LEVEL II SCOUR ANALYSIS FOR BRIDGE 61 (MTHOTH00100061) on TOWN HIGHWAY 10, crossing PERRY BROOK, MOUNT HOLLY, VERMONT

Open-File Report 98-054

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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LEVEL II SCOUR ANALYSIS FOR BRIDGE 61 (MTHOTH00100061) on TOWN HIGHWAY 10, crossing PERRY BROOK, MOUNT HOLLY, VERMONT

By MICHAEL A. IVANOFF

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Pembroke, New Hampshire
1998

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

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

OTHER ABBREVIATIONS

BF	bank full	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 61 (MTHOTH00100061) ON TOWN HIGHWAY 10, CROSSING PERRY BROOK, MOUNT HOLLY, VERMONT

***By* Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure MTHOTH00100061 on Town Highway 10 crossing Perry Brook, Mount Holly, 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 (U.S. Department of Transportation, 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 Green Mountain section of the New England physiographic province in west-central Vermont. The 5.38-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest.

In the study area, Perry Brook has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 28 ft and an average bank height of 2 ft. The channel bed material ranges from sand to boulder with a median grain size (D_{50}) of 96.8 mm (0.318 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 11, 1995, indicated that the reach was stable.

The Town Highway 10 crossing of Perry Brook is a 29-ft-long, one-lane bridge consisting of one 25-foot steel-beam span (Vermont Agency of Transportation, written communication, March 21, 1995). The opening length of the structure parallel to the bridge face is 22.9 ft. The bridge is supported by concrete capped “laid-up” stone abutments and wingwalls. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is zero.

The only scour protection measure at the site was type-3 stone fill (less than 48 inches diameter) at the entire base length of the upstream right wingwall, downstream end of the left abutment, along the entire base length of the right abutment, and along the entire base length of the downstream left and right wingwalls. 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. 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 0.3 to 0.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 4.6 to 11.7 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled "Scour Results". Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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.

Mount Holly, VT. Quadrangle, 1:24,000, 1986

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 MTHOTH00100061 ***Stream*** Perry Brook

County Rutland ***Road*** TH 10 ***District*** 3

Description of Bridge

Bridge length 29.0 ***ft*** ***Bridge width*** 14.0 ***ft*** ***Max span length*** 25.0 ***ft***

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

Abutment type Sloping, stone ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 10/11/95

Description of stone fill Type-3, along the upstream right wingwall, the downstream end of the left abutment, the right abutment, the downstream left and right wingwalls.

Brief description of piers/abutments Abutments and wingwalls are concrete capped "laid-up" stone.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 5

There is a mild channel bend in the upstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	10/11/95	0	0
Level II	10/11/95	0	0

Potential for debris Moderate. There is some debris caught on boulders and trees leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) A large pile of boulders is present along the downstream bridge face, pooling water under the bridge as of 10/11/95.

Description of the Geomorphic Setting

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

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

Date of inspection 10/11/95

DS left: Steep channel bank to steep valley wall.

DS right: Steep channel bank to steep valley wall.

US left: Steep channel bank to steep valley wall.

US right: Steep channel bank to steep valley wall.

Description of the Channel

Average top width 28 ***ft*** ***Average depth*** 2 ***ft***

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

Sinuous but stable

with non-alluvial channel boundaries.

10/11/95

Vegetative co Trees and brush.

DS left: Trees and brush.

DS right: Trees and brush.

US left: Trees and brush.

US right: Yes

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

None, 10/11/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 5.38 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/Green Mountain	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 -- ***mi***^{2}

Is there a lake/p No

Calculated Discharges

Q100 920 ***ft***^{3}***/s*** ***Q500*** 1,300 ***ft***^{3}***/s***

The 100-year discharge was obtained from the median of several flood frequency curves based on empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). The 500-year discharge was extrapolated from the median flood frequency curve.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of a boulder on the upstream right bank 10 ft bankward from the right abutment and 40 ft upstream (elev. 495.82 ft, arbitrary survey datum). RM2 is a nail in a spruce tree 6 ft up from the base, 105 ft bankward from the left abutment along the road, and 22 ft downstream of the center of the road (elev. 514.17 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXITX	-22	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	41	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.050 to 0.070.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0296 ft/ft, which was estimated from the appropriate topographic map (U.S. Geological Survey, 1986).

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

For the 100-year and 500-year discharges, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After 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 499.6 *ft*
Average low steel elevation 498.2 *ft*

100-year discharge 920 *ft³/s*
Water-surface elevation in bridge opening 491.8 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 79 *ft²*
Average velocity in bridge opening 11.7 *ft/s*
Maximum WSPRO tube velocity at bridge 14.9 *ft/s*

Water-surface elevation at Approach section with bridge 495.1
Water-surface elevation at Approach section without bridge 491.7
Amount of backwater caused by bridge 3.4 *ft*

500-year discharge 1,300 *ft³/s*
Water-surface elevation in bridge opening 493.0 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 100 *ft²*
Average velocity in bridge opening 13.0 *ft/s*
Maximum WSPRO tube velocity at bridge 16.9 */s*

Water-surface elevation at Approach section with bridge 496.6
Water-surface elevation at Approach section without bridge 492.3
Amount of backwater caused by bridge 4.3 *ft*

Incipient overtopping discharge -- *ft³/s*
Water-surface elevation in bridge opening -- *ft*
Area of flow in bridge opening -- *ft²*
Average velocity in bridge opening -- *ft/s*
Maximum WSPRO tube velocity at bridge -- *ft/s*

