LEVEL II SCOUR ANALYSIS FOR BRIDGE 15 (WRUTTH00060015) on TOWN HIGHWAY 6, crossing the CASTLETON RIVER, WEST RUTLAND, VERMONT

U.S. Geological Survey
Open-File Report 98-154

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 ERICK M. BOEHMLER

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

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 15 (WRUTTH00060015) ON TOWN HIGHWAY 6, CROSSING THE CASTLETON RIVER, WEST RUTLAND, VERMONT

By **Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure WRUTTH00060015 on Town Highway 6 crossing the Castleton 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 (Federal Highway Administration, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Taconic section of the New England physiographic province in west-central Vermont. The 15.3-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of wetland, forest, and pasture. Wetland dominates upstream of the bridge with a small house and yard of short grass on the left overbank area. The downstream right overbank is forest except for one house with a small yard of grass. The left overbank downstream is mostly short grass with a small house.

In the study area, the Castleton River has a straight channel with a slope of approximately 0.001 ft/ft, an average channel top width of 87 ft and an average bank height of 4 ft. The channel bed materials range from silt and clay to cobbles. A median grain size (D_{50}) could not be determined by sieving, as more than 50% of the material passed through the smallest mesh size of 0.0625 mm. Therefore, the median size was assumed to be medium silt with a size of 0.0310 mm (0.000102 ft). Stone fill placed under the bridge has a median size (D_{50}) of 95.4 mm (0.313 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 20, 1995, indicated that the reach was stable.

The Town Highway 6 crossing of the Castleton River is a 61-ft-long, two-lane bridge consisting of one 58-foot steel-beam span (Vermont Agency of Transportation, written communication, March 22, 1995). The opening length of the structure parallel to the bridge face is 37.8 ft. The bridge is supported by vertical “laid-up” stone work behind concrete walls. There were no wingwalls. The channel is skewed approximately 15 degrees to the opening while the computed opening-skew-to-roadway is zero degrees.

Scour protection measures at the site included type-1 (less than 12 inches diameter) and type-2 (less than 36 inches diameter) stone fill. The type-1 stone fill was observed on the streambed under the bridge and the type-2 stone fill was observed on the upstream and downstream ends of the abutment walls, and the upstream and downstream banks. 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 7.6 to 10.6 ft. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 13.8 to 15.5 ft at the left abutment and from 4.0 to 6.6 ft at the right abutment. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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 WRUTTH00060015 ***Stream*** Castleton River

County Rutland ***Road*** TH 6 ***District*** 3

Description of Bridge

Bridge length 61 ***ft*** ***Bridge width*** 16.3 ***ft*** ***Max span length*** 58 ***ft***

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

Abutment type Vertical, Stone ***Embankment type*** Sloping

Stone fill on abutment? No ***Date of inspection*** 9/20/95

Description of stone fill Type-2 at the upstream and downstream ends of both abutment walls and on the streambed under the bridge.

Abutments are “laid-up” stone walls behind a concrete facing. There are no wingwalls.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 15

There is a mild channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	9/20/95	0	0
Level II	9/20/95	0	0

Potential for debris Moderate. There is wetland and debris noted on the streambed upstream.

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

The assessment on 9/20/95 noted the bridge span was 42.5 feet, which is narrower than the span length provided in the bridge records and shown above. Differences in bridge inspection records suggest modifications to the bridge occurred between 5/13 and 11/14/1994.

Description of the Geomorphic Setting

General topography The channel is located in a low to moderate relief valley setting with a narrow, irregular flood plain and moderately sloping valley walls on both sides.

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

Date of inspection 9/20/95

DS left: Steep channel bank to an irregular over-bank.

DS right: Moderately sloping channel bank and an irregular over-bank.

US left: Mildly sloping channel bank and over-bank.

US right: Mildly sloping channel bank with TH 6 roadway surface on the over-bank.

Description of the Channel

Average top width 87 ***ft*** ***Average depth*** 4 ***ft***

Predominant bed material Silt to cobbles ***Bank material*** Silt to boulders

Perennial and straight with semi-alluvial channel boundaries and random variations in channel width.

9/20/95

Vegetative co Brush with grass on the over-bank.

DS left: Trees and brush

DS right: Swamp grass with brush and grass on the over-bank.

US left: Swamp grass.

US right:

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

The assessment of 9/20/95 noted the stone fill at the upstream and downstream ends of the abutment walls partially obstructs flow through the bridge opening.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 15.3 ***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***: There are a couple of houses on the left over-bank area immediately adjacent to the river.

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 [illegible] No

Calculated Discharges

Q100 1,800 ***ft³/s*** ***Q500*** 2,700 ***ft³/s***

The 100- and 500-year discharges selected and shown above are central to those from a range defined by flood frequency curves computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Tasker, 1974; Potter, 1957; and 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 None

Description of reference marks used to determine USGS datum. RM1 is a nail about 6 feet above the ground in a tree located 12.5 feet left of the left abutment and 22 feet upstream from roadway center-line (elev. 505.89 feet, arbitrary survey datum). RM2 is a nail about 5 feet above the ground in utility pole #19, 130 feet right of the right abutment (elev. 506.21 feet, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-32	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	11	1	Road Grade section
APPRO	60	1	Modelled 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 were 0.040, and overbank "n" values ranged from 0.035 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 0.00132 ft/ft, which was estimated from the appropriate topographic map (U.S. Geological Survey, 1964).

The surveyed approach section was moved without bed slope correction to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.6 ***ft***
Average low steel elevation 499.2 ***ft***

100-year discharge 1,800 ***ft^3/s***
Water-surface elevation in bridge opening 499.4 ***ft***
Road overtopping? Yes ***Discharge over road*** 226 ***ft^3/s***
Area of flow in bridge opening 186 ***ft^2***
Average velocity in bridge opening 8.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.5 ***ft/s***

Water-surface elevation at Approach section with bridge 501.6
Water-surface elevation at Approach section without bridge 500.0
Amount of backwater caused by bridge 1.6 ***ft***

500-year discharge 2,700 ***ft^3/s***
Water-surface elevation in bridge opening 499.4 ***ft***
Road overtopping? Yes ***Discharge over road*** 1200 ***ft^3/s***
Area of flow in bridge opening 186 ***ft^2***
Average velocity in bridge opening 8.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.9 ***/s***

Water-surface elevation at Approach section with bridge 502.6
Water-surface elevation at Approach section without bridge 501.3
Amount of backwater caused by bridge 1.3 ***ft***

Incipient overtopping discharge 1,370 ***ft^3/s***
Water-surface elevation in bridge opening 499.4 ***ft***
Area of flow in bridge opening 186 ***ft^2***
Average velocity in bridge opening 7.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.1 ***ft/s***

Water-surface elevation at Approach section with bridge 500.7
Water-surface elevation at Approach section without bridge 499.2
Amount of backwater caused by bridge 1.5 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and the scour depths are presented graphically in figure 8. The scour for the 500-year event does not appear in figure 8 as the total scour depths are less than those for the 100-year event.

Contraction scour for each discharge modeled was computed by use of the Laursen live-bed contraction scour equation (Richardson and Davis, 1995, p. 30, equation 17). At this site, all of the modeled discharges resulted in pressure-flow conditions. However, the Chang equation for pressure-flow scour (Richardson and Davis, 1995, p. 145-146) was derived solely with data for clear-water scour. The precision of the Chang equation for predicting scour depths in live-bed conditions is not well understood. Therefore, the results from Laursen's live-bed contraction scour equation are reported. The computed depth to streambed armoring suggests that armoring will limit the depth of contraction scour.

