderate. There is some debris in the channel upstream.

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

There was a point bar under the bridge and two culverts through the State Route 4 overpass as of 9/26/95.

Description of the Geomorphic Setting

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

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

Date of inspection 9/26/95

DS left: Steep channel bank to a narrow flood plain.

DS right: Steep channel bank.

US left: Steep channel bank to a narrow flood plain.

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

Description of the Channel

Average top width 52 *ft* ***Average depth*** 6 *ft*

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

Perennial and sinuous but stable with alluvial channel boundaries and a narrow flood plain.

9/26/95

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

DS left: Trees and brush.

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

US left: Trees and brush.

US right:

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

None, 9/26/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 46.4 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 3,510 ***ft³/s*** ***Q500*** 4,750 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(46.4/47.2)exp 0.67] with discharges from the VTAOT database (written communication, May 1995) for bridge number 16 in West Rutland. Bridge number 16 crosses the Clarendon River downstream of this site and has a drainage area of 47.2 square miles. These area adjusted values were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extrapolated 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 Add 11.5 ft to the USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a State of Vermont brass tablet on top of the upstream end of the left abutment (elev. 499.87 ft, arbitrary survey datum). RM2 is a chiseled "X" on top of the downstream end of the right abutment (elev. 498.62 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	-48	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	15	1	Road Grade section
APPRO	65	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 0.035 to 0.050, and overbank "n" values ranged from 0.040 to 0.090.

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 0.0033 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1964).

The approach section (APPRO) was surveyed one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.7 ***ft***
Average low steel elevation 495.9 ***ft***

100-year discharge 3,510 ***ft^3/s***
Water-surface elevation in bridge opening 494.2 ***ft***
Road overtopping? Yes ***Discharge over road*** 335 ***ft^3/s***
Area of flow in bridge opening 349 ***ft^2***
Average velocity in bridge opening 9.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.2 ***ft/s***

Water-surface elevation at Approach section with bridge 496.1
Water-surface elevation at Approach section without bridge 494.8
Amount of backwater caused by bridge 1.3 ***ft***

500-year discharge 4,750 ***ft^3/s***
Water-surface elevation in bridge opening 495.9 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,350 ***ft^3/s***
Area of flow in bridge opening 412 ***ft^2***
Average velocity in bridge opening 8.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.1 ***ft/s***

Water-surface elevation at Approach section with bridge 497.2
Water-surface elevation at Approach section without bridge 495.6
Amount of backwater caused by bridge 1.6 ***ft***

Incipient overtopping discharge 2,450 ***ft^3/s***
Water-surface elevation in bridge opening 493.3 ***ft***
Area of flow in bridge opening 317 ***ft^2***
Average velocity in bridge opening 7.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.3 ***ft/s***

Water-surface elevation at Approach section with bridge 494.8
Water-surface elevation at Approach section without bridge 493.9
Amount of backwater caused by bridge 0.9 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

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

For comparison, contraction scour for the 500-year discharge also was computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144) and is presented in appendix F. Furthermore, for the 500-year discharge, contraction scour was computed by substituting an estimate for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to this substitution also are provided in appendix F.

Abutment scour was computed by use of the HIRE equation (Richardson and Davis, 1995, p. 49, equation 29). The HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. Variables for the HIRE equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.0
Depth to armoring	1.6	1.2	0.7
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	11.8	13.3	9.2
Right abutment	8.6	10.7	6.2
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	500-year discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.9	1.5	1.4
Right abutment	1.9	1.5	1.4
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

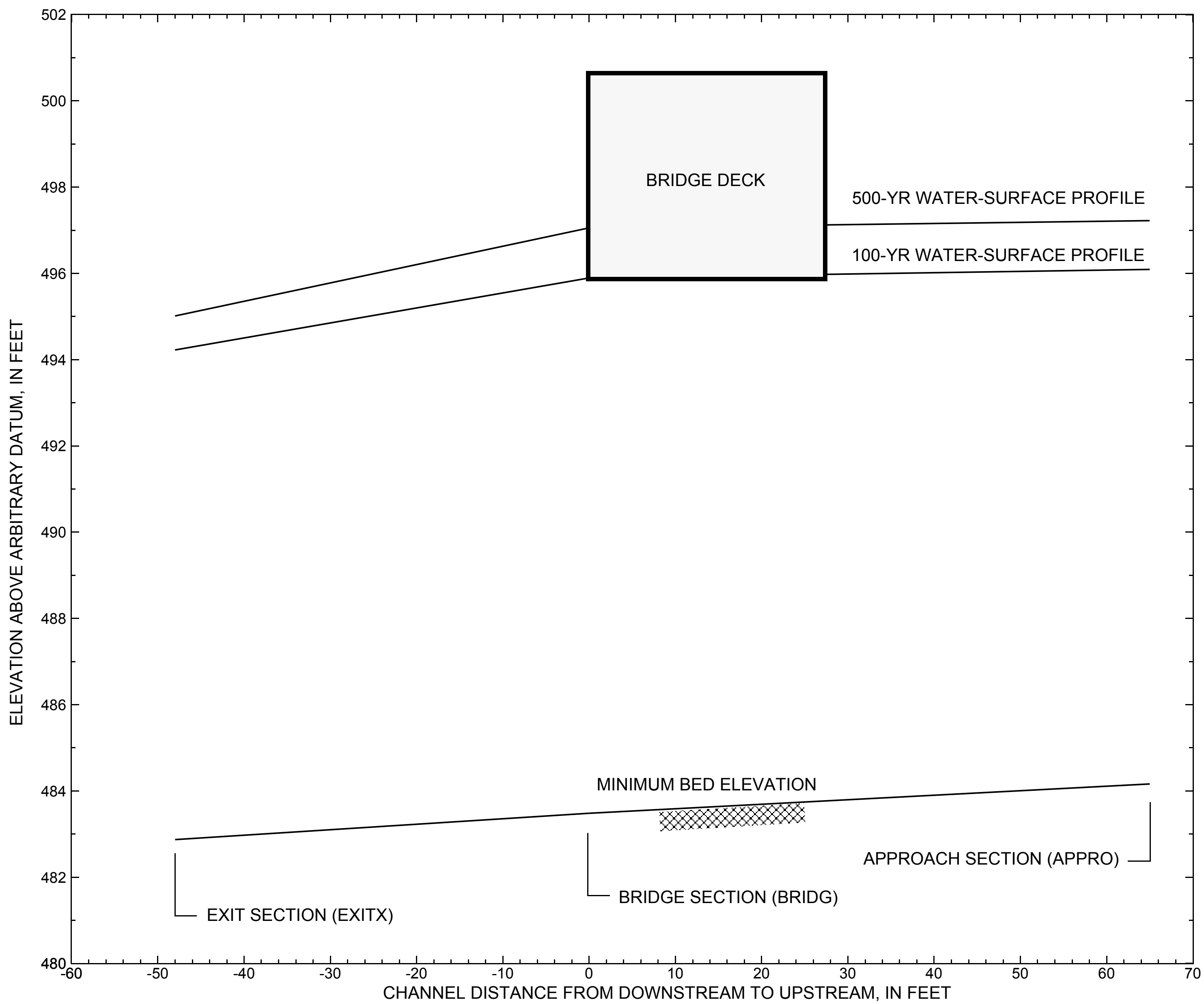

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure WRUTTH00050026 on Town Highway 5, crossing the Clarendon River, West Rutland, Vermont.