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

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	0.3	0.8	--
Depth to armoring	18.1	25.9	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	11.3	11.7	--
Left abutment	4.6	8.4	--
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:	1.8	2.2	--
Left abutment	1.8	2.2	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

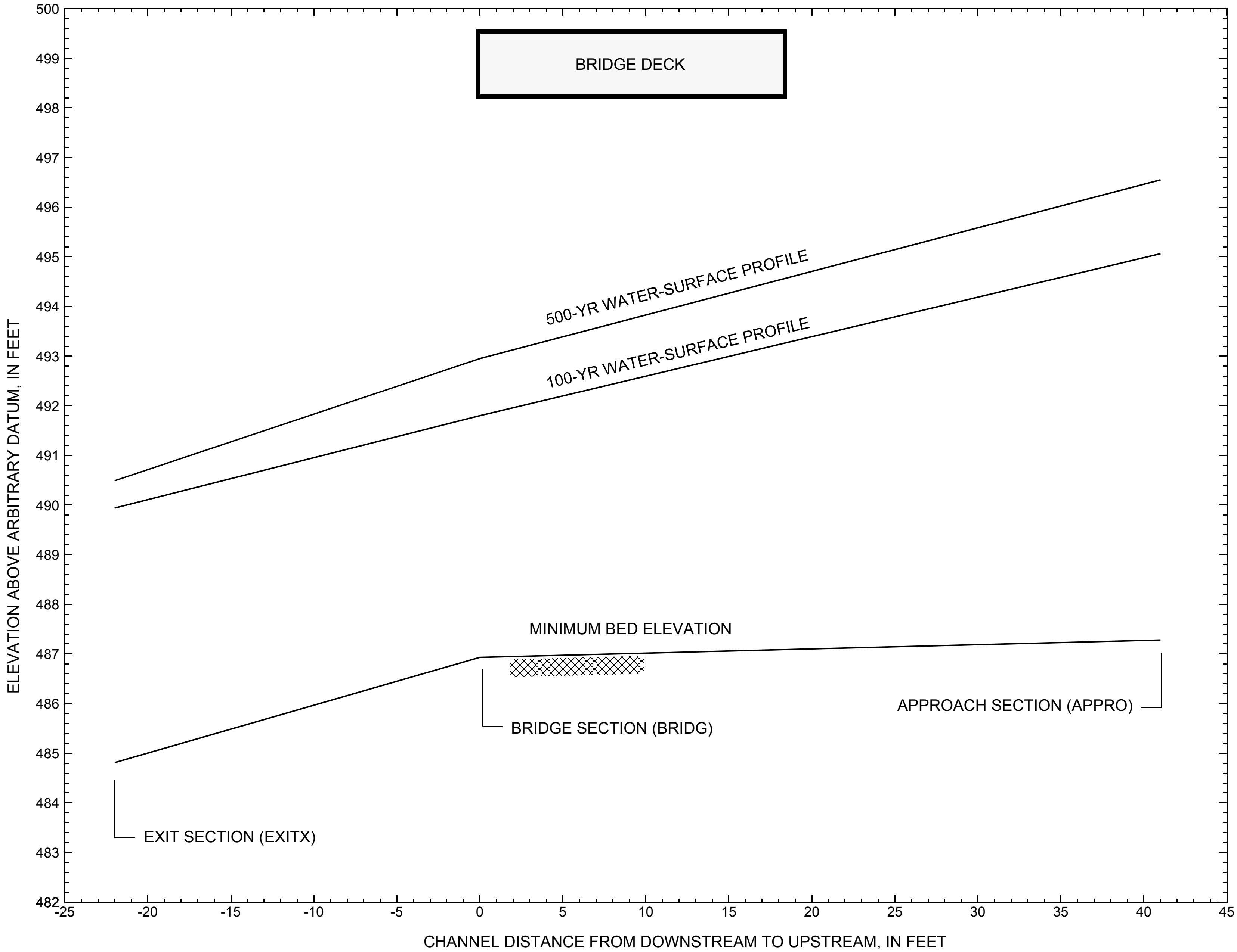

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure MTHOTH00100061 on Town Highway 10, crossing Perry Brook, Mount Holly, Vermont.

