LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (MAIDTH00050006) on TOWN HIGHWAY 5, crossing CUTLER MILL BROOK, MAIDSTONE, VERMONT

Open-File Report 98-419

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 LORA K. STRIKER

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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 6 (MAIDTH00050006) ON TOWN HIGHWAY 5, CROSSING CUTLER MILL BROOK, MAIDSTONE, VERMONT

By **Lora K. Striker**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure MAIDTH00050006 on Town Highway 5 crossing Cutler Mill Brook, Maidstone, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the White Mountain section of the New England physiographic province in northeastern Vermont. The 14.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is predominantly forest with some pasture upstream on the left bank.

In the study area, Cutler Mill Brook has an incised, straight channel with a slope of approximately 0.014 ft/ft, an average channel top width of 47 ft and an average bank height of 7 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 92.4 mm (0.303 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 13, 1995, indicated that the reach was stable.

The Town Highway 5 crossing of Cutler Mill Brook is a 25-ft-long, one-lane bridge consisting of one 23-foot concrete slab span (Vermont Agency of Transportation, written communication, August 5, 1994). The opening length of the structure parallel to the bridge face is 20.7 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 35 degrees to the opening while the computed opening-skew-to-roadway is 25 degrees.

A scour hole 1.5 ft deeper than the mean thalweg depth was observed in the middle of the channel 36 ft downstream of the bridge. Scour protection measures at the site included type-4 stone fill (less than 60 inches diameter) along the left and right banks upstream and the right bank downstream; type-3 stone fill (less than 48 inches diameter) along the entire base length of the upstream left and right wingwalls, the left and right abutments, and the downstream left wingwall. Type-3 stone fill was also observed at the downstream end of the downstream right wingwall and along the left bank downstream. 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 0.9 to 1.0 ft. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 7.7 to 11.4 ft. The worst-case abutment scour occurred at the 500-year discharge at the left abutment and at the 100-year discharge at the right abutment. 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. Figure 8 shows only the 100-year discharge scour elevations since total scour depths computed for the 100-year discharge were greater than those for the 500-year discharge. 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.

Groveton, N.H .- VT. Quadrangle, 1:24,000, 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 MAIDTH00050006 ***Stream*** Cutler Mill Brook

County Essex ***Road*** TH 5 ***District*** 7

Description of Bridge

Bridge length 25 ***ft*** ***Bridge width*** 17.2 ***ft*** ***Max span length*** 23 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 7/13/95

Description of stone fill Type-3, along the entire base length of the upstream left and right wingwalls, left and right abutments, downstream left wingwall, and at the DS end of the downstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 35

There is a moderate bend noted in the upstream reach. However, the stream is noted as straight in the immediate vicinity of the bridge.

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	7/13/95	0	0
Level II	7/13/95	0	0

Potential for debris Moderate due to bend in the channel and angle of bridge opening. The historical data form indicates ice build-up problems have occurred at the site in the past.

Describe any features near or at the bridge that may affect flow (include observation date) None.were observed on 7/13/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a flat to slightly irregular flood plain and steep valley wall on the right.

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

Date of inspection 7/13/95

DS left: Moderately sloping channel bank to narrow flood plain/wetland

DS right: Moderately sloping channel bank to irregular overbank

US left: Moderately sloping channel bank to narrow flood plain/wetland

US right: Steep channel bank to moderately sloping overbank

Description of the Channel

Average top width 47 ***ft*** ***Average depth*** 7 ***ft***

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

Straight and stable with semi-alluvial channel boundaries.

7/13/95

Vegetative co Trees and brush

DS left: Tree and brush

DS right: Grass and brush, with trees on the immediate banks more than 50 ft US

US left: Brush, grass, and a few trees

US right: Yes

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

None observed on 7/13/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 14.7 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: -

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 1,500 ***ft³/s*** ***Q500*** 2,240 ***ft³/s***

The 100- and 500-year discharges are flood frequency estimates available from the VTAOT database (written communication, May 1995) for this bridge. The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year discharge.

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

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

Datum tie between USGS survey and VTAOT plans Sea level (NGVD) was used as the datum for the USGS survey and the VTAOT plans.

Description of reference marks used to determine USGS datum. RM1 is VTAOT BM # 3, a spike near the base of a 12 inch Spruce tree, 50 ft left of the left abutment on TH5 and 10 ft off the downstream side of the road (elev. 1005.41 ft, NGVD). RM2 is VTAOT BM#4, a spike in the root of an 18 inch balsom tree, 80 ft right of the right abutment on TH5 and 30 ft off the downstream side of the road (elev. 1015.94 ft, NGVD).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-20	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	12	1	Road Grade section
APPRO	44	2	Modelled Approach section (Templated from APTEM)
APTEM	48	1	Approach section as surveyed (Used as a template)

[1] For location of cross-sections see plan-view sketch included with Level I field form, Appendix E.

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 0.040 to 0.050, and overbank "n" values ranged from 0.050 to 0.110.

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 0.0143 ft/ft, which was estimated from the appropriate topographic map (U.S. Geological Survey, 1988).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0148 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

A portion of the flow is diverted away from this bridge when the water surface overtops the left road approach. The water flows down Town Highway 4 and along the road embankment, returning to the main channel downstream of this site. Thus, a split-flow analysis was performed to determine the discharge diverted around the bridge. The 100- and 500-year discharges were reduced by the diverted discharges to model the hydraulics at the bridge.

For the 100-year and incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. Analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 1008.2 *ft*
Average low steel elevation 1007.0 *ft*

100-year discharge 1,500 *ft³/s*
Water-surface elevation in bridge opening 1003.6 *ft*
Road overtopping? No *Discharge over road* 110 *ft³/s*
Area of flow in bridge opening 104 *ft²*
Average velocity in bridge opening 13.4 *ft/s*
Maximum WSPRO tube velocity at bridge 17.7 *ft/s*

Water-surface elevation at Approach section with bridge 1006.9
Water-surface elevation at Approach section without bridge 1003.7
Amount of backwater caused by bridge 3.2 *ft*

500-year discharge 2,240 *ft³/s*
Water-surface elevation in bridge opening 1007.2 *ft*
Road overtopping? Yes *Discharge over road* 925 *ft³/s*
Area of flow in bridge opening 168 *ft²*
Average velocity in bridge opening 7.8 *ft/s*
Maximum WSPRO tube velocity at bridge 11.6 */s*

Water-surface elevation at Approach section with bridge 1008.2
Water-surface elevation at Approach section without bridge 1004.0
Amount of backwater caused by bridge 4.2 *ft*

Incipient overtopping discharge 1,310 *ft³/s*
Water-surface elevation in bridge opening 1003.3 *ft*
Area of flow in bridge opening 100 *ft²*
Average velocity in bridge opening 13.1 *ft/s*
Maximum WSPRO tube velocity at bridge 17.2 *ft/s*

Water-surface elevation at Approach section with bridge 1006.5
Water-surface elevation at Approach section without bridge 1003.6
Amount of backwater caused by bridge 2.9 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year and incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). At this site, the 500-year discharge resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for the 500-year discharge was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the 500-year discharge also was computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Furthermore, contraction scour was computed by substituting an estimate for the depth of flow at the downstream bridge face in the contraction scour equations for the 500-year discharge. Results with respect to 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-year discharge*	*500-year discharge*	*Incipient overtopping discharge*
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.0	0 0.0	0.9
Depth to armoring	23.8	N/A	22.8
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	11.2	11.4	10.8
Right abutment	9.3	7.7	8.9
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	*500-year discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	2.3	1.9	2.2
Right abutment	2.3	1.9	2.2
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

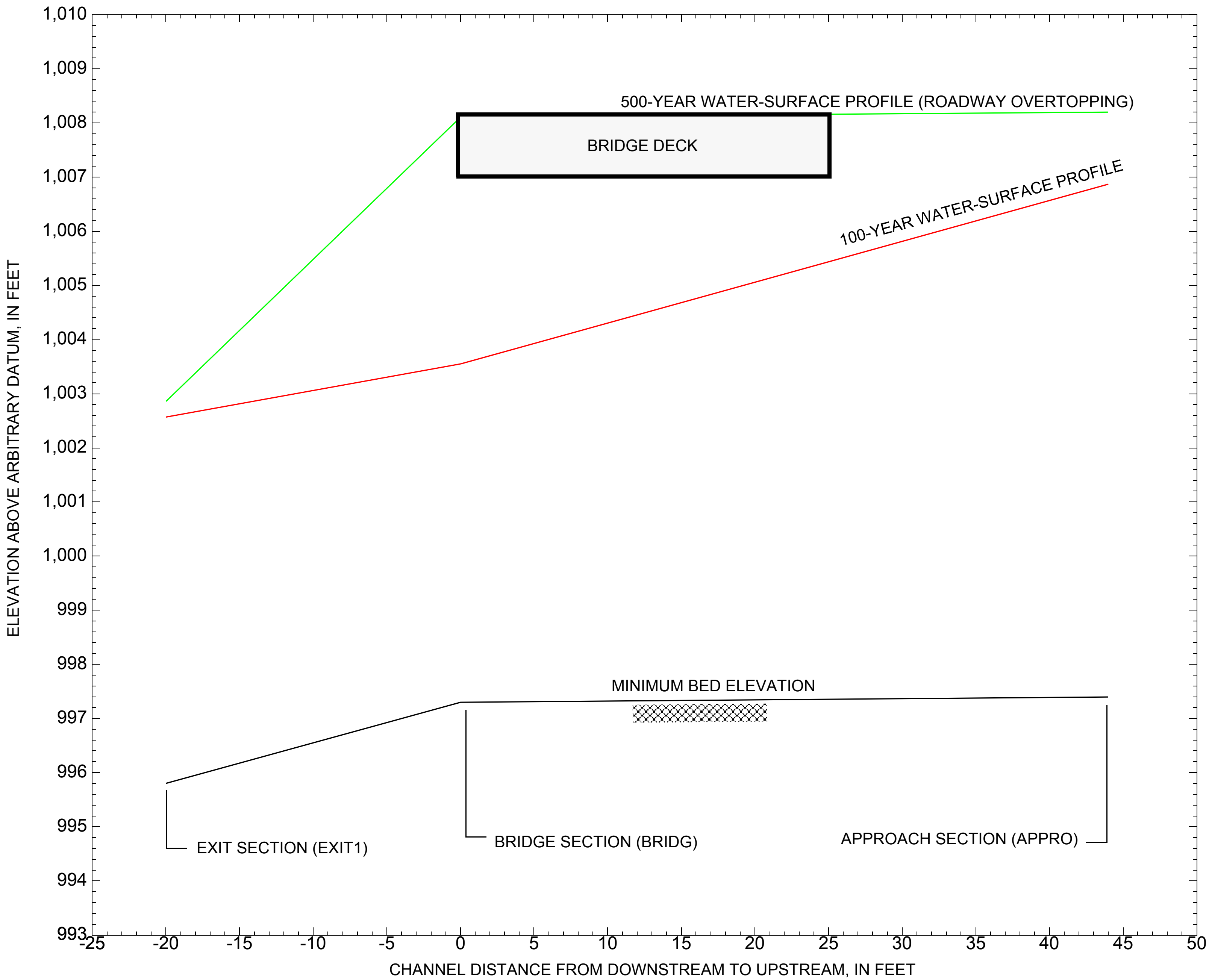

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure MAIDTH00050006 on Town Highway 5, crossing Cutler Mill Brook, Maidstone, Vermont.

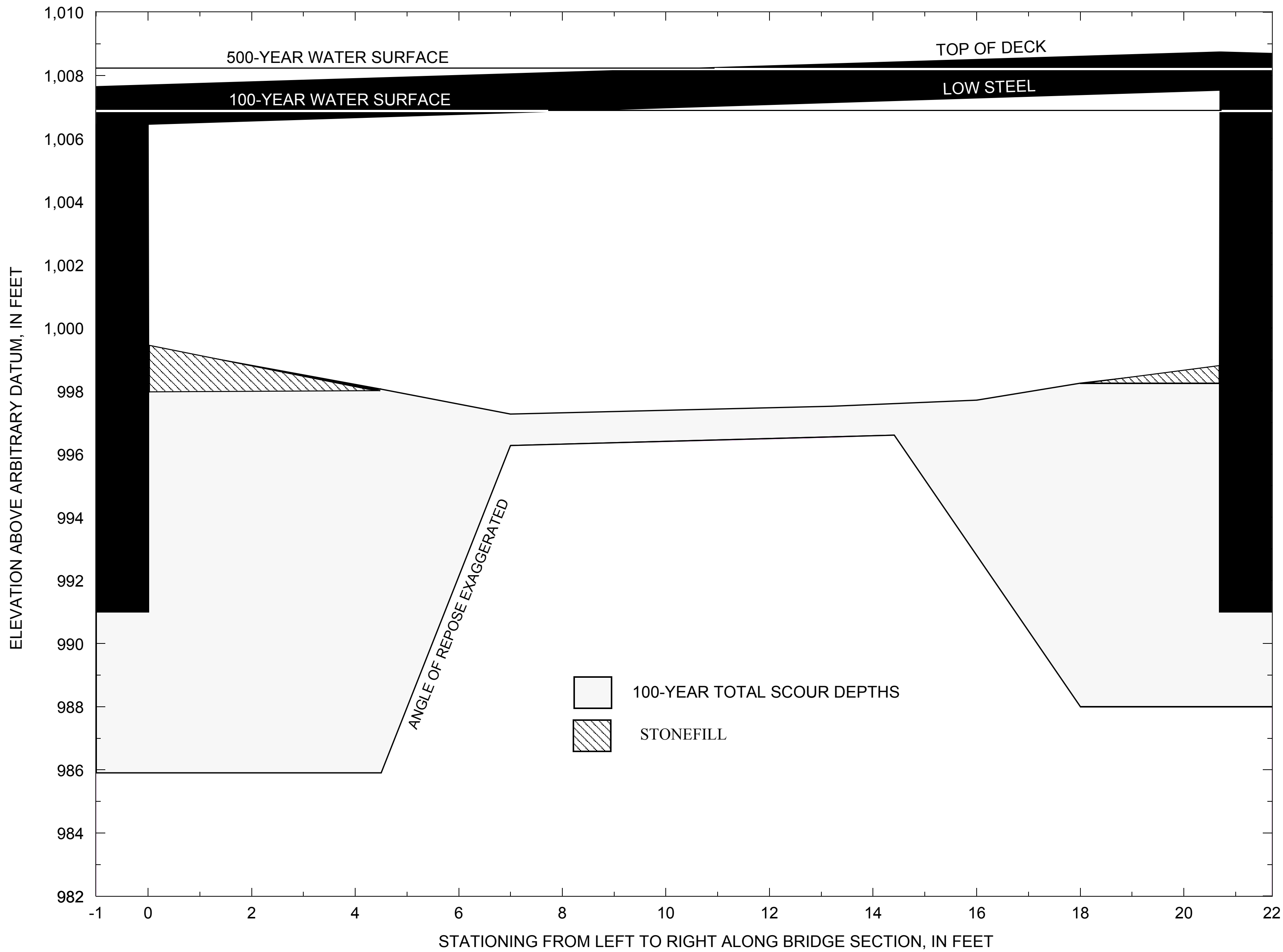

Figure 8. Scour elevations for the 100-year discharge at structure MAIDTH00050006 on Town Highway 5, crossing Cutler Mill Brook, Maidstone, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure MAIDTH00050006 on Town Highway 5, crossing Cutler Mill Brook, Maidstone, 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 1,500 cubic-feet per second											
Left abutment	0.0	--	1006.5	991.0	998.1	1.0	11.2	--	12.2	985.9	-5.1
Right abutment	20.7	--	1007.5	991.0	998.3	1.0	9.3	--	10.3	988.0	-3.0

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 MAIDTH00050006 on Town Highway 5, crossing Cutler Mill Brook, Maidstone, 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 2,240 cubic-feet per second											
Left abutment	0.0	--	1006.5	991.0	998.1	0.0	11.4	--	11.4	986.7	-4.3
Right abutment	20.7	--	1007.5	991.0	998.3	0.0	7.7	--	7.7	990.6	-0.4

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File maid006.wsp
T2        Hydraulic analysis for structure MAIDTH00050006   Date: 30-JUL-97
T3        TH 5 crossing Cutler Mill Brook, 0.05 Miles to Jct with TH 4,    LKS
*
J1           * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1400.0   1530.0  1310.0
SK          0.0143   0.0143  0.0143
*
XS   EXIT1    -20
* GR         -291.2,1011.62   -278.4,1010.52   -250.7,1009.88   -238.5,1011.56
* GR         -201.4,1006.03   -164.2,1004.62   -123.3,1004.61    -96.2,1005.20
* GR          -85.6,1004.06    -74.3,1003.28    -69.0,1005.46    -65.7,1006.53
GR          -56.3,1011.62    -56.3,1007.05    -18.0,1006.14
GR            0.0,1002.14      7.9, 997.85      9.2, 996.85     11.4, 996.13
GR           16.6, 995.84     27.2, 997.90     36.2,1001.26     45.6,1003.99
GR           67.7,1003.56    104.9,1009.24    123.8,1017.98
*
N            0.110       0.050        0.050
SA                -18.0         45.6
*
*
XS   FULLV      0  * * *   0.0361
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0   1006.99      25.0
GR            0.0,1006.45      0.1, 999.41      4.5, 998.06      7.0, 997.27
GR           13.2, 997.52     16.0, 997.71     18.0, 998.25     20.6, 998.76
GR           20.7,1007.53      0.0,1006.45
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      34.2 * *     42.5     12.1
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     12      17.2     2
* GR         -291.2,1012.78   -278.4,1011.68   -250.7,1011.04   -238.5,1012.72
* GR         -201.4,1007.19   -164.2,1005.78   -123.3,1005.77    -99.4,1006.29
* GR          -96.2,1006.36    -85.6,1005.22    -74.3,1004.44    -66.6,1005.25
* GR          -62.8,1006.43
GR          -52.5,1012.78    -52.5,1007.08    -23.9,1006.89      0.0,1007.69
GR           19.2,1008.74     52.1,1010.25    100.5,1011.45    113.2,1020.03
*
*
XT   APTEM     48           0.
GR         -286.2,1013.31   -273.4,1012.21   -245.7,1011.57   -233.5,1013.25
GR         -196.4,1007.72   -159.2,1006.31   -118.3,1006.23    -94.4,1006.75
GR          -91.2,1006.82    -80.6,1005.68    -60.6,1005.18
GR          -56.8,1006.51    -48.4,1006.80    -37.8,1006.28
GR          -22.0,1003.06    -15.2,1003.03     -4.2,1002.50      5.0, 998.51
GR            5.9, 997.78      8.8, 997.92     11.5, 997.45     14.8, 998.08
GR           17.8, 997.67     18.1, 998.51     25.6,1003.01     26.6,1007.41
GR           43.6,1010.01     70.8,1012.44     99.5,1013.11    117.7,1023.19
*
AS   APPRO     44 * * * 0.0148
GT          *  -56.8
N           0.050        0.050
SA                 -4.2
*
HP 1 BRIDG  1003.55 1 1003.55
HP 2 BRIDG  1003.55 * *  1400
HP 1 APPRO  1006.87 1 1006.87
HP 2 APPRO  1006.87 * *  1400
*
HP 1 BRIDG  1007.17 1 1007.17
HP 2 BRIDG  1007.17 * *  1315
HP 1 BRIDG  1002.99 1 1002.99
HP 2 RDWAY  1008.11 * *   215
HP 1 APPRO  1008.20 1 1008.20
HP 2 APPRO  1008.20 * *  1530
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File maid006.wsp
        Hydraulic analysis for structure MAIDTH00050006   Date: 30-JUL-97
        TH 5 crossing Cutler Mill Brook, 0.05 Miles to Jct with TH 4,    LKS
           *** RUN DATE & TIME: 02-04-98  11:56
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     104.    9347.    19.    28.                       1400.
  1003.55          104.    9347.    19.    28.  1.00     0.    21.   1400.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
      1003.55     0.0    20.7   104.4    9347.    1400.  13.41

X STA.         0.0         3.6         4.5         5.3         6.1         6.9
  A(I)            15.0         4.4         4.1         4.1         4.1
  V(I)            4.66       15.91       16.97       16.89       16.97

X STA.         6.9         7.6         8.3         9.0         9.7        10.4
  A(I)             4.0         4.0         4.0         4.1         4.1
  V(I)           17.60       17.70       17.32       17.00       17.08

X STA.        10.4        11.2        11.9        12.6        13.4        14.1
  A(I)             4.1         4.1         4.0         4.0         4.1
  V(I)           16.98       17.07       17.56       17.37       17.16

X STA.        14.1        14.9        15.6        16.4        17.2        20.7
  A(I)             4.0         4.0         4.1         4.2        15.8
  V(I)           17.42       17.47       17.27       16.73        4.43

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     114.    5662.    53.    53.                        957.
             2     226.   22616.    31.    37.                       3489.
  1006.87          341.   28278.    83.    90.  1.23   -57.    26.   3526.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      44.
         WSEL     LEW     REW    AREA        K        Q    VEL
      1006.87   -56.8    26.5   340.7   28278.    1400.   4.11

X STA.       -56.8       -17.7       -12.8        -8.4        -4.2        -0.8
  A(I)            58.9        19.0        18.4        17.8        17.7
  V(I)            1.19        3.69        3.80        3.93        3.96

X STA.        -0.8         1.5         3.3         4.9         6.3         7.6
  A(I)            14.7        13.4        12.6        12.8        11.6
  V(I)            4.75        5.21        5.54        5.49        6.06

X STA.         7.6         8.9        10.1        11.3        12.5        13.7
  A(I)            11.4        11.5        11.1        11.1        11.4
  V(I)            6.16        6.10        6.33        6.30        6.14

X STA.        13.7        15.0        16.3        17.5        19.3        26.5
  A(I)            11.4        11.2        11.3        14.9        38.6
  V(I)            6.16        6.25        6.21        4.69        1.81
```

```
       U.S. Geological Survey WSPRO Input File maid006.wsp
       Hydraulic analysis for structure MAIDTH00050006   Date: 30-JUL-97
       TH 5 crossing Cutler Mill Brook, 0.05 Miles to Jct with TH 4,    LKS
          *** RUN DATE & TIME: 02-04-98  11:56

 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     168.   14570.     6.    47.                        4928.
  1007.17          168.   14570.     6.    47.  1.00     0.    21.   4928.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
      1007.17     0.0    20.7   167.7   14570.    1315.   7.84

X STA.         0.0        3.9        4.9        5.8        6.6        7.4
  A(I)            26.7        7.8        7.2        7.2        7.1
  V(I)            2.46       8.47       9.12       9.15       9.30

X STA.         7.4        8.2        9.1        9.8       10.6       11.4
  A(I)             6.9        7.0        6.8        7.1        6.4
  V(I)            9.46       9.34       9.65       9.32      10.23

X STA.        11.4       12.2       13.0       13.8       14.5       15.2
  A(I)             6.8        7.3        7.2        5.9        5.9
  V(I)            9.60       9.01       9.18      11.05      11.09

X STA.        15.2       15.9       16.6       17.2       17.9       20.7
  A(I)             5.7        5.8        5.7        5.6       21.3
  V(I)           11.49      11.24      11.47      11.64       3.08

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      94.    8056.    19.    27.                        1196.
  1002.99           94.    8056.    19.    27.  1.00     0.    21.   1196.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      12.

         WSEL     LEW     REW    AREA        K        Q    VEL
      1008.11   -52.5     7.7    53.4     855.     215.   4.03

X STA.       -52.5      -48.8      -45.9      -43.2      -40.5      -37.8
  A(I)             3.8        3.1        3.0        2.9        3.0
  V(I)            2.81       3.49       3.58       3.66       3.60

X STA.       -37.8      -35.3      -32.8      -30.3      -28.0      -25.6
  A(I)             2.9        2.9        2.9        2.8        2.8
  V(I)            3.75       3.75       3.73       3.86       3.81

X STA.       -25.6      -23.4      -20.9      -18.1      -16.6      -15.0
  A(I)             2.8        2.9        3.0        1.5        1.5
  V(I)            3.89       3.71       3.62       7.25       7.19

X STA.       -15.0      -13.3      -11.4       -9.0       -6.1        7.7
  A(I)             1.6        1.6        1.8        2.0        4.8
  V(I)            6.93       6.61       6.04       5.51       2.24

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     184.   12343.    53.    55.                        1958.
             2     270.   27334.    36.    43.                        4168.
  1008.20          454.   39677.    89.    98.  1.11   -57.    32.   5525.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

         WSEL     LEW     REW    AREA        K        Q    VEL
      1008.20   -56.8    32.2   454.0   39677.    1530.   3.37

X STA.       -56.8      -26.0      -21.1      -16.9      -12.7       -8.7
  A(I)            69.1       24.0       22.1       22.2       21.4
  V(I)            1.11       3.19       3.46       3.44       3.57

X STA.        -8.7       -5.0       -1.6        0.9        2.9        4.7
  A(I)            20.7       21.2       18.4       17.5       16.4
  V(I)            3.70       3.61       4.17       4.37       4.65

X STA.         4.7        6.3        7.7        9.1       10.5       11.8
  A(I)            15.9       14.5       14.5       14.6       14.3
  V(I)            4.80       5.28       5.28       5.22       5.37

X STA.        11.8       13.2       14.5       15.9       17.3       32.2
  A(I)            14.3       14.3       14.4       14.4       69.8
  V(I)            5.33       5.35       5.33       5.33       1.10
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File maid006.wsp
        Hydraulic analysis for structure MAIDTH00050006   Date: 30-JUL-97
        TH 5 crossing Cutler Mill Brook, 0.05 Miles to Jct with TH 4,    LKS
           *** RUN DATE & TIME: 02-04-98  11:56

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     100.    8789.    19.    28.                        1311.
  1003.31          100.    8789.    19.    28.  1.00     0.    21.   1311.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
      1003.31     0.0    20.7    99.9    8789.    1310.  13.11

X STA.         0.0         3.6        4.5        5.3        6.1        6.8
  A(I)            14.2        4.2        4.1        3.9        4.0
  V(I)            4.62      15.54      16.07      16.92      16.47

X STA.         6.8         7.6        8.3        9.0        9.7       10.4
  A(I)             3.8        3.8        3.9        4.0        4.0
  V(I)           17.06      17.16      16.80      16.49      16.57

X STA.        10.4        11.2       11.9       12.7       13.4       14.1
  A(I)             3.9        3.9        3.9        3.9        3.9
  V(I)           16.74      16.82      16.71      16.93      16.73

X STA.        14.1        14.9       15.7       16.4       17.3       20.7
  A(I)             3.9        4.0        3.9        4.0       14.9
  V(I)           16.99      16.52      16.80      16.31       4.40
          CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      96.    5063.    41.    41.                         841.
             2     215.   20903.    31.    36.                        3234.
  1006.50          311.   25966.    71.    78.  1.17   -57.    26.   3411.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      44.

         WSEL     LEW     REW    AREA        K        Q    VEL
      1006.50   -56.8    26.4   311.3   25966.    1310.   4.21

X STA.       -56.8       -18.2      -12.9       -8.1       -3.7       -0.4
  A(I)            44.0       18.7       18.2       17.3       16.6
  V(I)            1.49       3.50       3.59       3.79       3.95

X STA.        -0.4         1.8        3.6        5.2        6.5        7.8
  A(I)            13.9       12.6       12.2       11.5       11.0
  V(I)            4.73       5.18       5.39       5.67       5.97

X STA.         7.8         9.0       10.3       11.4       12.6       13.8
  A(I)            10.7       10.9       10.5       10.5       10.5
  V(I)            6.10       6.01       6.23       6.23       6.22

X STA.        13.8        15.0       16.3       17.5       19.3       26.4
  A(I)            10.7       10.9       10.3       14.4       35.9
  V(I)            6.13       6.02       6.36       4.54       1.83
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File maid006.wsp
        Hydraulic analysis for structure MAIDTH00050006   Date: 30-JUL-97
        TH 5 crossing Cutler Mill Brook, 0.05 Miles to Jct with TH 4,    LKS
           *** RUN DATE & TIME: 02-04-98  11:56

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXIT1:XS   ******    -2.     165.  1.11 ***** 1003.68 1001.71   1400. 1002.57
      -20. ******    41.   11697.  1.00 ***** *******    0.76    8.47

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.90    1002.71    1002.43

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1002.07    1018.70    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1002.07    1018.70    1002.43

FULLV:FV      20.     0.     142.  1.52  0.35 1004.22 1002.43   1400. 1002.71
        0.    20.    39.    9694.  1.00  0.20   -0.01    0.91    9.87
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.13    1003.54    1003.74

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1002.21    1023.13    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1002.21    1023.13    1003.74

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =  1003.74    1023.13    1003.74

APPRO:AS      44.   -26.     149.  1.54 ***** 1005.28 1003.74   1400. 1003.74
       44.    44.    26.   10180.  1.13 ***** *******    1.03    9.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    1400.     1003.55

            <<<<<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      20.     0.     104.  2.80 ***** 1006.35 1003.55   1400. 1003.55
        0.    20.    21.    9340.  1.00 ***** *******    1.00   13.42

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ****** 1006.99 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.        <<<<<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      10.   -57.     341.  0.32  0.08 1007.19 1003.74   1400. 1006.87
       44.    11.    26.   28294.  1.23  0.77    0.00    0.40    4.11

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.599  0.275  20551.     0.    21.  1006.81

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -20.    -2.    41.   1400.   11697.     165.    8.47 1002.57
   FULLV:FV       0.     0.    39.   1400.    9694.     142.    9.87 1002.71
   BRIDG:BR       0.     0.    21.   1400.    9340.     104.   13.42 1003.55
   RDWAY:RG      12.**************      0.*****************    2.00********
   APPRO:AS      44.   -57.    26.   1400.   28294.     341.    4.11 1006.87

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL     WSEL
   EXIT1:XS   1001.71    0.76  995.84 1017.98************  1.11 1003.68 1002.57
   FULLV:FV   1002.43    0.91  996.56 1018.70  0.35  0.20  1.52 1004.22 1002.71
   BRIDG:BR   1003.55    1.00  997.27 1007.53************  2.80 1006.35 1003.55
   RDWAY:RG   *************** 1006.89 1020.03**********************************
   APPRO:AS   1003.74    0.40  997.39 1023.13  0.08  0.77  0.32 1007.19 1006.87
```

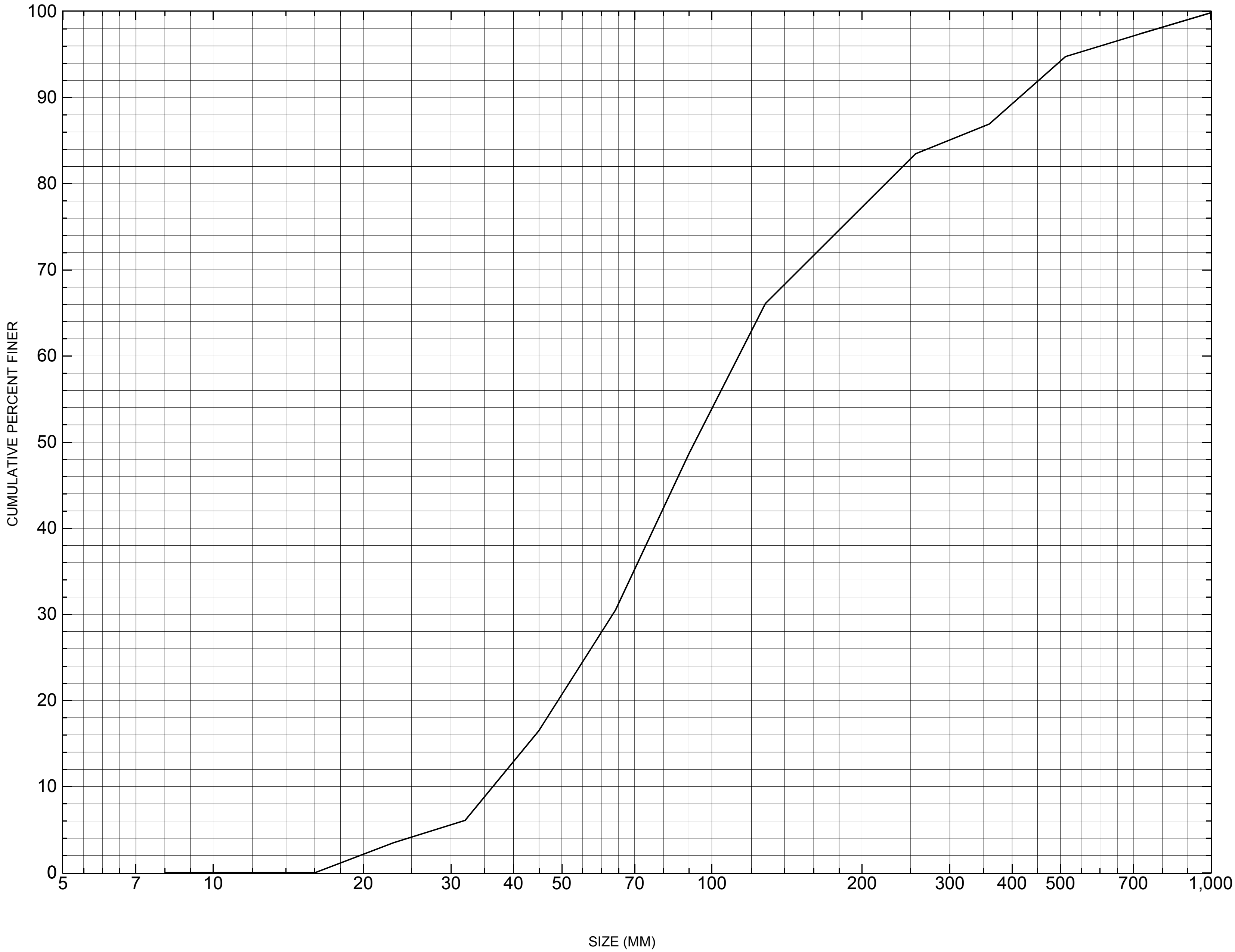
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File maid006.wsp
        Hydraulic analysis for structure MAIDTH00050006   Date: 30-JUL-97
        TH 5 crossing Cutler Mill Brook, 0.05 Miles to Jct with TH 4,    LKS
           *** RUN DATE & TIME: 02-04-98  11:56

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXIT1:XS   ******    -3.     178.  1.15 ***** 1004.01 1001.96   1530. 1002.86
      -20. ******    42.   12784.  1.00 ***** *******    0.76    8.59

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.90    1003.00    1002.69

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1002.36    1018.70    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1002.36    1018.70    1002.69

FULLV:FV      20.    -1.     153.  1.55  0.34 1004.55 1002.69   1530. 1002.99
        0.    20.    40.   10665.  1.00  0.20   -0.01    0.90   10.00
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.09    1003.81    1003.95
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1002.49    1023.13    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1002.49    1023.13    1003.95
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =  1003.95    1023.13    1003.95

APPRO:AS      44.   -27.     160.  1.61 ***** 1005.56 1003.95   1530. 1003.95
       44.    44.    26.   11104.  1.13 ***** *******    1.03    9.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =  1007.41       0.00    1003.91    1006.89
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =  1003.81    1007.17    1007.25    1006.99
 ===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      20.     0.     168.  0.96 ***** 1008.13 1003.33   1315. 1007.17
        0. ******    21.   14559.  1.00 ***** *******    0.49    7.84

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.420 ****** 1006.99 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.    27.  0.04  0.20 1008.36    0.00    215. 1008.11

            Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    215.    60.   -53.     8.   1.2   0.9   4.7   4.0   1.1   3.0
   RT:      0.     2.    10.    12.   0.1   0.0   2.3  11.8   0.3   2.6

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
APPRO:AS      10.   -57.     454.  0.20  0.04 1008.40 1003.95   1530. 1008.20
       44.    11.    32.   39710.  1.11  0.77    0.00    0.28    3.37

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K      AREA     VEL    WSEL
   EXIT1:XS     -20.    -3.    42.   1530.   12784.     178.    8.59 1002.86
   FULLV:FV       0.    -1.    40.   1530.   10665.     153.   10.00 1002.99
   BRIDG:BR       0.     0.    21.   1315.   14559.     168.    7.84 1007.17
   RDWAY:RG      12.*******   215.    215.*********       0.    2.00 1008.11
   APPRO:AS      44.   -57.    32.   1530.   39710.     454.    3.37 1008.20

   SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS   1001.96    0.76  995.84 1017.98************  1.15 1004.01 1002.86
   FULLV:FV   1002.69    0.90  996.56 1018.70  0.34  0.20  1.55 1004.55 1002.99
   BRIDG:BR   1003.33    0.49  997.27 1007.53************  0.96 1008.13 1007.17
   RDWAY:RG  *************** 1006.89 1020.03  0.04******  0.20 1008.36 1008.11
   APPRO:AS   1003.95    0.28  997.39 1023.13  0.04  0.77  0.20 1008.40 1008.20
```

```
        U.S. Geological Survey WSPRO Input File maid006.wsp
        Hydraulic analysis for structure MAIDTH00050006   Date: 30-JUL-97
        TH 5 crossing Cutler Mill Brook, 0.05 Miles to Jct with TH 4,    LKS
           *** RUN DATE & TIME: 02-04-98  11:56

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

 EXIT1:XS   ******    -1.     156.  1.09 ***** 1003.44 1001.51   1310. 1002.35
      -20. ******    40.   10945.  1.00 ***** *******    0.76    8.38

  ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
               FNTEST,FR#,WSEL,CRWS =  0.80    0.91    1002.50    1002.23
  ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                    WSLIM1,WSLIM2,DELTAY =  1001.85    1018.70    0.50
  ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                    WSLIM1,WSLIM2,CRWS =  1001.85    1018.70    1002.23

 FULLV:FV      20.     1.     134.  1.49  0.35 1003.99 1002.23   1310. 1002.50
        0.     20.    38.    8979.  1.00  0.20   -0.01    0.91    9.79
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
               FNTEST,FR#,WSEL,CRWS =  0.80    1.15    1003.35    1003.56
  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                    WSLIM1,WSLIM2,DELTAY =  1002.00    1023.13    0.50
  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                    WSLIM1,WSLIM2,CRWS =  1002.00    1023.13    1003.56
  ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
               ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                    WSBEG,WSEND,CRWS =  1003.56    1023.13    1003.56

 APPRO:AS      44.   -25.     140.  1.52 ***** 1005.08 1003.56   1310. 1003.56
       44.     44.    26.    9396.  1.12 ***** *******    1.05    9.36
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                    SECID "BRIDG"     Q,CRWS =    1310.     1003.31

            <<<<<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      20.     0.     100.  2.68 ***** 1005.98 1003.31   1310. 1003.31
        0.     20.    21.    8778.  1.00 ***** *******    1.00   13.12

      TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
        1. ****    1.  1.000 ****** 1006.99 ****** ****** ******

     XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      12.        <<<<<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      10.   -57.     312.  0.32  0.08 1006.83 1003.56   1310. 1006.50
       44.     11.    26.   25979.  1.17  0.76   -0.02    0.38    4.20

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.592  0.265   19152.     0.    21.  1006.44

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXIT1:XS     -20.    -1.    40.   1310.   10945.     156.    8.38 1002.35
    FULLV:FV       0.     1.    38.   1310.    8979.     134.    9.79 1002.50
    BRIDG:BR       0.     0.    21.   1310.    8778.     100.   13.12 1003.31
    RDWAY:RG      12.**************      0.******************    2.00********
    APPRO:AS      44.   -57.    26.   1310.   25979.     312.    4.20 1006.50

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS       0.    21.   19152.

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
    EXIT1:XS   1001.51    0.76  995.84 1017.98************  1.09 1003.44 1002.35
    FULLV:FV   1002.23    0.91  996.56 1018.70  0.35  0.20  1.49 1003.99 1002.50
    BRIDG:BR   1003.31    1.00  997.27 1007.53************  2.68 1005.98 1003.31
    RDWAY:RG  *************** 1006.89 1020.03**********************************
    APPRO:AS   1003.56    0.38  997.39 1023.13  0.08  0.76  0.32 1006.83 1006.50
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure MAIDTH00050006, in Maidstone, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number MAIDTH00050006

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 05 / 94

Highway District Number *(I - 2; nn)* 07

County *(FIPS county code; I - 3; nnn)* 009

Town *(FIPS place code; I - 4; nnnnn)* 42475

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

Waterway *(I - 6)* CUTLER MILL BROOK

Road Name *(I - 7)*: -

Route Number TH005

Vicinity *(I - 9)* 0.05 MI JCT TH 5 + TH 4

Topographic Map Groveton, NH

Hydrologic Unit Code: 01080101

Latitude *(I - 16; nnnn.n)* 44366

Longitude *(i - 17; nnnnn.n)* 71359

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10051500060515

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

Maximum span length *(I - 48; nnnn)* 0023

Year built *(I - 27; YYYY)* 1985

Structure length *(I - 49; nnnnnn)* 000025

Average daily traffic, ADT *(I - 29; nnnnnn)* 000010

Deck Width *(I - 52; nn.n)* 172

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

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

Opening skew to Roadway *(I - 34; nn)* 15

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 020.8

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

Vertical clearance from streambed (*nnn.n ft*) 020.7

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

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

Comments:

The structural inspection report of 8/31/92 indicates that the structure is a concrete slab bridge. The abutments have small diagonal cracks and leaks reported at the top corners. Stonefill coverage is noted as good in front of the abutments and wingwalls. Cut stone blocks are noted as present in the channel under the bridge. Photos show a Vermont bench mark on top of a wingwall. The photos also show moderate channel bends near the bridge crossing.

Bridge Hydrologic Data

Is there hydrologic data available? N if No, type ctrl-n h   VTAOT Drainage area (mi^2): 14.9

Terrain character: -

Stream character & type: -

Streambed material: Boulders

Discharge Data (cfs): $Q_{2.33}$ - Q_{10} 750 Q_{25} 1000

Q_{50} 1250 Q_{100} 1500 Q_{500} -

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

Estimated Discharge (cfs): - 	Velocity at Q 25 (ft/s): 11.6

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

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)	-	1004.5	1005.6	1006.7	1007.2
Velocity (ft / sec)	-	-	11.6	-	-

Long term stream bed changes: -

Is the roadway overtopped below the Q_{100}? (Yes, No, Unknown): Y 	Frequency: Q40

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:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 14.71 mi^2

Lake/pond/swamp area 0.35 mi^2

Watershed storage *(ST)* 2.4 %

Bridge site elevation 1009 ft

Headwater elevation 2520 ft

Main channel length 9.80 mi

10% channel length elevation 1080 ft

85% channel length elevation 1800 ft

Main channel slope *(S)* 97.97 ft / mi

Watershed Precipitation Data

Average site precipitation - in

Average headwater precipitation - in

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

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: 08 / 1984

Project Number BRZ 1447(4) Minimum channel bed elevation: 995.0

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

Benchmark location description:

BM#1, disc on a boulder, 200 ft from left bank on left side of VT 102 toward Guildhall, elevation 1008.937. BM#2, 12 inch spruce, spike in root 100 ft north of intersection of TH 4 & TH 5, 100 ft off the right side of TH 4, elevation 1006.23. BM#3, spike in tree, 12 inch spruce, 50' down TH 5 from left bank and 10 feet off right side of road, elevation 1005.41 (Continued below).

Reference Point (*MSL, Arbitrary, Other*): MSL Datum (*NAD27, NAD83, Other*): NGVD 1929

Foundation Type: 10 (*1-Spreadfooting; 2-Pile; 3- Gravity; 4-Unknown*)

If 1: Footing Thickness 06.0 Footing bottom elevation: 991

If 2: Pile Type: 2.0 (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: 993.0

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 available.

Comments:

BM#4, spike in root, 18 inch balsam, 80 feet from right bank on TH 5 and 30 feet off left side of road, elevation 1015.95. Ice problems are noted on plans; in the spring of 1980, 3 feet of ice were on roadway from ice jamming at the bridge. Hydraulic data on flow(Q), elevation, and velocity were taken from plans. Other elevation points located at the top of the wingwalls: upstream left 1007.64 and right 1008.85, downstream left 1007.74 and right 1008.83.

Cross-sectional Data

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

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

Comments: **There was no cross-section information available.**

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*)? **-There**

Comments: **was no cross-section information available.**

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: EW Date: 03/05/96
Computerized by: EW Date: 03/06/96
Reviewd by: LKS Date: 02/04/98

Structure Number MAIDTH00050006

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. BOEHMLER Date *(MM/DD/YY)* 07 / 13 / 1995

2. Highway District Number 07 Mile marker -

County Essex (009) Town Maidstone (42475)

Waterway *(I - 6)* Cutler Mill Brook Road Name -

Route Number TH05 Hydrologic Unit Code: 01080101

3. Descriptive comments:

The bridge is located 0.05 miles from the junction of TH 5 and TH 4.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 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 2 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 25 *(feet)* Span length 23 *(feet)* Bridge width 17.2 *(feet)*

Road approach to bridge:

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

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

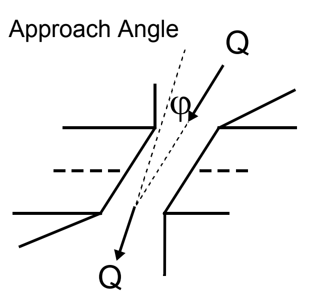
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

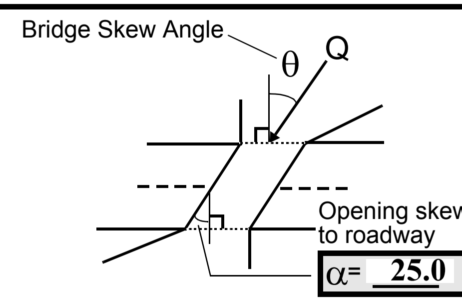
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	2	1	2	1
RBDS	0	-	0	0
LBDS	0	-	0	0

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

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 35





α= 25.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 2
Range? 35 feet US *(US, UB, DS)* to 0 feet DS

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 115 feet US *(US, UB, DS)* to 75 feet US

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

18. Bridge Type: **1a**

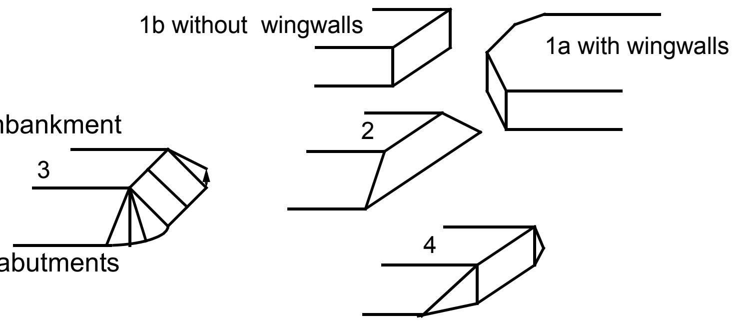
1a- Vertical abutments with wingwalls

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.)

#4: USLB - pasture, with forest bisected by TH4 beyond two bridge lengths
DSLB - very small area of grass along channel, then forest area
DSRB - very small area of grass along channel, then forest area
USRB - small area of grass, behind wingwalls, with forest beyond the area bisected by THS.

#7: Bridge dimension values are from VTAOT form. Field measured values include bridge length, 25 feet; span length, 22.5 ft; and bridge width, 17.2 feet.

#13: Erosion is evident from road wash behind the upstream right wingwall area (a small gully is present). This erosion may have affected the support material beneath the road. A storm drainage ditch is also present in the upstream right wingwall area.

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
25.0	**4.0**			**9.0**	**1**	**2**	**532**	**532**	**0**	**0**

23. Bank width **25.0** 24. Channel width **45.0** 25. Thalweg depth **30.5** 29. Bed Material **435**

30 .Bank protection type: LB **4** RB **4** 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.):

#27/29: There is a higher fraction of sand material in the banks compared to the bed. Cobbles and gravel in the bed are tightly embedded in the sand and fine gravel material.

#30/31: RB protection extends from 100 ft US to the US end of the USRWW. LB protection extends from 75 ft US to the US end of the USLWW. The protection consists of very large type-4 boulders US and grades to type-3 quarried stone blocks (less than 48 inches diameter) just US of the USLWW.

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.):

There are no pointbars upstream at this site.

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.):

There are no cut-banks upstream at this site.

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 present upstream at this site.

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):

There are no major confluences upstream at this site.

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
13.0		**1.0**		**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.):

7

#63: The bed material is composed of stone fill, boulders, cobbles, and gravel.

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

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

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

70. Debris and Ice Comments:

3

#68: A bend in the channel, boulders on the US banks, and the large opening angle increase the potential for debris to accumulate. The historical data form indicates that ice buildup problems have occurred in the past. The channel does not meander so debris is somewhat unlikely to get into the channel from erosion.

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		15	90	2	0	0	0	90.0
RABUT	1	-	90			2	0	19.0

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

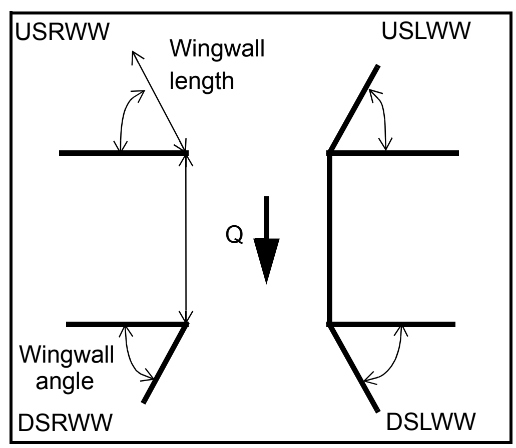
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
0
1
The abutments are well protected.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						19.0	
USRWW:	Y		1		0	0.5	
DSLWW:	0		0		Y	24.5	
DSRWW:	1		0		0	25.5	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	0	0	Y	0	1	1	1	1
Condition	Y	0	1	0	1	1	1	1
Extent	1	0	0	3	3	3	3	-

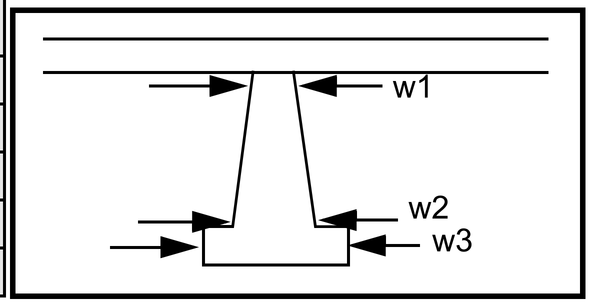
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
3
1
1
3
1
3

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		9.0		55.0	30.0	22.0
Pier 2				35.0	14.5	50.0
Pier 3		-	-	13.5	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e wing-	the	covers		LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	wall	wing	pri-		**1**- Solid pier, **2**- column, **3**- bent
88. Material	pro-	wall	mari		**1**- Wood; **2**- concrete; **3**- metal; **4**- stone
89. Shape	tec-	base	aly		**1**- Round; **2**- Square; **3**- Pointed
90. Inclined?	tion	s,	the	N	Y- yes; N- no
91. Attack ∠ (BF)	cov-	exce	DS	-	
92. Pushed	ers	pt on	end.	-	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	the	the		-	
95. Cross-members	entir	DSR		-	**0**- none; **1**- laterals; **2**- diagonals; **3**- both
96. Scour Condition	e	WW,		-	**0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed
97. Scour depth	lengt	wher		-	
98. Exposure depth	h of	e it		-	

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

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):
-
-
-

There are no piers.

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 **2** %LB to **2** %RB

Material: **543**

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

543
0
0
435

Is a cut-bank present? **3** *(Y or if N type ctrl-n cb)* Where? **4** *(LB or RB)* Mid-bank distance: **1**

Cut bank extent: **1** feet **Th** *(US, UB, DS)* to **e** feet **ove** *(US, UB, DS)*

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

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

nk vegetation cover is greater than 90 percent 50 feet DS of the bridge. The bank material DS has more gravel than the US banks, which are predominantly sand. The protection on the left and right banks extends from the ends of the wingwalls to 70 feet DS. The protection is type 4 to 45 ft DS then type-3 to 70 ft DS.

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to ____ %RB

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

N

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

Confluence 1: Distance **e is** Enters on **no** *(LB or RB)* Type **dro** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

e at this site.

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N
-
-
-
-
-
-
-
-
-

109. G. Plan View Sketch

- T

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:	MAIDTH00050006	Town:	MAIDSTONE
Road Number:	TH 5	County:	ESSEX
Stream:	CUTLER MILL BROOK		

Initials LKS   Date: 01/22/98 Checked: EMB

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

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

Approach Section Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1400	1530	1310
Main Channel Area, ft2	226	184	215
Left overbank area, ft2	114	270	96
Right overbank area, ft2	0	0	0
Top width main channel, ft	31	36	31
Top width L overbank, ft	53	53	41
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.303	0.303	0.303
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.3	5.1	6.9
y1, average depth, LOB, ft	2.2	5.1	2.3
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	28278	39677	25966
Conveyance, main channel	22616	27334	20903
Conveyance, LOB	5662	12343	5063
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1119.7	1054.0	1054.6
Ql, discharge, LOB, cfs	280.3	476.0	255.4
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	5.0	5.7	4.9
Vl, mean velocity, LOB, ft/s	2.5	1.8	2.7
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	10.5	9.9	10.4
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1400	1530	1310
(Q) discharge thru bridge, cfs	1400	1315	1310
Main channel conveyance	9347	14570	8789
Total conveyance	9347	14570	8789
Q2, bridge MC discharge,cfs	1400	1315	1310
Main channel area, ft2	104	168	100
Main channel width (normal), ft	18.8	18.8	18.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	18.8	18.8	18.8
y_bridge (avg. depth at br.), ft	5.55	8.92	5.31
Dm, median (1.25*D50), ft	0.37875	0.37875	0.37875
y2, depth in contraction,ft	6.57	6.23	6.21
ys, scour depth (y2-ybridge), ft	**1.02**	-2.69	**0.89**

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	1400	1315	1310
Main channel area (DS), ft2	104.4	94	99.9
Main channel width (normal), ft	18.8	18.8	18.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	18.8	18.8	18.8
D90, ft	1.3540	1.3540	1.3540
D95, ft	1.7280	1.7280	1.7280
Dc, critical grain size, ft	1.1837	1.3601	1.1578
Pc, Decimal percent coarser than Dc	0.130	0.099	0.132
Depth to armoring, ft	**23.79**	**N/A**	**22.75**

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	1400	1530	1310
Q, thru bridge MC, cfs	1400	1315	1310
Vc, critical velocity, ft/s	10.48	9.88	10.40
Va, velocity MC approach, ft/s	4.95	5.73	4.90
Main channel width (normal), ft	18.8	18.8	18.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	18.8	18.8	18.8
qbr, unit discharge, ft2/s	74.5	69.9	69.7
Area of full opening, ft2	104.4	167.7	99.9
Hb, depth of full opening, ft	5.55	8.92	5.31
Fr, Froude number, bridge MC	0	0.49	0
Cf, Fr correction factor (<=1.0)	0.00	1.00	0.00
**Area at downstream face, ft2	N/A	94	N/A
**Hb, depth at downstream face, ft	N/A	5.00	N/A
**Fr, Froude number at DS face	ERR	1.10	ERR
**Cf, for downstream face (<=1.0)	N/A	1.00	N/A
Elevation of Low Steel, ft	0	1006.99	0
Elevation of Bed, ft	-5.55	998.07	-5.31
Elevation of Approach, ft	0	1008.2	0
Friction loss, approach, ft	0	0.04	0
Elevation of WS immediately US, ft	0.00	1008.16	0.00
ya, depth immediately US, ft	5.55	10.09	5.31
Mean elevation of deck, ft	0	1008.22	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.97	1.00
**Cc, for downstream face (<=1.0)	ERR	0.86998	ERR
Ys, scour w/Chang equation, ft	N/A	**-1.62**	N/A
Ys, scour w/Umbrell equation, ft	N/A	-0.92	N/A

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

**Ys, scour w/Chang equation, ft	N/A	3.14	N/A

**Ys, scour w/Umbrell equation, ft	ERR	3.00	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	6.57	6.23	6.21
WSEL at downstream face, ft	--	1002.99	--
Depth at downstream face, ft	N/A	5.00	N/A
Ys, depth of scour (Laursen), ft	N/A	1.23	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	1400	1530	1310	1400	1530	1310
a', abut.length blocking flow, ft	56.8	56.8	56.8	7.7	13.4	7.6
Ae, area of blocked flow ft2	136.91	161.56	117.33	42.74	62.77	39.9
Qe, discharge blocked abut.,cfs	374.35	--	339.41	89.44	68.8	83.69
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.73	2.75	2.89	2.09	1.10	2.10
ya, depth of f/p flow, ft	2.41	2.84	2.07	5.55	4.68	5.25
--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	115	115	115	70	70	70
K2	1.03	1.03	1.03	0.97	0.97	0.97
Fr, froude number f/p flow	0.310	0.251	0.355	0.157	0.089	0.161
ys, scour depth, ft	**11.24**	**11.37**	**10.84**	**9.26**	**7.72**	**8.89**

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)	56.8	56.8	56.8	7.7	13.4	7.6
y1 (depth f/p flow, ft)	2.41	2.84	2.07	5.55	4.68	5.25
a'/y1	23.56	19.97	27.50	1.39	2.86	1.45
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.31	0.25	0.35	0.16	0.09	0.16
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	10.67	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	8.75	ERR	ERR	ERR
spill-through	ERR	ERR	5.87	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	1	1	1	1	1	1
y, depth of flow in bridge, ft	5.55	5.00	5.31	5.55	5.00	5.31
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	**2.32**	**1.85**	**2.22**	**2.32**	**1.85**	**2.22**