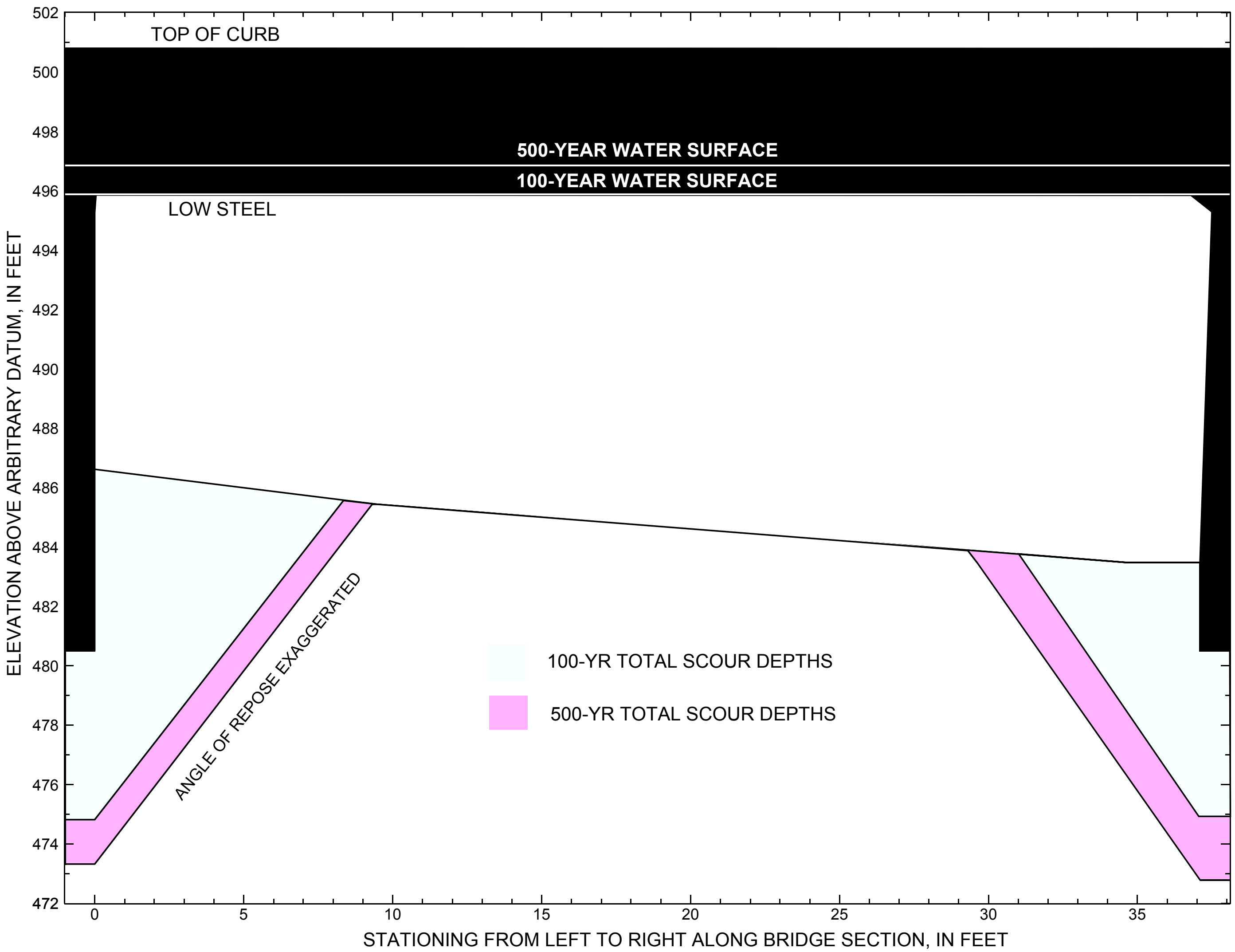

Figure 8. Scour elevations for the 100- and 500-year discharges at structure WRUTTH00050026 on Town Highway 5, crossing the Clarendon River, West Rutland, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WRUTTH00050026 on Town Highway 5, crossing the Clarendon River, West Rutland, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 3,510 cubic-feet per second											
Left abutment	0.0	506.6	495.9	480.5	486.6	0.0	11.8	--	11.8	474.8	-5.7
Right abutment	37.5	506.2	495.8	480.5	483.5	0.0	8.6	--	8.6	474.9	-5.6

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 WRUTTH00050026 on Town Highway 5, crossing the Clarendon River, West Rutland, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 4,750 cubic-feet per second											
Left abutment	0.0	506.6	495.9	480.5	486.6	0.0	13.3	--	13.3	473.3	-7.2
Right abutment	37.5	506.2	495.8	480.5	483.5	0.0	10.7	--	10.7	472.8	-7.7

