LEVEL II SCOUR ANALYSIS FOR BRIDGE 14 (WRUTTH00170014) on TOWN HIGHWAY 17, crossing the CLARENDON RIVER, WEST RUTLAND, VERMONT

Open-File Report 98-420

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 RONDA L. BURNS and ERICK M. BOEHMLER

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Pembroke, New Hampshire

1998

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
cfs	cubic feet per second
D_{50}	median diameter of bed material
DS	downstream
elev.	elevation
f/p	flood plain
ft^2	square feet
ft/ft	feet per foot
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
JCT	junction
LAB	left abutment
LABUT	face of left abutment
LB	left bank
LOB	left overbank
LWW	left wingwall
Max	maximum
MC	main channel
RAB	right abutment
RABUT	face of right abutment
RB	right bank
ROB	right overbank
RWW	right wingwall
TH	town highway
UB	under bridge
US	upstream
USGS	United States Geological Survey
VTAOT	Vermont Agency of Transportation
WSPRO	water-surface profile model
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 14 (WRUTTH00170014) ON TOWN HIGHWAY 17, CROSSING THE CLARENDON RIVER, WEST RUTLAND, VERMONT

By **Ronda L. Burns and Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure WRUTTH00170014 on Town Highway 17 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 40.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture downstream of the bridge and on the right bank upstream, with tree cover on the immediate banks. The upstream left bank is forested.

In the study area, the Clarendon River has a meandering channel with a slope of approximately 0.003 ft/ft, an average channel top width of 36 ft and an average bank height of 2 ft. The channel bed material ranges from sand to cobble with a median grain size (D_{50}) of 29.9 mm (0.098 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 21, 1995, indicated that the reach was laterally unstable. The upstream left and right banks and the downstream right bank have moderate fluvial erosion. There are also cut-banks upstream and downstream of the bridge.

The Town Highway 17 crossing of the Clarendon River is a 41-ft-long, one-lane bridge consisting of one 37-foot steel-stringer span (Vermont Agency of Transportation, written communication, March 15, 1995). The opening length of the structure parallel to the bridge face is 36.8 ft. The bridge is supported by vertical, concrete abutments with wingwalls. In addition, there is a 5 ft diameter, steel, corrugated culvert located 50 ft to the right of the bridge. The channel is skewed approximately zero degrees to the opening and the opening-skew-to-roadway is zero degrees.

A scour hole up to 2.0 ft deeper than the mean thalweg depth was observed in the upstream channel, under the bridge, and in front of the stone fill along the downstream right wingwall during the Level I assessment. Scour protection measures at the site included type-1 stone fill (less than 12 inches diameter) along the downstream left wingwall and type-2 stone fill (less than 36 inches diameter) along the upstream left bank, the upstream left and right wingwalls, the right abutment, the downstream right wingwall, and at the upstream end of the left abutment. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 1.7 to 2.4 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 3.7 to 5.6 ft. Right abutment scour ranged from 11.7 to 18.1 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.

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

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 WRUTTH00170014 ***Stream*** Clarendon River

County Rutland ***Road*** TH 17 ***District*** 3

Description of Bridge

Bridge length 41 ***ft*** ***Bridge width*** 14.7 ***ft*** ***Max span length*** 37 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 9/21/95

Description of stone fill Type-1, along the downstream left wingwall. Type-2, along the upstream left and right wingwalls, the upstream end of the left abutment, the right abutment, and the downstream right wingwall.

Abutments and wingwalls are concrete. There is a two foot deep scour hole under the bridge along the stone fill for both abutments.

No 0

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

There is a severe channel bend in the upstream reach. The scour hole has developed in the location where the flow impacts the upstream end of the left abutment.

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*
	9/21/95	0	0
Level I	9/21/95	0	0
Level II			

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

Describe any features near or at the bridge that may affect flow (include observation date) The stone fill protection along the abutments protrudes into the channel (observed on 9/21/95).

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley with narrow flood plains.

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

Date of inspection 9/21/95

DS left: Narrow flood plain

DS right: Narrow flood plain to a moderately sloped valley wall

US left: Narrow flood plain

US right: Narrow flood plain to a moderately sloped valley wall

Description of the Channel

Average top width 36 ft ***Average depth*** 2 ft

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

Perennial and meandering with alluvial channel boundaries and wide point bars.

9/21/95

Vegetative co Trees and brush with grass on the overbank

DS left: Few trees with grass on the overbank

DS right: Trees and brush

US left: Trees and brush with grass on the overbank

US right:

Do banks appear stable? No The upstream left and right banks and the downstream right bank have moderate fluvial erosion. There are also cut-banks upstream and downstream of the bridge.

date of observation.

None were observed on 9/21/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 40.9 ***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 3,320 ***ft³/s*** ***Q500*** 4,600 ***ft³/s***

The 100- and 500-year discharges are based on flood frequency estimates available from the VTAOT database (written communication, May 1995) for this site. The values used 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 extended graphically to the 500-year event.

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

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

Datum tie between USGS survey and VTAOT plans The USGS arbitrary survey datum was reduced by 399.04 to obtain the VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the left abutment (elev. 100.87 ft, VTAOT plans' datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 100.85 ft, VTAOT plans' datum). RM3 is a spike 5 ft above the ground in a locust tree located 21.5 ft to the left of the upstream end of the left abutment (elev. 104.84 ft, VTAOT plans' datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-38	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPR1	53	1	Approach section

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 0.030 to 0.046, and overbank "n" values ranged from 0.045 to 0.060.

Normal depth at the exit section (EXIT1) 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 0.0031 ft/ft, which was estimated from the appropriate topographic map (U.S. Geological Survey, 1964).

The surveyed approach section (APPR1) was modelled one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

For the incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles for this discharge, it was determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Culvert routines provided with WSPRO are not fully integrated. Therefore, it was necessary to develop individual ratings for the culvert and bridge to model this multiple-opening situation. The ratings were combined to determine the quantity of the total discharge diverted from the bridge through the culvert. The combined ratings indicate the culvert diverts 6.9% of the total peak discharge on average. Each modelled discharge was reduced by the flow through the culvert for the model provided in appendix A and B.

Bridge Hydraulics Summary

Average bridge embankment elevation 101.1 ***ft***
Average low steel elevation 98.7 ***ft***

100-year discharge 3,320 ***ft³/s***
Water-surface elevation in bridge opening 98.7 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,030 ***ft³/s***
Area of flow in bridge opening 237 ***ft²***
Average velocity in bridge opening 8.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.7 ***ft/s***

Water-surface elevation at Approach section with bridge 100.7
Water-surface elevation at Approach section without bridge 97.3
Amount of backwater caused by bridge 3.4 ***ft***

500-year discharge 4,600 ***ft³/s***
Water-surface elevation in bridge opening 98.7 ***ft***
Road overtopping? Yes ***Discharge over road*** 2,090 ***ft³/s***
Area of flow in bridge opening 237 ***ft²***
Average velocity in bridge opening 9.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.6 ***ft/s***

Water-surface elevation at Approach section with bridge 101.3
Water-surface elevation at Approach section without bridge 97.8
Amount of backwater caused by bridge 3.5 ***ft***

Incipient overtopping discharge 1,910 ***ft³/s***
Water-surface elevation in bridge opening 96.4 ***ft***
Area of flow in bridge opening 152 ***ft²***
Average velocity in bridge opening 11.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 15.0 ***ft/s***

Water-surface elevation at Approach section with bridge 98.8
Water-surface elevation at Approach section without bridge 96.7
Amount of backwater caused by bridge 2.1 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

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

For comparison, contraction scour for the 100-year and 500-year discharges also was computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Results from these computations are presented in appendix F. Furthermore, for the discharges which resulted in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are also provided in appendix F.

Abutment scour was computed by use of the HIRE equation (Richardson and Davis, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. 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	1.7	2.4	2.1
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	5.3	5.6	3.7
Right abutment	16.1	18.1	11.7
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	500-year discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	2.0	2.2	1.7
Right abutment	2.0	2.2	1.7
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

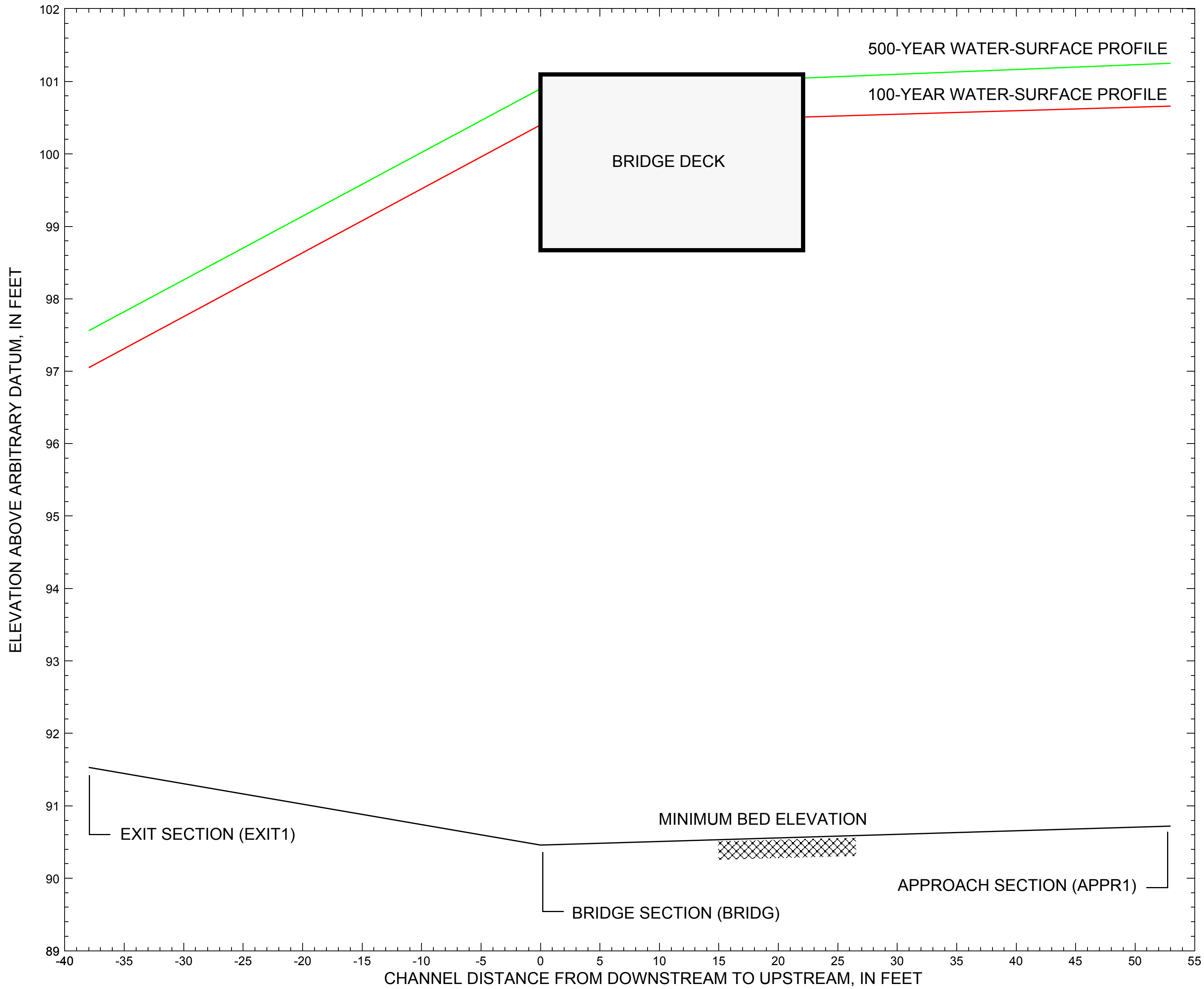

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure WRUTTH00170014 on Town Highway 17, crossing the Clarendon River, West Rutland, Vermont.