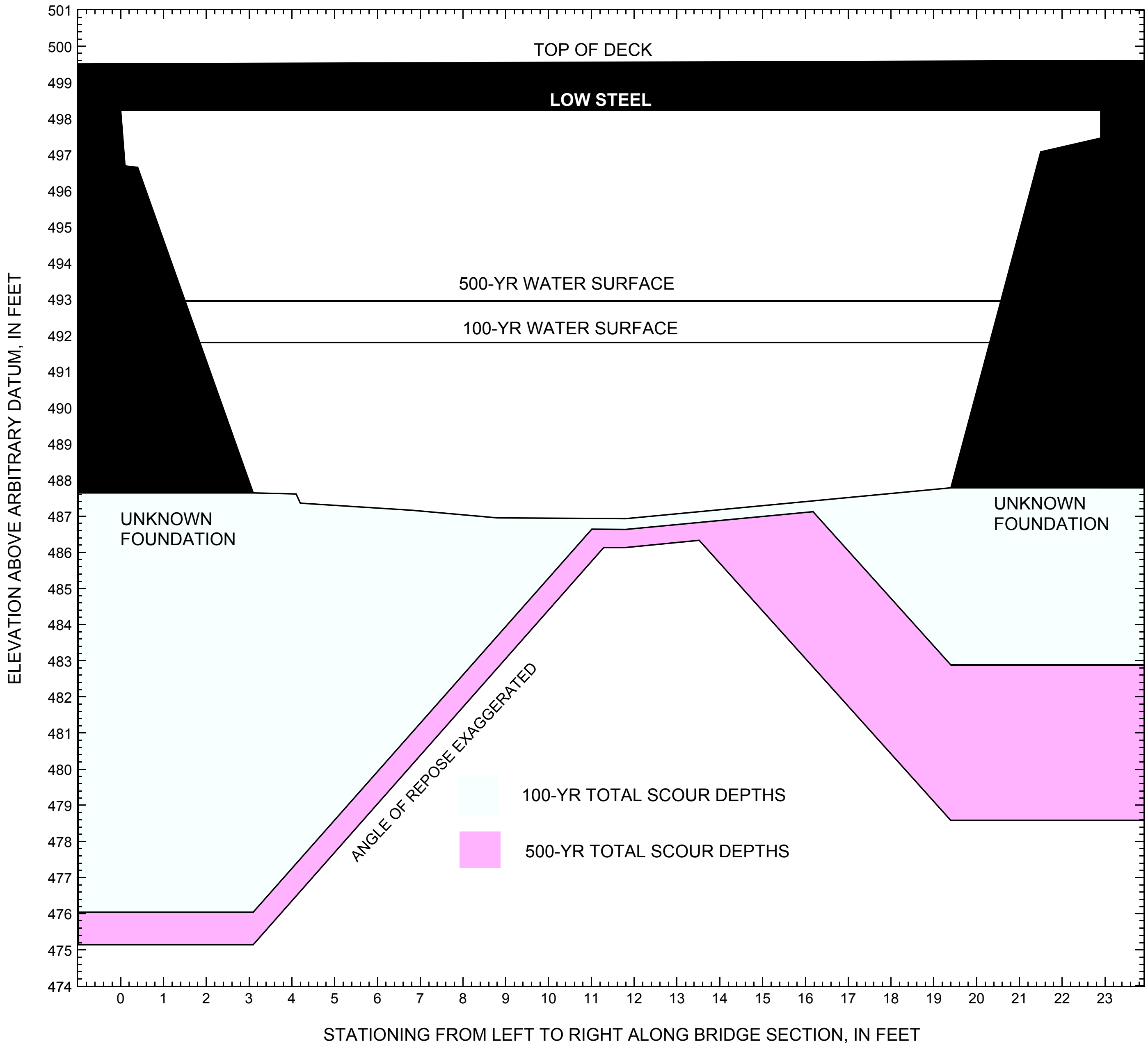

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure MTHOTH00100061 on Town Highway 10, crossing Perry Brook, Mount Holly, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure MTHOTH00100061 on Town Highway 10, crossing Perry Brook, Mount Holly, 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 920 cubic-feet per second											
Left abutment	0.0	--	498.2	--	487.6	0.3	11.3	--	11.6	476.0	--
Right abutment	22.9	--	498.2	--	487.8	0.3	4.6	--	4.9	482.9	--

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 MTHOTH00100061 on Town Highway 10, crossing Perry Brook, Mount Holly, 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 1,300 cubic-feet per second											
Left abutment	0.0	--	498.2	--	487.6	0.8	11.7	--	12.5	475.1	--
Right abutment	22.9	--	498.2	--	487.8	0.8	8.4	--	9.2	478.6	--

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

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U.S. Geological Survey, 1986, Mount Holly, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File mtho061.wsp
T2        Hydraulic analysis for structure MTHOTH00100061   Date: 16-DEC-97
T3        Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT  by  MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            920.0   1300.0
SK          0.0296   0.0296
*
XS   EXITX    -22
GR         -117.9, 511.03    -93.1, 506.84    -68.3, 500.96    -41.8, 489.27
GR          -17.3, 489.34      0.0, 487.29      4.3, 486.14      5.0, 485.53
GR            8.4, 484.81     12.8, 485.06     17.5, 485.16     22.4, 485.04
GR           22.9, 486.12     25.6, 489.66     46.1, 493.71     76.6, 500.77
GR           94.4, 505.70    131.5, 511.28
N           0.070
*
XS   FULLV       0  * * *   0.0286
*
*              SRD     LSEL    XSSKEW
BR   BRIDG      0    498.23       0.0
GR            0.0, 498.23      0.1, 496.69      0.4, 496.65      3.1, 487.64
GR            4.1, 487.61      4.2, 487.36      6.8, 487.16      8.8, 486.95
GR           11.8, 486.93     14.6, 487.25     18.4, 487.66     19.4, 487.78
GR           21.5, 497.08     22.9, 497.46     22.9, 498.22      0.0, 498.23
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV   WWANGL
CD           4      18.4     2.6     499.6     77.1
N           0.050
*
*              SRD    EMBWID   IPAVE
XR   RDWAY       9      14.0     2
GR         -203.2, 513.75   -141.3, 508.08    -75.5, 503.50    -24.4, 500.38
GR            0.0, 499.51     22.1, 499.60     75.9, 503.00    177.6, 511.41
*
XT   APTEM     32
GR         -121.5, 511.14   -104.5, 507.83    -65.8, 499.44    -24.4, 495.12
GR          -10.0, 491.26     -7.6, 489.27      0.0, 488.36      1.2, 487.75
GR            1.5, 487.73      7.2, 487.04     10.1, 487.35     12.9, 487.10
GR           16.5, 487.78     17.8, 488.03     21.2, 490.48     24.1, 492.45
GR           53.3, 494.52     64.5, 497.41     71.9, 505.29     92.9, 510.93
*
AS   APPRO     41 * * * 0.0265
GT
N           0.070
*
HP 1 BRIDG   491.80 1 491.80
HP 2 BRIDG   491.80 * * 920
HP 1 APPRO   495.06 1 495.06
HP 2 APPRO   495.06 * * 920
*
HP 1 BRIDG   492.95 1 492.95
HP 2 BRIDG   492.95 * * 1300
HP 1 APPRO   496.55 1 496.55
HP 2 APPRO   496.55 * * 1300
*
EX
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File mtho061.wsp
      Hydraulic analysis for structure MTHOTH00100061   Date: 16-DEC-97
      Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT  by  MAI
         *** RUN DATE & TIME: 01-05-98  15:44
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
          1       79.    5035.    18.    25.                          922.
 491.80           79.    5035.    18.    25.  1.00     2.    20.    922.


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

       WSEL     LEW     REW    AREA        K        Q    VEL
     491.80     1.9    20.3    78.7    5035.     920.  11.69

X STA.        1.9         5.0         5.7         6.4         7.1         7.8
  A(I)            11.0         3.2         3.1         3.2         3.2
  V(I)            4.19       14.47       14.73       14.52       14.51

X STA.        7.8         8.4         9.1         9.7        10.4        11.0
  A(I)             3.1         3.1         3.1         3.2         3.2
  V(I)           14.89       14.63       14.82       14.46       14.45

X STA.       11.0        11.7        12.3        13.0        13.7        14.3
  A(I)             3.2         3.1         3.1         3.2         3.2
  V(I)           14.56       14.63       14.68       14.43       14.49

X STA.       14.3        15.1        15.8        16.5        17.3        20.3
  A(I)             3.2         3.1         3.3         3.2        10.7
  V(I)           14.31       14.68       14.00       14.16        4.31

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
          1      280.   13622.    78.    81.                         3010.
 495.06          280.   13622.    78.    81.  1.00   -23.    54.   3010.



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

       WSEL     LEW     REW    AREA        K        Q    VEL
     495.06   -23.3    54.5   279.7   13622.     920.   3.29

X STA.      -23.3        -8.2        -6.1        -4.3        -2.5        -0.8
  A(I)            31.4        11.4        10.9        10.6        10.5
  V(I)            1.46        4.04        4.22        4.33        4.38

X STA.       -0.8         0.8         2.3         3.7         5.2         6.4
  A(I)            10.8        10.6        10.3        10.7         9.7
  V(I)            4.28        4.35        4.46        4.29        4.76

X STA.        6.4         7.5         8.7        10.0        11.2        12.4
  A(I)             8.4         9.5         9.2         9.2         9.3
  V(I)            5.46        4.85        5.01        4.98        4.96

X STA.       12.4        13.6        14.8        16.1        17.4        54.5
  A(I)             9.0         9.3         9.0         9.3        70.6
  V(I)            5.10        4.93        5.11        4.95        0.65
```

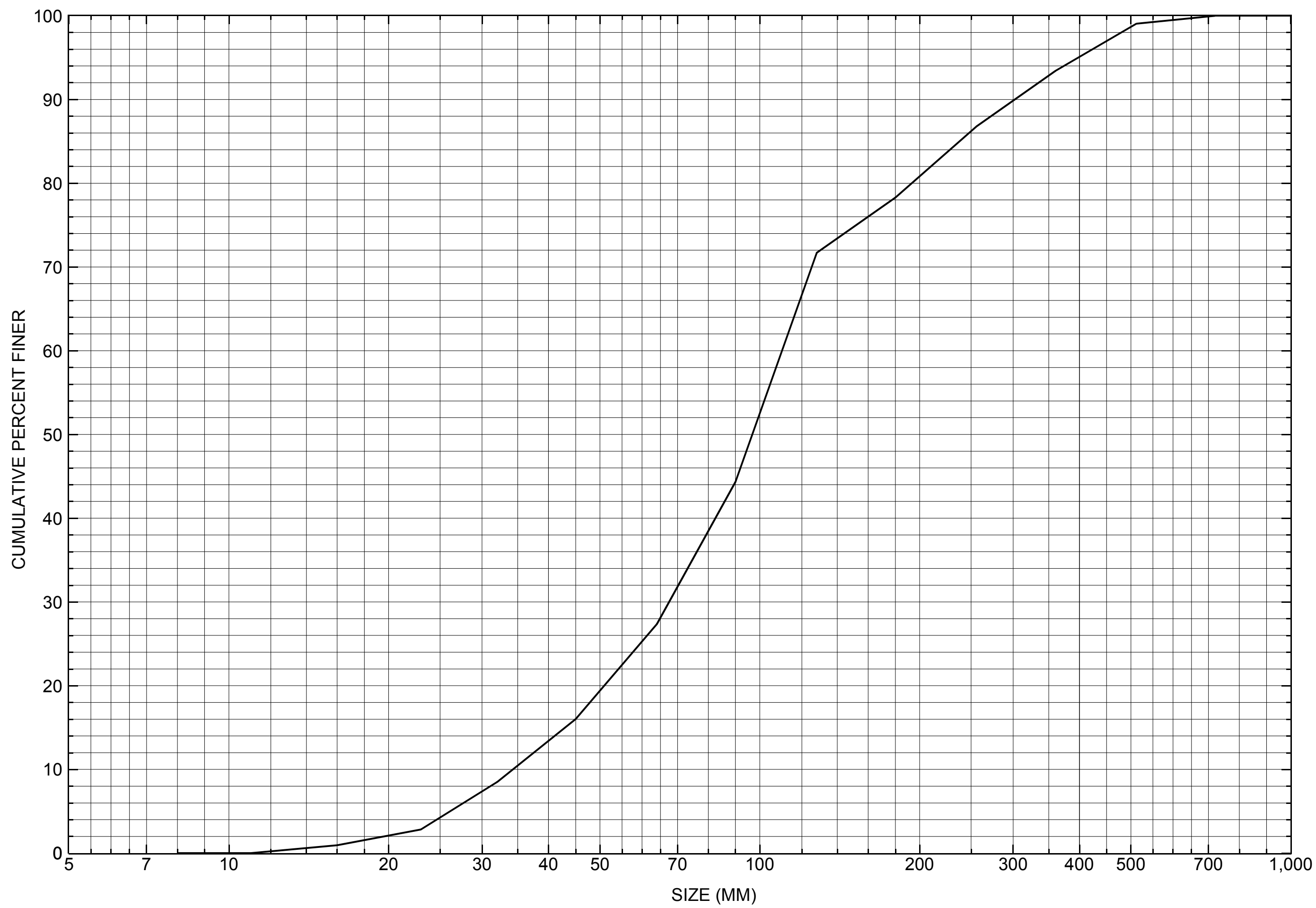
```
     U.S. Geological Survey WSPRO Input File mtho061.wsp
     Hydraulic analysis for structure MTHOTH00100061   Date: 16-DEC-97
     Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT  by  MAI
        *** RUN DATE & TIME: 01-05-98  15:44
 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

  WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1     100.    7097.    19.    27.                        1305.
492.95          100.    7097.    19.    27.  1.00     2.    21.   1305.


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

      WSEL     LEW     REW    AREA        K        Q    VEL
    492.95     1.5    20.6   100.2    7097.    1300.  12.97

X STA.        1.5        5.1        5.8        6.4        7.1        7.8
  A(I)            15.0        4.0        3.8        4.0        3.9
  V(I)            4.32      16.40      17.26      16.45      16.88

X STA.        7.8        8.4        9.1        9.7       10.4       11.0
  A(I)             3.8        3.9        3.9        3.9        4.0
  V(I)           16.91      16.65      16.87      16.47      16.45

X STA.       11.0       11.7       12.3       13.0       13.7       14.3
  A(I)             4.0        3.9        3.9        3.9        3.9
  V(I)           16.40      16.46      16.48      16.82      16.72

X STA.       14.3       15.0       15.7       16.5       17.2       20.6
  A(I)             3.9        3.9        4.0        3.9       14.8
  V(I)           16.58      16.57      16.28      16.52       4.39


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

  WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1     408.   22276.    96.    99.                        4774.
496.55          408.   22276.    96.    99.  1.00   -36.    60.   4774.


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

      WSEL     LEW     REW    AREA        K        Q    VEL
    496.55   -35.8    60.2   408.1   22276.    1300.   3.19

X STA.      -35.8       -8.0       -5.8       -3.8       -1.9        0.0
  A(I)            63.4       15.5       14.7       14.9       15.1
  V(I)            1.03       4.21       4.41       4.36       4.31

X STA.        0.0        1.8        3.5        5.1        6.8        8.4
  A(I)            14.7       14.8       14.6       14.8       15.0
  V(I)            4.41       4.39       4.44       4.39       4.35

X STA.        8.4       10.0       11.5       13.1       14.7       16.3
  A(I)            14.3       14.2       14.1       14.1       14.3
  V(I)            4.54       4.56       4.60       4.59       4.55

X STA.       16.3       17.9       20.1       24.1       30.7       60.2
  A(I)            13.8       16.3       20.5       24.0       64.9
  V(I)            4.71       3.99       3.17       2.71       1.00
```

```
       U.S. Geological Survey WSPRO Input File mtho061.wsp
       Hydraulic analysis for structure MTHOTH00100061   Date: 16-DEC-97
       Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT  by  MAI
          *** RUN DATE & TIME: 01-05-98  15:44

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

EXITX:XS   ******   -43.     154.  0.56 *****  490.50  489.45    920.  489.94
     -22. ******    27.    5347.  1.00 ***** *******    0.71    5.99

FULLV:FV      22.   -43.     156.  0.54  0.64  491.14 *******    920.  490.60
        0.    22.    27.    5449.  1.00  0.00    0.00    0.70    5.91
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.90     491.69     491.45
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   490.10     511.38    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   490.10     511.38     491.45

APPRO:AS      41.   -11.     103.  1.25  1.44  492.94  491.45    920.  491.69
       41.    41.    23.    4431.  1.00  0.35    0.00    0.90    8.97
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =     920.     491.80
            <<<<<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      22.     2.      79.  2.13 *****  493.93  491.80    920.  491.80
        0.    22.    20.    5028.  1.00 ***** *******    1.00   11.70

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   1.  1.000 ******  498.23 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
   RDWAY:RG       9.        <<<<<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      23.   -23.     280.  0.17  0.29  495.23  491.45    920.  495.06
       41.    24.    54.   13635.  1.00  1.01   -0.01    0.31    3.29

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.465  0.212   10779.    -2.    17.   494.94

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL    WSEL
   EXITX:XS     -22.   -43.    27.    920.    5347.     154.    5.99  489.94
   FULLV:FV       0.   -43.    27.    920.    5449.     156.    5.91  490.60
   BRIDG:BR       0.     2.    20.    920.    5028.      79.   11.70  491.80
   RDWAY:RG       9.**************      0.******************    2.00********
   APPRO:AS      41.   -23.    54.    920.   13635.     280.    3.29  495.06

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -2.    17.   10779.
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    489.45    0.71  484.81  511.28************  0.56  490.50  489.94
   FULLV:FV  ********    0.70  485.44  511.91  0.64  0.00  0.54  491.14  490.60
   BRIDG:BR    491.80    1.00  486.93  498.23************  2.13  493.93  491.80
   RDWAY:RG  ****************  499.51  513.75**********************************
   APPRO:AS    491.45    0.31  487.28  511.38  0.29  1.01  0.17  495.23  495.06
```

```
        U.S. Geological Survey WSPRO Input File mtho061.wsp
        Hydraulic analysis for structure MTHOTH00100061   Date: 16-DEC-97
        Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT  by  MAI
           *** RUN DATE & TIME: 01-05-98  15:44
 XSID:CODE   SRDL    LEW     AREA    VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******   -45.     193.  0.70 *****  491.19  489.97   1300.  490.49
      -22. ******    30.    7551.  1.00 ***** *******    0.74    6.73

FULLV:FV      22.   -45.     197.  0.68  0.63  491.85 *******   1300.  491.17
        0.    22.    30.    7766.  1.00  0.00    0.02    0.72    6.60
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.03     492.22     492.31
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   490.67     511.38    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   490.67     511.38     492.31
 ===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 =   492.31     511.38     492.31

APPRO:AS      41.   -13.     124.  1.70 *****  494.01  492.31   1300.  492.31
       41.    41.    24.    5725.  1.00 ***** *******    1.00   10.46
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    1300.     492.95
            <<<<<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      22.     2.     100.  2.62 *****  495.57  492.95   1300.  492.95
        0.    22.    21.    7093.  1.00 ***** *******    1.00   12.97

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   1.  1.000 ******  498.23 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<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      23.   -36.     408.  0.16  0.25  496.70  492.31   1300.  496.55
       41.    24.    60.   22248.  1.00  0.88   -0.01    0.27    3.19

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.504  0.325   15049.    -2.    17.   496.45

   FIRST USER DEFINED TABLE.
     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -22.   -45.    30.   1300.    7551.     193.    6.73  490.49
    FULLV:FV       0.   -45.    30.   1300.    7766.     197.    6.60  491.17
    BRIDG:BR       0.     2.    21.   1300.    7093.     100.   12.97  492.95
    RDWAY:RG       9.**************       0.******************    2.00********
    APPRO:AS      41.   -36.    60.   1300.   22248.     408.    3.19  496.55

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS      -2.    17.   15049.
 SECOND USER DEFINED TABLE.
     XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS     489.97    0.74  484.81  511.28************  0.70  491.19  490.49
    FULLV:FV   ********    0.72  485.44  511.91  0.63  0.00  0.68  491.85  491.17
    BRIDG:BR     492.95    1.00  486.93  498.23************  2.62  495.57  492.95
    RDWAY:RG   ****************  499.51  513.75**********************************
    APPRO:AS     492.31    0.27  487.28  511.38  0.25  0.88  0.16  496.70  496.55
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure MTHOTH00100061, in Mount Holly, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number MTHOTH00100061

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 21 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 47200

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

Waterway *(I - 6)* PERRY BROOK

Road Name *(I - 7):* -

Route Number TH010

Vicinity *(I - 9)* 0.75 MI TO JCT C3 TH 28

Topographic Map Mount Holly

Hydrologic Unit Code: 02010002

Latitude *(I - 16; nnnn.n)* 43272

Longitude *(i - 17; nnnnn.n)* 72505

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10111200611112

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

Maximum span length *(I - 48; nnnn)* 0025

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

Structure length *(I - 49; nnnnnn)* 000029

Average daily traffic, ADT *(I - 29; nnnnnn)* 000050

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

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

Channel & Protection *(I - 61; n)* 5

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

Waterway adequacy *(I - 71; n)* 7

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

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

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

Year Reconstructed *(I - 106)* 1947

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

Clear span (*nnn.n ft*) 016.2

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

Vertical clearance from streambed (*nnn.n ft*) 011.1

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

Waterway of full opening (*nnn.n ft²*) 179.4

Comments:

The structural inspection report of 6/24/94 indicates the structure is a steel stringer type bridge with a timber deck. The abutment walls and wingwalls are noted as consisting of large "laid-up" stone with concrete caps on the abutment walls. There is random spalling reported on the concrete caps overall. Also there are several small voids and some resulting displacement and breaking of the laid-up stone work. The channel bed consists of mainly cobbles and boulders. There are several large boulders across the channel at the downstream face of the bridge. The report indicates some small tree limbs scattered along the edges of the channel.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 5.38 mi^2 Lake/pond/swamp area 0.10 mi^2
Watershed storage *(ST)* 1.9 %
Bridge site elevation 1417 ft Headwater elevation 3286 ft
Main channel length 5.75 mi
10% channel length elevation 1476 ft 85% channel length elevation 1909 ft
Main channel slope *(S)* 100.37 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? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:

NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness ______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS.

Cross-sectional Data

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

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

Comments: **The low chord to bed lengths, and the distances between the stations were taken from a sketch dated 8/19/92 that was attached to a bridge inspection report. The elevation coordinate was made to match those in the report, they are lined up by the low chord points.**

Station	0	5.6	5	5.6	-	-	-	-	-	-	-
Feature	LAB	-	-	RAB	-	-	-	-	-	-	-
Low chord elevation	498.2	498.2	498.2	498.2	-	-	-	-	-	-	-
Bed elevation	487.6	486.2	486.8	487.7	-	-	-	-	-	-	-
Low chord to bed	10.6	12	11.4	10.5	-	-	-	-	-	-	-

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

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

Comments: -
-

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: **2/5/96**
Computerized by: **CG** Date: **2/5/96**
Reviewd by: **MAI** Date: **1/11/98**

Structure Number **MTHOTH00100061**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M**. **Ivanoff** Date *(MM/DD/YY)* **10** / **11** / 19**95**

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

County **Rutland (021)** Town **Mount Holly (47200)**

Waterway *(I - 6)* **Perry Brook** Road Name **-**

Route Number **TH 10** Hydrologic Unit Code: **02010002**

3. Descriptive comments:

The site is located 0.75 miles from Town Highway 28.

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 **29.0** *(feet)* Span length **25.0** *(feet)* Bridge width **14.0** *(feet)*

Road approach to bridge:

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

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

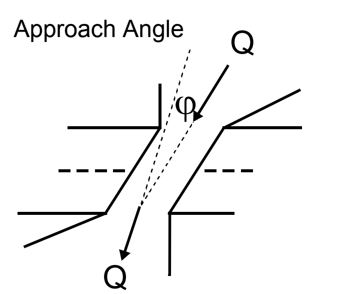
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

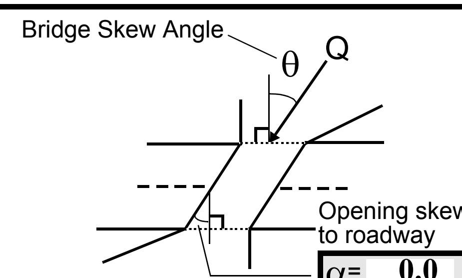
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	0	-	0	0
RBDS	2	1	0	0
LBDS	2	1	0	0

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

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **5**





α= **0.0**

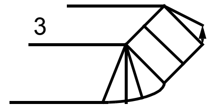
17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **20** feet **US** *(US, UB, DS)* to **40** feet **US**

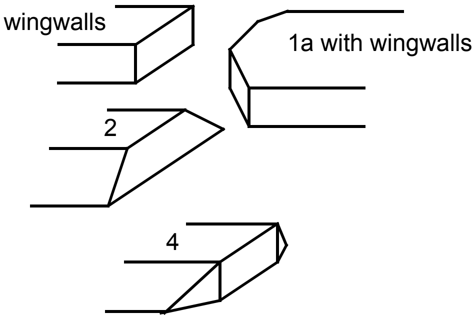
Channel impact zone 2: Exist? **N** *(Y or N)*
Where? **-** *(LB, RB)* Severity **-**
Range? **-** feet **-** *(US, UB, DS)* to **-** feet **-**

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

18. Bridge Type: 4

1a- Vertical abutments with wingwalls
1b- Vertical abutments without wingwalls
2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel to abut. face
3- Spill through abutments
4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.





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

7. The bridge dimensions are from the VTAOT database. The measured bridge length is 29.5 ft, span is 23 ft, width is 14.0 ft.

11. The left bank downstream side of the road approach has some timber failure eight feet from the abutment face. Stones protect the road embankment six ft from the abutment face.

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
17.5	2.0			2.5	4	4	342	432	0	1

23. Bank width **35.0** 24. Channel width **20.0** 25. Thalweg depth **31.5** 29. Bed Material **432**

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. The left bank material consists of gravel, cobbles and sand. The right bank material consists of cobbles gravel and sand.

29. The bed material consists of cobbles, gravel and sand.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **27** 35. Mid-bar width: **16**

36. Point bar extent: **6** feet **US** (US, UB) to **48** feet **US** (US, UB, DS) positioned **0** %LB to **25** %RB

37. Material: **23**

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

The point bar consists of sand and small gravel.

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: **31** 42. Cut bank extent: **15** feet **US** (US, UB) to **70** 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.):

Another cut bank exists along left bank from 100 ft to 175 ft upstream with steepened slopes and exposed roots.

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

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

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

NO CHANNEL SCOUR

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
26.0		**0.5**		**2**	**7**	**7**	**-**

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

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

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

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

432

The bed material consists of cobbles with gravel and some sand.

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? 2__ *(Y or N)* Ice Blockage Potential N____ *(1- Low; 2- Moderate; 3- High)*

70. Debris and Ice Comments:

2

Debris is scattered along the upstream banks with some trees leaning into the channel.

68. Debris capture is likely with large boulders across the downstream bridge face to the end of the wing-walls. Ice blockage will increase with large boulders obstructing flow.

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		0	85	2	0	0	0	90.0
RABUT	2	0	85			2	0	23.0

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

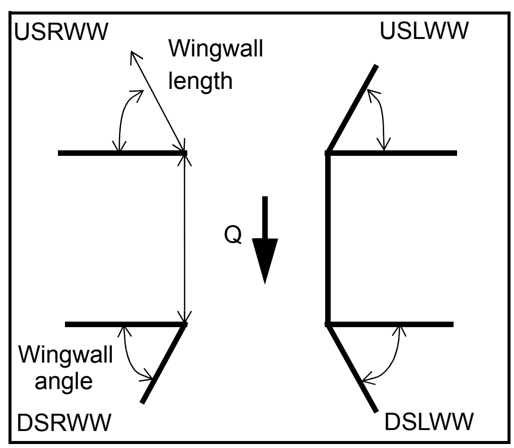
2

77. The abutments consist of "laid up" stone walls with concrete caps.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						23.0	
USRWW:	Y		2		0	0.5	
DSLWW:	0		0		Y	19.0	
DSRWW:	2		0		0	18.0	

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

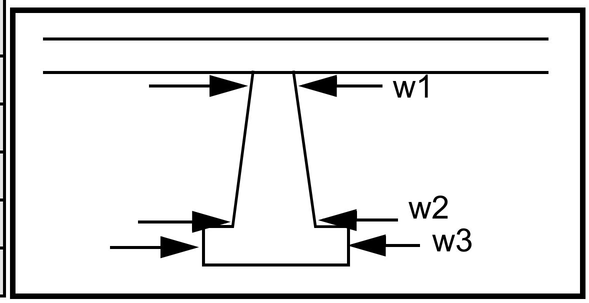
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

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				**70.0**	**15.0**	**85.0**
Pier 2	**8.0**	**9.5**	**6.5**	**75.0**	**100.0**	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

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

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

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

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

Comments (eg. bank material variation, minor inflows, protection extent, etc.):
-
-
-
-
-
NO PIERS

101. Is a drop structure present? **4** *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

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

105. Drop structure comments (eg. downstream scour depth):
43
435
0
1
4325
0

106. Point/Side bar present? 0 (Y or N. if N type ctrl-n pb) Mid-bar distance: - Mid-bar width: -

Point bar extent: The feet left (US, UB, DS) to bank feet ma (US, UB, DS) positioned teri %LB to al %RB

Material: con

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

sists of cobble and gravel. The right bank material consists of cobble, gravel and some boulders. The bed material consists of cobble, gravel, sand and some boulders.
There is a boulder pile between the downstream wing walls. It extends across the entire channel from just below the downstream bridge face to 20 ft downstream.

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

Cut bank extent: nel is feet ana (US, UB, DS) to bran feet che (US, UB, DS)

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

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

85 ft downstream. The flow cuts off a previous bend in the channel forming a mid-channel bar.

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

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

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

-

NO DROP STRUCTURE

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

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

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

Confluence comments (eg. confluence name):

-

-

F. Geomorphic Channel Assessment

107. Stage of reach evolution -

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

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

-

-

NO POINT BARS

A mid-channel bar begins 85 ft to 136 ft downstream. It consists of boulder and cobble. It is 25 feet wide at mid-bar, 105 feet downstream.

Y
RB
30
24
DS
48
DS

109. G. Plan View Sketch

- 1

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: MTHOTH00100061 Town: Mount Holly
Road Number: TH 10 County: Rutland
Stream: Perry Brook

Initials MAI Date: 01/05/98 Checked: ECW

I. 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	920	1300	0
Main Channel Area, ft2	280	408	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	78	96	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.3176	0.3176	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	3.6	4.3	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	13622	22276	0
Conveyance, main channel	13622	22276	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	920.0	1300.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	3.3	3.2	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.5	9.7	N/A
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	N/A
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	920	1300	0
(Q) discharge thru bridge, cfs	920	1300	0
Main channel conveyance	5035	7097	0
Total conveyance	5035	7097	0
Q2, bridge MC discharge,cfs	920	1300	ERR
Main channel area, ft2	79	100	0
Main channel width (normal), ft	18.4	19.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	18.4	19.1	0
y_bridge (avg. depth at br.), ft	4.29	5.24	ERR
Dm, median (1.25*D50), ft	0.397	0.397	0
y2, depth in contraction,ft	4.61	6.00	ERR
ys, scour depth (y2-ybridge), ft	0.31	0.77	N/A

Armoring
Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	920	1300	N/A
Main channel area (DS), ft2	79	100	0
Main channel width (normal), ft	18.4	19.1	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	18.4	19.1	0.0
D90, ft	0.9912	0.9912	0.0000
D95, ft	1.3051	1.3051	0.0000
Dc, critical grain size, ft	0.8683	0.9816	ERR
Pc, Decimal percent coarser than Dc	0.126	0.102	0.000
Depth to armoring, ft	18.07	25.93	ERR

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)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	920	1300	0	920	1300	0
a', abut.length blocking flow, ft	25.2	37.3	0	34.2	39.6	0
Ae, area of blocked flow ft2	93.37	135.85	0	65.08	106.84	0
Qe, discharge blocked abut.,cfs	309.73	379.17	0	42.4	186.88	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.32	2.79	ERR	0.65	1.75	ERR
ya, depth of f/p flow, ft	3.71	3.64	ERR	1.90	2.70	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.304	0.258	ERR	0.083	0.188	ERR
ys, scour depth, ft	11.31	11.70	N/A	4.60	8.44	N/A

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)	25.2	37.3	0	34.2	39.6	0
y1 (depth f/p flow, ft)	3.71	3.64	ERR	1.90	2.70	ERR
a'/y1	6.80	10.24	ERR	17.97	14.68	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.30	0.26	N/A	0.08	0.19	N/A
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	1	1	0	1	1	0
y, depth of flow in bridge, ft	4.29	5.24	0.00	4.29	5.24	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	1.79	2.19	ERR	1.79	2.19	ERR