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, 1964, West Rutland, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1972, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File wrut026.wsp
T2        Hydraulic analysis for structure WRUTTH00050026   Date: 25-NOV-97
T3        Bridge 26 on Town Highway 5 over Clarendon River West Rutland, VT  MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3510.0   4750.0   2450.0
SK          0.0033   0.0033   0.0033
*
XS   EXITX    -48
GR         -136.8, 497.22   -107.3, 491.56    -50.2, 491.61     -4.2, 491.00
GR            0.0, 488.05      7.8, 484.17      9.4, 483.06     16.0, 483.00
GR           20.3, 482.87     22.3, 482.95     26.4, 484.17     28.3, 484.57
GR           41.8, 490.28     44.3, 491.65     93.8, 493.77    124.2, 498.70
GR          173.8, 499.85
N           0.040        0.050
SA                  -4.2
*
XS   FULLV      0  * * *   0.0126
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.86       0.0
GR            0.0, 495.27      0.0, 486.62      9.5, 485.44     21.9, 484.53
GR           28.8, 483.93     34.6, 483.48     37.1, 483.48     37.1, 484.53
GR           37.5, 495.29     36.8, 495.85      0.4, 495.86      0.0, 495.27
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV   WWANGL
CD          4      29.7      3.3    500.7     38.4
N           0.035
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     15      25.4     1
GR         -500.0, 499.70
GR         -430.8, 496.84   -323.5, 494.99   -282.0, 494.80   -169.4, 497.94
GR          -98.0, 498.73    -32.0, 499.37     -1.4, 499.62     -1.3, 500.52
GR            0.0, 500.55     18.3, 500.62     35.0, 500.80     36.3, 500.80
GR           36.4, 499.78     72.9, 500.12    145.1, 500.27    267.2, 500.85
GR          370.1, 502.62    455.9, 505.59    562.3, 511.19
*
AS   APPRO     65
*    -356.7, 490.01   -157.5, 488.25     -155.7, 487.98   -151.4, 489.64
GR         -500.0, 499.70   -463.4, 497.93   -427.6, 496.29   -387.7, 490.88
GR         -341.8, 490.49   -229.2, 491.28   -162.1, 492.04   -115.0, 491.58
GR          -31.0, 493.26     -9.9, 491.50      0.0, 488.17      3.3, 485.64
GR            7.1, 484.93     12.1, 484.25     18.4, 484.16     24.9, 484.92
GR           30.9, 485.68     39.0, 486.44     48.5, 491.17     98.7, 491.70
GR          171.3, 492.18    256.3, 493.68    308.5, 501.03
N           0.040        0.045        0.090
SA                  -9.9         48.5
*
HP 1 BRIDG   494.17 1 494.17
HP 2 BRIDG   494.17 * * 3175
HP 2 RDWAY   495.89 * * 335
HP 1 APPRO   496.09 1 496.09
HP 2 APPRO   496.09 * * 3510
HP 1 BRIDG   495.86 1 495.86
HP 2 BRIDG   495.86 * * 3364
HP 1 BRIDG   495.14 1 495.14
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. Geological Survey WSPRO Input File wrut026.wsp
        Hydraulic analysis for structure WRUTTH00050026   Date: 25-NOV-97
        Bridge 26 on Town Highway 5 over Clarendon River West Rutland, VT  MAI
           *** RUN DATE & TIME: 01-07-98  11:33
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     349.  50610.    37.    55.                         6044.
   494.17          349.  50610.    37.    55.  1.00     0.    37.   6044.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.17     0.0    37.5   349.0   50610.    3175.   9.10

 X STA.        0.0        5.8        7.6        9.2       10.9       12.5
  A(I)            46.1       14.6       14.4       14.2       14.2
  V(I)            3.44      10.90      11.03      11.16      11.16

 X STA.       12.5       14.1       15.6       17.1       18.7       20.2
  A(I)            14.4       14.2       14.1       14.2       14.3
  V(I)           11.04      11.21      11.22      11.22      11.08

 X STA.       20.2       21.7       23.1       24.5       25.9       27.2
  A(I)            14.2       13.9       14.0       13.8       13.3
  V(I)           11.19      11.41      11.35      11.51      11.94

 X STA.       27.2       28.6       29.9       31.2       32.4       37.5
  A(I)            13.7       13.2       13.3       13.0       51.8
  V(I)           11.60      12.00      11.89      12.22       3.06

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      15.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.89  -375.7  -242.9    86.1    2402.     335.   3.89

 X STA.     -375.7     -335.8     -330.4     -325.9     -321.9     -318.1
  A(I)            13.7        3.9        3.7        3.5        3.5
  V(I)            1.22       4.25       4.49       4.77       4.77

 X STA.     -318.1     -314.5     -310.9     -307.3     -303.9     -300.6
  A(I)             3.4        3.4        3.4        3.4        3.3
  V(I)            4.95       4.93       4.90       4.89       5.13

 X STA.     -300.6     -297.2     -293.8     -290.5     -287.3     -284.2
  A(I)             3.4        3.5        3.5        3.4        3.3
  V(I)            4.88       4.81       4.85       4.91       5.08

 X STA.     -284.2     -281.1     -277.8     -273.9     -269.3     -242.9
  A(I)             3.4        3.4        3.5        3.7        9.7
  V(I)            4.95       4.99       4.73       4.51       1.73

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1820. 181098.   416.   417.                        21590.
             2     556.  80178.    58.    61.                         9733.
             3     824.  32415.   225.   225.                         8953.
   496.09         3200. 293691.   700.   703.  1.42  -426.   273.  32596.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.09  -426.1   273.4  3199.8  293691.    3510.   1.10

 X STA.     -426.1     -371.5     -347.6     -324.9     -300.4     -274.4
  A(I)           185.4      130.7      125.7      132.3      135.6
  V(I)            0.95       1.34       1.40       1.33       1.29

 X STA.     -274.4     -247.1     -218.4     -186.3     -149.3     -115.6
  A(I)           137.3      138.8      144.6      153.8      146.0
  V(I)            1.28       1.26       1.21       1.14       1.20

 X STA.     -115.6      -80.2      -23.1        2.8       11.5       19.1
  A(I)           147.6      188.4      140.5       96.5       90.7
  V(I)            1.19       0.93       1.25       1.82       1.94

 X STA.       19.1       26.9       36.1       61.7      136.6      273.4
  A(I)            88.8       95.4      161.7      331.2      428.7
  V(I)            1.98       1.84       1.09       0.53       0.41
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        U.S. Geological Survey WSPRO Input File wrut026.wsp
        Hydraulic analysis for structure WRUTTH00050026   Date: 25-NOV-97
        Bridge 26 on Town Highway 5 over Clarendon River West Rutland, VT  MAI
           *** RUN DATE & TIME: 01-07-98  11:33
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     412.  46372.     0.    96.                      ********
   495.86          412.  46372.     0.    96.  1.00     0.    38.********

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.86     0.0    37.5   411.8   46372.    3364.   8.17

X STA.         0.0        4.8        6.7        8.5       10.2       12.0
  A(I)             45.7       18.5       18.3       18.5       18.0
  V(I)             3.68       9.08       9.21       9.07       9.35

X STA.        12.0       13.7       15.3       17.0       18.6       20.2
  A(I)             18.1       18.1       17.7       17.7       17.9
  V(I)             9.27       9.28       9.49       9.50       9.40

X STA.        20.2       21.7       23.3       24.8       26.3       27.8
  A(I)             17.5       17.7       17.5       17.3       17.5
  V(I)             9.59       9.49       9.60       9.74       9.62

X STA.        27.8       29.2       30.6       32.0       33.4       37.5
  A(I)             17.3       16.7       16.8       17.1       47.8
  V(I)             9.75      10.09      10.01       9.86       3.52

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     385.  58346.    37.    57.                         7009.
   495.14          385.  58346.    37.    57.  1.00     0.    37.   7009.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      15.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.85  -431.0  -208.5   256.8   10523.    1349.   5.25

X STA.      -431.0     -361.0     -351.8     -344.0     -337.3     -331.2
  A(I)             42.7       11.8       11.3       10.4       10.3
  V(I)             1.58       5.70       5.98       6.47       6.55

X STA.      -331.2     -325.6     -320.3     -315.1     -310.1     -305.2
  A(I)              9.9        9.8        9.8        9.6        9.5
  V(I)             6.80       6.91       6.87       7.00       7.14

X STA.      -305.2     -300.1     -295.0     -290.0     -285.1     -280.3
  A(I)             10.0       10.1       10.0        9.9        9.7
  V(I)             6.74       6.66       6.73       6.84       6.95

X STA.      -280.3     -275.2     -269.4     -262.8     -255.0     -208.5
  A(I)             10.0       10.2       10.6       11.0       30.1
  V(I)             6.76       6.62       6.34       6.11       2.24

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    2305.  259560.   438.   439.                        30005.
             2     623.   96811.    58.    61.                        11533.
             3    1085.   50067.   233.   233.                        13290.
   497.23         4013.  406439.   730.   733.  1.38  -448.   282.  45521.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.23  -448.1   281.5  4013.1  406439.    4750.   1.18

X STA.      -448.1     -368.5     -344.1     -321.3     -296.8     -271.2
  A(I)            278.7      161.0      152.4      159.3      162.6
  V(I)             0.85       1.47       1.56       1.49       1.46

X STA.      -271.2     -244.5     -216.1     -185.1     -151.2     -119.3
  A(I)            164.2      168.6      174.5      179.7      173.8
  V(I)             1.45       1.41       1.36       1.32       1.37

X STA.      -119.3      -86.1      -43.5       -3.8        9.2       18.1
  A(I)            178.9      198.0      194.5      138.1      114.6
  V(I)             1.33       1.20       1.22       1.72       2.07

X STA.        18.1       27.5       38.3       78.5      150.0      281.5
  A(I)            118.8      122.6      264.5      389.0      519.3
  V(I)             2.00       1.94       0.90       0.61       0.46
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        Hydraulic analysis for structure WRUTTH00050026   Date: 25-NOV-97
        Bridge 26 on Town Highway 5 over Clarendon River West Rutland, VT  MAI
           *** RUN DATE & TIME: 01-07-98  11:33

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     318.  44133.    37.    54.                        5248.
   493.33          318.  44133.    37.    54.  1.00     0.    37.   5248.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.33     0.0    37.4   317.5   44133.    2450.   7.72

X STA.        0.0        5.7        7.6        9.3       10.9       12.6
  A(I)            40.5       13.8       13.2       13.4       13.0
  V(I)            3.03       8.89       9.29       9.13       9.40

X STA.       12.6       14.2       15.7       17.3       18.8       20.4
  A(I)            13.4       12.7       13.3       12.9       13.1
  V(I)            9.11       9.61       9.19       9.50       9.38

X STA.       20.4       21.8       23.3       24.7       26.1       27.5
  A(I)            13.0       13.1       12.6       12.7       12.6
  V(I)            9.45       9.33       9.76       9.65       9.74

X STA.       27.5       28.8       30.1       31.3       32.6       37.4
  A(I)            12.3       12.2       11.9       12.5       45.4
  V(I)            9.94      10.03      10.32       9.81       2.70


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1277.  101930.   406.   407.                      12839.
             2     479.   62518.    58.    61.                       7781.
             3     533.   16156.   216.   216.                       4763.
   494.77         2289.  180605.   680.   684.  1.54  -416.   264.  19204.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      65.

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.77  -416.4   264.0  2289.0  180605.    2450.   1.07

X STA.     -416.4     -370.2     -346.7     -323.3     -299.4     -272.5
  A(I)           125.2       97.2       99.0       97.1      104.6
  V(I)            0.98       1.26       1.24       1.26       1.17

X STA.     -272.5     -244.3     -213.2     -175.9     -133.3      -96.8
  A(I)           104.0      108.0      115.5      121.6      111.4
  V(I)            1.18       1.13       1.06       1.01       1.10

X STA.      -96.8      -24.0        2.4        9.4       15.3       21.1
  A(I)           155.3      104.4       67.4       61.8       60.6
  V(I)            0.79       1.17       1.82       1.98       2.02

X STA.       21.1       27.1       34.0       42.8      106.2      264.0
  A(I)            60.1       63.1       70.3      219.1      343.3
  V(I)            2.04       1.94       1.74       0.56       0.36
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        Hydraulic analysis for structure WRUTTH00050026   Date: 25-NOV-97
        Bridge 26 on Town Highway 5 over Clarendon River West Rutland, VT  MAI
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 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******  -121.     785.  0.32 *****  494.54  492.57   3510.  494.22
      -48. ******    97.   61056.  1.02 ***** *******    0.42    4.47

FULLV:FV      48.  -119.     681.  0.43  0.20  494.77 *******   3510.  494.34
        0.    48.    93.   49547.  1.04  0.06   -0.02    0.52    5.15
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  3.69

APPRO:AS      65.  -417.    2309.  0.06  0.09  494.86 *******   3510.  494.80
       65.    65.   264.  182889.  1.53  0.00    0.00    0.18    1.52
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   496.30       0.00     493.84     494.80

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.17     495.88     496.09     495.86

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

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.08     496.70     496.75

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

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

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

BRIDG:BR      48.     0.     349.  1.56  0.58  495.73  490.92   3175.  494.17
        0.    48.    37.   50588.  1.21  0.61    0.00    0.58    9.10

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   4.  0.908 ******  495.86 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.    40.  0.01  0.03  496.11    0.00    335.  495.89

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    335.   133.  -376.  -243.   1.1   0.6   4.4   3.9   0.9   3.1
   RT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****

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

APPRO:AS      35.  -426.    3201.  0.03  0.21  496.12  492.26   3510.  496.09
       65.    84.   273.  293885.  1.42  0.18    0.01    0.11    1.10

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.945  0.948   15165.  -118.   -80. ********

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS      -48.  -121.    97.   3510.   61056.     785.    4.47  494.22
   FULLV:FV        0.  -119.    93.   3510.   49547.     681.    5.15  494.34
   BRIDG:BR        0.     0.    37.   3175.   50588.     349.    9.10  494.17
   RDWAY:RG       15.*******   335.    335.*********       0.    1.00  495.89
   APPRO:AS       65.  -426.   273.   3510.  293885.    3201.    1.10  496.09

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS    -118.   -80.   15165.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     492.57    0.42  482.87  499.85************  0.32  494.54  494.22
   FULLV:FV   ********    0.52  483.47  500.45  0.20  0.06  0.43  494.77  494.34
   BRIDG:BR     490.92    0.58  483.48  495.86  0.58  0.61  1.56  495.73  494.17
   RDWAY:RG   ****************  494.80  511.19  0.01******  0.03  496.11  495.89
   APPRO:AS     492.26    0.11  484.16  501.03  0.21  0.18  0.03  496.12  496.09
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        U.S. Geological Survey WSPRO Input File wrut026.wsp
        Hydraulic analysis for structure WRUTTH00050026   Date: 25-NOV-97
        Bridge 26 on Town Highway 5 over Clarendon River West Rutland, VT  MAI
           *** RUN DATE & TIME: 01-07-98  11:33