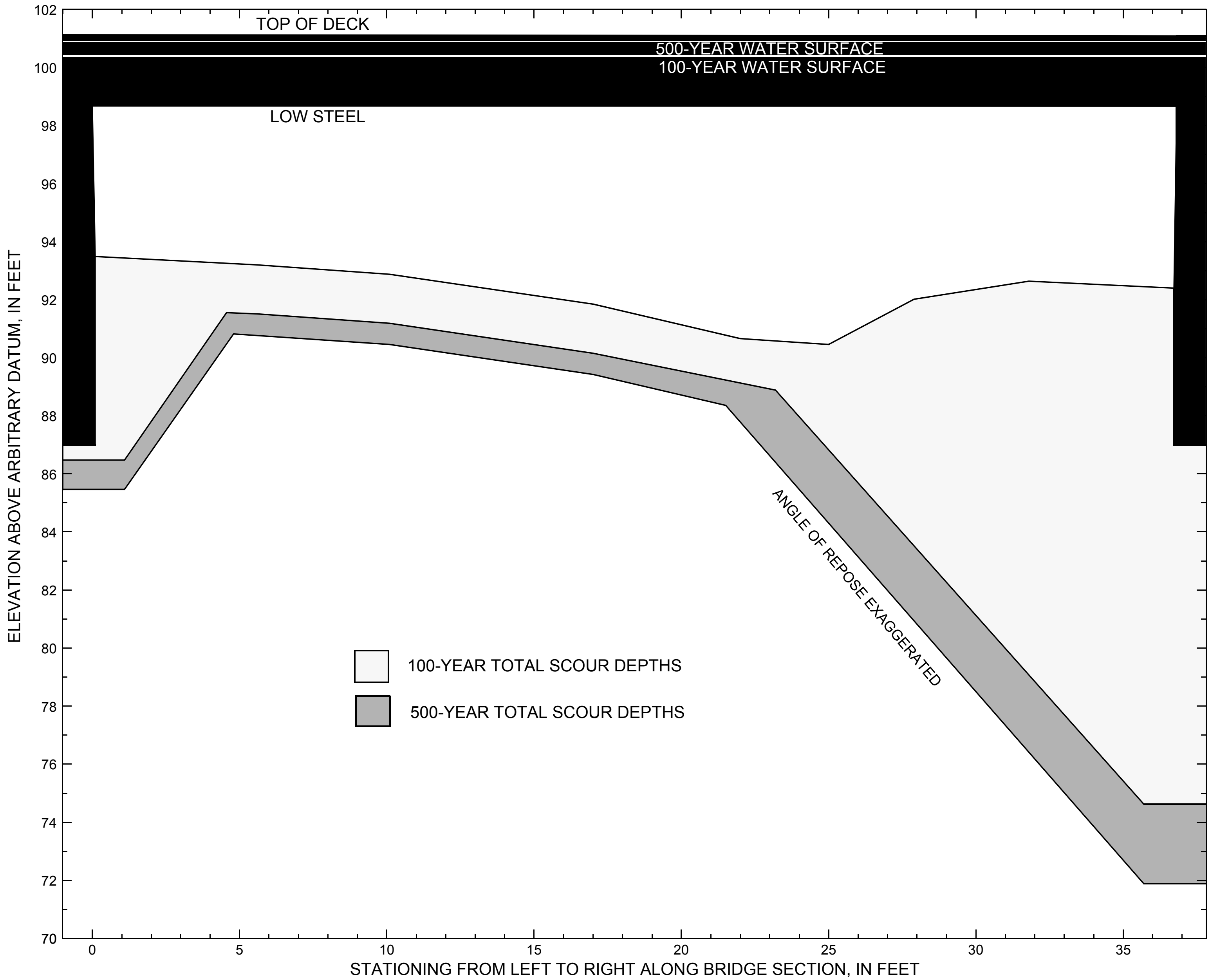

Figure 8. Scour elevations for the 100- and 500-year discharges at structure WRUTTH00170014 on Town Highway 17, crossing the Clarendon River, West Rutland, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WRUTTH00170014 on Town Highway 17, 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 3,320 cubic-feet per second											
Left abutment	0.0	98.6	98.7	87.0	93.5	1.7	5.3	--	7.0	86.5	-0.5
Right abutment	36.8	98.6	98.7	87.0	92.4	1.7	16.1	--	17.8	74.6	-12.4

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 WRUTTH00170014 on Town Highway 17, 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 4,600 cubic-feet per second											
Left abutment	0.0	98.6	98.7	87.0	93.5	2.4	5.6	--	8.0	85.5	-1.5
Right abutment	36.8	98.6	98.7	87.0	92.4	2.4	18.1	--	20.5	71.9	-15.1

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 wrut014.wsp
T2        Hydraulic analysis for structure WRUTTH00170014   Date: 25-FEB-98
T3        TH 17 CROSSING THE CLARENDON RIVER IN WEST RUTLAND, VERMONT   RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3070.0   4350.0   1760.0
SK          0.0031   0.0031   0.0031
*
XS   EXIT1    -38          0.
GR         -498.8, 114.32   -467.8,  98.06   -449.7,  98.03   -257.3,  95.99
GR          -99.8,  94.77    -76.0,  94.89      0.0,  95.61      3.7,  92.70
GR            5.3,  92.06      8.4,  92.67      9.3,  92.98     17.4,  93.15
GR           24.2,  92.97     30.3,  92.04     34.8,  91.53     38.8,  92.01
GR           40.8,  92.86     42.5,  95.27     82.8,  95.22    163.8,  94.51
GR          197.7,  98.46    234.6, 105.42
*
N           0.045       0.035       0.045
SA                   0.0         42.5
*
XS   FULLV      0  * * *   0.0000
*
*              SRD     LSEL    XSSKEW
BR   BRIDG     0      98.68       0.0
GR            0.0,  98.68      0.1,  93.49      5.6,  93.20     10.1,  92.88
GR           17.0,  91.85     22.0,  90.66     25.0,  90.46     27.9,  92.02
GR           31.8,  92.64     36.8,  92.40     36.8,  98.67      0.0,  98.68
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1       23.6 * *      40.3     10.8
N           0.030
*
*              SRD    EMBWID   IPAVE
XR   RDWAY      8      14.7     2
GR         -701.3, 127.27   -638.7, 111.92   -593.7, 106.93   -515.5, 107.86
GR         -483.5, 109.45   -457.9, 109.93   -447.9, 107.27   -422.7, 105.33
GR         -370.5, 103.35   -286.5, 100.86   -253.6, 100.15   -215.2,  99.49
GR         -155.0,  99.00    -89.2,  99.12    -30.7, 100.67     -1.5, 101.15
GR           -1.4, 101.91     39.2, 101.84     39.2, 100.96     54.0, 100.85
GR           86.8,  99.64    147.7, 100.40    226.9, 102.89    250.3, 110.41
*
AS   APPR1     53          0.
GR         -453.8, 109.01   -418.7, 105.52   -365.2, 104.21   -342.3, 101.98
GR         -276.5, 100.03   -215.6,  98.58   -147.5,  98.01   -118.8,  97.58
GR          -65.0,  96.57      0.0,  96.57      4.5,  92.98      5.9,  92.11
GR            9.6,  91.27     13.5,  90.72     15.9,  91.59     19.7,  92.97
GR           25.4,  93.27     29.4,  94.59     40.2,  94.93    194.2,  94.44
GR          219.6,  94.17    278.8,  96.91    394.9, 126.07
*
N           0.060       0.046       0.045
SA                   0.0         29.4
*
HP 1 BRIDG  98.68 1 98.68
HP 2 BRIDG  98.68 * * 2047
HP 1 BRIDG  97.19 1 97.19
HP 2 RDWAY  100.40 * * 1034
HP 1 APPR1  100.66 1 100.66
HP 2 APPR1  100.66 * * 3320
*
HP 1 BRIDG  98.68 1 98.68
HP 2 BRIDG  98.68 * * 2219
HP 1 BRIDG  97.71 1 97.71
HP 2 RDWAY  100.90 * * 2093
HP 1 APPR1  101.25 1 101.25
HP 2 APPR1  101.25 * * 4600
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File wrut014.wsp
      Hydraulic analysis for structure WRUTTH00170014   Date: 25-FEB-98
      TH 17 CROSSING THE CLARENDON RIVER IN WEST RUTLAND, VERMONT   RLB
         *** RUN DATE & TIME: 05-07-98  11:22

  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1      237.  23200.     0.    86.                          0.
  98.68           237.  23200.     0.    86.  1.00     0.    37.      0.

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

       WSEL     LEW     REW    AREA        K        Q    VEL
      98.68     0.0    36.8   237.0   23200.    2047.   8.64

X STA.        0.0        4.3        6.6        8.6       10.6       12.5
  A(I)             22.8       12.2       11.4       11.8       11.3
  V(I)             4.50       8.38       9.00       8.69       9.10

X STA.       12.5       14.3       15.9       17.4       18.9       20.2
  A(I)             11.0       10.7       10.5       10.2       10.0
  V(I)             9.33       9.61       9.70      10.08      10.25

X STA.       20.2       21.5       22.7       23.9       25.1       26.4
  A(I)             10.0       10.0        9.7        9.5       10.2
  V(I)            10.27      10.25      10.58      10.73      10.03

X STA.       26.4       27.9       29.6       31.3       33.2       36.8
  A(I)             10.6       10.7       11.1       11.1       22.4
  V(I)             9.65       9.55       9.19       9.26       4.56

  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1      182.  22729.    37.    46.                       2305.
  97.19           182.  22729.    37.    46.  1.00     0.    37.   2305.

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

       WSEL     LEW     REW    AREA        K        Q    VEL
     100.40  -265.2   147.7   243.3    7316.    1034.   4.25

X STA.     -265.2     -209.5     -198.3     -188.6     -180.1     -172.2
  A(I)             29.1       11.2       10.5        9.9        9.7
  V(I)             1.78       4.61       4.91       5.22       5.32

X STA.     -172.2     -164.8     -157.9     -151.3     -144.6     -137.9
  A(I)              9.5        9.4        9.1        9.3        9.2
  V(I)             5.44       5.52       5.66       5.55       5.60

X STA.     -137.9     -130.9     -123.9     -116.8     -109.4     -102.2
  A(I)              9.5        9.5        9.5        9.7        9.5
  V(I)             5.41       5.47       5.45       5.33       5.44

X STA.     -102.2      -94.8      -87.3      -78.2       88.6      147.7
  A(I)              9.6        9.6       10.1       27.6       21.8
  V(I)             5.38       5.39       5.13       1.88       2.37

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      53.
   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1      791.  37692.   298.   298.                       7319.
           2      233.  28616.    29.    32.                       3729.
           3     1476. 153682.   264.   265.                      19800.
 100.66          2501. 219991.   591.   594.  1.28  -298.   294.  25778.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      53.

       WSEL     LEW     REW    AREA        K        Q    VEL
     100.66  -297.8   293.7  2500.9  219991.    3320.   1.33

X STA.     -297.8     -111.7      -60.6      -18.2        8.4       17.0
  A(I)            354.9      188.4      173.6      134.5       80.6
  V(I)             0.47       0.88       0.96       1.23       2.06

X STA.       17.0       28.8       46.4       64.2       82.0       99.2
  A(I)             89.0      103.0      102.5      103.8      101.6
  V(I)             1.87       1.61       1.62       1.60       1.63

X STA.       99.2      116.1      133.0      149.5      165.6      181.8
  A(I)            100.5      101.4       99.9       98.2       99.2
  V(I)             1.65       1.64       1.66       1.69       1.67

X STA.      181.8      198.0      213.1      228.2      246.6      293.7
  A(I)            100.6       95.9       96.2      104.4      172.6
  V(I)             1.65       1.73       1.73       1.59       0.96
```

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        U.S. Geological Survey WSPRO Input File wrut014.wsp
        Hydraulic analysis for structure WRUTTH00170014   Date: 25-FEB-98
        TH 17 CROSSING THE CLARENDON RIVER IN WEST RUTLAND, VERMONT   RLB
           *** RUN DATE & TIME: 05-07-98  11:22

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     237.   23200.     0.    86.                           0.
    98.68          237.   23200.     0.    86.  1.00     0.    37.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
        98.68     0.0    36.8   237.0   23200.    2219.   9.36

X STA.         0.0        4.3        6.6        8.6       10.6       12.5
  A(I)            22.8       12.2       11.4       11.8       11.3
  V(I)            4.88       9.08       9.75       9.42       9.86

X STA.        12.5       14.3       15.9       17.4       18.9       20.2
  A(I)            11.0       10.7       10.5       10.2       10.0
  V(I)           10.11      10.42      10.52      10.93      11.12

X STA.        20.2       21.5       22.7       23.9       25.1       26.4
  A(I)            10.0       10.0        9.7        9.5       10.2
  V(I)           11.14      11.11      11.47      11.63      10.87

X STA.        26.4       27.9       29.6       31.3       33.2       36.8
  A(I)            10.6       10.7       11.1       11.1       22.4
  V(I)           10.46      10.36       9.96      10.04       4.95

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     201.   26440.    37.    47.                        2676.
    97.71          201.   26440.    37.    47.  1.00     0.    37.   2676.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

         WSEL     LEW     REW    AREA        K        Q    VEL
       100.90  -287.8   163.6   414.8   14839.    2093.   5.05

X STA.      -287.8     -221.4     -208.5     -197.0     -186.8     -177.2
  A(I)            46.1       18.0       17.4       16.4       16.1
  V(I)            2.27       5.81       6.00       6.39       6.51

X STA.      -177.2     -168.2     -159.6     -151.4     -143.0     -134.6
  A(I)            15.8       15.8       15.4       15.8       15.7
  V(I)            6.64       6.62       6.78       6.63       6.68

X STA.      -134.6     -126.1     -117.6     -108.9     -100.3      -91.6
  A(I)            15.9       15.7       15.8       15.5       15.7
  V(I)            6.60       6.66       6.64       6.75       6.67

X STA.       -91.6      -82.1      -69.7       88.5      109.4      163.6
  A(I)            16.1       17.8       54.5       23.3       32.3
  V(I)            6.48       5.89       1.92       4.50       3.24

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      53.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     973.   50936.   318.   318.                        9660.
             2     251.   32250.    29.    32.                        4152.
             3    1633.  180709.   267.   267.                       22931.
   101.25         2856.  263895.   614.   617.  1.28  -318.   296.  30889.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      53.

         WSEL     LEW     REW    AREA        K        Q    VEL
       101.25  -317.7   296.1  2856.4  263895.    4600.   1.61

X STA.      -317.7     -130.3      -75.5      -35.3        4.1       13.8
  A(I)           402.8      217.6      187.0      191.6       93.8
  V(I)            0.57       1.06       1.23       1.20       2.45

X STA.        13.8       24.7       42.0       60.1       78.0       95.9
  A(I)            95.9      115.9      115.1      114.8      115.8
  V(I)            2.40       1.98       2.00       2.00       1.99

X STA.        95.9      113.3      130.7      147.7      164.3      180.8
  A(I)           113.5      114.5      112.8      110.7      111.8
  V(I)            2.03       2.01       2.04       2.08       2.06

X STA.       180.8      197.5      213.1      228.6      247.6      296.1
  A(I)           113.3      107.8      108.0      118.0      195.5
  V(I)            2.03       2.13       2.13       1.95       1.18
```

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      U.S. Geological Survey WSPRO Input File wrut014.wsp
      Hydraulic analysis for structure WRUTTH00170014   Date: 25-FEB-98
      TH 17 CROSSING THE CLARENDON RIVER IN WEST RUTLAND, VERMONT   RLB
         *** RUN DATE & TIME: 05-07-98  11:22

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     152.   17232.    37.    44.                         1758.
  96.37          152.   17232.    37.    44.  1.00     0.    37.   1758.

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

       WSEL     LEW     REW    AREA        K        Q    VEL
      96.37     0.0    36.8   152.2   17232.    1760.  11.56

X STA.         0.0        5.5        7.9       10.2       12.2       14.0
  A(I)            16.4        8.0        7.7        7.3        7.2
  V(I)             5.38      11.01      11.36      12.08      12.26

X STA.        14.0       15.6       17.1       18.5       19.7       20.8
  A(I)             6.7        6.5        6.5        6.1        6.1
  V(I)            13.13      13.55      13.58      14.34      14.45

X STA.        20.8       22.0       23.0       24.0       25.0       26.1
  A(I)             6.2        6.0        5.9        5.9        6.2
  V(I)            14.29      14.75      14.98      14.84      14.10

X STA.        26.1       27.4       29.0       30.7       32.6       36.8
  A(I)             6.5        6.9        6.9        7.1       16.2
  V(I)            13.53      12.73      12.83      12.32       5.45

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      53.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     300.    9028.   224.   224.                         1966.
           2     178.   18284.    29.    32.                         2492.
           3     989.   80384.   257.   257.                        11012.
  98.79         1467.  107696.   511.   513.  1.26  -224.   286.  12569.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      53.

       WSEL     LEW     REW    AREA        K        Q    VEL
      98.79  -224.4   286.3  1467.1  107696.    1910.   1.30

X STA.      -224.4      -39.1        6.0       12.3       18.5       28.5
  A(I)           213.0      114.1       46.3       46.0       54.9
  V(I)             0.45       0.84       2.06       2.08       1.74

X STA.        28.5       44.4       61.2       77.9       93.8      109.7
  A(I)            63.5       65.7       65.9       63.7       64.6
  V(I)             1.50       1.45       1.45       1.50       1.48

X STA.       109.7      125.0      140.2      155.1      169.6      184.1
  A(I)            62.6       63.3       62.5       61.6       62.4
  V(I)             1.53       1.51       1.53       1.55       1.53

X STA.       184.1      198.3      211.9      224.9      240.8      286.3
  A(I)            61.6       60.6       59.3       63.6      112.0
  V(I)             1.55       1.58       1.61       1.50       0.85
```

```
       U.S. Geological Survey WSPRO Input File wrut014.wsp
       Hydraulic analysis for structure WRUTTH00170014   Date: 25-FEB-98
       TH 17 CROSSING THE CLARENDON RIVER IN WEST RUTLAND, VERMONT   RLB
          *** RUN DATE & TIME: 05-07-98  11:22

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

EXIT1:XS   ******  -357.     966.  0.27 *****   97.32   96.50   3070.   97.05
      -38. ******   186.   55087.  1.70 ***** *******    0.55    3.18

FULLV:FV      38.  -371.    1044.  0.22  0.11   97.41 *******   3070.   97.19
        0.    38.   187.   61007.  1.65  0.00   -0.01    0.49    2.94
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPR1:AS      53.  -106.     823.  0.26  0.16   97.60 *******   3070.   97.34
       53.    53.   281.   50385.  1.18  0.02    0.00    0.49    3.73
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   101.52       0.00      98.24      99.00
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =    97.42     100.21     100.31      98.68
 ===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      38.     0.     237.  1.16 *****   99.84   96.81   2047.   98.68
        0. ******    37.   23200.  1.00 ***** *******    0.60    8.64

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.474  0.000   98.68 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
   RDWAY:RG       8.    38.  0.01  0.03  100.68    0.00   1034.  100.40

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    914.   224.  -265.   -41.   1.4   0.9   5.0   4.3   1.2   3.0
   RT:    120.    82.    66.   148.   0.8   0.4   3.3   3.9   0.7   2.7

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

APPR1:AS      29.  -298.    2501.  0.03  0.07  100.69   96.30   3070.  100.66
       53.    54.   294.  219944.  1.28  0.24    0.00    0.12    1.23

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -38.  -357.   186.   3070.   55087.     966.    3.18   97.05
   FULLV:FV       0.  -371.   187.   3070.   61007.    1044.    2.94   97.19
   BRIDG:BR       0.     0.    37.   2047.   23200.     237.    8.64   98.68
   RDWAY:RG       8.*******   914.   1034.******************    2.00  100.40
   APPR1:AS      53.  -298.   294.   3070.  219944.    2501.    1.23  100.66

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO   VHD     EGL    WSEL
   EXIT1:XS     96.50    0.55   91.53  114.32************  0.27   97.32   97.05
   FULLV:FV  ********    0.49   91.53  114.32  0.11  0.00  0.22   97.41   97.19
   BRIDG:BR     96.81    0.60   90.46   98.68************  1.16   99.84   98.68
   RDWAY:RG  ****************   99.00  127.27  0.01******  0.03  100.68  100.40
   APPR1:AS     96.30    0.12   90.72  126.07  0.07  0.24  0.03  100.69  100.66
```

WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File wrut014.wsp
        Hydraulic analysis for structure WRUTTH00170014   Date: 25-FEB-98
        TH 17 CROSSING THE CLARENDON RIVER IN WEST RUTLAND, VERMONT   RLB
           *** RUN DATE & TIME: 05-07-98  11:22

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

EXIT1:XS   ******  -406.    1258.  0.29 *****   97.85   96.86   4350.   97.56
      -38. ******   190.   78059.  1.57 ***** *******    0.53    3.46

FULLV:FV      38.  -419.    1346.  0.25  0.11   97.96 *******   4350.   97.71
        0.    38.   191.   85409.  1.54  0.00    0.00    0.48    3.23
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS      53.  -136.    1019.  0.34  0.17   98.17 *******   4350.   97.83
       53.    53.   282.   67222.  1.20  0.04   -0.01    0.53    4.27
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===210 QUESTIONABLE CRITICAL-FLOW SOLUTION.
                   SECID "BRIDG"     Q,CRWS =  4350.00      98.68
 ===230 REJECTED FLOW CLASS 1 SOLUTION.
              WS1,WSSD,WS3 =   104.81       0.00       98.68
                      CRWS =    96.76   ********       98.68
                      YMAX =   126.07   ********       98.68
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =     98.04     100.87     100.98       98.68
 ===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      38.     0.     237.  1.36 *****  100.04   97.08   2219.   98.68
        0. ******    37.   23200.  1.00 ***** *******    0.65    9.36

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.487  0.000   98.68 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    38.  0.01  0.05  101.28   -0.01   2093.  100.90

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1718.   271.  -288.   -17.   1.9   1.2   5.9   5.1   1.6   3.1
   RT:    374.   117.    47.   164.   1.3   0.7   4.5   4.7   1.1   2.9

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

APPR1:AS      29.  -318.    2855.  0.05  0.10  101.29   96.76   4350.  101.25
       53.    56.   296.  263725.  1.28  0.22   -0.01    0.14    1.52

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS      -38.  -406.   190.   4350.   78059.    1258.    3.46   97.56
   FULLV:FV        0.  -419.   191.   4350.   85409.    1346.    3.23   97.71
   BRIDG:BR        0.     0.    37.   2219.   23200.     237.    9.36   98.68
   RDWAY:RG        8.******* 1718.   2093.*****************    2.00  100.90
   APPR1:AS       53.  -318.   296.   4350.  263725.    2855.    1.52  101.25

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS  **********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS     96.86    0.53   91.53  114.32************  0.29   97.85   97.56
   FULLV:FV  ********    0.48   91.53  114.32  0.11  0.00  0.25   97.96   97.71
   BRIDG:BR     97.08    0.65   90.46   98.68************  1.36  100.04   98.68
   RDWAY:RG  ****************   99.00  127.27  0.01******  0.05  101.28  100.90
   APPR1:AS     96.76    0.14   90.72  126.07  0.10  0.22  0.05  101.29  101.25
```

```
 U.S. Geological Survey WSPRO Input File wrut014.wsp
 Hydraulic analysis for structure WRUTTH00170014   Date: 25-FEB-98
 TH 17 CROSSING THE CLARENDON RIVER IN WEST RUTLAND, VERMONT   RLB
    *** RUN DATE & TIME: 05-07-98  11:22

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

EXIT1:XS   ******  -294.     625.  0.24 *****   96.62   96.04   1760.   96.38
      -38. ******   180.   31582.  1.98 ***** *******    0.61    2.82

FULLV:FV      38.  -309.     701.  0.19  0.10   96.72 *******   1760.   96.54
        0.    38.   181.   36470.  1.90  0.00    0.00    0.51    2.51
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS      53.   -72.     590.  0.16  0.14   96.87 *******   1760.   96.71
       53.    53.   274.   32560.  1.15  0.00    0.01    0.43    2.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                    SECID "BRIDG"     Q,CRWS =    1760.       96.37

            <<<<<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      38.     0.     152.  2.08 *****   98.45   96.37   1760.   96.37
        0.    38.    37.   17257.  1.00 ***** *******    1.00   11.55

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******   98.68 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS      29.  -224.    1465.  0.03  0.12   98.81   95.81   1760.   98.79
       53.    53.   286.  107504.  1.26  0.25   -0.02    0.14    1.20

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.894  0.884   12627.    83.   120.    98.78

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -38.  -294.   180.   1760.   31582.     625.    2.82   96.38
   FULLV:FV       0.  -309.   181.   1760.   36470.     701.    2.51   96.54
   BRIDG:BR       0.     0.    37.   1760.   17257.     152.   11.55   96.37
   RDWAY:RG       8.**************       0.*****************      2.00********
   APPR1:AS      53.  -224.   286.   1760.  107504.    1465.    1.20   98.79

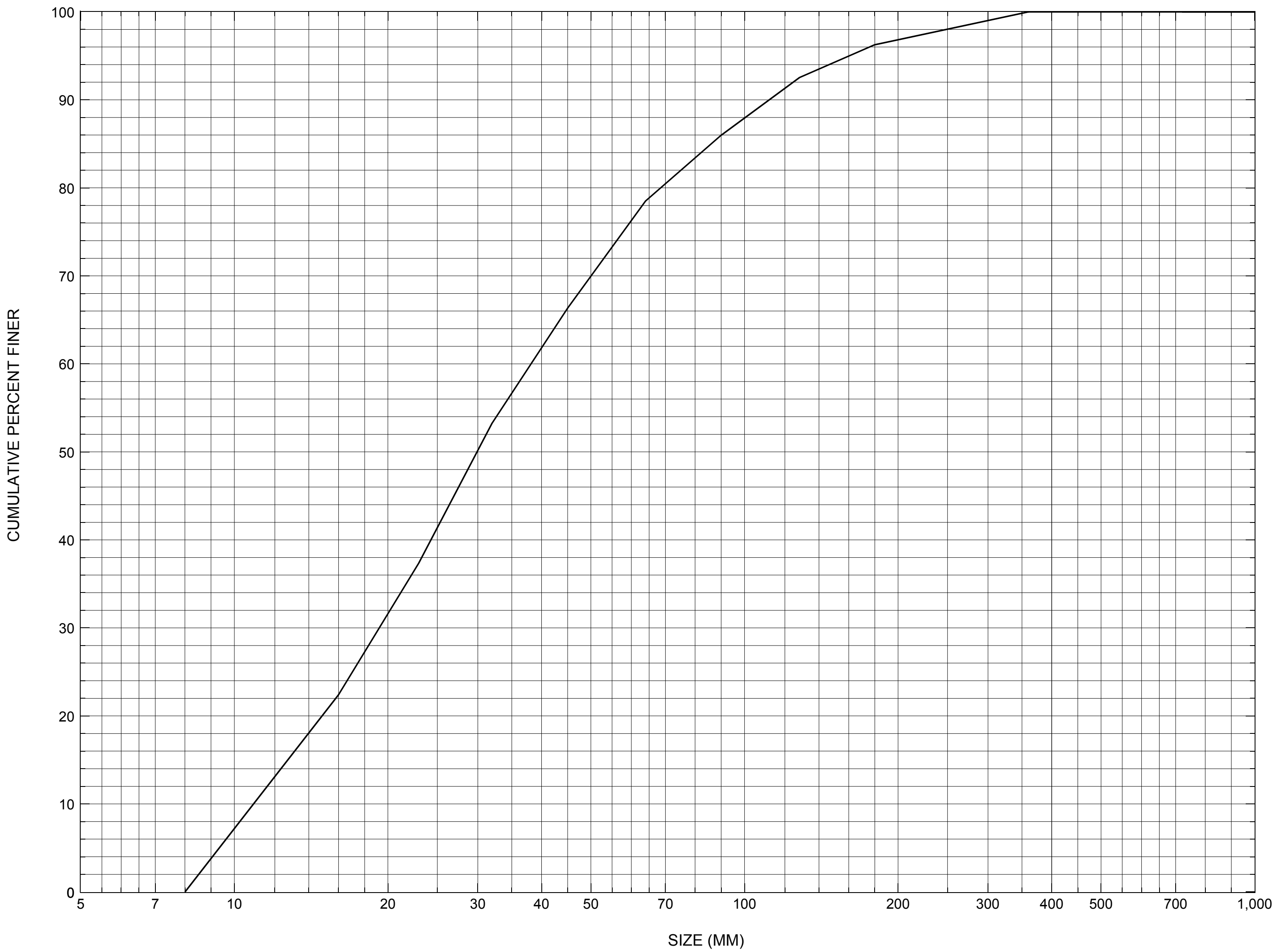
    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS      83.   120.   12627.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXIT1:XS     96.04    0.61   91.53  114.32************  0.24    96.62   96.38
   FULLV:FV  ********    0.51   91.53  114.32  0.10  0.00  0.19    96.72   96.54
   BRIDG:BR     96.37    1.00   90.46   98.68************  2.08    98.45   96.37
   RDWAY:RG ****************    99.00  127.27**********************************
   APPR1:AS     95.81    0.14   90.72  126.07  0.12  0.25  0.03    98.81   98.79
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure WRUTTH00170014, in West Rutland, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WRUTTH00170014

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 TH017

Vicinity *(I - 9)* 0.1 MI TO JCT W VT133

Topographic Map West Rutland

Hydrologic Unit Code: 02010002

Latitude *(I - 16; nnnn.n)* 43344

Longitude *(i - 17; nnnnn.n)* 73020

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10112800141128

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

Maximum span length *(I - 48; nnnn)* 0037

Year built *(I - 27; YYYY)* 1977

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

Average daily traffic, ADT *(I - 29; nnnnnn)* 000030

Deck Width *(I - 52; nn.n)* 147

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)* 7

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 037.1

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

Vertical clearance from streambed (*nnn.n ft*) 007.7

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

Waterway of full opening (*nnn.n* ft^2) 285.5

Comments:

The structural inspection report of 5/11/94 indicates the structure is a steel stringer type bridge. The abutment walls are concrete. The right abutment wall has some fine cracks reported. The left abutment wall has a full-height crack and some random fine cracks noted. The upstream and downstream left wingwalls have some random areas of map cracking indicated. The inspection report mentions general scour conditions throughout the area under the bridge. The channel makes a sharp bend into the crossing just upstream of the bridge. No exposure, undermining, or settlement is reported.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: 42.0

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} * 2870 Q_{25} * 3960
Q_{50} * 5205 Q_{100} - Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q 25 *(ft/s)*: 9.2

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*)	-	97.2	98.2	98.9	-
Velocity (*ft / sec*)	-	-	9.2	-	-

Long term stream bed changes: -

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

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

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

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

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

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

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

Comments:

*** The hydraulics report available is not a full report. The hydrologic data in the previous section is printed on the plans but is not readily available in the hydraulic section's bridge folders.**

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **40.93** mi^2 Lake/pond/swamp area **1.32** mi^2
Watershed storage *(ST)* **3** %
Bridge site elevation **520** ft Headwater elevation **1607** ft
Main channel length **16.27** mi
10% channel length elevation **600** ft 85% channel length elevation **1120** ft
Main channel slope *(S)* **42.47** 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):* **11** / **1976**

Project Number **DSR 0192** Minimum channel bed elevation: **91.0**

Low superstructure elevation: USLAB **98.63** DSLAB **98.63** USRAB **98.63** DSRAB **98.63**

Benchmark location description:

No specific benchmark information is on the plans. A couple points shown with elevations are: 1) The top streamward corner of the upstream right wingwall concrete where its slope changes from horizontal to downward, elevation 100.87; and 2) The point at the same location as in (1) but on the downstream left wingwall, the elevation is the same, 100.87.

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: **87.0**

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 planned was to be at least 2 feet above the top of each abutment footing.

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: RB Date: 2/22/96
Computerized by: RB Date: 2/22/96
Reviewd by: RB Date: 5/12/98

Structure Number WRUTTH00170014

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. BOEHMLER Date *(MM/DD/YY)* 9 / 21 / 1995

2. Highway District Number 03 Mile marker 0000

County RUTLAND (021) Town WEST RUTLAND (82300)

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

Route Number TH017 Hydrologic Unit Code: 02010002

3. Descriptive comments:

The bridge is located about 0.1 mile east of the intersection of TH017 with VT 133.

B. Bridge Deck Observations

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

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

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

7. Bridge length 41 *(feet)* Span length 37 *(feet)* Bridge width 14.7 *(feet)*

Road approach to bridge:

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

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

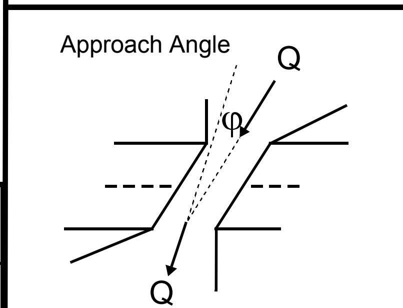
10. Embankment slope (*run / rise in feet / foot*):
US left 3.2:1 US right 2.2:1

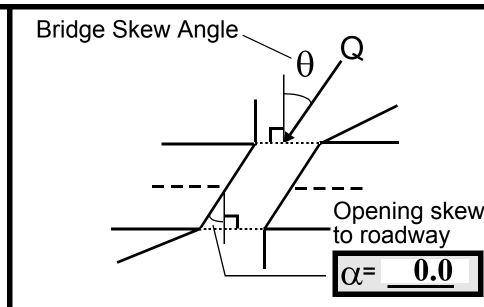
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	2	1	1	2
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	0	0

*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: 20 16. Bridge skew: 0





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 65 feet US *(US, UB, DS)* to 25 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 15 feet US *(US, UB, DS)* to 0 feet DS

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

18. Bridge Type: **4**

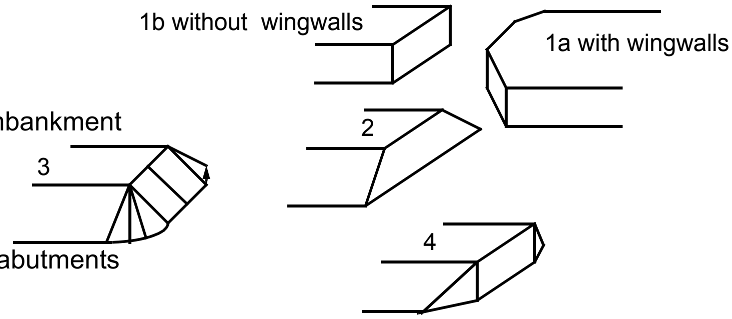
1a- Vertical abutments with wingwalls

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.)

7. Bridge dimension values are from VT AOT files. Measured bridge dimensions are: bridge length 41 feet, span length 37 feet, and bridge width 14.5 feet.
4. The surface cover US on the left bank is forest for at least 2 bridge lengths, and pasture beyond the trees. The US right bank is pasture except for a narrow (20 feet maximum) strip of trees between the bank and the pasture. Both the left and right banks DS are pasture except for a few trees on the bank edge. There is a small wetland area on the DS right bank.

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
37.0	**2.5**			**1.5**	**4**	**4**	**324**	**324**	**2**	**2**

23. Bank width **25.0** 24. Channel width **20.0** 25. Thalweg depth **29.5** 29. Bed Material **324**

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

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

32. Comments (bank material variation, minor inflows, protection extent, etc.):
The left bank is protected from 0 feet US to about 65 feet US. The channel US is in a state of transition. A point bar is located on the left bank side and this is also an impact zone as a channel is developing across the bankward part of the bar. During high flows, water occupies this channel and impacts the left road approach embankment. The embankment is protected and is also the left bank to about 65 feet US. At 65 feet upstream the channel makes a 70 degree bend to the right toward the bridge, then another bend left just US of the bridge opening. This second bend is about 45 degrees such that flow approaches the bridge skewed to the abutment wall. The US channel has a series of pools and riffles around multiple point bars and meanders toward the bridge.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 85 35. Mid-bar width: 23

36. Point bar extent: 110 feet US (US, UB) to 50 feet US (US, UB, DS) positioned 0 %LB to 60 %RB

37. Material: 34

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

The point bar is unvegetated where an overflow channel is eroding across the left bank side, and vegetated near mid-channel. The vegetated portion comprises about 25% of the bar area. An additional point bar is developing on the right bank from 55 feet US to 30 feet US. Mid-bar is 40 feet US where it is about 10 feet wide. It is composed of fine gravel and sand and is positioned 80% LB to 100% RB.

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

41. Mid-bank distance: 80 42. Cut bank extent: 95 feet US (US, UB) to 55 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.):

As the channel erodes behind the point bar on the left bank, this cut bank will be less impacted.

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

47. Scour dimensions: Length 98 Width 19 Depth : 2 Position 50 %LB to 80 %RB

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

The scour depth varies from .5 foot to 2 feet. The scour is along the channel thalweg US beginning where the thalweg impacts the stone fill on the US left wingwall and continues through the bridge along the stone fill on both abutments and along the toe of the stone fill on the DS right wingwall.

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

51. Confluence 1: Distance 105 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):

-

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
21.0		2.5		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.):

324

-

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

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

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

70. Debris and Ice Comments:

2

The channel meanders and the banks are well vegetated with trees. Point bars at the bends are likely to trap debris and ice US and DS of the bridge.

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	2	1	2	0	90.0
RABUT	1	15	90			2	1	37.0

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.):

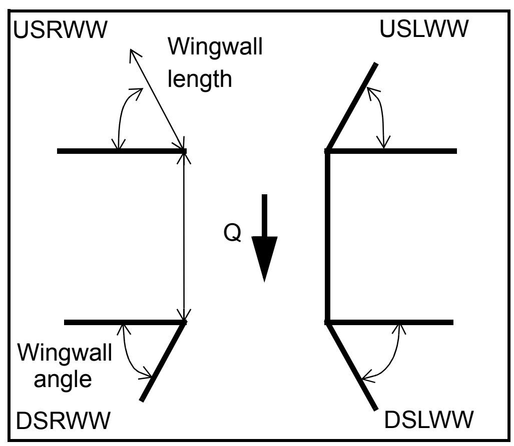
1.5
0
1

The scour hole runs along the toe of the stone fill visible at the US end of the left abutment and along the stone fill on the right abutment its entire length. The stone fill on the US end of the left abutment protrudes into the channel 12 feet from the wall. The stone fill on the right abutment protrudes into the channel 8 feet from the wall.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						37.0	
USRWW:	Y		1		0	2.5	
DSLWW:	0		0		Y	16.5	
DSRWW:	1		0		0	16.5	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	0	0	Y	0	1	2	1	1
Condition	Y	0	1	0	1	1	2	1
Extent	1	0	0	2	2	2	2	-

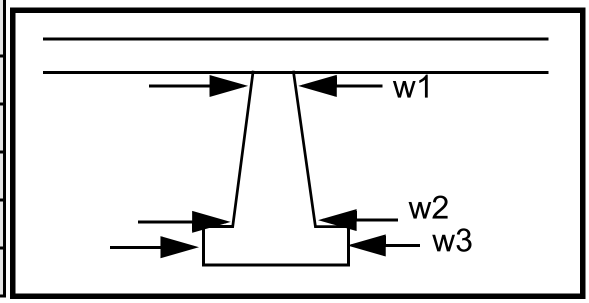
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
1
1
1
2
1
1

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				20.0	18.0	60.0
Pier 2				10.0	45.0	15.0
Pier 3			-	60.0	10.0	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e US	fill is	ment	chan-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	left	only	but	nel	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	wing	visi-	is	fill	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	wall	ble	prob	(san	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	has	at	ably	d,	*Y- yes; N- no*
91. Attack ∠ (BF)	the	the	cov-	silt,	
92. Pushed	most	US	ered	and	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	pro-	end	on	fine	
95. Cross-members	tec-	of	the	grav	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	tion.	the	DS	el) as	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	The	left	end	a	
98. Exposure depth	stone	abut	by	point	

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

bar begins on the left bank here. The DS left wingwall protection is mainly road fill. The US right wingwall protection is slumping in the area of the impact.

N

E. Downstream Channel Assessment

100.

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

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

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

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

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

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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

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

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

-
-
-
-
-
-

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

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

Material: -_____

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

-
-
-
-

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

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

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

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

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

Scour dimensions: Length **1**_____ Width **324**____ Depth: **324**____ Positioned **1**____ %LB to **2**____ %RB

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

324
0
0
-

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

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

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

Confluence comments (eg. confluence name):

point bars and cut banks alternating sides. The channel DS continues to bend left from where the left bend began US. The banks are unprotected.

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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

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

N

109. G. Plan View Sketch

- -

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: WRUTTH00170014 Town: WEST RUTLAND
Road Number: TH 17 County: RUTLAND
Stream: CLARENDON RIVER

Initials RLB Date: 5/5/98 Checked: ECW

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

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

Approach Section Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	3320	4600	1910
Main Channel Area, ft2	233	251	178
Left overbank area, ft2	791	973	300
Right overbank area, ft2	1476	1633	989
Top width main channel, ft	29	29	29
Top width L overbank, ft	298	318	224
Top width R overbank, ft	264	267	257
D50 of channel, ft	0.0981	0.0981	0.0981
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.0	8.7	6.1
y1, average depth, LOB, ft	2.7	3.1	1.3
y1, average depth, ROB, ft	5.6	6.1	3.8
Total conveyance, approach	219991	263895	107696
Conveyance, main channel	28616	32250	18284
Conveyance, LOB	37692	50936	9028
Conveyance, ROB	153682	180709	80384
Percent discrepancy, conveyance	0.0005	0.0000	0.0000
Qm, discharge, MC, cfs	431.9	562.2	324.3
Ql, discharge, LOB, cfs	568.8	887.9	160.1
Qr, discharge, ROB, cfs	2319.3	3150.0	1425.6
Vm, mean velocity MC, ft/s	1.9	2.2	1.8
Vl, mean velocity, LOB, ft/s	0.7	0.9	0.5
Vr, mean velocity, ROB, ft/s	1.6	1.9	1.4
Vc-m, crit. velocity, MC, ft/s	7.3	7.4	7.0
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	3320	4600	1910
(Q) discharge thru bridge, cfs	2047	2219	1760
Main channel conveyance	23200	23200	17232
Total conveyance	23200	23200	17232
Q2, bridge MC discharge,cfs	2047	2219	1760
Main channel area, ft2	237	237	152
Main channel width (normal), ft	36.8	36.8	36.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	36.8	36.8	36.8
y_bridge (avg. depth at br.), ft	6.44	6.44	4.14
Dm, median (1.25*D50), ft	0.122625	0.122625	0.122625
y2, depth in contraction,ft	7.06	7.57	6.20
ys, scour depth (y2-ybridge), ft	0.62	1.13	2.07

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	3320	4600	1910
Q, thru bridge MC, cfs	2047	2219	1760
Vc, critical velocity, ft/s	7.32	7.41	7.00
Va, velocity MC approach, ft/s	1.85	2.24	1.82
Main channel width (normal), ft	36.8	36.8	36.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	36.8	36.8	36.8
qbr, unit discharge, ft2/s	55.6	60.3	47.8
Area of full opening, ft2	237.0	237.0	152.2
Hb, depth of full opening, ft	6.44	6.44	4.14
Fr, Froude number, bridge MC	0.6	0.65	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	182	201	0
**Hb, depth at downstream face, ft	4.95	5.46	0.00
**Fr, Froude number at DS face	0.89	0.83	ERR
**Cf, for downstream face (<=1.0)	1.00	1.00	N/A

Elevation of Low Steel, ft	98.68	98.68	0
Elevation of Bed, ft	92.24	92.24	-4.14
Elevation of Approach, ft	100.66	101.25	0
Friction loss, approach, ft	0.07	0.1	0
Elevation of WS immediately US, ft	100.59	101.15	0.00
ya, depth immediately US, ft	8.35	8.91	4.14
Mean elevation of deck, ft	101.11	101.11	0
w, depth of overflow, ft (>=0)	0.00	0.04	0.00
Cc, vert contrac correction (<=1.0)	0.94	0.92	1.00
**Cc, for downstream face (<=1.0)	0.846814	0.864675	ERR
Ys, scour w/Chang equation, ft	1.69	2.42	N/A
Ys, scour w/Umbrell equation, ft	-2.42	-1.68	N/A

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

**Ys, scour w/Chang equation, ft	4.03	3.95	N/A
**Ys, scour w/Umbrell equation, ft	-0.93	-0.70	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	7.06	7.57	6.20
WSEL at downstream face, ft	97.19	97.71	--
Depth at downstream face, ft	4.95	5.46	0.00
Ys, depth of scour (Laursen), ft	2.12	2.11	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	2047	2219	1760
Main channel area (DS), ft2	182	201	152.2
Main channel width (normal), ft	36.8	36.8	36.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	36.8	36.8	36.8
D90, ft	0.3666	0.3666	0.3666
D95, ft	0.5264	0.5264	0.5264
Dc, critical grain size, ft	0.4898	0.4541	0.5560
Pc, Decimal percent coarser than Dc	0.058	0.066	0.044
Depth to armoring, ft	N/A	N/A	N/A

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and Davis, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	3320	4600	1910	3320	4600	1910

a’, abut.length blocking flow, ft	297.8	317.7	224.4	256.9	259.3	249.5
Ae, area of blocked flow ft2	608.87	655.9	311.92	1407.44	1516.54	959.75
Qe, discharge blocked abut.,cfs	--	--	178.29	--	--	1382.65
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	0.76	0.92	0.57	1.57	1.93	1.44
ya, depth of f/p flow, ft	2.04	2.06	1.39	5.48	5.85	3.85
--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	0.081	0.092	0.085	0.117	0.137	0.129
ys, scour depth, ft	9.04	9.88	6.53	19.89	22.38	16.22

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

a’(abut length blocked, ft)	297.8	317.7	224.4	256.9	259.3	249.5
y1 (depth f/p flow, ft)	2.04	2.06	1.39	5.48	5.85	3.85
a’/y1	145.65	153.89	161.44	46.89	44.34	64.86
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.08	0.09	0.09	0.12	0.14	0.13
Ys w/ corr. factor K1/0.55:						
vertical	6.49	6.83	4.49	19.63	22.07	14.25
vertical w/ ww’s	5.32	5.60	3.68	16.09	18.10	11.68
spill-through	3.57	3.76	2.47	10.80	12.14	7.84

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.89	0.83	1	0.89	0.83	1
y, depth of flow in bridge, ft	4.95	5.46	4.14	4.95	5.46	4.14
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	2.00	2.17	1.73	2.00	2.17	1.73