For comparison, contraction scour for each modeled discharge also was computed by use of the Chang pressure-flow contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). The results are presented in appendix F. Furthermore, for the incipient roadway-overtopping discharge, which resulted in unsubmerged orifice flow, 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 Froehlich equation (Richardson and Davis, 1995, p. 48, equation 28) for the left abutment. Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

For the right 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. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	10.6	7.6	9.5
Clear-water scour	--	--	--
Depth to armoring	1.2	0.7	0.6
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	14.6	15.5	13.8
Right abutment	5.8	6.6	4.0
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	1.4	1.2	1.2
Right abutment	1.4	1.2	1.2
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

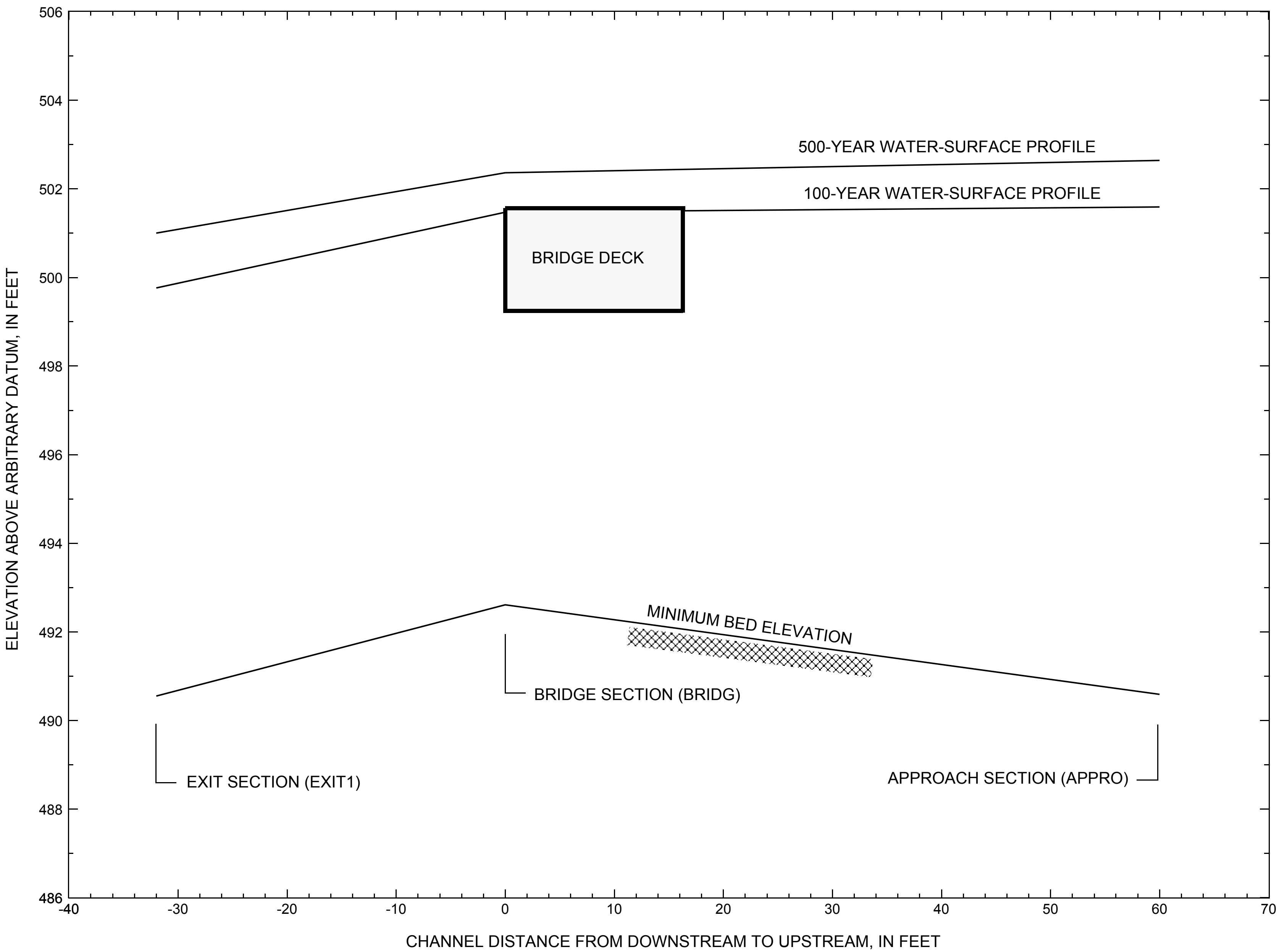

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure WRUTTH00060015 on Town Highway 6, crossing the Castleton River, West Rutland, Vermont.

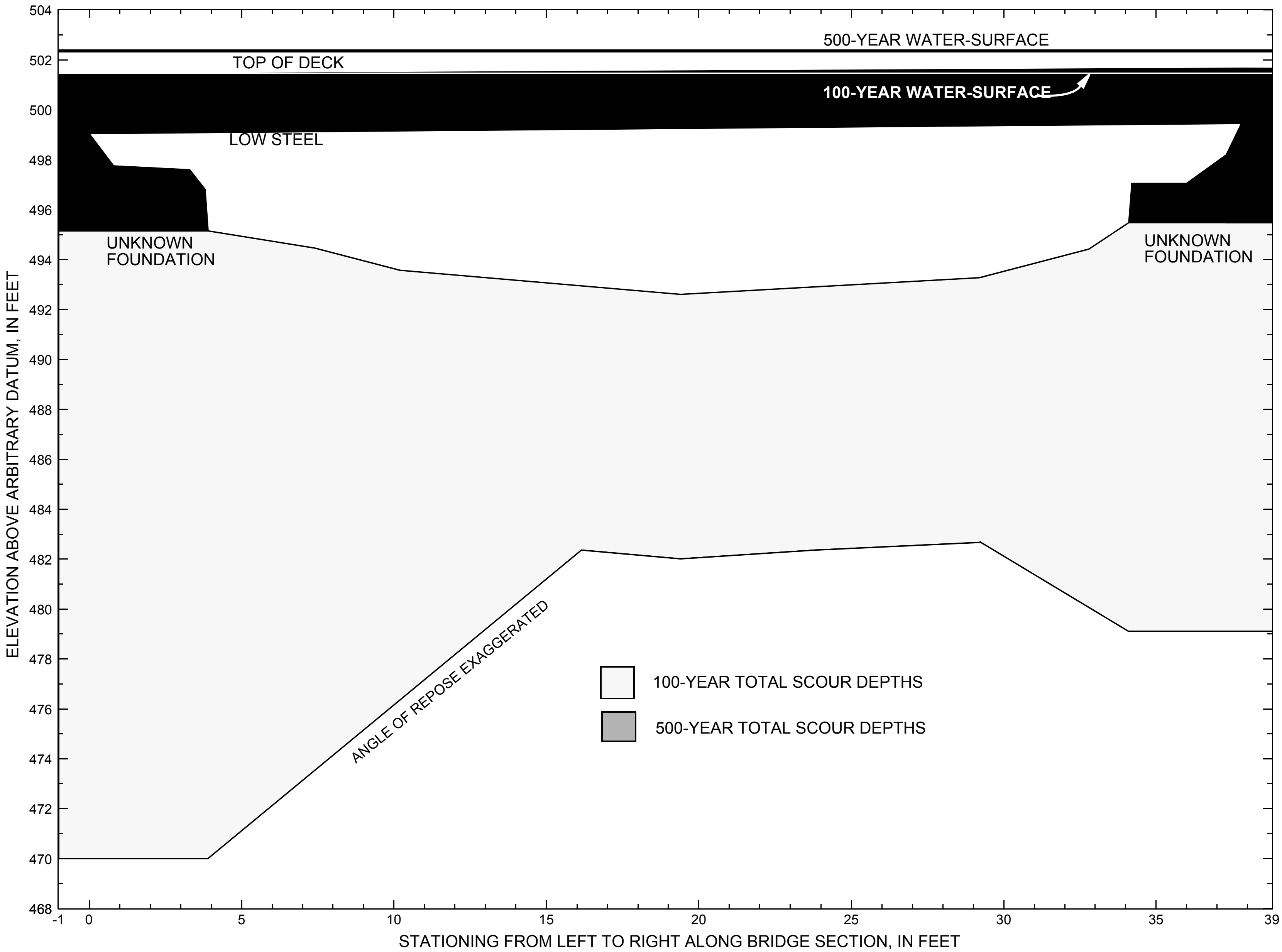

Figure 8. Scour elevations for the 100- and 500-year discharges at structure WRUTTH00060015 on Town Highway 6, crossing the Castleton River, West Rutland, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WRUTTH00060015 on Town Highway 6, crossing the Castleton River, West Rutland, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 1,800 cubic-feet per second											
Left abutment	0.0	--	499.0	--	495.2	10.6	14.6	--	25.2	470.0	--
Right abutment	37.8	--	499.4	--	495.5	10.6	5.8	--	16.4	479.1	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure WRUTTH00060015 on Town Highway 6, crossing the Castleton River, West Rutland, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 2,700 cubic-feet per second											
Left abutment	0.0	--	499.0	--	495.2	7.6	15.5	--	23.1	472.1	--
Right abutment	37.8	--	499.4	--	495.5	7.6	6.6	--	14.2	481.3	--

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

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U.S. Geological Survey, 1964, West Rutland, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1972, Contour interval, 20 feet; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File wrut015.wsp
T2        Hydraulic analysis for structure WRUTTH00060015   Date: 16-JUL-97
T3        Town Highway 6 Crossing the Castleton River in West Rutland, VT    EMB
*
J1         * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1800.0    2700.0    1370.0
SK          0.00132   0.00132   0.00132
*
XS   EXIT1    -32
GR         -204.1, 504.88   -156.6, 502.81   -138.0, 502.53   -127.0, 501.49
GR          -96.1, 501.59    -52.7, 500.24     -6.7, 499.32     -1.4, 494.84
GR            0.0, 494.18      0.0, 494.55      1.1, 493.06      3.4, 492.07
GR           11.4, 490.87     14.6, 490.55     20.5, 490.86     26.6, 491.49
GR           29.3, 491.54     30.2, 493.00     31.5, 494.44     35.5, 495.05
GR           39.6, 496.02     62.9, 496.89    134.4, 498.76    173.4, 504.77
GR          191.4, 511.28
*
*           62.9, 496.89    73.8, 502.82    100.3, 506.26
N           0.040        0.040        0.060
SA                  -6.7         39.6
*
XS   FULLV      0  * * *  0.0
*
*             SRD     LSEL
BR   BRIDG     0    499.25
GR            0.0, 499.05      0.8, 497.75      3.3, 497.60      3.8, 496.81
GR            3.9, 495.15      7.4, 494.46     10.2, 493.57     13.5, 493.24
GR           19.4, 492.61     23.8, 492.96     29.2, 493.27     32.8, 494.42
GR           34.1, 495.48     34.2, 497.05     36.0, 497.05     37.3, 498.20
GR           37.8, 499.45      0.0, 499.05
*
*            The coordinate 34.2, 497.05 was added to make the geometry more
*            like the left side of the opening as apparent from photographs
*            of the site.
*         BRTYPE  BRWDTH
CD           1      22.0
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     11      16.3     1
GR         -165.5, 504.17   -136.1, 504.55    -79.1, 501.01    -20.2, 500.89
GR            0.0, 501.44      0.0, 502.23     41.6, 502.69     41.6, 501.67
GR           92.1, 501.30    120.8, 500.74    135.4, 500.65    176.4, 504.77
GR          192.4, 511.28
*           The coordinates right of station 120.8 below were removed and the
*           valley wall points of the approach were used.
*           120.8, 500.74    155.5, 500.53    180.4, 502.84    225.4, 509.76
*           244.9, 515.59
*
*           The approach section was surveyed at 79 feet upstream but placed
*           at srd 60 instead of 79 with no templating due to no bed slope
*           between 60 and 79.
AS   APPRO     60
GR         -223.9, 505.33   -156.7, 503.57   -113.2, 502.35    -65.5, 498.36
GR          -44.1, 495.85    -31.6, 494.92    -21.7, 494.43    -11.5, 493.82
```

```
GR           -3.2, 493.02      0.0, 491.92      6.7, 490.94      8.8, 490.59
GR           12.4, 491.27     16.6, 491.86     23.4, 492.30     25.6, 492.26
GR           31.4, 492.05     37.1, 492.04     40.4, 493.94     43.1, 494.86
GR           45.3, 494.99     51.6, 497.09     54.6, 498.56     63.9, 500.25
GR           93.5, 500.46    135.4, 500.46    176.4, 504.77    192.4, 511.28
*           Removed gully along bankward side of roadway...
*           101.3, 499.33    119.2, 498.76
N           0.040        0.050        0.040        0.035
SA                 -65.5         -3.2         63.9
HP 1 BRIDG 499.45 1 499.45
HP 2 BRIDG 499.45 * * 1575
HP 2 RDWAY 501.47 * * 226
HP 1 APPRO 501.59 1 501.59
HP 2 APPRO 501.59 * * 1800
*
HP 1 BRIDG 499.45 1 499.45
HP 2 BRIDG 499.45 * * 1489
HP 2 RDWAY 502.36 * * 1201
HP 1 APPRO 502.64 1 502.64
HP 2 APPRO 502.64 * * 2700
*
HP 1 BRIDG 499.45 1 499.45
HP 2 BRIDG 499.45 * * 1370
HP 1 BRIDG 499.02 1 499.02
HP 1 APPRO 500.66 1 500.66
HP 2 APPRO 500.66 * * 1370
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File wrut015.wsp
      Hydraulic analysis for structure WRUTTH00060015   Date: 16-JUL-97
      Town Highway 6 Crossing the Castleton River in West Rutland, VT    EMB
         *** RUN DATE & TIME: 02-11-98  14:19

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     186.   11968.     0.    82.                            0.
 499.45          186.   11968.     0.    82.  1.00     0.    38.      0.

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

      WSEL     LEW     REW    AREA        K        Q    VEL
    499.45     0.0    37.8   186.0   11968.    1575.   8.47

X STA.         0.0        8.1        9.8       11.2       12.6       14.0
  A(I)            23.8        8.7        8.0        8.1        7.8
  V(I)            3.31       9.10       9.78       9.70      10.03

X STA.        14.0       15.2       16.5       17.7       18.8       20.0
  A(I)             7.7        7.8        7.7        7.5        7.6
  V(I)           10.16      10.13      10.21      10.47      10.30

X STA.        20.0       21.2       22.4       23.6       24.8       26.0
  A(I)             7.8        7.7        7.7        7.8        7.7
  V(I)           10.15      10.28      10.29      10.07      10.28

X STA.        26.0       27.3       28.5       29.8       31.3       37.8
  A(I)             7.8        7.8        7.9        8.3       20.9
  V(I)           10.15      10.11       9.96       9.54       3.77

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

      WSEL     LEW     REW    AREA        K        Q    VEL
    501.47   -86.5   143.6    68.0    1254.     226.   3.32

X STA.       -86.5      -74.0      -68.3      -62.7      -57.4      -52.2
  A(I)             4.1        2.7        2.7        2.7        2.6
  V(I)            2.78       4.16       4.13       4.23       4.27

X STA.       -52.2      -47.2      -42.3      -37.5      -33.0      -28.4
  A(I)             2.6        2.6        2.6        2.5        2.5
  V(I)            4.34       4.42       4.38       4.51       4.44

X STA.       -28.4      -24.1      -19.8      -14.4       97.8      112.0
  A(I)             2.5        2.5        2.7        6.5        6.0
  V(I)            4.59       4.53       4.25       1.74       1.89

X STA.       112.0      119.4      124.8      129.7      134.2      143.6
  A(I)             4.6        4.0        3.8        3.6        4.4
  V(I)            2.43       2.85       2.97       3.18       2.59

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      60.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1      62.    3190.    39.    39.                          450.
           2     386.   38692.    62.    63.                         5451.
           3     524.   75358.    67.    69.                         8304.
           4      90.    4065.    82.    82.                          534.
 501.59         1062.  121305.   250.   253.  1.24  -104.   146.  11141.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      60.

      WSEL     LEW     REW    AREA        K        Q    VEL
    501.59  -104.1   146.1  1062.1  121305.    1800.   1.69

X STA.      -104.1      -53.3      -40.3      -30.8      -22.6      -15.4
  A(I)           110.7       69.9       60.3       56.8       52.8
  V(I)            0.81       1.29       1.49       1.58       1.71

X STA.       -15.4       -8.6       -2.7        1.3        4.9        8.1
  A(I)            52.8       49.1       38.2       36.5       33.8
  V(I)            1.70       1.83       2.36       2.47       2.66

X STA.         8.1       11.1       14.5       18.1       21.9       25.9
  A(I)            32.1       34.6       36.0       35.8       37.6
  V(I)            2.80       2.60       2.50       2.51       2.39

X STA.        25.9       29.8       33.6       37.4       43.4      146.1
  A(I)            36.7       36.0       36.0       47.5      168.9
  V(I)            2.45       2.50       2.50       1.89       0.53
```

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     U.S. Geological Survey WSPRO Input File wrut015.wsp
     Hydraulic analysis for structure WRUTTH00060015   Date: 16-JUL-97
     Town Highway 6 Crossing the Castleton River in West Rutland, VT    EMB
        *** RUN DATE & TIME: 02-11-98  14:19

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     186.   11968.     0.    82.                          0.
 499.45          186.   11968.     0.    82.  1.00     0.    38.      0.

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.45     0.0    37.8   186.0   11968.    1489.   8.01

X STA.         0.0        8.1        9.8       11.2       12.6       14.0
  A(I)            23.8        8.7        8.0        8.1        7.8
  V(I)            3.13       8.61       9.25       9.17       9.49

X STA.        14.0       15.2       16.5       17.7       18.8       20.0
  A(I)             7.7        7.8        7.7        7.5        7.6
  V(I)            9.61       9.58       9.66       9.90       9.74

X STA.        20.0       21.2       22.4       23.6       24.8       26.0
  A(I)             7.8        7.7        7.7        7.8        7.7
  V(I)            9.60       9.72       9.73       9.52       9.72

X STA.        26.0       27.3       28.5       29.8       31.3       37.8
  A(I)             7.8        7.8        7.9        8.3       20.9
  V(I)            9.60       9.55       9.42       9.02       3.57

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

       WSEL     LEW     REW    AREA        K        Q    VEL
     502.36  -100.8   152.4   244.1    8243.    1201.   4.92

X STA.      -100.8      -76.3      -69.8      -63.2      -56.9      -50.6
  A(I)            18.4        8.9        9.0        8.8        8.8
  V(I)            3.26       6.73       6.66       6.80       6.84

X STA.       -50.6      -44.5      -38.3      -32.3      -26.3      -20.4
  A(I)             8.7        8.9        8.6        8.6        8.7
  V(I)            6.92       6.78       6.95       6.98       6.92

X STA.       -20.4      -14.0       -5.7       61.5       81.4       97.0
  A(I)             8.9        9.8       21.6       18.1       16.3
  V(I)            6.72       6.11       2.78       3.33       3.68

X STA.        97.0      108.5      118.0      126.0      133.5      152.4
  A(I)            14.7       13.9       13.0       12.6       17.8
  V(I)            4.09       4.31       4.63       4.77       3.38

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      60.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     110.    6310.    58.    58.                        865.
           2     451.   50229.    62.    63.                       6894.
           3     594.   92999.    67.    69.                      10035.
           4     182.   12132.    92.    92.                       1446.
 502.64         1338.  161670.   280.   282.  1.26  -124.   156.  14792.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      60.

       WSEL     LEW     REW    AREA        K        Q    VEL
     502.64  -123.5   156.1  1337.7  161670.    2700.   2.02

X STA.      -123.5      -59.8      -44.5      -34.1      -25.3      -17.3
  A(I)           136.6       89.6       74.7       68.3       66.3
  V(I)            0.99       1.51       1.81       1.98       2.04

X STA.       -17.3       -9.9       -3.2        1.4        5.4        9.0
  A(I)            64.3       61.8       47.6       45.6       42.3
  V(I)            2.10       2.19       2.84       2.96       3.19

X STA.         9.0       12.5       16.5       20.7       25.2       29.5
  A(I)            41.1       44.2       44.9       45.9       45.0
  V(I)            3.28       3.06       3.01       2.94       3.00

X STA.        29.5       33.7       38.2       45.1       87.2      156.1
  A(I)            44.9       46.7       58.3      141.7      127.9
  V(I)            3.01       2.89       2.32       0.95       1.06
```

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        U.S. Geological Survey WSPRO Input File wrut015.wsp
        Hydraulic analysis for structure WRUTTH00060015   Date: 16-JUL-97
        Town Highway 6 Crossing the Castleton River in West Rutland, VT    EMB
           *** RUN DATE & TIME: 02-11-98  14:19

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     186.   11968.     0.    82.                           0.
   499.45          186.   11968.     0.    82.  1.00     0.    38.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.45     0.0    37.8   186.0   11968.    1370.   7.37

X STA.         0.0        8.1        9.8       11.2       12.6       14.0
  A(I)            23.8        8.7        8.0        8.1        7.8
  V(I)            2.88       7.92       8.51       8.44       8.73

X STA.        14.0       15.2       16.5       17.7       18.8       20.0
  A(I)             7.7        7.8        7.7        7.5        7.6
  V(I)            8.84       8.81       8.88       9.11       8.96

X STA.        20.0       21.2       22.4       23.6       24.8       26.0
  A(I)             7.8        7.7        7.7        7.8        7.7
  V(I)            8.83       8.94       8.95       8.76       8.94

X STA.        26.0       27.3       28.5       29.8       31.3       37.8
  A(I)             7.8        7.8        7.9        8.3       20.9
  V(I)            8.83       8.79       8.66       8.30       3.28

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     177.   16827.    38.    44.                        2185.
   499.02          177.   16827.    38.    44.  1.00     0.    38.   2185.

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      60.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      32.    1290.    27.    28.                         192.
             2     328.   29505.    62.    63.                        4271.
             3     461.   60997.    67.    69.                        6865.
             4      18.     289.    73.    73.                          49.
   500.66          839.   92080.   230.   233.  1.18   -93.   137.   8369.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      60.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.66   -93.0   137.3   838.6   92080.    1370.   1.63

X STA.       -93.0      -47.0      -35.9      -27.3      -19.7      -13.0
  A(I)            94.4       55.5       48.6       47.1       43.5
  V(I)            0.73       1.23       1.41       1.45       1.58

X STA.       -13.0       -6.9       -1.9        1.6        4.9        7.7
  A(I)            42.5       38.2       30.5       29.8       27.6
  V(I)            1.61       1.79       2.25       2.29       2.48

X STA.         7.7       10.3       13.2       16.3       19.7       23.2
  A(I)            25.4       27.5       28.6       29.3       29.8
  V(I)            2.70       2.49       2.39       2.34       2.30

X STA.        23.2       26.8       30.3       33.8       37.1      137.3
  A(I)            30.0       30.0       29.7       28.7      121.8
  V(I)            2.29       2.28       2.30       2.39       0.56
```

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        U.S. Geological Survey WSPRO Input File wrut015.wsp
        Hydraulic analysis for structure WRUTTH00060015   Date: 16-JUL-97
        Town Highway 6 Crossing the Castleton River in West Rutland, VT    EMB
           *** RUN DATE & TIME: 02-11-98  14:19

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

EXIT1:XS   ******   -29.     543.  0.27 *****  500.03  496.25   1800.  499.76
      -32. ******   141.   49525.  1.60 ***** *******    0.41    3.32

FULLV:FV      32.   -32.     553.  0.27  0.04  500.08 *******   1800.  499.82
        0.    32.   141.   50533.  1.61  0.00    0.01    0.41    3.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.52

APPRO:AS      60.   -85.     723.  0.11  0.05  500.13 *******   1800.  500.02
       60.    60.    63.   76820.  1.14  0.00    0.00    0.21    2.49
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    499.82     499.25

            <<<<<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      32.     0.     186.  1.12 *****  500.57  498.04   1575.  499.45
        0. ******    38.   11968.  1.00 ***** *******    0.67    8.47

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  499.25 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG      11.    44.  0.01  0.06  501.63    0.00    226.  501.47

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    125.    86.   -86.     0.   0.6   0.4   3.6   3.3   0.6   3.1
   RT:    101.    74.    69.   144.   0.8   0.4   3.6   3.4   0.6   3.2

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

APPRO:AS      38.  -104.    1061.  0.06  0.08  501.64  495.67   1800.  501.59
       60.    43.   146.  121146.  1.24  0.00    0.00    0.16    1.70

       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     -32.   -29.   141.   1800.   49525.     543.    3.32  499.76
   FULLV:FV       0.   -32.   141.   1800.   50533.     553.    3.25  499.82
   BRIDG:BR       0.     0.    38.   1575.   11968.     186.    8.47  499.45
   RDWAY:RG      11.*******   125.    226.******************    1.00  501.47
   APPRO:AS      60.  -104.   146.   1800.  121146.    1061.    1.70  501.59

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS    496.25    0.41  490.55  511.28************  0.27  500.03  499.76
   FULLV:FV  ********    0.41  490.55  511.28  0.04  0.00  0.27  500.08  499.82
   BRIDG:BR    498.04    0.67  492.61  499.45************  1.12  500.57  499.45
   RDWAY:RG  ***************  500.65  511.28  0.01******  0.06  501.63  501.47
   APPRO:AS    495.67    0.16  490.59  511.28  0.08  0.00  0.06  501.64  501.59
```
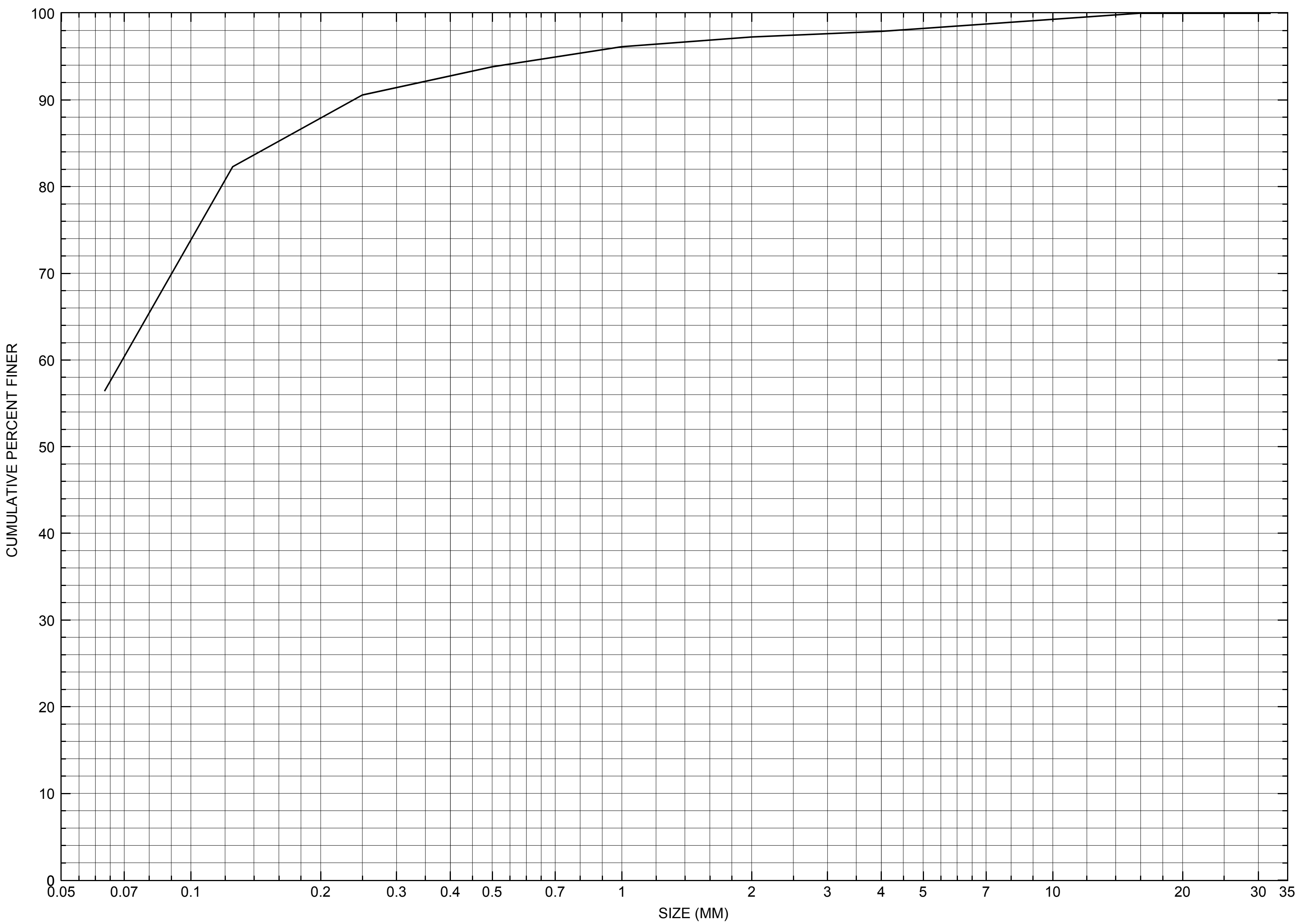

```
        U.S. Geological Survey WSPRO Input File wrut015.wsp
        Hydraulic analysis for structure WRUTTH00060015   Date: 16-JUL-97
        Town Highway 6 Crossing the Castleton River in West Rutland, VT    EMB
           *** RUN DATE & TIME: 02-11-98  14:19

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

EXIT1:XS   ******   -77.     792.  0.31 *****  501.31  497.85   2700.  501.00
      -32. ******   149.   74309.  1.71 ***** *******    0.42    3.41

FULLV:FV      32.   -79.     805.  0.30  0.04  501.36 *******   2700.  501.06
        0.    32.   149.   75750.  1.71  0.00    0.01    0.41    3.35
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.46

APPRO:AS      60.  -100.     981.  0.14  0.05  501.41 *******   2700.  501.26
       60.    60.   143.  110247.  1.23  0.00    0.00    0.27    2.75
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   501.06     499.25

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =    1201.      1165.    1.03

            <<<<<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      32.     0.     186.  1.00 *****  500.45  497.89   1489.  499.45
        0. ******    38.   11968.  1.00 ***** *******    0.64    8.01

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  499.25 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.    44.  0.01  0.08  502.70    0.00   1201.  502.36

              Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    610.   113.  -101.    12.   1.5   1.1   5.7   5.0   1.4   3.2
   RT:    591.   111.    42.   152.   1.7   1.1   5.6   4.9   1.4   3.1

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

APPRO:AS      38.  -123.    1337.  0.08  0.10  502.72  496.55   2700.  502.64
       60.    44.   156.  161511.  1.26  0.00    0.00    0.18    2.02

       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     -32.   -77.   149.   2700.   74309.     792.    3.41  501.00
   FULLV:FV       0.   -79.   149.   2700.   75750.     805.    3.35  501.06
   BRIDG:BR       0.     0.    38.   1489.   11968.     186.    8.01  499.45
   RDWAY:RG      11.*******   610.   1201.*****************    1.00  502.36
   APPRO:AS      60.  -123.   156.   2700.  161511.    1337.    2.02  502.64

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    497.85    0.42  490.55  511.28************  0.31  501.31  501.00
   FULLV:FV  ********    0.41  490.55  511.28  0.04  0.00  0.30  501.36  501.06
   BRIDG:BR    497.89    0.64  492.61  499.45************  1.00  500.45  499.45
   RDWAY:RG  ****************  500.65  511.28  0.01******  0.08  502.70  502.36
   APPRO:AS    496.55    0.18  490.59  511.28  0.10  0.00  0.08  502.72  502.64
```

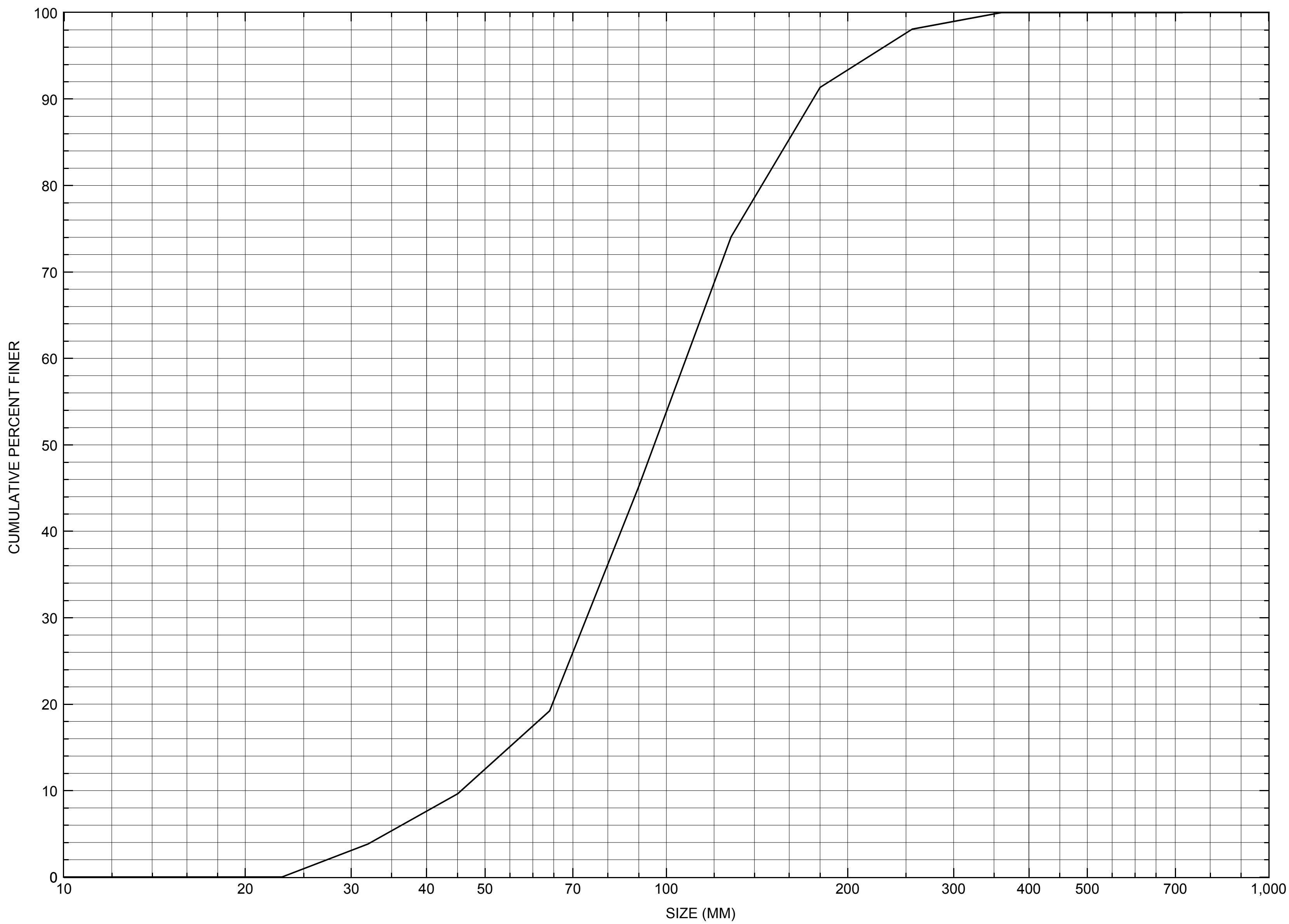
```
       U.S. Geological Survey WSPRO Input File wrut015.wsp
       Hydraulic analysis for structure WRUTTH00060015   Date: 16-JUL-97
       Town Highway 6 Crossing the Castleton River in West Rutland, VT    EMB
          *** RUN DATE & TIME: 02-11-98  14:19

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

EXIT1:XS   ******    -6.     423.  0.25 *****  499.21  495.51   1370.  498.96
      -32. ******   136.   37671.  1.54 ***** *******    0.41    3.24

FULLV:FV      32.    -6.     431.  0.24  0.04  499.26 *******   1370.  499.02
        0.    32.   136.   38460.  1.55  0.00    0.01    0.40    3.18
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

APPRO:AS      60.   -76.     610.  0.09  0.05  499.31 *******   1370.  499.22
       60.    60.    58.   61656.  1.16  0.00    0.00    0.20    2.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   498.51     500.06     500.13     499.25

 ===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      32.     0.     186.  0.84 *****  500.29  497.58   1370.  499.45
        0. ******    38.   11968.  1.00 ***** *******    0.59    7.37

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.468  0.000  499.25 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<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      38.   -93.     839.  0.05  0.07  500.71  495.13   1370.  500.66
       60.    42.   137.   92075.  1.18  0.21    0.00    0.16    1.63

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   500.65

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -32.    -6.   136.   1370.   37671.     423.    3.24  498.96
   FULLV:FV       0.    -6.   136.   1370.   38460.     431.    3.18  499.02
   BRIDG:BR       0.     0.    38.   1370.   11968.     186.    7.37  499.45
   RDWAY:RG      11.**************      0.       0.       0.    1.00********
   APPRO:AS      60.   -93.   137.   1370.   92075.     839.    1.63  500.66

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF     HO  VHD      EGL    WSEL
   EXIT1:XS    495.51    0.41  490.55  511.28************  0.25  499.21  498.96
   FULLV:FV  ********    0.40  490.55  511.28  0.04  0.00  0.24  499.26  499.02
   BRIDG:BR    497.58    0.59  492.61  499.45************  0.84  500.29  499.45
   RDWAY:RG  ****************  500.65  511.28************  0.05  500.70********
   APPRO:AS    495.13    0.16  490.59  511.28  0.07  0.21  0.05  500.71  500.66
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a sediment sample from the channel approach of structure WRUTTH00060015 in West Rutland, Vermont.



Appendix C. Bed material particle-size distribution for a pebble count at the bridge crossing of structure WRUTTH00060015 in West Rutland, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WRUTTH00060015

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 22 / 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)* CASTLETON RIVER

Road Name *(I - 7):* -

Route Number TH 6

Vicinity *(I - 9)* 0.05 MI TO JCT W VT4-A

Topographic Map West Rutland

Hydrologic Unit Code: 02010001

Latitude *(I - 16; nnnn.n)* 43363

Longitude *(i - 17; nnnnn.n)* 73039

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10112800151128

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

Maximum span length *(I - 48; nnnn)* 0058

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000061

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

Deck Width *(I - 52; nn.n)* 163

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

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

Opening skew to Roadway *(I - 34; nn)* 10

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 034.7

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

Vertical clearance from streambed (*nnn.n ft*) 007.2

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

Waterway of full opening (*nnn.n* ft^2) 249.6

Comments:

The structural inspection report of 11/14/94 indicates the structure is a steel stringer type bridge with a timber deck. The abutment walls are "laid-up" stone with concrete facing and concrete caps. All items of the substructure evaluation on the report indicate there are no problems on the abutment walls or wing-walls except for some minor concrete scaling. The banks are noted as heavily vegetated both up- and downstream of the bridge. Debris accumulation is reported as a potential problem with the wetlands upstream having alot of vegetation and some debris randomly distributed on the channel bottom under the bridge. Point bar development is noted as minor at this site. There is boulder **(Continued, page 35)**

Bridge Hydrologic Data

Is there hydrologic data available? N *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*)	-	-	-	-	-
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:

riprap indicated as placed around the ends of the abutments. The streambed is composed of silt and stones.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **15.33** mi^2 Lake/pond/swamp area **0.66** mi^2
Watershed storage *(ST)* **4.0** %
Bridge site elevation **480** ft Headwater elevation **1700** ft
Main channel length **8.73** mi
10% channel length elevation **490** ft 85% channel length elevation **620** ft
Main channel slope *(S)* **19.85** ft / mi

Watershed Precipitation Data

Average site precipitation **--** in Average headwater precipitation **--** in
Maximum 2yr-24hr precipitation event *(I24,2)* **2.49** in
Average seasonal snowfall *(Sn)* **5.75** ft

Bridge Plan Data

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

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:
NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness ______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

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

Comments:
NO PLANS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **CG** Date: **02/22/96**
Computerized by: **CG** Date: **02/22/96**
Reviewd by: **EMB** Date: **7/16/97**

Structure Number **WRUTTH00060015**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. Ivanoff** Date *(MM/DD/YY)* **9** / **20** / 19**96**

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

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

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

Route Number **TH 06** Hydrologic Unit Code: **02010001**

3. Descriptive comments:

This structure is located 0.05 mile from the junction with State Route 4A.

B. Bridge Deck Observations

4. Surface cover... LBUS **7** RBUS **7** LBDS **2** RBDS **2** Overall **7**
*(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 **61.0** *(feet)* Span length **58.0** *(feet)* Bridge width **16.3** *(feet)*

Road approach to bridge:

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

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

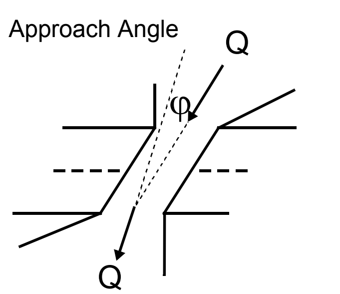
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

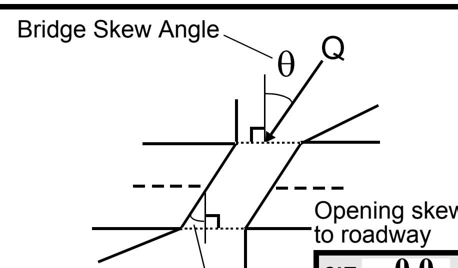
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	0	0
RBUS	2	1	0	0
RBDS	2	1	0	0
LBDS	2	1	0	0

*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: **30** 16. Bridge skew: **15**





α= **0.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **0**
Range? **25** feet **US** *(US, UB, DS)* to **0** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **0** feet **US** *(US, UB, DS)* to **40** feet **DS**

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

18. Bridge Type: **1b**

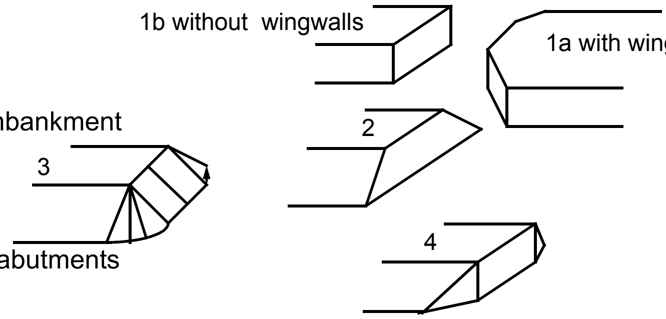
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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 measured bridge length is 44 feet. The measured span length is 42.5 feet. The measured bridge width is 24 feet.

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
55.5	**2.5**			**5.5**	**1**	**1**	**14**	**14**	**0**	**0**

23. Bank width **5.0**   24. Channel width **15.0**   25. Thalweg depth **128.0**   29. Bed Material **124**

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

SRD - Section ref. dist. to US face   *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*

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

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

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

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

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

The left bank protection extends 25 ft upstream with newer material 10 ft upstream to the bridge.
The right bank protection is road embankment material (fill) for the town highway. Water runs along the right roadway approach embankment. The upstream channel is pooled with wetland conditions and 4 to 5 ft water depths measured 300 feet upstream.

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

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

37. Material: -

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

NO POINT BARS

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? N *(Y or if N type ctrl-n mc)* 50. How many? -

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB 2 RB *(**1**- natural bank; **2**- abutment; **3**- artificial levee)*

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
89.0		4.5		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

The material under the bridge is composed of gravel and sand with some cobbles. Stone fill (type-1) was placed at the upstream and downstream bridge faces across the channel with a water depth of 1.5 ft upstream and 1.0 ft depth downstream.

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 **2**____ *(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

There is a swamp (wetland) upstream with debris in the 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		**30**	**90**	**2**	**0**	**0**	**0**	**90.0**
RABUT	**1**	**0**	**90**			**2**	**0**	**38.0**

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

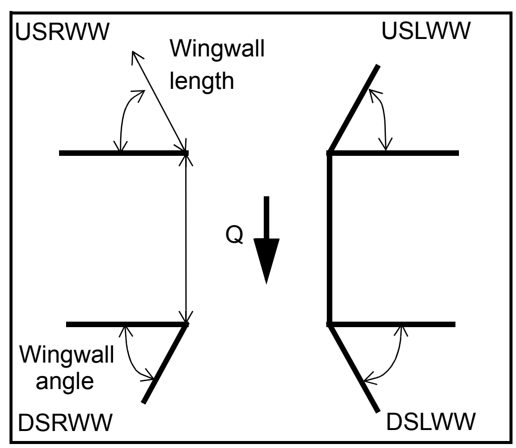
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
0
1
-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**38.0**	
USRWW:	**N**		**-**		**-**	**2.0**	
DSLWW:	**-**		**-**		**N**	**22.0**	
DSRWW:	**-**		**-**		**-**	**22.0**	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**-**	**-**	**N**	**-**	**-**	**-**	**1**	**1**
Condition	**N**	**-**	**-**	**-**	**-**	**-**	**4**	**4**
Extent	**-**	**-**	**-**	**-**	**-**	**2**	**2**	**-**

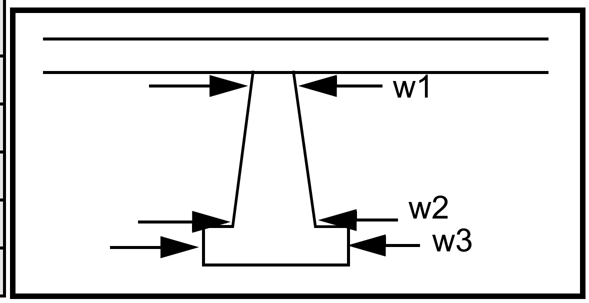
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

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



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

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
-	-			-	-	-	-	-	-	-

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.):
-
-
-
-
-
-
-
-
-
-
-
-
-
-

NO PIERS

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: **1** Mid-bar width: **4**

Point bar extent: **431** feet **415** *(US, UB, DS)* to **0** feet **0** *(US, UB, DS)* positioned **341** %LB to **2** %RB

Material: **2**

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

1
1
The left and right banks have large stones and boulders in place near the bridge, which extend to the railroad bridge downstream approximately 250 feet.

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

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

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

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

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

Scour dimensions: Length **-** Width **NO** Depth: **DR** Positioned **OP** %LB to **ST** %RB

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

RUCTURE
There is a small stone dam across the downstream bridge face with a foot of water above it.

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

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

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

Confluence comments (eg. confluence name):

-
-

F. Geomorphic Channel Assessment

107. Stage of reach evolution **-**

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

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

-

NO POINT BARS

N

-

-

-

-

-

-

-

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:	WRUTTH00060015	Town:	West Rutland
Road Number:	TH 6	County:	Rutland
Stream:	Castleton River		

Initials EMB   Date: 1/29/98   Checked: MAI

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	1800	2700	1380
Main Channel Area, ft2	524	594	461
Left overbank area, ft2	448	561	360
Right overbank area, ft2	90	182	18
Top width main channel, ft	67	67	67
Top width L overbank, ft	101	120	89
Top width R overbank, ft	82	92	73
D50 of channel, ft	0.000102	0.000102	0.000102
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.8	8.9	6.9
y1, average depth, LOB, ft	4.4	4.7	4.0
y1, average depth, ROB, ft	1.1	2.0	0.2
Total conveyance, approach	121305	161670	92080
Conveyance, main channel	75358	92999	60997
Conveyance, LOB	41882	56539	30795
Conveyance, ROB	4065	12132	289
Percent discrepancy, conveyance	0.0000	0.0000	-0.0011
Qm, discharge, MC, cfs	1118.2	1553.1	914.2
Ql, discharge, LOB, cfs	621.5	944.2	461.5
Qr, discharge, ROB, cfs	60.3	202.6	4.3
Vm, mean velocity MC, ft/s	2.1	2.6	2.0
Vl, mean velocity, LOB, ft/s	1.4	1.7	1.3
Vr, mean velocity, ROB, ft/s	0.7	1.1	0.2
Vc-m, crit. velocity, MC, ft/s	0.7	0.8	0.7
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	1	1	1

The armoring computations below are based on the D50 computed by use of the pebble count distribution of bed material (stone fill) under the bridge.

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	1575	1466	1370
Main channel area (DS), ft2	186	186	177
Main channel width (normal), ft	37.8	37.8	37.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	37.8	37.8	37.8
D90, ft	0.5751	0.5751	0.5751
D95, ft	0.7150	0.7150	0.7150
Dc, critical grain size, ft	0.3346	0.2899	0.2856
Pc, Decimal percent coarser than Dc	0.446	0.562	0.573
Depth to armoring, ft	1.25	0.68	0.64

Live-Bed Contraction Scour

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

Characteristic	Approach 100 yr	500 yr	Other Q	Bridge 100 yr	500 yr	Other Q
Q1, discharge, cfs	1800	2700	1380	1575	1489	1370
Total conveyance	121305	161670	92080	11968	11968	11968
Main channel conveyance	75358	92999	60997	11968	11968	11968
Main channel discharge	1118	1553	914	1575	1466	1370
Area - main channel, ft2	524	594	461	186	186	186
(W1) channel width, ft	67	67	67	37.8	37.8	37.8
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	67	67	67	37.8	37.8	37.8
D50, ft	0.000102	0.000102	0.000102			
w, fall velocity, ft/s (p. 32)	0.00194	0.00194	0.00194			
y, ave. depth flow, ft	7.82	8.87	6.88	4.92	4.92	4.92
S1, slope EGL	0.000833	0.000833	0.000833			
P, wetted perimeter, MC, ft	69	69	69			
R, hydraulic Radius, ft	7.594	8.609	6.681			
V*, shear velocity, ft/s	0.451	0.481	0.423			
V*/w	232.689	247.744	218.249			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.69	0.69	0.69			
y2,depth in contraction, ft	15.57	12.52	14.45			
ys, scour depth, ft (y2-y_bridge)	**10.65**	**7.60**	**9.53**			

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	1800	2700	1380
(Q) discharge thru bridge, cfs	0	0	0
Main channel conveyance	0	0	0
Total conveyance	0	0	0
Q2, bridge MC discharge,cfs	ERR	ERR	ERR
Main channel area, ft2	0	0	0
Main channel width (normal), ft	0.0	0.0	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	0	0	0
y_bridge (avg. depth at br.), ft	ERR	ERR	ERR
Dm, median (1.25*D50), ft	0.000128	0.000128	0.000128
y2, depth in contraction,ft	ERR	ERR	ERR
ys, scour depth (y2-ybridge), ft	N/A	N/A	N/A

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	1800	2700	1380
Q, thru bridge MC, cfs	1575	1466	1370
Vc, critical velocity, ft/s	0.74	0.75	0.72
Va, velocity MC approach, ft/s	2.13	2.61	1.98
Main channel width (normal), ft	37.8	37.8	37.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.8	37.8	37.8
qbr, unit discharge, ft2/s	41.7	38.8	36.2
Area of full opening, ft2	186.0	186.0	186.0
Hb, depth of full opening, ft	4.92	4.92	4.92
Fr, Froude number, bridge MC	0.67	0.64	0.58
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	177
**Hb, depth at downstream face, ft	N/A	N/A	4.68
**Fr, Froude number at DS face	ERR	ERR	0.63
**Cf, for downstream face (<=1.0)	N/A	N/A	1.00
Elevation of Low Steel, ft	499.25	499.25	499.25
Elevation of Bed, ft	494.33	494.33	494.33
Elevation of Approach, ft	501.59	502.64	500.66
Friction loss, approach, ft	0.08	0.1	0.07
Elevation of WS immediately US, ft	501.51	502.54	500.59
ya, depth immediately US, ft	7.18	8.21	6.26
Mean elevation of deck, ft	502.46	502.46	502.46
w, depth of overflow, ft (>=0)	0.00	0.08	0.00
Cc, vert contrac correction (<=1.0)	0.90	0.86	0.94
**Cc, for downstream face (<=1.0)	ERR	ERR	0.927089
Ys, scour w/Chang equation, ft	57.68	55.12	48.44
Ys, scour w/Umbrell equation, ft	10.09	14.13	7.77

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

**Ys, scour w/Chang equation, ft	N/A	N/A	49.44
**Ys, scour w/Umbrell equation, ft	N/A	N/A	8.00

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	15.57	12.52	14.45
WSEL at downstream face, ft	--	--	499.02
Depth at downstream face, ft	N/A	N/A	4.68
Ys, depth of scour (Laursen), ft	N/A	N/A	9.76

Abutment Scour

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

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1800	2700	1380	1800	2700	1380
a', abut.length blocking flow, ft	104.1	123.5	93	108.3	118.3	99.5
Ae, area of blocked flow ft2	440.7	473.8	386.4	182.5	208.8	121
Qe, discharge blocked abut.,cfs	--	--	516.7	--	--	68
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.44	1.75	1.34	0.82	1.26	0.56
ya, depth of f/p flow, ft	4.23	3.84	4.15	1.69	1.77	1.22
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--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	0.119	0.140	0.116	0.102	0.132	0.090
ys, scour depth, ft	**14.63**	**15.52**	**13.78**	7.38	8.87	5.43

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)	104.1	123.5	93	108.3	118.3	99.5
y1 (depth f/p flow, ft)	4.23	3.84	4.15	1.69	1.77	1.22
a'/y1	24.59	32.19	22.38	64.27	67.03	81.82
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.12	0.14	0.12	0.10	0.13	0.09
Ys w/ corr. factor K1/0.55:						
vertical	ERR	14.58	ERR	**5.77**	**6.58**	**3.99**
vertical w/ ww's	ERR	11.96	ERR	4.73	5.40	3.27
spill-through	ERR	8.02	ERR	3.17	3.62	2.20

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	0.67	0.64	0.63	0.67	0.64	0.63
y, depth of flow in bridge, ft	4.92	4.92	4.68	4.92	4.92	4.68
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.37	1.25	1.15	1.37	1.25	1.15
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR