LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (MENDTH00070020) on TOWN HIGHWAY 7, crossing MENDON BROOK, MENDON, VERMONT

Open-File Report 98-527

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (MENDTH00070020) on TOWN HIGHWAY 7, crossing MENDON BROOK, MENDON, VERMONT

By SUSAN A. WILLOUGHBY and TIMOTHY SEVERANCE

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 20 (MENDTH00070020) ON TOWN HIGHWAY 7, CROSSING MENDON BROOK, MENDON, VERMONT

By **Susan A. Willoughby and Timothy Severance**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure MENDTH00070020 on Town Highway 7 crossing Mendon Brook, Mendon, 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 south central Vermont. The 11.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forested upstream and downstream of the bridge.

In the study area, Mendon Brook is sinuous with a slope of approximately 0.006 ft/ft, an average channel top width of 57 ft and an average bank height of 5 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 123.1 mm (0.404 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 27, 1995 indicated that the reach was laterally unstable. Multiple point bars and cut-banks with slip failure of the bank material were observed both upstream and downstream of the site.

The Town Highway 7 crossing of Mendon Brook is a 30-ft-long, one-lane bridge consisting of one 26-foot steel-beam span (Vermont Agency of Transportation, written communication, March 13, 1995). The opening length of the structure parallel to the bridge face is 23.9 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 40 degrees to the opening while the computed opening-skew-to-roadway is 25 degrees.

As observed during the Level I assessment, the left and right abutments were undermined vertically by 0.5 and 1.0 foot, respectively. The downstream right wingwall also was undermined by 0.3 feet vertically. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) at the upstream end of the upstream left wingwall. Additional details describing conditions at the site are included in the Level II Summary and appendices
D and E.

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

There was no computed contraction scour for the modelled discharges. Abutment scour ranged from 10.4 to 15.2 ft. The worst-case left 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. 46). 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.

Chittendon, VT. Quadrangle, 1:24,000, 1961
Photorevised 1988

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 MENDTH00070020 ***Stream*** Mendon Brook

County Rutland ***Road*** TH 7 ***District*** 3

Description of Bridge

Bridge length 30 ***ft*** ***Bridge width*** 14 ***ft*** ***Max span length*** 26 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** None

Stone fill on abutment? No ***Date of inspection*** 9/27/95

Description of stone fill Type-2 was observed at the upstream end of the upstream left wingwall.

Abutments and wingwalls are concrete. There is a 1.25 ft deep scour hole upstream of the upstream right wingwall and along the left abutment. Both abutments and the downstream right wingwall are undermined.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 40

There is a mild channel bend through the bridge. Scour holes have developed under the bridge in an area where the stream narrows in an upstream to downstream direction.

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	9/27/95	0	0
Level II	9/27/95	0	0

Potential for debris Moderate. There are logs strewn along both upstream banks, and trees falling into the channel.

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

On 9/27/95, there were point bars observed on the right and left banks upstream, and large piles of boulders on the left and right banks near the upstream bridge face, which set up eddy currents through the bridge.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with little or no flood plain and steep valley walls.

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

Date of inspection 9/27/95

DS left: Steep channel bank and a narrow overbank.

DS right: Steep channel bank and a moderately sloped overbank.

US left: Steep channel bank and a moderately sloped overbank.

US right: Steep channel bank and a moderately sloped overbank.

Description of the Channel

Average top width 57 ***ft*** ***Average depth*** 5 ***ft***

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

Perennial, and sinuous but stable, with non-alluvial channel boundaries.

9/27/95

Vegetative co

DS left: Trees

DS right: Trees

US left: Trees

US right: Trees

Do banks appear stable? No

Several cut-banks and point bars were observed on 9/27/95 along the reach. Slip-failure of bank material and tree root exposure was observed at the cut-banks.

date of observation.

None were observed on 9/27/95

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 11.9 ***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 2,300 ***ft³/s*** ***Q500*** 3,000 ***ft³/s***

The 100- and 500-year discharges selected were based on flood frequency estimates available in the VTAOT database (written communication, May 1995). These selected discharges were within the range defined by flood frequency curves derived from various empirical methods (Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extrapolated to the 500-year event.

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

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

Datum tie between USGS survey and VTAOT plans A height of 5.3 feet was added to the USGS' survey to obtain the datum of the VTAOT plans.

Description of reference marks used to determine USGS datum. BM1 is a VTAOT metalic disk set in the top of a 12-foot diameter boulder on the upstream right bank, 15.3 feet upstream from the right abutment (elev. 502.54 ft, arbitrary survey datum). RM2 is a spike, 6 feet above the ground in a tree located 50 feet toward right bank from the right abutment and 17 feet downstream from the center of the roadway (elev. 500.34 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1] For location of cross-sections see plan-view sketch included with Level I field form, Appendix E.
For more detail on how cross-sections were developed see WSPRO input file.

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Shearman and others, 1986, and Shearman, 1990). The analyses reported herein reflect conditions existing at the site at the time of the study. Furthermore, in the development of the model it was necessary to assume no accumulation of debris or ice at the site. Results of the hydraulic model are presented in the Bridge Hydraulic Summary, appendix B, and figure 7.

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.055 to 0.075, and overbank "n" values ranged from 0.050 to 0.060.

Normal depth at the exit section (EXIT2) 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 0.0056 ft/ft, which was estimated from the surveyed data downstream of the bridge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0358 ft/ft) to establish the modelled approach section (APPR2), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 505.8 ***ft***
Average low steel elevation 502.3 ***ft***

100-year discharge 2,300 ***ft³/s***
Water-surface elevation in bridge opening 502.3 ***ft***
Road overtopping? Yes ***Discharge over road*** 885 ***ft³/s***
Area of flow in bridge opening 187 ***ft²***
Average velocity in bridge opening 7.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.3 ***ft/s***

Water-surface elevation at Approach section with bridge 504.3
Water-surface elevation at Approach section without bridge 503.2
Amount of backwater caused by bridge 1.1 ***ft***

500-year discharge 3,000 ***ft³/s***
Water-surface elevation in bridge opening 502.3 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,640 ***ft³/s***
Area of flow in bridge opening 187 ***ft²***
Average velocity in bridge opening 7.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.9 ***/s***

Water-surface elevation at Approach section with bridge 505.0
Water-surface elevation at Approach section without bridge 504.0
Amount of backwater caused by bridge 1.0 ***ft***

Incipient overtopping discharge 1,340 ***ft³/s***
Water-surface elevation in bridge opening 501.2 ***ft***
Area of flow in bridge opening 165 ***ft²***
Average velocity in bridge opening 8.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.9 ***ft/s***

Water-surface elevation at Approach section with bridge 502.3
Water-surface elevation at Approach section without bridge 501.7
Amount of backwater caused by bridge 0.6 ***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 discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32). At this site, the 100-year and 500-year discharges resulted in submerged 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- 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 alternative computations are provided in appendix F.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.0
Depth to armoring	0.3	0.2	3.6
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	12.9	15.2	13.0
Left abutment	11.0	11.6	10.4
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	1.2	1.1	1.3
Left abutment	1.2	1.1	1.3
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

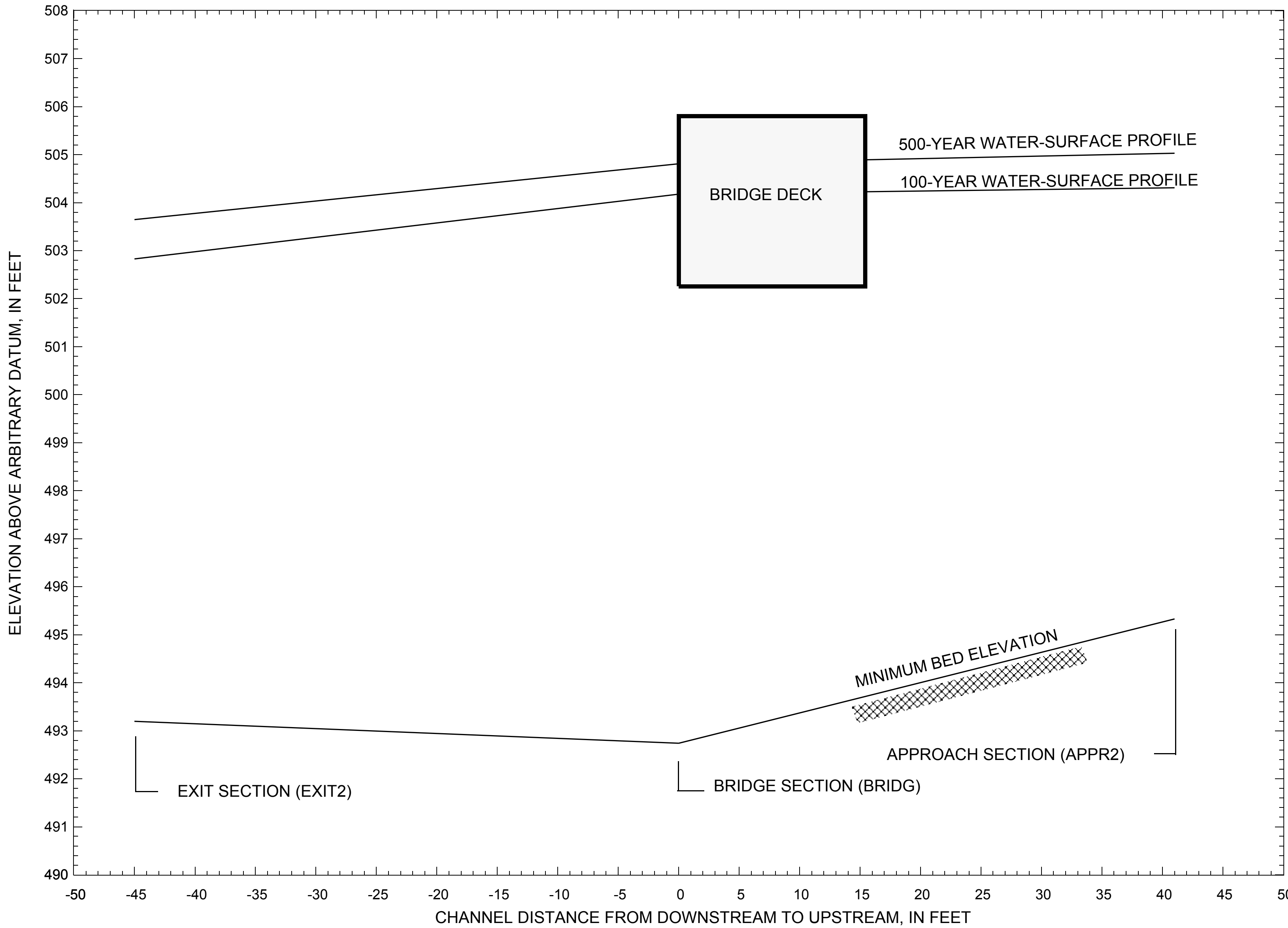

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure MENDTH00070020 on Town Highway 7, crossing Mendon Brook, Mendon, Vermont.

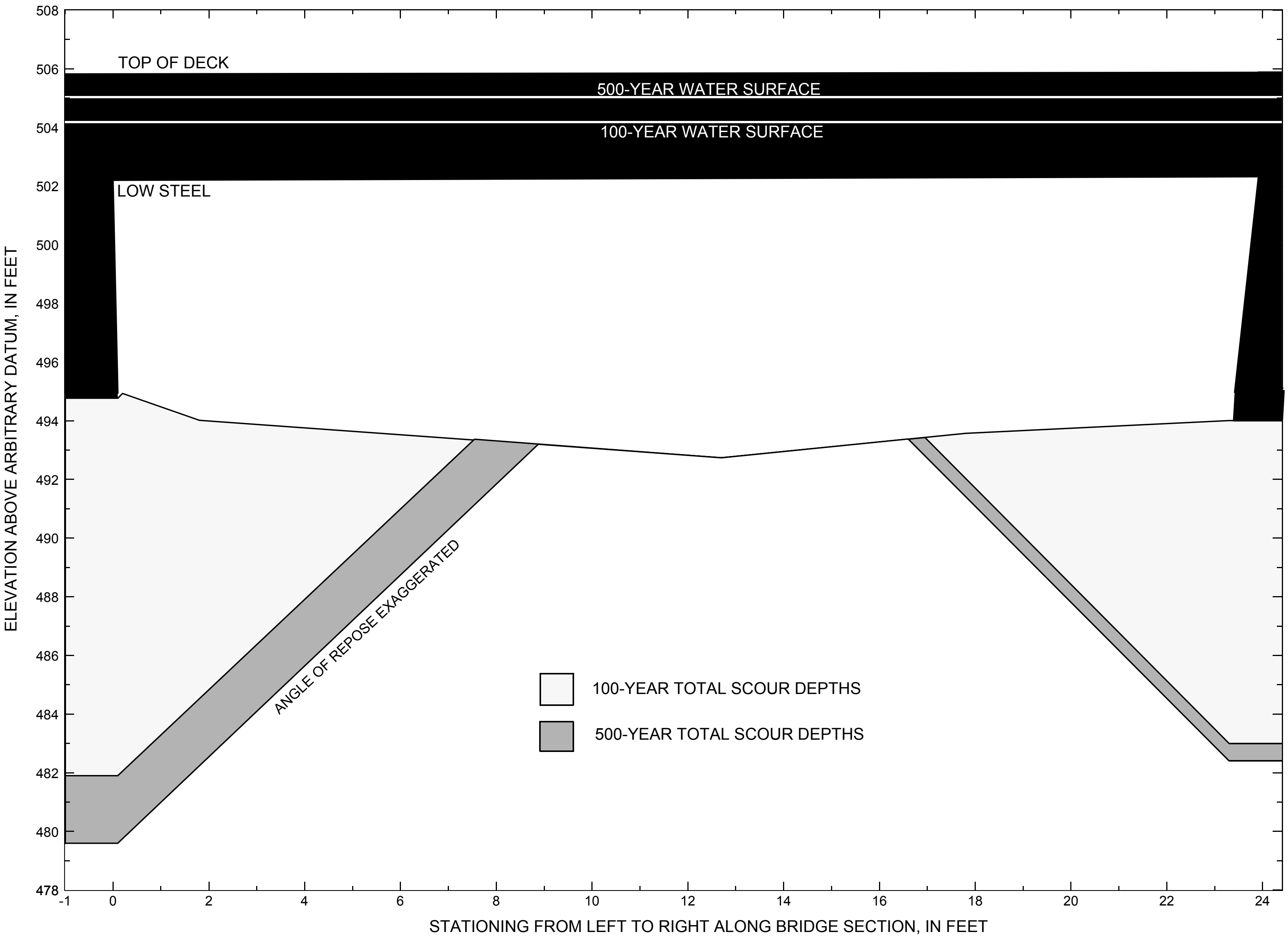

Figure 8. Scour elevations for the 100- and 500-year discharges at structure MENDTH00070020 on Town Highway 7, crossing Mendon Brook, Mendon Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure MENDTH00070020 on Town Highway 7, crossing Mendon Brook, Mendon, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2,3] (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 2,300 cubic-feet per second											
Left abutment	0.0	502.2	502.2	494.8	494.8	0.0	12.9	--	12.9	481.9	-12.9
Right abutment	23.4	502.2	502.3	494.0	494.0	0.0	11.0	--	11.0	483.0	-11.0

1.Measured along the face of the most constricting side of the bridge.
2.Arbitrary datum for this study.
3.Low-chord elevations are the same as bridge seat elevations

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure MENDTH00070020 on Town Highway 7, crossing Mendon Brook, Mendon, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2,3] (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 3,000 cubic-feet per second											
Left abutment	0.0	502.2	502.2	494.8	494.8	0.0	15.2	--	15.2	479.6	-15.2
Right abutment	23.4	502.2	502.3	494.0	494.0	0.0	11.6	--	11.6	482.4	-11.6

1.Measured along the face of the most constricting side of the bridge.
2.Arbitrary datum for this study.
3. Low-chord elevations are the same as bridge seat elevations

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U.S. Geological Survey, Chittendon, 1961, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1988, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File mend020.wsp
T2        Hydraulic analysis for structure MENDTH00070020   Date: 28-OCT-97
T3        TH7 CROSSING MENDON BROOK, MENDON, VT                          SAW
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2300.0   3000.0
SK          0.0056   0.0056
*
XS   EXIT2    -45
GR          -52.9, 518.30    -22.8, 499.91      0.0, 497.77      6.4, 494.77
GR           12.2, 493.20     14.6, 493.45     20.6, 493.94     23.5, 494.01
GR           26.6, 494.63     43.4, 499.26     59.7, 500.47    108.6, 502.32
GR          129.4, 503.17    166.1, 503.10    179.7, 504.57    200.4, 519.47
*
N           0.075        0.060
SA                  43.4
*
XS   FULLV      0  * * *  0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    502.26      25.0
GR            0.0, 502.20      0.0, 494.77      1.8, 494.02      5.2, 493.65
GR           12.7, 492.74     17.8, 493.57     23.3, 494.01     23.4, 494.95
GR           23.9, 502.32      0.0, 502.20
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      23.3 * *     63.1      3.3
N           0.055
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     10       14.0     2
GR          -88.9, 514.16     -70.0, 503.0    -34.5, 504.59
GR          -23.7, 505.36     -8.3, 505.90      0.0, 505.83     24.3, 505.88
GR           33.1, 505.85     63.7, 503.13     69.1, 502.32    108.6, 502.32
GR          129.4, 503.17    166.1, 503.10    179.7, 504.57    200.4, 519.47
*
*    For the incipient overtopping discharge the section below was truncated at
*    station -34.0 to keep WSPRO from modeling flow on the left overbank, which
*    is separated from the main channel flow.
*
XT   APTEM     58           0.
GR         -112.6, 515.95    -94.2, 504.94    -77.3, 502.58    -58.6, 503.36
GR          -34.0, 503.87    -12.8, 500.94     -3.9, 496.91     -1.3, 496.28
GR            8.7, 496.02     11.0, 496.44     16.4, 495.94     22.7, 496.33
GR           24.7, 496.88     26.1, 497.24     35.7, 503.02     43.9, 504.04
GR           57.6, 504.33     77.9, 504.39     92.3, 508.18    117.3, 521.89
*
AS   APPR2     41 * * * 0.0358
GT
N           0.050        0.060      0.060
SA                 -34.0        35.7
*
HP 1 BRIDG  502.32 1 502.32
HP 2 BRIDG  502.32 * * 1412
HP 2 RDWAY  504.18 * *  885
HP 1 APPR2  504.31 1 504.31
HP 2 APPR2  504.31 * * 2300
*
HP 1 BRIDG  502.32 1 502.32
HP 2 BRIDG  502.32 * * 1356
HP 2 RDWAY  504.81 * * 1639
HP 1 APPR2  505.03 1 505.03
HP 2 APPR2  505.03 * * 3000
*
HP 1 BRIDG  501.22 1 501.22
HP 2 BRIDG  501.22 * * 1340
HP 1 APPR2  502.30 1 502.30
HP 2 APPR2  502.30 * * 1340
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File mend020.wsp
        Hydraulic analysis for structure MENDTH00070020   Date: 28-OCT-97
        TH7 CROSSING MENDON BROOK, MENDON, VT                  SAW
           *** RUN DATE & TIME: 05-28-98  14:47

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     187.   10952.     0.    59.                           0.
   502.32          187.   10952.     0.    59.  1.00     0.    24.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.32     0.0    23.9   187.1   10952.    1412.   7.55

X STA.         0.0        3.3        4.3        5.3        6.3        7.3
  A(I)            23.6        7.7        7.8        7.9        7.7
  V(I)            2.99       9.14       9.01       8.93       9.20

X STA.         7.3        8.2        9.2       10.1       11.0       11.9
  A(I)             7.8        7.8        7.6        7.6        7.7
  V(I)            9.10       9.09       9.28       9.27       9.16

X STA.        11.9       12.8       13.7       14.6       15.5       16.5
  A(I)             7.7        7.6        7.6        7.7        7.7
  V(I)            9.23       9.27       9.30       9.13       9.17

X STA.        16.5       17.4       18.4       19.4       20.4       23.9
  A(I)             7.8        7.6        7.8        7.7       24.6
  V(I)            9.05       9.27       9.07       9.15       2.87

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

         WSEL     LEW     REW    AREA        K        Q    VEL
       504.18   -72.0   176.1   177.8    4986.     885.   4.98

X STA.       -72.0       64.7       69.5       73.2       76.9       80.7
  A(I)            24.0        7.4        7.0        6.9        7.1
  V(I)            1.84       5.98       6.33       6.43       6.26

X STA.        80.7       84.5       88.2       92.0       95.9       99.5
  A(I)             7.0        7.0        7.1        7.2        6.8
  V(I)            6.35       6.31       6.27       6.15       6.54

X STA.        99.5      102.9      106.5      110.2      114.4      119.3
  A(I)             6.3        6.7        6.8        7.1        7.5
  V(I)            7.01       6.58       6.53       6.20       5.87

X STA.       119.3      126.2      136.7      147.1      157.0      176.1
  A(I)             8.8       10.8       10.8       10.4       15.2
  V(I)            5.02       4.09       4.12       4.26       2.91

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR2;  SRD =      41.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      88.    3382.    60.    60.                         605.
             2     412.   32539.    70.    73.                        5684.
             3      33.     683.    44.    44.                         164.
   504.31          533.   36605.   174.   177.  1.21   -94.    80.    4823.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR2;  SRD =      41.

         WSEL     LEW     REW    AREA        K        Q    VEL
       504.31   -94.0    79.9   533.4   36605.    2300.   4.31

X STA.       -94.0      -64.5      -11.1       -6.5       -3.8       -1.5
  A(I)            46.1      102.8       26.2       20.6       18.3
  V(I)            2.49       1.12       4.38       5.57       6.27

X STA.        -1.5        0.5        2.5        4.5        6.6        8.3
  A(I)            17.9       17.4       17.7       18.0       15.0
  V(I)            6.42       6.61       6.50       6.40       7.68

X STA.         8.3       10.2       12.5       14.7       16.8       19.0
  A(I)            17.1       19.5       19.3       19.1       19.0
  V(I)            6.72       5.91       5.96       6.01       6.06

X STA.        19.0       21.1       23.2       25.7       28.8       79.9
  A(I)            18.4       18.6       19.9       21.8       60.5
  V(I)            6.25       6.17       5.79       5.27       1.90
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File mend020.wsp
        Hydraulic analysis for structure MENDTH00070020   Date: 28-OCT-97
        TH7 CROSSING MENDON BROOK, MENDON, VT                SAW
           *** RUN DATE & TIME: 05-28-98  14:47

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     187.   10952.     0.    59.                           0.
   502.32          187.   10952.     0.    59.  1.00     0.    24.       0.

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

         WSEL     LEW     REW    AREA        K        Q     VEL
       502.32     0.0    23.9   187.1   10952.    1356.   7.25

X STA.         0.0        3.3        4.3        5.3        6.3        7.3
  A(I)            23.6        7.7        7.8        7.9        7.7
  V(I)            2.87       8.77       8.65       8.57       8.84

X STA.         7.3        8.2        9.2       10.1       11.0       11.9
  A(I)             7.8        7.8        7.6        7.6        7.7
  V(I)            8.74       8.73       8.91       8.90       8.79

X STA.        11.9       12.8       13.7       14.6       15.5       16.5
  A(I)             7.7        7.6        7.6        7.7        7.7
  V(I)            8.86       8.90       8.93       8.77       8.80

X STA.        16.5       17.4       18.4       19.4       20.4       23.9
  A(I)             7.8        7.6        7.8        7.7       24.6
  V(I)            8.69       8.90       8.71       8.79       2.75

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

         WSEL     LEW     REW    AREA        K        Q     VEL
       504.81   -73.1   180.0   282.4    9658.    1639.   5.80

X STA.       -73.1      -57.4       65.5       70.5       74.9       79.2
  A(I)            22.0       36.2       11.6       10.8       10.9
  V(I)            3.72       2.27       7.06       7.57       7.55

X STA.        79.2       83.6       88.1       92.5       97.0      101.4
  A(I)            11.0       11.1       10.9       11.2       11.2
  V(I)            7.44       7.40       7.52       7.34       7.34

X STA.       101.4      105.8      110.2      115.0      120.6      127.5
  A(I)            10.9       10.8       11.4       11.7       12.9
  V(I)            7.55       7.59       7.20       7.01       6.37

X STA.       127.5      136.2      144.6      152.9      161.0      180.0
  A(I)            14.4       14.0       13.8       13.8       22.0
  V(I)            5.70       5.85       5.93       5.95       3.73

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR2;  SRD =      41.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     132.    6515.    61.    62.                        1097.
             2     462.   39409.    70.    73.                        6754.
             3      66.    2057.    47.    47.                         445.
   505.03          660.   47980.   178.   182.  1.20   -95.    83.    6583.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR2;  SRD =      41.

         WSEL     LEW     REW    AREA        K        Q     VEL
       505.03   -95.4    82.6   660.2   47980.    3000.   4.54

X STA.       -95.4      -71.4      -53.0      -15.7       -8.3       -4.6
  A(I)            49.5       44.9       92.7       39.1       27.6
  V(I)            3.03       3.34       1.62       3.84       5.44

X STA.        -4.6       -2.0        0.4        2.7        5.0        7.0
  A(I)            23.3       22.0       22.0       21.7       19.3
  V(I)            6.43       6.81       6.81       6.90       7.78

X STA.         7.0        9.2       11.8       14.3       16.8       19.1
  A(I)            21.2       24.1       23.6       23.5       22.8
  V(I)            7.06       6.21       6.35       6.39       6.59

X STA.        19.1       21.6       24.1       27.0       32.1       82.6
  A(I)            23.2       23.4       24.5       32.2       79.4
  V(I)            6.48       6.41       6.11       4.66       1.89
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File mend020.io.wsp
        Hydraulic analysis for structure MENDTH00070020   Date: 28-OCT-97
        TH7 CROSSING MENDON BROOK, MENDON, VT              SAW
           *** RUN DATE & TIME: 05-28-98  14:41

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     165.   12482.    22.    35.                        2578.
   501.22          165.   12482.    22.    35.  1.00     0.    24.   2578.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.22     0.0    23.8   164.6   12482.    1340.   8.14

X STA.         0.0        4.0        4.9        5.8        6.7        7.6
  A(I)             25.5        6.3        6.4        6.3        6.1
  V(I)             2.63      10.66      10.51      10.69      10.94

X STA.         7.6        8.5        9.3       10.2       11.0       11.9
  A(I)              6.2        6.4        6.3        6.3        6.4
  V(I)            10.73      10.47      10.69      10.68      10.55

X STA.        11.9       12.7       13.5       14.3       15.2       16.1
  A(I)              6.3        6.3        6.2        6.2        6.3
  V(I)            10.66      10.68      10.73      10.77      10.65

X STA.        16.1       16.9       17.8       18.7       19.6       23.8
  A(I)              6.2        6.2        6.3        6.2       26.4
  V(I)            10.82      10.86      10.68      10.79       2.54

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR2;  SRD =      41.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     275.   17818.    63.    65.                        3277.
   502.30          275.   17818.    63.    65.  1.00   -27.    36.   3277.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR2;  SRD =      41.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.30   -27.0    35.5   275.3   17818.    1340.   4.87

X STA.       -27.0       -2.9       -1.2        0.3        1.8        3.4
  A(I)             55.5       10.8       10.1       10.3       10.6
  V(I)             1.21       6.19       6.61       6.49       6.34

X STA.         3.4        4.9        6.4        7.9        9.5       11.0
  A(I)             10.2       10.3       10.4       10.5        9.8
  V(I)             6.57       6.50       6.41       6.39       6.83

X STA.        11.0       12.6       14.3       15.9       17.5       19.0
  A(I)             10.5       11.4       11.1       10.9       10.8
  V(I)             6.39       5.86       6.05       6.13       6.19

X STA.        19.0       20.7       22.3       24.1       25.9       35.5
  A(I)             11.0       10.9       11.2       11.1       27.7
  V(I)             6.08       6.14       5.98       6.01       2.42
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File mend020.wsp
        Hydraulic analysis for structure MENDTH00070020   Date: 28-OCT-97
        TH7 CROSSING MENDON BROOK, MENDON, VT                  SAW
           *** RUN DATE & TIME: 05-28-98  14:47

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

EXIT2:XS   ******    -28.     542.  0.32 *****  503.15  500.01   2300.  502.83
      -45. ******    121.   30735.  1.13 ***** *******    0.42    4.25

FULLV:FV      45.    -28.     583.  0.28  0.23  503.38 *******   2300.  503.11
        0.    45.    166.   33607.  1.14  0.00    0.00    0.39    3.94
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPR2"     KRATIO =  0.69

APPR2:AS      41.    -86.     358.  0.70  0.28  503.86 *******   2300.  503.16
       41.    41.     42.   23347.  1.10  0.21   -0.01    0.69    6.42
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                         WS3N,LSEL =   503.11     502.26

            <<<<<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      45.      0.     187.  0.89 *****  503.21  498.69   1412.  502.32
        0. ******     24.   10952.  1.00 ***** *******    0.48    7.55

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN    XLAB   XRAB
       1. ****   6.  0.800  0.000  502.26 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
   RDWAY:RG      10.    27.  0.11  0.35  504.55    0.00    885.  504.18

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     76.    28.   -72.   -44.   1.2   0.6   4.2   4.5   1.0   2.8
   RT:    810.   124.    52.   176.   1.9   1.3   5.8   5.0   1.7   3.0

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

APPR2:AS      18.    -94.     534.  0.35  0.17  504.66  501.04   2300.  504.31
       41.    20.     80.   36638.  1.21  0.00    0.00    0.48    4.31

       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
   EXIT2:XS     -45.   -28.   121.   2300.   30735.     542.    4.25  502.83
   FULLV:FV       0.   -28.   166.   2300.   33607.     583.    3.94  503.11
   BRIDG:BR       0.     0.    24.   1412.   10952.     187.    7.55  502.32
   RDWAY:RG      10.*******    76.    885.******************    2.00  504.18
   APPR2:AS      41.   -94.    80.   2300.   36638.     534.    4.31  504.31

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR2:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT2:XS    500.01    0.42  493.20  519.47************  0.32  503.15  502.83
   FULLV:FV  ********    0.39  493.20  519.47  0.23  0.00  0.28  503.38  503.11
   BRIDG:BR    498.69    0.48  492.74  502.32************  0.89  503.21  502.32
   RDWAY:RG  ****************  502.32  519.47  0.11******  0.35  504.55  504.18
   APPR2:AS    501.04    0.48  495.33  521.28  0.17  0.00  0.35  504.66  504.31
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188              MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File mend020.wsp
        Hydraulic analysis for structure MENDTH00070020   Date: 28-OCT-97
        TH7 CROSSING MENDON BROOK, MENDON, VT                  SAW
           *** RUN DATE & TIME: 05-28-98  14:47

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

EXIT2:XS   ******   -29.     690.   0.35 *****  504.01  500.74   3000.  503.65
      -45. ******   171.   40058.   1.20 ***** *******    0.45    4.35

FULLV:FV      45.   -29.     749.   0.29  0.23  504.24 *******   3000.  503.94
        0.    45.   174.   44463.   1.18  0.00    0.00    0.40    4.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR2:AS      41.   -92.     475.   0.74  0.26  504.71 *******   3000.  503.97
       41.    41.    79.   32024.   1.19  0.22   -0.01    0.73    6.31
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   503.94     502.26

            <<<<<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      45.     0.     187.   0.82 *****  503.14  498.54   1356.  502.32
        0. ******    24.   10952.   1.00 ***** *******    0.46    7.25

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  502.26 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    27.  0.11  0.39  505.31    0.00   1639.  504.81

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    212.    42.   -73.   -31.   1.8   0.9   5.3   5.4   1.4   2.9
   RT:   1427.   135.    45.   180.   2.5   1.8   6.9   5.9   2.3   3.0

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

APPR2:AS      18.   -95.     660.   0.39  0.20  505.41  501.99   3000.  505.03
       41.    22.    83.   47920.   1.20  0.00    0.00    0.46    4.55

       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
   EXIT2:XS     -45.   -29.   171.   3000.   40058.     690.    4.35  503.65
   FULLV:FV       0.   -29.   174.   3000.   44463.     749.    4.01  503.94
   BRIDG:BR       0.     0.    24.   1356.   10952.     187.    7.25  502.32
   RDWAY:RG      10.*******   212.   1639.******************    2.00  504.81
   APPR2:AS      41.   -95.    83.   3000.   47920.     660.    4.55  505.03

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR2:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX     HF    HO   VHD     EGL    WSEL
   EXIT2:XS    500.74    0.45  493.20  519.47************  0.35  504.01  503.65
   FULLV:FV  ********    0.40  493.20  519.47  0.23  0.00  0.29  504.24  503.94
   BRIDG:BR    498.54    0.46  492.74  502.32************  0.82  503.14  502.32
   RDWAY:RG  ****************  502.32  519.47  0.11******  0.39  505.31  504.81
   APPR2:AS    501.99    0.46  495.33  521.28  0.20  0.00  0.39  505.41  505.03
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File mend020.io.wsp
        Hydraulic analysis for structure MENDTH00070020   Date: 28-OCT-97
        TH7 CROSSING MENDON BROOK, MENDON, VT                SAW
           *** RUN DATE & TIME: 05-28-98  14:41

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

EXIT2:XS   ******   -25.     351.  0.25 *****  501.60  498.55   1340.  501.35
      -45. ******    83.   17894.  1.08 ***** *******    0.39    3.81

FULLV:FV      45.   -26.     381.  0.21  0.23  501.83 *******   1340.  501.62
        0.    45.    90.   19853.  1.10  0.00    0.01    0.36    3.51
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPR2:AS      41.   -23.     241.  0.48  0.25  502.21 *******   1340.  501.73
       41.    41.    35.   15096.  1.00  0.14    0.00    0.48    5.56
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR      45.     0.     165.  1.03  0.36  502.25  498.50   1340.  501.22
        0.    45.    24.   12475.  1.00  0.29    0.00    0.52    8.15

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  502.26 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR2:AS      18.   -27.     275.  0.37  0.15  502.67  499.49   1340.  502.30
       41.    19.    36.   17823.  1.00  0.27    0.01    0.41    4.87

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.585  0.202   14198.    -1.    23.   502.15

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXIT2:XS     -45.   -25.    83.   1340.   17894.     351.    3.81  501.35
   FULLV:FV       0.   -26.    90.   1340.   19853.     381.    3.51  501.62
   BRIDG:BR       0.     0.    24.   1340.   12475.     165.    8.15  501.22
   RDWAY:RG      10.**************       0.******************    2.00********
   APPR2:AS      41.   -27.    36.   1340.   17823.     275.    4.87  502.30

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR2:AS      -1.    23.   14198.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT2:XS    498.55    0.39  493.20  519.47************  0.25  501.60  501.35
   FULLV:FV  ********    0.36  493.20  519.47  0.23  0.00  0.21  501.83  501.62
   BRIDG:BR    498.50    0.52  492.74  502.32  0.36  0.29  1.03  502.25  501.22
   RDWAY:RG  ****************  502.32  519.47**********************************
   APPR2:AS    499.49    0.41  495.33  521.28  0.15  0.27  0.37  502.67  502.30
```
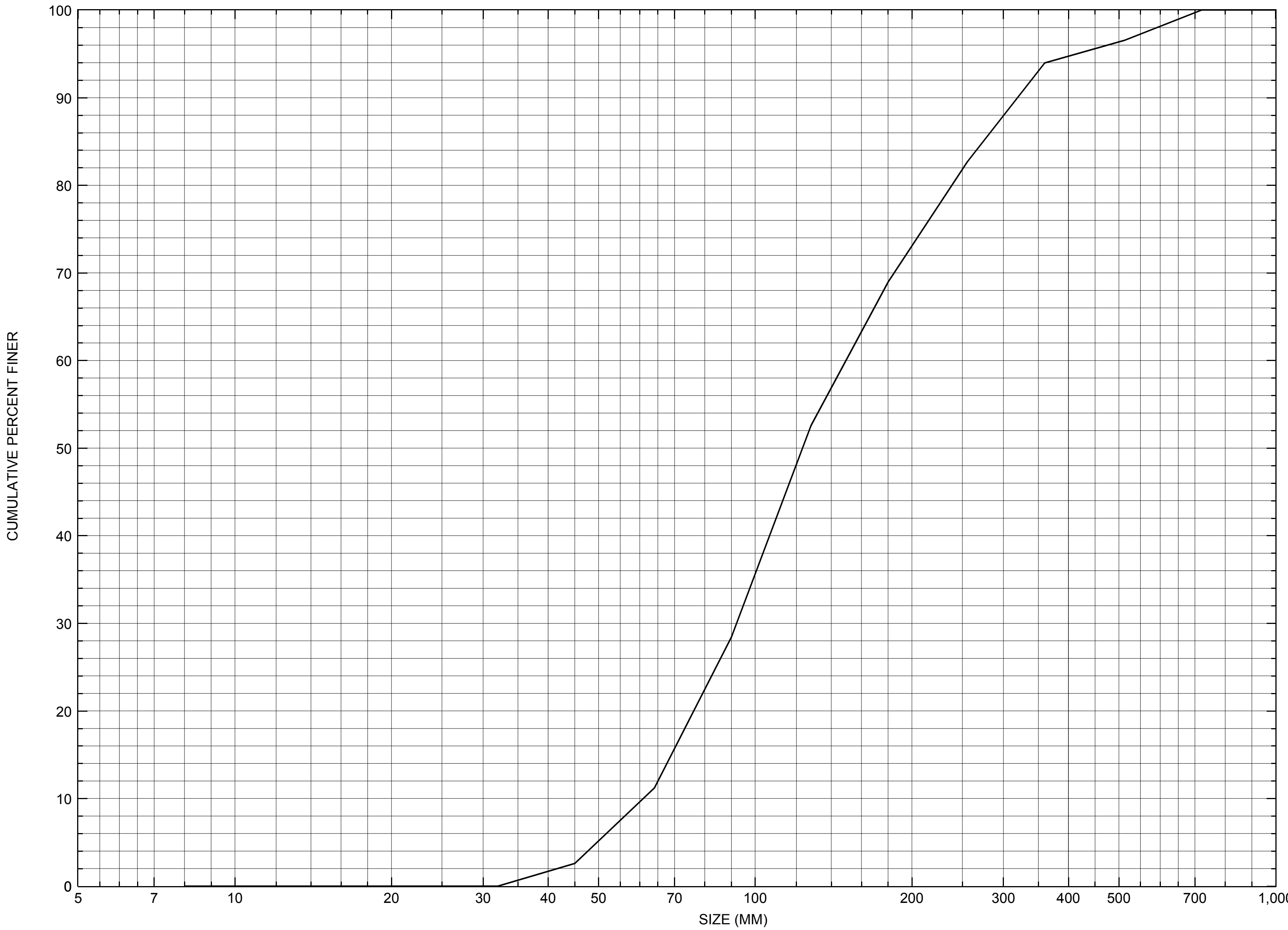

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure MENDTH00070020 in Mendon, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number MENDTH00070020

General Location Descriptive

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

Date (MM/DD/YY) 03 / 13 / 95

Highway District Number (I - 2; nn) 03

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

Town (FIPS place code; I - 4; nnnnn) 44125

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

Waterway (I - 6) MENDON BROOK

Road Name (I - 7): -

Route Number TH007

Vicinity (I - 9) 0.7 MI TO JCT W US4

Topographic Map Chittenden

Hydrologic Unit Code: 02010002

Latitude (I - 16; nnnn.n) 43385

Longitude (i - 17; nnnnn.n) 72536

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10111000201110

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0026

Year built (I - 27; YYYY) 1962

Structure length (I - 49; nnnnnn) 000030

Average daily traffic, ADT (I - 29; nnnnnn) 000080

Deck Width (I - 52; nn.n) 140

Year of ADT (I - 30; YY) 91

Channel & Protection (I - 61; n) 4

Opening skew to Roadway (I - 34; nn) 18

Waterway adequacy (I - 71; n) 5

Operational status (I - 41; X) R

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

Structure type (I - 43; nnn) 302

Year Reconstructed (I - 106) 0000

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

Clear span (nnn.n ft) -

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 8.2

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

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

Comments:

The structural inspection report of 9/10/93 indicates the structure is a steel stringer type bridge with a concrete deck. The abutments and wingwalls are concrete. The wingwalls are short in length. The right abutment and its wingwalls are noted as undermined up to 3 feet over the entire length of each with a penetration up to 8 inches beneath. The ends of both right wingwalls and the right abutment at the centerline of the roadway are resting on boulders. The left abutment also is undermined up to 30 inches for most of its length with penetration reaching 3 to 4 inches. Most of the channel flow is against the right abutment currently. Boulder riprap protection has been placed around the ends of the right **(Continued, page 33)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: **Sand and gravel with random boulders**

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -

Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

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

The watershed storage area is: - (*1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site*)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	-	-	-	-
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

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

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

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

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

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

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

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

Comments:

wingwalls. There is natural boulder riprap noted along the channel boundaries up- and downstream of the bridge. The bridge is open to very restricted traffic, with a sign that states "Bridge Closed - Pass at own risk".

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **11.87** mi^2 Lake/pond/swamp area **0.01** mi^2
Watershed storage *(ST)* **0** %
Bridge site elevation **1390** ft Headwater elevation **4235** ft
Main channel length **5.81** mi
10% channel length elevation **1450** ft 85% channel length elevation **2700** ft
Main channel slope *(S)* **286.87** ft / mi

Watershed Precipitation Data

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

Bridge Plan Data

Are plans available? **Y** *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: **06** / **1963**

Project Number **TF 16-1963** Minimum channel bed elevation: **498.7**

Low superstructure elevation: USLAB **502.2** DSLAB **502.2** USRAB **502.2** DSRAB **502.2**

Benchmark location description:

BM#1, [spike in trunk or root of] a 4 inch elm tree located about 75 feet right bankward from the right abutment and about 17 feet perpendicular from the centerline of the roadway in a downstream direction, Elevation 500.00.

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 **2.5** Footing bottom elevation: **494.7**

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:

Under the current conditions where both abutments are undermined, the footing at this bridge is indicated in the structural report to be boulders. These bridge plans are listed under the project number TF16/1963.
Note: The proposed streambed was graded level under the bridge at elevation 498.7, which is about 4 feet above the bottom of the footings or about 1.5 feet above the top of the footings.
Note: The bridge seat and low superstructure elevation are the same for this bridge.

N

Cross-sectional Data

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

Source (*FEMA, VTAOT, Other*)? NO

Comments: CROSS SECTION INFORMATION

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

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

Source (*FEMA, VTAOT, Other*)?

Comments: NO CROSS SECTION INFORMATION

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: CG Date: 1/29/96
Computerized by: CG Date: 2/5/96
Reviewd by: SAW Date: 10/17/97

Structure Number MENDTH00070020

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* T. Severance Date *(MM/DD/YY)* 09 / 27 / 1995
2. Highway District Number 03 Mile marker -
County Rutland (021) Town Mendon (44125)
Waterway *(I - 6)* Mendon Brook Road Name -
Route Number TH 007 Hydrologic Unit Code: 02010002
3. Descriptive comments:
This temporary steel bridge laid over old structure. The bridge is located 0.7 miles from the junction with US 4.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 6 RBDS 6 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 2 UB 1 DS 2 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length 30 *(feet)* Span length 26d *(feet)* Bridge width 14 *(feet)*

Road approach to bridge:

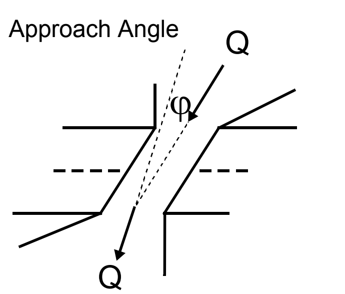
8. LB 2 RB 1 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

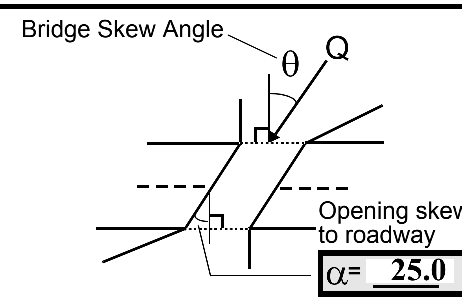
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

*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: 5 16. Bridge skew: 40





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 50 feet US *(US, UB, DS)* to 16 feet UB
Channel impact zone 2: Exist? N *(Y or N)*
Where? - *(LB, RB)* Severity -
Range? - feet - *(US, UB, DS)* to - feet -

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

18. Bridge Type: **1a**

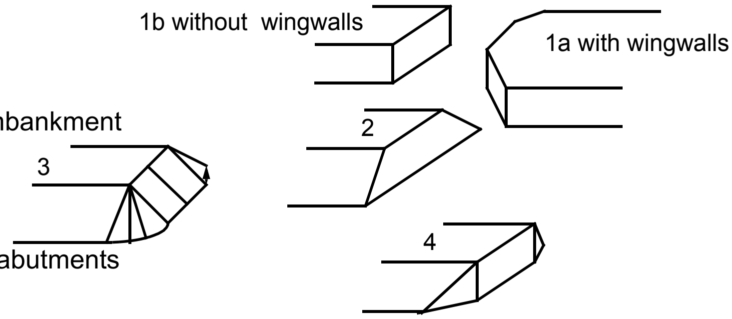
1a- Vertical abutments with wingwalls

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.)

As measured during the site visit, the bridge length equals 29.0 feet, span length is 27.0 feet, and bridge width is 14.0 feet.

13. Temporary structure is sitting on top of old structure with piled up dirt/gravel embankments on either bank which adjust for added height of temporary bridge deck. Much of dirt/gravel extends out both upstream and downstream. No noted erosion or protection.

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
39.0	**7.0**			**6.0**	**4**	**4**	**453**	**453**	**1**	**1**

23. Bank width **15.0** 24. Channel width **30.0** 25. Thalweg depth **69.5** 29. Bed Material **543**

30 .Bank protection type: LB **0** RB **0** 31. 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*

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

27. Bank material is composed of cobble, boulder and gravel.
29. Bed material is composed of boulder, cobble and gravel.
The banks are naturally protected to some extent due to the presence of boulders and cobbles.
The left road approach is present along the upstream left bank and is fairly close to the channel at one point (within 10 feet).
There are large boulders on the upstream right bank, where one of the very large boulders is within one bridge length.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **162** 35. Mid-bar width: **18**

36. Point bar extent: **126** feet **US** *(US, UB)* to **213** feet **US** *(US, UB, DS)* positioned **0** %LB to **45** %RB

37. Material: **43**

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

A second bar exists along the RB 250 ft US to 320 ft US; mid-bar distance 300 ft; mid-bar width 14 ft, positioned 30% LB to 100% RB; material is 4,3,5. A cut bank is evident opposite this bar, but is not severe - large boulders present along bank provide some stabilization. The roadway travels along the left bank opposite second point bar. There is a third bar upstream of the second bar on the left bank.

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: **55** 42. Cut bank extent: **45** feet **US** *(US, UB)* to **85** 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.):

Many tree roots are exposed with sandy gravel sub-bank material.
A second cut bank exists 112 ft US to 235 ft US on RB.
A third cut bank exists at upper end of left bank point bar (188 ft US to 220 ft US, mid-bank distance is 208 ft)
Both banks have #1 banks damage, with tree roots exposed. Trees are falling into the channel.

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.):

There is no channel scour, but there is natural localized scouring.

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

51. Confluence 1: Distance **400'** 52. Enters on **LB** *(LB or RB)* 53. Type **1** *(**1**- perennial; **2**- ephemeral)*

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

54. Confluence comments (eg. confluence name):

Confluence name is Beaver Brook.

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
30.0		**1.0**		**1**	**54**	**54**	**1**

58. Bank width (BF) **-** 59. Channel width **-** 60. Thalweg depth **90.0** 63. Bed Material **1**

*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.):

453
61. Bank material is composed of boulder and cobble.
63. Bed material is composed of cobble, boulder and gravel.
The water beneath the bridge is pooled.
There is a scour hole along the right bank at the upstream bridge face, extending approximately 5 feet upstream of bridge face. This hole is 8 ft long, 3 ft wide, 1.25 ft deep, and positioned 65% LB to 85% RB. There is another scour hole along the left bank beneath the bridge. This hole is 5 ft long, 2 ft wide, 0.25 ft deep, and positioned 20% LB to 25% RB.

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 Y____ *(1- Low; 2- Moderate; 3- High)*

70. Debris and Ice Comments:

3

Logs are strewn along both banks upstream. Trees are falling into 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		**-**	**90**	**2**	**1 (3)**	**0**	**-**	**90.0**
RABUT	**1**	**25**	**90**			**2**	**1 (3)**	**21.5**

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

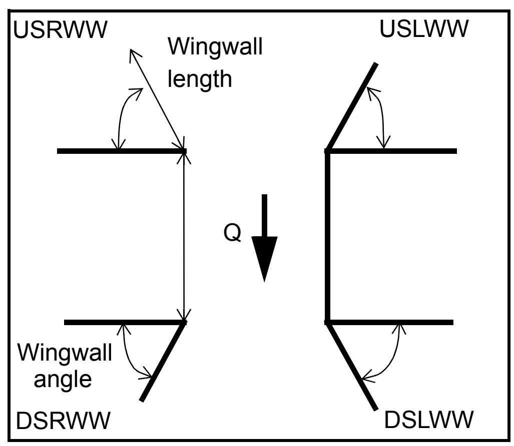
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
-
1
74. Abutments are both undermined. The entire right abutment is exposed/undermined; at the upstream end there is 2.25 ft of horizontal penetration underneath the wall.
75. Depth of water is not greater than upstream/downstream thalweg depth of 1 ft, therefore there is no measurable scour.
76. There are no footings. The right abutment is undermined 1 ft at upstream end. The left abutment is undermined 0.5 ft at upstream end. A bar exists on the left at the downstream end.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**21.5**	
USRWW:	**Y**		**1**		**0**	**2.0**	
DSLWW:	**-**		**-**		**Y**	**19.0**	
DSRWW:	**1**		**3**		**-**	**20.0**	

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	**-**	**-**	**Y**	**-**	**1**	**-**	**-**	**-**
Condition	**N**	**-**	**1**	**-**	**2**	**-**	**-**	**-**
Extent	**-**	**-**	**3**	**2**	**0**	**0**	**0**	**-**

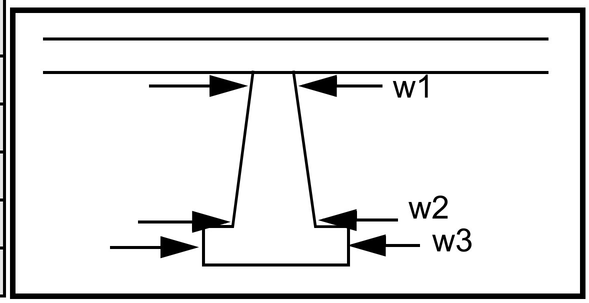
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
-
-
-
0
-
-

Piers:

84. Are there piers? **80.** *(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		**8.0**	**4.0**	**25.0**	**100.0**	**-**
Pier 2	**-**	**6.5**	**-**	**25.0**	**-**	**-**
Pier 3	**-**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**At the**	**foot-**	**ture/**	**ed).**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**DSR**	**ing**	**mate**	**The**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**WW**	**(or it**	**rial**	**DSR**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**there**	**coul**	**that**	**WW**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**appe**	**d**	**esca**	**was**	*Y- yes; N- no*
91. Attack ∠ (BF)	**ars**	**sim-**	**ped**	**pour**	
92. Pushed	**to be**	**ply**	**the**	**ed**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**rema**	**be**	**form**	**over**	
95. Cross-members	**ins**	**the**	**whil**	**a**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**of a**	**con-**	**e it**	**boul-**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**con-**	**crete**	**was**	**der.**	
98. Exposure depth	**crete**	**mix-**	**pour**	**Whil**	

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

e the DSRWW is undermined, no scour depth was noted as the flow depth is less than the average thalweg depth of 1.0 ft. There is no DSLWW.

The USRWW is undermined 0.75 feet vertically and the undermining penetrates 2.0 feet horizontally underneath the wall. No footing is evident. Note that the water depth is less than the upstream/downstream thalweg depth of 1.0 feet so no scour depth was noted.

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 **4** Width **54** Depth: **54** Positioned **1** %LB to **1** %RB

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

453
0
0
-

Are there major confluences? - (*Y or if N type ctrl-n mc*) How many? **100.**

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

Confluence 2: Distance **was** Enters on **not** (*LB or RB*) Type **plac** (***1**- perennial; **2**- ephemeral*)

Confluence comments (eg. confluence name):

ed along the banks. Bank material consists of boulders and cobble. The boulder/cobble material act as natural protection.

F. Geomorphic Channel Assessment

107. Stage of reach evolution **Be**

***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)*:

d material consists of cobble, boulders, and gravel.

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: MENDTH00070020 Town: MENDON
Road Number: TH7 County: RUTLAND
Stream: MENDON BROOK

Initials SAW Date: 11/24/97 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 others, 1995, p. 28, eq. 16)

Approach Section Characteristic	100 yr	500 yr	Incipient
Total discharge, cfs	2300	3000	1340
Main Channel Area, ft2	412	462	275
Left overbank area, ft2	88	132	0
Right overbank area, ft2	33	66	0
Top width main channel, ft	70	70	63
Top width L overbank, ft	60	61	0
Top width R overbank, ft	44	47	0
D50 of channel, ft	0.4044	0.4044	0.4044
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.9	6.6	4.4
y1, average depth, LOB, ft	1.5	2.2	ERR
y1, average depth, ROB, ft	0.8	1.4	ERR
Total conveyance, approach	36605	47980	17818
Conveyance, main channel	32539	39409	17818
Conveyance, LOB	3382	6515	0
Conveyance, ROB	683	2057	0
Percent discrepancy, conveyance	0.0027	-0.0021	0.0000
Qm, discharge, MC, cfs	2044.5	2464.1	1340.0
Ql, discharge, LOB, cfs	212.5	407.4	0.0
Qr, discharge, ROB, cfs	42.9	128.6	0.0
Vm, mean velocity MC, ft/s	5.0	5.3	4.9
Vl, mean velocity, LOB, ft/s	2.4	3.1	ERR
Vr, mean velocity, ROB, ft/s	1.3	1.9	ERR
Vc-m, crit. velocity, MC, ft/s	11.1	11.4	10.6
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

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	1412	1356	1340
Main channel area (DS), ft2	187	187	164.6
Main channel width (normal), ft	21.7	21.7	21.6
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	21.7	21.7	21.6
D90, ft	1.0469	1.0469	1.0469
D95, ft	1.3598	1.3598	1.3598
Dc, critical grain size, ft	0.2705	0.2495	0.5750
Pc, Decimal percent coarser than Dc	0.760	0.801	0.323
Depth to armoring, ft	0.26	0.19	3.62

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	2300	3000	1340
(Q) discharge thru bridge, cfs	1412	1356	1340
Main channel conveyance	10952	10952	12482
Total conveyance	10952	10952	12482
Q2, bridge MC discharge,cfs	1412	1356	1340
Main channel area, ft2	187	187	165
Main channel width (normal), ft	21.7	21.7	21.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	21.7	21.7	21.6
y_bridge (avg. depth at br.), ft	8.62	8.62	7.62
Dm, median (1.25*D50), ft	0.505494	0.5055	0.5055
y2, depth in contraction,ft	5.39	5.21	5.17
ys, scour depth (y2-ybridge), ft	-3.23	-3.41	-2.45

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	2300	3000	1340
Q, thru bridge MC, cfs	1412	1356	1340
Vc, critical velocity, ft/s	11.14	11.35	10.60
Va, velocity MC approach, ft/s	4.96	5.33	4.87
Main channel width (normal), ft	21.7	21.7	21.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	21.7	21.7	21.6
qbr, unit discharge, ft2/s	65.1	62.5	62.0
Area of full opening, ft2	187.0	187.0	164.6
Hb, depth of full opening, ft	8.62	8.62	7.62
Fr, froude number, bridge MC	0.48	0.46	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	502.26	502.26	0
Elevation of Bed, ft	493.64	493.64	-7.62
Elevation of Approach, ft	504.31	505.03	0
Friction loss, approach, ft	0.17	0.2	0
Elevation of WS immediately US, ft	504.14	504.83	0.00
ya, depth immediately US, ft	10.50	11.19	7.62
Mean elevation of deck, ft	505.85	505.85	505.85
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.95	0.94	1.00
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	-2.48	-2.73	N/A
Ys, scour w/Umbrell equation, ft	-1.51	-0.80	N/A

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

**Ys, scour w/Chang equation, ft	N/A	N/A	N/A
**Ys, scour w/Umbrell equation, ft	N/A	N/A	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	5.39	5.21	5.17
WSEL at downstream face, ft	--	--	--
Depth at downstream face, ft	N/A	N/A	N/A
Ys, depth of scour (Laursen), 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 others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	2300	3000	1340	2300	3000	1340
a', abut.length blocking flow, ft	35.1	35.1	28.1	29.2	29.2	12.7
Ae, area of blocked flow ft2	132.3	164.2	81.9	72.7	100.2	46.9
Qe, discharge blocked abut.,cfs	--	--	236.7	--	--	182.4
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve (Qe/Ae), ft/s	3.06	3.58	3.51	3.47	3.09	4.16
ya, depth of f/p flow, ft	3.77	4.68	2.91	2.49	3.43	3.69
--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	65	65	65	115	115	115
K2	0.96	0.96	0.96	1.03	1.03	1.03
Fr, froude number f/p flow	0.341	0.355	0.595	0.449	0.315	0.378
ys, scour depth, ft	12.88	15.23	12.95	10.95	11.62	10.36

HIRE equation (a'/ya > 25)

ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	35.1	35.1	28.1	29.2	29.2	12.7
y1 (depth f/p flow, ft)	3.77	4.68	2.91	2.49	3.43	3.69
a'/y1	9.31	7.50	9.64	11.73	8.51	3.44
Skew correction (p. 49, fig. 16)	0.92	0.92	0.92	1.06	1.06	1.06
Froude no. f/p flow	0.34	0.36	0.60	0.45	0.32	0.38
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.48	0.46	0.52	0.48	0.46	0.52
y, depth of flow in bridge, ft	8.62	8.62	7.62	8.62	8.62	7.62
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.23	1.13	1.27	1.23	1.13	1.27
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR