LEVEL II SCOUR ANALYSIS FOR BRIDGE 19 (SHEFTH00440019) on TOWN HIGHWAY 44, crossing TROUT BROOK, SHEFFIELD, VERMONT

Open-File Report 97-817

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 19 (SHEFTH00440019) on TOWN HIGHWAY 44, crossing TROUT BROOK, SHEFFIELD, VERMONT

By EMILY C. WILD and LAURA MEDALIE

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
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Denver, CO 80225-0286

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

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 19 (SHEFTH00440019) ON TOWN HIGHWAY 44, CROSSING TROUT BROOK, SHEFFIELD, VERMONT

By **Emily C. Wild and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure SHEFTH00440019 on Town Highway 44 crossing Trout Brook, Sheffield, 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 White Mountain section of the New England physiographic province in northeastern Vermont. The 3.0-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is grass on the upstream and downstream right overbanks, while the immediate banks have dense woody vegetation. The surface cover of the upstream and downstream left overbanks is shrub and brushland.

In the study area, Trout Brook has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 45 ft and an average bank height of 6 ft. The channel bed material ranges from sand to boulder with a median grain size (D_{50}) of 116 mm (0.381 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 31, 1995, indicated that the reach was stable.

The Town Highway 44 crossing of Trout Brook is a 24-ft-long, one-lane bridge consisting of a 22-foot steel-stringer span (Vermont Agency of Transportation, written communication, March 28, 1994). The opening length of the structure parallel to the bridge face is 19.8 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is zero degrees.

The scour countermeasures at the site include type-2 stone fill (less than 36 inches diameter) along the upstream left and right wingwalls, the upstream ends of the left and right abutments, the downstream end of the downstream left wingwall, and the upstream and downstream left channel banks. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was analyzed since it has the potential of being the 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 resulted in zero ft. Left abutment scour ranged from 4.4 to 5.6 ft. The worst-case left abutment scour occurred at the 500-year discharge. Right abutment scour ranged from 3.6 to 4.8 ft. The worst-case right abutment scour occurred at the incipient roadway-overtopping 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 others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

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

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number SHEFTH00440019 ***Stream*** Trout Brook

County Caledonia ***Road*** TH44 ***District*** 7

Description of Bridge

Bridge length 24 ***ft*** ***Bridge width*** 16.0 ***ft*** ***Max span length*** 22 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 7/31/95

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

Abutments and wingwalls are concrete.

Brief description of piers/abutments

Yes

Is bridge skewed to flood flow according to Level I survey? 10 ***Angle*** No

Is bridge located on a bend in channel? If so, describe (mild, moderate, severe)

7/31/95

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	0	0	7/31/
Level II	95	0	0

Potential for debris Low.

None, 7/31/95.

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

Description of the Geomorphic Setting

General topography The channel is located within a narrow, slightly irregular flood plain with moderately sloped valley walls on both sides.

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

Date of inspection 7/31/95

DS left: Narrow flood plain to a moderately sloped overbank.

DS right: Narrow flood plain.

US left: Narrow flood plain to a moderately sloped overbank.

US right: Narrow flood plain.

Description of the Channel

Average top width 45 ***ft*** ***Average depth*** 6 ***ft***

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

Sinuous but stable with non-alluvial channel boundaries and a narrow flood plain.

7/31/95

Vegetative co Shrubland and brushland with State Route 144 along the immediate bank.

DS left: Grass with some brush and shrubs.

DS right: Shrubland and brushland with State Route 144 along the immediate bank.

US left: Grass with a few trees.

US right:

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

None, 7/31/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 3.0 ***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***: None.

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 720 ***ft³/s*** ***Q500*** 1,100 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(3.0/2.0)exp 0.67] with bridge number 8 in Sheffield. Flood frequency estimates are available from the VTAOT database. The drainage area above bridge number 8 is 2.0 square miles. The values computed are within a range defined by several empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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 the downstream end of the left abutment (elev. 499.23 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 499.17 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-20	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPR1	40	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 0.055 to 0.072, and overbank "n" values ranged from 0.040 to 0.070.

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 0.034 ft/ft which was calculated from surveyed downstream thalweg points.

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

Bridge Hydraulics Summary

Average bridge embankment elevation 499.6 ***ft***
Average low steel elevation 497.5 ***ft***

100-year discharge 720 ***ft³/s***
Water-surface elevation in bridge opening 494.7 ***ft***
Road overtopping? N ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 70 ***ft²***
Average velocity in bridge opening 10.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.9 ***ft/s***

Water-surface elevation at Approach section with bridge 497.1
Water-surface elevation at Approach section without bridge 496.1
Amount of backwater caused by bridge 1.0 ***ft***

500-year discharge 1,100 ***ft³/s***
Water-surface elevation in bridge opening 497.5 ***ft***
Road overtopping? Y ***Discharge over road*** 227 ***ft³/s***
Area of flow in bridge opening 125 ***ft²***
Average velocity in bridge opening 6.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.8 ***ft/s***

Water-surface elevation at Approach section with bridge 498.5
Water-surface elevation at Approach section without bridge 496.9
Amount of backwater caused by bridge 1.6 ***ft***

Incipient overtopping discharge 880 ***ft³/s***
Water-surface elevation in bridge opening 495.1 ***ft***
Area of flow in bridge opening 78 ***ft²***
Average velocity in bridge opening 11.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.2 ***ft/s***

Water-surface elevation at Approach section with bridge 498.0
Water-surface elevation at Approach section without bridge 496.5
Amount of backwater caused by bridge 1.5 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in Tables 1 and 2 and a graph of the scour depths is presented 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 others, 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 others, 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 was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and the results are presented in Appendix F. Contraction scour was computed for the 500-year discharge by substituting an estimate for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to this substitution are provided in Appendix F.

Abutment scour for the left abutment was computed by use of the Froehlich equation (Richardson and others, 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 at the right abutment was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.0
Depth to armoring	8.8 2.2	12.0	--
Left overbank	--	--	--
Right overbank	--	--	4.4 5.6

Local scour:			
Abutment scour	5.1	4.3	3.6
Left abutment	4.8–	---	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	1.5	1.3
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	1.7	1.5	1.3
Left abutment	1.7	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--		
Pier 2			

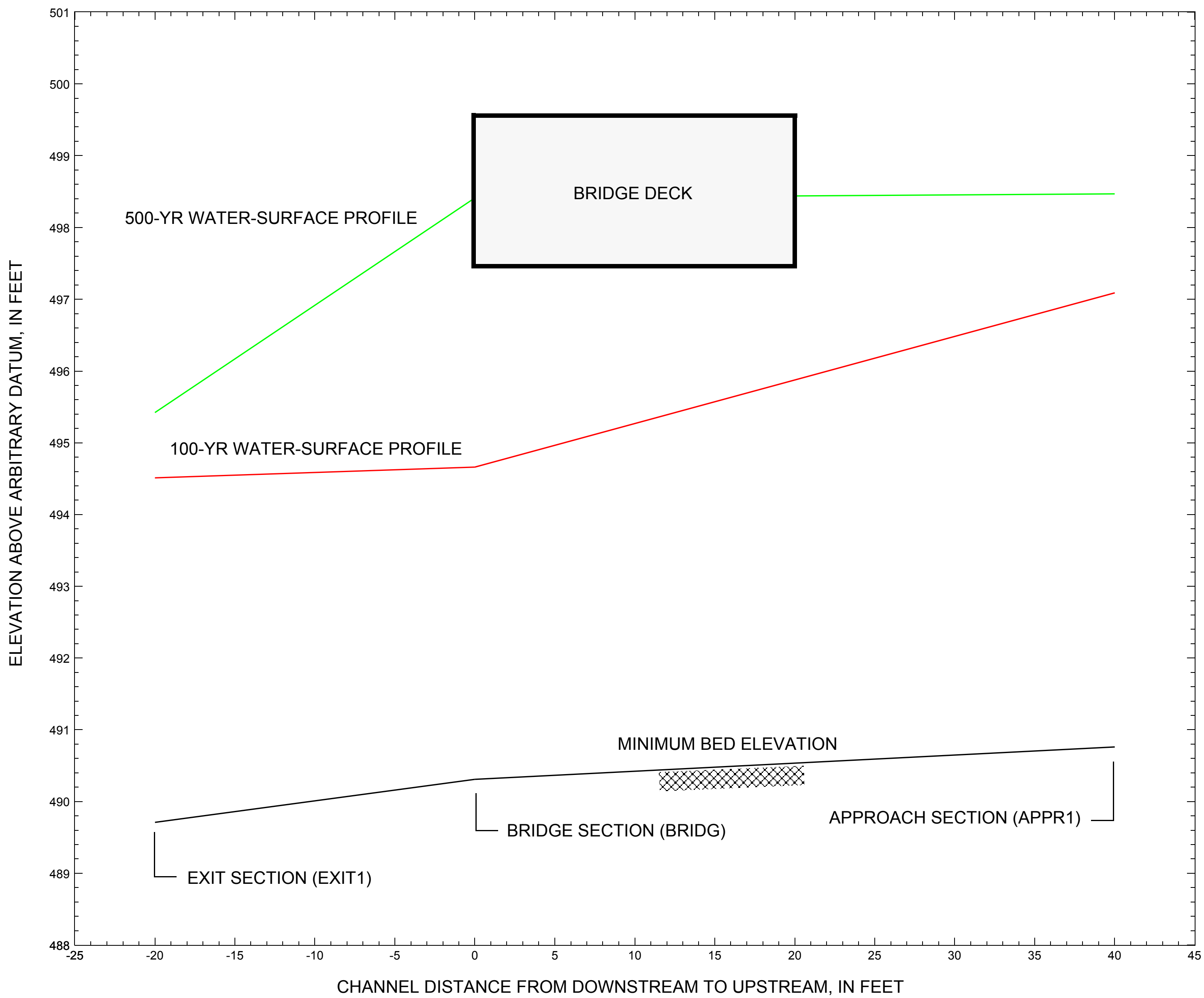

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure SHEFTH00440019 on Town Highway 44, crossing Trout Brook, Sheffield, Vermont.

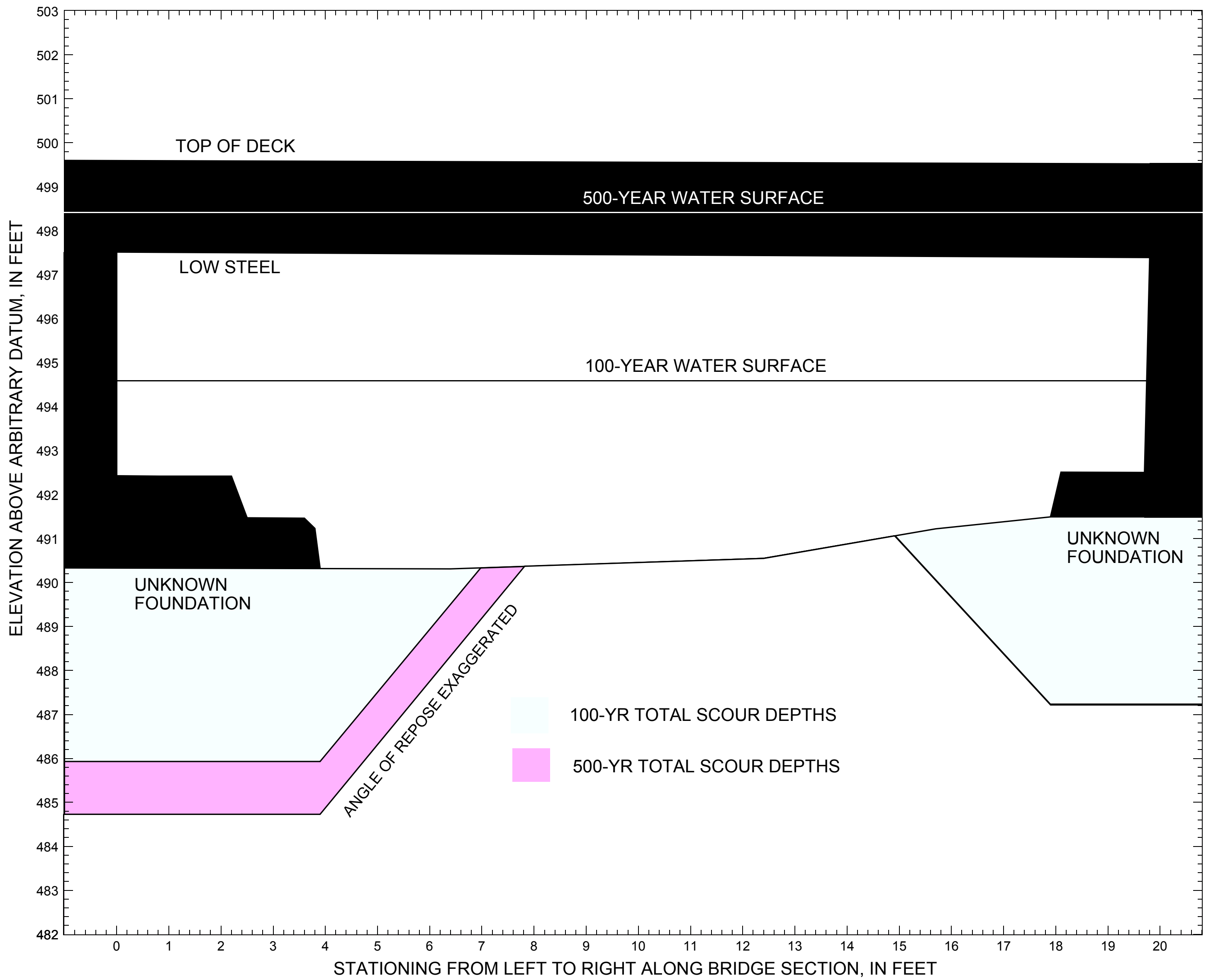

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure SHEFTH00440019 on Town Highway 44, crossing Trout Brook, Sheffield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure SHEFTH00440019 on Town Highway 44, crossing Trout Brook, Sheffield, 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-yr. discharge is 720 cubic-feet per second											
Left abutment	0.0	--	497.5	--	490.3	0.0	4.4	--	4.4	485.9	--
Right abutment	19.8	--	497.4	--	491.5	0.0	4.3	--	4.3	487.2	--

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 SHEFTH00440019 on Town Highway 44, crossing Trout Brook, Sheffield, 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-yr. discharge is 1,100 cubic-feet per second											
Left abutment	0.0	--	497.5	--	490.3	0.0	5.6	--	5.6	484.7	--
Right abutment	19.8	--	497.4	--	491.5	0.0	3.8	--	3.8	487.7	--

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, Stannard, 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 shef019.wsp
T2        Hydraulic analysis for structure SHEFTH00440019   Date: 05-SEP-97
T3        Town Highway 44, Trout Brook, Sheffield, Vermont                 ECW
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            720.0   1100.0    880.0
SK          0.0338   0.0338   0.0338
*
XS   EXIT1    -20           0.
GR          -71.9, 500.34    -58.7, 499.24    -47.2, 499.24    -37.7, 499.11
GR          -27.2, 498.78    -19.1, 497.96      0.0, 494.61      7.8, 490.31
GR            9.0, 489.71     13.1, 490.19     19.8, 490.08     21.6, 490.72
GR           28.8, 494.24     52.6, 494.83    114.3, 496.75    152.8, 495.84
GR          172.4, 495.83    191.5, 502.39
*
N           0.070        0.072        0.065
SA                -19.1         28.8
*
*
XS   FULLV      0  * * *   0.0166
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.45       0.0
GR            0.0, 497.51      0.0, 492.44      2.2, 492.42      2.5, 491.47
GR            3.6, 491.46      3.8, 491.23      3.9, 490.33      6.4, 490.31
GR           12.4, 490.55     15.7, 491.22     17.9, 491.49     18.1, 492.51
GR           19.7, 492.50     19.8, 497.39      0.0, 497.51
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      25.5 * *     45.3      5.8
N           0.055
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     10      16.0     2
GR         -176.3, 513.61   -139.3, 506.81   -121.9, 502.72    -69.6, 500.26
GR          -40.7, 500.01    -31.5, 499.89    -21.5, 499.48     -1.4, 499.22
GR            0.0, 499.60     20.1, 499.52     38.8, 498.05     65.1, 497.15
GR           92.7, 497.65    101.7, 497.58
*
*
AS   APPR1     40           0.
GR         -168.2, 513.83   -154.8, 511.85   -138.9, 508.08   -107.9, 501.89
GR          -66.9, 500.56    -34.3, 500.83    -24.9, 500.67    -14.4, 500.24
GR           -9.2, 499.88     -1.7, 496.09      0.0, 495.08      4.9, 491.73
GR            7.2, 490.76     10.5, 490.77     12.7, 490.95     14.8, 491.74
GR           19.3, 491.94     25.6, 495.30     29.4, 497.26     44.8, 497.05
GR          101.7, 497.58
*
N           0.040        0.060        0.045
SA                 -14.4        29.4
*
HP 1 BRIDG 494.66 1 494.66
HP 2 BRIDG 494.66 * * 720
HP 1 APPR1 497.09 1 497.09
HP 2 APPR1 497.09 * * 720
*
HP 1 BRIDG 497.45 1 497.45
HP 2 BRIDG 497.45 * * 869
HP 1 BRIDG 496.36 1 496.36
HP 2 RDWAY 498.41 * * 227
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
         U.S. Geological Survey WSPRO Input File shef019.wsp
         Hydraulic analysis for structure SHEFTH00440019   Date: 05-SEP-97
         Town Highway 44, Trout Brook, Sheffield, Vermont                 ECW
            *** RUN DATE & TIME: 10-31-97  10:50

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

      WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
              1       70      3637    20     27                          752
    494.66            70      3637    20     27  1.00      0     20      752

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        494.66     0.0    19.7    70.3    3637.     720.  10.25

 X STA.         0.0         2.7         4.1         4.9         5.7         6.4
   A(I)              6.5         4.7         3.6         3.2         3.1
   V(I)             5.55        7.67        9.93       11.35       11.59

 X STA.         6.4         7.1         7.7         8.4         9.1         9.7
   A(I)              3.0         2.9         2.9         2.8         2.8
   V(I)            12.20       12.51       12.49       12.72       12.80

 X STA.         9.7        10.4        11.1        11.8        12.5        13.2
   A(I)              2.8         2.8         2.9         2.9         3.0
   V(I)            12.83       12.91       12.40       12.36       11.94

 X STA.        13.2        14.0        14.9        15.9        17.2        19.7
   A(I)              3.1         3.3         3.6         4.1         6.4
   V(I)            11.57       10.94       10.11        8.86        5.63

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      40.

      WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
              2      130      7637    33     36                         1475
              3        0         0     7      7                            0
    497.09           130      7637    40     43  1.00     -3     49     1335

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      40.

          WSEL     LEW     REW    AREA        K        Q    VEL
        497.09    -3.7    49.1   130.4    7637.     720.   5.52

 X STA.        -3.7         2.9         4.6         5.8         6.8         7.7
   A(I)             12.1         7.8         6.6         6.2         5.5
   V(I)             2.98        4.62        5.42        5.84        6.52

 X STA.         7.7         8.5         9.4        10.2        11.0        11.8
   A(I)              5.3         5.3         5.0         5.2         5.1
   V(I)             6.81        6.74        7.14        6.99        7.06

 X STA.        11.8        12.6        13.5        14.5        15.5        16.6
   A(I)              5.1         5.3         5.4         5.6         5.8
   V(I)             7.01        6.79        6.62        6.42        6.23

 X STA.        16.6        17.7        18.9        20.3        22.3        49.1
   A(I)              5.8         6.2         6.9         8.0        12.1
   V(I)             6.18        5.79        5.20        4.49        2.98
```

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      U.S. Geological Survey WSPRO Input File shef019.wsp
      Hydraulic analysis for structure SHEFTH00440019   Date: 05-SEP-97
      Town Highway 44, Trout Brook, Sheffield, Vermont                 ECW
         *** RUN DATE & TIME: 10-31-97  10:50
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      125      7016     10     42                          2525
 497.45           125      7016     10     42  1.00      0     20     2525

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

       WSEL     LEW     REW    AREA         K        Q    VEL
     497.45     0.0    19.8   125.1    7016.     869.   6.94

X STA.         0.0        2.1        3.3        4.2        4.9        5.6
  A(I)             10.3        6.9        6.3        5.0        4.7
  V(I)             4.22       6.27       6.95       8.61       9.27

X STA.         5.6        6.2        6.9        7.5        8.1        8.8
  A(I)              4.6        4.5        4.4        4.5        4.5
  V(I)             9.46       9.65       9.84       9.64       9.68

X STA.         8.8        9.4       10.1       11.0       11.9       12.8
  A(I)              4.6        5.0        6.1        6.3        6.3
  V(I)             9.55       8.73       7.16       6.92       6.89

X STA.        12.8       13.8       14.9       16.0       17.3       19.8
  A(I)              6.6        7.0        7.1        8.1       12.5
  V(I)             6.60       6.24       6.14       5.34       3.48

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      104      6438     20     30                          1351
 496.36           104      6438     20     30  1.00      0     20     1351

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

       WSEL     LEW     REW    AREA         K        Q    VEL
     498.41    34.2   101.7    57.2    1163.     227.   3.97

X STA.        34.2       47.1       52.0       55.6       58.5       61.1
  A(I)              5.0        3.6        3.2        2.9        2.7
  V(I)             2.28       3.18       3.60       3.93       4.15

X STA.        61.1       63.3       65.3       67.2       69.2       71.3
  A(I)              2.5        2.5        2.4        2.5        2.4
  V(I)             4.48       4.62       4.77       4.63       4.78

X STA.        71.3       73.4       75.7       78.1       80.7       83.5
  A(I)              2.4        2.5        2.5        2.6        2.6
  V(I)             4.66       4.54       4.49       4.39       4.30

X STA.        83.5       86.5       90.0       93.8       97.7      101.7
  A(I)              2.7        2.9        3.0        3.0        3.3
  V(I)             4.15       3.93       3.75       3.80       3.45

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      40.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           2      178     12065     36     39                          2248
           3       86      3169     72     73                           532
 498.47           264     15234    108    113  1.18     -5    102     2154

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      40.

       WSEL     LEW     REW    AREA         K        Q    VEL
     498.47    -6.4   101.7   263.8   15234.    1100.   4.17

X STA.        -6.4        2.3        4.6        6.3        7.6        8.8
  A(I)             20.3       13.3       11.2       10.2        9.5
  V(I)             2.71       4.12       4.92       5.37       5.81

X STA.         8.8       10.0       11.2       12.4       13.6       14.9
  A(I)              9.2        9.0        8.9        9.2        9.2
  V(I)             6.01       6.14       6.21       5.98       6.00

X STA.        14.9       16.3       17.8       19.2       21.0       23.5
  A(I)              9.4        9.6        9.8       10.7       12.5
  V(I)             5.88       5.75       5.63       5.13       4.41

X STA.        23.5       32.1       46.4       60.7       78.0      101.7
  A(I)             19.4       19.2       19.2       20.5       23.7
  V(I)             2.84       2.87       2.87       2.68       2.32
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      U.S. Geological Survey WSPRO Input File shef019.wsp
      Hydraulic analysis for structure SHEFTH00440019   Date: 05-SEP-97
      Town Highway 44, Trout Brook, Sheffield, Vermont                ECW
         *** RUN DATE & TIME: 10-31-97  10:50
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1       78      4242     20     27                          879
 495.05            78      4242     20     27  1.00      0     20      879


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

       WSEL     LEW     REW    AREA        K        Q    VEL
     495.05     0.0    19.8    78.0    4242.     880.  11.29

X STA.        0.0        2.7        4.0        4.9        5.6        6.4
 A(I)             7.3        5.2        3.9        3.6        3.4
 V(I)            6.04       8.42      11.30      12.21      12.84

X STA.        6.4        7.0        7.7        8.4        9.1        9.8
 A(I)             3.3        3.2        3.2        3.1        3.1
 V(I)           13.51      13.64      13.90      14.15      14.23

X STA.        9.8       10.4       11.1       11.8       12.5       13.3
 A(I)             3.1        3.1        3.1        3.2        3.4
 V(I)           14.05      14.14      14.06      13.68      12.92

X STA.       13.3       14.1       15.0       16.0       17.2       19.8
 A(I)             3.5        3.6        4.0        4.4        7.2
 V(I)           12.71      12.31      11.05       9.90       6.09

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      40.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           2      163     10565     35     38                         1989
           3       55      1506     72     73                          271
 498.04           217     12071    107    111  1.23     -5    102     1584


  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      40.

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.04    -5.6   101.7   217.5   12071.     880.   4.05

X STA.       -5.6        2.4        4.5        6.0        7.2        8.3
 A(I)            17.0       11.3        9.5        8.6        7.8
 V(I)            2.60       3.91       4.66       5.11       5.63

X STA.        8.3        9.3       10.4       11.4       12.4       13.5
 A(I)             7.7        7.5        7.4        7.3        7.4
 V(I)            5.75       5.87       5.99       6.01       5.96

X STA.       13.5       14.6       15.9       17.1       18.4       19.9
 A(I)             7.7        7.8        7.9        8.1        8.6
 V(I)            5.71       5.62       5.58       5.46       5.09

X STA.       19.9       21.7       24.6       41.4       63.1      101.7
 A(I)             9.8       11.6       20.1       19.9       24.7
 V(I)            4.51       3.79       2.19       2.22       1.78
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        U.S. Geological Survey WSPRO Input File shef019.wsp
        Hydraulic analysis for structure SHEFTH00440019   Date: 05-SEP-97
        Town Highway 44, Trout Brook, Sheffield, Vermont                 ECW
           *** RUN DATE & TIME: 10-31-97  10:50

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

EXIT1:XS   ******      0       93  0.96 *****  495.47  493.96     720  494.51
       -19 ******     40     3915  1.03 ***** *******    0.90    7.75

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     495.36     494.29

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.01     502.72    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.01     502.72     494.29

FULLV:FV       20     -1      119  0.65  0.54  496.00  494.29     720  495.35
         0     20     59     4940  1.13  0.00    0.00    0.82    6.06
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       40     -1       99  0.82  0.79  496.90 *******     720  496.07
        40     40     27     5282  1.00  0.09    0.01    0.69    7.27
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR       20      0       70  1.63  0.73  496.29  494.57     720  494.66
         0     20     20     3635  1.00  0.09    0.00    0.96   10.25

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.45 ****** ****** ******

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

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

APPR1:AS       15     -3      130  0.47  0.28  497.57  495.17     720  497.09
        40     15     49     7641  1.00  1.00    0.02    0.54    5.52

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.313  0.000    7848.     2.    22.   496.88

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXIT1:XS     -20.     0.    40.    720.    3915.      93.    7.75  494.51
   FULLV:FV       0.    -2.    59.    720.    4940.     119.    6.06  495.35
   BRIDG:BR       0.     0.    20.    720.    3635.      70.   10.25  494.66
   RDWAY:RG      10.**************      0.******************    2.00********
   APPR1:AS      40.    -4.    49.    720.    7641.     130.    5.52  497.09

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS       2.    22.    7848.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF    HO   VHD      EGL    WSEL
   EXIT1:XS    493.96    0.90  489.71  502.39************  0.96  495.47  494.51
   FULLV:FV    494.29    0.82  490.04  502.72  0.54  0.00  0.65  496.00  495.35
   BRIDG:BR    494.57    0.96  490.31  497.51  0.73  0.09  1.63  496.29  494.66
   RDWAY:RG  ****************  497.15  513.61**********************************
   APPR1:AS    495.17    0.54  490.76  513.83  0.28  1.00  0.47  497.57  497.09
```

WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File shef019.wsp
       Hydraulic analysis for structure SHEFTH00440019   Date: 05-SEP-97
       Town Highway 44, Trout Brook, Sheffield, Vermont                 ECW
          *** RUN DATE & TIME: 10-31-97  10:50

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

EXIT1:XS   ******     -4      146  1.06 *****  496.48  495.41    1100  495.42
       -19 ******     72     5980  1.20 ***** *******    1.05    7.53

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.87     496.37     495.74

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.92     502.72    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.92     502.72     495.74

FULLV:FV       20     -7      204  0.61  0.51  496.97  495.74    1100  496.36
         0     20    173     7987  1.35  0.00   -0.01    0.87    5.38
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       40     -2      124  1.22  0.85  498.12 *******    1100  496.90
        40     40     29     7165  1.00  0.30    0.00    0.79    8.85
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   499.07       0.00     495.68     497.15

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   500.27         0.      1100.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

 ===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      125  0.75 *****  498.20  495.02     869  497.45
         0 ******     20     7016  1.00 ***** *******    0.49    6.94

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.414 ******  497.45 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    24.  0.12  0.32  498.67    0.00    227.  498.41

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    92.   -82.    10.   1.6   1.0   5.9   7.0   1.7   3.0
   RT:   227.    68.    34.   102.   1.3   0.9   4.6   3.9   1.1   2.9

===140 AT SECID “APPR1”:  END OF CROSS SECTION EXTENDED VERTICALLY.
                            WSEL,YLT,YRT =   498.47      513.8      497.6

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

APPR1:AS       15     -5      264  0.32  0.14  498.79  496.22    1100  498.47
        40     15    102    15264  1.18  0.00    0.00    0.51    4.16

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -20.    -5.    72.   1100.    5980.     146.    7.53  495.42
   FULLV:FV       0.    -8.   173.   1100.    7987.     204.    5.38  496.36
   BRIDG:BR       0.     0.    20.    869.    7016.     125.    6.94  497.45
   RDWAY:RG      10.*******     0.    227.       0.*********    2.00  498.41
   APPR1:AS      40.    -6.   102.   1100.   15264.     264.    4.16  498.47

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS     495.41    1.05  489.71  502.39************  1.06  496.48  495.42
   FULLV:FV     495.74    0.87  490.04  502.72  0.51  0.00  0.61  496.97  496.36
   BRIDG:BR     495.02    0.49  490.31  497.51************  0.75  498.20  497.45
   RDWAY:RG  ****************  497.15  513.61  0.12******  0.32  498.67  498.41
   APPR1:AS     496.22    0.51  490.76  513.83  0.14  0.00  0.32  498.79  498.47
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        U.S. Geological Survey WSPRO Input File shef019.wsp
        Hydraulic analysis for structure SHEFTH00440019   Date: 05-SEP-97
        Town Highway 44, Trout Brook, Sheffield, Vermont                 ECW
           *** RUN DATE & TIME: 10-31-97  10:50

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

EXIT1:XS   ******     -1      115  1.02 *****  495.98  494.47     880  494.95
       -19 ******     57     4784  1.12 ***** *******    1.02    7.67

FULLV:FV       20     -4      156  0.60  0.51  496.48 *******     880  495.88
         0     20     76     6375  1.21  0.00   -0.01    0.79    5.63
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       40     -1      111  0.98  0.79  497.46 *******     880  496.48
        40     40     28     6160  1.00  0.19    0.00    0.73    7.93
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   498.04       0.00     495.05     497.15

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   500.01         0.       880.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.10     498.08     498.19

 ===270 REJECTED 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       78  1.98  0.76  497.03  490.51     880  495.05
         0     20     20     4243  1.00  0.19    0.00    1.00   11.29

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.45 ****** ****** ******

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

===140 AT SECID "APPR1":  END OF CROSS SECTION EXTENDED VERTICALLY.
                             WSEL,YLT,YRT =   498.04      513.8      497.6

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

APPR1:AS       15     -5      218  0.31  0.23  498.36  495.65     880  498.04
        40     15    102    12092  1.23  1.10    0.00    0.55    4.04

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.349  0.145   10335.     2.    22.   497.92

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

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -20.    -2.    57.    880.    4784.     115.    7.67  494.95
   FULLV:FV       0.    -5.    76.    880.    6375.     156.    5.63  495.88
   BRIDG:BR       0.     0.    20.    880.    4243.      78.   11.29  495.05
   RDWAY:RG      10.**************      0.       0.*********    2.00********
   APPR1:AS      40.    -6.   102.    880.   12092.     218.    4.04  498.04

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS       2.    22.   10335.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXIT1:XS    494.47    1.02  489.71  502.39************  1.02  495.98  494.95
   FULLV:FV  ********    0.79  490.04  502.72  0.51  0.00  0.60  496.48  495.88
   BRIDG:BR    490.51    1.00  490.31  497.51  0.76  0.19  1.98  497.03  495.05
   RDWAY:RG  ****************  497.15  513.61************  0.27  498.35********
   APPR1:AS    495.65    0.55  490.76  513.83  0.23  1.10  0.31  498.36  498.04
  ER
NORMAL  END  OF  WSPRO  EXECUTION.
```
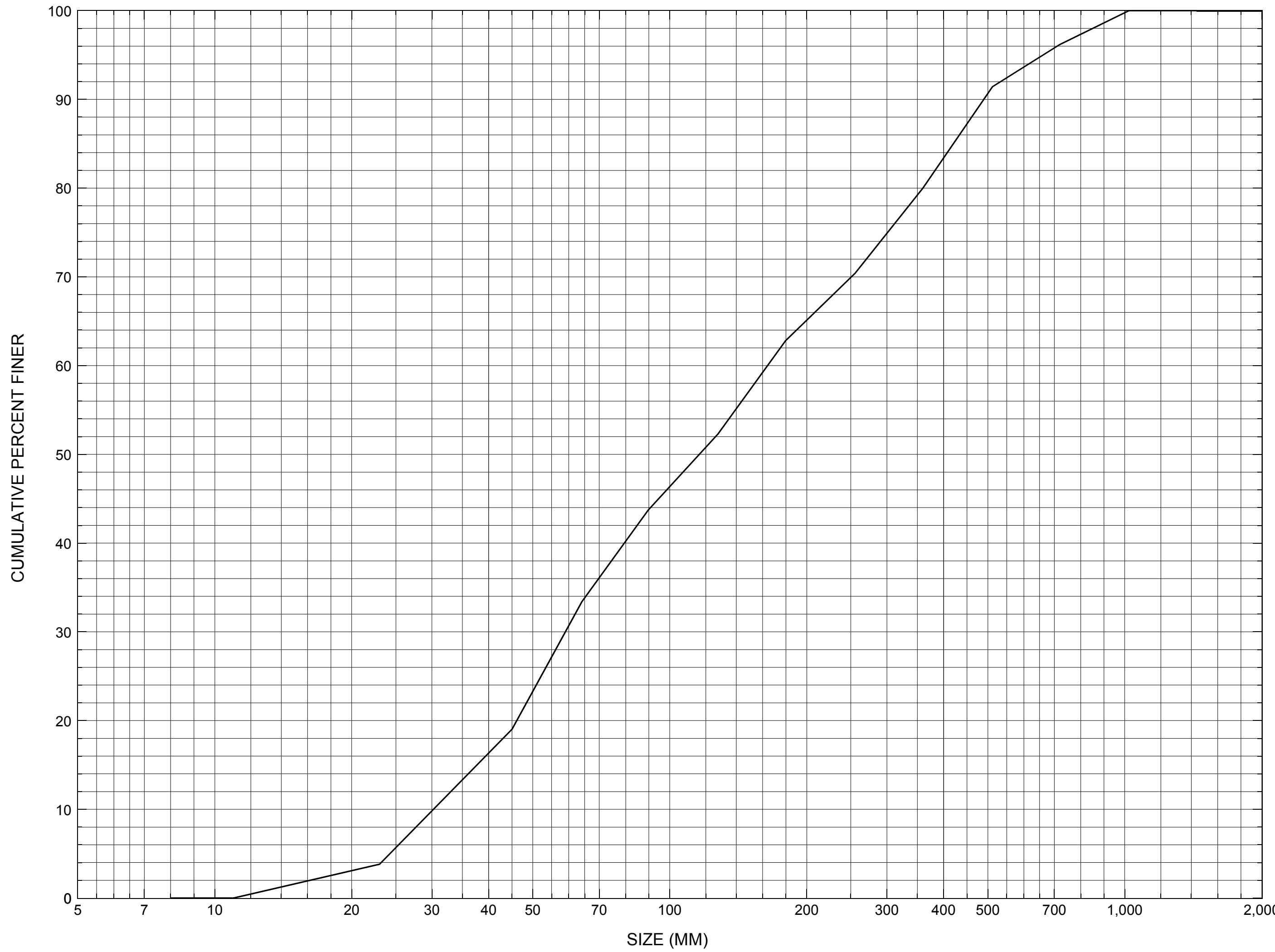

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure SHEFTH00440019, in Sheffield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number SHEFTH00440019

General Location Descriptive

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

Date (MM/DD/YY) 03 / 28 / 95

Highway District Number (I - 2; nn) 07

County (FIPS county code; I - 3; nnn) 005

Town (FIPS place code; I - 4; nnnnn) 64075

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

Waterway (I - 6) SHEFFIELD HEIGHTS BROOK

Road Name (I - 7): -

Route Number TH044

Vicinity (I - 9) 0.05 MI JCT TH 44 +VT122

Topographic Map Crystal Lake

Hydrologic Unit Code: 01080102

Latitude (I - 16; nnnn.n) 44377

Longitude (i - 17; nnnnn.n) 72080

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10031200190312

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0022

Year built (I - 27; YYYY) 1974

Structure length (I - 49; nnnnnn) 000024

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

Deck Width (I - 52; nn.n) 160

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) 6

Operational status (I - 41; X) B

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

Structure type (I - 43; nnn) 302

Year Reconstructed (I - 106) 0000

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

Clear span (nnn.n ft) -

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 006.7

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

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

Comments:

The structural inspection report of 10/31/94 indicates the structure is a steel stringer type bridge with a timber deck. The abutment walls and wingwalls are concrete, which have a few fine cracks and leaks overall. The top of the left abutment has alligator cracks and leaks, and is spalling for most of its length. Some boulder fill is noted around the ends of the wingwalls and along the banks. The footings of both abutment walls are exposed at the surface. The concrete of the footings are in good condition and the footings reportedly are not undermined. No settling is noted on the report. Channel scour is reported as normal. Point bar and debris accumulation problems are noted as minor at this bridge site.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

Watershed storage area (in percent): - %

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **2.98** mi^2

Lake/pond/swamp area **0.02** mi^2

Watershed storage *(ST)* **0.5** %

Bridge site elevation **1142** ft

Headwater elevation **2070** ft

Main channel length **3.88** mi

10% channel length elevation **1240** ft

85% channel length elevation **1673** ft

Main channel slope *(S)* **148.73** 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:

-

Cross-sectional Data

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

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

Comments: **This is the cross section of the upstream face. The low cord elevation is from the survey log done for this report on 07/31/95. The low cord to bed length data is from the sketch attached to a bridge inspection report dated 10/31/94.**

Station	0	4	11	17.1	19.8	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low chord elevation	497.5	497.5	497.4	497.4	497.4	-	-	-	-	-	-
Bed elevation	492.4	490.5	490.6	491.1	492.5	-	-	-	-	-	-
Low chord to bed	5.1	7	6.8	6.3	4.9	-	-	-	-	-	-

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: EW Date: 03/20/96
Computerized by: EW Date: 03/21/96
Reviewd by: EW Date: 11/07/97

Structure Number SHEFTH00440019

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* L. MEDLAIE Date *(MM/DD/YY)* 07 / 31 / 1995
2. Highway District Number 07 Mile marker -
County CALEDONIA (005) Town SHEFFIELD (64075)
Waterway *(I - 6)* TROUT BROOK Road Name -
Route Number TH044 Hydrologic Unit Code: 01080102
3. Descriptive comments:
This structure is located 0.05 miles to junction of TH44 and VT122.
This waterway is also Sheffield Heights Brook, as indicted within VTAOT data.

B. Bridge Deck Observations

4. Surface cover... LBUS 2 RBUS 4 LBDS 4 RBDS 4 Overall 4
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 2 UB 2 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 24 *(feet)* Span length 22 *(feet)* Bridge width 16 *(feet)*

Road approach to bridge:

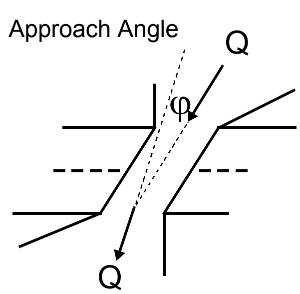
8. LB 1 RB 1 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

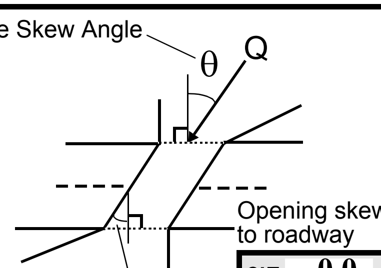
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	2	1	0	0

*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: 10 16. Bridge skew: 10





α= 0.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 12 feet US *(US, UB, DS)* to 20 feet DS
Channel impact zone 2: Exist? N *(Y or N)*
Where? - *(LB, RB)* Severity -
Range? - feet - *(US, UB, DS)* to - feet -

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

18. Bridge Type: **1a**

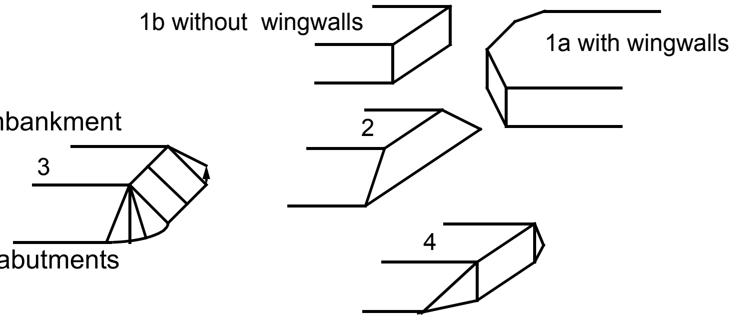
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel to abut. face

3- Spill through abutments

4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.



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

#4: One hundred feet from channel, row crops and forest area extend along the downstream right bank.
Along the upstream right bank, a lawn and house exist beyond the brushland area
A paved road (VT122) and lawn is present along the downstream left bank.
Along the upstream left bank, exists a grassy embankment from the paved road (VT122). In addition, a dirt road and trees are present on the left overbank.
#7: The values are from the VTAOT database. The measured bridge length equals 23.2 feet, the bridge span equals 20 feet and the bridge width equals 16.2 feet.
#8: The measured road width on the left equals 12 feet, and on the right equals 11 feet.
#11-14: Descriptions of road embankment for VT122 from 45 feet to 70 feet along the upstream left bank are: (#11) protection is less than 36 inches; (#12) protection is slumped; (#13) both channel erosion and road wash are present; (#14) erosion severity is slight.

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
21.0	**8.5**			**5.5**	**1**	**2**	**543**	**54**	**1**	**0**

23. Bank width **25.0** 24. Channel width **30.0** 25. Thalweg depth **44.0** 29. Bed Material **4532**

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

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

32. Comments (bank material variation, minor inflows, protection extent, etc.):
#26: Along the left bank, there is zero percent vegetation cover. The left bank grades into road embankment for VT122
#29: Bedrock exists in the stream approximately 105 upstream, and it extends upstream.
#30: Many "naturally placed" boulders exist along the right bank.

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

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

37. Material: -

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

NO POINT BARS

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

41. Mid-bank distance: 70 42. Cut bank extent: 45 feet US (US, UB) to 75 feet US (US, UB, DS)

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

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

A series of three "scalloped" zones, which are part of road embankment for VT122.

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? Y (Y or if N type ctrl-n mc) 50. How many? 1

51. Confluence 1: Distance 150 52. Enters on LB (LB or RB) 53. Type 1 (**1**- perennial; **2**- ephemeral)

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

54. Confluence comments (eg. confluence name):

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
14.5		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.):

453

A small row of rocks was built across the width of the channel, 10 feet US of the bridge. This creates a slight drop in the water surface (approximately 0.5 feet). In the area just upstream and downstream from this structure, water is 1.0 feet.

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

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

70. Debris and Ice Comments:

1

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		**10**	**90**	**0**	**2**	**-**	**1.75**	**90.0**
RABUT	**1**	**0**	**90**			**0**	**2**	**20.0**

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

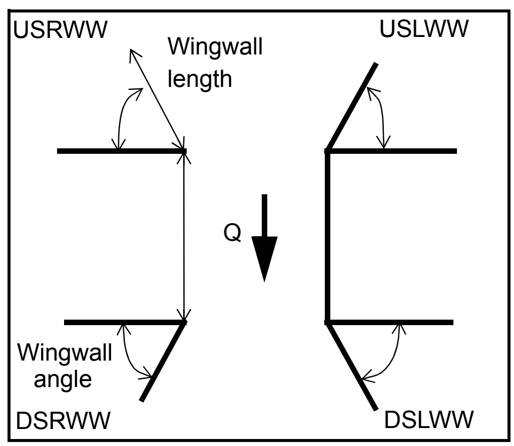
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
1.5
1
The footings are exposed along both abutments, but there is no evidence of scour.
The left abutment subfooting is exposed 0.75 feet above the stream bed. The overlying footing is 1.0 foot, vertically .
The right abutment footing is exposed 1.0 foot at upstream end and 1.5 feet at downstream end.
Footing and subfooting comments also apply to wingwalls; i.e. subfooting exists on USLWW and DSLWW but not on USRWW or DSRWW.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**20.0**	
USRWW:	**Y**		**1**		**2**	**1.0**	
DSLWW:	**-**		**1.75**		**Y**	**19.5**	
DSRWW:	**1**		**2**		**-**	**20.0**	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**1**	**2**	**Y**	**-**	**1**	**1**	**1**	**1**
Condition	**Y**	**-**	**1**	**1.5**	**1**	**1**	**2**	**2**
Extent	**1**	**1.75**	**2**	**2**	**2**	**2**	**2**	**-**

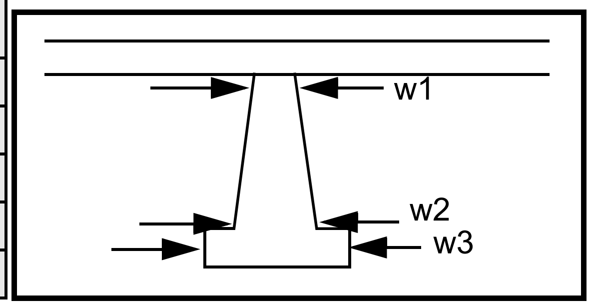
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
1
3
0
-
-

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		**8.0**	**8.5**	**50.0**	**40.0**	**40.0**
Pier 2	**9.0**	**9.0**	-	**45.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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
-	-			-	-	NO	PIE	RS		

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.):

3
3
54
54
0
0
543
2
0
1
-
The downstream reach is rather straight.

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

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

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

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

Point bar extent: _______ feet _____ *(US, UB, DS)* to **N** feet **-** *(US, UB, DS)* positioned **NO** %LB to **DR** %RB

Material: **OP**

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

STRUCTURE

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

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

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

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

-
-
-
-

Is channel scour present? **NO** *(Y or if N type ctrl-n cs)* Mid-scour distance: **POIN**

Scour dimensions: Length **T** Width **BAR** Depth: **S** 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? **-**

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

Confluence 2: Distance **NO** Enters on **CU** *(LB or RB)* Type **T** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

BANKS

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
-
-
-
-
-
-
NO CHANNEL SCOUR

N

109. G. Plan View Sketch

\- -

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: SHEFTH00440019 Town: SHEFFIELD
Road Number: TH 44 County: CALEDONIA
Stream: TROUT BROOK

Initials ECW Date: 10/31/97 Checked: MAI

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	720	1100	880
Main Channel Area, ft2	130	178	163
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	86	55
Top width main channel, ft	33	36	35
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	72	72
D50 of channel, ft	0.3808	0.3808	0.3808
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	3.9	4.9	4.7
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	1.2	0.8
Total conveyance, approach	7637	15234	12071
Conveyance, main channel	7637	12065	10565
Conveyance, LOB	0	0	0
Conveyance, ROB	0	3169	1506
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	720.0	871.2	770.2
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	0.0	228.8	109.8
Vm, mean velocity MC, ft/s	5.5	4.9	4.7
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	2.7	2.0
Vc-m, crit. velocity, MC, ft/s	10.2	10.6	10.5
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?

	100 yr	500 yr	other Q
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	720	1100	880
(Q) discharge thru bridge, cfs	720	869	880
Main channel conveyance	3637	7016	4242
Total conveyance	3637	7016	4242
Q2, bridge MC discharge,cfs	720	869	880
Main channel area, ft2	70	125	78
Main channel width (normal), ft	19.7	19.8	19.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.7	19.8	19.8
y_bridge (avg. depth at br.), ft	3.55	6.31	3.94
Dm, median (1.25*D50), ft	0.476	0.476	0.476
y2, depth in contraction,ft	3.34	3.91	3.95
ys, scour depth (y2-ybridge), ft	-0.21	-2.40	0.02

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	720	869	880
Main channel area (DS), ft2	70	104	78
Main channel width (normal), ft	19.7	19.8	19.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	19.7	19.8	19.8
D90, ft	1.6070	1.6070	1.6070
D95, ft	2.1692	2.1692	2.1692
Dc, critical grain size, ft	0.9815	0.5178	1.1104
Pc, Decimal percent coarser than Dc	0.252	0.412	0.217
Depth to armoring, ft	8.75	2.22	12.00

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	720	1100	880
Q, thru bridge MC, cfs	720	869	880
Vc, critical velocity, ft/s	10.21	10.61	10.50
Va, velocity MC approach, ft/s	5.54	4.89	4.73
Main channel width (normal), ft	19.7	19.8	19.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.7	19.8	19.8
qbr, unit discharge, ft2/s	36.5	43.9	44.4
Area of full opening, ft2	70.0	125.0	78.0
Hb, depth of full opening, ft	3.55	6.31	3.94
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	104	N/A
**Hb, depth at downstream face, ft	N/A	5.25	N/A
**Fr, Froude number at DS face	ERR	0.64	ERR
**Cf, for downstream face (<=1.0)	N/A	1.00	N/A
Elevation of Low Steel, ft	0	497.45	0
Elevation of Bed, ft	-3.55	491.14	-3.94
Elevation of Approach, ft	0	498.47	0
Friction loss, approach, ft	0	0.14	0
Elevation of WS immediately US, ft	0.00	498.33	0.00
ya, depth immediately US, ft	3.55	7.19	3.94
Mean elevation of deck, ft	0	499.56	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	0.920466	ERR
Ys, scour w/Chang equation, ft	N/A	-2.04	N/A
Ys, scour w/Umbrell equation, ft	N/A	-1.34	N/A

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

**Ys, scour w/Chang equation, ft	N/A	-0.76	N/A
**Ys, scour w/Umbrell equation, ft	ERR	-0.28	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	3.34	3.91	3.95
WSEL at downstream face, ft	--	496.39	--
Depth at downstream face, ft	N/A	5.25	N/A
Ys, depth of scour (Laursen), ft	N/A	-1.34	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	720	1100	880	720	1100	880
a’, abut.length blocking flow, ft	3.7	6.4	5.6	29.4	81.9	81.9
Ae, area of blocked flow ft2	6.78	14.93	11.9	23.06	64.43	86.67
Qe, discharge blocked abut.,cfs	20.18	40.46	30.8	87.43	--	222.93
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.98	2.71	2.59	3.79	3.01	2.57
ya, depth of f/p flow, ft	1.83	2.33	2.13	0.78	0.79	1.06
--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	0.387	0.313	0.313	0.754	0.436	0.441
ys, scour depth, ft	4.42	5.63	5.08	6.62	7.29	8.81

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)	3.7	6.4	5.6	29.4	81.9	81.9
y1 (depth f/p flow, ft)	1.83	2.33	2.13	0.78	0.79	1.06
a'/y1	2.02	2.74	2.64	37.48	104.11	77.39
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.39	0.31	0.31	0.75	0.44	0.44
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	5.20	4.35	5.87
vertical w/ ww's	ERR	ERR	ERR	**4.26**	**3.57**	**4.82**
spill-through	ERR	ERR	ERR	2.86	2.39	3.23

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.96	0.64	1	0.96	0.64	1
y, depth of flow in bridge, ft	3.55	5.25	3.94	3.55	5.25	3.94
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	1.33	ERR	ERR	1.33	ERR
Fr>0.8 (vertical abut.)	1.47	ERR	1.65	1.47	ERR	1.65