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

EXITX:XS   ******  -125.     961.  0.38 *****  495.39  493.15   4750.  495.01
      -48. ******   101.   82652.  1.00 ***** *******    0.42    4.94

FULLV:FV      48.  -123.     855.  0.49  0.19  495.62 *******   4750.  495.14
        0.    48.    99.   69273.  1.01  0.05   -0.01    0.50    5.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  3.64

APPRO:AS      65.  -423.    2886.  0.06  0.08  495.70 *******   4750.  495.64
       65.    65.   270.  252254.  1.45  0.00   -0.01    0.17    1.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   498.16       0.00     493.75     494.80

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.08     496.89     497.06     495.86

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

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

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

BRIDG:BR      48.     0.     412.  1.04 *****  496.90  491.14   3364.  495.86
        0. ******    38.   46372.  1.00 ***** *******    0.43    8.17

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****    5.  0.390 ******  495.86 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.    40.  0.01  0.03  497.26   -0.01   1349.  496.85

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1349.   222.  -431.  -209.   2.0   1.2   5.8   5.3   1.6   3.1
   RT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****

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

APPRO:AS      35.  -448.    4015.  0.03  0.07  497.26  492.65   4750.  497.23
       65.    85.   282.  406784.  1.38  0.16   -0.01    0.10    1.18

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -48.  -125.   101.   4750.   82652.     961.    4.94  495.01
   FULLV:FV       0.  -123.    99.   4750.   69273.     855.    5.56  495.14
   BRIDG:BR       0.     0.    38.   3364.   46372.     412.    8.17  495.86
   RDWAY:RG      15.******* 1349.   1349.*********       0.    1.00  496.85
   APPRO:AS      65.  -448.   282.   4750.  406784.    4015.    1.18  497.23

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     493.15    0.42  482.87  499.85************  0.38  495.39  495.01
   FULLV:FV   ********    0.50  483.47  500.45  0.19  0.05  0.49  495.62  495.14
   BRIDG:BR     491.14    0.43  483.48  495.86************  1.04  496.90  495.86
   RDWAY:RG   ****************  494.80  511.19  0.01******  0.03  497.26  496.85
   APPRO:AS     492.65    0.10  484.16  501.03  0.07  0.16  0.03  497.26  497.23
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        U.S. Geological Survey WSPRO Input File wrut026.wsp
        Hydraulic analysis for structure WRUTTH00050026   Date: 25-NOV-97
        Bridge 26 on Town Highway 5 over Clarendon River West Rutland, VT  MAI
           *** RUN DATE & TIME: 01-07-98  11:33

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

EXITX:XS   ******  -117.     600.  0.28 *****  493.62  489.90   2450.  493.34
      -48. ******    84.   42621.  1.07 ***** *******    0.43    4.08

FULLV:FV      48.  -114.     506.  0.42  0.19  493.88 *******   2450.  493.46
        0.    48.    72.   35574.  1.14  0.07    0.00    0.55    4.84
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPRO"      KRATIO =  3.40

APPRO:AS      65.  -410.    1711.  0.05  0.09  493.97 *******   2450.  493.91
       65.    65.   258.  121044.  1.70  0.00    0.00    0.21    1.43
         <<<<<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      48.     0.     317.  1.11  0.52  494.43  489.94   2450.  493.33
        0.    48.    37.   44102.  1.20  0.29   -0.01    0.51    7.72

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   1.  0.915 ******  495.86 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.         <<<<<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      35.  -416.    2288.  0.03  0.21  494.80  490.17   2450.  494.77
       65.    83.   264.  180473.  1.54  0.15   -0.02    0.13    1.07

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.944  0.929   12893.   -32.     5.   494.76

  FIRST USER DEFINED TABLE.

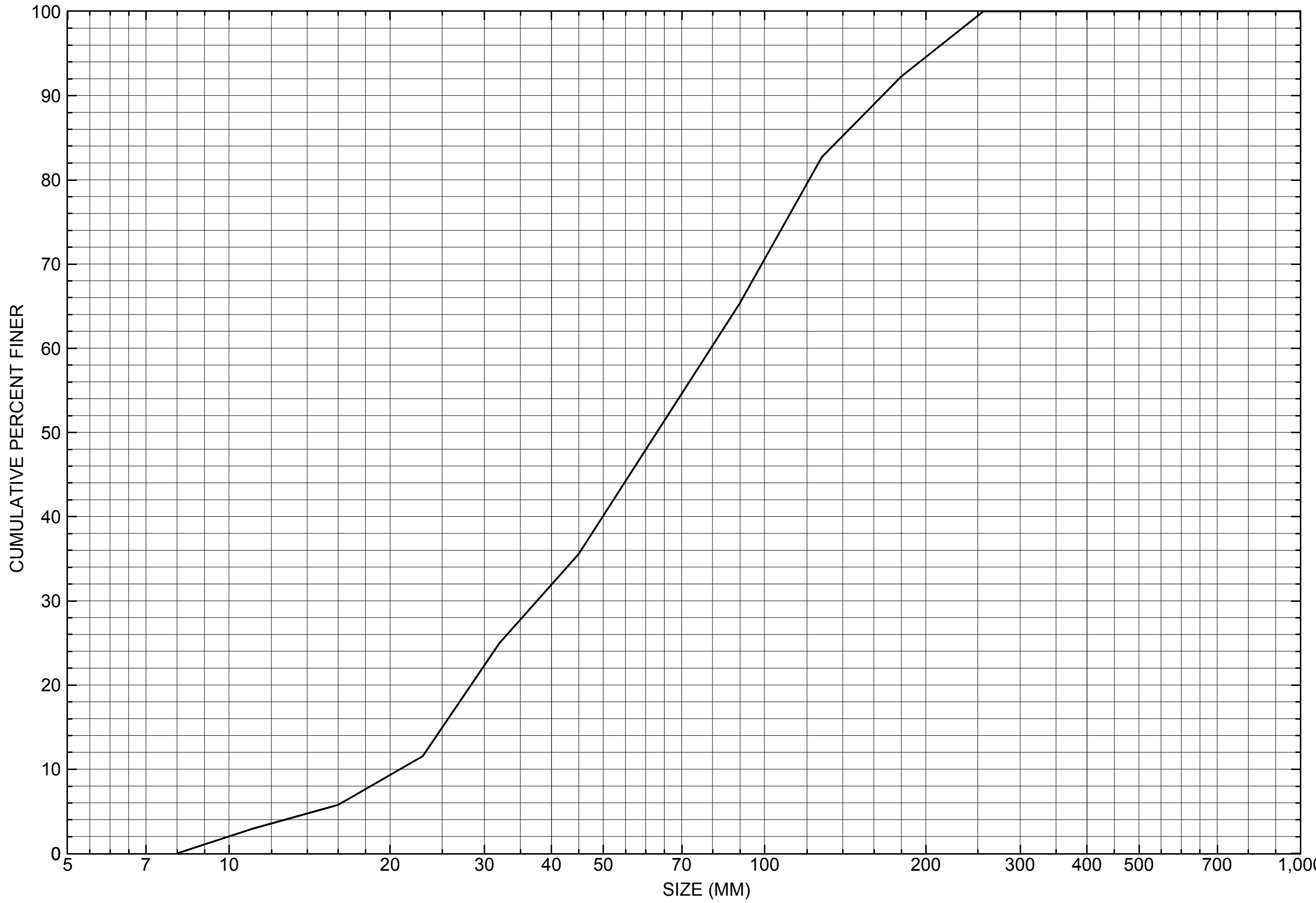
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -48.  -117.    84.   2450.   42621.     600.    4.08  493.34
   FULLV:FV       0.  -114.    72.   2450.   35574.     506.    4.84  493.46
   BRIDG:BR       0.     0.    37.   2450.   44102.     317.    7.72  493.33
   RDWAY:RG      15.**************      0.*****************    1.00********
   APPRO:AS      65.  -416.   264.   2450.  180473.    2288.    1.07  494.77

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    489.90    0.43  482.87  499.85************  0.28  493.62  493.34
   FULLV:FV  ********    0.55  483.47  500.45  0.19  0.07  0.42  493.88  493.46
   BRIDG:BR    489.94    0.51  483.48  495.86  0.52  0.29  1.11  494.43  493.33
   RDWAY:RG ***************  494.80  511.19**********************************
   APPRO:AS    490.17    0.13  484.16  501.03  0.21  0.15  0.03  494.80  494.77
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure WRUTTH00050026, in West Rutland, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WRUTTH00050026

General Location Descriptive

Data collected by *(First Initial, Full last name)* E. BOEHMLER

Date *(MM/DD/YY)* 03 / 15 / 95

Highway District Number *(I - 2; nn)* 03

County *(FIPS county code; I - 3; nnn)* 021

Town *(FIPS place code; I - 4; nnnnn)* 82300

Mile marker *(I - 11; nnn.nnn)* 000000

Waterway *(I - 6)* CLARENDON RIVER

Road Name *(I - 7)*: -

Route Number TH005

Vicinity *(I - 9)* 0.1 MI TO JCT W US4

Topographic Map West.Rutland

Hydrologic Unit Code: 02010002

Latitude *(I - 16; nnnn.n)* 43356

Longitude *(i - 17; nnnnn.n)* 73021

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10112800261128

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

Maximum span length *(I - 48; nnnn)* 0039

Year built *(I - 27; YYYY)* 1986

Structure length *(I - 49; nnnnnn)* 000041

Average daily traffic, ADT *(I - 29; nnnnnn)* 000100

Deck Width *(I - 52; nn.n)* 254

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

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

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

Waterway adequacy *(I - 71; n)* 8

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

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

Structure type *(I - 43; nnn)* 101

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 037.8

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

Vertical clearance from streambed (*nnn.n ft*) 012.0

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

Waterway of full opening (*nnn.n* ft^2) 454.0

Comments:

The structural inspection report of 5/11/94 indicates the structure is a concrete slab type bridge. The abutment walls are reinforced concrete. There are miscellaneous fine cracks on the abutment walls and wingwalls reported. The report indicates there is a tree lying across the river upstream of the bridge. There also is a shallow stone dam reported just upstream of the bridge. The channel bed is noted as mostly gravel. The report noted no footing exposure, undermining or settlement. There is stone fill indicated as placed along the wingwalls. The banks are well protected downstream with stone fill.

Bridge Hydrologic Data

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

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*)	**501.5**	**503.1**	**504.7**	**505.9**	**507.3**
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

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

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

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

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

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

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

Downstream distance (*miles*): -__________ Town: -__________________ Year Built: -______
Highway No. : -_______________ Structure No. : -_____ Structure Type: -____________________
Clear span (*ft*): -____ Clear Height (*ft*): -_____ Full Waterway (ft^2): -______

Comments:

The hydrologic data shown above is taken from that printed on the plan. There is no file in the hydraulics section readily available.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **46.44** mi^2 Lake/pond/swamp area **1.32** mi^2

Watershed storage *(ST)* **3** %

Bridge site elevation **490** ft Headwater elevation **1607** ft

Main channel length **17.90** mi

10% channel length elevation **520** ft 85% channel length elevation **1120** ft

Main channel slope *(S)* **44.69** 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)*: 06 / 1984

Project Number F 020-1(10) Minimum channel bed elevation: 496.5

Low superstructure elevation: USLAB 508.22 DSLAB 506.60 USRAB 508.42 DSRAB 506.21

Benchmark location description:

No specific benchmark information is printed on the plans. A couple points shown on the plans with elevations are: 1) the point on the top streamward edge of the upstream left wingwall concrete where the slope changes from horizontal to downward, elevation 511.57 ft, and 2) the point at the same location as in (1) but on the upstream right wingwall, elevation 511.76 ft.

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

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

If 1: Footing Thickness 2.0 Footing bottom elevation: 492.0

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

-

Comments:

The channel bed elevation was planned to be at least 2.5 ft above the top of both abutment footings.

Cross-sectional Data

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

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

Comments: NO CROSS SECTION INFORMATION

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

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

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

Comments: NO CROSS SECTION INFORMATION

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **CG** Date: **02/22/96**
Computerized by: **CG** Date: **02.22/96**
Reviewd by: **MAI** Date: **01/28/98**

Structure Number **WRUTTH00050026**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E**. **Boehmler** Date *(MM/DD/YY)* **09** / **26** / 19**95**

2. Highway District Number **03** Mile marker **0**

County **Rutland (021)** Town **West Rutland (82300)**

Waterway *(I - 6)* **Clarendon River** Road Name **-**

Route Number **TH 05** Hydrologic Unit Code: **02010002**

3. Descriptive comments:

This site is located 0.1 miles from the junction with west US 4.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **6** LBDS **4** RBDS **5** 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 **1** 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 **41.0** *(feet)* Span length **39.0** *(feet)* Bridge width **25.4** *(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)*

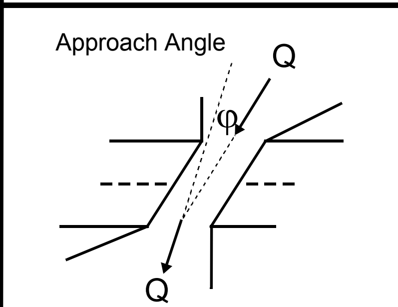
10. Embankment slope (*run / rise in feet / foot*):
US left **4.4:1** US right **2.2:1**

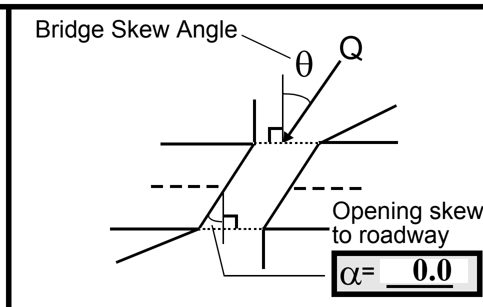
	Protection: 11.Type	Protection: 12.Cond.	13.Erosion	14.Severity
LBUS	1	1	0	0
RBUS	0	-	0	0
RBDS	1	1	2	1
LBDS	1	1	0	0

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

Channel approach to bridge (BF):

15. Angle of approach: **15** 16. Bridge skew: **5.0**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **20** feet **US** *(US, UB, DS)* to **10** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **35** feet **DS** *(US, UB, DS)* to **80** feet **DS**

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

18. Bridge Type: **4**

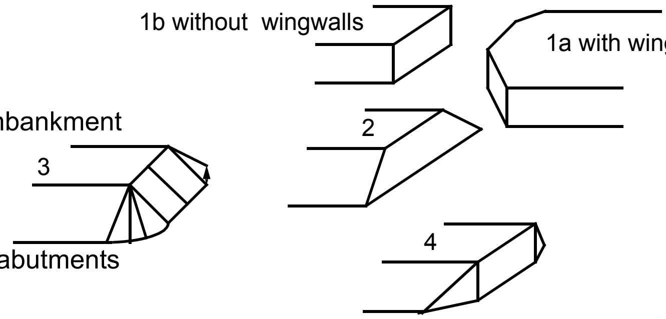
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

The bridge dimensions measured are the same as those in the VTAOT database. The surface cover on the left bank downstream is mostly pasture with a strip of trees and shrubs along the immediate bank. The right bank upstream cover is all forest. The downstream right bank is shrubs and brush with a few trees along the bank. The left bank downstream is pasture with a strip of trees, shrubs and brush along the banks.

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
39.5	6.0			5.5	1	4	213	213	1	1

23. Bank width **25.0** 24. Channel width **15.0** 25. Thalweg depth **58.5** 29. Bed Material **312**

30 .Bank protection type: LB **3** RB **3** 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 left bank is protected from 0 ft upstream to 65 ft upstream. The right bank is protected from 0 ft upstream to 40 ft upstream. The upstream channel is aligned virtually straight into the bridge. The banks show some signs of light fluvial erosion, but generally there are no signs of channel migration until about 20 ft upstream where a point bar has developed. The stream has multiple pools and riffles. These are more spread out upstream than downstream of the bridge. There is a high silt clay fraction to the bed and bank material. The ambient thalweg depth is up to 2 ft in the pools and 0.5 ft at the riffles, upstream and downstream.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **5 UB** 35. Mid-bar width: **27.0**

36. Point bar extent: **25** feet **US** (US, UB) to **30** feet **DS** (US, UB, DS) positioned **0** %LB to **80** %RB

37. Material: **324**

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

The mid-bar distance is 5 ft downstream from the upstream bridge face. The bar extends under the bridge and is unvegetated.

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

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

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

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

NO CUT BANKS

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

47. Scour dimensions: Length **-** Width **-** Depth : **-** Position **-** %LB to **-** %RB

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

NO CHANNEL SCOUR

49. Are there major confluences? **Y** (Y or if N type ctrl-n mc) 50. How many? **1**

51. Confluence 1: Distance **75** 52. Enters on **LB** (LB or RB) 53. Type **2** (1- perennial; 2- ephemeral)

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

54. Confluence comments (eg. confluence name):

This channel is a road drainage ditch entering the channel.

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
27.5		1.5		2	7	7	-

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

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

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

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

312

The bed material is cobbles intermixed with the silt, clay, sand and gravel. The thalweg under the bridge is along the right abutment wall. The flow impacts somewhat on this wall as flow proceeded around a slight bend under the bridge with a point bar developed on the left abutment side.

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

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

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

70. Debris and Ice Comments:

1

The channel upstream flows straight into the bridge. There is a lot of vegetation (trees and shrubs) along the banks in an overall straight to sinuous channel.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		-	90	0	0	0	0	90.0
RABUT	1	15.0	90			2	0	36.5

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.):

0

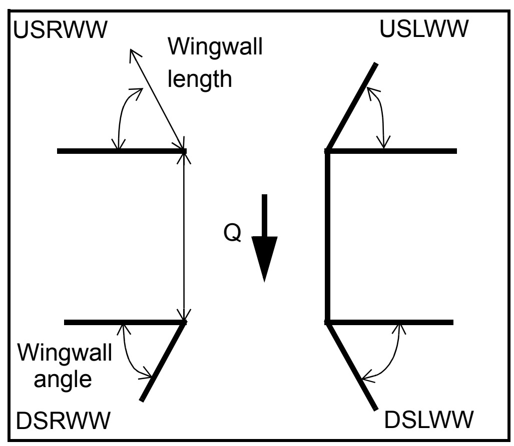
0

1

Except for a slight channel bend and slight attack on the right abutment wall, the abutments are in good condition.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						36.5	
USRWW:	Y		1		0	1.0	
DSLWW:	0		0		Y	30.0	
DSRWW:	1		0		0	29.5	



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	0	0	Y	0	1	1	-	-
Condition	Y	0	1	0	1	1	-	-
Extent	1	0	0	3	3	0	0	-

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

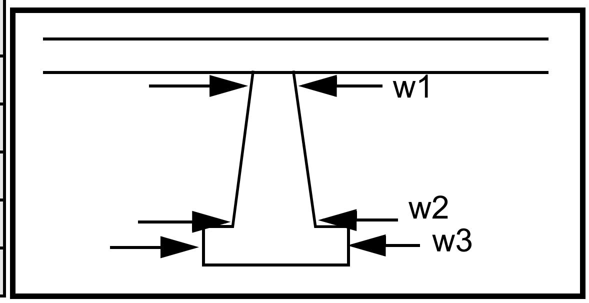
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
1
4
1
1

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				**40.0**	**17.0**	**35.0**
Pier 2				**19.5**	**50.0**	**17.0**
Pier 3			-	**50.0**	**20.0**	-
Pier 4	-	-	-	-	-	-



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

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

-
-
-
-
-
-
-
-
-
-

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	NO	PIE	RS		

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

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

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

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

2
2
23
23
2
1
312
2
2
1
1
The downstream channel impacts the left bank as it bends right. The channel has stone fill lining both banks from 0 ft downstream to about 350 ft downstream where the Clarendon passes under US 4. Beyond the right

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

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

105. Drop structure comments (eg. downstream scour depth):
the channel is artificially straight until the US 4 bridge where the channel bends to pass under it.

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

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

Material: **NO**

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

DROP STRUCTURE

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

Cut bank extent: **85** feet **15** *(US, UB, DS)* to **55** feet **DS** *(US, UB, DS)*

Bank damage: **115** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
60
100
234

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

Scour dimensions: Length **is** Width **unve** Depth: **geta** Positioned **ted** %LB to **and** %RB

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

makes up about 40% of the channel bottom on the right bank side.

Are there major confluences? **N** *(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):

NO CUT BANKS
The stone fill prevents a cut bank from developing on the left bank downstream in the vicinity of the afore-

F. Geomorphic Channel Assessment

107. Stage of reach evolution **me**

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)*:

ntioned point bar.

N
-
-
-
-
-
-
NO CHANNEL SCOUR

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: WRUTTH00050026 Town: West Rutland
Road Number: TH 5 County: Rutland
Stream: Clarendon River

Initials MAI Date: 12/9/97 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 others, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	3510	4750	2450
Main Channel Area, ft2	556	623	479
Left overbank area, ft2	1820	2305	1277
Right overbank area, ft2	824	1085	533
Top width main channel, ft	58	58	58
Top width L overbank, ft	416	438	406
Top width R overbank, ft	225	233	216
D50 of channel, ft	0.2054	0.2054	0.2054
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	9.6	10.7	8.3
y1, average depth, LOB, ft	4.4	5.3	3.1
y1, average depth, ROB, ft	3.7	4.7	2.5
Total conveyance, approach	293691	406439	180605
Conveyance, main channel	80178	96811	62518
Conveyance, LOB	181098	259560	101930
Conveyance, ROB	32415	50067	16156
Percent discrepancy, conveyance	0.0000	0.0002	0.0006
Qm, discharge, MC, cfs	958.2	1131.4	848.1
Ql, discharge, LOB, cfs	2164.4	3033.4	1382.7
Qr, discharge, ROB, cfs	387.4	585.1	219.2
Vm, mean velocity MC, ft/s	1.7	1.8	1.8
Vl, mean velocity, LOB, ft/s	1.2	1.3	1.1
Vr, mean velocity, ROB, ft/s	0.5	0.5	0.4
Vc-m, crit. velocity, MC, ft/s	9.6	9.8	9.4
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	3510	4750	2450
(Q) discharge thru bridge, cfs	3175	3364	2450
Main channel conveyance	50610	46372	44133
Total conveyance	50610	46372	44133
Q2, bridge MC discharge,cfs	3175	3364	2450
Main channel area, ft2	349	412	318
Main channel width (normal), ft	37.5	37.5	37.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.5	37.5	37.4
y_bridge (avg. depth at br.), ft	9.31	10.98	8.50
Dm, median (1.25*D50), ft	0.25675	0.25675	0.25675
y2, depth in contraction,ft	8.20	8.61	6.58
ys, scour depth (y2-ybridge), ft	**-1.11**	-2.37	**-1.92**

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	3510	4750	2450
Q, thru bridge MC, cfs	3175	3364	2450
Vc, critical velocity, ft/s	9.64	9.82	9.40
Va, velocity MC approach, ft/s	1.72	1.82	1.77
Main channel width (normal), ft	37.5	37.5	37.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.5	37.5	37.4
qbr, unit discharge, ft2/s	84.7	89.7	65.5
Area of full opening, ft2	349.0	411.8	318.0
Hb, depth of full opening, ft	9.31	10.98	8.50
Fr, Froude number, bridge MC	0	0.43	0
Cf, Fr correction factor (<=1.0)	0.00	1.00	0.00
**Area at downstream face, ft2	N/A	385	N/A
**Hb, depth at downstream face, ft	N/A	10.27	N/A
**Fr, Froude number at DS face	ERR	0.48	ERR

**Cf, for downstream face (<=1.0)	N/A	1.00	N/A
Elevation of Low Steel, ft	0	495.86	0
Elevation of Bed, ft	-9.31	484.88	-8.50
Elevation of Approach, ft	0	497.23	0
Friction loss, approach, ft	0	0.07	0
Elevation of WS immediately US, ft	0.00	497.16	0.00
ya, depth immediately US, ft	9.31	12.28	8.50
Mean elevation of deck, ft	0	500.66	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.97	1.00
**Cc, for downstream face (<=1.0)	ERR	0.95612	ERR
Ys, scour w/Chang equation, ft	N/A	**-1.61**	N/A
Ys, scour w/Umbrell equation, ft	N/A	-6.09	N/A

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

**Ys, scour w/Chang equation, ft	N/A	-0.72	N/A
**Ys, scour w/Umbrell equation, ft	ERR	-5.38	ERR

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

y2, from Laursen's equation, ft	8.20	8.61	6.58
WSEL at downstream face, ft	--	495.14	--
Depth at downstream face, ft	N/A	10.27	N/A
Ys, depth of scour (Laursen), ft	N/A	-1.65	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	3175	3364	2450
Main channel area (DS), ft2	349	385	318
Main channel width (normal), ft	37.5	37.5	37.4
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	37.5	37.5	37.4
D90, ft	0.5442	0.5442	0.5442
D95, ft	0.6680	0.6680	0.6680
Dc, critical grain size, ft	0.2927	0.2603	0.2172
Pc, Decimal percent coarser than Dc	0.350	0.400	0.476
Depth to armoring, ft	**1.63**	**1.17**	**0.72**

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	3510	4750	2450	3510	4750	2450
a', abut.length blocking flow, ft	426.1	448.1	416.4	235.9	244	226.6
Ae, area of blocked flow ft2	1805.41	2129.77	1333.81	912.76	1181.88	605.54
Qe, discharge blocked abut.,cfs	--	--	1458.86	516.9	730.09	320.17
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.20	1.32	1.09	0.57	0.62	0.53

ya, depth of f/p flow, ft	4.24	4.75	3.20	3.87	4.84	2.67

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

K1	0.82	0.82	0.82	0.82	0.82	0.82

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

theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.100	0.101	0.108	0.051	0.049	0.057
ys, scour depth, ft	18.30	20.19	15.62	16.11	12.61	8.52

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)	426.1	448.1	416.4	235.9	244	226.6
y1 (depth f/p flow, ft)	4.24	4.75	3.20	3.87	4.84	2.67
a'/y1	100.57	94.28	130.00	60.97	50.37	84.80
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.10	0.10	0.11	0.05	0.05	0.06
Ys w/ corr. factor K1/0.55:						
vertical	14.41	16.22	11.17	10.52	13.06	7.55
vertical w/ ww's	**11.82**	**13.30**	**9.16**	**8.63**	**10.71**	**6.19**
spill-through	7.93	8.92	6.14	5.79	7.18	4.15

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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.58	0.48	0.51	0.58	0.48	0.51
y, depth of flow in bridge, ft	9.31	10.27	8.50	9.31	10.27	8.50
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	**1.94**	**1.46**	**1.37**	**1.94**	**1.46**	**1.37**
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR